DOCTOR OF PHILOSOPHY


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Catherine Angharad Sharp
School of Psychology
January 2017

Thesis submitted to Bangor University, in partial fulfilment for the degree of Doctor of Philosophy.
This thesis is dedicated to my mother, Lorna Sharp. Throughout my life she has taught me to strive for my dreams, providing endless support and belief that I can achieve anything I put my mind to. She has been invaluable throughout this chapter of my life!
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Supervisor/Department: Prof Pauline Horne and Dr Mihela Erjavec, School of Psychology

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<table>
<thead>
<tr>
<th>Option</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>a)</td>
<td>I agree to deposit an electronic copy of my thesis (the Work) in the Bangor University (BU) Institutional Digital Repository, the British Library ETHOS system, and/or in any other repository authorized for use by Bangor University and where necessary have gained the required permissions for the use of third party material.</td>
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</tr>
</tbody>
</table>

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## List of Contents

<table>
<thead>
<tr>
<th>Declaration</th>
<th>iii</th>
</tr>
</thead>
<tbody>
<tr>
<td>Funding</td>
<td>vi</td>
</tr>
<tr>
<td>Conferences</td>
<td>vii</td>
</tr>
<tr>
<td>Acknowledgements</td>
<td>viii</td>
</tr>
<tr>
<td>List of Contents</td>
<td>viii</td>
</tr>
<tr>
<td>List of Figures</td>
<td>ix</td>
</tr>
<tr>
<td>List of Tables</td>
<td>xv</td>
</tr>
<tr>
<td>List of Appendices</td>
<td>xvi</td>
</tr>
</tbody>
</table>

### Thesis Summary

1

### Chapter One

**Literature Review**

1.1 Obesity

1.2 Children’s Eating Behaviours

1.3 Children’s Physical Activity

1.4 Settings to Target

1.5 Behaviour Change

1.6 Measuring Changes in Behaviours

1.7 Interventions Targeting Healthy Eating and Physical Activity

1.8 Super Dynamic Food Dudes Programme

2

4

7

10

12

23

25

28

### Chapter Two

**Controlled Evaluation of a Modified Food Dudes Healthy Eating Intervention Targeting Pre-school Children’s Consumption of Fruit and Vegetables**

- Abstract: 41
- Introduction: 43
- Method: 45
- Results: 61
- Discussion: 75

41

### Chapter Three

**Validation of the Fitbit Zip as a Measure of Pre-school Children’s Step Count: A Cross-Sectional Study.**

- Abstract: 78
- Introduction: 79
- Method: 80
- Results: 84
- Discussion: 85

78

### Chapter Four

**Development and Feasibility of Four Interactive, Audio-Visual Stories to Increase Pre-school Children’s Physical Activity Levels in a Nursery Setting**

- Introduction: 89

89

Part 4A

- Design and Production of Four Interactive Stories: 90

Part 4B

- Feasibility Trial of the Interactive Stories in a Nursery Setting: 94

90

94

98

103
<table>
<thead>
<tr>
<th>Chapter</th>
<th>Title</th>
<th>Pages</th>
</tr>
</thead>
<tbody>
<tr>
<td>Five</td>
<td>Development and Feasibility of Four Exercise Videos Designed to Increase Pre-school Children’s Physical Activity Levels in a Nursery Setting</td>
<td></td>
</tr>
<tr>
<td>Part 5A</td>
<td>Design and Production of Four Exercise Videos</td>
<td>106</td>
</tr>
<tr>
<td>Part 5B</td>
<td>Feasibility Trial of the Exercise DVD in a Nursery Setting</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>110</td>
</tr>
<tr>
<td></td>
<td>Results</td>
<td>114</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>120</td>
</tr>
<tr>
<td>Six</td>
<td>Let’s Have Some Adventures! Increasing Preschool Children’s Physical Activity Levels with a Role-Modelling Dynamic Dudes Intervention</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>122</td>
</tr>
<tr>
<td></td>
<td>Method</td>
<td>123</td>
</tr>
<tr>
<td></td>
<td>Results</td>
<td>133</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>140</td>
</tr>
<tr>
<td>Seven</td>
<td>Modifications to components of the Food Dudes Healthy Eating intervention and the Dynamic Dudes Physical Activity intervention to create the Super Dynamic Food Dudes Intervention for Pre-school Children</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>Abstract</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>143</td>
</tr>
<tr>
<td></td>
<td>Food Dudes Healthy Eating Intervention</td>
<td>142</td>
</tr>
<tr>
<td></td>
<td>Dynamic Dudes Physical Activity Intervention</td>
<td>152</td>
</tr>
<tr>
<td>Chapter</td>
<td>Evaluation of a multi-component healthy eating and physical activity behaviour change intervention targeting 3 – 4 year old children in primary schools</td>
<td>158</td>
</tr>
<tr>
<td>Eight</td>
<td>Abstract</td>
<td>158</td>
</tr>
<tr>
<td></td>
<td>Method</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>Results</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>167</td>
</tr>
<tr>
<td>Part 8A</td>
<td>Assessing Physical Activity Levels of Nursery Classes in Five Primary Schools</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>Method</td>
<td>160</td>
</tr>
<tr>
<td></td>
<td>Results</td>
<td>164</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>167</td>
</tr>
<tr>
<td>Part 8B</td>
<td>Evaluation of a Multi-Component Healthy Eating and Physical Activity Behaviour Change Intervention</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td>Introduction</td>
<td>168</td>
</tr>
<tr>
<td></td>
<td>Method</td>
<td>170</td>
</tr>
<tr>
<td></td>
<td>Results</td>
<td>184</td>
</tr>
<tr>
<td></td>
<td>Discussion</td>
<td>202</td>
</tr>
<tr>
<td>Nine</td>
<td>General Discussion</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>Research Summary</td>
<td>205</td>
</tr>
<tr>
<td></td>
<td>Contribution to Theory</td>
<td>207</td>
</tr>
<tr>
<td></td>
<td>Contribution to the Literature</td>
<td>208</td>
</tr>
<tr>
<td></td>
<td>Strengths</td>
<td>214</td>
</tr>
<tr>
<td></td>
<td>Limitations</td>
<td>216</td>
</tr>
<tr>
<td></td>
<td>Future Implications</td>
<td>217</td>
</tr>
<tr>
<td>Figure</td>
<td>Page Number</td>
<td>Figure Title</td>
</tr>
<tr>
<td>--------</td>
<td>-------------</td>
<td>--------------</td>
</tr>
<tr>
<td>2.01</td>
<td>46</td>
<td>Figure</td>
</tr>
<tr>
<td>2.02</td>
<td>48</td>
<td>Figure</td>
</tr>
<tr>
<td>2.03</td>
<td>49</td>
<td>Figure</td>
</tr>
<tr>
<td>2.04</td>
<td>50</td>
<td>Figure</td>
</tr>
<tr>
<td>2.05</td>
<td>51</td>
<td>Figure</td>
</tr>
<tr>
<td>2.06</td>
<td>63</td>
<td>Figure</td>
</tr>
<tr>
<td>2.07</td>
<td>64</td>
<td>Figure</td>
</tr>
<tr>
<td>2.08</td>
<td>65</td>
<td>Figure</td>
</tr>
<tr>
<td>2.09</td>
<td>67</td>
<td>Figure</td>
</tr>
<tr>
<td>2.10</td>
<td>69</td>
<td>Figure</td>
</tr>
</tbody>
</table>
Figure 3.01  Custom-made “Rainbowtop®” tabard with inside pockets securing the two Fitbits in position. Consent was obtained for the publication of this figure.

Figure 3.02  Bland-Altman plots illustrating the relationship between observer count and (a) Fitbit 1 and (b) Fitbit 2. Solid line represents the mean difference between the two measures, and dashed lines represent limits of agreement (± 1.96 SD).

Figure 4.01  Screenshot from each of the interactive stories during the song component, set in their location theme: (a) Tom at the farm, (b) Razz on a boat, (c) Rocco in the jungle, and (d) Charlie at the castle.

Figure 4.02  Mean steps performed by the children during Presentation 1 (unfilled bars) and Presentation 2 (grey bars) of each character’s interactive story. Error bars represent ±1 of the standard error of the mean.

Figure 4.03  Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Razz’s interactive story. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

Figure 4.04  Total number of steps emitted by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Tom’s interactive story. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

Figure 4.05  Total number of steps emitted by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Rocco’s interactive story. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

Figure 5.01  Flowchart of exercise video progression

Figure 5.02  Four recruited children and their animated Dynamic Dudes character counterparts: (a) Charlie, (b) Tom, (c) Rocco, and (d) Razz.

Figure 5.03  Mean steps performed by the children during Presentation 1 (unfilled bars) and Presentation 2 (grey bars) of each character’s exercise video. Error bars represent ±1 of the standard error of the mean.

Figure 5.04  Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Razz’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

Figure 5.05  Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Tom’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

Figure 5.06  Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 andPresentation 2 of
Rocco’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

Figure 5.07 Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Charlie’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

Figure 6.01 Schematic outlining the design of the study.

Figure 6.02 Dynamic Dudes calendar illustrating the alternating presentation schedule for the interactive story and exercise DVD components of the school intervention phase.

Figure 6.03 Dynamic Dudes Home Adventures chart for each child to record their participation at home during the home intervention phase.

Figure 6.04 Mean total number of steps performed by the children in the intervention (grey bars) and control conditions (unfilled bars) at baseline (T0) and at post-intervention (T2). Error bars represent ±1 of the standard error of the mean.

Figure 6.05 Mean number of steps performed during each of the three 8-day intervention phase blocks; intervention condition (grey bars) received the physical activity components and the control condition (unfilled bars) continued with standard practice. Error bars represent ± 1 standard error of the mean.

Figure 6.06 Mean number of steps performed by the intervention condition (grey bars) during the 3rd presentation of each of the four exercise videos, and by the control condition (unfilled bars) during the equivalent time frames. Error bars represent ±1 of the standard error of the mean. Figure based on raw data.

Figure 6.07 Mean number of steps performed by the intervention condition (grey bars) during the 3rd presentation of the four interactive stories, and by the control condition (unfilled bars) in the equivalent time frames. Error bars represent ± 1 standard error of the mean.

Figure 6.08 Mean number of steps performed by the intervention children during the three successive presentations of each character’s interactive story. Error bars represent ± 1 standard error of the mean.

Figure 7.01 Three energy tubes and energy tokens as used in (a) the modified intervention evaluation, (b) the slotted energy tube component pilot, and in (c) the multi-component intervention evaluation.

Figure 7.02 Super Dynamic Food Dudes calendar to inform nursery staff which fruit and vegetable pairings to present and which activity element to complete on each day of the intervention phase.

Figure 7.03 Modified materials distributed to parents for the Parent Home DudeKit.

Figure 7.04 Dynamic Dudes Home Adventures materials as presented in (a) the pilot evaluation (upper panel) and in (b) the multi-
component intervention evaluation (lower panel).

Figure 8.01 Median number of total in-school steps performed by each school over a 5-day period. Error bars represent the interquartile range.

Figure 8.02 Schematic detailing the experimental design of the study.

Figure 8.03 Photograph of the target foods in their specified portions with a one-centimetre grid border for size reference.

Figure 8.04 Median change scores for the in-school steps performed by the intervention children (grey bars) and the control children (unfilled bars) between baseline and post-intervention (T2 – T0), 2-months follow-up and baseline (T6 - T0), and 2-months follow-up and post-intervention (T6 - T2). Error bars represent inter-quartile range.

Figure 8.05 Mean number of total in-school steps performed during each of the three 8-day intervention phase blocks; intervention condition (grey bars) received the intensive phase of the Dynamic Dudes intervention and the control condition (unfilled bars) continued with their standard nursery curriculum. Error bars represent ± 1 standard error of the mean.

Figure 8.06 Mean number of steps performed by the intervention children (grey bars) whilst completing three presentations of a character’s exercise video, and the mean number of steps performed by the control children (unfilled bars) during matched time frames. Error bars represent ± 1 standard error of the mean.

Figure 8.07 Mean number of steps performed by the intervention condition (grey bars) and the control condition (unfilled bars) during the three successive presentations of each character’s interactive story. Error bars represent ± 1 standard error of the mean.

Figure 8.08 Mean number of steps performed by Intervention School 1 (grey spotted bars) and by Intervention School 2 (unfilled spotted bars) during each character’s exercise video (upper panel) and interactive story (lower panel). Error bars represent ± 1 standard error of the mean.

Figure 8.09 Mean number of steps performed by the intervention children (grey bars) during the presentations of four Dynamic Dudes components delivered during the Super Dynamic Food Dudes phase, and by the control children (unfilled bars) over the corresponding time frame. ED denotes presentation of an exercise DVD, and IS, an interactive story. Error bars represent ± 1 standard error of the mean. Figure based on raw data.

Figure 8.10 Mean number of steps performed by the intervention children (grey bars) during the presentations of four Dynamic Dudes components delivered during the Super Dynamic Food Dudes phase, and by the control children (unfilled bars) over the corresponding time frame. ED denotes presentation of an exercise DVD, and IS, an interactive story. Error bars represent ± 1 standard error of the mean. Figure based on raw data.

Figure 8.11 Median pieces of fruit and vegetables consumed per child in the intervention condition (grey bars) and in the control condition (unfilled bars) at baseline 2 (T3), and at post-intervention 2 (T5). Error bars represent the inter-quartile range.
Figure 8.12  Median pieces of fruit and vegetables consumed by the poorest and highest eaters in the intervention and control condition at baseline 2 (T3; unfilled bars) and post-intervention 2 (T5; grey bars). Error bars represent inter-quartile range.

Figure 8.13  Median pieces consumed of the individual target fruit (upper panel) and vegetables (lower panel) by the intervention condition (filled bars) and control condition (white bars), at baseline 2 (T3; plain bars) and at post-intervention 2 (T5; patterned bars). Error bars represent inter-quartile range.

List of Tables

<table>
<thead>
<tr>
<th>Table</th>
<th>Description</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>Table 2.01</td>
<td>Mean scores of the anthropometric measures taken by condition, with SDs in parentheses</td>
<td>62</td>
</tr>
<tr>
<td>Table 2.02</td>
<td>Wilcoxon signed rank test comparing the consumption of fruit against vegetables in both conditions at each time point.</td>
<td>66</td>
</tr>
<tr>
<td>Table 2.03</td>
<td>Median scores of the children and their parents' home consumption of fruit, vegetables, and HFSS at baseline (T0) and post-Intensive phase (T2) measures. Interquartile range shown in parentheses.</td>
<td>70</td>
</tr>
<tr>
<td>Table 2.04</td>
<td>Median scores of the children and their parents' home consumption of fruit, vegetables, and HFSS at baseline (T0) and 3-months follow-up (T4). Interquartile range shown in parentheses.</td>
<td>71</td>
</tr>
<tr>
<td>Table 2.05</td>
<td>Median scores of the children and their parents' home consumption of fruit, vegetables, and HFSS at post-Intensive phase (T2) and 3-months follow-up (T4). Interquartile range shown in parentheses.</td>
<td>72</td>
</tr>
<tr>
<td>Table 2.06</td>
<td>Median scores of the children and their parents' home consumption of fruit, vegetables, and HFSS at baseline (T0), post-Intensive phase (T2) and 3-months follow-up (T4). Interquartile range shown in parentheses.</td>
<td>73</td>
</tr>
<tr>
<td>Table 4.01</td>
<td>Children’s gender, and age at the start of testing.</td>
<td>95</td>
</tr>
<tr>
<td>Table 5.01</td>
<td>Target actions modelled by each character in the exercise videos.</td>
<td>106</td>
</tr>
<tr>
<td>Table 5.02</td>
<td>Children’s gender, and their age at the start of testing</td>
<td>109</td>
</tr>
<tr>
<td>Table 6.01</td>
<td>Sections of the exercise DVD delivered in each presentation block.</td>
<td>124</td>
</tr>
<tr>
<td>Table 6.02</td>
<td>Mean scores of the anthropometric measures taken by condition, with SDs in parentheses.</td>
<td>126</td>
</tr>
<tr>
<td>Table 8.01</td>
<td>Pairwise comparisons, with adjusted p-values, of the differences in the children's total in-school step counts between the five schools.</td>
<td>165</td>
</tr>
<tr>
<td>Table 8.02</td>
<td>Number of children, by condition and total, consented for each measure.</td>
<td>172</td>
</tr>
<tr>
<td>Table 8.03</td>
<td>Mean scores of the anthropometric measures taken by condition, with SDs in parentheses.</td>
<td>185</td>
</tr>
<tr>
<td>Table 8.04</td>
<td>Number of visits to each interactive story and exercise video during the Dynamic Dudes Home Adventures.</td>
<td>195</td>
</tr>
</tbody>
</table>
List of Appendices (provided on a disk)

Appendix 2.01 Intervention condition consent letter
Appendix 2.02 Control condition consent letter
Appendix 2.03 Instructional DVD children’s consent letter
Appendix 2.04 Instructional DVD staff consent letter
Appendix 2.05 Home consumption questionnaire – baseline (T0)
Appendix 2.06 Home consumption questionnaire – post-intervention (T3)
Appendix 2.07 Home consumption questionnaire – 3-months follow-up (T6)
Appendix 2.08 Nursery staff feedback questionnaire (Intervention condition only)
Appendix 2.09 Intensive phase instructions
Appendix 2.10 Picnic phase instructions
Appendix 2.11 Day 20 Food Dudes letter
Appendix 2.12 Parent letter for Picnic phase
Appendix 2.13 Parent meeting letter
Appendix 2.14 Picnic phase poster
Appendix 2.15 Control parents questionnaire free comments
Appendix 2.16 Intervention parents questionnaire free comments
Appendix 2.17 Nursery staff questionnaire responses (intervention condition only)
Appendix 3.01 Consent letter
Appendix 4.01 Potential Target Actions – “Simon Says” Task
Appendix 4.02 Consent letter
Appendix 4.03 Tom’s interactive story script
Appendix 4.04 Razz’s interactive story script
Appendix 4.05 Rocco’s interactive story script
Appendix 4.06 Charlie’s interactive story script
Disk V.1 Interactive story videos
Appendix 5.01 Characters filming consent letters
Appendix 5.02 Characters certificate
Disk V.1 Exercise videos
Appendix 6.01 Intervention condition consent letters
Appendix 6.02 Control condition consent letters
Appendix 6.03 Nursery staff feedback questionnaire
Appendix 6.04 Dynamic Dudes Home Adventures letter
Appendix 6.05 Intervention condition: Head Teacher information sheet
Appendix 6.06 Control condition: Head Teacher information sheet
Appendix 6.07 Intervention condition instructions
Appendix 6.08 Parent session letter (intervention condition)
Appendix 6.09 Within groups-comparison descriptive statistics
Appendix 7.01 Visual of researcher’s disguise
Appendix 7.02 Synopsis of Food Dudes Healthy Eating intervention modifications
Appendix 7.03 Instructional DVD children’s consent letter
Appendix 7.04 Piloting opt-out consent letters
Appendix 7.05 Synopsis of Dynamic Dudes Physical Activity intervention modifications
Appendix 7.06 Tom’s interactive story script
Appendix 7.07 Rocco’s interactive story script
Appendix 7.08 Razz’s interactive story script
Appendix 7.09 Charlie’s interactive story script
Disk V.2.

Interactive Story Videos (Edited)

Disk V.2.

Exercise Videos (Edited)

Appendix 8.01

Study information sheet

Appendix 8.02

Consent letter – Probe baseline measure

Appendix 8.03

Feedback questionnaire

Appendix 8.04

Procedural instructions

Appendix 8.05

Tabard box instructions

Appendix 8.06

Intervention condition consent letter – Main trial

Appendix 8.07

Control condition consent letter – Main trial

Appendix 8.08

Intervention condition consent letter – Fruit and vegetables

Appendix 8.09

Control condition consent letter – Fruit and vegetables

Appendix 8.10

Dynamic Dudes newsletter

Appendix 8.11

Super Dynamic Food Dudes newsletter

Appendix 8.12

Physical activity intervention-based questionnaire

Appendix 8.13

Healthy eating intervention-based questionnaire

Appendix 8.14

Control condition questionnaire

Appendix 8.15

Consent letter – Teacher interview

Appendix 8.16

Interview questions – intervention condition

Appendix 8.17

Interview questions – control condition

Appendix 8.18

Research handbook

Appendix 8.19

A4 Fruit and vegetable poster

Appendix 8.20

Congratulations slip

Appendix 8.21

Picnic phase letter

Appendix 8.22

Picnic phase poster

Appendix 8.23

Junior scientist certificate

Appendix 8.24

Nursery staff feedback questionnaire responses

Appendix 8.25

Transcriptions of nursery staff interviews
Thesis Summary

The global obesity epidemic is a multifactorial problem associated with severe health consequences. The lifestyle behaviours of diet and physical activity are learned early, often tracking into adulthood. Identifying preventive interventions to establish children’s healthy lifestyle behaviours, in line with recommended guidelines, is a public health priority.

The ‘Food Dudes’ programme is a well-evidenced behaviour change intervention, producing large and lasting increases in children’s consumption of fruit and vegetables in primary school settings. An extension of the programme, targeting physical activity, is the novel ‘Dynamic Dudes’ intervention, recently trialled in primary schools.

This thesis aimed to develop and evaluate a ‘Super Dynamic Food Dudes’ intervention, underpinned by the same behavioural principles as the respective primary school programmes. Chapter 1 provides a detailed literature review and identifies a paucity of such interventions. Chapter 2 modified and evaluated the Food Dudes Early Years intervention designed to increase pre-school children’s consumption of fruit and vegetables. To identify a suitable activity measurement tool, Chapter 3 validated use of the consumer-grade Fitbit Zip accelerometer to measure pre-school children’s step counts. Chapter 4 and Chapter 5 describe the development and feasibility of two physical activity components, interactive stories and in-class exercise DVDs, respectively, which were later integrated in a controlled pilot of the new physical activity intervention in Chapter 6. Drawing on outcomes and process evaluation from the preceding chapters, Chapter 7 describes and justifies further modifications to the interventions. Chapter 8 presents a controlled evaluation of the finalised two-pronged multi-component intervention in the school setting, with extension to the home. Main short-term outcomes were large and significantly greater increases in consumption of fruit and vegetables, and physical activity, in the intervention conditions, compared to the control conditions, replicating findings in primary school children. The pre-school multi-component intervention provides a promising method of preventing childhood obesity.
CHAPTER ONE: Literature Review

1.1 Obesity

Childhood obesity is a major public health crisis of the 21st century. The World Health Organisation (WHO, 2016a) has labelled it a “global epidemic”; indeed, the prevalence of obesity is high around the world (Wang & Lobstein, 2006). In developed countries, from 1980 to 2013, the prevalence of overweight and obesity in children and adolescents has increased by 6.90% and 6.40%, to 23.80% and 22.60% for boys and girls, respectively. Similar increases were found in developing countries (Ng et al., 2014). It has been estimated that by 2025, the number of overweight or obese children will rise to 70 million if action is not taken (WHO, 2014). Since 1990, childhood overweight and obesity has increased globally by 31%, with 43 million pre-school children (0 – 5 years) already classified as overweight or obese (WHO, 2013). A further 92 million pre-school children are at risk of becoming overweight (de Onis, Blössner, & Borghi, 2010). The UK is no exception; in Wales alone, measures conducted between 2014 and 2015 found that 26.20% of children aged 4 – 5 years were already overweight or obese (Bailey, 2016).

Overweight and obesity are labels used to describe when an individual’s adiposity exceeds the level associated with good health outcomes (Waters et al., 2011). Unfortunately, children who are overweight or obese tend to carry their weight status into later life (Clarke & Lauer, 1993; Freedman et al., 2005, 2008). Recent evidence has quantified this trajectory; as compared with their healthy-weight peers, 5 year-old children who were overweight at kindergarten were four times more likely to be obese by age 14 years (Cunningham, Kramer, & Narayan, 2014). If obesity trends continue, it has been estimated that by 2050, the economic annual cost of obesity in the UK alone will be £9.7 billion (Morgan & Dent, 2010). Action must be taken to prevent such a financial burden.

In addition to these economic impacts, associations have been found between obesity and physical, social and psychological factors (Waters et al., 2011). Increased prevalence of obesity is considered accountable for the international upsurge of several non-communicable diseases (Webber et al., 2012), for example, some cancers (Lichtman, 2010; World Cancer Research Fund / American Institute for Cancer Research, 2007), cardiovascular disease (Joshipura et al., 2001) and Type 2 diabetes (Ford & Mokdad, 2000). Indeed, obesity has been categorised as one of the five leading risk factors of mortality (WHO, 2009), raising major health as well as financial concerns. Children’s environments may influence their susceptibility to becoming overweight or obese; parental obesity is significantly associated with children’s weight status (Fuemmeler, Lovelady, Zucker, & Østbye, 2013; Magarey, Daniels, Boulton, & Cockington, 2003). Associations between childhood depression and obesity are also emerging (Reeves, Postolache, & Snitker, 2008). Clearly, there is a pressing need to devise preventative interventions to offset the development of obesity in pre-school children.
In order to tackle the obesity crisis, the root causes of obesity must be addressed. Obesity is a multifactorial problem, which is driven by genetic, environmental, and behavioural factors (Karnik & Kanekar, 2012; Lobstein, Baur, & Uauy, 2004). Recent studies using cohorts of monozygotic and dizygotic twins have concluded that genetic factors strongly influence adiposity in childhood (Llewellyn, Trzaskowski, Plomin, & Wardle, 2013; Wardle, Carnell, Haworth, & Plomin, 2008) such that some children are more predisposed to obesity than their peers as a result of their biology. However, others have argued that genetic factors change too slowly to account for the rapid rise in human obesity over the past few decades, suggesting that the other two major determinants, environmental and behavioural factors are the main drivers of the obesity epidemic (Horne et al., 2011; Lanigan, Barber, & Singhal, 2010). Changes in food and physical activity environments over the past decade have been extensively evidenced in the literature (Cohen, 2008), and the behaviour of individuals has adapted to those environmental changes.

It is widely cited that obesity results from a homeostatic biological system (Butland et al., 2007), where a sustained imbalance occurs between calorie intake and energy expenditure over a long period of time (Hill & Melanson, 1999). Two lifestyle behaviours, diet and physical activity, are reported to provide the greatest influence on obesity (Lanigan et al., 2010); eating behaviour is responsible for calorie intake, and physical activity for energy expenditure. Both lifestyle behaviours in relation to obesity have been investigated across the lifespan (Martin, Chater, & Lorencatto, 2013). There is a profusion of interventions targeting primary school children, however, in comparison there are fewer interventions that target healthy eating and physical activity in British pre-school children (McSweeney, Rapley, Summerbell, Haighton, & Adamson, 2016).

Birch and Ventura (2009) highlighted that targeting pre-school children is a prime preventative opportunity given that in excess of 20% of children are already at risk of being overweight or obese by the time they enter school aged 5 years. Little research has been conducted on the relation between obesity and pre-school children’s physical activity and eating behaviour. Timmons et al. (2012) proposed that the lack of physical activity research is a result of an over assumption that the pre-school period is a time in a child’s life when they are naturally active, and consequently that intervention to increase activity is not required. Given that children learn such habitual behaviours early, it is important to understand and harness their determinants (De Craemer et al., 2012; Lanigan et al. 2010; Smith, Garner, & Hamer, 2014) to prevent the development of a positive energy imbalance. Prevention is key (Lobstein et al., 2004). According to Hills, King, and Armstrong (2007) individuals are “evolutionary-derived” and “genetically-primed” to participate in physical activity. A preventative approach could avoid the need for later behaviour modification, but continuous scaffolding of the target behaviour to maintain it in the long-term is also important. Adopting healthy behaviours is less
challenging in young children than in older children who have established their habits (Goldfield, Harvey, Grattan, & Adamo, 2012). Establishing a healthy diet and active lifestyle multi-component intervention requires complex interventions, comprising complementary methods of modifying behaviour (Martin et al., 2013; Summerbell et al., 2005). First, we must review the existing literature on both target behaviours in the context of the target population independently. Next, we will consider the main theoretical approaches to targeting such behaviours, appropriate methods of tracking change in the target behaviours, identify successful interventions, before proceeding to outline the development and evaluation of a two-pronged multi-component intervention targeting both fruit and vegetable and physical activity in pre-school children.

1.2 Children’s Eating Behaviours

Adopting a diet rich in fruit and vegetables is consistently advocated because of their well-established health-promoting properties (Horne et al., 2011; Slavin & Lloyd, 2012; Slyper, 2004; WHO, 2000). For example, fruit intake is correlated with a lower risk of developing cancer (Maynard, Gunnell, Emmett, Frankel, & Davey Smith, 2003). Although current guidelines recommend that children should consume at least 5 portions of fruit and/or vegetables a day, the literature has repeatedly shown that children are failing to reach this target (Dennison, Rockwell, & Baker, 1998; Lorson, Melgar-Quinonez, & Taylor, 2009; Siega-Riz et al., 2010; Shim, Kim, & Lee, 2016; Valmörbida & Vitolo, 2014), despite national initiatives targeting their consumption of these foods. However, valid comparison of consumption levels is difficult given the different measurement units used and definitions applied across studies. The British Heart Foundation concluded from national surveys in the UK that only 1 in 5 children consumed fruit and vegetables at government target levels (Townsend et al., 2013; p. 87). The recently published Welsh Health Survey (2016) reported on 4–15 year old children’s daily consumption of fruit and vegetables in 2015. The report concluded that only 64% of children (N = 1960) consumed any fruit and the figure decreased to 52% for vegetables. Pre-school children’s consumption was not evaluated. Guenther, Dodd, Reedy, and Krebs-Smith (2006) found that only 48% of 2–3 year old American children (n = 369) consumed 4 or more servings of fruit and vegetables daily. However, fruit juice was categorised as a fruit and is likely to have overestimated fruit consumption in the study population. The general consensus is that children are not consuming fruit and vegetables at optimal levels for a healthy diet, therefore research must consider why children are not reaching the targets, and how their eating behaviour can be modified so that they do consume the recommended amounts of fruit and vegetables each day.

The pre-school years are considered to be a sensitive period for children to establish their eating habits (Cashdan, 1994; Schwartz, Scholtens, Lalanne, Weenen, & Nicklaus, 2011). Children have
an innate preference for consuming sweet tasting, energy-dense foods (Birch, 1999; Steiner, 1974), which are now readily available. Infants are typically introduced to solid foods between 4 – 6 months old with no effect on susceptibility to obesity dependent on time of introduction (Barrera, Perrine, Li, & Scanlon, 2016). When solids are introduced, caregivers typically experience low levels of resistance from their infant to consume a novel food, providing the food is re-presented eight times (Maier, Chabanet, Schaal, Issanchou, & Leathwood, 2007).

However, a little later in development unwillingness to consume novel foods often emerges (Birch, McPhee, Shona, Pirok, & Steinberg, 1987). At the age of 2 years, many children exhibit a reaction termed “food neophobia” (Rozin, 1976). This is when children refuse to consume foods and extra presentations are required to encourage acceptance. Research has shown that children aged 2 – 3 years require five to 10 exposures to a novel food (Birch & Marlin, 1982; Birch et al., 1987), and that children aged 3 – 4 years require up to 15 exposures (Sullivan & Birch, 1990). These findings support the need for multiple presentations to provide children with the opportunity to learn to like the foods. Research shows that parents only tend to present previously refused foods between 3 – 5 times (Carruth, Ziegler, Gordon, & Barr, 2005), limiting the child’s opportunities to learn to like them.

Unfortunately, it is unhealthy foods that are re-presented, and research has shown that portion size and energy density of the food affects the quantity of food consumed (Kling, Roe, Keller, & Rolls, 2016). When the portion size was doubled, 120 children aged 3 – 5 years consumed 26% more compared to when a single portion was presented, and when the energy density of the meal was increased by 42%, the children consumed 40% more. Adults need to be aware of what a child’s portion constitutes when they present foods to their children.

From the age of 0 – 5 years, children learn (a) what food they like to eat, (b) when they like to eat, and (c) the portion size they want to consume (Savage, Fisher, & Birch, 2007). Given children’s biological preferences (Harris & Coulthard, 2016; Steiner, 1976), and acknowledging that vegetables are a bitter tasting food (Drewnowski & Gomez-Carneros, 2000), it is unsurprising that their reluctance to consume vegetables is greater than for fruit. These findings highlight a critical window of opportunity to establish a broad and durable fruit and vegetable consumption repertoire in pre-school children.

The higher acceptance rates of fruit compared to vegetables has resulted in researchers often targeting vegetable consumption only (Anzman-Fransca, Savage, Marini, Fisher, & Birch, 2012; de Wild, de Graaf, Boshuizen, & Jager, 2015; de Wild, de Graaf, & Jager, 2013). Despite the need for children to consume a range of foods, interventions often target only a single vegetable and the potential carry-over effects to other vegetables remain unevaluated (Caton et al., 2014; Corsini, Slater, Harrison, Cooke, & Cox, 2013; Fildes, van Jaarsveld, Warlde, & Cooke, 2014; Holley, Haycraft, &
Farrow, 2015; Staiano Marker, Frelier, Hsia, & Martin, 2016). Some researchers have attempted to justify use of a single target food by claiming, without supporting evidence, that it reduces the risk of overwhelming a child or causing feelings of aversion towards the intervention (Holley et al., 2015). Moreover, in order to establish a diet including a wide range of healthy foods, interventions should target multiple foods from the target category. To my knowledge studies targeting multiple foods have not reported negative reactions from children following their presentation (Dazeley & Houston-Price, 2015; Horne et al., 2004, 2011; Horne, Hardman, Lowe, Tapper et al, 2009; Lowe et al., 2004; Sharma et al., 2016; Sharp, 2013).

One international initiative administered across Europe for over a decade in an attempt to increase school children’s consumption of fruit and vegetables is the ‘School Fruit and Vegetable Scheme’. The initiative is not however administered in Wales. In England, the scheme provides children aged 3 – 7 years with a free portion of fruit or vegetable daily to consume at snack-time whilst attending government-funded schools. It is the largest scheme of its kind since the introduction of free school milk in 1946 (Ransley et al., 2007). Within just the first two years of rollout, the scheme was reported to have cost the Department of Health £119 million, with assistance from Big Lottery Funding (Ransley et al.). Regardless of the financial input, the effectiveness of the initiative has been limited with independent studies finding no long-lasting increases in consumption of the fruit and vegetables once provision of the foods under the scheme ended (see Blenkinsop et al., 2007; Fogarty et al., 2007; Hughes et al., 2012; Ransley et al., 2007; Wells & Nelson, 2005). The evidence shows that the initiative does not sustain any increases in consumption achieved during the provision phase of the scheme. Therefore the UK School Fruit and Vegetable Scheme fails to deliver maintenance and generalisation of target food consumption, and is not cost-effective. Behavioural interventions are required in order to achieve such target outcomes; availability and exposure to target foods alone are not sufficient.

Empirical studies have investigated a range of methods to achieve increases in target food consumption with mixed results. Examples of different intervention strategies are: exposure alone (Birch & Marlin, 1982), providing choice (Dominguez et al., 2013), story books (Houston-Price, Butler, & Shib, 2009; Houston-Price et al., 2009), fruit and vegetable gardens (Nameneck Brouwer, & Benjamin Neelon, 2013), farm-to-school (Izumi, Eckhardt, Hallman, Herro, & Barberis, 2015), associative flavour-flavour (Ahern, Caton, Blundell, & Hetherington, 2014), associative flavour-nutrient (de Wild et al., 2013), pressurising (Galloway, Fiorito, Francis, & Birch, 2006), branding (de Droog, Valkenburg, & Buijzen, 2011; Roberto, Baik, Harris, & Brownell, 2010), modelling (Greenhalgh et al., 2009; Harper & Sanders, 2000; Houldcroft, Haycraft, & Farrow, 2013), rewards (Lowe et al., 1998) rewards and modelling (Cooke, Chaters, Anez, Croker et al., 2011; Corsini et al., 2013; Horne et al., 1995, 1998, 2004, 2011; Horne, Hardman, Lowe, Tapper et al, 2009; Lowe et al., 2004). The methods have also
been explored in a variety of settings such as laboratories (Birch, 1979), schools (Horne et al., 2004, Lowe et al., 2004; Wengreen, Madden, Aguilar, Smits, & Jones, 2013); homes (Fildes, et al., 2013), and one-to-one settings (Wardle, Herrera, Cooke, & Gibson, 2003). Outcomes have differed, with many interventions failing to produce or not investigating long-term increases in the target behaviour (Knai, Pomerleau, Lock, & McKee, 2006). Producing interventions with long-term effects is vital, as children need to continue to consume fruit and vegetables after delivery of the intervention has been completed. Multi-component interventions have been identified as having the greatest efficacy (Knai et al.). However, which components are critical to successful and lasting outcomes needs careful consideration.

1.3 Children’s Physical Activity

Physical activity is a requirement for the normal growth and development of children in terms of cognitive, social and physical health and wellbeing (Hills et al., 2007). The WHO (2016b) defines physical activity as the production of energy expenditure through bodily movement produced by skeletal muscles, which can be conducted through exercise. Sedentary behaviour (e.g. passively watching television) is the opposite of physical activity (Reilly, 2008). A large international study (N = 284,675) found that pre-school children were watching 1 – 3 hours of television and proposed that this increased their risk of overweight or obesity by 10 – 27% (De Craemer et al., 2012). A small but significant negative association has been found between sedentary behaviour and physical activity, with the largest negative association in studies that used objective measures and smaller samples (Pearson et al., 2014). Despite the benefits of establishing healthy lifestyles early, the vast majority of previous research has targeted primary school children, although more recent research has targeted activity in pre-school children.

It is widely believed that in the first five years of their lives, children learn more physical skills than at any other time in their life (British Heart Foundation [BHF], 2012). This emphasises the importance of targeting early as physical activity levels decline as children get older (Bradley, McRitchie, Houts, Nader, & O’Brien, 2011; Taylor, Williams, Farmer, & Taylor, 2013). Given that between 6 – 10% of non-communicable diseases are a result of physical inactivity (Lee et al., 2012), there is a strong need to target physical activity levels of pre-school children. Moore et al. (2003) used objective measures to investigate the change in body composition of individuals (N = 103) over the course of 8 years as they developed from pre-school to adolescence. They found that children who were more active during their pre-school years had smaller increases in body mass index (BMI), and less subcutaneous fat. Despite the positive benefits of physical activity, levels in children have declined (BHF, 2015, p. 29). Parents overestimate their children’s activity levels (Adamo et al., 2010), a
confounding factor when researchers use proxy questionnaire measures of pre-school children’s physical activity.

In 2012, the UK Chief Medical Officers produced the first set of new guidelines advocating that walking pre-school children should participate in a minimum of 180 minutes of activity every day (Department of Health, 2011). Inconsistency in activity guidelines for pre-school children across the world could be due to a paucity of literature quantifying the relationship between physical activity levels and health benefits (Skouteris et al., 2012). For the majority of individuals, it is difficult to use time spent in activity as a criterion measure therefore researchers have attempted to translate activity time targets into the more commonly used step count targets (De Craemer et al., 2015). Relative to the latest UK guidelines, 180 minutes of activity has been empirically equated to ‘6000-steps-per-day’ by Gabel et al. (2013), but to ‘over 9000-steps-per-day’ target by Vale, Trost, Duncan and Mota (2015). The difference in step count targets is likely the result of different accelerometer cut-points being applied to the data. Young children’s physical activity is typically characterised by an “intermittent pattern of long periods of low activity intensity mixed with very short bursts of high intensity activity” (Barbosa & de Oliveira, 2016). The current UK guidelines do not stipulate a specific intensity for pre-school children as they do for older children. There are four types of physical activity intensity, which are measured on a continuum: sedentary, light, moderate, and vigorous (Batacan, Duncan, Dalbo, Buitrago, & Fenning, 2016). These types of physical intensities are differentiated by the mean step counts produced by an individual in a minute (Hussey, Bell, Bennett, O’Dwyer, & Gormley, 2007). Contrary to the guidelines, research has shown that bursts of moderate-to-vigorous activity (MVPA) yields stronger health outcomes than low intensity activity over a longer time period (Collings et al., 2013; Janz et al., 2009), indicating that interventions should set their activity targets in this intensity range.

As highlighted in the most recent systematic review of correlates and determinants of physical activity during the early years, reported activity levels in pre-school children are inconsistent (Bingham et al., 2016), irrespective of the method of measurement used (Goldfield et al., 2012). A recent quantitative study found that 123 children aged 2 – 4 years spent over 50% of their day engaging in sedentary behaviour (Johansson et al., 2015). Reilly (2010) evaluated high-quality evidence of pre-school children’s activity in childcare settings and also concluded that the recommended activity guidelines were not achieved. Likewise, the Health Survey for England (2012) found that only 1 in 10 children aged 2 – 4 years met the activity guidelines (Towsend, Wickramasinghe, Williams, Bhatnagar, & Rayner, 2015; p. 26). However, these findings are contradicted by those of Hesketh and colleagues (2014) who conducted objective measures of British pre-school children’s physical activity levels and concluded that all 593 children measured reached the recommended guideline levels of activity.
However, in the latter study only one day of valid data were required for inclusion in the analysis, and research has shown that a minimum of three days of data are required for an accurate representation of children’s habitual activity levels (Addy, Trilk, Dowda, Byun, & Pate, 2014).

A recent systematic review of pre-school children’s activity also found high variability of intensity levels (Hnatiuk, Salmon, Hinkley, Okely, & Trost, 2014) with sedentary behaviour accounting for 34 – 94% of the day, light intensity for 4 – 33% of the day, and MVPA for 2 – 41% of the day. The authors suggest that the use of different accelerometer cut-points and analyses could explain part of the outcome variability across studies (and see Vale, Silva, Santos, Soares-Miranda, & Mota, 2010; Timmons, Naylor, & Pfeiffer, 2007). The variability across studies could also be representative of the sporadic and intermittent nature of pre-school children’s activity (Cliff, Reilly, & Okely, 2009). Pre-school children are simply not consistent in the amount of activity they exhibit daily, strengthening the argument that studies based on one day of data should be interpreted with caution.

Vanderloo and Tucker (2015) used accelerometers to assess weekday activity levels of 101 children aged 2.5 – 5 years and found that the children were most active on Tuesday, Wednesday and Thursday (mid-week), with lower levels at the beginning and end of the week. Comparison between weekday and weekend activity found that 2 – 6 year old children (N = 245) in Portugal accumulated significantly more total activity and MVPA during weekdays as compared to weekends (Vale et al., 2010).

It is regularly reported in primary school children that boys are more active than girls (Ridgers, Salmon, Parrish, Stanley, & Okely, 2012) therefore researchers have explored the effects of gender in pre-school children. Since 2008, four systematic reviews have been published; two reviews (Bingham et al., 2016; Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008) concluded that young boys accumulated more activity than young girls, whereas two others (De Craemer et al., 2012; Li, Kwan, King-Dowling, & Cairney, 2015) found no evidence of gender differences. Li and colleagues suggest the lack of difference could be a result of pre-school children not being categorised into socially constructed roles at such a young age. Further research is required to establish the reasons for the different conclusions relating to gender and activity levels in preschoolers.

Fundamental movement skills (FMS) are a correlate of children’s physical activity levels (Cliff, Okely, Smith, & McKeen, 2009). The pre-school age has been identified as an optimum opportunity for the development of such skills (Foweather et al., 2015). FMS have been divided into two domains: locomotor skills (e.g. jump, hop, run) and object-control skills (e.g. kick, catch, throw), and such skills are the building blocks for more complex and refined movements (Foweather et al.; Goldfield et al., 2012). However, Goldfield et al. conclude that children require opportunities to practice movement skills in order to become competent, and those opportunities need to be offered in supportive and
stimulating environments. Scaffolding the development of FMS is important, as research has shown that children who master FMS opt to participate in more physical activity (Fisher et al., 2005) than those who fail to achieve mastery (Stodden et al., 2008). A validated procedure called ‘Test of Gross Motor Development-2’ (TGMD2) found that object-control skills were significantly higher in boys (n = 52) than in girls (n = 47) at aged 3 – 5 years, but that girls were higher than boys for locomotor skills (Foweather et al.). This evidence shows that opportunities to attain FMS need to promote skills in both domains, in both genders. It is also beneficial to start training FMS early in development. Barnett, Salmon, and Hesketh (2016) also employed the TGMD2 procedure administered with Actigraph accelerometry, and found that the quantity of MVPA 3.5-year-old children completed was predictive of 5-year-old children’s actual locomotor skills, but not their perceived locomotor skills.

With emerging research targeting pre-school children’s physical activity, a range of methods has been trialled with variable results. The methods trialled include modifying playground equipment (Cardon, Labarque, Smits, & De Bourdeaudhuji, 2009; Hannon & Brown, 2008), making outdoor playground sessions available (Barber et al., 2016), additional daycare activity sessions with a home component (Reilly et al., 2006), role-modelling (Bellows, Davies, Anderson, & Kennedy, 2013), and family-based active play (Houghton et al., 2013; O’Dwyer, Fairclough, Knowles, & Stratton, 2012). Multi-component interventions are also being designed (Howie, Brewer, Brown, Saunders, & Pate, 2014; Sanchez-Lopez et al., 2015).

1.4 Settings to Target

Given the multifaceted nature of obesity, there are a range of possible settings in which to target children’s health behaviours, with varying effectiveness. Hendrie and colleagues (2012) highlight home, schools, childcare, and community settings as locations, which can yield successful obesity prevention. The literature has recently been saturated with reviews advocating interventions targeting the home environment (Campbell & Hesketh, 2007) and the early education setting (Mehtala, Saakslahti, Inkinen, & Poskiparta 2014). The WHO ‘Global Strategy on Diet, Physical Activity and Health’ (2004, p.9) identifies schools as a setting that has a large influence on children across the world, and stipulates that schools should implant healthy eating and physical activity in their policies and programmes. Unfortunately policies do not always translate into practice, and this is why school-based interventions are required. Nevertheless, the literature positions school-based interventions as universally applicable and a promising strategy (Kreimler et al., 2011). Evidence has suggested increased effectiveness of interventions adopting a multi-setting approach (Summerbell et al., 2005) because this immerses the target population more effectively in the intervention messages (Hendrie et al.).
Both parents and teachers in early education settings provide role models for children’s lifestyle behaviours (Goldfield et al., 2012; Savage et al., 2008; Ward, Vaughn, McWilliams, & Hales, 2010). Home and school are seen as ideal settings for implementing preventive interventions (Lobstein et al., 2004). As a result of the control both parents and childcare providers exert over young children’s eating and physical activity behaviours, they are both categorised as top tier components to target those behaviours (Goldfield et al.). A significant problem regarding physical activity is that parents appear to rely on childcare staff to provide sufficient activity for their children (Irwin, He, Bouch, Tucker, & Pollett, 2005), whereas childcare staff expect parents to provide an active environment at home (Tucker, van Zandvoort, Burke, & Irwin, 2011). NICE guidelines (2015) advocate that pre-school establishments should provide period’s of physical activity activities throughout the day, and that parents should be motivated to participate in physical activity with their child. Unfortunately, the effectiveness of this recommendation depends on compliance within the daycare and home settings (Alhassan & Whitt-Glover, 2014) and parents (Holley et al., 2015). Additionally, intervention studies need to consider variability in and across settings to increase their effectiveness (Pfeiffer et al., 2013). For example, in early years settings, children are engaged in different learning contexts and locations, with different equipment and space available (Pfeiffer et al.) throughout the day; day-to-day variability in childcare settings is also high.

From 2014 – 2015 in England alone, nine out of 10 parents with children aged 3 – 4 years responded ‘yes’ to a national survey questioning whether their child was enrolled in government funded early education (Department for Education, 2016). Given the access to pre-school children this provides, the early education setting provides a low cost opportunity to positively influence a large cohort of children (Manios et al., 2012; Ward, 2010). However, childcare has been identified as a risk factor for development of overweight in children (Gubbels, Gerads, & Kremers, 2015), and practices can include negative role-modelling, the use of high fat foods as a reward, and of physical activity as a punishment (Ward, Belanger, Donovan, & Carrier, 2015), highlighting that childcare practices need to be more effectively regulated to align then with Public Health dietary and activity targets.

The Early Years Foundation Phase framework (EYFP; Welsh Government; 2015) is a curriculum, which early education settings must deliver to pre-school children. One of the seven themes is ‘Personal and social development, well-being and cultural diversity’ which stipulates that “Children should be given opportunities to: develop an understanding that exercise and hygiene and consuming the right food and drink are important for healthy bodies” (p. 11). This means that nursery staff are required to teach children about healthy eating and physical activity. Interventions should be designed to facilitate the curriculum to reduce as much burden on nursery staff as possible, given the
behavioural and environmental opportunities that arise from the setting (Ward, Vaughn, McWilliams, & Hales, 2010).

Measured using Actiheart monitors, 202 UK pre-school children were found to be more active in the day care setting as compared to home (Hesketh, Griffin, & van Sluijs, 2015). Contradictory findings were obtained in a study of 731 Australian pre-school children, contributing four or more days of data, which found that physical activity was lower in childcare as compared to the home (Hinkley, Salmon, Crawford, Okely, & Hesketh, 2016), demonstrating the high variability across countries. In relation to food consumption, pre-school children were observed to perform significantly less physical and verbal refusal in the care setting as compared to the home setting (Luchini, 2016). Interestingly, a focus group with 30 mothers felt that an intervention targeting children’s physical activity and eating behaviours would be more effective if administered in a pre-school setting by pre-school staff (Bellows, Spaeth, Lee, & Anderson, 2013). It could be hypothesised that parents do not feel confident to target the behaviours on their own, and require the support of childcare settings to initiate interventions prior to making their contribution to changing their children’s diets.

1.5 Behaviour Change

A Cochrane review of interventions for preventing obesity in children concluded that researchers should adopt a multifactorial theoretical approach when designing interventions, with a specific focus on behavioural models (Summerbell et al., 2005). Martin et al. (2013) affirm that successful preventative interventions must be complex, multi-component, and include a matrix of behaviour change methods. As fundamentally the issue of obesity is behaviourally based, a behaviour change approach is the appropriate method of addressing the worldwide problem of obesity (Newson et al., 2013).

In order to target health behaviours such as healthy eating and physical activity, it is essential that these behaviour change interventions are underpinned by established theories, which map across appropriately to the intervention under design (Nutbeam, 1999). Theory-based interventions, which target causal determinants of behaviour, have a greater chance of being effective (Michie, Johnston, Francis, Hardeman, & Eccles, 2008; Michie & Prestwich, 2010). Prior to combining different theory-based techniques, Michie and Abraham (2004) suggest that the effectiveness of each technique should be experimentally tested independently and cumulatively. Unfortunately, researchers often claim the use of theory to create behaviour change interventions, but the theory simply explains the behaviour itself, not the actual change variable (Michie et al.), and does not serve as a fundamental component of the process (Michie & Prestwich). Furthermore, in order to identify any weak
components of an intervention following an evaluation, a solid theoretical understanding of the mechanisms of the intervention to yield behaviour change is essential (Craig et al., 2008).

In a systematic review of behavioural models and behaviour change strategies, Nixon and colleagues (2012) acknowledged that the developmental maturity of the target population must be taken into account when considering the most appropriate behavioural model to underpin a prospective intervention. The authors identified behavioural models and conceptual frameworks that have been cited in the literature to underpin childhood obesity interventions. These included the “trans-theoretical model, theory of planned behaviour, health belief model, social cognitive theory and socio-ecological models”. The latter models all have a moderating variable such as “self-control” and “intentions” making them inapplicable to pre-school children and interventions to target physical activity and diet given that very young participants do not have the required level of control of their decision making (Baranowski, Cullen, Nicklas, Thompson, & Baranowski, 2003; Nixon et al). For example, Galkowska, Hernik, and Haman (2010) investigated understanding of a causal action plan in 48 children aged 4 – 6 years. The authors defined a casual plan as the intention to action behaviour using a particular method. The children were read three stories containing a goal and a method of achieving the goal. The story depicted the main character stating their intention, concealing the action plan, and executing the intention, which did not result in the anticipated outcome, before the goal was achieved by chance. Individually, the children were asked two 2-choice test questions about the plan of the main character and the actual cause of the intended action. The ability to answer accurately varied by age. The majority (87%) of 6-year old children answered correctly showing an understanding of causal action plans, while, only a small portion (20%) of the 4-year old children answered correctly showing their lack of understanding. This study is an example of pre-school children’s inability to comprehend intentions, however, the small sample size means the conclusions must be considered carefully until replicated. A systematic review by Campbell and Hesketh (2007) identified ‘Social Behavioural Theory as the most used strategy underpinning healthy eating and physical activity interventions targeting children aged 0 – 5 years. Social Cognitive Theory developed from Social Learning Theory (SLT).

**Social learning theory (SLT).** Bandura (1977) argued that internal motivators cannot be solely responsible for behaviour due to the high variance in behaviours individuals performed in different contexts (pg. 2), and so SLT focuses on a “continuous relationship interaction between behaviour and its controlling conditions”. SLT posits that new behaviours are learnt as a result of direct experience or observing the behaviour being performed by others. According to Bandura, the consequences of a particular behaviour determine whether or not that behaviour will be retained (rewarded) or disregarded (punished). Amongst others, four factors are identified as increasing the likelihood of a
CHAPTER ONE

behaviour being displayed in adults and in children: (a) seeing the behaviour performed by multiple models, (b) the model(s) are individuals already admired by the observer, (c) seeing a reward being given to the model for performing the target behaviour, and (d) receiving a reward when they perform the target behaviour themselves. Bandura postulated that many of the behaviours that individuals currently enjoy would have previously had an aversive value prior to learning their consequences, and consuming particular foods is no exception (Baeyens, Vansteenwegen, Houwer, & Crombez, 1996). However, through the operation of three behavioural principles consuming novel or previously refused foods can be learnt, positively valued, and maintained (Horne et al., 1995). The three behaviour change components are (a) repeated exposure, (b) peer modelling, and (c) rewards contingent on performing the target behaviour; rewards are initially extrinsic, but increasingly intermittent when consumption is maintained by the positive intrinsic consequences of the new behaviour. Evidence bearing on each of these behaviour change components, particularly in preschool children given the developmental differences in maturity between primary and pre-school children, will next be considered.

Repeated exposure. A phenomenon called the ‘mere exposure’ effect refers to an individual being repeatedly exposed to a stimulus, which results in formation of a positive attitude to that stimulus (Zajonc, 1968). Authors have drawn on classical conditioning to explain the mechanism of the effect, comparing it to pairing an unconditioned stimulus with a conditioned stimulus (Birch et al., 1987); however, the actual psychological mechanism is yet to be defined (Cooke, Chambers, Anez, & Wardle, 2011).

Eating behaviour. For the past four decades researchers have attempted to investigate effects of a variable they term “mere exposure” on eating behaviour. However, authors fail to acknowledge that mere exposure protocols tend to be contaminated with demand characteristics and other social variables (Horne et al., 2011). A well-cited paper by Birch and Marlin (1982) claimed that exposure alone increased 2-year old children’s consumption of target cheese and target fruit. A later paper, Wardle and colleagues (2003) also described an ‘exposure only’ condition with 5 – 7 year old children, which resulted in significant increases in target vegetable consumption. In both cases children were invited by adults to consume the foods, a social situation likely to elicit demand characteristics for compliance (Greenhalgh et al., 2009; Horne et al.), and some form of verbal encouragement and/or praise is likely to have been administered transforming the condition undesirably into a non-tangible reward condition (Cooke, Chambers, Anez, Croker et al., 2011). Additionally, in Wardle et al. the experimenter consumed the target food prior to the invitation to consume, changing the “exposure” condition to a “modelling and exposure” condition (Horne et al.). These interpretations suggest that repeated exposure alone is a difficult phenomenon to study. Nevertheless, recent reviews still
conclude that repeated presentation conditions alone are feasible and effective in changing children’s perceptions (Nicklaus, 2016; Wadhera, Phillips, & Wilkie, 2015). Moreover, it shows promise for repeated presentation conditions coupled with modelling and rewards to be effective.

Physical activity. Repeated practice of target skills is important for individuals to develop those skills to the full, and discriminate the benefits of skills competence for their own psychosocial and physiological wellbeing in general. From a behaviour analytic perspective (Horne, 2016, personal communication), a target behaviour can be learnt from exposure to modelling of that behaviour followed by the reinforcing consequences (whether extrinsic or intrinsic) for successfully copying the behaviour. Few would disagree that mastery of a FMS is the result of repeated practice (Madrona, Iniesta, Espinosa, & Sanchez, 2014), and that proficiency in a skill is a correlate of participation in physical activity (Cliff et al., 2009). This suggests that the more competent an individual feels the more likely they are to participate. Nevertheless, a socially supportive environment is necessary to provide regular opportunities for practice, for example, through school curriculum–based interventions (Kriemler et al., 2011) to encourage repeated practice and the cycle from modelling to mastery.

Modelling. The effects of modelling on eating behaviours and physical activity have been explored. Parents and families have been identified as the initial significant role models for both lifestyle behaviours (Golan & Weizman, 2001; Goldfield et al., 2012) and survey methods have identified best practices for encouraging children to be more active (Vaughn, Hales, & Ward, 2013).

Eating behaviours. Parental influences, including what they consume, influence the foods that their children consume (Birch & Fisher, 2000; Cooke et al., 2004; Hughes et al., 2008). This unfortunately means that if the parent’s diet is narrow, there is a reduced chance of the parent presenting a range of foods (Mitchell, Farrow, Haycraft, & Meyer, 2013). Consequently, children with less opportunity to view their parents positively modelling their consumption of a variety of foods (Carruth & Skinner, 2000; Wardle, Carnell, & Cooke, 2005) and will themselves be more likely to develop a narrow diet. Specifically, parental modelling has been associated with children’s vegetable intake (Blissett, 2011).

Harper and Sanders (1975) presented a novel food to 80 children aged 1 – 4 years, and found that children consumed significantly more when the food was modelled being consumed compared to simply presented to the child. There was also a significantly higher acceptance of the food by the child when presented by the mother compared to a visitor (experimenter). Acceptance was defined as the child placing the food item in their mouth within 1 minute of its presentation. A later study found that when pre-school children were presented with a target food, and two teachers and their parents modelled eating that food, the children significantly increased their liking for it, as compared to the children who were not exposed to modelling (Jansen & Tenney, 2001). However, it is not clear from
the study whether the teachers or the parents were the more significant models. The study also did not describe the reaction displayed if the children consumed the target food. Caution must be exhibited, as even though studies have concluded correlation between children’s ‘liking’ and their ‘likelihood of consumption’ (Brug, Tak, te Velde, Bere, & de Bourdeaudhuij, 2008), this does not necessarily result in actual consumption (Cooke, Chambers, Anez, Croker et al., 2011). Liking is only a single motive of a spectrum of motives (Birch, 1999), and evaluation of consumption is more informative than liking.

Individuals other than parents can influence children’s eating behaviour’s. In a study conducted by Addessi, Galloway, Visalberghi, and Birch (2005), 2 – 5 year old children were presented with a target food in one of three conditions, (a) model present but not consuming, (b) model present but target food was a different colour to the child’s target food, and (c) model present and consumed the same food as the child. The results were that children in condition (c) consumed significantly more than children in the other two conditions, supporting evidence (Wang, Beydoun, Li, Liu, & Moreno, 2011) that individuals other than mothers can influence children’s consumption; investigations of influence should extend beyond parents and teachers to peers given the considerable amount of time children spend in early years settings (Houldcroft et al., 2013). An experimental study which measured children’s (N = 26) consumption found that if a teacher modelled consuming a novel or a familiar food silently, the modelling had no effect on the children’s consumption, however if the teacher modelled consuming a novel food enthusiastically, the children’s consumption increased (Hendy & Raudenbusch, 2000). However, when peers were introduced into the condition and tasked with modelling consumption of an alternative target food to the one consumed enthusiastically by the teacher, the children (N = 14) aligned their acceptance with that of the peer. This shows that the peer-modelling effect was stronger than the teacher-modelling effect. Overall, this research shows that positive modelling has an important impact on young children’s eating behaviours.

Researchers have questioned the effect of different modes of modelling, behavioural or verbal, on influencing children’s behaviours (Palfreyman, Haycraft, & Meyer, 2014). Following consideration of the effectiveness of positive role modelling, it is important to consider the effect of negative role modelling as children are constantly exposed to an environment where people behave as ‘visceral repulsors’, meaning they “passionately, emotively and vehemently dislike or very deliberately avoid a particular food (usually only one) because they find that food to be utterly repulsive” (Uprichard, Nettleton, & Chappell, 2013). Research has shown when children aged 3 – 4 years were presented with two coloured foods, the children exposed to negative modelling consumed the target food at “floor levels”, which positive modelling administered afterwards failed to counteract (Greenhalgh et al., 2009). This alarming finding highlights the importance of individuals
being aware of their behaviour and the effect it has on young children. Moreover, interventions should be designed using role modelling as a key behaviour strategy given its effectiveness.

**Physical activity.** Parental behaviours have been considered the most common method of role modelling for children regarding physical activity (Welk, Wood, & Morss, 2003). However, few studies have explored the relationship in pre-school children. Using objective measures, Moore and colleagues (1991) explored the physical activity of 102 children aged 4 – 7 years and their parents, and found that children whose mothers and fathers were active, were 2 times and 3.5 times more likely to be active, respectively, as compared to inactive parents. Moreover, they found that when both parents were active, children were between 4.5 and 7.2 times more likely to be active, respectively. More recently, Sebire and colleagues (2016) found that the amount of modelling support parents exhibited, assessed via self-report, was positively correlated with the amount of MVPA completed by the 5 – 6 year old children, as assessed by accelerometry. When the behaviour of 3 – 5 year old children and their parents were explored, the influence of parental physical activity on child physical activity levels was also found to be a significant predictor; a finding in line with SLT (Zecevic, Tremblay, Lovsin, & Michel, 2010). Ideally, this study needs to be repeated with validated questionnaires in order to strengthen the finding.

As with eating behaviour, parents are not the only influence on children’s physical activity behaviour given the time they spend away from the home environment (Ward, Belanger, Donovan, & Carrier, 2016). A systematic review of peer influence found predominately positive correlations (4/6 studies) between children’s physical activity and peer presence (Ward et al.). One reviewed study used direct observation to code physical activity of 892 children aged between 1 – 7 years, and identified an age difference (Lehto, Reunamo, & Ruismaki, 2012). Physical activity in groups of children became more prevalent as age increased. Children less than 3 years preferred single peer company, whilst, children aged 3 – 5 years exhibited increased activity when part of a group. The authors found that peers influenced children’s behaviour significantly; specifically active children sought other active children. Increased activity whilst in groups of children aged 3 – 6 years has also been found using accelerometers (Barkley et al., 2014). These results suggest that interventions targeting pre-school children should include participation in groups given the positive influence peer role modelling has on their physical activity levels.

**Rewards.** As discussed previously, according to Bandura (1977), an individual’s behaviour is often regulated by the consequences that result from the performance of a behaviour. Additionally, he described responsiveness as high when the presentation of a reward was delivered on a fixed-ratio schedule, meaning an individual was dependent on himself or herself to perform the behaviour required to earn the reward. For young children especially, it is recommended that once target
behaviour has been performed, the reward should be administered immediately (Bray & Bouchard, 2014). Rewards have been identified as a frequent behaviour change component of interventions targeting lifestyle behaviours (Golley, Hendrie, Slater, & Corsini, 2010). However, the effectiveness of rewards to learn and maintain behaviour has been under scrutiny for some time, with some researchers concluding that rewards impede instead of catalyse the learning process (Birch & Fisher, 1995). Two theories specifically critical of using rewards are (a) the over-justification theory (Lepper, Greene, & Nisbett, 1973) and (b) self-determination theory (SDT; Ryan & Deci, 2000).

Firstly, Lepper et al. (1973) a defining aspect of over-justification theory is “the proposition that a person’s intrinsic interest in an activity may be undermined by inducing him to engage in that activity as an explicit means to some extrinsic goal”. The authors emphasise that individuals will only engage in the behaviour to achieve the extrinsic goal, and once the extrinsic goal is removed the behaviour will revert to baseline levels. Following an experiment with 51 pre-school children where participants were assigned to one of three conditions, (a) expected reward, (b) unexpected reward, and (c) no-reward, it was concluded that children who participated in the expected reward condition showed less intrinsic interest in the task as compared to the other conditions, including baseline, suggesting that the extrinsic reward was detrimental to the behaviour. However, a pre-requisite for the task was that the children had an established interest in the task prior to participation. Lepper et al. highlighted themselves that to achieve a desired behaviour, the use of external rewards can be necessary in scaffolding children’s learning to establish an interest.

SDT also focuses on intrinsic motivation, and is concerned with environmental factors that may undermine individuals’ self-motivation, social functioning, and personal well being (Ryan & Deci, 2000). SDT presents motivation as a continuum, from controlled motivation where an external reinforcer is required, to autonomous motivation, where the motivation is intrinsic (Ryan & Deci). Intrinsic motivation was defined as “…doing an activity for its inherent satisfaction” (p. 72), however, behaviourists would argue that behaviour could also become inherently satisfying following previous reinforcement (Catania, 1998). Interestingly, Ryan and Deci acknowledge that the theory is not concerned with where the intrinsic motivation originated from, just its sustainability. In SDT terms, certain needs are innate and predominately based on three types (a) competence, (b) autonomy, and (c) relatedness; these are not learnt (Deci & Ryan, 2000).

A subcomponent of SDT, which focuses on determinants of intrinsic motivation, is ‘Cognitive Evaluation Theory’ (CET; Deci, Koestner, & Ryan, 2001; Ryan, Williams, Patrick, & Deci, 2009). Moreover, an underpinning factor of CET is similar to that of the over-justification hypothesis: to be able to apply the principles of CET to explain learning, an individual must already hold an intrinsic interest in the behaviour to be learned. Applying the above theories, and sub-theory to children’s
consumption of fruit and vegetables, and physical activity, it is unlikely that children reliably have an intrinsic interest in engaging in these behaviours (Horne et al., 2011), and therefore application of the over-justification theory, SDT, and CET may have limited application for pre-school children.

Recently, there has been an increase in the number of published studies evaluating whether rewards can increase the consumption of target fruit and vegetables in pre-school children (see Añez, Remington, Warlde, & Cooke, 2012; Blissett, Bennett, Donohoe, Rogers, & Higgs, 2013; Cooke, Chambers, Añez, Croker et al., 2011; Corsini et al., 2013; Holley et al., 2015; Horne et al., 2011; Remington, Añez, Croker, Wardle, & Cooke, 2012). However, there is very little research that has systematically evaluated the effects of rewards to target physical activity in pre-school children.

Eating behaviour. Across the United Kingdom, parents have reported using rewards as a method of engaging children in desired eating behaviours (Moore, Tapper, & Murphy, 2007). However, their use of rewards is often inappropriate: parents tend to use promise and delivery of pudding to reward children’s consumption of vegetables (Campbell, Crawford, & Hesketh, 2006; Moore et al.), conveying the wrong message, namely, that the pudding is a high status and tasty food, and that the vegetables are not. It is important that rewards are administered correctly to achieve the desired behaviour, and that pressurising children to consume foods and providing rewards for consumption are not viewed interchangeably (Blissett & Higgs, 2013).

Evaluations of the effectiveness of rewards have yielded mixed results, however, Cooke, Chambers, Anez, and Wardle (2011) highlighted that when the outcome measures are considered individually, the effects of rewards on actual consumption results are positive, but when the outcome measure is “liking”, the results are mixed. A confounding variable is that rewards can be administered in different forms, tangible and/or non-tangible, and research has attempted to investigate their effects individually (Grubliauskiene, Verhoeven, & Dewitte, 2012). A non-tangible reward is typically described as verbal praise. Studies often do not report the verbal interaction between the participant and experimenter, and so it is difficult to conclude whether some experimental conditions are contaminated with a non-tangible reward, and results achieved are due to conditioning (Appleton et al., 2016, Cooke et al.). A well-cited paper for the ineffectiveness of rewards is Wardle and colleagues (2003). The conditions in the study have been criticised on the grounds that condition labels (e.g. exposure) do not accurately reflect the procedures employed (Cooke et al.; Horne et al., 2011). Researchers must be careful when drawing conclusions that they have considered all variables, as this study is still cited as an example portraying rewards negatively.

One study conducted in a UK school environment with a final sample of 422 children aged 4 – 6 years (Cooke, Chambers, Anez, Croker et al., 2011) compared four conditions: (a) exposure and tangible reward (sticker), (b) exposure plus social reward (praise), (c) exposure only, and (d) control (no-
treatment). The target foods were six different vegetables. Each child’s target food was identified by systematically following a ranking procedure using three cartoon faces with different expressions showing “yummy”, “just OK” and “yucky”. Each target food was presented, the child was invited to taste that food then assign it to one of the three face categories. When multiple foods were assigned to the same face, the children were required to identify which they preferred most and the question repeated successively for the remaining foods. The food thereby identified as 4th in their preference list was the child’s target vegetable for the intervention. Throughout the intervention phase, the children were invited to consume their target vegetable 12 times. The children’s consumption was measured in grams. Short-term results from baseline to post-intervention found that children in the three experimental conditions (but not the control condition) significantly increased their consumption of their target vegetable. The long-term results suggest that contingent delivery of rewards is an effective means of increasing consumption as both the tangible and social reward conditions showed significant increases in consumption from baseline, at 1-month and at 3-month follow-up, whereas the initial relative small increase in the exposure group was not non-significantly different from that the control condition at 3-month follow up. The result obtained in the exposure only condition could have been induced by the experimenter inviting the child to taste the food (Horne et al., 2011).

A similar protocol using directly weighed measures of the target food has been administered in a British home environment (Remington et al., 2012), and in an Australian home environment (Corsini et al., 2013). Both studies found results similar to those in the school-based intervention. The method of identifying the target food though widely used is questionable, as in essence the measure relies on the child’s verbal response. This preference method has been used in many studies (Anzman-Frasca et al., 2012; Birch & Sullivan, 1991; Corsini et al.; Fisher et al., 2012; Guthrie, Rapoport, & Wardle, 2000; Savage, Peterson, Marini, Bordi, & Birch, 2013; Wardle, Sanderson, Leigh Gobson, & Rapoport, 2002; Wardle et al., 2003). However, one home-based study asked parents to list six vegetables that their child was reluctant to consume, but to avoid vegetables that they strongly disliked (Corsini et al.). When children were asked to rate their liking of the target food (using the 3-point scale described above), less than 40% (N = 138) rated the target vegetable as “yucky”. This finding questions the validity of the verbal preference measure with pre-school children as it is not clear whether or not they understand the questions asked during task. An earlier study reported a medium rank-order correlation coefficients ($rs \geq 0.61$) between the 3-point measure and 3 – 5 year old children’s consumption (Guthrie et al., 2000); however, reliability of the measure decreased with the younger the child. Validation of the measure in pre-school children separately in representative samples of children at age 2, 3, 4, and 5 years in order to determine the useful range of use of this preference test methodology.
In the three studies described above (Cooke, Chambers, Anez, Croker et al., 2011; Corsini et al., 2013; Remington et al., 2012) research staff conducted the procedures, including data collection. The staff costs were considerable and not sustainable long-term, therefore Wardle, Cooke and colleagues next opted to evaluate the effectiveness of a parent administered intervention in a randomised controlled trial (Fildes et al., 2014). Parents were responsible for identifying a target food that their twin children did not like and for assessing their children’s intake and liking individually at three time points (baseline, before the intervention, and immediately after the intervention). Twin population provide information on family environments due to the genetic similarities between the dyads (Wardle et al., 2008). Consumption was measured by parents in terms of number of pieces eaten (including half pieces), and the children’s liking was reported by parents using a 9-point scale range from “dislikes a lot” and “likes a lot”. No specification of what constituted as a ‘piece’ was provided. The authors described that parents were instructed to respond neutrally during measurement phases, and rewards were not offered. Following baseline, the intervention condition was presented with the target vegetable for 14 days throughout which period they received a sticker for consuming the food. The control condition was not provided with any information until after all data phases were completed. The results showed that the control children’s (n = 246) intake remained consistent across the three time points, however the intervention condition (n = 196) significantly increased following the intervention phase with the greatest improvement in ‘noneaters’ (children classed as consuming less than 1 piece at baseline). Collectively, these findings provide further evidence that rewards can be delivered effectively in both childcare and home settings, that parents can be recruited to deliver an intervention targeting their children’s vegetable consumption with positive results, although, more information on portion specification would be helpful.

A recent review on the effectiveness of rewards on increasing target food consumption concludes that a child’s initial liking of the target food and reward may affect the impact of the reward (Cooke, Chambers, Anez, & Wardle, 2011). However, given that typically behaviour change interventions are designed to target consumption of foods that are novel or previously refused, the rewards would not be hypothesised to have detrimental effects on consumption of those foods according to SDT (Ryan & Deci, 2000) and over-justification theory (Lepper et al., 1973). In addition, the aforementioned theories predict that rewards will decrease the behaviour once the rewards were removed, however, none of the studies mentioned above reported that the children’s consumption of the target foods fell below baseline levels following the removal of rewards (Cooke Chambers, Anez, Croker et al., 2011; Horne et al., 2011).

Physical activity. Limited research has been conducted using rewards to increase pre-school children’s physical activity levels, with researchers drawing on SDT as a justification for not “coercing”
children to participate in activity (Fitzgibbon, Stolley, Dyer, VanHorn, & KauferChristoffel, 2002). In an intervention called Hip-Hop to Health Jnr, the authors acknowledged the difficulty of engaging children in 20 minutes of activity. Despite no explicit description, it is probable that verbal praise was delivered to the children to reinforce their participation, and upon completion of the task, as is the case in most other physical activity interventions.

There are two studies in which pre-school children were presented with tangible rewards contingent on the completion of desired target behaviour. The first study mentioned below provided no rationale in the introduction or discussion for the inclusion of rewards in the intervention. O’Dwyer, Fairclough, Knowles, and Stratton (2012) conducted a family focused intervention targeting active play and investigated its ability to increase physical activity and decrease sedentary behaviour. The intervention required parents and children to attend five sessions hosted every other week for 70 minutes. In the sessions, the dyads were initially split for 20 minutes; parents participated in an educational workshop and the children engaged in active play, followed by parents and children engaging in active play together. At the outset, the children were provided with a logbook, as a mechanism for self-monitoring their activity with their family. Progressive reward contingencies were linked to completion of the logbook. Examples of prizes awarded are: activity bags, an active dance DVD, and a key fob. However, the authors did not describe the reward contingencies. Accelerometers were used to assess the primary outcome of the intervention on children’s total activity; the intervention condition performed significantly more steps than the control condition. As consistently noted in the literature, modelling plays a large role in the context of physical activity, and a parental modelling component was used in this intervention. However, the separate effects of this modelling component were not assessed.

The second multi-component study targeted physical activity levels in the school playground was called “Preschoolers in the Playground” (PIP; Barber et al., 2013, 2016). Parents were invited to attend three 30-minute outdoor play sessions over the course of 30 weeks. The protocol paper listed two reward components of the intervention: (a) praise and stickers as an encouragement behaviour change technique, and (b) play equipment awarded once a week as a reward behaviour change technique (Barber et al., 2013). Consistent with O’Dwyer et al. (2012) no further detail was provided as to the contingencies under which the rewards were administered. Barber et al. (2013) allude to Bandura’s social cognitive theory (1977) as justification for the inclusion of rewards in the intervention, but do not refer to any previous physical activity research investigating the use of rewards with pre-school children or acknowledge its novelty for this behaviour. The study found no difference in children’s physical activity using accelerometry, but in qualitative measures teachers and parents reported that the intervention was feasible, despite the low retention levels of the trial. As before, the
role of the rewards in the intervention cannot be ascertained due to the multi-component nature of the intervention. Further research is required to evaluate separately the role of rewards component in physical activity with pre-school children.

1.6 Measuring Changes in Behaviours

To be able to compare outcomes across studies, it is essential that researchers use validated and reliable methods of assessment for accurate conclusions to be drawn. Measurement of obesity can be performed in many modes (Townsend, 2009). Unfortunately, as there are some inconsistencies in the measurement of obesity, this can present difficulty when attempting to draw comparative conclusions (Summerbell et al., 2005). The most informative method of collecting data is through objective measures (Michie & Abraham, 2004), as the use of objective and subjective measures can yield different conclusions, causing some discrepancies in the literature (Li, Kwan, King-Dowling, & Cairney, 2015). Studies have also been criticised for not reporting whether the measure used is validated for the population reported (Ward et al., 2015), as validity of a measurement tool should not be assumed. Tracking changes in children’s behaviours and the effects of those changes on obesity are regularly reported through three categories of measurement variables: anthropometrics, blood pressure, food consumption, and physical activity levels.

Anthropometrics. Body Mass Index (BMI) is the most commonly used parameter of obesity (Townsend, 2009), and widely accepted as a valid measure of obesity (Cole, Bellizzi, Flegal, & Dietz, 2000). BMI is an indirect proxy measure of adiposity, which is calculated using measurements of weight and height ($\text{Kg} / \text{m}^2$). Freedman and colleagues (2004) concluded BMI in children is a strong indicator of BMI in adulthood. It is also a measure, which can be collected with all ages; however, the calculation for children adjusts for the child’s age (Must & Anderson, 2006). BMI-for-age reference growth charts are available nationally and internationally. The Centre for Disease Control and Prevention (CDC; 2015) growth charts are the most commonly used, and also provide an electronic spreadsheet to compute the measure.

Recent evidence in adults has discovered that individuals who were categorised as overweight and obese using BMI charts, were cardio-metabolically healthy, and that some individuals categorised as having a healthy weight were not cardio-metabolically healthy (Tomiyama, Hunger, Nguyen-Cuu, & Wells, 2016). In pre-school children, a regression analysis has suggested that an increase in BMI is positively correlated with an increase in percentage fat, and therefore it is fit for purpose (Sakai, Demura, & Fujii, 2012). The measure is not without its limitations, as it correlates with fat mass and fat-free mass (Maynard et al., 2001). However, it is low cost, non-invasive, acceptable to adults and children, requires only simple portable equipment (De Miguel-Etayo et al., 2014), and can be collected
in epidemiological studies and clinical settings (Wang, 2004), making the method feasible and comparable across populations.

Waist circumference is a measure of abdominal obesity (Magalhães, Sant’Ana, Priore, & Franceschini, 2014), which is found to correlate highly with BMI (Townsend, 2009). In comparison to BMI in terms of identifying whether a child is overweight or obese, waist circumference is considered to be a more sensitive measure (Magalhaes et al.; McCarthy & Ashwell, 2006). A potential weakness of the measure is the precision required when taking the free-hand measure, making it more difficult to take than height and weight, and very few studies have assessed intra- and inter-observer agreement (De Miguel-Etayo et al., 2014). It is recommended that both waist circumference and BMI measures should be collected (Bigaard et al., 2003).

**Blood Pressure.** There is a well-established link between blood pressure, obesity, and cardiovascular disease (Narkiewicz, 2006). There is increasing incidence of elevated blood pressure in children coinciding with the current obesity epidemic (Rosner, Cook, Daniels, & Falkner, 2013), highlighting the need for empirical studies in children to collect this measure to monitor this health outcome. Comparison of pre-school children who were sufficiently active/healthy weight \((n = 502)\) to overweight/obese children \((n = 231)\), found that the latter cohort were four times more likely to have elevated systolic blood pressure (Vale, Trost, Rego, Abreu, & Mota, 2015). Investigating blood pressure as an outcome of a physical activity intervention has been encouraged (Daniels, 2015). However, potential limitations are that researchers must be trained to conduct this measure, which in children has been found to be particularly sensitive to the “white coat” effect (Jurko Jr., Minarik, Jurko, & Tonhajzerova, 2016), and the equipment is highly sensitive and easy to damage (Tholl, Forstner, & Anlauf, 2004).

**Food Consumption.** There is a range of validated methods to measure food consumption (Olafsdottir et al., 2016). One gold standard measure of food consumption is weighing food, which is often impractical in a field setting such as schools due to time constraints (Kenney et al., 2015). One method of measurement found to be feasible in schools is visual estimation. Three studies have compared weighed criterion measures of consumption of snack foods, including fruit and vegetables, with visual estimation measures and found strong inter-rater reliability when using a 4-point Likert scale (Kenney et al.) and a 5-point Likert scale (Horne et al., 2004; Lowe et al., 2004). Given the low-cost (Kenney et al.) and accurate recordings achieved by this visual estimate measurement tool, it is considered a suitable method of measuring children’s consumption of fruit and vegetables.

**Physical Activity.** There are multiple methods of measuring physical activity in children, including accelerometry, which directly measures an individual’s movement (Rowlands & Eston, 2007). It is important to develop reliable measures of pre-school children’s habitual activity (Hnatiuk et al.,
Activity in young children can be difficult to assess because their movements tend to be highly transitory with “very short bursts of intense physical activity interspersed with varying intervals of low and moderate intensity” (Bailey et al., 1995), therefore it cannot be assumed that a measure shown to be valid for primary school children is valid for pre-school children (Cliff et al., 2009; Kelly et al., 2004).

To-date, validated devices used to measure pre-school children’s step counts are research-grade accelerometers (e.g. Actigraph; Pate, O’Neil, & Mitchell, 2000) and pedometers (e.g. Omron; De Craemer et al., 2015). However, research-grade devices have their limitations: Actigraphs are expensive and require expertise to interpret the data (Oliver, Schofield, & Kolt, 2007). Additionally, researchers apply different cut-points making comparisons between studies difficult to draw (Pate, Almeida, McIver, Pfeiffer, & Dowda, 2006). Therefore identifying and validating more cost-effective and easy-to-use devices is important to facilitate research on habitual activity in pre-school children.

Recently, there has been a marked increase in the availability of consumer-grade activity monitors, which are increasingly being trialled as potentially reliable and low-cost measures of physical activity for use in research studies (Ferguson, Rowlands, Olds, & Maher, 2015). The ‘Fitbit’ brand has been identified as the most popular range of activity monitors (Ferguson et al.; Evenson, Goto, & Furberg, 2015). One function of Fitbit devices is the measurement of total step count, as well as steps performed minute-by-minute over the recording period. When compared to nine similar activity trackers, the Fitbit Zip was found to be the most valid measure of step count in the population assessed (Kooiman et al., 2015). However, to-date, the Fitbit Zip has only been validated as a measure of physical activity for “healthy adults” (Ferguson et al.; Tully, McBride, Heron, & Hunter, 2014) and “older adults” (Paul et al., 2015). Fitbit claim that the Fitbit Zip can be “worn on or very close to the body”, including external pieces of clothing (Fitbit, 2015a). Other brands of accelerometers and pedometers are typically worn on the right hip, secured on an elastic belt and require adult input to ensure that children continue to wear the device in the correct place and do not modify settings (Pate et al., 2010). Non-compliance due to children refusing to wear the elastic belt has been noted in the literature (Costa, Barber, Cameron, & Clemes, 2015). A novel and low-maintenance approach to reducing such limitations would be to place each device in a pocket sewn inside an external piece of clothing, making the device inaccessible to the child. This is investigated in the present thesis.

1.7 Interventions Targeting Healthy Eating and Physical Activity

Interventions should be designed to target both healthy eating and physical activity to most effectively combat childhood obesity (Hardman, Horne, & Lowe, 2009; Hardman, Horne, & Rowlands, 2009; Ling, Robbins, & Wen, 2015; Summerbell et al., 2012). As pre-school children are a relatively new
target population, there are few peer-reviewed interventions targeting both lifestyle behaviours simultaneously. Although some interventions have published protocols, many results are yet to be published, for example the ToyBox-study (Manios et al., 2012) and therefore efficacy is not known.

Examples of multi-component interventions targeting pre-school children.

**Health Exercise Nutrition for the Really Young (HENRY) Programme.** One widely commissioned intervention delivered in Wales and England is called the Health Exercise Nutrition for the Really Young (HENRY) programme (Willis, Roberts, Berry, Bryant, & Rudolph, 2016). The programme has five core components: (a) parenting, (b) nutrition, (c) healthy eating behaviour, (d) physical activity, and (e) emotional wellbeing (Rudolph, Hunt, George, Kajibagheri, & Blair, 2010). The intervention is administered to parents over eight weeks by a trained group facilitator, with an aim to provide parents of babies and pre-school children with the tools to establish a healthy home and family environment (Rudolph et al.). Parents are skilled with modelling techniques and how to administer rewards for desired behaviour correctly (Roberts, 2015). A recent evaluation of the HENRY programme assessed children’s food intake and physical activity levels using proxy questionnaire measures, before the intervention started or in session one, and at the last session (Willis et al.). Parents were asked to respond for all their children in the target age of 0–5 years as opposed to individual children. Results collated over two years found parents (N = 624) reported significant increases in the children’s consumption of fruit and vegetables, a significant reduction in high fat and sugar snack foods, and a significant increase in physical activity. The positive results suggest the programme is a promising means of increasing children’s lifestyle behaviours, however, reported outcomes must be viewed with caution as limited description of the programme is available, and the reported results are based exclusively on self-report and susceptible to the halo effect. Outcomes need to be compared to a control condition. Local authorities need to consider quality of the research evidence base before commissioning such programmes. However, it highlights a gap in the field that interventions using direct measures can fill.

**Hip-Hop to Health Jr.** An example of a school-based intervention developed to target healthy eating and physical activity behaviours specifically in pre-school minority children (3–5 years) is the Hip-Hop to Health Jr. intervention (Fitzgibbon et al., 2002, 2005, 2011; Kong et al., 2016; Stolley et al., 2003). The programme was originally evaluated with the programme delivered by research staff (Fitzgibbon et al., 2005; Stolley et al., 2003). Across the studies, the programme consists of bi-weekly curriculum based sessions delivered for 14 weeks in the classroom, with a different theme each week, and the sessions consist of (a) a healthy eating or physical activity lesson (20 minutes), and (b) an interactive physical activity component delivered using a CD (20 minutes). Parents were asked to complete weekly homework assignments with $5 reward for their completion, provided with the
physical activity CD, and a weekly newsletter. The control condition participated in once per week curriculum sessions for a matched duration, and parents received the newsletters only. Fitzgibbon et al. (2005) measured the effect of the intervention using parental recall of the children’s frequency and intensity of their physical activity levels, and dietary intake at 1-year follow-up and at 2-year follow-up, outcomes for children (N = 389) who had received the intervention were compared to those in a control condition. No difference was reported between conditions for either target behaviour at follow-up. In order to investigate a “real-world” implementation of the intervention a subsequent evaluation was conducted (Kong et al., 2016). Proxy measures comparing pre-school children (N = 553) at baseline and 1-year follow-up revealed no long-term difference in children’s total screen viewing time in either condition. However, the intervention children’s consumption of fruit and vegetables remained constant over time, and significant decreases were found in the control condition for the target behaviour. As only self-report measures were presented, future evaluations of the intervention should employ objective measures for all target outcomes. That said, Kong et al. study shows that nursery staff are capable of delivering the core components of a healthy eating and physical activity intervention for children in a pre-school setting.

**Tooty Fruit Veggie.** This programme was tailored for pre-school children following successful trials with primary school children in Australia (Miller, Newell, Huddy, Adams, & Holden, 2001). It is a multi-component flexible programme targeting healthy eating and physical activity, which consisted of a nursery staff delivered curriculum, health professionals hosted parent workshops, adjustments were made to school policies, and monthly newsletters (Adams, Zask, & Dietrich, 2009). In the healthy eating component, nursery staff were provided with an ideas manual to take ownership and deliver as desired, in addition, children participated in interactive sessions categorising foods, tasting foods, created illustrations using the foods, grew a fruit and vegetable path and took part in healthy cooking classes. A strong modelling component was evident as a puppet show visited the children encouraging fruit and vegetable consumption. In the physical activity component, for two school terms the nursery staff delivered a ‘FunMoves’ session, which was focused on FMS. The session was administered bi-weekly for a total of 10 sessions, and lasted approximately 25 minutes. Evaluation of the intervention with 560 pre-school children in Australia was conducted prior to the children receiving the intervention and 10 months later. No description of the procedures during the 10-month follow-up were given, therefore it is unclear whether the intervention was suspended or continued, and despite the repeated measures design of the study, children were included even if they only had data at one time-point (Zask, Adams, Brooks, & Hughes, 2012). Not stipulating intervention procedures makes collapsing schools into conditions difficult, as the children will not have all received matched intervention provision. The results concluded that the intervention condition decreased their BMI z-
score significantly more than the control condition (as measured by height and weight); a significant improvement in the intervention condition as compared to the control condition was found for movement skills (as measured by Test of Gross Motor Skills Development), and intervention children had significantly greater provision of fruit and vegetables in their lunch box as compared to the control condition (as measured by servings/number of items), other researchers have found provision and consumption to be linked (Horne, Hardman, Lowe, Tapper et al, 2009), although that has not been measured here. The protocol paper (Adams et al.) described a proxy parent survey of children’s physical activity levels, however, no results were reported (Zask et al.). The intervention findings are positive and establish promising strategies to decrease adiposity and increase movement skills. Further investigation is required to determine effectiveness for healthy eating, as provision is not a measure of consumption.

**Conclusion of interventions available.** The sample of interventions described above show the potential to have positive effects on increasing pre-school children’s fruit and vegetable consumption and physical activity and one was included in a Cochrane review (Summerbell et al., 2005), one was mentioned in the NICE guidelines (2015) and both feature a systematic review (Nixon et al., 2012), however, one major pitfall of such interventions, and many others, is that they do not do not measure the actual target behaviour objectively, which is crucial to ensure real behaviour change.

1.8 Super Dynamic Food Dudes Programme

**Foundations.** Two successful behaviour change interventions that are underpinned by SLT are the ‘Food Dudes Healthy Eating programme’, and the recently developed ‘Dynamic Dudes Physical Activity Programme’. The long-term goal of the Food and Activity researchers at Bangor University has been to create a behaviour change programme that targets both healthy eating and physical activity (Horne, Hardman, Lowe, & Rowlands, 2009).

**Food Dudes Healthy Eating Programme.** The Food Dudes research programme directed by Lowe and Horne who set out, in 1990, to systematically devise an effective whole school intervention targeting 4 – 11 year old children’s consumption of fruit and vegetables (see Horne et al., 1995, 1998, 2004; Horne, Hardman, Lowe, Tapper et al, 2009; Lowe et al., 1998, 2004). From 2007, the programme has been implemented successfully in special schools alongside main stream schools during a nine-year national rollout of Food Dudes to all primary schools in Ireland, and to special schools in the Midlands of England; effectiveness in children with intellectual disabilities, using a more recent version incorporating the principles of choice architecture, has been evaluated recently in a controlled study conducted in Denbighshire (Roberts-Mitchell, 2014). The Food Dudes programme has also been
successfully adapted for pre-school aged children attending nursery classes (Horne et al. 2011; Sharp 2013).

The ‘Food Dudes’ intervention, is a whole-school programme designed to encourage children to taste repeatedly and thereby acquire a long-term liking for a range of fruit and vegetables (Horne et al., 1998, 2004; Horne, Hardman, Lowe, Tapper et al, 2009; Lowe et al, 1998, 2004). Evaluated using direct measurement methods (weighing, visual estimation of standardised portions on a 5-point scale), the intervention has successfully persuaded children to repeatedly taste and consume fruit and vegetables in school, and at home. The biggest effects have been found in the children who were categorised as the poorest eaters at baseline (Horne et al, 2004; Lowe et al., 2004).

The theoretical perspective of the intervention draws on Skinnerian and social learning principles and the empirical literature on the determinants of children’s food preferences (see Horne et al., 1998). This conjunction led to identification of the three potential behaviour change principles: (a) role-modelling, (b) rewards, and (c) repeated presentation for tasting, collectively referred to as the 3R’s for simplicity of discussion. Early multiple baseline studies identified a powerful behaviour change synergy when these three independent variables were used in combination to target children’s consumption of fruit and vegetables (Lowe et al., 1998).

**Food Dudes: Behaviour change components.** Role modelling of the target behaviour is provided by the Food Dudes, four child characters who enjoy consuming fruit and vegetables, and thereby obtain “special energy”. Each character has a favourite fruit or vegetable. In a series of video episodes the Food Dudes engage in battle with the evil General Junk and the Junk Punks to prevent their persistent attempts to steal children’s fruit and vegetables and deprive them of the special energy they need to grow, and have fun. Consistent with Bandura’s social learning theory (1977), the characters are depicted as heroes who are slightly older than the target children. Regarding the rewards component, clear contingencies are explained to the children at the outset of the programme so that children understand how they can earn rewards by performing the desired target behaviours of initially tasting, then later eating all of the fruit and vegetables provided over the 16-day intensive phase. The rewards are inexpensive (e.g., pencil case, ruler, pedometer, drink bottle, erasers), desired, and Food Dudes customised signifying their approval for consuming target fruit and vegetables and membership of the Dudes gang. The rewards help to generalise the influence of the Dudes from school to home where they keep parents informed of their child’s progress and serve as a cue to children to eat fruit and vegetables when the opportunity arises throughout the day. To instantiate the third principle, repeated presentation of target foods to be tasted and consumed, occurs initially in a friendly and inviting classroom environment. After the intensive phase, the contingency extends to fruit and vegetables available at lunchtime in the school canteen or in lunch boxes brought in from the
home. This further extends generalisation of the programme to different eating contexts and environments (i.e., snack time to lunch time, classroom to dining room, as well as school to home).

*Pre-school children.* Following successful trials of the primary school programme, a longitudinal proof-of-principle study (Horne et al., 2011) trialled the effectiveness of a rewards and role modelling intervention in 2–4 year old pre-school children attending the Bangor University Daycare and Child Research Centre. The children watched a cartoon peer modelling video showing two characters, Jarvis and Jess, who told the children they could receive exciting rewards for eating the fruit and vegetables provided every day and that if they ate those foods at snack-time they’d have lots of special energy for fun and play; the children received small rewards (stickers, a lego brick) for consuming the target foods. Children’s consumption of the standardised portions of fruit and vegetables presented at snack-time and again at lunchtime was measured by researchers via visual estimation using 5-point Likert scale. At the 6-month follow up, the intervention was found to produce very large and long lasting increases relative to baseline in all 8 fruit and 8 vegetables. In this repeated measures procedure, only half of the foods per category were directly targeted, with the remainder serving as within category controls. Nevertheless, by the end of the study the intervention effects had generalised to within each food category. The intervention was never applied to lunchtime fruit and vegetables. However the effects also generalised from snack-time to lunchtime. Although this within repeated measures, within-category control procedure is a very strong experimental design, the findings required replication in a standard between groups controlled study.

Following the proof-of-principles study, the Food Dudes programme was modified for pre-school children, by creating a video with younger versions of the Food Dudes characters and new concepts (e.g., eating fruit and vegetable from all colours in a rainbow; rainbow picnics) and new reward systems (tokens, rainbow energy tubes; character fridge magnets; transition from individual rewards in Phase 1 to groups rewards in Phase 2); no reference was made to General Junk and the Junk Punks. To evaluate the effectiveness of the pre-school programme for nursery classes in primary schools, a mixed design controlled trial was conducted in the West Midlands with 289 children from nursery classes attached to four primary schools (Sharp, 2013). The study employed a 4-day baseline, 32-day intervention, 4-day post-intervention, 12-week maintenance phase, and a 4-day 3-months follow-up. The children watched the animated role modelling video of the “Diddy” Food Dudes characters, then were presented with two pieces of target fruit and two pieces of target vegetable (there were 4 fruit and vegetable pairs in total, a different pair presented each day on a 4-day cycle), and earned small rewards for consuming the foods. Intervention procedures were suspended during measurement periods. Compared to baseline, children in the intervention condition had increased their consumption of target fruit and vegetables significantly more than those in the control condition.
CHAPTER ONE

at 3-month follow-up. This controlled study provided strong evidence that the pre-school Food Dudes programme was effective in 3–4 year old children attending nursery classes in primary schools, and could be integrated into the school curriculum, however, some procedural elements requiring modification were identified in this initial trial and once incorporated the pre-school programme was subjected to further controlled evaluation (see Chapter 2, p. 43).

**Implementation and further evaluation.** The on-going process of evaluation and modification conducted in the Food Dudes pre-school and primary school research programmes is consistent with the model outlined by the Medical Research Council on designing and evaluating complex interventions (Craig et al., 2008). The cycle outlines: (a) development, (b) feasibility and piloting, (c) evaluation, and (d) implementation. By way of illustration of the final stage (d), the Food Dudes programme has been rolled out successfully to over 700,000 children and has consistently yielded large and lasting increases in both fruit and vegetable consumption. Following the evaluation of the award-winning pre-school Food Dudes programme, UK local authorities have commissioned the programme for delivery to approximately 200 nurseries.

In addition to the studies listed above, other national and international research groups have conducted independent Food Dudes studies, with published findings further validating the effectiveness of the intervention. For example, trials have been conducted in the UK (Clarke, Ruxton, Hetherington, O’Neil, & McMillan, 2009), Italy (Laureati, Bergamaschi, & Pagliarini, 2014; Presti, Cau, Oppo, & Moderato, 2015), and the USA (Morrill, Madden, Wengreen, Fargo, & Aguilar, 2016; Wengreen et al., 2013); the latter location found significant increases up to 2 years following baseline (Wengreen & Fox, 2015). When compared to other initiatives delivered worldwide, the Food Dudes programme has been reviewed favourably as a means of assisting children to meet fruit and vegetable consumption guidelines (Rekhy & McConchie, 2014).

**Dynamic Dudes Physical Activity intervention.** To target children’s energy expenditure, the theory and fundamental behavioural principles underpinning the Food Dudes programme were next evaluated as a means of targeting primary school children’s physical activity levels. Early basic research studies on the determinants of physical activity in primary school children employed four characters referred to as the ‘Fit’n’Fun Dudes (Hardman, Horne, & Lowe, 2011; Hardman, Horne, & Rowlands, 2009; Horne, Hardman, Lowe, & Rowlands, 2009). However, in anticipation of future development of a programme complementary to the Food Dudes programme, in 2012, the Food Dudes peer modelling videos were remade with characters who not only had signature favourite foods (fruit or vegetable) but also signature activity skills which were deployed in the course of new video adventures to defeat the evil General Junk, Miss Demeanour and the Junk Punks. Informed by outcomes from the basic research using the Fit’n’Fun Dudes pictorial modelling materials and
rewards, and by the empirical literature on physical activity interventions for schools, the new Food Dudes characters next featured in a new physical activity intervention as Super Dynamic Food Dudes or Dynamic Dudes for short.

*Fit’n’Fun Dudes studies.* The first study investigated whether a rewards and role modelling intervention would increase 9 – 11 year old school children’s activity by at least 1500 steps relative to baseline (Horne, Hardman, Lowe, & Rowlands, 2009). During the 8-day intervention children in the intervention met their personalised targets of 1500 steps above baseline levels in order to receive the scheduled tangible rewards, but at 12-week follow up this increased daily activity was only maintained in girls. A second study compared in a wider age range of 7 – 11 year olds at primary school the effects of role modelling, tangible rewards and social praise (as employed in the previous study) with role modelling and only social praise for meeting their personalised daily pedometer targets (Hardman et al., 2011). During the intervention, the tangible rewards condition showed the largest increase in daily (+2456 steps per day; effect size=0.8), with the social praise group significantly smaller increase (+1033 steps per day; effect size =0.3), and no change in the control condition. However, contrary to the authors’ hypothesis, during the 13-week follow-up measure, the children in the non-tangible rewards condition continued to increase their daily steps relative to baseline (+2030; effect size=0.65) whereas daily steps in the tangible rewards condition returned to baseline levels. The authors consider the possibility that the researchers, who were not in the schools following the end of the 12-day intervention period, had become associated during the intervention with delivery of tangible rewards in the modelling, tangible rewards and social praise group. When they returned 12 weeks later to conduct follow-up measures, the non-delivery of tangible rewards is likely to have triggered a strong extinction effect. However, in the modelling and praise condition, no such association would have been established. In addition, it is not known whether the researchers withdrew praise in the latter condition during follow-up. If social praise continued to be delivered, it could be argued that this continued to motivate the children in the modelling and social reward condition to engage in the target behaviour because they were not exposed to a change in contingency during follow-up measures. The positive effects with modelling and social praise nevertheless informed the subsequent development of Dynamic Dudes, a new physical activity intervention in which tangible rewards are not only replaced with social praise, but also children’s continued self-monitoring of their own success at achieving multi-level activity skills taught during the new programme. Given the different effects of tangible rewards in the physical activity and food preferences research, the authors proposed that the determinants of these two different target behaviours target behaviours may not be the same (Hardman et al., 2011), but that remains an empirical matter.
In 2013, funding was secured from two Local Authority Commissioners and the Technology Strategy Board and two KESS studentships to develop and trial a multi-component Dynamic Dudes intervention. The main components developed and to be trialled were: a) classroom exercise DVDs; b) playground activity stations for use in free play at breaktime and during PE lessons; c) a PE teacher training DVD and d) Dude-athlon competitions to be held on school sports days; e) school-to-home links via creation of Dynamic Dudes way marked active travel routes to school. The aim of the classroom exercise modelling DVDs is to increase daily MVPA in all children at school while at the same time teaching them some of the FMS that underpin physical literacy in the domains of dance, football, martial arts, and gymnastics (see Whitaker, 2016). Prior to 2013, positive effects of classroom-based physical activity interventions have been reported (Donnelly & Lambourne, 2011; Fairclough et al., 2013; Gao et al., 2016; Reznik, Wylie-Rosett, Kim, & Ozuah, 2015). The second component, playground activity stations were designed to train and enable children to discover for themselves, additional FMS and skills pertaining to tennis, basketball, football, skipping, jumping, dance, and running, that cannot be learned and practiced in the classroom. Three stations provided training in ball based skills, one station per skill and dance; two others focused on running, skipping, hopping, and jumping. This component was designed to be achieved with play equipment and playground markings with associated equipment (e.g., skipping lanes and skipping ropes providing digital feedback). All playground elements were thematically linked by being customised with Dynamic Dudes characters. Prior to 2013, some studies had investigated the effects on key activity outcomes of playground equipment, and others the effects of playground markings, but without a focus on the overarching concept of physical literacy development (see Cardon et al., 2009; Ridgers, Stratton, Fairclough, & Twisk, 2007; Stratton & Mullan, 2005). However, to my knowledge, none have focussed on the development of FMS using purpose built equipment and markings in combinations with role modelling and reward systems in a thematically coherent manner, across classrooms, school playgrounds, and children’s homes.

So far, two controlled studies have been conducted both with two intervention and two control primary schools. The classroom exercise videos were first developed and trialled from 2013 – 2014 with KESS funding. Mitchell (2014) who demonstrated very large impacts on MVPA of “Beginner’s” versions of the classroom exercise DVDs relative to time-matched activity in control schools although no effects on anthropometric measures and accelerometer measured daily step counts were found in this relatively short-term controlled study.

In a second KESS funded studentship (Whitaker, 2016), the intensity of the classroom exercise DVDs was increased to provide “Advanced” versions, and the playground activity stations were developed and trialled. A mixed design controlled evaluation in the West Midlands with four primary
school’s (N = 399) measured the children’s cardiovascular fitness using the 20m shuttle run test, and their daily physical activity levels (step counts) on weekdays using Fitbit Flex accelerometers. Measures were conducted at three time-points (baseline, 9-week follow-up and 17-week follow-up) to assess the short- and long-term effectiveness of the intervention. There was no significant difference between the intervention and control condition for cardiovascular fitness or daily step counts. No short-term differences in fitness were found between the conditions, nevertheless, at the 17-weeks follow-up, the intervention children had a significantly higher level of fitness than the control children (p = .03, r = .08). Analysis of the children’s step count revealed short- and long-term success for the intervention on increasing daily step count, as the intervention children performed significantly more steps than the control condition at 9-week follow-up (p = .003, r = .15) and at the 17-week follow-up (p = .04, r = .10). Given the positive results of the intervention in its initial stages, funding is currently being sought for a longitudinal trial of all planned Dynamic Dudes components.

The new multi-component intervention provides a promising strategy for increasing primary school children’s physical activity levels, but has not been tailored for pre-school children prior to the research presented in this thesis. The present thesis therefore aims to develop a Dynamic Dudes intervention suitable for 3 – 4 year olds attending nursery classes in primary schools. Parental questionnaire measures suggest that 3 – 4 year old children now watch 29.28 hours/minutes of TV per week (Ofcom, 2016), however it is not clear whether that viewing time is active or sedentary. Screen time is one means of inducing physical activity in children; it has been proposed that young children having fun do not necessarily engage in activity consciously (Hansen & Sanders, 2008). This research field is not well developed, and physical activity research with pre-school children in play settings is quite limited. Of the few published studies, Cardon et al. (2009) recruited 40 pre-school settings and randomly assigned 10 pre-schools (N = 583) to one of four conditions, (a) play equipment provided, (b) playground markings provided, (c) playground equipment and marking provided, (d) control condition. Measured by accelerometry, none of the interventions have been shown to significantly increase any physical activity intensities (sedentary behaviour, light activity, moderate activity, vigorous activity). A study that reviewed the physical activity determinants of 20 pre-schools (N = 299 children) found that children in pre-school settings with less fixed equipment and more portable equipment performed higher quantities of MVPA as compared to those who offered more fixed equipment and less portable equipment (Dowda et al., 2009). Studies such as this are important if we are to establish which components are suited for the target population, as it cannot be assumed that playground equipment preferences of primary school children are the same as those for pre-school children.
Overall, playground markings and playground equipment have the potential to increase physical activity in preschoolers, however, their efficacy is dependent on support and enthusiasm from nursery staff (Cardon, Van Cauwenbergh, E., Labarque, V., Haerens, L., & De Bourdeaudhuij, 2008; Cardon et al., 2009; Kreichauf et al., 2012). Future interventions should focus on integrating portable equipment for pre-school children as opposed to fixed equipment. Given that outdoor space, no matter how small, is available in the majority of schools, classroom-based interventions should be developed to target the outdoor play area to help generalise the effects of the intervention across contexts and social environments.

Present Research

The previous research conducted at the Centre for Activity and Eating Research (CAER) showcases the effectiveness of the SLT to target healthy eating and physical activity in primary school children; however, the research targeting pre-school children’s healthy eating was under-development, and physical activity was not initiated. The research reported in this thesis aims to further both interventions, and conclude with a novel two-pronged intervention titled ‘Super Dynamic Food Dudes’. The intervention was designed for implementation in the school environment, with transfer into the home to increase generalisability. The primary aims of the intervention was to increase pre-school children’s consumption of fruit and vegetables, and their physical activity levels whilst attending nursery, assessed via objective measures. Due to financial and time restraints, this thesis has only developed and evaluated the indoor classroom-based activity component, and does not explore the effectiveness of the playground component for pre-school children.

The thesis comprises of six experimental chapters, and one descriptive chapter of explanations and justifications of modifications to the interventions prior to the final experimental chapter. A synopsis of each chapter is presented below including hypotheses. As this chapter has covered the relevant literature, the experimental chapters include method, results and a brief discussion; with the main discussion presented in a general discussion chapter concluding the thesis.

**Chapter 2: Controlled Evaluation of a Modified Food Dudes Healthy Eating Intervention Targeting Pre-school Children’s Consumption of Fruit and Vegetables.**

Drawing on feedback from a previous evaluation (Sharp, 2013), this chapter presents the justification for and process of simplifying the Early Years Food Dudes Healthy Eating Programme before conducting a controlled evaluation of the modified programme in four schools to measure the effectiveness of the modified intervention. The primary outcome variable is children’s consumption of four target fruit and vegetables measured at baseline, post-intervention, and 3-month follow up.
Additionally, children’s BMI was measured and parent questionnaires were administered during each of the three measurement time points, and nursery staff questionnaires were administered following completion of the study. Based on previous findings, a mixture of directional and non-directional hypotheses were devised:

H₁ – Food Consumption
   a) The intervention children will increase their consumption of target fruit and vegetables significantly more than the control condition following their participation in the Food Dudes intervention, and the effects will generalise to the home environment.
   b) Children who were “poorest eaters” at baseline will show greater increases at follow up than those initially classified as “highest eaters”.
   c) The intervention will be effective in increasing children’s consumption of all 8 target foods.

H₂ - Anthropometrics
   a) – Due to the short time frame of the trial, no change in BMI is expected in either condition.

The results of the healthy eating intervention informed the later modifications outlined in Chapter 7, prior to its integration with the physical activity intervention in Chapter 8.

Chapter 3: Reliability and Validity of the Fitbit Zip as a Measure of Pre-school Children’s Step Count: a cross-sectional study.

Ensuring that the measurement tool is reliable and valid for the target population is crucial. This chapter describes evaluation of the reliability and validity of a consumer-grade accelerometer (Fitbit Zip) used to measure of pre-school children’s step count, as compared to direct observation of those children’s steps, during a cross-sectional study. The measurement tool was used in all subsequent studies measuring physical activity.

H₁ – Physical Activity
   a) It is predicted that the Fitbit Zip when compared to direct observation will prove to be a valid measure of pre-school children’s step count
   b) It is expected that the two Fitbit Zip’s worn simultaneously by each child will yield high inter-reliability scores.
Chapter 4: Development and Feasibility of Four Interactive, Audio-Visual Stories to Increase Pre-school Children’s Physical Activity Levels in a Nursery Setting.

Story telling is a component of the EYFP Framework (Welsh Government, 2015), and was identified as an ideal nursery curriculum component to change from a typically sedentary to an active format. Interactive stories were designed as a component of the Dynamic Dudes intervention for pre-school children. This chapter is split into two parts: (a) development and production of four interactive stories, and (b) a proof-of-principle study assessing the feasibility of the interactive stories. The latter part measured steps performed by the children during the interactive stories and informal observations were conducted.

H₁ – Physical Activity and Informal Observations

a) The interactive stories will be feasible for the children to complete and effective in engaging children in physical activity step counts as a group and individually.

b) Children will perform more steps with successive presentations of the interactive story.

c) There will be no difference in performance by gender.

d) There will be no difference in the children’s step count compared to the on-screen modelled steps.

Chapter 5: Development and Feasibility of Four Exercise Videos Designed to Increase Pre-School Children’s Physical Activity Levels in a Nursery Setting.

Based on the success of the exercise videos used in the Dynamic Dudes Primary School programme, the component was tailored for the pre-school children. This chapter is divided into two parts: a) development and production of four exercise videos, and (b) a proof-of-principle study assessing the feasibility of the exercise videos. The measures and hypotheses are consistent with those raised in Chapter 4.

Chapter 6: Let’s Have Some Adventures! Increasing Pre-school Children’s Physical Activity Levels with a Role-Modelling Dynamic Dudes Intervention.

The two newly developed physical activity components, interactive stories and exercise videos, were presented to pre-school children in the classroom to assess their effects on children’s total in-school step counts measured using Fitbit Zip accelerometers, as compared to pre-schoolers in a control school who continued to participate in their standard nursery curriculum. Children’s BMI measurements were also collected, parental engagement with a home intervention, and nursery
feedback. Due to time constraints the intervention was only assessed at baseline and post-intervention. The following hypotheses were devised:

**H1 – Physical Activity**

a) After participating in the Dynamic Dudes intervention, the children will perform more daily in-school step counts at post-intervention than the control condition, with no gender difference expected.

b) During the intervention phase, the number of daily in-school step counts performed by the intervention children will be significantly greater than those performed by the control children.

c) Interactive stories and exercise videos will generate more steps in children taking part in the intervention condition compared to children in the control condition participating in their standard nursery curriculum, and children in the intervention condition will produce more steps with successive presentations.

**H2 – Anthropometrics**

a) As the time between baseline and post-intervention is only 7 weeks, no changes in BMI are expected in either condition.

**H3 – Parent Engagement**

a) Due to the exploratory nature of this component, it is unknown whether parents will engage with the intervention or not.

**H4 – Nursery Feedback**

a) Nursery staff will see the intervention as a feasible and fun intervention that can be delivered as part of the nursery curriculum.

Chapter 7: Modifications to Components of the Food Dudes Healthy Eating Intervention and the Dynamic Dudes Physical Activity Intervention to Create the Super Dynamic Food Dudes Intervention for Pre-school Children.

In order to explain and justify all the changes made to each intervention, this chapter is predominately descriptive to support the understanding of the reader prior to the combined trial of the two separately developed behaviour change interventions. As this chapter is purely descriptive, no hypotheses were raised.
Chapter 8: Evaluation of a Multi-Component Healthy Eating and Physical Activity Behaviour Change Intervention Targeting 3–4 Year Old Children in Primary Schools.

Separated into two parts, this chapter first presents pre-baseline assessment of pre-school children’s physical activity levels in five schools, followed by evaluation of the combined healthy eating and activity interventions, developed in research described in previous chapters. Behaviour and health outcomes were assessed including physical activity, food consumption, anthropometrics, parental engagement, and nursery staff feedback. The physical activity intervention spanned three measurement periods, and the healthy eating spanned two measurement periods.

H₁ – Physical Activity

a) Intervention children will perform a greater number of daily in-school step counts than the control children at post-intervention 1 (T2) and at 2-month follow-up (T6), with boys performing more steps than girls.

b) Children in the intervention condition will perform a higher number of daily steps during the three intervention phase blocks (T1) compared to the control condition.

c) The interactive stories and exercise videos will generate a higher step count in the intervention children compared to control children over matched time-frames while participating in their standard nursery curriculum.

H₂ – Food Consumption

a) Intervention children will consume a greater quantity of the target fruit and target vegetables than the control condition at post-intervention.

b) The greatest increases in consumption will be found in the poorest eaters.

c) The intervention will be successful in increasing the consumption of all 8 target foods.

H₃ – Anthropometrics

a) The anthropometric measures (BMI, waist circumference) will increase over time in the intervention and control condition. However, the intervention will provide a protective effect such that increases will be smaller in the intervention than in the control condition.

H₄ – Blood pressure

a) Due to lack of data in the literature with pre-school children, no directional hypothesis was devised for the change in 6 months.
H5 – Parent Engagement

a) Due to its exploratory nature, no directional hypothesis was generated.

H6 – Nursery staff feedback

a) The intervention will be acceptable and feasible to implement in the nursery environment.

Chapter 9: General Discussion

This chapter has considered in depth all the interventions conducted throughout the thesis, drawing on the relevant literature.
CHAPTER TWO: Controlled Evaluation of a Modified Food Dudes Healthy Eating Intervention
Targeting Pre-school Children’s Consumption of Fruit and Vegetables.

Abstract

Objectives: This study investigated the effectiveness of a modified version of the Early Years Food Dudes healthy eating intervention designed to increase fruit and vegetable consumption in 3 – 4 year old children (see Sharp, 2013), which was based on three key behavioural principles: role modelling, repeated presentation and rewards.

Design: Four nursery classes, each located in a different primary school in Walsall, Birmingham, participated in a controlled evaluation of the revised protocol. The selected nurseries were randomly allocated to either the intervention or control condition. The independent variable was the Food Dudes Healthy Eating intervention. During a 4-day baseline (T0), participants received a standardised portion of target fruit and vegetables, a different pair each day. Over the next 20 days (Intensive phase [T1], in the intervention nurseries only, the target foods continued to be presented on a 4-day cycle. The children watched a Food Dudes video that showed four characters who love to eat fruit and vegetables to increase their “special energy”; they then received small-customised rewards if they ate the provided target foods. After the Intensive phase, a 4-day post-Intensive phase measure (T2) was conducted in all nurseries under baseline conditions. For the following three-months (T3), the intervention children brought fruit and vegetables from home into the nursery on one day per week to be eaten during classroom “rainbow picnics”, and received rewards for their consumption. In parallel, the home intervention (T3 – T4) was provided to the intervention condition parents. A 3-months follow-up (T4) was conducted in all nurseries, 3-months after the end of the Intensive phase.

Participants: Final sample included 179 children aged 3 – 4 years.

Measure: Children’s anthropometric measures (height and weight) to calculate Body Mass Index (BMI) were collected at baseline (T0) and at the 3-months follow-up (T4). Consumption of target foods was recorded using visual inspection and digital photographs of any food remaining on children’s plates at baseline (T0), at post-Intensive phase (T2), and at 3-months follow-up (T4). The images were blind-coded via visual inspection on a five-point scale (0%; 25%; 50%; 75%; 100%). Excellent inter-observer reliability was achieved (k = .85). Partial data collected in one control nursery were excluded from the analysis because the nursery teacher departed from the study protocol and delivered rewards to the children in her group contingent on their fruit and vegetable consumption. Home consumption was measured through proxy questionnaires at baseline (T0), at post-Intensive phase (T2), and at 3-months
follow-up (T4). Feedback was obtained through questionnaires completed by parents and nursery staff at T2 and T4.

**Results:** Analysis of the intervention and control conditions BMI scores revealed a marginally significant change in BMI between baseline to 3-months follow-up ($p = .047, r = .16$). Compared to children in the control condition, the intervention condition made significantly larger improvements in their consumption of the target fruit ($p = .001, r = .26$) and of target vegetables ($p < .001, r = -.35$) between baseline (T0) and 3-month follow-up (T4).

**Conclusion:** The modified role-modelling and rewards intervention was effective in increasing pre-school children’s consumption of fruit and vegetables, therefore promises to be an effective preventative intervention to help prevent the onset of obesity.
This chapter describes the evaluation of a modified version of the Early Years Food Dudes healthy eating intervention first trialled by Sharp (2013). Post evaluation feedback suggested that some parts of the Phase 1 protocol were considered to be too intensive for nursery staff to deliver in the long-term. The Phase 1 protocol in particular was therefore simplified in order to retain the core reward contingencies, and the duration of this phase was reduced. Modifications to the intervention were made in consultation with the lead PhD supervisor and are summarised below.

**Shortening of Intensive phase**

In the initial pilot study, there were two phases: (a) the Intensive phase (32 days), and (b) the Picnic phase (12 weeks). In the initial evaluation (Sharp, 2013), a probe measure of the children’s target food consumption was conducted during the Intensive phase in order to assess the level of behaviour change achieved on Days 17 – 20 relative to baseline. The measure was conducted in both the intervention condition, while the intervention was still being administered, and in the control condition who were receiving just the target fruit and vegetables without the intervention.

Median consumption during the probe measure showed that substantial and significant increases in target food consumption in the intervention condition (n = 133) had already occurred (fruit: \( p < .001, r = .49 \); vegetables: \( p < .001, r = .55 \)), while no significant change was found in the control condition (n = 144) for either target food consumed (fruit: \( p = .23, r = .07 \); vegetables: \( p = .99, r = .0006 \)). From the probe measure to the post-Intensive phase measure, the intervention condition sustained their consumption; no significant difference in target food consumption was found for either fruit (\( p = .72, r = .02 \)) or vegetables (\( p = .11, r = .10 \)). However, a small increase was found in the control condition in their consumption of fruit (\( p = .001, r = .19 \)), with no change in vegetable consumption (\( p = .40, r = .05 \)).

Following the Picnic phase, some nursery staff commented in an open-ended feedback questionnaire that the programme contained too many components to be administered simultaneously and consumed too much curriculum time. Nevertheless, the majority commented that they would be happy to deliver the programme again if it was simplified. Consequently, the duration of the Intensive phase in the present study was justifiably decreased from 32 to 20 days as there was no significant change in the intervention condition’s consumption level, and this would decrease nursery staffs concern of the disruption to the curriculum.
Staff-Training Materials

A new instructional DVD was produced to show the nursery staff how to deliver the simplified protocol during staff training. The video was also made available to nursery staff to refer to whenever they felt unsure about any of the steps involved in the Programme.

Intensive Phase Target Foods

To ensure that seasonality had no impact on target food availability during the present study, the modified protocol used the same foods as were already being provided to schools taking part in Food Dudes Health programme rollouts of both the primary school and nursery. This contrasts with the initial pilot trial (Sharp, 2013), which used target foods that were chosen based on low consumption by 3–4 year olds during an earlier unpublished pilot study. However, it was also decided that the researcher would continue to prepare the foods throughout the measurement periods to ensure consistency of the portion sizes for coding purposes.

Picnic Phase Target Foods

Previously in the Picnic phase, the target foods presented during the Intensive phase were also presented during the Picnic phase. However, to promote transfer of the intervention into the home environment, and reduce the cost of the programme, parents were asked to supply a portion of fruit and a portion of vegetables, of their choosing, once a week in a Food Dudes plastic container given to each child.

Reduction in Rewards

During the original evaluation (Sharp, 2013), there were multiple rewards administered to children for the same contingency, therefore, two surplus rewards were removed, and one was transferred from the Intensive phase into the Picnic phase. Previously, the contingency for the children consuming the target fruit only and the target vegetable only resulted in red and green stickers, respectively. Each child also had a ‘Passport to Healthy Eating’, which contained a progress chart for nursery staff to tick if the child had consumed the fruit and/or vegetable, and a box to place a gold stamp if the child consumed both. The purpose of the chart was to enable nursery staff to track each child’s progress. The Passport also contained Dude Den pictures, where for consuming both fruit and vegetables, the children could earn a character sticker to place in the Dude Den. An additional reward for the contingency of consuming both food categories was a ‘Rainbow Energy Tube’ and ‘yellow energy tokens’. A delayed gratification reward to encourage the children to continue consuming both food categories was the proposition of earning a fridge magnet for every four energy tokens collected.
Finally, at the end of every session, one child was titled ‘Dude of the Day’ and received a child-friendly medal to keep.

Following the initial evaluation, it became apparent that the progress chart in the Passport to Healthy Eating was not serving its purpose, and that the nursery staff found it an unnecessary burden, therefore the progress chart, along with the gold stamp was removed. As two rewards for the contingency of consuming both target food categories remained, the Dude Den pictures and character stickers were transferred into the Picnic phase, meaning children could only earn one reward for one contingency.

Method

Ethical Approval

Permission to evaluate the effectiveness of a modified Food Dudes healthy eating intervention with pre-school aged children was granted by the School of Psychology Ethics and Research Governance Committee at Bangor University (Ethics application No.: 2013-11864).

Participants

NHS Walsall commissioned the delivery of the Early Years Food Dudes healthy eating intervention to nursery classes in primary schools; therefore this research was conducted in Walsall. Schools taking part in the present study were selected using the following criteria: (a) nursery housed within the primary school, (b) Ofsted report (overall effectiveness of the school performance), (c) nursery separate to reception class (d) children attended either a morning and afternoon nursery session for 2.50 hours, 5 days a week (attendance was not compulsory), (e) a minimum of 15 children in both sessions, (f) compatible snack-time routine, (g) socioeconomic status (above average percentage of free school meal provision) and (h) less than 20 minutes drive between schools. Four schools were identified, contacted by telephone and/or email, and arrangements made to see the Head Teacher. During the meeting, the researcher outlined the study requirements, and obtained the Head Teacher’s written consent for participation of their school. The nursery classes were randomly assigned to a condition, with two intervention schools and two control schools.

Parental consent for each child’s participation, including anthropometric measures, was obtained using a condition tailored opt-out consent letter (intervention condition, Appendix 2.01; control condition, Appendix 2.02). The consent letters specified the 8 target foods presented in the study, and asked parents to report whether or not their child had any food allergies and to which foods. At the outset of the study, 231 children (M = 3.77 years, SD = 0.36, range: 3.08 to 4.92 years; 48.50% girls) were recruited to participate. Each school provided the children’s dates of birth.
Experimental Design

This study employed a mixed, between-groups repeated-measures design (see Figure 2.01). The children’s consumption of target fruit and vegetables at snack time was measured over 4 days under baseline conditions (see Procedures) in both the intervention and control nurseries at three measurement points: baseline (T0), at post-Intensive phase measure (T2), and at 3-months follow-up (T4). In addition, a probe measure (T1) was taken on Days 13 to 16 in the intervention condition to explore behaviour change at this point; given that reward contingencies were still being administered this probe measurement is not directly comparable with the main measurement points conducted under baseline conditions. Nevertheless, the probe provides a measure of the children’s target food consumption behaviour useful in considering even further reductions in duration of the Intensive Phase.

Figure 2.01. Schematic outlining the design of the study.

The independent variable was the delivery of the modified Food Dudes healthy eating intervention. The primary dependent variables for each child were (a) consumption of each standardised portion of target fruit and vegetable within and between each measurement period, and (b) anthropometric measures (height, weight, and BMI) at baseline and at 3-months follow-up. Secondary dependent variables were (a) the self-reported parent and the child’s consumption in the
home environment of three target food categories: fruit, vegetables, and high fat and sugar snacks, (b) parental feedback of the intervention and (c) nursery staff feedback.

Materials

Target foods. Eight target foods, 4 fruit and 4 vegetables, were selected for presentation during three measurement periods (baseline (T0), post-Intensive phase (T2), and 3-months follow-up (T4) in both the intervention and control condition; and also in the Intensive phase (T1) of the intervention condition only (see Procedures). Each target food was presented fresh and raw, randomly assigned into four pairs (1 fruit and 1 vegetable), and presented on a fixed 4-day cycle to all participants at specified times. An alternative food was presented to a child allergic to a target food.

To ensure the freshness of the target foods, the researcher sourced and supplied all target foods to the schools. The researcher, who has a ‘Level 2 Food Safety in Catering’ certificate, prepared the foods for the three measurement periods to ensure portions presented were standardised across the four nurseries (see Figure 2.02 for target pairs and detailed specifications). The researcher trained the catering staff in the intervention schools on the portion specifications required for presentation during the Intensive phase; the same portions were presented on all occasions. The training was supplemented with illustrated guidelines.
Figure 2.02. Photograph illustrating the portion specifications of the each target food, in their pairs, with a one-centimetre grid border for reference.

Portions were specified in terms of volume, as in previous similar research with pre-school children (see Horne et al., 2011; Sharp, 2013). Each target food was first washed, cut, and stored in airtight plastic containers in a fridge ready for consumption at snack-time. The target foods were presented to the children at the outset of the routine snack-time, prior to the consumption of any other foods. During the measurement periods, the target foods were presented on a white plastic plate (diameter = 15cm) labelled with the child’s participant number. At the end of the target food presentation, the food residue on every plate was photographed using an Apple iPad (see Measures). During the Intensive phase (T1), the target foods were presented on paper towels to reduce the burden on the nursery staff (intervention condition only).

Peer-modelling DVD. During the intervention phases, the intervention children were shown an 8-minute peer-modelling DVD produced by a media company in collaboration with the Food Dudes research team prior to the Sharp (2013) study. The DVD consisted of four young animated characters,
the “Food Dudes”, who interacted with live action children in a nursery setting. The four characters were younger versions of the Primary School Food Dudes characters, Rocco, Tom, Charlie and Razz, slightly older than the pre-school children targeted with the intervention. Throughout the DVD, the Dudes consume fruit and vegetables with obvious enjoyment, and explaining that the children will now be full of “special energy”, highlighting the benefits of consuming those foods. Age-appropriate language is used throughout. Other live child characters are shown in their nursery setting consuming fruit and vegetables, and enthusiastically receiving small Food Dudes customised rewards for doing so as well as having loads of special energy for going out to play and having lots of fun. At the end of the DVD, the Dudes sing a Food Dudes song with clear healthy eating messages instructing themselves to consume lots of fruit and vegetables. The children watch the peer-modelling DVD in their nursery environment using audio-visual equipment available in the nursery classroom (e.g., on an interactive white board).

Rewards. During the intervention phases only, the intervention children were able to earn rewards for their consumption of fruit, vegetables, and both foods. In the Intensive phase, the children could receive (a) green and red Food Dudes ‘School-to-home’ customised stickers, (b) yellow branded “energy” tokens, which they placed in their personalised ‘Rainbow Energy tube’, (c) Food Dudes character magnets; and a (d) ‘Dude of the Day’ medal (see Figure 2.03). On Day 20 of the Intensive phase, the children were read a letter (Appendix 2.11) from the Food Dudes to deliver a non-biasing reason for suspension of the reward deliveries during the post-Intensive phase measure (T2).

Figure 2.03. Pictures of the reward items the intervention children were able to earn during the Intensive phase (T1) of the intervention. The rewards were (a) green and red Food Dudes ‘school-to-home’ stickers, (b) yellow branded “energy” tokens and a Rainbow Energy tube, (c) Food Dudes character magnets, and (d) a ‘Dude of the Day’ medal.
During the Picnic phase (T3), the intervention children could continue to earn red and green school-to-home stickers, and the Dude of the Day medal as in the Intensive phase (T1). In addition, the following rewards (Figure 2.04) were introduced: (a) a personalised Food Dudes ‘Passport to Healthy Eating’ in which the children could stick Food Dudes character stickers they had earned, (b) tri-coloured pom-poms to place in a ‘Class Rainbow Energy Tube’, and (c) home cueing rewards: Food Dudes customised placemat, cutlery set, beaker, and toothbrush. Full description of the materials, rewards and how the children could earn them are described in the Procedures section below.

Figure 2.04. Rewards the intervention children could earn during the Picnic phase (T3). The rewards were (a) Food Dudes ‘Passport to Healthy Eating’ and character stickers, (b) tri-coloured pom-poms to place in a ‘Class Rainbow Energy tube’, (c) placemat, (d) cutlery set, (e) beaker, and (f) toothbrush.

Parent Home DudeKit. To support transfer of the school intervention effects into the home environment, materials were sent home with the children for the parents to target the fruit and vegetables they wished their child to consume (T3 – T4). All of the intervention children received (a) an
A5 ‘Parent Home DudeKit’ booklet, which included instructions and tips; (b) an A5 ‘Taste-Bud Training Chart’ for children to record their progress for 20 days; and (c) each child’s personalised Rainbow Energy Tube’ plus 20 yellow energy tokens (see Figure 2.05).

Figure 2.05. Screenshots of the Parent Home DudeKit materials: (a) A5 instruction booklet, and (b) ‘Taste-Bud Training Chart’.

**Nursery staff instructional DVD.** To support the nursery staff, an instructional DVD was produced to provide a visual reference for the simplified protocol. The DVD was shown during initial training, and nursery staff were provided password-protected online access to view the DVD to further concrete their understanding of the protocol if required.

**Production of the instructional DVD.** The researcher drafted the voice-over script and shot list required for the instructional DVD, which was edited and approved by the PhD supervisor. Bangor University Daycare and Child Research Centre was contacted, and permission obtained from the nursery manager for the filming to be undertaken at the nursery. Informed parental consent (Appendix 2.03) was obtained for the children’s participation. All children aged 2 – 4 years who were scheduled to attend the nursery on the filming days received a letter. The researcher visited the nursery ahead of filming to train the children on the intervention protocol, and recruited and trained a member of
nursery staff who agreed (Appendix 2.04) to play the role of the teacher in the DVD. A media production company called ‘Light House Media’ was recruited to conduct the filming over 2 days and post-production of the instructional DVD. On the filming days, the nursery staff member and children were filmed confidently completing the intervention procedures. A member of the media production company, whose voice was recorded as the voice-over, and the second PhD supervisor led post-production, with input from the researcher, and sign-off approval was then obtained from the first PhD supervisor.

Measures

**Anthropometric measures.** To calculate BMI, all children’s height and weight were measured at baseline (T0) and at 3-months follow-up (T4) by the same trained researcher. All measurements were taken following training based on the National Child Measurement Programme guidelines (Public Health England, 2013). The children’s height was measured using a stadiometer (Leicester Height Measure Mk II) to the nearest 0.1cm, and their weight was measured to the nearest 0.1kg using professionally calibrated Seca 864 digital scales. During both measurements, the children removed their jumpers and shoes. BMI scores were derived using an online calculator resource http://apps.nccd.cdc.gov/dnpabmi/Calculator.aspx?CalculatorType=Metric produced by the Centre for Disease Control and Prevention, which used the following formula: weight (kg)/height²(m). This BMI calculator has been used to reduce the risk of human error in calculation (Himes, 2009).

**Consumption of target foods.** Each child received 2 pieces of a target fruit and 2 pieces of a target vegetable. Two trained researchers through visual estimations of plate residue independently coded consumption using a 5-point scale: 0%, ≤ 25%, ≤ 50%, ≤ 75%, ≤ 100%. The on-site researcher coded consumption from each child’s physical plate residue, and took digital photographs. A second researcher then coded the digital photographs. In cases where discrepancies in coding occurred, the first researcher consulted the photographs and notes, and made an informed decision; where the discrepancy was not clear, the researchers consulted to agree a score. The children’s consumption was assessed at baseline (T0), probe measure (T1), post-Intensive phase (T2), and at the 3-months follow-up (T4).

**Home consumption questionnaire.** Parents of the children in the intervention and control conditions were asked to report via questionnaires on their own daily consumption of three target food categories, and those of their child who had participated in the intervention. The food categories were fruit, vegetables, and high fat sugar snack foods (HFSS). A 7-point Likert scale was provided for their responses (0 – 3 portions; 0.50 portion intervals). Parents were asked to complete a questionnaire at baseline (T0), post-Intensive phase (T2), and 3-months follow-up (T4) measurement phases. The
The purpose of the questionnaire was to gather supplementary information on what the children and one of their parents consumed at home before, during, and after receiving the intervention to determine whether the effects had generalised to the home setting. A free style section was included on all questionnaires for parents to add any further style should they wish to do so.

Both conditions received the same questionnaire at baseline (Appendix 2.05), and the control condition received the same questionnaire for the later two measurement periods as well. However, for the intervention condition, the questionnaires administered in the post-Intensive phase (Appendix 2.06) and the 3-months follow-up (Appendix 2.07) also included feedback questions about the intervention components.

**Nursery staff feedback questionnaire (intervention condition only).** To gather feedback on the intervention from the perspective of the nursery staff, they were asked to complete a questionnaire (Appendix 2.08) during the 3-months follow-up measure (T4). The questionnaire contained a mixture of open and closed questions relating to the overall intervention, individual intervention components, and about any changes to their own consumption levels as a result of their participation in the intervention.

**Procedure**

Food Dudes Health Ltd (a social enterprise) were commissioned by Walsall NHS to deliver the Early Years Food Dudes healthy eating programme to nursery classes in Walsall primary schools. Each school commissioned was carefully considered in relation to the inclusion criteria, and suitable schools were contacted. A face-to-face meeting was held with the Head Teacher to gain written consent for their nursery’s participation in the evaluation. It was arranged that schools assigned to the control condition would receive the intervention the following academic year, but would not be evaluated. A meeting was held with all nursery staff in their respective schools ahead of the study commencing to provide a brief overview of key dates, and to also provide them with information about the baseline procedures.

**Intervention condition.**

**School baseline (T0): Food consumption and anthropometric measures (4 days).** Each target fruit and vegetable pair was presented on one of the four days following a pre-determined schedule. The children were seated on the floor in their usual snack-time environment. On each of the 4 days, before the food was distributed, the nursery staff were reminded not to encourage or pressurise the children to consume the foods, or to consume the foods themselves in front of the children. A plate pre-labelled with the child’s participant number was placed in front of each child. Two pieces of target vegetable were placed on each plate first, and the children were given 2 minutes before 2 pieces of...
target fruit were placed on the plate. The children were allowed a total of 10-minutes to consume the foods if they wished to. Once the time had elapsed, the researcher collected the plates, recorded consumption (see Measures), and photographed the plates for blind-coding. To ensure that each plate was a reliable representation of the child’s consumption, the children were observed throughout the food presentations by the researcher and nursery staff to prevent food being transferred between plates, and/or placed on the floor. The floor area was checked for any disposed of foods prior to coding.

At an agreed time with the nursery teacher, the researcher collected the children’s height and weight measures in a spacious and quiet area of the classroom with access to a wall, and where the digital display of the scales could be directed away from any viewers. The children were called individually or in groups of up to five children, asked to sit on the floor, and take their shoes and jumpers off. The researcher asked each child whether they had anything in their pockets and if so the child was asked to remove any items. To conduct the height measure, the children were asked to place their feet on the stadiometer base, and to maintain contact between their heels and the back of the base. The researcher instructed the child to place their arms by their sides, to stand up tall, and to focus on an identified location. When the child was comfortable, and in position, the height measure arm was adjusted to sit on top of the child’s head, and the measurement recorded to the nearest 0.1cm. To measure the children’s weight, each child was asked to step onto the scales, rest their hands by their sides, and look away from the display; the measurement was then recorded to the nearest 0.1kg. On completion of the measures, the children were supported in putting their shoes and jumpers back on, verbally praised for their participation, and directed back to their nursery activity.

No intervention was delivered during the measurement phases. However, training was administered to the nursery staff on how to deliver the intervention during the Intensive phase and the Picnic phase. Training was provided to the nursery staff by the researcher. The nursery staff watched the new instructional DVD, which was embedded into a PowerPoint presentation. In addition, nursery staff received written instructions for each phase (Intensive phase, Appendix 2.09; Picnics phase, Appendix 2.10), and a list of the target foods that they would receive on each date. Nursery staff are very important role models for the children, therefore during the training it was highlighted that their verbal and physical reactions towards the target food would influence the children’s willingness to taste and consume the foods.

**Home baseline (T0): Food consumption.** A pre-intervention questionnaire (Appendix 2.05) was sent home on Day 1 of the baseline measurement period. Parents were asked to return the questionnaire within a week. They were asked to report how many portions of fruit, vegetables, and high fat and sugar snack (HFSS) were consumed daily (a) by themselves and (b) by their child.
School Intensive phase (T1): Intervention and food consumption and probe measure (20 days).

The Intensive phase was delivered in the school nursery classroom over 20 consecutive days by the nursery staff, with supportive visits from the researcher. For each of the 20 days, before the nursery’s routine snack-time, the children were seated as a class in front of a digital screen (nursery facilities) to watch the Food Dudes peer-modelling DVD. During the song chapter of the DVD (1 minute), the children were encouraged to stand up, sing-along, and dance to the song. In the closing scene, a variety of fruit and vegetables fly through the sky, and at this point a member of staff showed the children a laminated A4 colour sheet of the vegetable then fruit that they were going to be presented with that day. Each sheet contained a photograph of the target food whole, and as it would appear when cut up. First, the nursery staff named the target food and its respective category (i.e., a “fruit” or a “vegetable”). For example, if the scheduled target fruit was plum, the staff would illustrate on the sheet accordingly and say, “This is a plum. This is what it looks like whole and this is what it looks like cut up. Plum is a type of fruit”. As the foods became more familiar to the children, they were encouraged to name the food, its corresponding food category and various other characteristics as identified by the nursery staff (e.g. colour, texture, juicy).

The children were then dispersed into their family groups (5 – 13 children per group) whereupon the foods were presented as described at baseline, including the order of target food presentation. The only two exceptions to baseline were that the target foods were presented on paper towels, not plastic plates, and that nursery staff were now encouraged to motivate the children to consume the foods and encouraged to model their liking for the foods.

On the first 4 days the children were given praise and a green “school to home” sticker for tasting the vegetable and praise plus red “school to home” sticker for tasting the fruit. If they tasted both the fruit and the vegetable they received a yellow token to put in their rainbow energy tube. On Days 5 - 20, the children were given a green sticker if they ate all the vegetable and a red sticker if they ate all the fruit and if they ate both foods they were given a token to put in their personalised rainbow tube. Whenever the child accumulated 4 tokens, a different Food Dudes character fridge magnet was given as a bonus prize. Over the 20 days of the Intensive phase, the child could earn a total of five fridge magnets, one of each character, and a group of characters magnet. The magnets also served as home healthy eating cues. To conclude each session, one child was selected as “Dude of the Day” and given a child-safe medal (to take home and keep) in front of the class and applauded by the children and teachers. The medal was awarded at the discretion of the staff to the child who they judged had made the greatest effort to consume the foods. However, every child received a medal by the end of the intervention.
To monitor the nursery’s progress, nursery staff were given log-in details for an online data collection system where they were asked to input daily how many children were present in the session, how many had tasted/eaten (day dependent) the target fruit, the target vegetable, and both foods.

At the start of the session on Day 20, the researcher read a letter (Appendix 2.11) from the Food Dudes to the children explaining that the Dudes were going to be away for a few days to help other children to start their Food Dudes adventure. This was to prepare the children for a change in the reward process during the next 4 days when the post-Intensive phase measure was taken. The children were then shown a Food Dudes customised plastic orange container and letter (Appendix 2.12) to take home. The researcher explained to the children that they would need to bring the container back into nursery with a portion of fruit and a portion of vegetables inside it when asked by the nursery staff to do so. They were then given a letter to take home for the primary caregiver explaining the purpose of the container. Rewards were not discussed in relation to the container or the provision of the fruit and vegetables from home.

Probe measure (T1): Food consumption measure (Days 13 – 16). A probe measure of the children’s consumption was conducted on Days 13 – 16 of the Intensive phase. During these 4 days, the pre-labelled white plastic plates were used for target food presentation instead of paper towels. The researcher assisted with the distribution and collection of the plates, and then coded consumption from the plate residue; the plates were photographed and blind-coded by a second researcher, as for the baseline procedures.

Parent Session. A letter was issued to parents (Appendix 2.13) at the end of the Intensive phase inviting them to collectively meet with the researcher on Day 19 or Day 20 of the Intensive phase. As agreed with the school, two meetings were scheduled in both intervention nurseries, morning and afternoon, to accommodate the parents of both sessions. The meeting was to inform and engage parents with the intervention being undertaken in their child’s nursery, and tell them about the Parents’ Home DudeKit they would receive at a later date (see below).

Scheduled visits. The intervention nurseries were visited (both morning and afternoon sessions) on Days 1, 2, 5, and 20 to ensure that correct procedures were being employed and provide additional support and guidance if required. The researcher led the intervention delivery on Day 1 in order to model the procedures live to the nursery staff; thereafter the researcher assisted the nursery staff only on the subsequent pre-planned visits.

Post-Intensive phase measure (T2): Food consumption (4 days). Consumption of the target foods was measured as in baseline, replicating the day-to-day order of the target food presentation; the delivery of the DVD, the rewards and verbal encouragement were suspended. Height and weight measurements were not collected.
A post-evaluation questionnaire (Appendix 2.06) was sent home on Day 1 of the post-Intensive phase measurement; parents were asked to return this within one week. The questionnaire consisted of three components: (a) parents were asked to report consumption as in the first questionnaire; this was to determine whether any changes in consumption in the home had occurred since the children completed the 20-day Intensive phase; (b) parents were asked questions specific to the intervention, and asked to answer on behalf of themselves and their participating child; and (c) related to the Parents’ Home DudeKit, parents were asked to specify the foods they would like to target using the home intervention tool they were going to be provided with.

Following completion of the post-Intensive phase measure, the intervention nurseries received a poster charting their behaviour change from baseline to the post-Intensive phase measure. This feedback on the children’s progress was designed to motivate the nursery staff to continue with the programme.

**Parent Home DudeKit (T3 – T4): Questionnaire measures (Continuous).** The Parents’ Home DudeKit (see Figure 2.05), which incorporated materials and procedures similar to those used to achieve behaviour change during the Intensive phase of the school intervention, was distributed to parents at the end of the post-Intensive phase. Parents were asked to use the Dudekit to target foods they wished their children to learn to eat, but were not yet incorporated into their diets at home, and to display the Taste-Bud Training Chart to serve as a healthy eating visual cue for the children. Targeting pre-determined fruit and vegetables, parents were asked to present 2 pieces of the foods to the children for consumption (vegetable first followed by the fruit); if the children consumed the home target food in each food category they were to receive a tick in the respective boxes on the chart. As in the school intervention, if the children consumed both foods, they were to earn a yellow energy token to place in their rainbow energy tube. For every 4 tokens the children received, parents were asked to give their child a reward of their choosing; a food reward was not permitted. Similar to the school intervention, a shaping procedure was included. For the first 4 days, parents were to reward after their child tasted each food; between Days 5 – 8, the children had to consume one piece; and from Day 9 onwards they had to consume both pieces. The additional shaping step was included recognising that the children were not supported by their peers in the home setting. Teaching children to try the foods might be harder for parents in the home environment than it is in the school environment. Once the children completed their chart parents were invited to print another chart from an online site, and continue to target new foods.

**School Picnic phase (T3): Maintenance only, no measures (12 weeks).** During the Picnic phase, the intervention was delivered on one day per week, when the children participated in “Food Dudes Rainbow Picnics” on a day pre-selected by the nursery staff. A poster (Appendix 2.14) was displayed
prominently in the window of each nursery highlighting their specific Picnic day so as to cue parents to send in a portion of fruit and a portion of vegetable with their child, as explained in the Day 20 letter. Nursery staff were informally re-briefed on the Picnic phase procedures and written instructions for the phase were provided (Appendix 2.10). Each week, the nursery staff recorded what kinds of fruit and/or vegetables the children had brought into nursery in their containers.

During the picnics, the children were reminded of the letter read to them on Day 20 of the Intensive phase, stating that the Dudes would be “back to visit them from time to time” and that the designated day had arrived. There were similarities in the procedures employed between the Intensive and Picnic phases. The children continued to be seated together to watch the Food Dudes peer-modelling DVD, however, the nursery staff were given the option of only playing a chapter of the DVD, (i.e., the song chapter). The children moved to be seated in their snack-time environment, and the nursery staff distributed the containers to the children. Children who had not brought in their box were given an item from the School Fruit and Vegetable Scheme. Rewards were administered based on consumption; if the container only had fruit, the child could only earn a fruit sticker, and not the reward contingent on eating both a fruit and vegetable. In situations when this arose, nursery staff explained to the children why they could not earn the respective contingent rewards to motivate the child to ask their parent to send in both food categories in future.

The Intensive phase rewards that continued into the Picnic phase were (a) the red and green school to home stickers for consumption of fruit and vegetables, respectively, and (b) the Dude of the Day medal for one child per session. Additional rewards for eating a fruit and a vegetable were introduced. These were (a) a personalised Food Dudes ‘Passport to Healthy Eating’ in which the children could affix character stickers earned for consuming both their fruit and vegetable, and (b) a group reward contingency where children earned tri-coloured pom-poms for consuming both a fruit and vegetable; the children placed the pom-poms in a ‘Class Rainbow Energy Tube’. The morning and afternoon classes had separate class rainbow energy tubes. Each class was told that they must work together to fill the container with the pom-poms, and when completed every child would receive a special Food Dudes prize to take home. A pre-determined schedule for distribution of the home cueing healthy eating rewards was given to the nursery staff. The Dudes-customised rewards were presented in the following order: placemat; cutlery set; beaker; and toothbrush.

Scheduled visits. During the Picnic phase, the intervention nurseries were visited (both morning and afternoon sessions) on Weeks 1, 3, and 8; phone calls were conducted on Weeks 5 and 12. The purpose of maintaining the contact was to increase programme fidelity and to monitor how many parents were sending fruit and vegetables into nursery for the picnics.
School 3-months follow-up measure (T4): Food consumption and anthropometric measures (4 days). Three months after each nursery completed the Intensive phase, baseline measure procedures were repeated for target food consumption, height, weight, and the parent questionnaire (Appendix 2.07) presented at post-Intensive phase, was presented once again. A nursery staff feedback questionnaire (Appendix 2.08) was distributed to all nursery staff involved in the delivery of the intervention to gather their opinions and insights about the programme.

Once the measure was completed, a second feedback poster was provided to each school to illustrate the change achieved in the children’s target food consumption.

Control condition. The control condition only participated in three measurement periods (baseline [T0]; post-Intensive phase [T2]; 3-months follow-up [T4]), all under baseline conditions (as described above). The questionnaire issued to the intervention condition during baseline (Appendix 2.05) was issued to the control condition at each of the three measurement periods. The nursery staff were instructed to continue with their standard nursery curriculum during their snack-times throughout the study. The control nurseries received the intervention in the academic year following this trial; their performance was not evaluated.

Statistical Analysis

All analyses were conducted using SPSS 22, the alpha level was set to p < .05, and the correlational coefficient effect size Cohen’s r is reported throughout using the following cut points: small effect as .10, medium effect as .30, and large effect as .50 (Cohen, 1992).

Anthropometrics (T0; T4). Children were included in the BMI analysis providing they were present on both measurement days during baseline (T0) and the 3-month follow-up (T4) and were also included in the consumption data analysis. Data were assessed for outliers and met the criteria for parametric analysis. A significant difference in BMI score was found between the two conditions at baseline (p = .01, r = .20) therefore, change scores were calculated. Van Breukelen (2006) highlighted that the analysis method of change scores are as unbiased as ANCOVA to accommodate for unmatched baseline, providing that condition assignment was conducted randomly, therefore the change scores analysis method were deemed appropriate. An independent t-test was performed to explore any change in the intervention and control condition BMI score from baseline to 3-month follow-up.

Food consumption (T0; T1; T2; T4). For each of the four measurement periods, a ‘mean consumption score’ variable was calculated for both food categories (fruit; vegetables) for each child. Each variable was the number of food category pieces consumed (0 – 8 pieces) divided by the number of days they were present per measurement period; the minimum number of days for inclusion was 2
out of a possible 4. Children’s data were excluded if they were present on less than 2 days in any of the three comparable measurement periods (T0; T2; T4). An additional two children were excluded; one child was smaller than a typically developing child in the 3 - 4 years age band (RCPCH, 2013), and a second child was under assessment for Attention Deficit Hyperactivity Disorder and was unable to sit with their plate for the snack-time period. Also, one nursery staff member in one control school revealed that throughout the Intensive phase and the post-Intensive phase measure she had given her group of children (n = 21) stickers during their snack-time. As this contravened the set protocol, those children were removed from the analysis. The other control condition nursery staff members were asked if they too had delivered rewards contingent on the children’s consumption, but they denied doing so.

Preliminary analysis found the baseline data to be severely positively skewed, with platykurtic kurtosis. As transformed data (log, square-root, and reciprocal) still failed to meet the assumptions of parametric analysis, non-parametric analysis was deemed appropriate. A marginally significant difference in consumption for vegetables was found between the intervention and control condition at baseline (p = .048, r = .15); no such difference was found for fruit (p = .09, r = .13). As assignment to condition was random, ‘changes scores’ were considered an appropriate analysis (Van Breukelen, 2006). Three changes scores were calculated to compare the improvement within each condition using Wilcoxon signed-rank test, and between the measurement periods using Mann Whitney U. The change scores calculated were (a) post-Intensive phase (T2) minus baseline (T0), (b) 3-months follow-up (T4) minus baseline (T0), and (c) 3-months follow-up (T4) minus post-Intensive phase (T2). The probe consumption measure (T1) on Days 13 – 16 were only considered descriptively, because the measure was not conducted under baseline conditions (T0).

In order to further investigate the change in consumption, the difference in consumption between the target food categories was explored; the Wilcoxon signed rank test was employed to investigate the difference in consumption of fruit and vegetables at the three measurement periods. Previous research has found greater increases in children who consumed the least at baseline (Fildes et al., 2014; Lowe et al., 2004). Fildes and colleagues created three sub-sets at baseline using six pieces presented, children who consumed half the target quantity were considered as ‘eaters’. Based on this research, as a sub-analysis was performed where the children in the current study were split into two categories at baseline as only two pieces were presented. The subsets were: (a) children who consumed less than 1 piece of the respective food categories (poorest eaters), and (b) children that consumed 1 piece or more (highest eaters). As there were no significant differences at baseline (T0) between the conditions relative to each subset, Wilcoxon analysis was employed on the ‘mean total
consumption scores’. Thirdly, visual inspection of the eight individual target foods to see how their consumption changed over time was conducted.

**Home consumption (parent) questionnaires (T0; T2; T4).** The analysis considered descriptive changes to the children’s and the parent’s consumption of fruit, vegetables, and HFSS foods between: (a) baseline (T0) and post-Intensive phase (T2) to investigate if the effects of the intervention transferred to home; (b) between post-Intensive phase (T2) and 3-months follow-up (T4) to explore the impact of the school intervention and the home intervention; and (c) from baseline (T0) to 3-months follow-up (T4) to explore the overall impact of the intervention on home consumption. As the data is categorical, non-parametric tests were employed. Wilcoxon signed-rank test explored within-condition differences between the measurement periods, and Mann Whitney U was applied to compare between the intervention and control condition at each measurement phase. Children are included in each analysis if their parents returned completed questionnaires at each of the measurement periods. Free-comments made by control condition parents are presented in Appendix 2.15.

**Nursery staff questionnaire (T4).** The nursery staff responses will be considered in descriptive analysis, with further detail presented in Appendix 2.17.

**Results**

**Anthropometrics**

Table 2.01 shows the height, weight and BMI scores of 159 children whose data were collected at baseline (T0) and at 3-month follow-up (T4). Inspection of the descriptive statistics shows that the intervention children increased ($M = 0.08, \ SD = 0.88$) and the control condition decreased ($M = -0.18, \ SD = 0.65$). An independent $t$-test of the intervention and control conditions revealed a marginal significant difference in the change between baseline and 3-month follow-up ($t(157) = 2.00, \ p = .047, \ r = .16$).
Table 2.01.
Mean scores of the anthropometric measures taken by condition, with SDs in parentheses.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Condition</th>
<th>Baseline</th>
<th>3-Month Follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention</td>
<td>94</td>
<td>100.33 (4.61)</td>
</tr>
<tr>
<td></td>
<td>Control</td>
<td>65</td>
<td>101.35 (5.57)</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>94</td>
<td>16.72 (2.46)</td>
<td>17.73 (2.69)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>65</td>
<td>16.55 (1.63)</td>
<td>16.63 (1.66)</td>
</tr>
<tr>
<td>BMI score (kg/m(^2))</td>
<td>94</td>
<td>16.55 (1.63)</td>
<td>16.63 (1.66)</td>
</tr>
<tr>
<td></td>
<td>65</td>
<td>15.71 (1.45)</td>
<td>15.70 (1.46)</td>
</tr>
</tbody>
</table>

Target Food Consumption (baseline [T0], probe [T1], post-Intensive [T2], and 3-months follow-up [T4]).

The final sample included 179 children (M age = 3.80 years, SD = 0.37, range: 3.08 – 4.92 years; 77.49% retention). No significant difference between the genders was found at any measurement period for either food category (all p > .10). The level of agreement between the two coders coding the amount of target food consumed was categorised as excellent (k = .85 (95% CI, .84 to .86), p < .001).

**Target fruit consumption.** Baseline levels of fruit consumption were high, with the intervention children (Mdn = 1.50, IQR = 1.13) consuming less than the control children (Mdn = 1.75, IQR = 0.00). The probe measures conducted in the intervention condition revealed that the intervention condition was approaching ceiling levels as they were consuming a median of 2 pieces (IQR = 0.27), which maintained at post-Intensive phase (Mdn = 2.00, IQR = 0.27).

The children’s change scores of median consumption of target fruit (in pieces) over the three measurement phases is presented in Figure 2.06. Relative to the intervention condition, their consumption increased from baseline (T0) to post-Intensive phase measure (T2) by a median of 0.38 (IQR = 0.76), from baseline to 3-month follow-up (T4) by 0.25 (IQR = 0.63) pieces, and from post-Intensive phase to 3-month follow-up consumption remained stable (Mdn = 0.00, IQR = 0.00). Relative to the control condition, they did not increase their median piece consumed (Mdn = 0.00, IQR = 0.31), from baseline to post-Intensive phase (Mdn = 0.00; IQR = 0.38), or from baseline to 3-month follow-up, and stabilised from post-Intensive phase to 3-month follow-up (Mdn = 0.00, IQR = 0.23).
Figure 2.06. Median change scores of the quantity of fruit pieces consumed by the intervention children (grey bars) and the control children (unfilled bars) between baseline and post-Intensive phase (T0 – T2), 3-month follow-up and baseline (T4 – T0), and 3-month follow-up and post-Intensive phase (T4 – T2). Errors bars represent inter-quartile range.

Mann Whitney comparison of change scores between each condition found that change from baseline (T0) to post-Intensive phase (T2) in the intervention condition was significantly greater than the change over the same time period in the control condition ($U = 2490.00$, $z = -4.25$, $p < .001$, $r = -.32$). This was also the case for change from baseline up to 3-month follow-up; the intervention condition improved their fruit consumption significantly more than the control condition ($U = 2760.00$, $z = -3.43$, $p = .001$, $r = -.26$).

**Vegetable consumption.** Vegetables consumption at baseline for the intervention and control condition was a median of 0.50 pieces (IQR = 1.13) and 0.85 pieces (IQR = 1.22), respectively. The intervention condition approached ceiling levels ($Mdn = 2.00$, IQR = 1.19) during the probe measure over Days 13 – 16.

Figure 2.07 shows the change in consumption in target vegetables (in pieces) over the three measurement phases. The intervention condition increased their median consumption of vegetables by 0.63 (IQR = 1.00) pieces between baseline to post-Intensive phase, which maintained, as the children consumed 0.63 (IQR = 0.87) pieces more between baseline and 3-month follow-up. Such results were not evident in the control condition. No change in consumption of pieces was found.
between baseline and post-Intensive phase (Mdn = 0.00, IQR = 0.62), which was consistent throughout as no change was found from baseline to 3-month follow-up (Mdn = 0.00, IQR = 0.60).

Figure 2.07. Median change scores of the number of vegetables pieces consumed by the intervention children (grey bars) and the control children (unfilled bars) between baseline and post-Intensive phase (T0 – T2), 3-months follow-up and baseline (T4 – T0), and 3-months follow-up and post-Intensive phase (T4 – T2). Errors bars represent inter-quartile range.

Mann Whitney U analysis of the vegetable change scores between baseline and post-Intensive phase revealed that the intervention condition increased significantly more than the control condition (U = 2053.00, z = -5.45, p = .001, r = .41). The significant difference maintained between baseline and 3-month follow-up (U = 2299.50, z = -4.73, p = .001, r = -.35).

**Difference in Food Categories.** Visual inspection of Figure 2.08 shows that more fruit was consumed than vegetables at every measurement point. This was consistent in both the intervention and the control condition.
Figure 2.08. Median pieces of fruit (grey bars) and vegetables (unfilled bars) consumed per child in the intervention (left panel) and control condition (right panel) under zero reinforcement conditions at baseline (T0), post-Intensive phase (T2), and 3-month follow-up (T4). Error bars represent inter-quartile range.

Wilcoxon signed-rank tests confirmed this, as a significant difference between the food categories was found in both conditions, at every measurement period (Table 2.02). At the outset the largest difference in the consumption of the food categories occurs in the intervention condition, however, over time the gap does decrease but a large effect size difference between the food categories remains. Minimal change is found in the control condition over time; the large difference remained throughout.
Table 2.02.

*Wilcoxon signed rank test comparing the consumption of fruit against vegetables in both conditions at each time point.*

<table>
<thead>
<tr>
<th>Condition</th>
<th>Measurement phase</th>
<th>Fruit vs. vegetables $T$</th>
<th>$p$</th>
<th>$r$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Baseline</td>
<td>280.00</td>
<td>&lt; .001</td>
<td>-.51</td>
</tr>
<tr>
<td></td>
<td>Post-Intensive phase</td>
<td>1545.00</td>
<td>&lt; .001</td>
<td>-.40</td>
</tr>
<tr>
<td></td>
<td>3-Month follow-up</td>
<td>135.50</td>
<td>&lt; .001</td>
<td>-.38</td>
</tr>
<tr>
<td>Control</td>
<td>Baseline</td>
<td>120.50</td>
<td>&lt; .001</td>
<td>-.46</td>
</tr>
<tr>
<td></td>
<td>Post-Intensive phase</td>
<td>1418.00</td>
<td>&lt; .001</td>
<td>-.44</td>
</tr>
<tr>
<td></td>
<td>3-Month follow-up</td>
<td>39.00</td>
<td>&lt; .001</td>
<td>-.46</td>
</tr>
</tbody>
</table>

Poorest Eaters. Figure 2.09 shows that the children who consumed less than 1 piece (22.91% and 60.89% for fruit and vegetables, respectively) at baseline (T0) made larger increases at post-Intensive phase (T2), and 3-month follow-up (T4) than those who already consumed 1 piece or more. Greater gains are seen in fruit and vegetable consumption in the intervention condition in comparison to the control condition.
Figure 2.09. Median pieces of fruit (upper panel) and vegetables (lower panel) consumed in the intervention (grey bars) and control condition (unfilled bars) across the three measurement phases: baseline (T0; first bar), post-Intensive phase (T2; second bar) and 3-month follow-up (T4; third bar). Error bars present interquartile range.

Fruit consumption. For the poorest eaters, Friedman’s analysis revealed a significant main effect of fruit consumption over time in the intervention condition ($n = 26, \chi^2(2) = 37.59, p < .001$), however, no significant main effect was found in the control condition ($n = 15, \chi^2(2) = 56.20, p = .07$). This confirming that only the intervention children increased over time. Pairwise comparison of the significant main effect in the intervention condition found a significant increase in target fruit.
consumption between baseline and post-Intensive phase \( (z = -5.13, p < .001, r = .71) \), and between baseline and 3-month follow-up \( (z = -4.65, p < .001, r = .64) \).

For the highest eaters, Friedman’s analysis found a significant main effect of consumption in both the intervention \( (n = 77, \chi^2(2) = 56.20, p < .001) \) and the control condition \( (n = 61, \chi^2(2) = 9.63, p = .008) \). Relative to the intervention condition, significant increases in consumption were found between baseline and post-Intensive phase \( (z = -4.92, p < .001, r = .40) \), and between baseline and 3-month follow-up \( (z = -4.63, p < .001, r = .42) \). Despite the significant main effect found in the control condition, pairwise analysis revealed no significant changes between baseline and post-Intensive phase \( (z = -1.31, p = .57 r = .12) \), or between baseline and 3-month follow-up \( (z = -2.35, p = .056, r = .21) \).

**Vegetable consumption.** For the poorest eaters, a significant main effect of consumption was revealed for both the intervention \( (n = 69, \chi^2(2) = 67.50, p < .001) \) and control conditions \( (n = 40, \chi^2(2) = 10.45, p = .005) \). Pairwise comparison of the intervention condition showed significant increases in consumption between both baseline to post-Intensive phase \( (z = -6.68, p < .001, r = .57) \), and between baseline and 3-month follow-up \( (z = -6.73, p < .001, r = .57) \). However, relative to the control condition, there was no short-term significant increase from baseline to post-Intensive phase \( (z = -1.90, p = .17, r = .21) \); a significant increase was only found from baseline to 3-month follow-up \( (z = -2.96, p = .009, r = .33) \).

Analysis of the highest eaters concluded a significant main effect of consumption for the intervention condition only \( (n = 34, \chi^2(2) = 37.59, p < .001) \); no significant main effect was found in the control condition \( (n = 36, \chi^2(2) = 2.10, p = .35) \). Pairwise comparison of the intervention condition showed significant increases in consumption between baseline and post-Intensive phase \( (z = -4.23, p < .001, r = .51) \), and between baseline and 3-month follow-up \( (z = -4.31, p < .001, r = .52) \).

**Individual foods.** To explore the effect of the intervention on individual foods as opposed to food categories only, Figure 2.10 shows the median pieces consumed of each target fruit and vegetable at baseline, post-Intensive phase, and 3-months follow-up. Visual inspection shows that for fruit, ceiling levels were found for blueberries \( (n = 162) \), strawberries \( (n = 150) \), and pineapple \( (n = 122) \) at baseline in both conditions limiting the scope for change. However, the consumption of plum \( (n = 150) \) reached absolute ceiling levels following the Intensive phase in the intervention condition. Median consumption in the control children also reached ceiling levels, but with a large IQR's. In the case of vegetables, much lower baseline levels are evident, although some children were consuming at ceiling levels in both conditions. Ceiling levels of consumption were found at post-Intensive phase and 3-months follow-up for all four vegetables in the intervention condition but with large IQRs in all cases. The largest increase occurred in baby corn during the intervention condition. The control
condition did not show comparable increases; only baby corn and mangetout reached ceiling levels albeit with large IQRs by 3-month follow-up.

Figure 2.10. Median pieces of the individual fruit (upper panel) and vegetables (lower panel) consumed at baseline (T0), post-Intensive phase (T2), and at 3-month follow-up (T4). Error bars represent the interquartile range.

Home Consumption (baseline [T0], post-Intensive [T2], and 3-month follow-up [T4])

Baseline (T0) to post-Intensive phase (T2) measurement. Two hundred and ten questionnaires were issued between both conditions; 23% of parents (n = 48; intervention = 29; control = 19) returned the questionnaires at both measurement periods. Of those returned, on both occasions, the children’s mothers completed 87.50% of the questionnaires. At baseline, 29% of the families reported having
had previous experience with the Food Dudes programme (e.g. siblings, parents working in schools, cousins), and at post-Intensive phase, 35% of the families reported having had exposure.

Descriptive analysis found that the children in the intervention condition increased their consumption of vegetables by half a portion, and decreased their consumption of HFSS by 0.5 portions; and their parents increased their consumption of fruit by 0.5 portions. The only median change in the control condition was the children’s consumption of HFSS, which increased by half a portion.

**Table 2.03.**

Median scores of the children and their parents’ home consumption of fruit, vegetables, and HFSS at baseline (T0) and post-Intensive phase (T2) measures. Interquartile range shown in parentheses.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Time</th>
<th>Child</th>
<th>Parent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fruit (n = 29)</td>
<td>Veg (n = 29)</td>
</tr>
<tr>
<td>Intervention</td>
<td>Baseline</td>
<td>2.50 (1.00)</td>
<td>1.50 (1.00)</td>
</tr>
<tr>
<td></td>
<td>Post-Intensive phase</td>
<td>2.50 (1.00)</td>
<td>2.00 (1.25)</td>
</tr>
<tr>
<td>Control</td>
<td>Baseline</td>
<td>2.00 (0.50)</td>
<td>1.50 (1.00)</td>
</tr>
<tr>
<td></td>
<td>Post-Intensive phase</td>
<td>2.00 (1.00)</td>
<td>1.50 (1.00)</td>
</tr>
</tbody>
</table>

In the intervention children’s consumption, Wilcoxon tests found a significant change in fruit consumption \( (T = 127.00, p = .013, r = .33) \), and in vegetable consumption \( (T = 182.00, p = .003, r = .39) \); but not in HFSS \( (T = 37.50 p = .106, r = .21) \). For their associated parents consumption, a significant difference was found in fruit consumption \( (T = 148.50, p = .001, r = .46) \) but no significant change for vegetables \( (T = 95.50, p = .359, r = .12) \), or HFSS \( (T = 73.50, p = .590, r = .07) \). For the control children and their parents’ consumption, no significant changes were found in fruit, vegetable or HFSS \( (p > .05) \).

**Baseline (T0) to 3-month follow-up (T4).** Of the questionnaires issued, 13% of the children returned the questionnaires at both baseline and 3-month follow-up \( (n = 32; \text{intervention} = 23, \text{control} = 9) \); the children’s mothers completed the majority \( (\text{baseline} = 90.60\%; \text{3-month follow-up} = 93.09\%) \).
At baseline, 17.40% and 44.40% of the intervention and control children families’, respectively, reported having had previous experience with the Food Dudes Programme. This increased by the 3-month follow-up with 30.40% of the intervention and 77.80% of the control having had family links to the Programme. Visual inspection of the medians in Table 2.04 show that the intervention children increased their consumption of fruit and vegetables at home, but that the control condition decreased their consumption of both. Relative to parents of the control children, decreases were found in their fruit and vegetable consumption.

Table 2.04.

Median scores of the children and their parents’ home consumption of fruit, vegetables, and HFSS at baseline (T0) and 3-month follow-up (T4). Interquartile range shown in parentheses.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Time</th>
<th>Child</th>
<th></th>
<th>Parent</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fruit</td>
<td>Veg</td>
<td>HFSS</td>
<td>Fruit</td>
</tr>
<tr>
<td>Intervention</td>
<td>Baseline</td>
<td>2.00</td>
<td>1.50</td>
<td>1.50</td>
<td>2.00</td>
</tr>
<tr>
<td>(n = 23)</td>
<td>3-month follow-up</td>
<td>(1.00)</td>
<td>(1.00)</td>
<td>(1.00)</td>
<td>(2.00)</td>
</tr>
<tr>
<td>Control</td>
<td>Baseline</td>
<td>2.00</td>
<td>1.50</td>
<td>1.00</td>
<td>1.50</td>
</tr>
<tr>
<td>(n = 9)</td>
<td>3-month follow-up</td>
<td>(0.50)</td>
<td>(1.00)</td>
<td>(0.50)</td>
<td>(1.30)</td>
</tr>
</tbody>
</table>

Wilcoxon found a significant increase in the intervention children’s vegetable consumption ($T = 173.50, p = .001, r = .48$), and their respective parents’ vegetable consumption ($T = 106.50, p = .007, r = .40$). No other significant changes were found (all $p > .05$).

Post-Intensive phase (T2) to 3-month follow-up (T4). Twenty-six questionnaires were returned at both measurement periods (intervention = 14; control = 12). Mothers were reported to have completed 96.20% of the questionnaires at post-Intensive phase, and 88.50% at 3-month follow-up. Previous experience with the Food Dudes programme was found amongst 34.60% of the children at post-Intensive phase, and 46.20% at 3-month follow-up. Descriptive analysis highlights increases in the intervention children’s consumption of vegetables, and a decrease in their HFSS consumption; and a
decrease in the control children’s fruit, vegetables and HFSS consumption, and mirroring decreases in their parents’ consumption (see Table 2.05).

Table 2.05.

Median scores of the children and their parents’ home consumption of fruit, vegetables, and HFSS at post-Intensive phase (T2) and 3-month follow-up (T4). Interquartile range shown in parentheses.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Time</th>
<th>Child</th>
<th>Parent</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Fruit</td>
<td>Veg</td>
<td>HFSS</td>
</tr>
<tr>
<td>Intervention (n = 14)</td>
<td>Post-Intensive</td>
<td>2.50</td>
<td>1.75</td>
</tr>
<tr>
<td></td>
<td>3-month follow-up</td>
<td>(1.00)</td>
<td>(0.63)</td>
</tr>
<tr>
<td>Control (n = 12)</td>
<td>Post-Intensive</td>
<td>2.00</td>
<td>1.50</td>
</tr>
<tr>
<td></td>
<td>3-month follow-up</td>
<td>(1.38)</td>
<td>(0.88)</td>
</tr>
</tbody>
</table>

Wilcoxon found a significant increase in the intervention children’s vegetables consumption ($T = 50.50, p = .013, r = .47$). All other comparisons were non-significant ($p > .05$).

Baseline (T0) to post-Intensive phase (T2) to 3-month follow-up (T4). Parents of 23 children returned all three questionnaires at the three measurement periods (intervention = 13; control = 10). The questionnaires were predominately completed by the children’s mothers, at baseline (87.00%), post-Intensive phase (95.70%), and at 3-month follow-up (91.30%). Parents reported that at baseline 26.10% of the children’s family had had previous experience with the Food Dudes Programme, 39.10% at post-Intensive phase, and 52.20% at 3-month follow-up. Descriptive analysis as shown in Table 2.06 found increases in the intervention children’s consumption of fruit, vegetables and decreases in their HFSS consumption; and a decrease in the control children’s consumption of fruit and vegetables. The only changes found in parental consumption were in the control condition, which showed a decrease in fruit consumption and vegetable consumption.
Table 2.06.
Median scores of the children and their parents’ home consumption of fruit, vegetables, and HFSS at baseline (T0), post-Intensive phase (T2) and 3-month follow-up (T4). Interquartile range shown in parentheses.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Time</th>
<th>Child</th>
<th></th>
<th></th>
<th>Parent</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fruit</td>
<td>Veg</td>
<td>HFSS</td>
<td>Fruit</td>
<td>Veg</td>
<td>HFSS</td>
</tr>
<tr>
<td>Intervention</td>
<td>Baseline</td>
<td>2.00</td>
<td>1.50</td>
<td>1.50</td>
<td>2.00</td>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td>(n = 13)</td>
<td></td>
<td>(1.00)</td>
<td>(1.00)</td>
<td>(1.00)</td>
<td>(2.00)</td>
<td>(1.50)</td>
<td>(1.50)</td>
</tr>
<tr>
<td></td>
<td>Post-Intensive</td>
<td>2.50</td>
<td>2.00</td>
<td>1.00</td>
<td>2.00</td>
<td>2.00*</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>3-months</td>
<td>2.00</td>
<td>1.50</td>
<td>1.00</td>
<td>2.00</td>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Follow-up</td>
<td>(0.75)</td>
<td>(0.75)</td>
<td>(1.25)</td>
<td>(1.00)</td>
<td>(1.00)</td>
<td>(1.25)</td>
</tr>
<tr>
<td>Control</td>
<td>Baseline</td>
<td>2.00</td>
<td>1.50</td>
<td>1.00</td>
<td>1.75</td>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td>(n = 10)</td>
<td></td>
<td>(0.50)</td>
<td>(1.00)</td>
<td>(0.50)</td>
<td>(1.10)</td>
<td>(0.80)</td>
<td>(1.10)</td>
</tr>
<tr>
<td></td>
<td>Post-Intensive</td>
<td>2.00</td>
<td>1.50</td>
<td>1.50</td>
<td>1.25</td>
<td>2.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>3-months</td>
<td>1.50</td>
<td>1.25</td>
<td>1.00*</td>
<td>1.00</td>
<td>1.50</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>Follow-up</td>
<td>(1.13)</td>
<td>(1.50)</td>
<td>(0.50)</td>
<td>(1.25)</td>
<td>(0.63)</td>
<td>(1.00)</td>
</tr>
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</table>

* This measure was not reported by 1 parent (not the same parent).

Friedman’s test found one significant main effect: intervention children’s vegetable consumption, $X^2 (2) = 13.32, p = .001$. Pairwise comparisons of the significant main effect found a significant increase in their consumption from baseline to 3-month follow-up ($T = 1.27$, $p = .004$, $r = .63$), but no other significant interactions between the time-points (both $p > .05$).

**Intervention Specific Questionnaire Feedback (post-Intensive phase [T2] and 3-month follow-up [T4])**

**Post-Intensive phase (T2) questionnaire.** Parents were asked to tick all boxes that applied on a list of intervention components to report that their child enjoyed that particular element; 40 parents responded (38.83% retention) to this section. Parents reported that 67.50% of their children had enjoyed taking part in the intervention; 37.50% enjoyed the DVD; 70.00% enjoyed the school to home stickers; 30.00% enjoyed the energy tubes and tokens; 65.00% enjoyed the Dude of the Day medals; 87.50% enjoyed the fruit; and 67.50% enjoyed the vegetables. Despite medium scores on the majority
of the components, only one of 40 parents (2.50%) said that there were parts of the intervention that their child did not enjoy, but failed to give further information in the space provided.

Parents were asked questions to investigate generalisation of the intervention to the home environment; 38 of the 40 parents responded. Since their child had participated in the intervention, 86.84% of parents said their child had asked for more fruit and vegetables at home; 71.11% reported that the family consumption of fruit and vegetables had increased; 92.10% felt that the intervention had had a positive impact on their child’s eating habits; and 97.37% thought it would be beneficial for children’s health if the intervention was introduced in all nursery classes.

A positive response was obtained through free-comments received from parents in the space available. A representative comment is (further comments please see Appendix 2.16):

“This is a really good programme as it has encouraged my son to eat fruit and veg he wouldn’t eat before. He is always coming home proud that he has collected the stickers. He is now eating a larger range of fruit and veg thanks to the Food Dudes.”

3-Month follow-up (T4) questionnaire. Parents were asked to tick the boxes to indicate yes response if their child enjoyed the listed components; 33 parents responded (32.04% retention). All of the parents reported that their child enjoyed the picnics; 90.91% enjoyed the school-to-home stickers; 39.39% enjoyed the passport to healthy eating; 63.64% enjoyed the character stickers; 48.48% enjoyed the class energy tube and pom-poms; 84.85% enjoyed the placemat; 87.88% enjoyed the cutlery; and 87.88% enjoyed the beaker. No parent reported that there were aspects of the intervention their child did not enjoy. All parents responded that they were happy to send fruit and vegetables in with the children on picnic days.

Additional free-comments were received from parents; all but one, which does not refer to the intervention, reported its success. Here is an example of a comment received (other comments available in Appendix 2.16):

“This has been the most effective programme I have seen. My child has been really motivated by the programme. He will now eat a variety of fruit and veg without any prompts. I would definitely recommend this programme.”

Parent Home DudeKit. Parents received the home intervention resource on completion of the post-Intensive phase (T2) measure. Using open questions, the parents were asked in the post-Intensive phase questionnaire to say which fruit and vegetables they would target using the resource. Limited consistency was also found amongst questions asking (a) what fruit and vegetables did you target, (b) which were you unsuccessful at targeting, and (c) which were you successful at targeting. As a result, no valid conclusion can be drawn on the effect of the home intervention to increase target foods in the home setting.
However, parents were also asked about the different elements of the home intervention. The majority of parents (n = 31; 93.55%) said their child enjoyed continuing the intervention at home, and that their child (n = 30; 93.33%) liked and understood the training chart; a similar outcome was found for the energy tubes and tokens. A small percentage of parents (n = 30; 12.90%) found the instruction booklet difficult to follow, and found the training chart (n = 30; 6.67%), and energy tube and tokens (n = 31; 9.68%) difficult to use; the remainder considered them okay to very easy. Moreover, all but one parent (n = 31) felt that the Parent Home DudeKit contained everything needed to implement the home intervention. Overall, 78.13% and 81.25% of parents (n = 32) reported that their child and their families, respectively, were consuming more fruit and vegetables since their child participated in the nursery intervention.

Nursery staff

Eight members of nursery staff from the two intervention nurseries completed the questionnaire. Overall the nursery staff considered that the intervention was quite successful, with the introduction of children to new fruit and vegetables deemed to be a major strength. The nursery staff felt that they had received adequate training to deliver the programme, with five of seven staff members finding the instructional DVD helpful to them to learn the intervention procedures. They judged that the Intensive phase took between 40 – 50 minutes to administer and 20 minutes for the Picnic phase. Despite the longer time to deliver the daily intervention session in the Intensive phase, the nursery staff thought this was acceptable for the 20 days required to complete the phase, but that the procedure would nevertheless benefit from being shortened. All staff reported positively when asked whether the children enjoyed participating in the intervention; they rated the Food Dudes song, Food Dudes movie, and Dude of the Day medals as the most liked components of the intervention. Seven of eight staff reported a noticeable improvement in the children’s consumption of provided fruit and vegetables at snack-time. See Appendix 2.17 for a more detailed breakdown of the responses from the nursery staff.

Discussion

The main objective of this study was to evaluate the effectiveness of a modified role modelling and rewards intervention to increase and sustain pre-school children’s consumption of fruit and vegetables in a nursery environment, in comparison to control children’s consumption of those foods in nursery classes following their standard nursery curriculum. This study confirmed the successful findings of previous studies that employed the same key psychological principles with a similar target age (Horne et al., 2011 [2 – 4 year olds]; Sharp, 2013), and in primary school aged
children (Horne et al., 2004; 2008; Lowe et al., 2004). Although both the intervention and control conditions increased their consumption of fruit and vegetables over time, the increases made by the intervention condition were significantly greater than those of the control condition both in the short- and long-term.

A probe measure was conducted on Days 13 – 16 of the 20-day Intensive phase to investigate how much the children were consuming prior to the last exposure to the target foods followed by suspension of the reward contingencies. Only a small increase in the variance of scores between the probe measure and the post-Intensive phase measures was found for both fruit and vegetable consumption. At both measurement phases, the median remained at ceiling levels for fruit consumption with no significant difference between the two measurement phases ($p = .97,$ $r = .002$), and only a small non-significant ($p = .20,$ $r = .09$) decrease in the median vegetable consumption was found. In line with previous modifications to the duration of the intervention, the minimal change in the children’s consumption across the probe and post intervention measurement points suggests that the intervention could be further reduced to 16 days. The reduction in days would further reduce the cost of the intervention and any burden of daily delivery on the nursery staff.

**Strengths**

This study was a controlled evaluation of the effects of the interventions in comparison to standard nursery practice. Furthermore, the research has strong ecological validity as all procedures were conducted in settings familiar to the children, namely, the nursery setting (primary measure) and home setting (secondary measure). The primary measures, children’s consumption of target fruit and vegetables, were conducted using visual estimation by a trained researcher who prepared and coded the plate waste on-site. Additionally, photographs of each child’s plate waste were taken by the first observer and subsequently blind-coded by a second researcher. Visual estimation is a direct and objective measure, which has been found to be a reliable and valid measure when compared to the gold-standard method of weighing (Kenney et al., 2015). The main measures (baseline; post-Intensive phase; 3-month follow-up) were all conducted under baseline conditions using the same procedures in both conditions. Despite the suspension of the contingencies from the end of the Intensive phase to 3-month follow up in the intervention condition the children’s consumption increases were maintained. The probe measures show how rapidly the role modelling and reward contingencies raised consumption of both fruit and vegetables to near ceiling levels. It could be argued that the sudden withdrawal of the contingencies at the end of the 20-day Intensive phase is not ideal, however this was necessary to ensure comparable procedures across conditions.
CHAPTER TWO

Limitations

The behaviour change achievable for the fruit category in this study was capped due to near ceiling levels of consumption at baseline. Extra care must be taken in future when choosing the target foods to avoid limiting the scope for behaviour change. As participation of the nurseries in the present study was staggered at baseline it was not possible to know in advance that the consumption of target fruit would be so high. To minimise this risk in the future, fruit that pre-school children tend to consume at low baseline levels should be identified by presenting children of this age with a range of unfamiliar fruit; the least preferred fruit can then be used as target foods in further controlled studies. The fruit used in this study are not suitable target foods for future trials.

Conclusion

Establishing diets rich in fruit and vegetables in early childhood could have large long-term cost-savings to health and the UK economy. This successful evidence-based intervention provides the promise to reach targets set. However, healthy eating is only one side of the obesity equation, and behaviour change interventions should also target physical activity. This study adds to the literature (Horne et al., 2004, 2011; Horne, Hardman, Lowe, Tapper et al., 2009; Lowe et al., 2004; Sharp, 2013) showing that role modelling and rewards interventions can produce large and lasting increases in children’s consumption of fruit and vegetables. Mirroring previous results (Lowe et al.), the intervention had the largest impact on increasing the consumption of children who were the poorest eaters at baseline. As highlighted by Horne et al. (2004), it is paramount that the intervention is successful with this target cohort in particular as they are likely to profit the most from positive dietary modification. This study will be discussed in more detail in the General Discussion Chapter (p. 205).
CHAPTER THREE: Validation of the Fitbit Zip as a Measure of Pre-school Children’s Step Count: A Cross-Sectional Study.

Abstract

Objective: To determine the relationship between physical activity and health in human populations it is essential to validate measurement devices used to record activity in the target age group. This study investigated the validity and reliability of Fitbit Zip step counts by comparing them to observer counts of steps performed by preschoolers during a standardised activity.

Design & Participants: This study employed a cross-sectional study with 56 children aged 3 – 4 years (29 girls, mean age 3.69 years ± 0.58) recruited from 10 nurseries in North Wales. The independent variable was a video-recorded 5-minute walking task in which the children participated whilst wearing a custom-made tabard containing two Fitbit Zip devices enclosed separately in vertically aligned pockets located over the child’s right hip.

Measures: The Fitbit Zip step counts for each child were compared to the corresponding steps coded by observers from the video footage. Intra-class correlations, two-way repeated ANOVA, concordance correlation, Bland-Altman plots, and relative percent error were calculated to assess the reliability and validity of the consumer-grade device.

Results: An excellent intra-class correlation was found between the two Fitbit Zips (ICC = 0.91). Concordance between the Fitbit Zips and observer counts was also high (r = 0.77). Percent relative error was acceptable at 6 – 7%. For Fitbit 1, the Bland-Altman analysis identified a bias of 22.77 steps (SD = 19.10); limits of agreement were -14.67 to 60.21 steps. For Fitbit 2, a bias of 25.16 steps (SD = 23.16) was found; limits of agreement were -20.19 to 70.51 steps.

Conclusion: The Fitbit Zip devices are a reliable and valid method of recording pre-school children’s step count.
Accelerometry is the standard method of capturing physical activity levels in pre-school children (Oliver et al., 2007), and from accelerometry a measure of step count is often derived to evaluate activity levels in everyday settings. To-date, validated devices used to measure pre-school children’s step counts are research-grade accelerometers (e.g. Actigraph; Pate et al., 2006) and pedometers (e.g. Omron; De Craemer et al., 2015). However, such devices have their limitations, for example, Actigraphs are expensive and require expertise to interpret the data (Oliver et al.). Therefore identifying and validating more cost-effective and easy-to-use devices is important to facilitate research on habitual activity in pre-school children. It cannot be assumed that a measure shown to be valid for any other target population is valid for pre-school children (Cliff et al.; Kelly et al., 2004).

Recently, there has been a marked increase in the availability of consumer-grade activity monitors, which are increasingly being trialled as potentially reliable and low-cost measures of physical activity for use in research studies (Ferguson et al., 2015). The ‘Fitbit’ brand has been identified as the most popular range of such activity monitors (Evenson et al., 2015; Ferguson et al.). One function of Fitbit devices is the measurement of total step count, as well as steps performed minute-by-minute over the recording period. When compared to nine similar activity trackers, the Fitbit Zip was found to provide the most valid measure of step count (Kooiman et al., 2015). However, to-date, the Fitbit Zip has only been validated as a measure of physical activity for ‘healthy adults’ (Ferguson et al.; Tully et al., 2014) and ‘older adults’ (Paul et al., 2015).

To our knowledge, no peer-reviewed validations of Fitbit devices have been conducted with pre-school children. Fitbit claim that the Fitbit Zip produces reliable measures of activity when “worn on or very close to the body”, including location in or on external pieces of clothing (Fitbit, 2015a). Other brands of accelerometers and pedometers are typically worn on the right hip, secured on an elastic belt and require adult input to ensure that children continue to wear the device in the correct place and do not modify settings (Pate et al., 2010). A novel and low-maintenance approach to reducing such limitations would be to place each device in a pocket sewn inside an external piece of clothing, making the device comfortable to wear and inaccessible to the child.

The main objectives of this study are to (a) validate steps recorded by two Fitbit Zip devices (worn by each child) against observed steps performed by the child during a 5-minute walking task, and (b) assess inter-device reliability.
Method

Ethical Approval

The School of Psychology Ethics and Research Governance Committee at Bangor University granted ethical consent to investigate the validity and inter-device reliability of the Fitbit Zip accelerometer as a measure of pre-school children’s step count (Ethics application No.: 2013-11864).

Participants

Fourteen nurseries in North Wales were contacted to recruit for participants to the present study; verbal agreement was obtained from the nursery manager or school Head Teacher of 10 nurseries for their children’s participation. Following informed consent by their parents (Appendix 3.01), 66 children aged 3 – 4 years (50% girls, mean age 3.66 years ± 0.58) were invited through opportunity sampling to participate in a single test session. Each child’s date of birth was obtained from the nursery they attended.

Experimental Design

This study employed a cross-sectional design to investigate the validity and inter-device reliability of the Fitbit Zip. The independent variable was a 5-minute walking task performed by each child. The dependent variables were (a) steps recorded by two Fitbit Zip devices (worn by each child), and (b) steps performed by children during the walking task as coded by observers.

Materials

Produced for the series of studies on children’s physical activity presented in this thesis, the children wore a close-fitting “Rainbowtop®”. These were custom-made, rainbow-striped, cotton-tabards designed to closely cover the children’s clothing and to hold securely in place a Fitbit Zip device in each of two inside pockets (see Figure 2.01, Measures). A HD video camera (Sony Handycam CX190) and tripod were used to record the 5-minute walking task. Observers used hand-held tally counters to code steps performed by each child.

Measures

Accelerometry. Fitbit Zip accelerometers were used to measure the number of steps performed per minute by the children, whilst they completed the 5-minute walking task. The Fitbit Zip is a small (2.8cm x 3.6cm x 9.7cm), lightweight (8g), inexpensive (£49.99), and water-resistant commercial activity monitor with a function to measure step count. Specifically, the device contains a microelectromechanical tri-axial accelerometer and uses proprietary algorithms to calculate step...
counts recorded on the device. Each device was assigned an identification number, which was affixed to the silicone casing, and a unique email address. Using the email address, each device was connected to an online Fitbit account through wireless Bluetooth technology. To do so, a generic date of birth, height and weight was entered for each participant; this was the average baseline anthropometric measures collected in Chapter 2. The devices collected and stored participants’ activity data, which were later “synced” with their unique Fitbit accounts wirelessly using the Bluetooth technology.

The majority of accelerometers and pedometers are typically secured to the right hip using an elastic belt and require adult input to ensure continued wear compliance and placement specified by the manufacturer (Pate et al., 2010). Based on the manufacturer’s claim that the Fitbit Zip can be worn in or on an external piece of clothing, each child wore two devices (“Fitbit 1” and “Fitbit 2”) each secured inside the close-fitting “Rainbowtop®”, a custom-made, rainbow-striped, cotton tabard covering their own clothing, to reduce such wear limitations. The tabards were designed using measurements of similar items for pre-school children. Two pockets were placed on the inner face of the tabard, positioned one above the other in the region of the child’s right hip (Fitbit 1 placed in the upper pocket). The face of each Fitbit Zip was hidden inside the pockets and the children were not otherwise exposed to it or aware of the function of the device.

![Figure 3.01. Custom-made “Rainbowtop®” tabard with inside pockets securing the two Fitbits in position. Consent was obtained for the publication of this figure.](image)

**Direct Observation.** Two coders independently, coded the children’s steps using the video footage.
Procedure

Local nurseries were contacted by telephone, and an outline of the study requirements was given to the nursery manager. On confirmation of willingness to participate, a researcher visited the nursery to provide opt-in consent letters (Appendix 3.01) to be distributed to children who matched the age criteria of 3 – 4 years. During this visit, the researcher assessed the environment to identify a suitable location to conduct the study (open space, typically classroom or hallway). A suitable testing time was arranged with each nursery once consent letters were returned.

During the test session, the consented children were invited, one at a time, to take part in a “walking adventure” with the researcher; a member of nursery staff was either present in the test room or observed the test session from a neighbouring room. Each child was invited to wear a tabard with two Fitbit Zips already in situ. The walking task was first demonstrated to the child, who was then invited to perform a practice walk with the researcher before engaging in the 5-minute walking task unaccompanied. The task consisted of the child walking continuously between “Point A” and “Point B” for 5 minutes in an open space identified within each nursery. The researcher sat at “Point A” controlling the video camera and tripod; a marker was placed in front of the camera to reduce the likelihood of a child walking out of the camera frame. An iPad was located at “Point B” showing the popular British children’s series “Thomas the Tank Engine”. This provided an audio-visual reference point for the child, as well as entertainment during the task. Verbal encouragement was given throughout the task. When a child was too shy to walk alone, either a teacher or second researcher walked alongside the child. Following the task, the child was congratulated for their efforts. After removing the child’s tabard the researcher returned him or her to the classroom. At the end of each testing day, each Fitbit Zip was synced with its online account to transfer the data. Minute-by-minute data were subsequently extracted through a third-party company (whatAdata, Swansea, UK). The Fitbit Zips were not purchased through Fitbit Inc.; Fitbit Inc. did not contribute to this study (Tully et al., 2014).

To compare the number of steps recorded by the Fitbit Zips, the pre-school children’s step count was also measured through direct observation, using the video footage to maximise the accuracy of the observer counts and enable inter-rater reliability assessment of coders. Whilst similar validation studies using direct observation have not published their coding framework, the present study defined a step as “Lifting and setting down one’s foot or one foot after the other in order to walk somewhere or move to a new position” (Oxford dictionary, 2015). The child’s entire foot was required to leave the floor completely to be coded as a step; if both feet left the ground simultaneously this counted as two steps. If a child slid their feet along the ground, or the movement was so small that the researcher could not identify a step-like movement, a ‘no-step’ was recorded. To
establish consistency, two coders took part in practice sessions using the coding framework. The footage was coded at 35% of the full speed to give clear visualisation of the children’s steps. The coders used a hand-held tally counter, and to help maintain their attention on the coding task, they articulated orally their recording of each valid step. This method enabled the coders to maintain their visual focus on the screen. Each minute was coded individually (e.g. 09:40:00 – 09:40:59). To identify each minute, the footage was time stamped with hours, minutes and seconds. Where a step occurred during the crossover of a minute, the step was attributed to the minute in which contact with the floor was re-established. Where the coders differed by more than 6 steps, the coding was reviewed and differences resolved (Takacs et al., 2014). The step counts of the coder who constructed the coding framework were used as the gold standard criterion measure to compare with step counts recorded by the Fitbit devices.

The data from five children were not coded because they did not perform the task as requested. Due to loss of valid minutes eligible for direct observation coding in the video recordings, only 3 of the 5 minutes of data could be considered for comparison with the Fitbit Zip. Consequently, a further five children were excluded due to having less than three valid minutes of video footage and Fitbit data. Where a child had more than three valid minutes, a random number generator calculator was used to select the minutes included in the analyses. For each child, a ‘total number of steps’ variable was calculated for each of the four measures (two observer counts; two Fitbit Zips).

**Data Analysis**

Data analysis was conducted using SPSS 22. No statistical outliers were identified. Intra-class correlation (ICC) was calculated for each measure to assess reliability using recommended procedures (Hallgreen, 2012). Reliability of observer count was assessed using a two-way mixed effects model with absolute agreement applied. Inter-device reliability was assessed using a two-way random effects model, also with absolute agreement applied. To interpret the findings, the following cut-off criteria were used: an ICC of 0.75 and above is classed as “excellent”; 0.60 – 0.74 as “good”; 0.40 – 0.59 as “fair”, and 0.39 and below as “poor”.

To evaluate whether the Fitbit Zip is a valid measure of pre-school children’s step count, three analyses were conducted. A repeated measures ANOVA compared steps recorded by direct observation with those recorded by each Fitbit Zip. Post hoc comparisons were employed with Bonferroni corrections applied at p < 0.016. Concordance correlation coefficients (CCC) were calculated to evaluate the consistency between each pair of step counts (Lin, 1989). The same cut-off criteria as for ICC were applied. Bland-Altman plots were used to investigate agreement between the two measurements (Bland & Altman, 1999; Giavarina, 2015). To enable cross comparison between the
devices, percent relative error was calculated using the following equation: \[
\frac{\text{Fitbit output} - \text{Observer count}}{\text{Observer count}} \times 100.
\]

**Results**

The final sample included 56 children (29 girls; 3.69 ± 0.58 years). Excellent inter-coder agreement was achieved between coder one (M = 367.68, SD = 40.89) and coder two (M = 369.09, SD = 41.00; ICC = 1.00; 95% CI = 0.99-1.00). Also excellent inter-device agreement was found between Fitbit Zip 1 (M = 344.91, SD = 41.11) and Fitbit Zip 2 (M = 342.52, SD = 52.91; ICC = 0.91; 95% CI = 0.85-0.95).

A repeated-measures ANOVA found a significant difference between the observed count and the two Fitbit Zip placements, \( F(2, 110) = 49.30, p < .001 \). Post hoc tests found that Fitbit 1 recorded significantly fewer steps than the observed count \( (t(55) = 8.92, p < .001, d = 0.56) \); and similar results were found for Fitbit 2 \( (t(55) = 8.14, p < .001, d = 0.54) \). No significant difference was found between the Fitbit Zips \( (t(55) = .88, p = .383, d = .05) \). Good concordance was found between observer count and both Fitbit 1 \( (r = 0.77; 95\% \ CI = 0.66 – 0.85) \), and Fitbit 2 \( (r = 0.77; 95\% \ CI = 0.67 – 0.84) \).

The Bland-Altman plots compared observer count with Fitbit 1 (Figure 3.02a) and Fitbit 2 (Figure 3.02b). For Fitbit 1, the Bland-Altman analysis identified a bias of 22.77 steps \( (SD = 19.10) \), and the limits of agreement interval were -14.67 to 60.21 steps. For Fitbit 2, there was a bias of 25.16 steps \( (SD = 23.16) \), and the limits of agreement were -20.19 to 70.51 steps. The absolute percent error for Fitbit 1 was 6.44\% \( (SE = 0.66) \) and 7.27\% \( (SE = 0.94) \) for Fitbit 2.
CHAPTER THREE

Figure 3.02. Bland-Altman plots illustrating the relationship between observer count and (a) Fitbit 1 and (b) Fitbit 2. Solid line represents the mean difference between the two measures, and dashed lines represent limits of agreement (± 1.96 SD).

Discussion

The main aim of this study was to assess the inter-device reliability and validity of the Fitbit Zip as a measure of pre-school children’s step count while performing a walking task in their nursery setting. We found excellent inter-device reliability with an ICC value similar to that observed in a study with “healthy adults” (Kooiman et al., 2015). In the current study, the Fitbit Zip showed an acceptable mean deviation from the gold standard observational measure (10%; Kooiman et al.) in a non-laboratory setting. The Fitbit Zip is a valid and reliable measure of pre-school children’s step count.

Despite the exclusion of 10 children, the attrition rate of 15% is low as compared with developmental studies with children of a similar age (Howie & Straker, 2016), such a figure highlights
the importance of over-recruiting participants when working with pre-school children. Children of this age are highly distractible and so less likely than older children to complete the task.

In the present study, agreement between Fitbit Zip step counts and observer step counts was assessed using CCC and Bland-Altman plots. Although both Fitbit Zips had good agreement with the criterion measure, the Bland-Altman analyses identified a small undercount of the number of steps recorded by Fitbit 1 and Fitbit 2 of 22.77 and 25.17, respectively. In line with other studies, the majority of points fall within the 95% limits of agreement.

Fitbit calculates step count using an “algorithm (...) designed to look for motion patterns most indicative of people walking” (Fitbit, 2015b). The motion must exceed the proprietary threshold to be recorded as a step. As Fitbit Inc. acknowledges, “If that threshold is not met, the algorithm won’t count the motion as a step”. For reasons of commercial sensitivity Fitbit Inc. have not published their algorithms (Diaz et al., 2016), preventing researchers from modifying thresholds. In the present study, both Fitbit Zips underestimated the number of steps in comparison to the observer count, a finding that is consistent with validations of the Fitbit Zip with adults (Ferguson et al., 2015; Paul et al., 2015; Tully et al., 2014). However, comparison of the Bland-Altman plots from the present study with those reported in the studies in adults shows that the undercount is larger for pre-school children. If replicated, this finding would suggest that Fitbit need to develop more sensitive, age-related thresholds: the current generic threshold may be set too high for accurate measurement in young children. Change in the threshold would, however, require re-validation of the device. The issue of threshold criteria is not new: others have highlighted this potential source of variability in activity estimates between different brands of accelerometer (Hnatiuk et al., 2014).

Strengths

The present study is associated with numerous strengths. Conducting the study in a real-world nursery environment increased its ecological validity, although it should be acknowledged that a greater element of error could be expected in comparison to laboratory-based studies (Diaz et al., 2016; Takacs et al., 2014). Furthermore, the present study also followed the analysis strategy employed in a recent validation study and related guidelines (Hallgreen et al., 2012; Giavarina, 2015; Takacs et al., 2014). Comparison of the outcomes found here for the Fitbit Zip with those for alternative devices has proved difficult because published studies aiming to validate those tools in pre-school children have typically reported only correlation coefficients (Oliver et al., 2007), which can be misleading (Giavarina, 2015). As others have argued, measures of correlation and measures of agreement do not evaluate the same construct (Cliff et al., 2009; Oliver et al.; Giavarina). These studies have also not reported absolute percent error.
Accelerometers are an objective method of assessing pre-school children’s step count (Pate et al., 2010), and are typically validated worn on the hip or wrist. When identifying a measurement tool for the present study, practical implications (Cliff et al., 2009) and the developmental stage of pre-school children (Oliver et al., 2007) were considered. The solution for low-acceptability of elasticated belts, and the risk of damage or loss of the device led to the development of a novel and low-maintenance means for pre-school children to engage freely with their daily environment while wearing activity monitors. Whilst the tabard-worn monitors cannot be compared and contrasted to a directly attached hip-mounted placement, the use and placement of such an item is not only in accord with manufacturer instructions, but was found to be reliable in comparison to the gold standard of direct observation. It could therefore be postulated that the Rainbowtop© tabard does not adversely impact on the accuracy of the device and could be used as an integrative research tool to minimise compliance issues associated with young children (Costa et al., 2015). Furthermore, the custom-made tabards were judged acceptable to the children and nursery staff. The results obtained provide preliminary support for Fitbit (2015a) claims that the Fitbit Zip can be worn in or on external clothing.

Limitations

In the present study, the Fitbit Zip showed very good inter-device reliability when pre-school children performed a timed walking task in their nursery environment, wearing two devices located one above the other over the child’s right hip. However, the spatial limits of this inter-device reliability need to be investigated systematically by varying the locations of the devices worn in the pockets of the children’s tabards. For example, devices could be worn over the right and left hips, at both the front and back, and at the child’s chest level. This would provide a rigorous investigation of Fitbit’s claim that the Fitbit Zip can be worn in or on clothing. Relatedly, there is also the need to investigate inter-device reliability over the entire nursery day during which children would engage in a wide range of active and sedentary behaviours, both indoors and outdoors, which will likely entail a wider range of motion than that measured in the walking task. If inter-device reliability remains high over the entire range of nursery activities the Fitbit Zip would be an excellent tool for establishing pre-school children’s’ present day levels of habitual activity across cultures. It would also be helpful to compare the Fitbit Zip with the more expensive Actigraph to provide a cost benefit analysis for the use of commercial activity monitors with pre-school children. Finally, whilst researchers have criticised Fitbit monitors for only having one minute epochs, it is important to acknowledge that such implications only affect time spent in physical activity intensities. As such, the use of such monitors for measuring step count is warranted.
Conclusion

This study, to our knowledge, is the first to validate a consumer-grade activity monitor with a Rainbowtop tabard showing that the device is a valid tool to assess pre-school children’s step-count. The device was also found to have strong inter-device reliability. Studies in adults (Ferguson et al., 2015; Kooiman et al., 2015) have reported that the Fitbit Zip has stronger validity than more expensive devices. On the basis of research conducted to date, the Fitbit Zip appears to provide a valid, cost-effective alternative to research-grade activity monitors. The results of this study will be further considered in the General Discussion (Chapter 9, p. 205).
CHAPTER FOUR: Development and Feasibility of Four Interactive, Audio-Visual Stories to Increase Pre-school Children’s Physical Activity Levels in a Nursery Setting.

The Chief Medical Officers advocate that pre-school children should be active for a minimum of 180 minutes every day (Department of Health, 2011). According to the Department of Education (2014, pg. 1) a large percentage of children attend childcare (e.g., in England 97% of 3 – 4 year old children), making childcare settings an ideal location to promote physical activity (Townsend et al., 2015, p. 10). Designing physical activity interventions that can be incorporated into the Early Years Foundation Phase (EYFP) framework (Welsh Government, 2015) could be an important means of increasing levels of activity in this target group.

Storytelling is one of the oldest methods of teaching (Hamilton & Weiss, 2005), and its role in improving young children’s language learning has been recognised (Isbell, Sobol, Lindauer, & Lowrance, 2004). The EYFP framework (Welsh Government, 2015) stipulates that nursery children should be able to “follow simple action words e.g. through games and songs” (p. 18), and “listen and join in with songs, rhymes and stories that have a mathematical theme” (p. 32). Children are also encouraged to engage with mathematical themes that are embedded into daily pre-school activities. Given the time-pressure on teachers to deliver the curriculum it is important that classroom physical activity interventions complement and enrich the curriculum delivered rather than compete with it. As storytelling is a pivotal teaching tool in nursery age children, we identified story time as an opportunity to encourage children’s daily activity in the classroom.

This two-part chapter will firstly outline the design and production of four interactive, audio-visual adventure stories between 10 -12 minutes long. There is a different story for each of the four ‘Super Dynamic Food Dudes’ characters (hereafter the characters are referred to as the ‘Dynamic Dudes’ for simplicity). Secondly, this chapter reports the outcomes of a feasibility trial of the interactive stories in pre-school children conducted in a nursery environment. The interactive stories are one main component of a physical activity intervention evaluated in Chapter 6, and of a combined intervention targeting both physical activity and healthy eating in Chapter 8. It was considered important to trial the component on its own prior to its inclusion in a multi-component intervention.

The aim of the interactive stories is to increase physical activity in the childcare setting to help children achieve recommended daily physical activity targets. To assess the children’s activity levels whilst participating in the newly developed interactive stories, the children wore Fitbit Zip accelerometers, validated as a measure of pre-school children’s step count (Chapter 3). Informal observations of the children’s ability were also considered. Results of this feasibility trial show that the interactive stories were successful in engaging pre-school children in physical activity in the nursery.
environment: no significant difference in step count was found between Presentation 1 and Presentation 2 ($p = .27 - .47, r = .41 - .43$).

**Part 4A: Design and Production of Four Interactive Stories**

**Ethical Approval**

Approval was obtained from the School of Psychology Ethics and Research Governance Committee at Bangor University to develop (Part 4A), and evaluate (Part 4B), the feasibility of the interactive story components of a Dynamic Dudes physical activity intervention for 3 – 4 year old children (Ethics application No.: 2013-11864).

**Information Gathering – Story Writing**

The researcher, well practised in storytelling in a nursery setting, read a variety of age-appropriate stories, and searched Internet sources on the methodology of writing for children to ensure that the stories would be appropriate for 3 – 4 year olds. The researcher also discussed with nursery teachers some suitable themes for the stories.

**Information Gathering – Target Actions**

Children attending the Bangor University Daycare Nursery and Child Research Centre visit a nearby gymnasium every day as part of their daily nursery routine. With the agreement of the nursery manager, the researcher accompanied the children on multiple trips to the gymnasium to informally observe their usual behaviour in this setting. As the researcher was well known to the children, her presence in the gymnasium was not expected to alter the children’s behaviour. It was assumed, therefore, that the informal observations would be representative of the children’s activity skills. The researcher was also well known to the nursery staff, as she has been present previously during the children’s classroom-based and outdoor-based activities, therefore, it was not anticipated that the researcher’s presence would affect the nursery nurses’ interactions with the children.

**Potential Target Actions**

The aim at this exploratory stage was to determine which of the target set actions most nursery children could perform. Therefore, based on her informal observations of the children’s behaviour in the gymnasium, the researcher generated a table of 50 potential target actions (Appendix 4.01) for the target age group.

Opt-in consent (Appendix 4.02) was obtained from parents of the 29 children attending the University Nursery for the children’s participation in the activities and for their responses to be filmed.
This consent applies to the “Simon Says” activity (see below), the feasibility evaluation of the interactive stories (see below), and the exercise videos (see Chapter 5). To be eligible for inclusion the children were required to be between 2.5- and 4-years old.

The children participated in an informal and exploratory Simon Says exercise to assess their ability to perform the potential target actions, and the session was filmed. The session was conducted in the gymnasium the children routinely visited. The researcher led the session, with two cameras providing footage, one from the front and one from behind the group of children taking part. During the session, the researcher stood in front of the children and verbalised the Simon Says instruction while she modelled the target action, and then gave the children time to copy it. Due to the exploratory nature of the session, neither the time allocated to the children performing the moves nor the number of repetitions of the action were standardised. As the objective of the session was to identify a set of actions the children could all perform well, the researcher adjusted the complexity of behaviour modelled in response to the children's competence as she progressed through the target action list. As the children became tired, the researcher was unable to complete the full list of target actions. This in itself was informative, as it provided an indication of how long the physical activity intervention must be to ensure that children of this age do not become fatigued and disengaged.

At the end of the first Simon Says session, the researcher and supervisors reviewed the film footage to agree which actions the children were either already able to perform, or could perform with practice; remaining actions were judged to be too difficult for 3 – 4 year olds to perform and removed from the target list. Target actions that had not yet been tested were trialled informally with the children at the University Nursery in order to identify the full set required for the study.

**Audio Stories**

Discussion between the researcher and supervisors, led to the agreement of the main theme for each character’s story: (1) Tom – farm, (2) Razz – boat, (3) Rocco – jungle, and (4) Charlie - castle. Four stories were then drafted by the researcher, and edited by the first supervisor (see Appendices Tom, 4.03; Razz, 4.04; Rocco, 4.05; Charlie, 4.06). In each story the presentation format alternates between story and song. Children are invited throughout the narrative and songs to copy the character’s actions (as modelled by the narrator), and sing along with the narrator. At the end of each story, the narrator modelled taking 3 deep breaths and invited the children to join in as a well-earned recovery period.

Within each story, the narrator describes the character marching through a series of different scenes, related to the main theme of the story. The character is described as performing various activities, which the children are invited to join in; depending on the action, the children are asked to
perform them either 5 or 10 times. A positive reinforcing statement follows each such sequence. An example from Tom’s story is: “Tom loves puddles, so he starts jumping around. Shall we all jump into puddles; let’s jump together 10 times. Don’t forget to move your arms too! Ready… 1, 2, 3, 4, 5, 6, 7, 8, 9, 10! Those were big strong jumps – well done Dudes!” In addition to continuous marching throughout the narrative, there are a total of 75 target actions modelled during each story.

**Story Themed Music**

The researcher contacted a Senior Lecturer from the School of Music, at Bangor University. Following preliminary discussions, the Senior Lecturer gave permission for the researcher to ask his students whether they were interested in composing music for the interactive stories. The researcher first presented the project to these Masters and third year Undergraduate students during a seminar, provided a brief of the project and a draft composition idea to accompany one of the songs, before inviting interested students to contact her via e-mail. The researcher, having previous music training, gave guidance on the kind of music required through regular meetings during the composition stage to ensure the desired tempo and tonality was achieved. Each music student received a £20 gift, a copy of the story their music accompanied, their name was placed on the credits of their corresponding story, and they were also permitted to submit their composition as part of their degree dissertations.

**Development of Story Production**

The feasibility of presenting the story through the mode of audio only, with the researcher modelling the accompanying target actions was informally trialled with one of the stories. The researcher found that the children became distracted, as there were insufficient visual cues to hold their interest. Therefore, following discussion with her main supervisor, the researcher designed and developed audio-visual versions of the interactive stories.

Photographs were shown on the left of the screen to illustrate what was being narrated in the story, whilst on the right of the screen, the researcher was filmed narrating, singing, and performing the target actions throughout the story. Synchronised with her singing, each line of verse was also presented in a box beneath its respective photograph. See Figure 4.01 for an example scene from each story.
Photographs

The researcher sourced photographs of locations that would illustrate visually the events in each story as it unfolded to help the children to view the story as a movie. Contact was made with establishments in North Wales with access to locations that matched the story themes. Free entry was obtained to the following venues: Beaumaris Castle for Charlie’s story; the Welsh Mountain Zoo, Conwy, for Rocco’s story; Conwy Marina boats for Razz’s story; and a local farm in Caernarfon, North Wales, for Tom’s story. A volunteer student photographer was recruited for 3 days to visit the listed locations with the researcher who directed the desired shots. Additional photographs were obtained by the researcher from personal contacts, and Wiki Commons (https://commons.wikimedia.org/wiki/Main_Page). The researcher, student volunteer, and personal contacts, conducted the editing of photographs. Full acknowledgement to all contributors was given on the credits pages of each story.

Filming

The researcher produced a storyboard for each story illustrating the desired interactive media sequence to aid post-digital production. The storyboards showed the visuals that were required on-screen to match to the audio track.

The researcher was filmed for each story, narrating, singing, and modelling the target actions, against a green or blue background screen. A media technician in the School of Psychology at Bangor
University conducted the filming using the School’s equipment. The researcher wore a t-shirt customised with the Dynamic Dudes character that featured in the story being filmed. The script was displayed on an auto-cue to guide the researcher’s narration, and a microphone was placed on the researcher to record the sound. The appropriate music to accompany the story was played quietly in the background for guidance, as key words were synchronised to the music.

Post-Digital Production

The media technician inputted all the media (photographs, video footage, music) into Final CutPro software. The researcher advised on the visuals required. Using this software, crossover slides were inserted to mark the transition from narrative to song, and the words of the songs were inputted onto the screen. The composed music overlaid the visual film, and the audio was synced to the visual movements. The researcher was present for the majority of the digital production and provided regular feedback and additional edits when required. Once created, the interactive stories were shown to the supervisor, edits were made following supervisor feedback, and they were then transferred on to a DVD with interactive function. See ‘Disk V1 – Interactive Story’ to view each characters video.

Part 4B: Feasibility Trial of the Interactive Stories in a Nursery Setting

To investigate the feasibility of the interactive stories, they were shown to the target-age children in a typical nursery environment. Due to time restrictions, only three of the four interactive stories (those for Tom, Rocco, and Razz) were shown to the children during this trial. As three stories were similar in length and format, and had an equal number of target actions, this was considered acceptable.

Method

Participants

The University Nursery was selected to trial the interactive stories as parental consent for children’s participation and filming had already been obtained (see Potential Target Actions above). Of the 19 children (42% girls) aged between 2.48 – 4.58 years ($M = 3.64$, $SD = 0.65$) who participated during the week of the trial, only 12 children contributed paired data and were included in the quantitative analysis ($M = 3.85$, $SD = 0.49$; see Table 4.01 for details). All but one of the 19 children had previous exposure to the Food Dudes characters from previous pilot trials of the Food Dudes Healthy Eating Programme. However, this child did not have sufficient data for inclusion in the quantitative
The children’s attendance varied from 1 to 5 days in accordance with their registration at the nursery.

Table 4.01.
Children’s gender, and age at the start of testing.

<table>
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<th>Child</th>
<th>Gender (Girl/Boy)</th>
<th>Age at start of testing (years.months)</th>
<th>Child</th>
<th>Gender (Girl/Boy)</th>
<th>Age at start of testing (years.months)</th>
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<td>Girl</td>
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<td>LS</td>
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<td>3.96</td>
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<td>Boy</td>
<td>3.52</td>
</tr>
</tbody>
</table>

Experimental Design

This study employed a within-groups design to investigate the feasibility of the three interactive stories. The children watched two interactive stories each day for 5 days, one in the morning and one in the afternoon. The stories were shown on a 3-story cycle in the following order: Razz, Tom, and Rocco, for a total of three presentations each (Presentation 1; Presentation 2; Presentation 3).

The primary dependent variables evaluated using Fitbit Zip accelerometers (see Measures) were (a) the number of steps performed by the children during each story, (b) how the number of steps performed compared to the number of steps modelled on screen by the narrator, and (c) whether the children emitted more or less steps as they became more familiar with the stories. The secondary dependent variables were measured through informal observations to determine whether the children could (a) complete all modelled target actions, (b) engage for the full duration of the story, (c) whether the resource was suitable for delivery in a nursery environment, and (d) whether any additional content was required in each story. The researcher and first supervisor conducted the informal observations. The independent variables were the target actions modelled in the interactive stories.
CHAPTER FOUR

Materials

The children watched the three interactive stories on a television screen whilst wearing custom-made tabards containing Fitbit Zip accelerometers. A HD camera (Sony Handycam CX190) and tripod was placed at the side of the television screen to video record the children’s responses to the interactive stories from a front view angle.

Measures

Accelerometry. Fitbit Zip accelerometers were used to measure the pre-school children’s step counts during delivery of the interactive stories. Each child was allocated a specific device, which was worn in a pocket in a tabard (see Chapter 3, p.80 for full explanation). The face of the Fitbit Zip was hidden inside the pocket and the children were not exposed to it or aware of the function of the device. The children were told that the device was “a button” that helped the researcher to identify who each tabard and device belonged to. The children wore the tabards for the duration of their attendance at the nursery; nursery staff put them on as the children arrived, and removed them when the children left. The researcher checked daily, prior to morning delivery of the interactive stories, to ensure the children were wearing the correctly allocated tabard.

Informal observations. These were conducted using the footage filmed during the delivery of the interactive stories to enable the researcher and supervisor to assess the children retrospectively. Whilst reviewing the footage the following criteria were applied, in the order of the listed dependent variables above:

(a). Completed all modelled target actions – ‘yes, yes with practice, or no’ response to each target action.

(b). Engaged for the duration of the interactive story – ‘yes or no’ response to each story as to whether the children completed the story.

(c). Suitable for delivery in nursery environment – ‘yes or no’ response to whether the children were able to perform the target actions in the provided space without injury to themselves or others.

(d). Whether any additional content was required in each story.

Procedure

The researcher contacted the nursery manager, described the purpose of the research, and agreed suitable testing times. She then briefed the nursery staff on the protocol of the study, and they agreed to put the tabards, each with the child-allocated Fitbit in situ, on the children as they entered the nursery and remove them prior to the children leaving, on 5 consecutive days.
Each child was assigned a designated Fitbit Zip, which was identifiable by the label number taped on the silicone casing. The children wore the tabards throughout their nursery day. The morning story session took place around 11.00am, and the afternoon story at around 1.30pm.

At the appropriate times, the children were taken into a classroom with the researcher, where no other children were playing. The researcher introduced the interactive story to the children by asking if they would like to join in an adventure. The children were then told which character would be in the story they were watching that day and what the setting of the story was. The children were reminded at the start of the story to copy what was shown on the screen, and encouraged to count aloud when appropriate. The researcher played the interactive story, and completed the moves with the children. Verbal cues were provided to encourage the children throughout the stories, and verbal praise was given at the end. No tangible rewards were delivered. The children were then returned to their classroom. The story session was video-recorded to provide on-going measures of the children’s ability to perform the modelled target behaviours. The researcher recorded the start and end timings of the story video intervention delivery.

Nursery nurses removed the tabards from the children before they left the nursery at the end of the day. The procedure was repeated for the following four days. On completion of Day 5, the researcher collected the Fitbit Zips and synced the devices to a computer via Bluetooth to transfer the recorded steps data, which were stored online in each individual Fitbit account.

Data Analysis

Granulated minute-by-minute Fitbit data of steps performed were extracted through a third-party company called whatAdata. From the granulated data, a ‘total number of steps’ variable for each child for each interactive story was calculated. Manually, the appropriate minutes of Fitbit data were identified, assigned to the appropriate child in Excel, and totalled. As the children’s attendance at the University Nursery depended on the sessions that he or she was registered to attend, each child’s individual exposure to each interactive story was classified in terms of the number of presentations they had actually received (e.g. if one child was only present for the second scheduled exposure of Rocco’s interactive story, but that was the child’s first exposure to that story, the corresponding data were assigned to the Presentation 1 variable and not the Presentation 2 variable). As few children’s attendance enabled them to take part in all three scheduled presentations, a Presentation 3 variable was not included in the analysis.

Inferential statistical analysis was conducted using SPSS 22. Parametric analysis was employed as the group data fulfilled the normality assumptions. The children’s data were included in the analysis if they provided a data points for both Presentation 1 and Presentation 2 of an interactive story.
Children’s variable attendance resulted in a minimal number of children providing data for the third presentation of each story so data from Presentation 3 was not been included in the analyses. The children’s step counts for each interactive story were first plotted as a group for visual inspection. Paired samples t-tests were then employed to investigate any significant changes over time.

The direct-observation coding framework employed in Chapter 3 was used to identify the total number of steps modelled in each story. The number of modelled target actions were matched between the interactive stories, however, due do the different type of body movements required for each target action, the number of steps modelled varied. One sample t-tests were used to examine the differences in the children’s group step counts compared to the number of steps modelled onscreen in each interactive story.

Each child’s step count level at Presentation 1 and at Presentation 2 was explored by visual inspection of a figure showing these data separately for each story. In these single-cases figures, a child’s singular data points were also included on an interactive story if they also had paired data for another interactive story; these additional data points provide further depth to the visual analysis. The following equation was next used to calculate the children’s ‘percentage change of step count’:

\[
\frac{\text{Presentation 2} - \text{Presentation 1}}{\text{Presentation 1}} \times 100.
\]

Point-biserial and bivariate correlations were conducted to explore any gender and age effects, respectively. Singular data points were not included in the correlational analysis. Due to the small sample sizes, outcomes must be interpreted with caution, until replicated in larger samples in future studies.

Conclusions from the informal observations were applicable to all children who participated in any presentation regardless of whether they had paired data at Presentation 1 and Presentation 2 for inclusion in the quantitative analysis.

**Results**

**Accelerometry**

**Group analysis.** Twelve children (58% girls; age, \(M = 3.85, \text{SD} = 0.49\)) contributed to the final quantitative analysis. Visual inspection of Figure 4.02 shows that over time the children increased the mean number of steps they performed by 13.60% whilst taking part in Tom’s interactive stories. However, a decrease in mean steps is evident in the other two interactive stories (20.29% for Razz and 24.23% for Rocco).
CHAPTER FOUR

Paired-samples t-tests found no significant difference in the number of steps emitted by the children between Presentation 1 and Presentation 2 for any of the stories (Razz; \( t(7) = 1.19, p = .27, r = .41 \); Tom; \( t(9) = -0.76, p = .47, r = .25 \); Rocco; \( t(6) = 1.18, p = .28, r = .43 \)). The total number of steps modelled onscreen in Razz’s interactive story was 586. One sample t-tests showed that the children produced significantly less steps than were modelled at Presentation 1, \( t(7) = -7.59, p < .001, r = .94 \), and at Presentation 2 \( t(7) = -11.78, p < .001, r = .98 \). The number of steps modelled onscreen in Tom’s interactive story was 732. The children completed significantly less steps compared to the onscreen model at Presentation 1 \( t(9) = -7.71, p < .001, r = .93 \) and at Presentation 2 \( t(9) = 6.83, p < .001, r = .92 \). The number of steps modelled in Rocco’s interactive story was 853, the highest count across the three stories. Once again, the children performed significantly less than the modelled steps at Presentation 1 \( t(6) = -8.63, p < .001, r = .96 \) and at Presentation 2 \( t(6) = -8.76, p < .001, r = .96 \).

**Individual change in steps for each character’s interactive story.** To explore by visual inspection individual children’s performances in relation to gender and age, each child’s raw scores for each interactive story are shown in Figure 4.03, Figure 4.04, and Figure 4.05 below.

**Razz’s interactive story.** Figure 4.03 shows paired data for eight children at Presentation 1 and 2, with an additional boy’s (JW) data only at Presentation 1. Visual inspection suggests that with the exception of one girl (EG), the boys performed more steps that the girls. One girl (MS) increased her number of steps by 64.38%, whereas four girls (EG, HR, RT, LS) showed a decrease in steps ranging from 18.75% to 36.75%. One boy (PJ) increased his number of steps by 59.80%, compared to two boys.
(AT, JM) who decreased their steps by 18.75% and 33.64%, respectively. Inspection by age suggests no difference in performance between the youngest and oldest children.

Exploratory point-biserial correlations found no significant correlation between gender and the number of steps performed in Razz’s interactive story at either Presentation 1 ($r_{pb} = .23$, $n = 8$, $p = .58$), or Presentation 2 ($r_{pb} = .54$, $n = 8$, $p = .17$); although a stronger correlation is evident for the latter, it remains non-significant. Relative to age, at Presentation 1 a non-significant negative weak correlation was found ($r = -.27$, $n = 8$, $p = .52$), and also a non-significant correlation at Presentation 2 ($r = -.07$, $n = 8$, $p = .86$).

**Tom’s interactive story.** Ten children provided data for Tom’s interactive story at Presentation 1 and Presentation 2, with an additional child (EW) providing data at just Presentation 1. Figure 4.04 suggests that during Presentation 1 the boys typically outperformed the girls, with a more even distribution across the genders at Presentation 2, although the highest score is still obtained by the oldest boy (JM). Examination of behaviour change shows that three girls (JJ, EG, HR) increased their number of steps (range of increase from 51.35% to 420.00%). Similarly, three boys (JM, AT, PJ) also increased their steps but through a lower range (12.75% - 48.08%) as compared to the girls. However,
as the boys had higher step counts at the outset, smaller increases may be expected. Two girls (RT, LS) decreased their step count by 18.18% and 25.50% respectively. Larger decreases were found in two boys (SL, 49.36% and JW, 61.60%). Visual inspection suggests that children’s age has no systematic relation to steps performed at either time point.

Point-biserial correlations confirmed visual inspection as a significant strong correlation was found between gender and the number of steps performed during Presentation 1 ($r_{pb} = .64$, $n = 10$, $p = .04$), but the significant correlation was not maintained at Presentation 2, meaning the genders were performing similar levels of steps by the second presentation ($r_{pb} = .03$, $n = 10$, $p = .93$). There was a medium positive correlation, which was not significant, between age and the number of steps the children performed at Presentation 1 ($r = .47$, $n = 10$, $p = .15$). The relationship weakened substantially and remained non-significant at Presentation 2 ($r = -.09$, $n = 10$, $p = .80$).

**Rocco’s interactive story.** Paired data were obtained from seven children (2 boys) for Rocco’s interactive story, with an additional five children contributing data for Presentation 1 only. Figure 4.05 shows that the number of steps performed by the boys fell mid-way within the range performed by the girls at both presentations. Inspection of step count change shows that two girls (JJ, RT) increased by 31.59% and 79.57%, respectively. However, three girls (EW, EG, LS) also decreased their step count.
Both boys decreased their step count (SL by 36.56% and PJ by 60.05%). Visual inspection suggests that there is no age effect.

A weak relationship was found between gender and the number of steps performed at Presentation 1 ($r_{pb} = .23, n = 7, p = .62$) and at Presentation 2 ($r_{pb} = -.22, n = 7, p = .63$), however, neither reached significance. In addition, a weak but non-significant relationship was found between age and the number of steps performed at Presentation 1 ($r = -.38, n = 7, p = .42$), and no relationship was found at Presentation 2 ($r = -.13, n = 7, p = .78$).

**Informal Observations**

The researcher and supervisor conducted retrospective visual observation of the video footage regarding the children’s ability to complete the target actions, and considered all the target actions within the three interactive stories to be either ‘yes’ or ‘yes with practice’. For each story, as the children remained in their allocated space to complete the intervention, maintained focus with the television screen and did not ask to return to the playroom, it was concluded that ‘yes’ the children engaged for the full duration of each story. The stories were considered suitable for delivery in the nursery environment as the children executed the actions in their own space, and no children were injured. No modifications or additional content were considered necessary for the interactive stories.
Discussion

The primary aim of this two-part chapter was to (a) design and produce four interactive stories, and (b) assess the feasibility of a new interactive stories component to engage pre-school children in semi-structured physical activity in a nursery setting. This intervention component has later been included in a physical activity intervention (Chapter 6), prior to the trialling of a new two-pronged multi-component intervention (Chapter 8).

The current study found that the interactive stories were successful in engaging pre-school children in physical activity, with an average step count ranging between 186.13 and 344.29 steps during each of the three interactive stories. As far as I am aware, no published research has created and trialled the effects of interactive stories on physical activity in pre-school children. As such, this study provides a novel behaviour change component that cannot be compared to others in the relevant literature.

Strengths

The results show that storytelling, a core component of the national curriculum for the target age (Welsh Government, 2015), is an opportunity for encouraging children to be physically active in the nursery classroom. In addition, the children appeared to be comfortable wearing the tabards whilst participating in the interactive stories; no children requested removal of their tabard. The researcher observed that the stories were effective in maintaining the children’s attention although, as for the normal curriculum, occasional verbal reinforcement was necessary for some children to maintain their participation. Furthermore, the study shows that the interactive stories were suitable for delivery in a classroom environment.

Limitations

When considered as a group, the children’s step counts increased from the first to the second presentation of Tom’s interactive story, but decreased over presentations during Razz and Rocco’s stories. Visual inspection of the children’s individual data shows that on 41.67% of occasions a child’s step count increased from the first presentation to the second presentation. The first presentation of an interactive story could have induced novelty effects, which would explain a lower step count during second presentation; further presentations would be required to assess the effects of exposure on performance. Furthermore, the children were completing two interactive stories daily, which may have induced fatigue effects. Future deliveries of the component should only be once per day.

Due to the sporadic nature of children’s arrival and departure at the University nursery, consistent full nursery session data could not be collected. Consequently, the whole nursery session
data were not analysed in the study. However, the children wore the tabards throughout the nursery day, which would have helped reduce any novelty effects of the garment had it been worn only during delivery of the interactive story. The nursery staff were responsible for placing the tabards on the children and were happy to undertake that part of the procedure, suggesting that this could be a viable option in future research. However, as the University Nursery is also a research centre the nursery staff may see the role as being part of their job. The opinions of nursery staff about putting on and removing the tabards at set times of day needs to be explored in nurseries external to the University.

Due to limited time being available for the production of the interactive stories and evaluating them, only three of the four interactive stories could be produced and evaluated in the present study. Given the common format employed in each interactive story this was considered acceptable. No gender or age differences were found for step counts performed by the children, so it can be concluded that the interactive stories are an effective means of engaging 3–4-year-old children in physical activity in a nursery class setting. However, given the small sample size, these findings must be replicated.

**Conclusion**

In conclusion, the interactive stories were successful in encouraging children to participate in physical activity, and were appropriate for delivery in the nursery classroom. Based on informal observation, and that children had successfully completed the interactive stories, no changes were deemed necessary prior to their inclusion in the physical activity intervention (Chapter 6). The interactive stories component will be discussed in further detail in the General Discussion (Chapter 9, p. 205), drawing on findings in subsequent studies.
Chapter 4 showed that an audio-visual interactive story was successful in maintaining pre-school children’s attention, and their imitation of the actions of the on-screen presenter throughout each story, resulting in an increase in their overall physical activity. Using information derived from the Simon Says sessions conducted previously, and from creating and evaluating the effectiveness of the interactive stories, four exercise videos were designed and produced as an additional component of the physical activity intervention under development.

In a previous series of studies conducted by Mitchell (2014), four Dynamic Dudes classroom exercise DVDs (one video per character) were created to target physical activity in 5-11 year olds at primary school. In the final study, a controlled trial, the videos resulted in significant increases in classroom activity with very large effect sizes (all $p < .001$, $r = .43 - .84$) as compared with the activity of children engaged in their routine school curriculum during a matched time frame (see also Whitaker, 2016). These videos for primary school children informed the development and design of the four exercise videos in the present study, which were tailored for the developmental level of 3-4 year olds attending nursery classes.

This two-part chapter follows the same structure as Chapter 4. The design and production of these four exercise videos is described in Part A. Each exercise video lasts between 8 – 10 minutes, and each ‘Dynamic Dude’ character has their own video showcasing their specific activity. Part B assesses the feasibility of the exercise videos designed for use with pre-school children in a nursery setting. The exercise videos are presented as one main component of a physical activity intervention, which when combined with the interactive stories is evaluated in Chapter 6, and later evaluated as part of a multi-component intervention targeting physical activity and healthy eating in Chapter 8. As with the interactive stories, it was considered essential to trial the component on its own in the target population prior to its inclusion in the multi-component intervention.

Consistent with the interactive stories, the aim of the exercise videos is to create a behaviour change component that can be used in nursery classrooms to generate short bursts of physical activity to help young children achieve the recommended daily physical activity target. To measure the number of steps performed by the children during their participation in each exercise video, they wore Fitbit Zip accelerometers. The researcher and supervisor conducted informal observations of video footage filmed during delivery of the exercise videos. Results show that the exercise videos were suitable for pre-school children: they participated in the semi-structured physical activity, and
accelerometer measures showed that they completed significantly more steps \((p < .001 - .052, r = .63 - .81)\) at Presentation 2 as compared to Presentation 1.

**Part 5A: Design and Production of Four Exercise Videos**

**Ethical Approval**

The School of Psychology Ethics and Research Governance Committee at Bangor University approved the development (Part 5A), and evaluation (Part 5B) of the exercise DVD components of a Dynamic Dudes activity intervention for 3 - 4 year old children (Ethics application No.: 2013-11864).

**Information Gathering**

The process of identifying actions that pre-school children were able to imitate is described in the method section of Chapter 4. Additional target actions identified from the Simon Says session were trialled informally with pre-school children attending the University Nursery. Likewise, the target actions employed in the primary school exercise videos (Mitchell, 2014; Whitaker, 2016) were also considered for their suitability in pre-school children.

**Target Actions**

Four target actions specific to each role model character’s favourite activity were identified and agreed upon for inclusion in the exercise videos by the researcher and her supervisor. To help the children learn the sequence of target actions, a name was given to each of the different actions (see Table 5.01).

**Table 5.01.**

*Target actions modelled by each character in the exercise videos.*

<table>
<thead>
<tr>
<th>Character</th>
<th>Rocco (Football)</th>
<th>Razz (Dance)</th>
<th>Tom (Gymnastics)</th>
<th>Charlie (Martial Arts)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Monkey leaps</td>
<td>Across-apart jump</td>
<td>March*</td>
<td>Kick ‘n’ push</td>
</tr>
<tr>
<td>2</td>
<td>Upward leap</td>
<td>Roll ‘n’ fold</td>
<td>Run*</td>
<td>Frog jump</td>
</tr>
<tr>
<td>3</td>
<td>Heel kicks</td>
<td>Sky arms turn</td>
<td>Star jump*</td>
<td>Surf twist</td>
</tr>
<tr>
<td>4</td>
<td>Goal save</td>
<td>Twist ‘n’ shake</td>
<td>Sky jump*</td>
<td>Skate hop</td>
</tr>
</tbody>
</table>

*Same as primary school exercise video*
Exercise DVD Content and Layout

The researcher drafted the voiceover lines and storyboards for each character, which were then edited and approved by the supervisor. The exercise DVD was sectioned into four chapters, one for each character: (a) Rocco, (b) Razz, (c) Tom, and (d) Charlie. Each character’s chapter was divided into two sub-sections: (a) a ‘Slow Motion’ section and (b) a ‘Levels 1 – 10 section’. Figure 5.01 shows the structure of each character’s chapter.

Figure 5.01. Flowchart of exercise video progression
In the ‘Slow Motion’ section of each DVD chapter, each of the character’s four different target actions (see Table 5.01) were shown individually, at half speed, and named when it initially appeared on the screen. The character modelled the target action for the children, first to show them how it was performed but without an invitation to copy it. Next, the children were shown the action and invited to copy it, with three such successive model and copy trials in total per target action. This procedure was designed to enable the children to observe and practice each of the target actions prior to commencing the Levels section.

In the “Levels section”, the four target actions for each character were shown for the first time as a sequence and at full speed; each target action was repeated four times before modelling the next action in the sequence, making a total of 16 modelled actions per sequence, completion of which constituted one “level”. The children were provided with visual feedback on their progress from level to level. A white bar presented at the bottom of the screen filled in accordance with the number of levels accomplished. A number was also presented inside a shape within the white bar to enable the child to keep track of the number of levels they had completed throughout the session. Each character had a different shape, and each level had a different colour. The order of colours presented mapped to the sequence of colours of the rainbow, followed by bronze, silver, and then gold. Each time a level was completed, a screen with a yellow star and the level number achieved appeared as positive reinforcement for the children’s performance. The character then appeared performing celebratory gestures (e.g. thumbs up, clapping), accompanied by a celebration voiceover statement, and the newly achieved level number was animated in the white bar. The children were then instructed by the voiceover to perform ‘3 big breaths’ in synchrony with those modelled by the character on the screen to give the children a brief recovery period between each level up to Level 10. The celebration and motivational messages differed between levels to maintain feedback novelty and effectiveness. Children heard an audio statement at the end of Level 10 praising them for their effort and encouraging them to continue being active.

Sound

A music student from the School of Music at Bangor University was recruited to compose the music for each of the exercise videos in keeping with the theme of the each character’s favourite activity. However, the compositions were not completed in time for the feasibility trial and were incorporated at a later date (See Discussion).

As an interim measure the researcher obtained a royalty free music track from www.purplemusic.com. The music was imported into ‘GarageBand’, a software package available on Apple Mac computers that can be used to edit audio material. Initially, a 10-second excerpt was
selected from the track. A shorter section of the track was selected and applied to the slow motion sections of the DVD, and the researcher decreased the tempo in GarageBand so that the tempo of the music matched that of the actions for each characters exercise video. This track was then subsequently looped and applied to the levels section. The sound of children clapping (which accompanied appearance of the yellow star on the screen to provide positive reinforcement) was recorded using a Dictaphone by the researcher at the University Nursery. The voiceovers were spoken by the researcher and recorded in the University’s Media room with the help of the media technician who then layered them onto the exercise videos.

**Character Actors/Actresses**

The researcher recruited four children through word of mouth to serve as live-action Dynamic Dudes characters. Figure 5.02 shows the recruited children and their animated character counterparts. The requirements for recruitment were that they (a) were aged 6 – 7 years, (b) resembled their respective character, (c) were available for filming during a certain time period, and (d) had a responsible adult who was willing to transport them to Bangor for filming sessions. Informed consent was obtained from the children’s parents for their participation in the exercise DVD (Appendix 5.01). Where possible, the researcher rehearsed the children prior to filming. Where rehearsal was not possible, the researcher sent visual recordings of the actions with written instructions for parents to help the children to practice the target actions at home prior to filming.

During filming, the children were asked to wear Dynamic Dudes customised t-shirts provided by the researcher. To thank the children for their participation, they were awarded a certificate (Appendix 5.02) and given their own copy of the final exercise video in which they had featured.

Figure 5.02. Four recruited children and their animated Dynamic Dudes character counterparts: (a) Charlie, (b) Tom, (c) Rocco, and (d) Razz.
Filming

The researcher created a storyboard, which included a shot list for each character, and directed the filming over the two days. As for the production of the interactive stories, the media technician shot the required footage. Rocco was filmed outside on a grass-covered location; Charlie and Tom were filmed at two different University gymnasiums on an exercise mat and in front of climbing bars, respectively; and Razz was filmed in a nursery room in front of a curtain with flashing lights placed behind. The children were asked to perform their actions in time with a metronome beating at 55 beats per minute (bpm). The researcher stood behind the camera, modelling the actions, to serve as a visual cue and maintain the attention of the children. The children were also asked to perform a piece to camera where they verbally introduced their character’s name and signature activity (e.g., saying “Hi, I’m Tom, and I love gymnastics”).

Post-Digital Production

The media technician uploaded the media and produced the videos using Final CutPro software. For each character, the researcher viewed the footage, and identified the shots to be included in the videos. For the slow motion sections, each action was individually abstracted from the sequence, and the tempo was decreased. All media elements were made to overlay each other (e.g., motivating music, voice-over, clapping). The researcher was present for the majority of the digital production, and provided feedback and additional storyboards when necessary. Once created, the videos were shown to the PhD supervisor and her feedback implemented. The videos were then transferred onto a DVD with interactive functions. Henceforward, the exercise videos when discussed collectively will be referred to as the ‘exercise DVD’. See Disk V1 – Exercise DVD to view each character’s exercise video.

Part 5B: Feasibility Trial of the Exercise DVD in a Nursery Setting.

As mentioned above, before incorporating the exercise DVD into the Dynamic Dudes multi-component intervention, it was considered important to explore whether this exercise component was suitable for use with pre-school children in the nursery environment. Therefore, the objective of the present study was to present the four exercise videos, one for each character, to pre-school children.

Method

Participants

Pre-school children from the University Nursery, who also participated in the interactive stories feasibility study (see Chapter 4 for full details), also participated in the present study. Of the 29
consented children, 17 children were available for participation (41.17% girls), aged from 2.50 – 4.60 years ($M = 3.74$ years, $SD = 0.66$). Only 13 children were present for a minimum of two presentations of the same exercise video and therefore included in the final statistical analyses ($M = 3.70$ years, $SD = 0.61$, see Table 5.02 for details). The children’s attendance varied from 1 to 5 days in accordance with their registration at the nursery.

### Table 5.02.

*Children’s gender, and their age at the start of testing.*

<table>
<thead>
<tr>
<th>Child</th>
<th>Gender (Girl/Boy)</th>
<th>Age at start of testing (years.months)</th>
<th>Child</th>
<th>Gender (Girl/Boy)</th>
<th>Age at start of testing (years.months)</th>
</tr>
</thead>
<tbody>
<tr>
<td>RT</td>
<td>Girl</td>
<td>4.19</td>
<td>LS</td>
<td>Girl</td>
<td>4.49</td>
</tr>
<tr>
<td>EV</td>
<td>Girl</td>
<td>3.54</td>
<td>JW</td>
<td>Boy</td>
<td>2.74</td>
</tr>
<tr>
<td>JB</td>
<td>Boy</td>
<td>4.01</td>
<td>SL</td>
<td>Boy</td>
<td>3.81</td>
</tr>
<tr>
<td>HR</td>
<td>Girl</td>
<td>3.21</td>
<td>MC</td>
<td>Boy</td>
<td>2.50</td>
</tr>
<tr>
<td>MS</td>
<td>Girl</td>
<td>4.55</td>
<td>JH</td>
<td>Boy</td>
<td>4.49</td>
</tr>
<tr>
<td>AT</td>
<td>Boy</td>
<td>3.91</td>
<td>FJ</td>
<td>Boy</td>
<td>3.98</td>
</tr>
</tbody>
</table>

### Experimental Design

A within-groups design was used to explore the feasibility of the exercise DVD, comprising four videos, one per Dynamic Dudes character. The children watched one video each day, and were shown the different videos on a 4-day cycle, in the following order: Charlie, Tom, Razz, and Rocco, for a total of three presentations each (Presentation 1, Presentation 2, Presentation 3). This differs from the feasibility trial of the interactive stories, in which two interactive stories were administered daily (see Chapter 4). The decision was taken to reduce the daily delivery of the exercise DVD due to the children reportedly feeling tired after completing two interactive stories per day, and the novelty of the stories decreasing. Also, it was considered improbable that nursery staff would be willing to administer the same resources twice a day to the same children.

To measure the primary dependent variables, the children wore Fitbit Zip accelerometers placed in custom-made tabards (see Chapter 3, p. 80 for further details). The primary dependent variables were: (a) the number of steps performed by the children during each video, (b) the proportion of steps performed in relation to the number of steps modelled in each video, and (c) change in number of steps performed across successive presentations. In addition, informal
observations were conducted by the researcher and supervisor to measure the secondary dependent variables, which reflected the children’s capacity to: (a) complete all modelled target actions, (b) maintain engagement for the duration of each exercise video, (c) complete the exercise DVD in the nursery environment, and whether (d) any modifications or additions were required to the exercise DVD. All variables are consistent with those described for the evaluation of the interactive stories in Chapter 4. The independent variables were each character’s action sequence modelled over the 10 levels in the exercise videos.

**Materials**

The children wore tabards with the Fitbit Zip accelerometers in situ whilst watching the exercise DVD shown on a television screen displayed in a classroom. A HD digital video camera (Sony Handycam CX190) and tripod were placed at a front view angle to the children, and used to video record their responses to the exercise videos.

**Measures**

- **Accelerometry.** The number of steps performed during each exercise video was measured using Fitbit Zip accelerometers in tabards worn by each child (see Chapter 3 for further details).

- **Informal observations.** The researcher and supervisor watched the video footage following the experimental period to assess the feasibility and suitability of each character’s exercise video. As in Chapter 4, the following criteria were considered for the exercise DVD to establish whether: (a) the children able to complete all modelled target actions, (b) each exercise video engaged and maintained the children’s attention for the full duration, (c) the delivery of the exercise videos was feasible in the nursery environment, and (d) the exercise videos required modification or additional content.

**Procedure**

The researcher described the aim of the research and procedures to be conducted to the nursery manager, and agreed suitable testing times. The children already had prior exposure to the Dynamic Dudes characters from their participation in the interactive stories (see Chapter 4). For 12 consecutive days, the consented children were taken into a room with the researcher, and periodically a member of nursery staff was also present.

Every day the researcher placed a tabard, containing a Fitbit Zip with an identification number affixed to it, on to each child. This is procedurally different to Chapter 4; the children previously wore the tabards for the duration of the nursery session, whereas in this study the children wore them only
for the duration of the exercise video. In this trial, the researcher placed the tabards on the children just before the video started, and removed them immediately afterwards.

The children were asked to stand behind a line, and find a space where they were not touching each other. The researcher observed during the interactive story that the children would drift forwards as the intervention progressed, and become too close to the television, therefore the notion of ‘staying behind a line’ was introduced to help reduce this occurring.

The researcher explained to the children that they were “starting a new adventure” and that they would be shown an exercise video each day, one for each Dynamic Dudes character, including Charlie’s. Whereas Charlie’s interactive story was not produced in time for the feasibility study reported in Chapter 4, all the exercise videos were produced in time and evaluated here.

The children were asked to join in with the target actions for as long as possible, to clap when they could hear clapping, and to verbalise out loud the level completed each time. The researcher set the video recorder to record, started the video and completed the target actions with the children. No tangible rewards were delivered to the children for their participation; however, the children were provided with verbal praise such as “Great effort dudes” throughout to encourage their participation.

First, the children completed the slow motion section followed by the levels section. When the children repeatedly said, or otherwise showed evidence that they were becoming tired, they were told they could sit down, and watch any of their peers who wished to continue. The researcher reminded the children that should they wish to join back in, they were welcome to do so. When approximately 80% of the children had dropped out, the researcher ended the session. The children were verbally praised for their efforts and reminded of their level achieved in the session. The recording video camera was turned off, the tabards were removed, and the children returned to their classroom. The researcher recorded the times that the exercise DVD intervention began and ended.

After every five days, the researcher synced the Fitbits to a computer via Bluetooth to transfer the recorded steps data, which were stored online in each individual Fitbit Zip account.

**Data Analysis**

For each child, a ‘total number of steps’ variable was calculated manually using the extraction of minute-by-minute data provided by whatAdata. As mentioned previously in Chapter 4 (p. 89), due to the children’s variable attendance, each exercise videos data was assigned to each child based on the individual child’s own completion schedule (e.g. their first, second, or third), and not the group schedule delivered.

Analysis was performed using SPSS 22. The calculated variable met the normality assumptions of parametric analysis. A paired samples t-test calculated to explore any change in the number of
steps performed across Presentation 1 and Presentation 2. The direct-observation coding framework
developed in Chapter 3 was next administered for each exercise video to measure the total number of
steps modelled. The levels across the exercise videos were matched on being a 4-action sequence,
however, different target actions yield different numbers of steps resulting in differences in the overall
number of steps modelled. As the time recorded for the exercise DVD intervention delivery included
both the slow motion sections and the levels section, the total number of steps modelled included
both sections. To compare the number of steps actually performed by the children to the number of
steps modelled on screen by the presenter, one sample t-tests were performed for each exercise
video

To investigate change in the children’s target behaviour on an individual level by visual
inspection, each child’s paired data for Presentation 1 and Presentation 2 were also plotted for each
video (see Figures 5.04 to 5.07). To maximise data inclusion for visual inspection, when a child
provided only one data point for the relevant exercise video, it was added to the graph but not
included in the statistical analyses. Following visual inspection, each child’s ‘percentage change of
step count’ was calculated (see Chapter 4, p. 89 for equation). To explore gender and age effects,
exploratory point-biserial and bivariate correlations were applied, respectively. Caution must be
applied when interpreting the outcomes due to the small sample size in the study.

Outcomes of the informal observations were assessed including all children present at each
presentation, and were not specific to the children included in the qualitative analysis.

Results

Accelerometry

Group analysis. The final quantitative analysis included data from 13 children (38.46% girls, M
= 3.70 years, SD = 0.61). Visual inspection of Figure 5.03 shows that collectively the children showed
positive progression in their step counts from Presentation 1 to Presentation 2. Presented in the order
of smallest to largest positive behaviour change, the children’s step counts increased by: (a) 25.86%
during Rocco’s exercise video; (b) 47.82% during Razz’s exercise video; (c) 84.85% during Charlie’s
exercise video; and (d) 106.82% during Tom’s exercise video.
Paired samples $t$-test confirmed visual inspection of Figure 5.03. All four exercise videos resulted in a significant increase in the number of steps performed at Presentation 2 as compared to Presentation 1 (Razz: $t(7) = -3.31, p = .013, r = .78$; Tom: $t(11) = -8.74, p < .001, r = .93$; Rocco: $t(8) = -2.28, p = .052, r = .63$; Charlie: $t(5) = -3.08, p = .028, r = .81$).

One samples $t$-tests were conducted to compare the children’s performance of steps with those modelled on screen. No significant difference was found between the children’s step counts and the 378 steps modelled in Rocco’s exercise video at either Presentation 1 ($t(8) = -.95, p = .37, r = .32$), or at Presentation 2 ($t(8) = 1.12, p = .30, r = .37$). However, the children performed less than the number of steps modelled at Presentation 1 and more than the modelled steps at Presentation 2. The same pattern was found for Razz’ (328 steps modelled) and Charlie’s (306 steps modelled) exercise videos; the children performed significantly less steps than were modelled at Presentation 1 (Razz: $t(7) = -4.02, p = .005, r = .84$; Charlie: $t(5) = -3.88, p = .012, r = .87$). However, at Presentation 2 there was no significant difference between steps modelled and steps performed, with the children performing more steps than were modelled in both cases (Razz: $t(7) = 0.47, p = .65, r = .17$; Charlie: $t(5) = 1.08, p = .33, r = .43$). The largest amount of steps was modelled in Tom’s exercise video (608 steps), and the children performed significantly less steps as compared to the modelled steps at Presentation 1 ($t(11) = -12.65, p < .001, r = .97$) and at Presentation 2 ($t(11) = -2.73, p = .02, r = .64$).

Figure 5.03. Mean steps performed by the children during Presentation 1 (unfilled bars) and Presentation 2 (grey bars) of each character’s exercise video. Error bars represent ±1 of the standard error of the mean.
Individual change in steps for each character's exercise video. To investigate by visual inspection the children’s individual behaviour change for each exercise video in relation to gender and age, each child’s raw score is shown in Figure 5.04, Figure 5.05, Figure 5.06 and Figure 5.07 below.

Razz’s exercise video. Figure 5.04 shows the data for eight children at Presentation 1 and 2 for Razz’s exercise video, together with Presentation 1 data only for an additional five children. Visual analysis shows that all four boys increased their step counts (range: 79.20% - 248.78%) from Presentation 1 to Presentation 2. Three girls (LS, HR, EG) increased their step counts with a similar range of percent change to the boys (87.54% - 247.83%). However, one girl (RT) decreased her step count by 39.03%. Given that only one girl deviated from the increase in steps over Presentation 1 and Presentation 2, and there is an equal distribution of age across the step scores, there does not appear to be an effect of gender or age for Razz’s exercise video.

Figure 5.04. Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Razz’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.

A point-biserial correlation identified a weak relationship between the number of steps performed and gender at Presentation 1 ($r_{pb} = .37$, $n = 8$, $p = .36$), which decreased at Presentation 2 ($r_{pb} = .15$, $n = 8$, $p = .73$); however, both relationships were non-significant. At Presentation 1, a significant strong positive correlation was found between the age of the child and the number of step
performed \(r = .74, n = 8, p = .035\), however, the effect diminished and was not significant at Presentation 2 \(r = .12, n = 8, p = .78\).

**Tom’s exercise video.** All but one child (JW) provided paired data for Tom’s exercise video. Figure 5.05 shows that Tom’s exercise video was successful in encouraging all children to be active, and compared to Presentation 1, all children increased their activity levels at the second presentation. Visual inspection of the graph shows that the two youngest boys produced very differing changes in behaviour: the youngest boy (FJ) increased his step count by 8.22\%, whilst a boy 3 months older (MC) increased by 585.71\%. However, the step count for the youngest boy (FJ) at Presentation 1 exceeds that for all boys except JH. The remaining five boys increased their step count in the range of 67.10\% – 183.64\%. In comparison, two girls who are a year apart in age showed similar percent increases (MS, by 63.47\% and EG, by 64.87\%). The other three girls (LS, RT, HR) increased their step counts in the range of 119.42\% – 356.79\%. Visually, performance across the genders looks similar. However, inspection across the ages suggests that the older children performed more steps at Presentation 2 than the younger children.

![Figure 5.05](image)

*Figure 5.05. Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Tom’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.*

Exploratory correlation analysis confirms the visual inspection. A point-biserial correlation found no effect of gender at Presentation 1 \(r_{pb} = .02, n = 12, p = .96\), or at Presentation 2 \(r_{pb} = .09, n = 12, p = .78\). A bivariate correlation found a non-significant but weak correlation with age at
Presentation 1 ($r = .40, n = 12, p = .20$), however, a significant and strong correlation was confirmed at Presentation 2 ($r = .70, n = 12, p = .01$); this suggests that the older children responded with greater intensity during Presentation 2.

**Rocco’s exercise video.** Smaller changes in step count are apparent in Rocco’s exercise video (see Figure 5.06), however the nine children who contributed paired data cumulated the highest average of steps at Presentation 1 as compared to the other three exercise videos. The child (HR) with the highest steps at Presentation 1 was the only child to decrease her steps (18.12%) at Presentation 2 however, her step count at Presentation 2 still exceeded that for the other five children. Three girls made small increases (RT, 3.59%; EG, 6.69%; LS, 12.50%), whilst the oldest girl improved by 68.91%. The four boys improved by similar amounts (29.17% - 57.67%).

![Figure 5.06. Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Rocco’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.](image)

No significant effects were found for gender or age at Presentation 1 or at Presentation 2. A weak and non-significant relationship with gender was found at Presentation 1 ($r_{pb} = .44, n = 9, p = .23$), and no relationship at Presentation 2 ($r_{pb} = .03, n = 9, p = .94$). No relationship with age was found at Presentation 1 ($r = .18, n = 9, p = .65$), although a weak but non-significant relationship was apparent at Presentation 2 ($r = .48, n = 9, p = .18$).
Charlie’s exercise video. The least number of steps are modelled on screen in Charlie’s exercise video; however, the number of steps produced by the six children providing paired data are similar to those of the other exercise videos (see Figure 5.07). Four girls (RT, LS, HR, EG) increased their step count in the range of 50.87% – 168.18%, and one boy (PJ) increased by 74.58%. Only one child, a boy (AT), showed a small decrease in step count (13.99%). Visual inspection suggests that there is no gender effect or an age effect.

![Figure 5.07. Total number of steps performed by girls (solid lines) and boys (dashed lines) during Presentation 1 and Presentation 2 of Charlie’s exercise video. Each child’s initials are displayed adjacent to their data point, with age at the outset of the study in parentheses.](image)

A point-biserial correlation found no relationship between gender and step count at Presentation 1 ($r_{pb} = .14, n = 6, p = .79$), however, a weak relationship is apparent at Presentation 2 ($r_{pb} = .40, n = 6, p = .43$); both relationships were non-significant. A strong positive relationship was found at Presentation 1 ($r = .74, n = 6, p = .09$) but this failed to reach significance; however, there was no relationship at Presentation 2 ($r = -.02, n = 6, p = .97$). This shows that older children performed more steps during their first attempt; however, the younger children increased their steps as they became more familiar with the target actions, matching those of the older children.

Informal Observations

The following conclusions were derived from the informal observations by the researcher and supervisor: (a) the children were able to complete the actions, or would be able to do so with practice,
however, the children might benefit from a middle-tier additional learning section in which the children respond to each target action sequence shown in slow motion (‘slow motion 4-moves’), and additional verbal instructions to prepare the child for each transition in the moves within the action sequence; (b) the children were able to complete the actions in the space provided, and (c) the children remained engaged with the exercise videos for the full duration.

Discussion

The primary objective of this two-part chapter was (a) to create four exercise videos specifically tailored to the developmental and physical maturity of 3 – 4 year old children, and (b) to investigate their ability to evoke physical activity in the target population. The long-term aim of the Dynamic Dudes research programme described in this thesis is to combine the interactive stories and classroom exercise DVD to produce a new multi-component activity intervention for pre-school children (see Chapter 6 and Chapter 8).

The findings from the present study show that the video-modelled exercise component was effective in engaging the children in physical activity in the classroom setting, with the children completing an average range of 185.25 and 489.08 steps within an 8 – 10 minute time frame. This evidence is consistent with the success of the exercise videos previously administered to primary school children (Mitchell, 2014; Whitaker 2016), showing that the component is suitable for children aged 3 – 11 years. Consistent with the results of the interactive stories, there were no gender effects for any of the character’s exercise videos. Tom’s exercise video generated the largest total step count. However, the older children performed more steps during the second presentation of Tom’s exercise video compared to the younger children. Given the small sample size, this finding requires replication.

Strengths

The exercise component draws on some aspects of active gaming, a mechanism that has not previously been evaluated with pre-school children (Norris et al., 2016), which adds to the originality of this study. This study provides an initial demonstration of the effectiveness of exercise DVDs in the pre-school population. However, comparison with a control condition engaging in standard nursery practice is next required. The exercise videos included a slow-motion individual moves section, which provided the children with an opportunity to familiarise with the moves and learn the target actions prior to completing them at full speed. The purpose of the section was to increase children’s confidence in completing the modelled target actions during the levels section.

Visual inspection of the figures displaying the children’s individual data reveals that 85.29% of children increased their step counts during the second presentation of an exercise video (see Figure
5.03. This is more than double the increase from first to second presentation of the interactive stories (see Chapter 4). It could be hypothesised that the children used the first presentation as a familiarisation period, particularly as this included the slow motion section. However, further presentations are required to verify this difference and its significance for achieving behaviour change in the pre-school population.

**Limitations**

Within-group comparison of performance of the exercise videos could not be reported in the results section, as the presentations were not strictly comparable. The time capture of step counts period during the first presentation included the slow motion individual moves section. However, there was no slow motion section during the second presentation. Furthermore, informal observations indicate that the progression from the slow motion individual moves section to the levels section was too large. The children would benefit from an additional shaping section in order to practice the 4-moves together sequence at a decreased pace before proceeding the normal speed levels section.

**Conclusion**

In summary, the exercise videos were found to be effective in generating physical activity and feasible for delivery in the nursery environment with children aged 3 - 4 years. Minimal modifications to the exercise videos are considered to be required prior to their inclusion in the multi-component physical activity intervention. These modifications have been noted in Chapter 6 (p. 122). The exercise videos require further investigation to evaluate their effectiveness with a larger sample size and with a control condition participating in the standard nursery curriculum. The General Discussion Chapter 9 (p. 205) will consider the effectiveness of the exercise videos in further detail.
CHAPTER SIX: Let’s Have Some Adventures! Increasing Pre-school Children’s Physical Activity Levels with a Role-Modelling Dynamic Dudes Intervention.

Abstract

Objectives: To explore the effectiveness of the new Dynamic Dudes physical activity intervention for 3 – 4 year old children in terms of increases in their total in-school physical activity.

Design & Participants: A mixed, between-groups repeated measures design was employed in two nursery classes attached to primary schools in North Wales. Sixty-nine children were recruited to participate. The independent variable was the Dynamic Dudes intervention. One school was assigned to the intervention condition whilst the second school continued with their standard nursery curriculum. The intervention was delivered in the classroom and consisted of two main components: Dynamic Dudes exercise DVDs and Dynamic Dudes interactive stories presented on alternate days over a 24-d period.

Measures: To evaluate the effectiveness of the intervention, anthropometric measures (height, weight, and BMI) were conducted in both schools at baseline (T0) and post-intervention (T2). Fitbit Zip accelerometers were used to measure children’s total in-school step counts at baseline (T0), intervention (T1), and post-intervention (T2). During the intervention phase (T1), accelerometer measures of steps performed in each exercise video and interactive story session in the intervention school, and during the equivalent time periods in the control school, were also conducted. Google analytics monitored the participants’ use of the online home intervention (T3).

Results: No significant differences in BMI were found (between-groups: $p = .88$, $r = .02$; within-groups: $p = .69$, $r = .06$). A two-way ANCOVA, controlling for baseline levels and gender, found that at post-intervention the intervention condition performed significantly more steps than the control condition (T2; $p = .025$, partial $\eta^2 = .09$). Children also performed significantly more steps in the intervention condition during delivery of the exercise videos, and the interactive stories, as compared to steps performed by children over the same time period in the control school during their standard nursery curriculum (all $p$'s $\leq .002$, $r = .59 - .85$). No engagement with the online home intervention was found (T3).

Conclusion: The results of this study show that the Dynamic Dudes intervention is suitable for delivery to 3 – 4 year old children attending primary school classes, enabling them to perform a 15-minute burst of physical activity every day, a significant contribution to the daily-recommended activity targets for children of this age.

Results from the exploratory studies reported in Chapter 4 and Chapter 5 showed that the Dynamic Dudes video-modelling component enables pre-school children, both girls and boys, to
participate in structured physical activity in the nursery classroom environment. In Chapter 5, only three of the four interactive stories were trialled. To complete the planned Dynamic Dudes story component, Charlie’s interactive story was next produced and included in the present trial along with the stories for Tom, Rocco and Razz.

Modifications were made to the exercise DVD component. In each exercise video, an additional target behaviour learning section was added to support the children’s transition from the first section, a slow motion (half-speed) demonstration of each character’s four individual target behaviours presented separately, to the final “levels” section in which the four target behaviours are presented as a sequence, and at full speed. During the new intermediate section, named ‘slow motion 4-moves together’, the sequence of four target behaviours is shown at 75% speed to help scaffold the children’s learning to perform the four target actions at full speed in the final “levels” section. The Dynamic Dudes story and exercise components were presented in the intervention school on an alternating schedule, and evaluated here as a novel physical activity intervention for delivery to pre-school children attending primary school, with possible extension to the home environment.

Method

Ethical Approval

The School of Psychology Ethics and Research Governance Committee, Bangor University granted ethical approval to evaluate the effectiveness of a new Dynamic Dudes video-modelling intervention to increase pre-school children’s physical activity levels (Ethics application No.: 2013-11864).

Participants

Twenty-six primary schools were identified in three neighbouring counties of North Wales, including Gwynedd, and through direct contact by the researcher information was gathered from each of them to identify two schools that were matched for (a) nursery attached to the primary school, (b) Estyn report on school performance (c) nursery independent of reception class, (d) children scheduled to attend their nursery class for 2.50 hours on 5 days a week, for either a morning or afternoon session (although attendance was not compulsory) (e) minimum of 15 children in each nursery class (f) socio-economic status (eligible for Bangor University Widening Access Support), (g) number of weekly physical activity sessions. Two schools well matched on these criteria were recruited to participate in the study. As one school was a Welsh-medium primary school they were only willing to participate in
the control condition because the intervention components were only available in English; allocation to condition was therefore conducted on a pragmatic basis.

Informed parental consent was sought for the children’s participation. Recruitment to the intervention condition was conducted using opt-in information and consent letters to request permission both for participation in the study and filming of the children during the intervention (Appendix 6.01); however no filming was undertaken until after completion of the trial in case the presence of a camera biased the children’s responding to the intervention components. Parents of children taking part in the intervention condition were asked to report any medical conditions that may make their child’s participation inadvisable. The control condition received opt-out information and consent letters (Appendix 6.02); no child was opted out. Children’s dates of birth were obtained from each school. In total, 69 pre-school children (M = 4.17 years, SD = 0.50, range 3.75 to 4.67 years; 49.30% girls) were recruited to the study at baseline.

**Experimental Design**

A mixed, between-groups repeated-measures design was employed with measures taken throughout the study (see Figure 6.01).

![Figure 6.01](image.png)

**Figure 6.01.** Schematic outlining the design of the study.

The independent variable was the Dynamic Dudes classroom intervention, which was delivered in three 8-day blocks in the intervention school. In the course of each 8-day block, presentation of the exercise videos and interactive stories alternated across days and a different one of the four exercise videos or the four interactive stories was presented per day so that after 8 days all
elements in each component had been delivered once. Over the three blocks, children therefore received a total of three presentations of each story, and of each exercise video, if they were present on every day of the intervention phase. The home intervention phase made both video-modelling components available in the home environment for the children to complete. The dependent variables were: (a) anthropometric measures (height, weight, and body mass index [BMI]), (b) children’s total in-school step counts during their participation in the standard nursery curriculum, (c) children’s total in-school step counts during the Dynamic Dudes intervention phase, (d) children’s step counts in the exercise DVD and interactive story sessions (intervention condition), or during equivalent time periods in the control school and (e) engagement with the home intervention (intervention condition only). To gather feedback on the intervention, a questionnaire (Appendix 6.03) was administered to the intervention teachers.

A researcher attended both schools during every day of the study to ensure that step count measures were taken consistently throughout all phases. However, to minimize disruption of the standard nursery curriculum, and demand characteristics due to her presence, the researcher did not remain in the nursery environment after placing the rainbow custom-made tabards on the children.

Materials

**Dynamic Dudes physical activity intervention (school and home phases).** The interactive story and exercise DVD components described in Chapters 4 and 5, respectively, were shown to the intervention children only. In summary, the video-modelling components featured four young Dynamic Dudes characters: Rocco, Razz, Tom, and Charlie. Each character had their own interactive story and exercise video each set in their own location, and performing target actions specific to their respective favourite activities.

In the school intervention phase (T1), the components were delivered in accordance with the alternating presentation schedule described above. Two A3 Dynamic Dudes calendars (Figure 6.02) were displayed at child level on a wall in the nursery class room, so that the children could see which interactive story or exercise video would be completed on each particular day. Given that the children who attended in the mornings were different from those attending in the afternoons, there were separate calendars for the morning and afternoon sessions.
For the home intervention phase, the four interactive stories and four exercise videos were hosted on the research lab’s website (caer.bangor.ac.uk/dynamic-dudes) for the parents and children to access. Each child received a Dynamic Dudes Home Adventures letter (Appendix 6.04) explaining the intervention, and an Adventure Chart (Figure 6.03) similar to the in-school classroom calendar, to record their achievements at home.

**Figure 6.02.** Dynamic Dudes calendar illustrating the alternating presentation schedule for the interactive story and exercise DVD components of the school intervention phase.

**Figure 6.03.** Dynamic Dudes Home Adventures chart for each child to record their participation at home during the home intervention phase.

**Measures**

**Anthropometric.** The children’s height and weight were measured in accordance with National Child Measurement Programme guidelines (Public Health England, 2013) and as outlined in Chapter 2 (p. 52). Accelerometry measures were collected at baseline (T0) and post-intervention (T2) phases.

**Accelerometry.** To measure the children’s physical activity levels, all children wore Fitbit Zip accelerometers housed in tabards to record their step counts (see Chapter 3, p. 80, for full details of
the Fitbit Zips and tabards). Consistent with previous chapters, the researcher told the children that the device was a “button” inside their tabard, to tell the researcher who each tabard belonged to, and that they were going to wear the tabards whilst in nursery. The children accepted this explanation, and were happy to wear the tabards throughout the study. A researcher was responsible for putting the tabards on, and taking them off the children each day. Accelerometer measures were collected throughout the baseline (T0), the school intervention (T1), and the post-intervention (T2) phases of the study.

**Home intervention phase (intervention condition only).** To evaluate the engagement of the parents and children with the home intervention phase, Google Analytics, a web analytics service to track activity on customised websites, was created to monitor activity on the ‘Dynamic Dudes Home Adventures’ websites (T3). As each parent and child had their own website (see Procedures), a Google Analytics tracking page was set up to monitor each individual account to record the following information: (a) when an individual logged onto the website, (b) which pages they accessed, (c) which interactive stories and videos they played, and (d) how long they played the videos, specified in terms of the following duration of engagement categories: play, 10%, 25%, 50%, 90%, or end.

**Feedback questionnaire (intervention condition only).** Following completion of the post-intervention (T2) measure, the nursery staff members that had been involved in delivery of the intervention were asked to complete a feedback questionnaire (Appendix 6.03). The questionnaire consisted of a mixture of open and closed questions to gather feedback on specific elements of the intervention. A free-comments section was also provided.

**Procedure**

Following detailed consideration of the Estyn reports, the researcher contacted suitable local schools in the three local Welsh counties, and made appointments to see the Head Teachers to outline verbally the study requirements; where a face-to-face meeting was not possible, details were discussed over the telephone. Written information was also given to Head Teachers during the meeting or by email (intervention condition, Appendix 6.05; control condition, Appendix 6.06).

Following agreement for the nursery classes’ participation, condition-appropriate consent letters were distributed to parents (intervention condition, Appendix 6.01; control condition, Appendix 6.02). In both conditions, the morning nursery sessions were scheduled from 9am until 11.30am, and the afternoon session from 12.30pm until 3pm.

**Baseline (T0): Anthropometric and accelerometry measures (10 days).** The tabards with Fitbit Zips in situ were placed on the morning session children between 9:00 – 9:20am as they entered the nursery, then removed between 11.15 – 11:30am before they left the nursery. The tabards were placed
on the afternoon session children between 12:30 – 12:50pm, and removed between 2:45 – 3:00pm. Each Fitbit Zip had an identification number for each child, to ensure they wore the same tabard every day. The children were encouraged to remember their identification number, and instructed to keep their tabard on until an adult took it off. They were unaware that their steps were being counted, and no feedback on their step counts was provided. The Fitbit Zips were synced to a computer every Friday evening to transfer the recorded steps data via Bluetooth. The data were then stored online in each individual Fitbit account ready for later extraction (see Data Analysis).

Anthropometric measurements were conducted during baseline by the same researcher, following the same protocol, as outlined in Chapter 2 (p. 52). The measures were conducted in a designated area of each nursery classroom, in full view of the nursery staff.

No intervention was delivered during the 10-days of baseline; both nurseries were instructed to continue with their standard nursery curriculum. In the intervention condition only, the researcher provided training on delivery of the school intervention to the nursery staff, and explained what would be required of them, however it emphasised that a researcher would always be present and lead the intervention delivery. Written instructions were also provided (Appendix 6.07).

Intervention condition

**School intervention phase (T1): Accelerometry measure (24 days).** The children continued to wear the Fitbit Zips and tabards throughout the school intervention in order to continuously measure their step counts each day. On Day 1 of the intervention, the researcher explained to the children that they were going to start a very exciting adventure with four Dynamic Dudes characters, namely, Tom, Rocco, Charlie and Razz, who all have lots of very special energy, and like to be very active. The children were given a brief description of each of the character’s adventures, and were asked related questions (e.g. Rocco goes to the jungle, and he runs like a cheetah; Razz loves to dance, who here loves to dance?). The intervention children had experienced a small sample (days < 5) of the Early Years Food Dudes healthy eating intervention 6-months previously, and consequently had some familiarity with the characters. The researcher then proceeded to show the Dynamic Dudes calendar (Figure 6.02) to the children, and explained that they could use it to find out which interactive story or exercise video they would be completing each day; a box with a character performing an action symbolised an exercise video, and a box with a character set in their story location symbolised an interactive story. The children’s role in completing the white boxes on the calendar was also explained; on interactive story days, the children were asked to place a tick in the box to show they had completed the scheduled interactive story, and on exercise DVD days, the children were asked to write the number of the level they had completed; assistance by an adult was given when required. The calendars were displayed at child-level in the classroom. This provided the class with a visual
record of their achievements each day and provided the children with a sense of ownership, encouraging them to explore the calendar, in turn raising the profile of the Dynamic Dudes in the classroom.

The researcher arranged with the teachers that the intervention could be conducted around 10.00am during the morning session, and around 1.30pm during the afternoon session. At the allocated time, the researcher invited the children to stand in front of the interactive white board, and to get into a space where they could perform the target actions without accidently touching any of their friends. On Day 1, the children watched the exercise DVD ‘Meet the Dudes’ section, which provided further visual information about the intervention and “set the scene” for the scheduled video-modelling component that followed, in this instance Rocco’s exercise video.

The video-modelling DVDs were shown on an 8-day presentation cycle following the alternating schedule, for 3 presentation blocks; this provided a total of 3 presentations to each interactive story and exercise video. On the days that the interactive stories were shown, they were presented in their entirety. However, the presentation of the exercise DVD was shaped to help the children to learn the target actions. Table 6.01 illustrates which sections of the exercise DVD were shown dependent on the presentation block.

Table 6.01.

Sections of the exercise DVD delivered in each presentation block.

<table>
<thead>
<tr>
<th>Presentation Block</th>
<th>Intervention Day</th>
<th>Slow Motion Individual Moves</th>
<th>Slow Motion 4-Moves Together</th>
<th>Slow Motion 1 – 10 Levels</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1, 3, 5, 7</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>2</td>
<td>9, 11, 13, 15</td>
<td>x</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>3</td>
<td>17, 19, 21, 23</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In every exercise DVD session, the children were encouraged to complete up to 10 levels, however, if the researcher judged that 80% of the children had stopped participating, the exercise DVD ended. The researcher noted the time when the intervention commenced and when it was completed. When the session ended, one of the children was chosen to record on their class Dynamic Dudes calendar the performance achieved by their class. The children were told a child was chosen based on their effort whilst completing the respective interactive story or exercise DVD.

Each day of the intervention, a researcher was only present in the classroom to administer and collect tabards, and to deliver the intervention. A researcher led and participated in the video-
modelling components; a teacher was always present in the classroom, and periodically joined in. The researcher provided verbal prompts to the children, and verbally praised them for their performances.

**Parent session.** The researcher liaised with the nursery staff to identify the most suitable day and time to host a brief parent session. All parents were invited by a letter (Appendix 6.08) to attend a short morning meeting on Day 23 of the school intervention phase. During the session, the researcher briefed the parents on the nursery intervention, showed a short clip of an interactive story and an exercise video, and completed the session by explaining the home intervention phase.

**Post-intervention measure (T2): Anthropometric and accelerometry measures (9 days).** Baseline procedures were repeated for 9 days; the children continued to wear the Fitbit Zips and tabards, and anthropometric measures were also collected. The intervention questionnaire was administered to the nursery staff who were asked to complete the questionnaire independently, and were assured that their responses would remain anonymous.

**Home intervention phase (T3): Google analytics (summer holidays).** On completion of the post-intervention measures, the parents received a letter (Appendix 6.04) describing the home intervention phase, and providing them with their tailored log-in details. Parents were encouraged in the letter to show the Dynamic Dudes intervention, hosted on the research lab website, to their children during the 6-week summer holidays, and record which interactive stories and exercise videos they completed, and when, on an A4 Dynamic Dudes Home Adventures chart (Figure 6.03). The chart was to be returned after the holidays. Parents’ login password was their child’s first name to make the password as memorable as possible. Google analytics monitored the use of each of the login codes; parents were informed that their engagement would be monitored. The parents and children were also invited to invent a story plot for a new interactive story. They were asked to submit their stories online through the site, and were told that the best four story plots would receive a prize; the prize was not disclosed.

**Control condition.** The control condition also participated in the anthropometric and accelerometry measures at baseline (T0) and post-intervention (T2), following the procedures outlined above for the intervention condition. During the Dynamic Dudes intervention phase (T2), the nursery staff members were asked to continue with their delivery of the standard nursery curriculum. As in the intervention condition, a researcher put the tabards with Fitbits in situ on the children at the start of the session, and removed them at the end, which ensured that the number of daily visits was matched across schools. The researcher did not remain in the classroom during the remainder of the session.
Data Analysis

**Anthropometric measures (T0; T2).** Children were required to be present for both the height and weight measures at both measurement periods in order to be included in the anthropometric analyses. The data met the criteria for parametric analysis. Descriptive statistics were calculated for height, weight, and BMI, and planned contrasts were conducted for BMI using independent samples t-tests to investigate whether there were any significant differences in the measure between the intervention and control conditions at baseline (T0), and post-intervention (T2), and a paired samples t-test investigated within each condition. A Pearson’s product moment correlation test was conducted to explore the relationship between BMI and the mean number of steps performed (Bonis et al., 2014; Duncan, Nevill, Woodfield, & Al-Nakeedbd, 2010; Hardman et al., 2011).

**Accelerometry (T0; T1; T2).** Following completion of the study, the granulated minute-by-minute Fitbit data were obtained from a third-party source (whatAdata). Within the data, cut-off time points were determined for the nursery sessions based on when the tabards had been placed on all the children, and when they were removed, throughout the study. As in both conditions the children wore the tabards between the same time frames, R studio was used to extract the required data, and assign a ‘total step count score’ for each daily session to each child. The cut-off times were: (i) morning – 9:20am to 11:15am, and (ii) afternoon – 12:50pm to 2:45pm. In both sessions, 115 minutes of data were obtained. The daily data were then assigned to the corresponding phases (baseline, intervention, or post-intervention). The accelerometer data were considered separately as (a) baseline and post-intervention measures; (b) school intervention phase measures; and (c) intervention component measures (see respective sections below).

**Comparison of baseline (T0) and post-intervention (T2) measures.** The Day 1 baseline data were discarded to decrease any novelty effects that may have caused by a change in the children’s routine and the initial presence of the researcher, therefore a maximum of 9 days of data were obtained for each child. For the post-intervention measure, school trips and other unanticipated school events prevented the children from wearing the tabards on several days resulting in a maximum of 7 days of post-intervention data. To be included in the analysis the children were required to have a minimum of 3 days of data during both the baseline and post-intervention measurement points. Addy et al. (2014) recommend that 3 days of data for total in-school physical activity assessment are sufficient to provide a representative sample based on an intra-class correlation of 0.75 for their data set.

At both measurement periods, a ‘mean step count score’ was calculated for every child. The computed mean step count scores were assessed for outliers, and the data met the criteria for parametric analysis. Descriptive statistics were calculated and plotted. A-priori independent t-tests
found significant differences between the two conditions at baseline ($p < .001$, $r = .88$), and between the number of steps performed by girls and boys at baseline in the intervention school ($p = .025$, $r = .29$); therefore baseline and gender were next considered as covariates in a two-way analysis of covariance (ANCOVA) with the post-intervention measure as the dependent variable.

**Intervention phase measure (T1): Mean daily total in-school steps (115 mins).** The data were partitioned into the 3 presentation blocks, and children were included in the analysis if they had a minimum of 3 days of data in each block. A ‘mean step count score’ was calculated for each child for each presentation block. The calculated mean count scores were assessed for outliers, and the data met the criteria for parametric analysis. Within-group comparison across the 3 blocks of the intervention condition was not appropriate because the children received different elements of the exercise DVD component in each block to help them learn the target actions, with the result that the blocks were not directly comparable independent variables. Consequently, independent t-tests were employed to explore any differences in the number of steps performed in each condition during each block, and a one-way repeated measures analysis of variance (ANOVA) was performed to investigate any changes in step count over time in the control condition.

**Intervention phase measures (T2): Mean steps during exercise/story sessions.** Step counts during the exercise videos and interactive stories in the intervention school during Presentation Block 3 were compared with steps performed over the matched time interval in the control school while those children were engaged in their standard nursery curriculum activities. Presentation block 3 was chosen for the comparison as this included only the ‘Levels’ section of the exercise videos, which is the main element of the exercise DVD component of the intervention; the slow-motion elements in Blocks 1 and 2 were designed to scaffold the children’s learning of the target actions. The data were found to be positively skewed and so were log transformed. However, the raw data are reported for the purpose of descriptive analysis. Independent t-tests were conducted to evaluate differences in the number of steps performed by the intervention and control children for the duration of each exercise video, and duration of each interactive story. One-sample t-tests compared the number of steps modelled on-screen during each exercise video, and during each interactive story, to the average number of steps actually performed by the children. The interactive stories were visually coded for steps modelled using the direct observations framework outlined in Chapter 3. Additionally, as outlined for the school intervention phase measure, no within-group effects could be calculated for the exercise videos, as the delivery was not directly comparable across presentation blocks. However, as the interactive stories were administered identically in each presentation block, and the within-group effects of all four interactive stories have not been assessed previously (see Chapter 4), a one-way repeated measures ANOVA was performed across the 3 presentation blocks for each of the four
interactive stories. Planned comparisons to explore differences between the presentations were performed using paired samples t-tests.

**Results**

A total 59 children (M age = 4.17 years, SD = 0.50 years, range 3.75 – 4.67 years; 85.51% retention) were included in the analysis comparing total in-school physical activity at baseline (T0) and post-intervention (T1). However, only 45 of the 59 children (76.27%) contributed to the anthropometric analyses.

**Anthropometric**

Table 6.02 shows the intervention and control mean anthropometric scores obtained at baseline (T0) and at post-intervention (T2). There were no significant between-groups differences found for the BMI measure (baseline: $t (43) = 0.15$, $p = .88$, $r = .02$; post-intervention: $t (43) = 0.40$, $p = .69$, $r = .06$), or within-groups differences between baseline and post-intervention (intervention: $t (25) = -0.58$, $p = .57$, $r = .12$; control: $t (25) = 0.82$, $p = .43$, $r = .16$). The children’s BMI was not significantly correlated with their mean step count at baseline ($r = .03$, $p = .84$).

**Table 6.02.**

Mean scores of the anthropometric measures taken by condition, with SDs in parentheses.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Measurement</th>
<th>Height (cm)</th>
<th>Weight (kg)</th>
<th>BMI (kg/m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intervention</td>
<td>Baseline</td>
<td>104.05 (4.69)</td>
<td>17.95 (2.20)</td>
<td>16.55 (1.45)</td>
</tr>
<tr>
<td>(n = 26)</td>
<td>Post-intervention</td>
<td>104.81 (4.89)</td>
<td>18.27 (2.40)</td>
<td>16.58 (1.54)</td>
</tr>
<tr>
<td>Control</td>
<td>Baseline</td>
<td>102.48 (3.88)</td>
<td>17.32 (1.81)</td>
<td>16.48 (1.39)</td>
</tr>
<tr>
<td>(n = 19)</td>
<td>Post-intervention</td>
<td>103.97 (4.12)</td>
<td>17.75 (2.04)</td>
<td>16.40 (1.49)</td>
</tr>
</tbody>
</table>

**Accelerometry**

**Baseline to post-intervention total in-school physical activity.** Figure 6.04 shows the children’s mean total number of steps performed during their daily morning or afternoon nursery class session at baseline (T0) and post-intervention (T2). At baseline, on average the intervention children performed 733.41 steps ($SD = 202.64$) and the control children performed 1734.35 steps ($SD = 324.80$). At post-intervention, the gap in the children’s step count reduced substantially, with the intervention children performing 1555.91 steps ($SD = 487.62$), exceeding the control children’s 1482.25 steps ($SD = 264.29$).
Figure 6.04. Mean total number of steps performed by the children in the intervention (grey bars) and control conditions (unfilled bars) at baseline (T0) and at post-intervention (T2). Error bars represent ±1 of the standard error of the mean.

A two-way ANCOVA found that the covariate, baseline, was significantly related to the number of steps performed by the children at post-intervention, $F (1, 54) = 5.47, p = .023$, partial $\eta^2 = .09$. No significant main effect of gender was found, $F (1, 54) = 0.004, p = .95$, partial $\eta^2 < .001$, and there was no significant interaction between gender and condition, $F (1, 54) = 0.05, p = .82$, partial $\eta^2 = .001$. However, a significant main effect of condition was revealed on the mean number of steps performed by the children after adjusting for the effect of baseline, $F (1, 54) = 5.33, p = .025$, partial $\eta^2 = .09$. The intervention children performed an adjusted mean of 1809.41 (SE = 137.58) steps and the control condition performed an adjusted mean of 1225.25 (SE = 139.28) steps.

**School Dynamic Dudes intervention phase.**

**Total in-school physical activity.** Sixty-two children (89.86% retention) provided data for the total in-school physical activity measure. Figure 6.05 shows the mean number of steps performed by the intervention and control children during the 3 presentation blocks. The intervention condition performed on average 1169.20 (SD = 290.67) steps during Block 1, 1576.82 (SD = 344.41) steps during Block 2, and 1266.33 (SD = 283.53) steps during Block 3. However, the control children consistently outperformed the intervention children with 1645.05 (SD = 248.37) steps during Block 1, 1843.98 (SD = 311.65) steps during Block 2, and 1597.69 (SD = 412.35) steps during Block 3. Both conditions follow the same pattern over time, with an increase from Block 1 to Block 2, followed by a decrease from Block 2 to Block 3.
Between-groups comparisons at each presentation block revealed that the control children, as compared to the intervention children, performed significantly more steps during Block 1 ($t(60) = -6.91$, $p < .001$, $r = .66$), during Block 2 ($t(60) = -3.20$, $p = .002$, $r = .34$), and during Block 3 ($t(60) = -3.71$, $p < .001$, $r = .43$).

As only the control condition is directly comparable within-groups, a one-way repeated measures ANOVA was performed. As the assumption of sphericity was violated ($X^2 = .70$, $p = .007$, $\epsilon_{\text{Greenhouse-Geisser}} = 0.77$), a Greenhouse-Geisser correction was applied. The ANOVA found a significant change in the number of steps performed by the control children over the presentation blocks $F(1.54, 44.74) = 12.24$, $p < .001$, partial $\eta^2 = .30$. Planned comparisons between the blocks found that the control children significantly increased their steps from Block 1 to Block 2, ($t(29) = -5.34$, $p < .001$, $r = .33$), and significantly decreased from Block 2 to Block 3 ($t(29) = 246.29$, $p < .001$, $r = .32$). There was no significant increase from Block 1 to Block 3 ($t(29) = 4.51$, $p = .46$, $r = .07$).

**School Dynamic Dudes Intervention Delivery**

**Exercise videos.** To assess how effective the exercise videos were in engaging the children in short bursts of physical activity, the mean number of steps achieved during their 3rd exposure to the respective videos is shown in Figure 6.06. The control condition’s mean step counts over the corresponding time frames whilst participating in the standard nursery curriculum are also shown. During Rocco’s exercise video, on average, the intervention children performed 333.45 steps (SD =...
120.46) compared to the control children who performed 25.45 steps (SD = 29.17). The intervention children performed 293.30 steps (SD = 157.26) during Charlie exercise video, whereas the control children performed 157.50 steps (SD = 262.41). During Razz’s exercise video, the intervention children performed 319.86 steps (SD = 94.82) compared to the control children’s 42.29 steps (SD = 58.30). The intervention children performed 392.43 steps (SD = 84.49) during Tom’s exercise video, whilst the control children only performed 40.52 steps (SD = 56.47).

![Mean number of steps performed by the intervention condition (grey bars) during the 3rd presentation of each of the four exercise videos, and by the control condition (unfilled bars) during the equivalent time frames. Error bars represent ±1 of the standard error of the mean. Figure based on raw data.](image)

As the data were skewed, log-transformed data were used in statistical analyses. Between-condition comparisons show that the exercise videos were successful in engaging the intervention children in physical activity. During the delivery of the all four exercise videos the intervention children outperformed the control children in the matched time who were in engaged in standard nursery curriculum (Rocco: $t(23.83) = 8.79$, $p < .001$, $r = .84$; Charlie: $t(37) = 16.55$, $p = .002$, $r = .59$; Razz: $t(21.07) = 8.01$, $p < .001$, $r = .84$; Tom: $t(22.79) = 8.73$, $p < .001$, $r = .85$).

The intervention children performed the most steps during Tom’s exercise video. However, comparison of the steps performed by the children in relation to the number of steps that were modelled in each exercise video revealed that the intervention children performed significantly more steps than were modelled during Razz’s exercise video (250 steps modelled; $t(21) = 3.46$, $p = .002$, $r = .35$), and there was no significant difference between steps modelled and steps children performed.
during Charlie’s exercise video (240 steps modelled: $t(22) = 1.63, p = .12, r = .19$), or during Rocco’s exercise video (300 steps modelled; $t(21) = 1.30, p = .21, r = .14$). However, the children performed significantly less steps than were modelled during Tom’s exercise videos (500 steps modelled; $t(20) = -5.83, p < .001, r = .54$).

**Interactive stories.** To evaluate the number of steps performed by the children whilst participating in the interactive stories, the children’s mean number of steps performed during their 3rd presentation of each interactive story is presented in Figure 6.07. For comparison, the control condition steps counts from the same time frames whilst engaging in standard nursery curriculum are also plotted. The intervention children performed 427.88 steps (SD = 145.20) during Rocco’s interactive story, while the control children performed 143.28 steps (SD = 83.34). Whilst completing Charlie’s interactive story, the intervention children performed 303.43 steps (SD = 127.22), while the control children performed 41.04 steps (SD = 47.95). During Razz’s interactive story, the intervention children performed 406.48 steps (SD = 112.83) and the control children performed 46.31 steps (SD = 59.51). The intervention children performed 405.64 steps (SD = 166.09) during Tom’s interactive story, whilst the control children performed 82.42 steps (SD = 55.22).

![Figure 6.07](image)

*Figure 6.07.* Mean number of steps performed by the intervention condition (grey bars) during the 3rd presentation of the four interactive stories, and by the control condition (unfilled bars) in the equivalent time frames. Error bars represent ± 1 standard error of the mean.

As for the exercise videos, the interactive stories evoked more steps in the intervention children, who all performed a significantly larger number of steps as compared to the control children participating in their standard nursery curriculum (Razz: $t(47) = 14.21, p < .001, r = .84$; Charlie: $t(27.49) = 0.50, p = .62, r = .14$).
\[ t(29.06) = 9.25, p < .001, r = .83; \text{Tom: } t(22) = 9.25, p < .001, r = .83; \text{Rocco: } t(36.36) = 8.37, p < .001, r = .78. \]

One sample t-tests found that the children performed significantly less than the number of steps modelled in all four interactive stories (Razz: 586 steps modelled, \( t(22) = -7.63, p < .001, r = .62 \); Tom’s: 732 steps modelled, \( t(24) = -9.83, p < .001, r = .70 \); Charlie: 617 steps modelled, \( t(22) = -11.82, p < .001, r = .78 \); Rocco: 853 steps modelled, \( t(23) = 14.34, p < .001, r = .83 \)).

**Within-groups comparison.** Figure 6.08 shows the mean step counts of the children who participated in all three presentations of an interactive story (see Appendix 6.09 for descriptive statistics). There is an increasing trend in step count over presentations with the exception of Charlie’s interactive story.

![Figure 6.08. Mean number of steps performed by the intervention children during the three successive presentations of each character’s interactive story. Error bars represent ± 1 standard error of the mean.](image)

Four individual one-way repeated ANOVA’s were conducted, one for each interactive story. No significant main effect of time was found for Rocco’s interactive story (\( F(2, 46) = 1.93, p = .16, \) partial \( \eta^2 = .08 \)) or Charlie’s interactive story (\( F(2, 44) = 2.64, p = .08, \) partial \( \eta^2 = .11 \)). In the case of Tom’s story, the data violated the sphericity assumption (\( X^2 = .66, p = .008, \epsilon_{\text{Geisser}} = 0.74 \)). A significant main effect of time was found after application of the Greenhouse-Geisser correction (\( F(1.48, 35.72) = 10.96, p = .001, \) partial \( \eta^2 = .31 \)). Planned comparisons between the three presentations of Tom’s interactive story found no significant change in step count between Presentation 1 and Presentation 2 (\( t(24) = -0.66, p = .52, r = .07 \)). However, the intervention children significantly increased their step
counts from Presentation 1 to Presentation 3 (t (24) = -3.41, p = .002, r < .001), and also from Presentation 2 to Presentation 3 (t (24) = -4.26, p < .001, r = .38). In the case of Razz’s interactive story, a significant main effect of time was also found. As sphericity was violated (X² = .70, p = .024, \( \varepsilon_{\text{Greenhouse-Geisser}} = 0.77 \)), the Greenhouse-Geisser correction was first applied (F (1.54, 33.89) = 19.41, p < .001, partial \( r^2 = .47 \)). Planned comparisons found only a trend towards a significant increase in step count from Presentation 1 to Presentation 2 (t (22) = -1.88, p = .07, r = 1.00); however, the children significantly increased their step counts from Presentation 1 to Presentation 3 (t (22) = -9.09, p < .001, r = .64), and from Presentation 2 to Presentation 3 (t (22) = -3.60, p = .002, r = .41).

**Comparison of exercise videos and interactive stories.** Paired samples t-test found that the children performed significantly more steps during Rocco’s interactive story compared to Rocco’s exercise video (t (15) = -2.70, p = .017, r = .57). A similar significant result was found between Razz’s components (t (17) = -2.53, p = .022, r = .52). However, there was no significant difference between the components for Charlie (t (18) = 0.92, p = .37, r = .21) or Tom (t (18) = -1.15, p = .27, r = .26).

**Feedback Questionnaire (intervention condition only)**

After completing the post-intervention measures, nursery staff members in the intervention school were invited to complete a feedback questionnaire (Appendix 6.03); all four members of staff consented.

When asked on a 5-point scale, the nursery staff were all in agreement that the children ‘really liked’ the programme. When asked how well the children could complete the target actions in each interactive story and each exercise video, all members of staff reported ‘very well’ for all four interactive stories; three members of staff responded ‘very well’ for Rocco, Tom, and Razz’s exercise video, and one responded ‘well’. However, for Charlie’s exercise video all four members of staff reported ‘well’.

The nursery staff unanimously answered ‘yes’ to the question about suitability of the intervention materials for the children and whether they could understand the Dynamic Dudes calendar. Two nursery staff members reported that they believed that the exercise DVD should be modified; through free comments they suggested that the voiceover should be recorded after the filming, and then layered together. One of two nursery staff members suggested the use of the character’s voice for the voiceover. They also reported that both feedback points were applicable to the interactive stories. The members of staff were asked whether they felt the programme had made the children more active. Three members of staff responded ‘more active’ and one member of staff did not respond. As the programme was researcher-led, the nursery staff were asked if they felt they could administer the programme without assistance; three responded ‘yes’, and one responded ‘no’
but added in the free comment section that the programme “needed explaining in the beginning but after that yes – would be easier to fit in the school schedule”. When asked if they could integrate the programme with the curriculum, three responses reported ‘yes’, with two free comments suggesting that they “could use in P.E”, and a second “with knowledge of the school themes – base programmes”; one staff member responded “sometimes”. Concluding free comments from two members of nursery staff were that programme delivery would be more effectively scheduled at the start or end of the nursery session as opposed to in the middle.

**Home Intervention (Intervention condition only)**

No online activity was found on Google analytics showing that neither parents nor the children engaged with the online Dynamic Dudes Home Adventures intervention. Also, no stories were submitted and no Home Adventures Charts were returned.

**Discussion**

The main aim of the present study was to investigate the short-term effectiveness of the new Dynamic Dudes classroom intervention to increase 3 – 4 year old children’s step count during their nursery session compared to a control condition engaging in standard nursery curriculum. The results provide the first evidence that the behaviour change intervention can successfully increase pre-school children’s physical activity levels: controlling for baseline activity levels, the intervention condition performed significantly more steps at post-intervention than the control condition. These findings are consistent with the behaviour change obtained with primary school children (Mitchell, 2014; Whitaker, 2016).

A gender difference was found at baseline, with the boys performing more steps than the girls, however, a main effect of gender was not found. This finding contributes to the on-going dispute in the literature, which is currently inconclusive as to whether a gender difference exists at pre-school age with some systematic reviews reporting differences (Bingham et al., 2016; Hinkley et al., 2008) whilst others report that there are none (De Craemer et al., 2012; Li et al., 2015).

During the intervention phase, the control children consistently outperformed the intervention condition. Visual inspection of Figure 6.04 and 6.05 clearly shows that the control condition performed a consistent average number of steps across baseline, the intervention phase, and post-intervention, whereas the intervention condition showed large increases in their step count following baseline maintained at post-intervention.
Strengths

This study demonstrates the alternative method of collecting accelerometry measures with larger numbers of pre-school children wearing non-intrusive tabards throughout the nursery session; no resistance to wearing the tabards was displayed unlike the difficulties found with attaching other accelerometer devices with this target population (Costa et al., 2015). During a 150 minutes nursery session, the tabards and Fitbit Zips were successfully worn for 115 minutes (76.67%), capturing a representative amount of the session given that the start and end of the nursery session are transition phases (e.g. coats on and off the children). Furthermore, the results of the interactive stories and the exercise videos concur with Chapters 4 and 5, respectively, as they successfully engaged the children in short bursts of physical activity resulting in their consistent performance of significantly more steps than the control children over a matched time-frame.

Limitations

There were limitations in this study, which can be addressed in future studies. Despite matching the schools on a detailed set of criteria, an objective measure showed a significant difference in physical activity levels across the two schools at baseline. In order to ensure that schools are matched, a pre-baseline measure could be conducted in order to pair schools more closely on baseline activity. From the outset of delivery of the exercise videos, with the exception of Day 1, the intervention children completed all 10 levels. This finding suggests that the levels could be extended if they are achievable from the beginning. As reported in Chapter 5, delivery of the exercise videos were not directly comparable. Future studies should only capture the “levels” section to enable the comparison. Unfortunately, no engagement with the parent intervention was found suggesting that the application of additional behaviour change variables may be required to motivate their participation.

Conclusions

In summary, when comparing the children’s step count to the empirical equivalent (6000 steps; Gabel et al., 2013) of the 180 minutes of physical activity guidelines (Department of Health, 2011), the intervention condition performed 12.22% at baseline and increased to 25.84% at post-intervention. Such positive findings are promising whether the intervention is administered as a stand-alone intervention, or as part of a multi-component intervention; however the long-term effectiveness of the intervention should also be investigated. The results of this study will be discussed further in the General Discussion (Chapter 9, p. 205).
CHAPTER SEVEN: Modifications to Components of the Food Dudes Healthy Eating Intervention and the Dynamic Dudes Physical Activity Intervention to Create the Super Dynamic Food Dudes Intervention for Pre-school Children.

Four of the previous chapters in this thesis have described the development and evaluation of two separate behavioural interventions for pre-school children, one targeting healthy eating (Chapter 2) and the other physical activity (Chapters 4 – 6). As explained at the beginning of the thesis, this PhD research programme aims to design and evaluate a multi-component intervention targeting both healthy eating and physical activity to teach pre-school children two prerequisite repertoires for a healthy lifestyle. Outcomes from the previous experimental studies (Chapters 2, 4 – 6) highlighted the need for modification of some aspects of the intervention procedures and materials. Some of these changes are required to ensure the successful merger of the interventions to create the multi-component ‘Super Dynamic Food Dudes Intervention’ (Chapter 8). Others were needed to increase ease of delivery of the procedures by nursery staff whilst at the same time maintaining effectiveness of the intervention. This chapter will explain each modification, by (a) re-stating how each relevant protocol was delivered in preceding studies, (b) describing how it would be modified for the final controlled evaluation of the multi-component intervention, and (c) providing a justification for the change. Where procedures were modified, this often required changes to the relevant materials.

One modification applicable to the research overall relates to the presence or absence of the researcher during delivery of the intervention. In the earlier studies described in this thesis, the researcher was either fully or partially involved in delivery of the intervention. However, the long-term goal for this new healthy eating and physical activity intervention is for it to be implemented entirely by school staff. Evaluating the intervention when delivered by school staff increases the ecological validity of its impacts on the target behaviours. In addition, during the physical activity intervention, the researcher was also the presenter on screen who modelled the target actions during the interactive video stories. If the children were to recognise the common identity of researcher and presenter, this could be considered a potential confounding variable in the previous physical activity intervention studies; it is also a situation that would not occur in future large-scale deliveries of the intervention. Consequently, it was decided that, after pre-training, the nursery staff would be responsible for delivery of the multi-component intervention evaluation, aided with scripts, and that when the researcher needed to visit the schools she would adopt a disguise that would prevent the children from recognising her as the on-screen model (see Appendix 7.01 for visual of the disguise).
Food Dudes Healthy Eating Intervention

A total of 11 modifications were applied to the Food Dudes healthy eating intervention (see Appendix 7.02 for synopsis). These modifications were based on trial outcomes of a new nursery Food Dudes healthy eating intervention (Sharp, 2013), and then again following the trial of a more modified version described in Chapter 2. In addition to nursery teacher feedback following the latter trial, in parallel, Food Dudes Health (FDH) co-ordinators delivered the same version of the healthy eating intervention to a number of UK nurseries. Modifications made after completion of Chapter 2 were informed by teacher feedback received from the latter controlled study and from teacher feedback gathered by FDH co-ordinators during that parallel rollout.

School Intervention

**Duration of the intervention.** Translational research in a school setting is constrained by the duration of the academic year and holiday periods within and between terms; therefore experimental designs must take into account the number of weeks available in each of the three school terms and the dates of holidays. Based on feedback from nursery staff, we found that schools are resistant to nursery children taking part in research before the October half term. This is because the children need first to adapt to their new environment, teachers and fellow pupils, settle into a new routine, and learn to be comfortable without their parents in the school nursery class setting. From a research perspective, failure to respect this period of transition from home to school is likely to result in behaviour that is not representative of the children’s true learning capabilities.

A reduction in the duration of the healthy eating intervention was required to fit delivery of both the healthy eating and the physical activity interventions into the academic year. The Intensive phase of the healthy eating intervention was reduced from 20 days to 16 days based on the outcomes of the controlled study described in Chapter 2. The lack of change in the children’s consumption across baseline and probe measure taken during the intervention on Days 17 - 20 justified the decrease in days required for successful delivery of the healthy eating intervention in the Intensive phase (see Chapter 2, p. 76).

In the experimental design for the multi-component intervention evaluation, after delivery of the physical activity intervention and the Intensive phase of the healthy eating intervention, only 6 weeks remained in the school year. Consequently, the Picnic phase was reduced to 4 weeks to ensure collection of the post-Intensive phase measure, and accommodate requests made by nursery staff that the research ends a few weeks before the end of the term to avoid a clash with scheduled sports days and other end of term events.
Training materials. An instructional DVD was produced for use during the study described in Chapter 2 to serve as a simple visual reminder of procedures and intervention. During the evaluation of the modified version of the nursery programme, and its parallel rollout delivery by FDH staff, the nursery staff responded positively to the instructional DVD and reported that the resource was a very useful tool to support their understanding. To incorporate procedural changes and modifications to the intervention protocols and materials in response to nursery staff feedback obtained following the evaluation described in Chapter 2, and the parallel rollout of that version of the nursery programme, a new instructional DVD was produced for use in the final controlled trial of the combined healthy eating and physical activity intervention (see Chapter 8).

Similar procedures were followed as for production of the previous instructional DVD described in Chapter 2 (p.51). The researcher modified the original script and shot list to accommodate the required changes to protocols and materials, which were later edited and approved by her supervisor. The same media company used for the original instructional DVD was recruited to conduct the filming and produce the DVD. The University Nursery was recruited as the location for filming, and opt-in consent letters (Appendix 7.03) were distributed to parents of children aged 2 – 4 years. A difference to the original instructional DVD was that the researcher played the role of nursery teacher rather than recruiting a member of nursery staff. This reduced training time and increased efficiency during filming. A member of the media company performed the voice-over. The researcher liaised with the media company on the final edits during post-production, which was finalised following feedback and approval obtained from her first supervisor.

Target foods. Eight foods, 4 fruit and 4 vegetables, were selected as target foods for presentation during the healthy eating intervention. Selection of the target foods has been informed by (a) results of an unpublished study investigating whether pre-school children were willing to taste or consume a comprehensive range of fruit and vegetables, (b) availability of a particular food throughout the study, and (c) durability and suitability of the foods for delivery and preparation on a large-scale. During the modified intervention evaluation (Chapter 2), there was insufficient time to pre-assess consumption levels of a range of fruit and vegetables before a staggered design was implemented. Unfortunately, median ceiling effects were obtained for three of the four target fruit at the outset of the research, limiting the scope for behaviour change. For the multi-component intervention evaluation, the decision was made to select uncommon fruit as opposed to those commonly consumed, to increase the chance that the target foods were not those that children had already learned to like. Additionally, the schools in the multi-component intervention were responsible for purchasing their own foods presented to the children during their routine snack-time, and were not recipients of the school fruit and vegetable scheme. Therefore to avoid selecting foods
already presented in the schools, prior to the baseline measure, nursery staff were asked to inform the researcher over a 3-week period which snack foods the school had presented to the children.

Taking into consideration the foods presented in the schools, 4 target fruit and 4 target vegetables were identified. To investigate whether children were willing to taste and consume 4 identified target fruit, which were papaya, pink grapefruit, guava, and fig, the identified foods were piloted with pre-school children attending the University Nursery. As no individual consumption data were being collected, and different foods were presented to the children to try as part of the nursery’s healthy eating policy, a member of the ethics committee and the nursery manager were satisfied that informed consent was not required from the children’s parents. Foods that the children refused to taste or evoked negative facial expressions after tasting were considered suitable. For the target vegetables, three of the four were selected based on children’s consumption of those foods in previous evaluations. The new target vegetable, cauliflower, was presented to the children during the pilot when it was found that children were not willing to consume that food.

In the modified intervention evaluation (Chapter 2), the researcher sourced and delivered the foods throughout the measures and the intervention phase, but only prepared the foods during the measurement periods to ensure that standardised portions were presented to the children; catering staff prepared the foods during the intervention phase. A portion specification document was given to the nursery staff to help them to ensure that correct portions sizes were being delivered. During the delivery, inspection of the target foods identified that portion specification was not consistently being adhered to and could minimize the effects of the intervention if children were being given too little or too much of the target foods. Additionally, during FDH implementations, FDH staff reported that the food presentation schedule and the portion specification were also not always adhered to. Consequently, in the multi-component evaluation (Chapter 8), the researcher sourced, delivered, and prepared all foods for the duration of the intervention to ensure consistency of portion sizes throughout the intervention within and between the schools.

**Conjugate fruit and vegetable consumption reward contingency in the Intensive phase.**

Throughout the 20 days of the Intensive phase conducted in the Chapter 2 study, the child had to eat both the target fruit and the target vegetable provided on a given each day in order to earn an ‘energy token’ to place in their personalised transparent ‘rainbow energy tube’. For every four energy tokens the children accumulate over successive days of the intervention they are given a different Food Dudes character fridge magnet. This daily conjugate reward contingency, coupled with the 4-token fridge magnet contingency, encourages children to consume both target food categories to earn the attractive tangible rewards.
During the first (Sharp, 2013) and subsequent modified (Chapter 2) versions of the nursery programme the rainbow energy tubes were placed in front of the children on a table or on the floor, dependent on their snack-time seating arrangements. After a child had received their individual contingency rewards for target food consumption (a red school to home sticker for consuming the fruit, and a green school to home sticker for consuming the vegetable), the nursery staff were instructed to give the child a yellow energy token, and the child was required to remove the lid and place the energy token in their energy tube. However, the nursery staff did not respond favourably to the procedure.

During the modified intervention evaluation (Chapter 2) and the parallel FDH rollout, nursery staff raised the following issues relating to the energy tubes:

(a). The component took too much time to deliver.

(b). The children were unable to release the lids of the energy tubes themselves to put the tokens inside, requiring extra adult support to do so.

(c). Some children could get the lids off the energy tubes and the energy tokens were being scattered on to the floor.

(d). The children were shaking the energy tubes and the noise disrupted the class.

(e). The energy tubes were breaking.

In response to the feedback, the PhD supervisor advised the following solutions for the dual-contingency reward:

(a). New energy tubes, more durable and stable, and with potentially different functioning lids;

(b). Instead of only yellow tokens, new rainbow-coloured energy tokens paired by colour to the Food Dudes characters would be used; whenever a child earns four energy tokens, the colour of the token indicates to the teacher which fridge magnet to award e.g. four red energy tokens means Tom’s fridge magnet should be awarded.

(c). The children would no longer handle their energy tubes except under direct supervision by the nursery staff. All children’s energy tubes would be stored in the Food Dudes energy box. Each day, children who had eaten both their target fruit and their target vegetable as evidenced by their wearing a red Food Dudes sticker (fruit) and a green Food Dudes (vegetable) sticker would be asked to queue up to see the designated teacher, receive their new special energy token to place in their own tube held by the nursery teacher who also asked them what colour their new token was and how many of that colour they had already in their tube. This provided the opportunity for the teacher to ask the colour of the newly awarded token and how many the child had earned of each colour so far. The nursery staff member would maintain hold of the energy tubes and be responsible for taking the lid on and off the tubes. The pre-labelled energy tubes
Under the direction of her first supervisor, the researcher sourced new energy tubes and piloted two different functioning lids for the tubes before finalising solutions (a) and (b). The two lids differed in that one was solid and required removal before an energy token could be placed inside, and the second was a slotted lid, eliminating the need to remove the lid, enabling the children to place the energy token through the slot. The University Nursery and a local primary school were recruited to participate in a three-part pilot of the tubes with a slotted lid. The objectives of the pilot were to investigate the suitability of the slotted lids and to assess the feasibility of solution (b). Opt-out consent letters (Appendix 7.04) were distributed to parents of children aged 2 – 4 years for their participation and for the session to be filmed for future reference. For Part A of the pilot, the children only completed the energy tube and energy token component of the intervention. Three children from the University Nursery participated, and the researcher trialled placing the energy tokens in the energy tubes, with the children maintaining possession of the energy tubes. The children were capable of placing the energy tokens in the energy tubes. Under instruction to shake the energy tube, 0 of 10 tokens fell out through the slot when performed softly, and 1 of 10 tokens fell out when performed vigorously. During part B, seven children from the University Nursery participated in solution (b) with the researcher acting as the teacher; the session was also filmed for reference. The children engaged positively in the routine and were able to place the energy tokens through the slot whilst the researcher held the energy tube. Part C of the pilot was conducted with 17 children in a nursery class attached to a local primary school. The nursery teacher was trained by the researcher to administer the healthy eating intervention procedures, and the children participated in the entire intervention for 5 days for both the children and the teacher to become familiar with the procedures. On Day 5, the researcher visited the nursery to film the procedure, showcasing a member of nursery staff successfully delivering the intervention with the suggested solution. The new procedure reduced congestion during distribution of the energy tokens, there was minimal noise from the energy tubes, and the teacher was able to engage in curriculum questions, for example: ‘How many energy tokens do you have in your energy tube?’ One negative outcome was that as the diameter of the energy tube had to be a minimum size to accommodate the slotted lid, there was movement space in the energy tubes for the energy tokens. At times this resulted in the energy tokens falling down the side of the stacked energy tokens and not resting on top of them as desired. This could aggravate nursery staff as the energy tube would not function as designed.

Figure 7.01 shows the energy tubes and corresponding energy tokens used in (a) the modified intervention evaluation, (b) the slotted energy tube component pilot, and (c) the multi-component
intervention evaluation. Based on the conclusions drawn from the three-part pilot and feedback received from the nursery teacher, the decision was made that the energy tubes would be taller and sturdier, and they would have a solid and not a slotted lid to reduce the diameter of the energy tube. As the nursery staff would be responsible for taking the lids on and off, reverting to a solid lid was not anticipated to be a problem. This also reduced the cost as placing a slot in the lids of the energy tubes increased the unit price.

![Figure 7.01](image)

**Figure 7.01.** Three energy tubes and energy tokens as used in (a) the modified intervention evaluation, (b) the slotted energy tube component pilot, and in (c) the multi-component intervention evaluation.

**Monitoring of children’s consumption during the Intensive phase.** During the Chapter 2 evaluation of the modified intervention and FDH implementation, nursery staff were required to input the following information daily throughout the Intensive phase. The information reported was (a) how many children were present, (b) how many children had consumed the target fruit, (c) how many children had consumed the target vegetable, and (d) how many children had consumed both the fruit and the vegetable. This process was introduced to monitor the schools performance and ensure they were engaging with the intervention; electronic alerts were scheduled if a school did not input their information for 2 days. The reported data were used during FDH implementation to provide schools at the end of the Intensive phase with their children’s target food consumption results. During evaluation of the modified intervention, the school-reported consumption data were not considered to be as reliable as measures collected by the researcher. As a result, the daily reporting of children’s consumption was an avoidable burden for the nursery staff.

**Super Dynamic Food Dudes calendar.** Previously the healthy eating intervention has only been implemented as a stand-alone intervention. The multi-component intervention evaluation is the first time the healthy eating intervention has been integrated with the physical activity intervention. To help the nursery staff to keep track of what to deliver on each day in the physical activity intervention a calendar was introduced. This calendar now guides delivery of the healthy eating intervention to inform nursery staff which fruit and vegetable pair they are presenting to the children on each day,
and for the activity intervention, which activity video to complete on a specific day. Figure 7.02 shows an example of the Super Dynamic Food Dudes calendar.

![Super Dynamic Food Dudes calendar](image)

Figure 7.02. Super Dynamic Food Dudes calendar to inform nursery staff which fruit and vegetable pairings to present and which activity element to complete on each day of the intervention phase.

**Contact with parents.** During evaluation of all versions of the intervention, a parent session was offered during the Intensive phase for parents to meet the researcher (during evaluations) or FDH staff member (during roll-out implementation) to discuss the school intervention and inform parents of the corresponding home intervention. In most cases, minimal attendance (< 10%) was found; therefore a new method of delivering the information was required. In the multi-component intervention evaluation, to increase the chance of information reaching more parents, the parent session was removed. In its place, a newsletter was designed and distributed to parents following the Intensive phase. The newsletter contained information about the intervention, and a class-tailored photograph to increase the likelihood that the parents would be motivated to read the sheet as it showed a picture that included their child.

**Conjugate fruit and vegetable consumption reward contingency in the Picnic phase.** In the original (Sharp, 2013) evaluation, the children received their own ‘Passport to Healthy Eating’, which contained a consumption monitoring chart and a colourful sticker book. During the modified intervention evaluation, the monitoring chart was removed, but the sticker book element remained and the component was shifted from the Intensive phase into the Picnic phase. The children received a character sticker of their choosing to place in their sticker book for consuming both their fruit and their vegetable. This meant that the children continued to receive their reward for meeting the fruit and vegetable contingency for consumption after the energy tubes and energy tokens were sent home.
Feedback from researchers, FDH staff, and nursery staff was that the Passport to Healthy Eating component was a surplus reward; some schools receiving the intervention under FDH implementation were not administering the component but still achieving increases in consumption. Therefore, during the multi-component intervention evaluation, the Passport to Healthy Eating component was completely removed.

**Home healthy eating cueing rewards.** During the Picnic phase, the children earn home healthy eating cueing rewards when the class energy tube was filled with pom-poms. Children earned a pom-pom to place in the class energy tube by consuming both their fruit and vegetable brought in from home in their Food Dudes box during the picnic day. The home cueing rewards were presented on a pre-determined schedule. During the original intervention evaluation (Sharp 2013), the Picnic phase spanned 12 weeks, during which the children received two home cueing rewards administered at Week 4 and Week 8, respectively; the rewards were a customised beaker and placemat. The intervention children yielded larger effect sizes ($r = -.56$ and -.67 for fruit and vegetables, respectively) between baseline and 3-month follow-up as compared to baseline and post-Intensive phase measure ($r = -.45$ and -.50 for fruit and vegetables, respectively).

During the modified intervention evaluation (Chapter 2), the children received four home cueing rewards, also administered every 4 weeks. However, the intervention schools were instructed to continue the phase until the end of the academic year. The prizes were a customised placemat, cutlery set, beaker and toothbrush. An opposite pattern of results was found to the original trial (Sharp, 2013). The intervention children made larger short-term improvements in consumption compared to long-term improvements achieved (see Chapter 2, p. 61).

In the multi-component intervention evaluation, as mentioned previously in the ‘Duration of the intervention’ section, the Picnic phase was scheduled for 4 weeks due to limited time available in the academic year. Consequently, the number of rewards reverted to two, the customised beaker and placemat.

**Curriculum links to the Early Years Foundation Phase (EYFP).** Feedback obtained from nursery staff during the modified intervention evaluation and FDH implementation was that the intervention was too time-consuming, and in some schools resulted in the suspension of certain learning topics to accommodate delivery of the intervention. In response, the first supervisor proposed that a curriculum toolkit containing an energy tube and rainbow-coloured tokens, with guidance on how to use those materials to support teachers’ delivery of the EYFP be provided. The aim of the curriculum kit and guidance was to incentivise nursery staff to administer the intervention and to use elements of the intervention to complement their teaching curriculum and child observations. The supervisor identified the curriculum links, which related to numeracy, literacy, social and cognitive development.
Informal feedback from nursery staff to FDH staff was positive, and nursery staff were pleased to have the curriculum links made overt. No measure has been obtained on the usage of the curriculum links, but the informal communication with nursery staff has shown that the availability of such links appeals to nursery staff.

**Home Intervention**

**Parent Home DudeKit.** Limited feedback has been obtained on the Parent Home DudeKit, however, during the modified intervention evaluation, some parents reported that they found the instruction booklet and training chart difficult to use. To address this issue for the multi-component intervention evaluation, the shaping contingency was simplified by aligning it with that employed in school thereby providing greater consistency for the children. The ‘Taste-Bud Training Chart’ component of the Parent Home DudeKit in all previous implementations has employed a shaping contingency, which instructed parents that for their child to receive an energy token for their energy tube, the child must taste the target foods for the first 4 days, consume 1 piece on the following 4 days, and consume 2 pieces from then on. This shaping contingency was evaluated with the waiting-control schools in the original (2013) intervention evaluation of the school intervention, and no difference in consumption increases was found with the additional shaping contingency step. The decision was made not to include the middle step in the school any further. The instructions in the A5 information booklet were simplified and the imagery made easier for parents to understand, and the colours of the energy tokens displayed on the Taste-Bud Training Chart were changed to correspond with the rainbow-coloured energy tokens (Figure 7.03). The previous materials for comparison are illustrated in Figure 2.05.
Dynamic Dudes Physical Activity Intervention

A total of seven modifications were applied to the Dynamic Dudes physical activity intervention (see Appendix 7.05 for synopsis). The modifications to the Dynamic Dudes physical activity intervention were based on the results of individual feasibility trials of the interactive stories (Chapter 4), the exercise videos (Chapter 5), and the pilot evaluation of the Dynamic Dudes physical activity intervention (Chapter 6); and where applicable, knowledge obtained from the implementation of the healthy eating intervention was used.

School Intervention

Interactive stories (Edited; Rocco, Tom, and Razz). Three of the four interactive, audio-visual stories designed and produced in Chapter 4 were adapted for inclusion in the multi-component intervention. The adaptations were based on the researcher’s informal observations of the children’s engagement during the pilot intervention evaluation (Chapter 6), and following the supervisors’ visit to the intervention school of the pilot evaluation following its completion. For the purpose of the visit the children completed an interactive story for the supervisors to observe. The main observation derived was that children were most active during the song element of the interactive stories, and their attention strayed during the narrative sections. The children found it difficult to follow the ‘march’ action without repeated verbal instruction. Consequently, the scripts for Tom’s (Appendix 7.06), Rocco’s (Appendix 7.07), and Razz’ (Appendix 7.08) videos were reworked by the researcher and first
supervisor in order to reduce the narrative sections. In addition, the first verse of each song was repeated at the end of each song. These modifications resulted in a total of 12 song verses compared to the previous 8 song verses. Symbolically, the interactive story format was: narrative, A-A-B-B, narrative, A-A-C-C, narrative; this was converted to: narrative, A-A-B-B-A-A, narrative, A-A-C-C-A-A, narrative.

In addition to support data collection procedures, where a photograph is required as a time reference of when the intervention delivery commences and completes, an interactive instruction prompt screen for the nursery staff to take a photograph at both time-points was included. Its purpose was to reduce the frequency of forgetting to take the time stamped photograph.

The media technician who supported the original production of the interactive stories was approached, and the researcher highlighted the required edits. Using Final Cut Pro software, the three interactive stories were edited to reflect the script changes. The researcher was present for all editing to ensure the cut-ins did not look obscure and would therefore not be distracting to the children. Once completed, the new versions of the interactive stories were viewed and approved by the first supervisor. See Disk 'V2 – Interactive story' to view the edited stories.

Interactive story (New; Charlie). Charlie’s interactive story was the last story to be produced and unfortunately was not available for inclusion in the feasibility trial (Chapter 4), but was included in the pilot intervention evaluation (Chapter 6).

In the pilot intervention evaluation, the within-groups comparison over the three presentations of Charlie’s interactive story found no significant change ($p > .05$) in the number of steps performed by the children. Visual inspection of Figure 6.08 shows that the children’s step count decreased after the first exposure, an opposite pattern of behaviour found compared to the other three interactive stories. Charlie’s interactive story was also the least engaging for the researcher and supervisors. As a result, a new interactive story was designed, and produced for Charlie.

The researcher and lead supervisor explored castle themes online for inspiration and identified new ideas, which the researcher fed into the draft of Charlie’s new script (Appendix 7.09). The supervisor edited and then approved the script ahead of production. Photographs from the previous story were re-used where possible, and the researcher obtained new photographs from Wikki Commons (https://commons.wikimedia.org/wiki/Main_Page). The photographs were edited by the researcher or by her personal contacts; full credit to individuals’ photographs and contributions were given in the story credits. The narrative specific elements of the previously composed music were edited to fit the new script, and the researcher composed new music for the songs using ScoreCloud software. The additional interactive instruction prompt screen for nursery staff, noted above, was also included in Charlie’s interactive story. All amendments received feedback from the first supervisor.
prior to final approval. The interactive story was re-filmed and produced following the same procedures as outlined in Chapter 4. See Disk 'V2 – Interactive story' to view the new story.

Exercise DVD (All four characters videos). The four exercise videos designed and produced in Chapter 5 were adapted for delivery in the multi-component intervention evaluation. Each video contained a Dynamic Dudes character performing a 4-move action sequence. During the pilot intervention evaluation (Chapter 6), the children completed all 10 levels from the outset, with the exception of the morning class on Day 1 who only completed up to level 6, therefore the decision was made to make the exercise videos more challenging. In each level, the target behaviour in each level was doubled. As a result the children will be required to complete the 4-action sequence twice to complete a level. A similar finding and action arose in the evaluation of the Dynamic Dudes intervention for primary school children with positive results (Mitchell, 2014, Whitaker, 2016).

For each exercise video, the researcher identified the timings from within each level to be repeated to increase the flow of the level, and decrease any obscure change in visual or dramatic change in audio, which could distract the children. Consistent with the interactive stories, an interactive instruction prompt screen for the nursery staff to take a photograph at the start and end of the intervention was included in each video. See Disk ‘V2 – Exercise DVD’ to view the edited videos.

Completion of the physical activity components. Previously, the physical activity intervention was terminated if 80% of children withdrew from participating in the intervention. A systematic review identified that children are motivated by social influence of their peers, and will perform higher levels and intensity of physical activity in a group as compared to alone (Ward et al., 2016). Therefore, the decision was made that the intervention should only be terminated if all children stopped participating, as after a small break children could be motivated to re-join participating with their friends; this behaviour was observed in the pilot intervention evaluation (Chapter 6).

Contact with parents. Matched to the healthy eating intervention, during the pilot intervention evaluation (Chapter 6) a parent session was held to provide more information about the intervention to parents, and inform them of the home intervention. However, only 18% of parents attended. Subsequently, as in the healthy eating intervention, in the multi-component intervention evaluation a newsletter, in a similar format to the healthy eating intervention, was issued to all parents of the intervention condition containing a class-tailored photograph to provide further information as a replacement.

Home Intervention

Time of intervention delivery. In the pilot intervention evaluation (Chapter6), the school intervention was delivered in the summer term, resulting in the home intervention being delivered
over the summer holidays. Google analytics showed that no families engaged in the home intervention. To increase the chance of parental engagement in the home intervention of the multi-component intervention evaluation, the home intervention component will be administered during the school term. Its delivery coinciding with the delivery of the healthy eating intervention in school. 

The intention was that parents would be primed to engage in the home intervention with the visibility of the Food Dudes intervention in school, and the children returning home wearing customised stickers.

Dynamic Dudes Home Adventures materials. To increase engagement in the home intervention, a greater emphasis was placed on communicating with parents. In the pilot intervention evaluation (Chapter 6), the only contact with parents regarding the home intervention was the parent session, which yielded minimal attendance, and an A4 letter (Figure 7.04[a]) detailing the home intervention and providing each parent with their individual login details. On reflection, this was not appealing to parents, and would have limited capacity to attract the attention of families. Drawing on the Parent Home DudeKit from the healthy eating intervention, an A5 information booklet (Figure 7.04[b]) containing instructions and imagery was designed and produced. The Dynamic Dudes Home Adventures Chart (Figure 7.04[a]) included in the pilot intervention evaluation contained boxes for the parents, or child with the support of a parent, to complete by writing the name of the video completed, the date, and the number of the level completed for an exercise video or a tick for completing an interactive story. The latter stage was tied with the requirement of the children completing the Dynamic Dudes calendar during the school intervention in order to provide consistency and familiarity for the children. However, as none of the charts were returned following the summer holidays or used in conjunction with the online-videos, a re-design was opted for in the multi-component intervention evaluation, which required minimal parental input to complete. The adventure chart contained unfilled stars, and the children were instructed to colour a star in the colour of the Dude’s t-shirt whose video they had completed (Figure 7.04[b]). As Google analytics would record information about which video was watched and when, this information was not required through the adventure charts.
In the pilot intervention evaluation (Chapter 6), no reward was offered for the target behaviour of physical activity. A reward was only offered for the submission of the best four interactive story ideas. As completing the home intervention was not sufficient to intrinsically motivate the parents to engage the children in the home intervention, an extrinsic reward was introduced. In the multi-component intervention evaluation (Chapter 8), the children will be required to complete their adventure chart, which would be confirmed by Google analytics, in order to receive a free child’s ticket to a local attraction site, the Welsh Mountain Zoo in North Wales; the value of the prize is £10.05. The researcher recruited the Welsh Mountain Zoo to financially sponsor the prize by donating the tickets.

To increase researcher-parent communication, a ‘Dynamic Dudes Home Adventures’ Facebook group page was established for the researcher to post positively reinforcing statements to motivate the parents to engage in the intervention. Parents would also be invited to report on their children’s performance at home, and interact with each other. This was to increase social influence, which has been identified as a solution for weak engagement with online interventions, and is thought to result in high behaviour-adoption rates (Poirier & Cobb, 2012). Figure 7.04 shows how the new
elements of the home intervention have been modified for the multi-component intervention evaluation as compared to their presentation in the pilot evaluation, which yielded no engagement.

**Video-modelling component.** To remain consistent with the school intervention, the new and modified interactive stories and exercise videos were uploaded to the Dynamic Dudes Home Adventures website for the children and parents to access.
CHAPTER EIGHT: Evaluation of a Multi-Component Healthy Eating and Physical Activity Behaviour Change Intervention Targeting 3 – 4 Year Old Children in Primary Schools.

Abstract

Objectives. This study investigated the effectiveness of the Super Dynamic Food Dudes multi-component intervention tailored for 3 – 4 year old children at school to increase their daily consumption of fruit and vegetables as well as their total in-school activity.

Design. Following a baseline probe measure of the in-school activity of children while attending the nursery classes of five primary schools in North Wales, four of the schools took part in a 7-month controlled trial of the multi-component intervention. A mixed, between-groups repeated-measures design was employed. Schools were randomly assigned to condition; intervention children received the multi-component intervention, and the control children continued with their standard nursery curriculum. The independent variable was the Super Dynamic Food Dudes intervention, which combined the Dynamic Dudes physical activity intervention, and the Food Dudes healthy eating intervention. These two main behaviour change components were delivered in the following order: (a) the Dynamic Dudes physical activity intervention (main phase, daily over 5 weeks); (b) the Food Dudes component (main phase, 4 days per week over 4 weeks), then (c) the Dynamic Dudes component continued to be delivered on 1 day per week alongside the 4 day per week Food Dudes component during the Super Dynamic Food Dudes component. A 12-week home activity intervention was introduced at the start of the latter component.

Participants: Informed consent was obtained for a total of 199 children to participate in a minimum of 1 measurement collected during the study.

Measures. Primary anthropometric dependent variables measured at the start (T0) and end (T6) of the combined intervention were height, weight, BMI, waist circumference; systolic and diastolic blood pressure were also collected at matched measurement periods. In addition, at the start (T0), immediately after the Dynamic Dudes component (T2), and at the end of the study (T6), children’s total in-school activity was measured using Fitbit Zip accelerometry. Total in-school activity was also measured throughout the Dynamic Dudes intervention phases at (T1) and (T4). Generalisation of the intervention to the home was monitored (from T4 to T8) using page alerts and Google analytics to track online access to the Dynamic Dudes activity videos by participant’s families. Baseline and post measures of target fruit and vegetable consumption were taken under baseline conditions before (T3), and immediately after (T5), delivery of the Food Dudes component. Verbal feedback about study outcomes was collected from nursery staff using questionnaires and interviews with nursery staff at T6 and T8.
Results. Except for waist circumference, there were no significant between-groups differences for the anthropometric measures or blood pressure at baseline (all $p > .05$). Children in the control condition had a significantly smaller waist circumference than the intervention condition at baseline ($p = .005$, $r = .26$). For the Dynamic Dudes component, analysis of total in-school physical activity found a borderline significant difference between the intervention and control conditions at baseline ($p = .047$, $r = .16$). Between-groups comparison of ‘baseline to post-intervention phase’ change scores found that children in the intervention condition increased their step counts significantly more than children in the control condition ($p = .04$, $r = .17$); however, a comparison of “baseline to 2-month follow-up” change scores in each condition found no significant difference ($p = .10$, $r = .14$). This outcome for baseline and post-intervention total in-school step counts contrasts with activity measures taken throughout the Dynamic Dudes intervention phase of the study, which showed that children taking part in the eight video-modelling elements were consistently more active than children in the control condition at the comparable time of day (all $p < .001$, $r = .85 – .90$). The intervention children (39.80%) watched a total of 205 Dynamic Dudes videos during the home intervention. For the Food Dudes component, although fruit and vegetable consumption in the intervention and control conditions was matched at baseline, the intervention children consumed significantly more fruit ($p < .001$, $r = .26$) and vegetables ($p < .001$, $r = .33$) at post-intervention as compared to the control condition. Very good inter-rater reliability was achieved between the two coders of food consumption ($k = .76$). As all days of the multi-component intervention were successfully delivered, this indicates that the intervention is suitable for the primary school environment. Nursery staff feedback was predominately positive about the intervention and the provided materials.

Conclusion. The multi-component intervention promises to be a preventative, feasible and cost-saving method of establishing a healthy lifestyle in 3 – 4 year old children attending primary schools.
Part 8A: Assessing Physical Activity Levels of Nursery Classes in Five Primary Schools

Accelerometry results from the pilot evaluation of the Dynamic Dudes intervention (Chapter 6) discovered high variation in children’s baseline step counts in two local nursery classes ($p < .001$, $r = .88$) despite matching in terms of: school setup, academic performance, socio-economic status, and weekly physical activity sessions. This difficulty in predicting large baseline differences in young children’s activity at school has also been highlighted by Pate, Pfeiffer, Trost, Ziegler, and Dowda (2004). In an attempt to reduce uncertainty about pre-study levels of activity, an objective pre-baseline measure was conducted in the nursery classes of schools that otherwise met the recruitment criteria. Pairs of schools that could be approximately matched were then recruited to participate in the main evaluation of the multi-component intervention.

Procedural modifications were required to the method of collecting the accelerometry data. With the exception of Chapter 4, the researcher had been responsible for placing the tabards on and off the pre-school children during all previous measures of children’s step count reported in this thesis. In the present study, nursery staff took over task of placing the Fitbit Zip and tabards on the children. To support this transition, the procedure was simplified by ensuring that each child’s first name was written on a white label, ironed onto the inside pocket of the tabard which contained the corresponding Fitbit Zip. This provided nursery staff with a quick reference between the child’s name and Fitbit number written on the data collection sheet. The nursery staff were also required to take time-stamp photographs using a provided digital camera to record (a) when the tabards were placed on the children and (b) when they were taken off. To ensure that the Fitbit measure was being conducted, attempts were made to remotely monitor whether the photographs were being taken, by linking the digital camera to the school Wi-Fi. However, despite recruiting the support of the school Wi-Fi network providers, Wi-Fi connection with the digital cameras could not be established. Therefore, initially, remote monitoring was not possible for this part of the present study, but was in place for the second part (Part 8B).

The main aim of this study (Part 8A) was to identify four schools in which children performed a similar mean number of total in-school step counts, measured using accelerometry.

**Method**

**Ethical Approval**

Permission to measure pre-school children’s physical activity levels whilst attending their nursery session was granted by the School of Psychology Ethics and Research Governance Committee at Bangor University (Ethics application No.: 2013-11864).
School Recruitment

A list of 47 primary schools in Denbighshire, North Wales, which were screened for the following criteria: (a) nursery attached, (b) Estyn report classification (adequate/good), (c) nursery class not combined with reception class, (d) nursery session duration of 2.50 hours and children attend a morning or afternoon session, 5 days a week (attendance not compulsory), (e) minimum of 15 children in each class, (f) had a formal snack-time routine, (g) children had access to outdoor space, (h) located a maximum of 40 miles from the University, and (i) had no previous exposure to the Super Dynamic Food Dudes characters. Due to the small number of schools that met the listed criteria, socioeconomic status could not be considered, as it would have excluded too many schools for the study to be viable. Additionally, as the schools were being matched for baseline levels of total in-school activity, this was considered acceptable.

Only Denbighshire schools could be recruited due to the intervention materials being available in English but not in Welsh. This language barrier was encountered during attempts to recruit schools in Gwynedd and Isle of Anglesey. An additional constraint to school recruitment was that Conwy County Borough council were administering a physical literacy initiative, with all school teachers to train them how to increase physical activity across the school day. Consequently, the Conwy County Borough schools were not considered, as the additional training would have confounded the evaluation. Denbighshire was the next neighbouring county.

Information for recruitment was sought online and through direct contact with schools. Five schools met the criteria, and were willing to participate in the research. The researcher contacted the schools by phone and/or email, and provided brief information about the study. With participation approval obtained from the Head Teacher, the researcher met with the nursery teachers of each school, provided an information sheet (Appendix 8.01) and explained the initial 1-week pre-baseline probe measurement procedure. Prior to their agreement to take part, the nursery teacher of each school was made aware of the time commitment required for the main evaluation beyond the pre-baseline measure (Part 8B), if selected. This was necessary to reduce the likelihood of withdrawal following the pre-baseline measure. However, no information about the intervention was disclosed. In recognition of their time and the additional responsibility that the nursery staff-led data collection brought, it was considered appropriate to provide a gift to the school. Each nursery class was offered a gift of £20 if they completed the pre-baseline measure, with a promise of a further £80 for completing the main evaluation. The money was awarded directly to the nursery teacher after completion of the agreed research phase.
Participants

Parental consent for the children’s participation was acquired using opt-out consent letters (Appendix 8.02) distributed to all children at the five nurseries; two children were opted out, with no reason given. A total of 154 children were selected for inclusion across the morning and afternoon sessions. The sample was limited to the number of Fitbit Zip devices available at the time. The selection of children included was performed systematically from the consented children. Every alternate child on the class list was selected, plus an additional three reserve children. Dates of birth for the selected children were obtained from each school.

Experimental Design

This study employed a between-groups design. The independent variable was the school each child attended, and the dependent variable was the mean total number of in-school step counts performed by each child whilst attending their nursery session.

Materials

Children wore custom-made tabards, housing the Fitbit Zip accelerometers (see Chapter 3, p. 80). Each school received a digital camera to provide time-stamps of when the accelerometry measure was conducted (see Procedure). Each camera was synced with GMT time. Each school was given a plastic box to store the accelerometry data collection materials.

Measures

Accelerometry. Children’s physical activity levels were assessed for 6 days by measuring their total in-school step counts.

Feedback questionnaire A questionnaire (Appendix 8.03) was given to all nursery staff to gather their independent views on the new accelerometry data collection procedures. The questionnaire contained a mixture of open and closed questions.

Procedure

Following participation approval, a particular week was identified as suitable in all five schools for the measures to be conducted simultaneously. The researcher visited each school the day before the measure to deliver the materials and provide training on the procedure of collecting the accelerometry measure; written instructions (Appendix 8.04) were also provided for reference. The researcher guided the nursery staff through the procedures using the materials combined with role-
play to teach: (a) the correct way to put the tabard on a child, (b) how to use the camera, and (c) what information they were required to record (see below).

For 6 days, the nursery staff placed the tabards with the Fitbit Zips in situ on the selected children, identifying the child and tabard by the name ironed onto the tabard, and the identification number on the Fitbit Zips matched to the data sheet. The nursery staff ticked the data sheet to acknowledge that the child was wearing their tabard, and a cross if a child was absent. If a child was absent, the nursery staff were instructed to put the tabard on the reserve child and note the Fitbit Zip number on the data sheet under the date and child’s name. Once all the tabards were on the children, the nursery staff took a photograph of the data collection sheet to provide a ‘Fitbits on’ time-stamp. In line with the previous chapters, the nursery staff were instructed to tell the children that the device was “a button”; the children were not to be informed that their activity levels were being monitored. At the end of the nursery session, the nursery staff took a second photograph of the data sheet to provide a ‘Fitbits off’ time-stamp before proceeding to remove the tabards from the children, and depositing them in the provided plastic box ready for the next nursery session.

The researcher visited each nursery on the morning of Day 1, and Day 3 to ensure fidelity of the procedures. At the end of Day 4, the researcher collected the materials, synced each Fitbit Zip with its online account, and downloaded the photographs from the camera. On Day 5, the researcher returned the materials before the morning nursery session began. At the end of Day 6, the researcher collected the materials again, synced the Fitbits Zips, and downloaded the photographs. Following completion of the accelerometry measure, a feedback questionnaire (Appendix 8.03) was issued to all nursery staff to gather their views on the feasibility of the procedures.

Following analysis of the step count results, four suitable schools were identified and invited to participate in the main evaluation (Part 8B). The children’s physical activity levels of the invited schools were not disclosed to them. The school that was not invited was visited, thanked for their participation, and provided with a poster showing their results. All schools were given £20 to thank them for their participation.

**Data Analysis**

A third-party company (whatAdata) extracted the granulated minute-by-minute Fitbit data. The photographs taken by the nursery staff identified the time points when the tabards had been placed on the selected children, and when they were removed, in their respective school, on each measurement day. Where photographs were not available, the researcher identified cut-off points through visual inspection of the minute-by-minute data, identifying when activity was recorded in all the Fitbit Zips, and when activity ceased. An a priori criterion specified a minimum duration of 100
minutes in each session for the data to be included in subsequent analyses. This cut-off was selected, as it is approximately 10% less than the 115 minutes used in the pilot evaluation of the Dynamic Dudes intervention (Chapter 6), which was the maximum captured during the researcher-led data collection during a 150-minute nursery session. Only one school (control school 2) had two invalid sessions. The minute-by-minute data were manually transferred and assigned to each corresponding child from sessions that met the duration criterion. A ‘total step count score’ was calculated from the assigned data for each session for each child.

Data analysis was performed in SPSS 22. Consistent with Chapter 6, to reduce any novelty effects as a result of the children wearing the tabards, Day 1 data were not included in the analysis. Children were required to have a minimum of 3 days of data to provide a representative sample of total in-school physical activity (Addy et al., 2014). For each child, a ‘mean step count score’ was computed. The calculated variable was assessed for outliers, and whether the data met the criteria for parametric analysis. Data from two schools were positively skewed. The data for all schools were log transformed and met the assumptions of normality, but failed the test for homogeneity of variance. As a result, non-parametric analyses were conducted. An independent samples Kruskal-Wallis test investigated any differences in the children’s step counts across the five schools, followed by pairwise comparisons with p values adjusted for multiple comparisons. Alpha was set at p < .05 and correlation coefficient effect sizes reported to indicate the magnitude of the differences. Nursery staff’s responses in the feedback questionnaire were summarised and considered when selecting suitable schools to participate in the main evaluation (Part 8B).

Results

Accelerometry

There were 139 pre-school children in the final sample, including 65 girls (M age = 3.73 years, SD = 0.30 years, range 3.08 – 4.17; 81.29% retention), recruited from five schools in Denbighshire. The average daily wear time of the Fitbit Zip over the 5 days was 122 minutes (range: 101 – 138 minutes). Visual inspection of Figure 8.01 suggests that there were differences in the number of steps performed by the children across the schools. Exploring highest to lowest, the 28 children in School YP performed the greatest number of steps (Mdn = 1729.63, IQR = 919.69), followed by the 25 children in School CC (Mdn = 1020.40, IQR = 697.70), and the 29 children in School BH (Mdn = 957.67, IQR = 559.80). However, a lower step count is apparent by the 31 children in School BC (Mdn = 548.00, IQR = 334.10) and the 25 children in School LL (Mdn = 466.96, IQR = 236.85).
Kruskal-Wallis analysis confirmed a significant difference in the number of steps performed by the children in each school ($H(4) = 75.55, p < .001$). Pairwise comparisons, with adjusted p-values, found no significant difference between the following schools: (a) LL and BC, (b) BH and CC, (c) BH and YP, and (d) CC and YP (see Table 8.01). However, significant differences were present between (a) LL and BH, (b) LL and CC, (c) LL and YP, (d) BC and BH, (e) BC and CC, (f) BC and YP.
Table 8.01.

Pairwise comparisons, with adjusted p-values, of the differences in the children’s total in-school step counts between the five schools.

<table>
<thead>
<tr>
<th>School comparison</th>
<th>Median difference</th>
<th>Std. t stat</th>
<th>p</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>LL and BC</td>
<td>81.05</td>
<td>-0.88</td>
<td>1.00</td>
<td>.12</td>
</tr>
<tr>
<td>LL and BH</td>
<td>490.72</td>
<td>4.89</td>
<td>&lt; .001</td>
<td>.67</td>
</tr>
<tr>
<td>LL and CC</td>
<td>533.45</td>
<td>-4.99</td>
<td>&lt; .001</td>
<td>.71</td>
</tr>
<tr>
<td>LL and YP</td>
<td>1262.68</td>
<td>-7.11</td>
<td>&lt; .001</td>
<td>.98</td>
</tr>
<tr>
<td>BC and BH</td>
<td>409.67</td>
<td>4.21</td>
<td>&lt; .001</td>
<td>.54</td>
</tr>
<tr>
<td>BC and CC</td>
<td>472.40</td>
<td>4.33</td>
<td>&lt; .001</td>
<td>.58</td>
</tr>
<tr>
<td>BC and YP</td>
<td>1181.63</td>
<td>6.53</td>
<td>&lt; .001</td>
<td>.85</td>
</tr>
<tr>
<td>BH and CC</td>
<td>62.73</td>
<td>-0.28</td>
<td>1.00</td>
<td>.04</td>
</tr>
<tr>
<td>BH and YP</td>
<td>771.96</td>
<td>-2.32</td>
<td>.21</td>
<td>.31</td>
</tr>
<tr>
<td>CC and YP</td>
<td>709.23</td>
<td>-1.96</td>
<td>.50</td>
<td>.27</td>
</tr>
</tbody>
</table>

Feedback questionnaire

All nursery staff (N = 10) reported that the data collection procedures were acceptable, with one free comment noting, “clear and helpful in order to set things in place”. An open question asked the nursery staff, how long the procedures took to complete; both responses from School BC reported 10 minutes, whilst four schools reported 5 minutes, however, two nursery staff members did not respond. All nursery staff reported that the children seemed comfortable wearing the tabards, however, the three responses from School CC reported that “some children refused” to wear the tabards, and one nursery staff member from School BC reported “they did however try to remove device out of the pocket maybe better if they were sewn in”. Four schools adhered to the instructions not to inform the children that their step counts were being monitored, as the respective nursery staff circled ‘no’ that the children were not aware that their physical activity was being monitored. However, the three nursery staff of School CC circled ‘yes’, and added free comments “we explained that it would count how much they moved”, “some children were aware and started to jump up and down”. Nametags were added to the tabards to help the nursery staff to identify which child the tabard belonged to. All nursery staff reported that the labels were in a suitable place, however two noted locations they believed would make the labels quicker and easier to view. Responding to an open question asking for suggestions on how the tabard procedure could be made easier, five nursery staff members considered that the Fitbit Zip devices should be sewn into the pockets of the tabards.
schools felt the intervention in the main evaluation (Part 8B) would be best delivered during the period 61 – 90 minutes of the 150 minutes nursery session, and two schools felt the intervention would be better delivered during the 31 – 60 minutes period of the session.

**Discussion**

The primary reason for conducting a pre-baseline probe measure was to evaluate total in-school step counts in five primary school nursery classes, which fitted the recruitment criteria. Taking these probe pre-baseline measures provided the basis for informed selection of four of those schools to take part in a controlled evaluation of the newly developed multi-component intervention. The accelerometer data identified one pair of low-activity schools (School BC and School LL), which performed comparable step counts. The three remaining schools (School BH, School YP and School CC) did not differ significantly from each other in terms of steps performed. However, the questionnaire measure revealed that the staff at School CC had not followed the protocol and had disclosed to the children that their activity was being measured and described the function of the tabards. Therefore, their probe pre-baseline data were considered unreliable and the participants’ expectations would in any case be likely to affect their performances on future trials. Consequently, School BH and School YP were paired to participate in the main evaluation (Part 8A).

**Strengths**

In addition to successfully pairing schools with similar baseline step counts using accelerometer measures, the study also showed that, in 4 of the 5 schools, nursery staff could collect accelerometer measures in accordance with the protocol. This strengthens the findings of Chapter 4 where staff in the University Nursery had also expressed their willingness to perform the task, extending that compliance to staff in nursery classes in schools with no connection to the University.

Non-biased feedback was obtained that the children were comfortable wearing the tabards as nursery staff rather than researchers administered the accelerometer measures. Moreover, having nursery staff conducting the measure decreases the cost of the evaluation. The questionnaire measure enabled users to anonymously input information about the evaluation of the multi-component intervention. Finally, socioeconomic status was previously acknowledged to be a variable that could not be easily matched across schools. However, the excluded School CC had a much higher percentage of free school meals (60%) compared to the four schools selected to take part in the main evaluation which all had less than 25% of pupils taking free school meals. Consequently, the level of socioeconomic status in the main evaluation study is essentially controlled.
Limitations

A procedural weakness arising from nursery staff conducting the accelerometer data collection was the low-level of control over when the tabards were placed on and removed from the children. Due to technical problems and restricted time, the researcher was unable to set up a system to monitor that the time-stamp photographs were being taken. In the event, not all photographs were successfully taken, with “forgetting” as the main reason for the procedural error. Nursery staff also reported that some children had attempted to take the Fitbit devices out of the tabard pockets indicating that modifications to the tabards were required. Furthermore, School CC reported some children refused to wear the tabards; no reason was provided for their refusals. However, no such difficulties were encountered in the other 4 schools.

Conclusion

The main objective of this study was to objectively identify two pairs of primary schools, which can be randomly assigned to condition in the main evaluation study (Part 8B). Additionally, the study also shows that the nursery staff were willing to perform the accelerometer data collection procedures with support from the researcher. With external monitoring of compliance with photo time-stamping step in the protocol, this will further strengthen the evaluation of the multi-component intervention.


Four schools identified during the probe pre-baseline measure (Part 8A) were invited to participate in the main evaluation of the new multi-component intervention designed to increase pre-school children’s physical activity levels and their consumption of fruit and vegetables, in the school and home environments. In addition to the procedural and materials modifications made to the physical activity intervention and healthy eating intervention as described in Chapter 7 (p. 152), modifications were also made to the ethics proposal for the study, additional measures collected, and following the pre-baseline measures, to the accelerometry data collection procedures in order to enable remote monitoring.

In accordance with ethics procedures, an amendment was submitted to the School of Psychology Ethics and Research Governance Committee, Bangor University, to collect the additional measures, and conditional approval was granted. The reviewer requested modification of the method of obtaining parental consent by converting the opt-out procedure to an opt-in procedure, and each parent was required to authorise separately their child’s participation to each of the measures, and the intervention procedures.
Previous studies in this thesis (Chapter 2 and 6) using anthropometric measures have only collected height and weight, enabling the calculation of BMI as a measure of adiposity. However, this study also collected two additional measures of adiposity, children’s waist circumference and blood pressure (see Chapter 1, p. 23).

Three modifications were made to the accelerometry measure, one based on previous studies, and two informed by nursery staff feedback received in Part 8A. As mentioned previously in Part 8A, remote monitoring of the time-stamp photographs being taken by the nursery staff was desired, but could not be put in place ahead of the pre-baseline measures. For the present study, an alternative solution was devised. A mobile phone with a camera, which contained a 500GB SIM card was assigned to each school. The phones were each set-up with a school-specific email address, and linked to a school-specific Dropbox account (Dropbox is a file hosting service, which can store any files, in this case photographs, that can be accessed online). As the SIM card provided Internet service to the mobile phone, the mobile phones were set to automatically sync with the Dropbox account every time a photograph was taken on the phone. The researcher could log into the Dropbox account and check that photographs had been taken successfully. If photographs were not uploaded, the researcher was able to contact the school, as opposed to contacting each school every day to check that the accelerometer measure was being conducted, removing a potential burden to the school staff. The written instructions previously provided were adapted to contain imagery-based instruction in addition to text. The instructional poster (Appendix 8.05) was attached to the lid of the plastic accelerometry materials box to provide a daily cue of the required procedures for the nursery staff.

The two accelerometry related modifications based on feedback from nursery staff concerned the tabards; neither modification directly affected the accelerometer measure. An additional pocket flap was sewn over all the tabard pockets to conceal the device, maintaining an opening at the top for the entry and removal of the Fitbit Zip. A popper fastening was placed at the top of each flap to secure each device inside. The reason for this modification was to deter the children from removing the devices, and for the devices to be more effectively concealed. Secondly, the ironed-on names were placed on the top back panel of the tabard (as opposed to on the inside pocket). This made it easier for the nursery staff to identify quickly which child the tabard belonged to. Spare tabards were provided in case of soiling. The Fitbit Zips could be transferred between tabards if required as the nursery staff could identify the Fitbit Zip identification number affixed to the device and note the change on the data sheet. The aim was to ensure that procedures were as simple as possible for the nursery staff to administer so as to increase their acceptability of the procedures.
The aim of this study was to evaluate the effectiveness of a multi-component intervention to increase pre-school children’s physical activity levels and their consumption levels of target fruit and vegetables.

Method

Ethical Approval

The School of Psychology Ethics and Research Governance Committee at Bangor University granted permission for the evaluation of a multi-component intervention targeting physical activity and healthy eating to be conducted with pre-school children (Ethics application No.: 2013-11864).

Participants

Four schools from Part 8A were invited to participate in the main evaluation, and assigned into pairs based on there being no significant difference in step counts between the schools. Using a random number generator one school per pair was randomly assigned to either the intervention condition or the control condition.

All nursery children attending the selected schools were invited to participate in the study. Condition-tailored opt-in consent letters were distributed to all parents by the nursery staff (intervention condition, Appendix 8.06; control condition, Appendix 8.07). Parents were asked to indicate in writing whether their child had any medical conditions or food allergies and if so to provide the relevant details. As parents were required to authorise their children’s participation in each of the measures, this resulted in a variation in the number of children consented to participate in each measure. Nursery staff reported that the change in method of providing consent for their child’s participation caused confusion amongst parents; therefore, a second consent letter (intervention condition, Appendix 8.08; control condition, Appendix 8.09) was distributed prior to the baseline measure 2 (see Experimental Design). This provided parents with a second opportunity to consent to the food consumption measure and intervention. Table 8.02 shows the number of children consented to each measure. Each school provided the date of birth for each child.
Table 8.02.
Number of children, by condition and total, consented for each measure.

<table>
<thead>
<tr>
<th>Measure</th>
<th>Condition</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention</td>
<td>Control</td>
</tr>
<tr>
<td>Physical activity</td>
<td>88</td>
<td>84</td>
</tr>
<tr>
<td>Food consumption</td>
<td>98</td>
<td>101</td>
</tr>
<tr>
<td>Height and weight</td>
<td>86</td>
<td>82</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>86</td>
<td>82</td>
</tr>
<tr>
<td>Blood pressure</td>
<td>86</td>
<td>82</td>
</tr>
</tbody>
</table>

The intervention condition received the full multi-component intervention, and the control condition continued with their standard nursery curriculum, and received the physical activity intervention materials only following their completion of the current study. The healthy eating intervention materials were not provided to the waiting-control schools as the food intervention requires external support to be implemented effectively. As promised at the outset of the research, each school received £80 in vouchers, however, it was not disclosed that each nursery staff member who contributed to the study was to receive a £20 voucher; both were awarded in recognition of their contribution and time to complete the study.

Experimental Design

A mixed, between-groups repeated-measures design was employed in this study and delivered over 7 months (see Figure 8.02). The independent variable was the delivery of the Super Dynamic Food Dudes intervention, which included the Dynamic Dudes physical activity intervention (Chapter 6), and the Food Dudes healthy eating intervention (Chapter 2). For each child, the quantitative dependent variables were: (a) anthropometric measures (body mass index (BMI), and waist circumference), (b) systolic and diastolic blood pressure, (c) children’s total in-school step counts during delivery of standard nursery curriculum, (d) children’s total in-school step counts during the Dynamic Dudes intervention phase (intervention children), or at a matched time of day during standard nursery curriculum (control condition), (e) intervention children’s step counts whilst participating in the classroom interactive story and exercise DVD sessions, or the control children’s step counts during matched time intervals, (f) consumption of standardised portions of 4 target fruit and 4 target vegetables, and (g) engagement with the Dynamic Dudes Home Adventures online intervention. Secondary dependent variables were (a) nursery staff feedback questionnaires, and (b) nursery staff interviews.
CHAPTER EIGHT

Figure 8.02. Schematic detailing the experimental design of the study.

**Materials**

Descriptions of the materials have been presented in Chapter 2, Chapter 6, and Chapter 7. Materials used during the Dynamic Dudes component in the intervention schools included: four interactive stories (1 new, 3 modified) and four exercise videos (4 modified), an A3 Dynamic Dudes calendar (Figure 6.02) and intervention-specific newsletters (Dynamic Dudes intervention, Appendix 8.10; Food Dudes intervention, Appendix 8.11). The Dynamic Dudes Home Adventures materials included: the website, Adventures booklet, and Adventure chart. Intervention materials used in the Super Dynamic Food Dudes phase included: the instructional DVD, peer-modelling intervention DVD, target foods, rewards, and presentation calendar depicting which target food was to be presented and which Dynamic Dudes element the children would complete. Eight new target foods, 4 fruit and 4 vegetables, were presented to the children. Figure 8.03 shows the target food pairs and detailed portion specifications. The home component of the Food Dudes intervention included the instruction booklet, and A4 Taste-Bud Training Chart (Figure 7.03).
CHAPTER EIGHT

173

Figure 8.03. Photograph of the target foods in their specified portions with a one-centimetre grid border for size reference.

Measures

Anthropometric and blood pressure. Three anthropometric measures, which were: a) height, (b) weight, (c) waist circumference, and blood pressure measure were collected in the presence of nursery staff at T0 (baseline 1) and at T6 (2-month follow-up). Full details of height and weight measures are described in Chapter 2 (p. 52). Waist circumference and blood pressure measures are described in the Procedure section below. A medical student who had previously received training to conduct the blood pressure measure was recruited to collect this specialist measurement.

Accelerometry. Fitbit Zip accelerometers, housed in a closed pocket on the inside of tabards worn by the children, measured the pre-school children’s total in-school step counts (see Chapter 3). This measure was time matched across the intervention and control conditions, and collected at T0 (baseline 1), at T1 (the Dynamic Dudes Intensive intervention phase), at T2 (post-intervention 1), at T4 (Super Dynamic Food Dudes phase), and at T6 (2-month follow-up).

Food consumption. This measure was conducted through direct observations and digital photography of the children’s plate residue (see Chapter 2, p. 52 for full explanation). The children’s
food consumption of target foods was assessed at baseline 2 (T3; after delivery and post measures for the main Dynamic Dudes component), and again at post-intervention 2 (T5).

**Dynamic Dudes Home Adventures; home (intervention condition only).** Engagement with the online Dynamic Dudes Home Adventures website was monitored using (a) page launch alerts, and (b) Google analytics (from T4 – T8). The website was automated with nine launch page triggers. Every time a child or parent accessed the home page or any of the eight video pages, a page launch alert email was triggered detailing the date, time, and page accessed. The page launch alert was sent directly to the researcher’s email. The details of the page launch alert were used to facilitate the Google analytics monitoring. The information monitored by Google analytics was consistent with the pilot physical activity intervention (Chapter 6, p. 130), but streamlined to determine which videos were played and by how many children.

**Feedback questionnaires (Nursery staff).** To gather feedback questionnaires were administered to nursery staff in the intervention and control conditions. The intervention condition nursery staff completed a physical activity intervention-based questionnaire (Appendix 8.12) following completion of the post-intervention 1 measure (T5) to elicit their views on (a) the physical activity data collection procedures, and (b) administering the Dynamic Dudes intervention phase. On completion of the present evaluation (T8), the intervention condition nursery staff received a second questionnaire (Appendix 8.13) eliciting their views on (a) the food consumption, anthropometric and blood pressure data collection procedures, (b) implementing the Super Dynamic Food Dudes phase, and (c) overall participation in the evaluation. The control condition nursery staff received a questionnaire (Appendix 8.14) eliciting their views on all data collection procedures, and their overall experience of participation in the present study.

**Interviews (nursery staff).** To further explore themes from the questionnaires, the researcher conducted 1:1 semi-structured interviews with each member of nursery staff. All nursery staff provided written consent for those interviews to be recorded (Appendix 8.15). The interviews were conducted in a private room and recorded using a Dictaphone (Zoom H1 Handy Recorder). Condition specific questions were asked (intervention condition, Appendix 8.16; control condition, Appendix 8.17). When a member of nursery staff asked for clarification of a question, the researcher re-worded the question.

**Procedure**

On completion of Study 8A probe pre-baseline measures, the researcher visited the nursery staff of the suitable schools to inform them of their assigned condition, and further explain their role.
Each school received a school-tailored ‘Research Handbook’ (Appendix 8.18 for example). The booklet initially contained only a study introduction, schedule of delivery and baseline 1 (T0) instructions. Instructions for each intervention and measurement phase of the study were issued to each condition, prior to the commencement of the particular phase, to prevent overloading the nursery staff with information. The schools were asked to nominate a member of nursery staff as a ‘Practitioner Scientist’ who would be responsible for overseeing the research in their respective nursery, and to liaise with the researcher. Details of the overall intervention were not disclosed prior to baseline 1 (T0), only the time commitment required.

New opt-in consent letters were issued to all nursery children of the intervention (Appendix 8.06) and control schools (Appendix 8.07). One pair of schools was scheduled to commence a week prior to the second pair to enable the researcher to conduct all the necessary visits.

**Baseline 1 (T0): Anthropometric and accelerometry measures (10 days).** The procedure for the accelerometer measures described in Part 8A was administered during the 10-day baseline measure. The researcher delivered the measurement materials box (containing tabards and Fitbit Zips, mobile phone, charger, and data sheet) to the nursery classes on a Monday morning before 8.30am prior to the arrival of the children, and collected the materials on a Friday afternoon after 3.30pm, following the children’s return to their parents. The accelerometer materials were reset over the weekend ready for re-distribution the following week. The Fitbits Zips were synced with their account and batteries changed if necessary, and each phone was charged and photographs were downloaded. The tabards were washed every few weeks.

Throughout the 10-day baseline measure, the schools were instructed to continue with their standard nursery curriculum; no intervention was delivered. The researcher visited the nurseries to ensure the procedures were being conducted correctly, but she did not intervene in the nursery routine or remain in the nursery environment, with the exception of the day the anthropometric and blood pressure measures were collected. This was considered important to minimise disruption and the risk of biasing the children’s physical activity behaviour as a result of her presence.

Anthropometric and blood pressure measures were conducted in a quiet area of the nursery environment in full view of the nursery staff. The children’s height and weight were measured in accordance with the procedures described in Chapter 2 (p. 52) by the same researcher. Two additional measures collected, waist circumference and blood pressure, are described below.

To measure waist circumference, the researcher introduced the measure as a game. Before taking the child’s measurement, the researcher placed the inelastic fabric tape around her own waist, to model to the child what the measure would entail. The researcher then asked each child if they could keep the tape around their waist area to help the child understand the procedure. Using role-
play, each child was next invited to find their belly button using their own index finger with their left hand. Once the index finger was in position, they were asked to hold their finger in place. Whilst verbally instructing the child, the researcher assisted the child in placing their index and middle finger from their right hand above their already positioned left hand index finger. The child was invited to release their left hand, and lift their right hand index finger for the researcher to place the inelastic fabric tape beneath the finger. The child held the tape in position before slowly turning around through 360 degrees. The researcher ensured that the tape remained level around the child’s waist by inspecting it at eye-level, before taking a reading from the tape to the closest 0.1cm. The tape was released, and the child was verbally praised before progressing on to the next measure.

To measure blood pressure, two child-size seats were positioned at approximately a 45-degree angle. Each child was invited to take a seat beside the medical student. The medical student explained the procedure using child-appropriate terminology, for example, “shall we hear your heart go boom boom boom?”. The children were allowed to handle the stethoscope, paediatric blood pressure cuff and aneroid sphygmomanometer prior to the measure being conducted to help familiarise them with the equipment. The medical student placed the child’s right elbow on the edge of her knee, with the arm positioned at approximately a 135-degree opening between their wrist and bicep, whilst keeping their hand open. Using the positioning outline on the blood pressure cuff, the cuff was wrapped around the child’s arm and fastened with the Velcro strip. The aneroid sphygmomanometer was placed on the medical student’s other knee and the children were encouraged to watch it. Using the stethoscope, the child’s pulse on their inner arm was identified. The cuff was inflated slowly and released gradually to identify the systolic value (first pulse), and secondly the diastolic value (final pulse). Once deflated, the cuff was removed, and the child was verbally praised for their participation.

At the end of the baseline measure, the researcher delivered training on the Dynamic Dudes intervention phase procedures to the nursery staff. They were shown an excerpt of both an exercise video and an interactive story. The importance of their status as role models for the children was explained and emphasised, and the researcher modelled the effort levels that were expected from the nursery staff during participation in the physical activity components. Following the viewing of an interactive story, the researcher instructed the nursery staff not to disclose to the children that she was the story presenter shown in the videos. The researcher visited the nursery in disguise to prevent the children from connecting her with the on-screen model. To supplement the training, written instructions plus delivery scripts for Day 1, Day 2, Day 9, Day 17, and Day 24 were provided for use on specific days. The documents were added to the research handbook (Appendix 8.18) for safekeeping and easy reference. The researcher visited each nursery to provide support.
Curriculum links between the Early Years Foundation Phase and the Dynamic Dudes intervention phase were highlighted and provided in written format (Appendix 8.18) to help integrate the intervention into the nursery curriculum. During the training, nursery staff were reminded to continue the accelerometry measure procedure throughout the Dynamic Dudes intervention phase.

**Dynamic Dudes Intensive intervention phase (T1): Accelerometry measure (24 days).** The Dynamic Dudes intervention was delivered as described in the pilot physical activity intervention evaluation (Chapter 6, p. 123), with minor modifications (Chapter 7, p. 152). The nursery staff led the delivery with the support of scripts (Appendix 8.18). The interactive stories were presented in their entirety, and the exercise videos were presented as outlined in Table 6.01 (Chapter 6, p. 129).

As the children were unfamiliar with the peer-modelling characters, on Days 1 and 2, the children were shown two brief introductory clips, one on each day to interactively introduce the Dynamic Dudes characters. One clip showed the characters in their live-actor form in the exercise video setting; the second clip showed animation versions of the characters and the interactive story setting. The nursery staff then proceeded to show the scheduled video-modelling element, and deliver it as described in Chapter 6 (p. 123), with nursery staff taking the time-stamp photographs.

A researcher visited each nursery periodically to ensure fidelity of the procedures by observing unobtrusively at the back of the class. All children completed the Dynamic Dudes intervention components as the Head Teacher had given permission for the class to participate and deemed the intervention to be of no harm to the children; however, data were only recorded for consented children (Fairclough et al., 2016).

Following completion of the phase, an A4 newsletter (Appendix 8.10) was created and sent out to parents in the intervention schools. The newsletter was tailored for each parent by including a class photo showing their child taking part with their classmates in the Dynamic Dudes intervention (see Chapter 7, p. 152). Permission to take and include the photograph of the children was granted by both intervention schools and parents of children shown in the photo. If consent was not in place, the relevant child was not included in the photograph.

**Post-intervention measure 1 (T2): Accelerometry and questionnaires (10 days).** For a further 10 days the children wore their Fitbit Zip and tabard under baseline conditions as for measure 1. The nursery staff were asked to independently complete a feedback questionnaire (Appendix 8.12) about the Dynamic Dudes intervention phase.

**Baseline 2 (T3): Food consumption (4 days).** Prior to this measure, a second opt-in consent letter (intervention condition, Appendix 8.08; control condition, Appendix 8.09) was distributed to the parents of the children who had not previously consented. The researcher briefed the nursery staff on the measurement protocol and provided written instructions (Appendix 8.18). This measure was
researcher-led, with the assistance of the nursery staff. The food consumption measurements were conducted as described in Chapter 2 (p. 52), using the target foods shown in Figure 8.03.

At the end of baseline 2, the researcher provided training on the delivery of the 'Super Dynamic Food Dudes' phase. Nursery staff were trained how to deliver role modelling using the intervention materials, the instructional DVD (see Chapter 7), and written instructions (Appendix 8.18). In this phase, teacher scripts were provided for Day 1, Day 6, and Day 19 (Appendix 8.18). A curriculum kit containing an energy tube and rainbow-coloured energy tokens was provided to each intervention school, along with a document describing pedagogical links (Appendix 8.18) between the Early Years Foundation Phase curriculum and the Super Dynamic Food Dudes intervention.

**Super Dynamic Food Dudes phase (T4): Accelerometry measure (20 days).** This phase consisted of (a) the Food Dudes healthy eating intervention, which was delivered for a total of 16 days, on 4 days each week (Monday to Thursday), and (b) a tapered Dynamic Dudes physical activity phase, in which the activity intervention was delivered on one day per week (Fridays) for a total of 4 weeks. Each intervention school was provided with two A3 Super Dynamic Food Dudes Calendars (Appendix 7.02) illustrating the presentation schedule for each fruit and vegetable pair, and the interactive story or exercise video the children were to complete. An A4 poster (Appendix 8.19) of the target foods presented during the phase was also displayed at the nursery entrances as visual information for parents.

On the scheduled Food Dudes days, the intervention was delivered using the modified healthy eating intervention procedure described in Chapter 2 (p. 45), integrating the modifications described in Chapter 7 (p. 143). Two interactive stories and two exercise videos were selected for presentation. Elements selected were those that modelled the highest number of steps. The number of steps modelled in each element was identified using the direct observation coding framework devised in Chapter 3. On the first Dynamic Dudes day, the nursery staff re-introduced the physical activity intervention guided by a script (Appendix 8.18). Accelerometry measures (as conducted in the Dynamic Dudes intervention phase) were also conducted on these days.

On Day 20, the nursery staff read a letter (Appendix 8.18) ‘from the Dudes’ to the children in anticipation of the suspension of the food intervention contingencies. The letter forewarned the children that the Super Dynamic Food Dudes were going away for a while to help other children get lots of special energy by eating their fruit and vegetables every day. Following completion of the Super Dynamic Food Dudes phase, a second class-tailored A4 newsletter (Appendix 8.11) was issued to all intervention condition parents to provide them with further information.

**Dynamic Dudes Home intervention phase (T4 – T8): Engagement monitoring (12 weeks).** The Dynamic Dudes Home intervention was launched in school at T4, on the first Dynamic Dudes day of
the Super Dynamic Food Dudes phase. Each child received a personalised information booklet and an Adventure Chart to complete during the home intervention (see Figure 7.04). The children were set a target of completing the adventure chart using 28 star stickers provided in order to win a free child’s ticket to visit a local attraction, the Welsh Mountain Zoo, North Wales. Initially a deadline for completion was not set to explore whether any adventure charts would be returned. Eight weeks following initial distribution, parents were given four weeks notice for the children to complete the adventure charts. The target was considered appropriate, as the reward contingency required the children to complete three elements (exercise videos or interactive stories) each week, which would amount to 30 minutes of physical activity per week. Extra charts were downloadable from the website if parents required them. This deadline was noted in the (a) Super Dynamic Food Dudes phase newsletter (Appendix 8.11), which was distributed in the Rainbow Picnic and Activity phase, (b) on an A4 poster (Appendix 8.19) displayed at the nursery entrances, and (c) on the group Facebook page.

In school, the nursery staff were instructed to encourage the children to participate in the Home Adventures intervention and complete their adventure chart. A reminder of login details slip was included in the Parent Home DudeKit issued after the Super Dynamic Food Dudes phase (see below). A written prompt was also sent home to parents two weeks ahead of the deadline. When a child returned their adventure chart, the completion of the chart was verified using Google analytics. If a child had not completed and returned their chart, a motivational note and adventure chart were sent home with the child. If a returned chart was successfully verified, the child received in front of their friends a congratulations slip (Appendix 8.20) and their free ticket to the Welsh Mountain Zoo in a sealed envelope. The nursery staff kept the tickets until the end of the nursery session when they were given directly to their parents for safekeeping.

The information on engagement was extracted manually every week from the page launch alerts and Google analytics. Based on the launch page alerts generated from the Dynamic Dudes Home Adventures pages, each Google analytics account was searched for the additional information being measured.

Post-intervention 2 (T5): Food consumption (4 days). Baseline measurement procedures were replicated; the target foods were presented to the children without any intervention or encouragement.

Parent Home DudeKit home intervention (T7 – T8): No measures (Continuous). The Parent Home DudeKit was introduced to the children in school before being sent home during the 2-month follow-up (T6 and see below). The children also received a customised Food Dudes container and an information sheet (Appendix 8.21), providing age-appropriate portion size recommendations to be placed in the box. The letter asked parents to send a portion of fruit and a portion of vegetable into
school in their child’s container once a week on a nursery determined day, to enable their child to consume fruit and vegetables during the Rainbow Activity-Picnic Phase (see below).

2-Month follow-up (T6): Anthropometrics, accelerometry, and questionnaires (10 days). Baseline measure 1 (T0) procedures were employed two-months after the completion of the Dynamic Dudes intervention phase. The consented children participated in anthropometric measures, and wore the tabards with the Fitbit Zip in situ for 10 days. At the end of the measure, the researcher delivered training on the procedures of the Rainbow Activity-Picnics phase to the nursery staff. Written instructions were provided for reference (Appendix 8.18). A feedback questionnaire was distributed to the intervention condition nursery staff (Appendix 8.13) to gather their views on the interventions and data collection procedures. The nursery staff were all asked to complete the questionnaire independently.

Rainbow Activity-Picnics phase (T7): Maintenance only, no measures (4 weeks). To maintain the positive behaviour change established in the two previous intervention phases, the multi-component intervention was tapered further. The intervention schools delivered one ‘Activity’ day and one ‘Picnic’ day, every week for 4 weeks. The nursery staff selected the day they would like to host the picnic day, and a poster (Appendix 8.22) was displayed at the entrance to the nursery as a reminder for parents to provide fruit and vegetables for their child on the chosen Picnic day.

On the Activity days, the children were invited to select and complete an interactive story or exercise video as in previous phases. There were no accelerometer measures collected or Dynamic Dudes calendar to mark on completion of the element. The Picnic days were conducted as described in Chapter 2 (p. 57), with the modification outlined in Chapter 7 (p. 143). During Week 4, the children all received their special prizes of a Food Dudes-customised beaker and a placemat to take home, and were encouraged to continue their Super Dynamic Food Dudes Adventures at home.

Nursery staff interviews. The researcher interviewed the nursery staff using a range of questions (Appendix 8.16) relating to the intervention phases and data collection procedures. A Dictaphone was used to record the discussions, which were later transcribed verbatim.

Control condition. The control condition also participated in all anthropometric, accelerometry, and food consumption measurements, throughout baseline 1 (T0), post-intervention 1 (T2), baseline 2 (T3), post-intervention 2 (T5), and the 2-month follow-up (T6). All measures were conducted as in the intervention condition. The nursery staff completed a questionnaire (Appendix 8.14) at the 2-month follow-up 1 (T6) to elicit their views on the data collection procedures, before being interviewed by the researcher with short questions (Appendix 8.17) to obtain further information where possible (T8).
Throughout the study, the nursery staff were instructed to continue with their standard nursery curriculum. The researcher visited the nursery bi-weekly to distribute and collect the accelerometry measure resources, which maintained regular contact with the schools. Information about the intervention was not disclosed to the control schools until all measurement phases were completed. At the end of the Rainbow Activity-Picnics phase, the researcher visited the nurseries to explain the Dynamic Dudes intervention phase to the nursery staff and provide them with all the materials they would need to implement the intervention with their next cohort of children.

Acknowledgement of participation. To thank all the children for their participation they each received a personalised ‘Junior Scientist’ certificate (Appendix 8.23). The schools and nursery staff who had contributed to the study received their financial gift as described previously. Each school received a report illustrating their results.

Data Analysis

Anthropometric and blood pressure measures (T0; T6). For inclusion in the anthropometric and blood pressure measures, each child was required to provide a data point at both baseline 1 (T0) and 2-month follow-up (T6). The data were assessed for outliers and the criteria for parametric analysis were fulfilled. Independent and paired samples t-tests were conducted to explore differences between- and within-conditions, for BMI, waist circumference, systolic blood pressure, and diastolic blood pressure. To investigate the relationship between the children’s BMI and their step counts, a Pearson’s correlation was performed.

Accelerometry measures. Set up and the application of inclusion criteria for the accelerometry data followed the procedures outlined in Part 8A (p. 162). Consistent with Chapter 6, total in-school steps data were analysed separately for: baseline, post-intervention, and follow up test measures conducted under baseline conditions at T0, T2, and T6 respectively; sessions conducted during T1, the Dynamic Dudes Intensive intervention phase and during T4, the Super Dynamic Dudes intervention “taper” phase. Total in-school steps data for each Dynamic Dudes interactive story session and each Dynamic Dudes exercise video session during intervention phases (T1) and (T4) were also analysed separately.

Total in-school steps performed at baseline (T0), Dynamic Dudes post-intervention (T2) and 2-month follow-up (T6). A significant difference was found in the number of steps performed by the intervention and control condition at baseline 1 (T0) ($p = .047$, $r = .16$). Both the raw, and log transformed data violated the homogeneity of regression slopes ($p < .001$) required to conduct an ANCOVA, and the assumption of homogeneity of variance (Levene’s test and Hartley F max test) for
mixed ANOVA. Consequently, non-parametric analyses were conducted. No significant difference in step counts was found between girls and boys at baseline in either condition ($p > .05$).

Van Breukelen (2006) concluded that if assignment to condition was randomised, change scores were as unbiased as ANCOVA, and therefore an appropriate means of correcting for unequal baselines across condition. Change scores were therefore calculated between the three measurement phases (post-intervention 1 [T2] – baseline 1 [T0]; 2-month follow-up [T6] – baseline 1 [T0]; and 2-month follow-up [T6] – post-intervention 1 [T2]). Mann Whitney U analysis was employed to investigate any differences in change scores between the intervention and control conditions.

**Total in-school steps performed during the intervention phase of the Dynamic Dudes intervention (T1):** The intervention phase was divided into 3 presentation blocks. The intervention and control children were eligible for inclusion if they provided 3 days of data in each of the blocks. For each block, a ‘mean step count score’ was computed for each child. The data were assessed for outliers and fit to the criteria for parametric analyses. For each block, an independent $t$-test explored any differences in step counts between children taking part in the Dynamic Dudes intervention, and the control condition during their standard nursery curriculum. Within-condition comparison over time was not appropriate for the intervention condition as the intervention procedures varied over successive blocks to scaffold the children’s learning of the target behaviours. This limitation did not apply to children in the control condition who were engaged in their usual nursery curriculum activities. Children’s step counts in each measurement block were therefore compared using a one-way repeated measures ANOVA to explore any changes over time.

**Total in-school steps performed during the Super Dynamic Food Dudes phase (T4):** The data set up and tests for parametric analysis were consistent with previous analyses. The 4 days of total in-school physical activity data were combined to calculate a ‘mean step count’ score. An independent samples $t$-test investigated differences in total in-school step counts between the intervention and control conditions.

**Total steps performed during the story and exercise sessions of the Dynamic Dudes intensive intervention phase (T1; T4):** To provide a measure of children’s steps performed during each interactive story and exercise video session, the time-stamps provided by the nursery staff were applied to steps recorded per child on each intervention day. A ‘total number of steps performed’ during each session of each component story or video was calculated for each child. For each intervention component, children were included if they could provide data for all three presentations. Due to variation in attendance by each child the data for each child were categorised in terms of their opportunities to experience a given component (e.g. their first, second, or third opportunity) rather than the pre-scheduled order of daily deliveries for each component.
To investigate any changes in step count performance over successive presentations of each intervention element, independent repeated measures ANOVA’s were performed for each character’s exercise video and interactive story. To compare the steps generated by children in the intervention to the number of steps generated in control children during their standard curriculum over the equivalent time frame, independent t-tests were performed at Presentation 3 of each element. Only Presentation 3 was tested to reduce the number of comparison tests, and to be consistent with data analyses employed in Chapter 6. Additionally, to compare the mean number of steps the intervention children performed whilst completing each exercise video and during each interactive story in comparison to the number of steps modelled on-screen, one-sample t-tests were employed. The total on-screen step count was determined using the direct observation framework devised in Chapter 3.

**Total steps performed during the Dynamic Dudes story and exercise sessions during the Super Dynamic Food Dudes phase (T4).** Data were compiled as for previous intervention component analyses. Examination for fit to the normal curve found the data to be positively skewed therefore a square root transformation was conducted. The transformed data met the criteria for parametric analysis. For the descriptive analysis, the raw data are reported. Independent t-tests were conducted on the transformed data to explore differences in the steps performed during each of the four components presented, as compared to steps performed over the matched time frames during the standard nursery curriculum.

**Dynamic Dudes Home Adventures (T4 – T8).** Data extracted from page launch alerts and Google analytics were converted into frequencies of (a) the number of children who accessed the online intervention, (b) the number of occasions the website was visited, (c) the number of videos watched, and (d) the number of children who watched each video.

**Food consumption: Mean pieces of target food consumed at consumption baseline (T3) and the Food Dudes intensive phase post-intervention (T5).** To be eligible for inclusion in this measure, the children were required to have a minimum of 2 days of data in both measurement phases (T3 and T5) conducted under baseline conditions. A ‘mean consumption score’ for the children whose data met the inclusion criteria was computed separately for the fruit and vegetables food categories.

Non-parametric analyses were conducted as the food consumption data were positively skewed. Independently for each food category, Mann Whitney U tests were employed to compare across conditions the consumption levels at T3, prior to the Food Dudes intensive phase and at T5, immediately after the intervention. Wilcoxon signed rank tests explored any changes over time within each condition. Change scores were also calculated, and the difference in change between conditions was explored using Mann Whitney U.
To explore the difference in consumption of the food categories, and to investigate whether the difference changed over time, Wilcoxon signed rank tests were performed separately for intervention and control conditions at baseline 2 (T3) and at post-intervention 2 (T5). In addition to analyses of the whole sample in each condition, visual inspection suggested that the children could be sub-grouped into poorest and highest eaters. The poorest eaters were children who consumed less than 1 piece at baseline, and the highest eaters were children who consumed 1 piece or more (see Chapter 2, p. 60 for explanation). Wilcoxon signed rank tests investigated the changes over time between each food category (fruit versus vegetables) for the lowest and highest eaters.

To ensure that any increases in consumption of target food categories between baseline and post-intervention are not governed by a change in only some of the target foods, descriptive analysis of each of the eight target foods is presented for visual inspection.

**Nursery staff feedback questionnaires.** Summaries of the nursery staff responses to their respective questionnaires are provided. Full responses are provided in Appendix 8.24.

**Nursery staff interviews.** Verbatim transcriptions (Appendix 8.25) were created for each interview. The researcher identified key points from each staff member’s questionnaire based on the questions asked and provided a summary of their responses.

### Results

**Anthropometrics and Blood Pressure**

For each measure, Table 8.03 shows the mean scores obtained by each condition at baseline 1 (T0) and at the 2-month follow-up (T6). Except for waist circumference, there were no significant differences between the measures at baseline 1 (T0) for each condition ($p > .36, r = .008 – .09$). Waist circumference was significantly smaller in the control condition than in the intervention condition ($t(116) = 2.88, p = .005, r = .26$). No significant differences between conditions were found for any of the anthropometric measures at 2-months follow-up ($p > .18, r = .003 – .13$).
Table 8.03.
*Mean scores of the anthropometric and blood pressure measures taken by condition, with SDs in parentheses.*

<table>
<thead>
<tr>
<th>Measure</th>
<th>Baseline</th>
<th>2-Months follow-up</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Intervention condition:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>58</td>
<td>101.13 (4.53)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>58</td>
<td>16.96 (2.01)</td>
</tr>
<tr>
<td>BMI score (kg/m²)</td>
<td>58</td>
<td>16.55 (1.21)</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>57</td>
<td>55.61 (3.72)*</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>54</td>
<td>98.02 (6.41)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>54</td>
<td>60.09 (5.71)</td>
</tr>
<tr>
<td><strong>Control condition:</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height (cm)</td>
<td>66</td>
<td>100.50 (4.34)</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>66</td>
<td>16.52 (1.91)</td>
</tr>
<tr>
<td>BMI score (kg/m²)</td>
<td>66</td>
<td>16.47 (1.57)</td>
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<tr>
<td>Waist circumference (cm)</td>
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<td>53.79 (3.27)*</td>
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<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>55</td>
<td>97.06 (6.21)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>55</td>
<td>60.92 (6.35)</td>
</tr>
</tbody>
</table>

* Independent samples significant comparisons p < .05
** Paired samples significant comparisons p < .05

Within-groups comparisons in the intervention condition found that children’s BMI scores significantly decreased over time (t (57) = 2.23, p = .03, r = .28), as did their waist circumference (t (55) = 3.37, p = .001, r = .41). The intervention children showed a significant increase in the systolic blood pressure (t (53) = -2.78, p = .008, r = .36), but no significant change was found for diastolic blood pressure (t (52) = 0.00, p = 1.00, r = .00).

Within-group comparisons over time revealed no significant difference in BMI in the control condition (t (64) = .91, p = .37, r = .11); however, a significant increase in the children’s waist circumference was found (t (59) = -3.38, p = .001, r = .40). Additionally, no significant change was found in systolic blood pressure (t (52) = .172, p = .09, r = .23), although diastolic blood pressure showed a significant decrease (t (52) = 3.23, p = .002, r = .41). No significant correlation was found between the children’s BMI and their mean step counts (n = 106, r = .03, p = .75).
Accelerometry Data

Total in-school steps performed at baseline 1 (T0), Dynamic Dudes intensive phase post-intervention (T2) and 2-month follow up (T6). A total of 147 children (M age = 3.86 years, SD = 0.30, range: 3.25 – 4.33 years; 85.47% retention) who were present at all three measurement phases provided data for this analysis. The average wear time of the tabards and Fitbit Zips was 116 minutes (range: 100 to 141 minutes) during baseline 1 (T0), 121 minutes (range: 100 to 141 minutes) during post-intervention 1 (T2), and 120 minutes (range: 100 to 134 minutes) during 2-month follow-up (T6).

Figure 8.04 shows the median change scores for total in-school steps performed by the intervention and control children between the three measurement phases. Between baseline and post-intervention the intervention condition (n = 76) improved their median step count by 496.17 (IQR = 375.34) steps, and the control condition (n = 71) improved by 282.33 (IQR = 775.49) steps. However, change between baseline and 2-month follow up was smaller: in the intervention condition total in-school daily steps improved by 253.32 (IQR = 595.27) while the control condition improved by 45.78 (IQR = 639.62) steps. Between post-intervention and 2-month follow-up, the intervention condition decreased their step counts by 280.85 (IQR = 746.82) steps and the control condition decreased by 188.36 (IQR = 464.70) steps.

Figure 8.04. Median change scores for the in-school steps performed by the intervention children (grey bars) and the control children (unfilled bars) between baseline and post-intervention (T2 – T0), 2-months follow-up and baseline (T6 - T0), and 2-months follow-up and post-intervention (T6 - T2). Error bars represent inter-quartile range.
Mann Whitney U analysis of the change scores found that the intervention condition made a significantly larger increase in total in-school steps from baseline 1 to post-intervention 1 as compared to the control condition ($U = 2168.00, z = -2.05, p = .04, r = .17$), however, no significant difference was found between baseline 1 and 2-month follow-up ($U = 2275.00, z = -1.64, p = .10, r = .14$) or between 2-month follow-up and post-intervention 1 ($U = 2872.00, z = 0.67, p = .67, r = .06$).

**Total in-school steps performed during the intensive phase of the Dynamic Dudes intervention (T1).** The mean numbers of total in-school steps performed by the children during each block of the Intensive phase of the Dynamic Dudes intervention are shown in Figure 8.05. A total of 149 children’s data (86.67% retention) contributed to this measure. During Block 1, the intervention condition performed on average 1365.01 ($SD = 549.35$) steps, whereas the control condition performed 1379.78 ($SD = 656.53$) steps. However, the intervention condition outperformed the control condition during Block 2 with 1643.29 ($SD = 820.04$) steps, and during Block 3 with 1653.82 ($SD = 747.83$) steps, as the control condition maintained a constant level of performance throughout with 1338.59 ($SD = 714.10$) steps during Block 2, and 1329.10 ($SD = 692.53$) steps during Block 3.

![Figure 8.05. Mean number of total in-school steps performed during each of the three 8-day intervention phase blocks; intervention condition (grey bars) received the intensive phase of the Dynamic Dudes intervention and the control condition (unfilled bars) continued with their standard nursery curriculum. Error bars represent ± 1 standard error of the mean.](image)

Independent samples t-tests at Block 1 found no significant difference between the mean number of total in-school steps performed by the intervention and control conditions ($t(147) = -0.15, p = .88, r = .01$). At Block 2, the intervention condition performed significantly more steps than the...
A one-way repeated measures ANOVA was performed on the control condition to assess any change in step counts across the presentation blocks. As the assumption of sphericity was violated ($X^2 = 6.41, p = .041, \varepsilon_{\text{Greenhouse-Geisser}} = 0.92$), a Greenhouse Geisser correction was applied. No significant main effect of time was found across the presentation blocks, $F(1.84, 130.57) = 0.86, p = .42$, partial $\eta^2 = .01$, confirming that the number of steps performed by the control children remained constant throughout the Dynamic Dudes intervention phase.

**Intervention delivery.** The final sample included in this measure was 169 children (98.28% retention). Both intervention schools delivered every component of the intervention, however, due to variation in attendance, only 17.65% of the included sample experienced the full 24-day intervention. Moreover, the majority of children (74.10%) completed 75% or more of the intervention trials.

**Exercise videos component.** To investigate how many steps the children performed whilst completing the levels section of each of the characters’ exercise videos, the children’s mean number of steps performed during each of three presentations blocks is presented in Figure 8.06. To enable comparison between steps performed during the standard nursery curriculum, and the control children’s mean number of steps over the matched time intervals are also presented. Visual inspection shows that the intervention children consistently outperformed the control children, and that the intervention children performed similar numbers of steps during each of the four exercise videos, a different one for each character.
Repeated measures ANOVA conducted on each exercise video found no significant main effect of time for Charlie’s exercise video ($F(2, 100) = 0.81$, $p = .446$, partial $\eta^2 = .02$), for Razz’s exercise video ($F(2, 104) = 0.78$, $p = .46$, partial $\eta^2 = .02$), or for Tom’s exercise video ($F(2, 90) = 2.19$, $p = .118$, partial $\eta^2 = .02$). However, a significant main effect of time was found for Rocco’s exercise video ($F(2, 96) = 4.32$, $p = .016$, partial $\eta^2 = .08$). Planned comparisons found no significant change in step counts between Presentation 1 and Presentation 2 ($t(48) = -0.50$, $p = .621$, $r = .07$), but a significant increase in step counts was found between Presentation 1 and Presentation 3 ($t(48) = -2.42$, $p = .019$, $r = .33$), and between Presentation 2 and Presentation 3 ($t(48) = -2.36$, $p = .023$, $r = .32$).

Independent samples t-tests at Presentation 3 of each character’s exercise video found that the exercise videos were successful in engaging the intervention children in physical activity as they significantly surpassed the step count of the control children (with very large effect sizes), who were participating in standard nursery curriculum, during Rocco’s exercise video ($t(51.67) = 14.83$, $p < .001$, $r = .90$), Charlie’s exercise video ($t(59.72) = 13.85$, $p < .001$, $r = .87$), Razz’s exercise video ($t(70.29) = 13.42$, $p < .001$, $r = .85$), and during Tom’s exercise video ($t(48.82) = 13.76$, $p < .001$, $r = .89$).

At Presentation 3, the intervention children performed the most steps during Tom’s exercise video (600.70 steps), followed by Rocco’s exercise video (597.35 steps), then Charlie’s exercise video (514.69 steps) and the least during Razz’s exercise video (435.70 steps). Four independent one sample
t-tests were performed to compare the number of steps modelled on-screen during the levels section of each exercise video in relation to the number of steps performed by the children. At Presentation 3, there were no significant differences in the number of steps performed by the intervention children and the number of steps modelled during Rocco’s exercise video (600 steps; t(48) = -0.07, p = .94, r = .01), or during Charlie’s exercise video (500 steps; t(50) = 0.50, p = .62, r = .07). However, the intervention children performed significantly less than the number of steps modelled during Tom’s exercise video (1000 steps; t(45) = -10.70, p < .001, r = .85), and during Razz’s exercise video (520 steps; t(53) = -9.19, p < .001, r = .78).

Interactive stories. To determine the effectiveness of the interactive stories to engage the intervention children in short bursts of physical activity, the children’s mean step counts during each presentation of the four characters’ stories is presented in Figure 8.07. In comparison, the mean number of steps performed by the control children during the standard nursery curriculum within equivalent time frames is also shown. Consistent with the data for the exercise videos, in all cases the intervention children outperformed the step counts of the control children.

![Figure 8.07](image.png)

Figure 8.07. Mean number of steps performed by the intervention condition (grey bars) and the control condition (unfilled bars) during the three successive presentations of each character’s interactive story. Error bars represent ± 1 standard error of the mean.

Four repeated measures ANOVA’s analysing the children’s performance of each interactive story over time mirrored the main effects of time patterns found for the characters’ respective exercise videos. No significant main effect of time was found for Charlie’s interactive story (F(2, 116) = .11, p = .896, partial $\eta^2 = .002$), for Razz’s interactive story (F(2, 104) = .43, p = .649, partial $\eta^2 = .01$), or for
Tom’s interactive story \((F(1.64, 82.17) = .79, p = .436, \text{partial } \eta^2 = .02)\). However, a significant main effect of time was found for Rocco’s interactive story \((F(2, 88) = 3.85, p = .025, \text{partial } \eta^2 = .08)\). Planned comparisons identified a significant increase in the children’s step counts from Presentation 1 to Presentation 2 \((t(44) = -2.51, p = .016, r = .35)\), and from Presentation 1 to Presentation 3 \((t(44) = -1.76, p = .085, r = .26)\). No significant change in step counts was found between Presentation 2 and Presentation 3 \((t(44) = 1.15, p = .257, r = .17)\).

Between-groups comparison of the number of steps performed by the children during Presentation 3 of each characters interactive story as compared to the standard nursery curriculum, confirms the large differences apparent from visual inspection. The intervention children significantly (again with very large effect sizes) outperformed the control children whilst completing all four interactive stories (Rocco: \(t(55.42) = 11.34, p < .001, r = .84\); Charlie: \(t(75.92) = 13.67, p < .001, r = .84\); Razz: \(t(70.28) = 6.84, p < .001, r = .62\); and Tom: \(t(64.58) = 10.12, p < .001, r = .78\)).

Comparison of the number of steps performed by the intervention children during Presentation 3 of each interactive story showed a similar relation to that found for the exercise videos. In both cases, the order from highest to lowest number of steps was Charlie (362.15 steps), Rocco (318.47 steps), Tom (280.43 steps), and then Razz (247.72 steps). However, comparison between the number of steps performed and the number of steps modelled showed that the intervention children performed significantly less steps in relation to the number of steps modelled (Charlie: 883 steps modelled, \(t(58) = -26.81, p < .001, r = .96\); Rocco: 603 steps modelled, \(t(44) = -13.37, p < .001, r = .90\); Tom: 588 steps modelled, \(t(50) = -15.91, p < .001, r = .91\); Razz: 453 steps modelled, \(t(53) = -9.19, p < .001, r = .78\)).

**Comparison of steps data across the two intervention schools.** Based on the varying responses given by nursery staff in the intervention condition to the questionnaires, and the important role nursery staff play as role models to the children to encourage their participation, the children’s mean steps performance of the intervention components was compared across the schools. Figure 8.08 shows the mean step counts performance of Intervention School 1 and Intervention School 2 during each exercise video delivery (upper panel) and each interactive story delivery (lower panel). Visual inspection shows that children’s performance in Intervention School 1 exceeds that in Intervention School 2 in 83.00% of instances during delivery of the exercise videos, and 100% of instances during delivery of the interactive stories.
Figure 8.08. Mean number of steps performed by Intervention School 1 (grey spotted bars) and by Intervention School 2 (unfilled spotted bars) during each character’s exercise video (upper panel) and interactive story (lower panel). Error bars represent ± 1 standard error of the mean.

**Total in-school steps during the taper phase of the Dynamic Dudes intervention (T4).** Figure 8.09 shows the mean in-school steps performed by the intervention condition, which received the Dynamic Dudes intervention once a week, and the control condition that continued to participate in the standard nursery curriculum. The analysis included data for 150 children (87.21% retention). Visual inspection of Figure 8.09 shows that the intervention children produced, on average, 1573.17 (SD = 542.11) steps, exceeding those for the control children who completed 1284.32 (SD = 645.16) steps.
An independent samples t-test found that the intervention children performed significantly more steps on the scheduled Dynamic Dudes days as compared to the control children ($t(148) = 2.97, p = .004, r = .24$).

**Steps performed during Dynamic Dudes story and exercise video sessions in the taper phase** (T4). To assess the number of steps performed by the children during the delivery of each Dynamic Dudes component presented in the taper phase, compared to the standard nursery curriculum, Figure 8.10 shows the intervention and control children’s mean step counts, achieved in equivalent time frames. Visual inspection suggests that the intervention children continued to engage with the exercise videos and interactive stories, whilst the control condition continued to perform a consistently lower number of steps.
Figure 8.10. Mean number of steps performed by the intervention children (grey bars) during the presentations of four Dynamic Dudes components delivered during the Super Dynamic Food Dudes phase, and by the control children (unfilled bars) over the corresponding time frame. ED denotes presentation of an exercise DVD, and IS, an interactive story. Error bars represent ± 1 standard error of the mean. Figure based on raw data.

Square-root transformations were used in the statistical analyses to correct for positively skewed data. In all four comparisons between the intervention and control children, the intervention condition performed significantly more steps during Rocco’s interactive story \( t(153) = 9.51, p < .001, r = .61 \), during Razz’s exercise video \( t(141) = 14.38, p < .001, r = .77 \), during Charlie’s interactive story \( t(150) = 14.00, p < .001, r = .75 \), and during Tom’s exercise video \( t(128.23) = 16.67, p < .001, r = .83 \).

**Dynamic Dudes Home Adventures: home.** Over the 12-week period, page alerts were triggered on the accounts of 39 children out of 98 children recruited (39.80% engagement). This showed that more than a third of children and their families engaged with the intervention. The online intervention was accessed on 115 occasions. Google analytics identified that 34 children played a total of 205 videos. Table 8.04 shows that Razz’s interactive story was played most frequently, and Tom’s exercise video was played the least. The maximum number of video/story elements completed was 30, and the least was 1 video. Some children completed multiple videos on a single occasion.
Table 8.04.
Number of visits to each interactive story and exercise video during the Dynamic Dudes Home Adventures.

<table>
<thead>
<tr>
<th>Element</th>
<th>Page number on website</th>
<th>Number of Visits</th>
<th>Number of children</th>
</tr>
</thead>
<tbody>
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<td>57</td>
<td>29</td>
</tr>
<tr>
<td>Rocco’s interactive story</td>
<td>2</td>
<td>29</td>
<td>15</td>
</tr>
<tr>
<td>Tom’s interactive story</td>
<td>3</td>
<td>20</td>
<td>13</td>
</tr>
<tr>
<td>Rocco’s exercise video</td>
<td>4</td>
<td>22</td>
<td>12</td>
</tr>
<tr>
<td>Tom’s exercise video</td>
<td>5</td>
<td>14</td>
<td>10</td>
</tr>
<tr>
<td>Razz’s exercise video</td>
<td>6</td>
<td>17</td>
<td>9</td>
</tr>
<tr>
<td>Charlie’s exercise video</td>
<td>7</td>
<td>31</td>
<td>17</td>
</tr>
<tr>
<td>Charlie’s interactive story</td>
<td>8</td>
<td>15</td>
<td>8</td>
</tr>
</tbody>
</table>

Food Consumption (baseline 2 [T3] and post-intervention 2 [T5])

The final sample included 189 children (M age = 3.86 years, SD = 0.30, range: 3.25 – 4.33 years; 94.97% retention). Figure 8.11 shows that at baseline 2 the children’s median fruit consumption in the intervention condition (Mdn = 0.17, IQR = 0.88) and control condition (Mdn = 0.25, IQR = 0.77) were similar. However, at post-intervention 2 the intervention condition (Mdn = 0.88, IQR = 1.62) increased their consumption, while the control condition (Mdn = 0.25, IQR = 1.00) remained at baseline levels. Matched baseline consumption levels were found for vegetable consumption as the intervention and control conditions consumed the same number of pieces (Mdn = 13, IQR = 0.63). At post-intervention 2, the intervention children (Mdn = 1.50, IQR = 1.50) showed a larger increase in consumption compared to the control condition (Mdn = 0.31, IQR = 1.38). Substantial inter-rater agreement was found between the two coders of fruit and vegetables, $k = .76$ (95% CI, .74 to .78), $p < .001$. 
Target fruit consumption. Mann Whitney U confirmed that there was no significant difference in fruit consumption between the intervention and control conditions at baseline 2 (T5; \( U = 4681.50, z = 0.59, p = .58, r = .04 \)). For the intervention children, Wilcoxon signed-rank test found a significant increase in fruit consumption between baseline 2 (T3) and post-intervention 2 (T5; \( z = 6.10, p < .001, r = .44 \)), but only borderline significant change over time for the control children (\( z = 1.95, p = .051, r = .14 \)). At post-intervention (T5) the intervention children consumed significantly more fruit than the control children (\( U = 3140.00, z = -3.56, p < .001, r = .26 \)). Statistical comparison of change scores shows that the intervention condition increased their consumption significantly more than the control condition (\( U = 2693.50, z = -4.74, p < .001, r = .34 \)).

Target vegetable consumption. Mann Whitney U found no significant difference in the baseline 2 (T3) consumption of target vegetables between the conditions (\( U = 4701.50, z = 0.64, p = .52, r = .05 \)). Comparison between consumption at baseline 2 (T3) and post-intervention 2 (T5) found that the intervention condition significantly increased their consumption levels (\( z = 7.71, p < .001, r = .56 \)); a significant but smaller increase over time was found in the control condition (\( z = 4.75, p < .001, r = .35 \)). However, at post-intervention 2 (T5) the intervention children consumed significantly more vegetables than the control condition (\( U = 2780.50, z = -4.54, p < .001, r = .33 \)). A comparison based on change scores found that vegetable consumption in the intervention condition increased significantly more than in the control condition (\( U = 2287.00, z = -5.82, p < .001, r = .42 \)).

*Figure 8.11. Median pieces of fruit and vegetables consumed per child in the intervention condition (grey bars) and in the control condition (unfilled bars) at baseline 2 (T3), and at post-intervention 2 (T5). Errors bars represent the inter-quartile range.*
Difference in food categories. At baseline 2 (T3), a Wilcoxon signed-rank test found no significant difference between the consumption of fruit and vegetables in either the intervention condition ($n = 95$, $z = 0.91$, $p = .37$, $r = .07$), or in the control condition ($n = 94$, $z = 0.65$, $p = .52$, $r = .05$). At post-intervention 2 (T5), the intervention condition consumed significantly more vegetables than fruit ($z = 3.74$, $p < .001$, $r = .27$), as did the control condition ($z = 2.41$, $p = .016$, $r = .18$).

Poorest eaters. Figure 8.12 shows the median number of pieces of fruit and vegetable consumed by the poorest ($n = 72$) and highest eaters ($n = 23$) in intervention condition, and the poorest ($n = 74$) and highest eaters ($n = 20$) in the control condition. The poorest eaters of fruit in each condition consumed similar quantities of fruit at baseline 2 (T3; intervention, $Mdn = 0.13$, IQR = 0.31) and control, $Mdn = 0.38$, IQR = 0.38). However, at post-intervention 2 (T5), the poorest eaters in the intervention condition ($Mdn = 0.56$, IQR = 1.33) had increased their consumption while for the poorest eaters in the control condition consumption ($Mdn = 0.13$, IQR = 0.50) remained at baseline levels. For vegetables, the poorest eaters of vegetables at baseline 2 (T3) consumed similar levels of vegetables (intervention, $Mdn = 0.13$, IQR = 0.25 and control, $Mdn = 0.13$, IQR = 0.25). At post-intervention 2 (T5), the intervention condition ($Mdn = 1.00$, IQR = 1.75) showed a large increase in their vegetable consumption, and the control condition ($Mdn = 0.25$, IQR = 0.75) showed a minimal increase. The highest eaters of fruit in each condition consumed similar quantities of fruit at baseline 2 (T3; intervention condition, $Mdn = 1.25$, IQR = 1.00, and control condition, $Mdn = 1.25$, IQR = 0.46). However, at post-intervention 2 (T5) the intervention condition ($Mdn = 1.63$, IQR = 0.67) showed a larger increase than the control condition ($Mdn = 1.44$, IQR = 1.00). For vegetables, highest eaters consumed similar levels across conditions (intervention, $Mdn = 1.44$, IQR = 0.65; control, $Mdn = 1.38$, IQR = 0.50). However, at post-intervention 2 (T5) both conditions approached ceiling levels (intervention, $Mdn = 2.00$, IQR = 0.28; control: $Mdn = 2.00$, IQR = 0.50).
A Wilcoxon signed-rank test found a significant increase in fruit consumption from baseline 2 to post-intervention 2 in the intervention condition poorest eaters ($z = 6.40$, $p < .001$, $r = .53$), but no significant increase was found in the intervention condition highest eaters ($z = 0.63$, $p = .53$, $r = .08$). There was no significant change in the control condition poorest eaters ($z = 1.70$, $p = .089$, $r = .14$) or highest eaters ($z = 0.92$, $p = .36$, $r = .15$).

Vegetable consumption showed significant increases from baseline 2 (T3) to post-intervention 2 (T5) in the intervention condition poorest eaters ($z = 7.01$, $p < .001$, $r = .56$), and in the highest eaters ($z = 3.19$, $p = .001$, $r = .53$). Similar, but smaller effects were found in the control condition as the poorest eaters significantly increased their consumption ($z = 4.37$, $p < .001$, $r = .36$) from baseline 2 (T3) to post-intervention 2 (T5), and a borderline significant increase was found amongst the highest eaters ($z = 1.94$, $p = .052$, $r = .31$).

**Individual foods.** To investigate the effects of the intervention on the individual target foods, Figure 8.13 shows the median pieces consumed of each fruit and vegetable at baseline 2 (T3) and post-intervention 2 (T5). Across both conditions, with the exception of grapefruit for the control condition, all fruit was consumed at floor level, over a similar range of consumption levels with the exception of guava. The intervention shifted the consumption of all 4 fruits by a minimum of 0.50 pieces in the intervention children, whilst the control condition remained and reverted to floor effects for all fruit. Similar baseline results were found in the children’s vegetable consumption, floor effects were found for all foods except for spinach in the control condition. However, at post-intervention 2,
the intervention children consumed three vegetables at ceiling levels, and one increased by 1.00 piece. Variance in consumption scores in the control condition increased, but the median scores for each vegetable were maintained across the measurement phases.

Figure 8.13. Median pieces consumed of the individual target fruit (upper panel) and vegetables (lower panel) by the intervention condition (filled bars) and control condition (white bars), at baseline 2 (T3; plain bars) and at post-intervention 2 (T5; patterned bars). Error bars represent interquartile range.

**Nursery staff feedback questionnaires**

Nursery staff were invited to complete questionnaires to provide feedback to inform future controlled evaluations. Both the intervention and control nursery staff were invited to respond to questions relating to the data collection procedures, and the intervention condition questionnaires were extended to ask about the intervention procedures. All nursery staff (N = 14) reported that the
children were happy to wear the tabards and Fitbits daily. Eleven out of 13 nursery staff members found the accelerometry procedure acceptable and the 12 nursery staff that responded found the fruit and vegetable measurement procedure acceptable; however, one school of the intervention schools commented independently that both procedures were time consuming.

Post-intervention 1 questionnaire (intervention condition only). The nursery staff (N = 9) all responded positively to the children’s and their own participation in the Dynamic Dudes intervention, with 6 out of 8 reporting the intervention was of a suitable length for integration into the school’s nursery curriculum timetable. However, the nursery staff did not feel that the programme had changed how active the children were. The nursery teacher of one school reported using the curriculum links provided.

Intervention specific questions identified that 8 out of 9 nursery staff members thought the children understood the purpose of the Dynamic Dudes calendar, and nursery staff reported that it was marked daily as instructed. Conflicting responses were received from the two intervention schools regarding the intervention. One school reported the children’s ability to complete the moves modelled in the exercise videos and interactive stories more highly than the other school. The highest rated exercise video was Razz’s dance, with Charlie’s martial arts exercise video rated the lowest. The slow motion element included in the first two blocks of the exercise videos produced opposing views, with one school viewing the section as needed, whilst the other reported that it was not needed, and that the children tended to become disinterested because it made the component too long.

Additionally, one school thought that the exercise videos were of suitable length, whilst the second school did not, the latter suggesting that a 5-minute intervention would be better. When asked about the suitability of the moves for the classroom, opinion was divided with one school saying ‘no,’ commenting that the classroom space was not sufficient for certain moves, whilst the second school commented that the moves were suitable for the classroom. Free-comment suggestions for future modifications of the exercise videos emphasised making the videos “more enjoyable”, and “shorter”, and that “some moves were too quick”. In feedback regarding the interactive stories, Rocco’s jungle story and Tom’s farm story received matching highest ratings, with no negative responses reported for any of the interactive stories. However, one member of nursery staff reported that the stories were not of a suitable length. Of 8 nursery staff members, 7 of them judged that the stories were suitable for delivery in the classroom, and 7 out of 9 of them could not suggest any changes for the interactive stories.

2-month follow-up questionnaire (intervention condition only). Nursery staff in the intervention condition were first presented with questions regarding the Food Dudes intervention. All nursery staff (N = 7) thought that the healthy eating intervention had increased the children’s consumption of fruit
and vegetables, and that the children enjoyed participating. Despite being made available online, the teachers but not the nursery assistants in the intervention schools watched the instructional DVD before the intervention started, however, all staff reported that they had received adequate training. The intervention was reported to take between 15 – 20 minutes, and all nursery staff considered that the time was well spent in view of the consumption improvements achieved. The nursery staff reported that the children liked the movies, song, stickers, tubes and tokens, magnets, and medals, with the magnets and ‘Dude of the day’ medal rated the highest. In written comments, the reward system employed in the intervention was highlighted consistently as a strength; however, one member of staff considered the length of the DVD to be a weakness. As for the Dynamic Dudes phase of the intervention, the same member of staff reported use of the provided curriculum links.

All nursery staff found it acceptable to continue the Dynamic Dudes intervention once a week, and reported positively on the children’s enjoyment. The majority of one school reported that they had been discussing the home intervention with the children; however, this was not the case in the second school.

Interviews

To coincide with the questionnaires, the nursery staff, if willing, were interviewed to conduct further process evaluation. The opinions from three of the four schools were that the data collection (accelerometry, food consumption, anthropometric and blood pressure measures) created limited or no disruption to the nursery, and that the children enjoyed taking part. However, Intervention School 2 referred to the project as “a little bit disruptive”, although they received positive feedback from parents on the schools inclusion in the project.

When intervention nursery staff were asked specifically about the intervention, feedback varied between the schools. Intervention School 1 commented on the benefit of the project on the children and staff, and that numerous learning outcomes were achieved through the links between the intervention and the curriculum. The nursery staff felt that the Dynamic Dudes intervention integrated into the nursery routine, and that the children “loved it”, and “responded really well”. They identified the interactive stories as the best part of the intervention, highlighting that they were “age-appropriate” and “enjoyed them”. Children also enjoyed marking the calendar on completion of the exercises. The exercise DVD was identified as the least liked part of the intervention: the repetitiveness of the levels meant that children required more motivation from staff to continue, however, the children did achieve level 10. A suggestion for improvement was to increase the number of stories, and decrease the exercise DVD to once a week. The nursery staff of Intervention School 2 found the intervention “too long”, “good at the start but then by the end they (children) were a bit
bored”. They also identified the interactive stories as the best part, naming Rocco and Charlie’s stories specifically; however they felt that they should be made simpler. The nursery staff felt that shortening and simplifying the videos and stories, and including more upbeat music would improve the intervention. All schools answered “no” when asked whether the children recognised the researcher as the on-screen model in the interactive stories.

Nursery staff in Intervention School 1 found the intervention “interesting” and viewed the use of novel foods as a positive aspect, as well as their having learned new methods of encouragement to perform the target behaviour. The reward system was considered the best part of the intervention, though the transition from tasting to consuming both pieces was viewed as too large a step, and a more gradual transition was suggested. The instruction not to praise children during data collection procedures was also highlighted. Increases in the children’s consumption during the intervention phase were obvious to the nursery staff. Intervention School 2 found the intervention “a little bit disruptive” but manageable. The children’s enjoyment of the DVD and rewards was highlighted. Despite pointing to the introduction of new foods to the children as a strength in the feedback questionnaire, the use of raw and novel foods was viewed negatively, and it was suggested that more common foods should be presented. In addition, the reliance on parents to provide foods for picnic days was identified as a limitation as parents did not engage. However, all nursery staff commented that the project was “interesting” to participate in.

Discussion

The primary aim of the current study was to evaluate the effectiveness of a new multi-component behaviour change intervention to increase 3–4 year old children’s (1) daily consumption of fruit and vegetables, (2) total in-school physical activity, and (3) how well effects transferred to the home environment. Dependent measures collected in the multi-component intervention condition were compared to those from children in a control condition who were presented with matched target foods during measurement periods but otherwise continued with their standard nursery practice for the duration of the study. Both the healthy eating intervention and physical activity intervention produced significant short-term increases in the respective target behaviours.

Outcomes for the healthy eating intervention provide further evidence that role modelling and rewards can be successfully used to increase pre-school children’s consumption of target fruit and vegetables with a shorter (16-day) Intensive phase than previously trialled in the pre-school population. Children in the control condition only showed a borderline significant increase in fruit consumption, and a significant but considerably smaller increase in vegetable consumption. These outcomes add to the evidence that a behavioural intervention is required to obtain large increases in
consumption with effects exceeding those for simple exposure to the target foods. These results are consistent with outcomes in the study reported in Chapter 2 and previous published studies underpinned by the same behaviour change principles (Horne et al., 2004, 2011; Horne, Hardman, Lowe, Tapper et al., 2009; Lowe et al., 2004; Sharp, 2013). Consistent with previous findings, the poorest eaters showed the biggest increases.

Outcomes for the intervention, show that peer modelling of target behaviours results in increases in total in-school physical activity in the short-term as compared to the control condition. However, the increase of in-school physical activity was not sustained in the long-term as there was no difference between the conditions from baseline 1 to 2-month follow-up. The short-term effects of the intervention are consistent with the results of the pilot trial reported in Chapter 6. As the opportunity to engage in physical activity in a nursery session is in part dictated by the nursery staff, the removal of the physical activity intervention during the measurement periods is not surprising as perhaps the nursery staff view the measurement period as a break and do not replace the previously structured element of physical activity exercise with a complementary activity. Comparison across the conditions for total in-school physical activity during the intervention phase blocks shows that the intervention condition performed significantly more steps during block 2, block 3 and the taper phase delivery as compared to the control condition. This result suggests that when the intervention is administered children in the intervention condition are more active, however, the intervention was suspended thereafter to enable true comparison with the baseline measure. The intervention components successfully engaged the intervention children in additional activity in the classroom, and engagement with the home-based intervention was achieved.

**Strengths**

A major strength of this controlled evaluation is that all primary outcomes were assessed using objective and validated measurement methods (e.g., visual food estimation: Kenney et al., 2015; step count measures in pre-school children using the Fitbit Zip: see study reported in Chapter 3). In addition, where possible, nursery staff were trained to conduct the objective measures reducing the cost of the intervention evaluation. Potential confounding variables present in previous studies reported in this thesis, for example, researcher-led delivery of the intervention in addition to data collection, on-screen model in the classroom identifiable as main researcher, high baseline consumption levels, and large differences in physical activity levels at baseline were minimised and the results of the present evaluation were nevertheless consistent with outcomes in those previous evaluations. This finding strengthens the findings of the thesis.

**Limitations**
Due to the time restraints of the academic year, long-term effects of the multi-component intervention could only be assessed for the physical activity intervention. In addition, the objective measurements are restricted to the school environment and therefore generalisability is restricted despite measures of engagement with the Home Adventure physical activity intervention. Future research should identify means of objectively assessing transfer of the target consumption and physical activity behaviours into the home environment.

Conclusion

This study presents the first controlled evaluation of the two-pronged Super Dynamic Food Dudes intervention with 3 – 4 year old children. The outcomes are consistent with those found for the Food Dudes healthy eating intervention in both pre-school children and primary school children, and Dynamic Dudes physical activity intervention for primary school children. The intervention promises to be a preventative, feasible, and cost-effective method of establishing positive lifestyle behaviours in pre-school children in a school setting, with transfer into the home environment. The overall effectiveness of the new behaviour change intervention will be further considered in the General Discussion (Chapter 9, p. 205).
CHAPTER NINE: General Discussion

With more than 42 million pre-school children worldwide categorised as overweight or obese (WHO, 2013), evidence-based preventive interventions are required to help combat the rising obesity epidemic. The aim of this thesis was to develop and evaluate a two-prong multi-component intervention targeting 3 – 4 year old children’s consumption of fruit and vegetables and physical activity in the school environment, with extension to the home environment. The results of each study have been described in their respective chapters (Chapter 2 – 6, 8), therefore this chapter will summarise the core outcomes and consider their contribution to the relevant literature.

Research Summary

A gap in the literature identified in Chapter 1 was the paucity of interventions that (1) target both sides of the energy equation, (2) are tailored for pre-school children, and (3) have been evaluated using objective methods of measurement. The behavioural principles underlying the Primary School Food Dudes Programme (Horne et al., 1998, 2004; Horne, Hardman, Lowe, Tapper et al., 2009; Lowe et al., 2004) have been shown to produce large and lasting increases in the fruit and vegetable consumption of 5 – 11 year old primary school children, and of 2 – 4 year old children (Horne et al., 2011; Sharp, 2013). Although the pre-school children showed large and lasting increases in target fruit and vegetable consumption in the initial evaluations and trials of the Early Years Food Dudes healthy eating intervention, feedback from some of the nursery teachers involved indicated that adjustments were required to improve feasibility of its routine delivery to nursery children in primary schools.

Chapter 2 explored the effectiveness of a version of the Early Years Food Dudes healthy eating intervention modified to address those feasibility issues, in comparison to a control condition that received the target foods during baseline and post-measurement phases, but not while the intervention was delivered in the intervention condition. Measures of change in consumption of the fruit and vegetable target food categories showed that the intervention condition made significantly larger short- and long-term increases in their consumption of the target fruit and vegetables than the control condition. These findings suggest that despite a decrease in length of the Intensive phase of the intervention, and simplification of the reward contingencies employed in the previous evaluation (Sharp, 2013), the intervention maintained fully its effectiveness in changing the children’s consumption of the target foods. In addition, a probe measure taken during the shortened Intensive phase found minimal difference in consumption between the probe and post-Intensive phase measures, providing evidence that the intervention could be shortened yet further. This study also adds to the literature on the determinants of children’s food preferences showing that behaviour
change interventions are required to achieve immediate, large, and lasting shifts in target food consumption; presentation alone is not sufficient (Cooke, Chambers, Croker et al., 2011; Horne et al., 2011; Sharp, 2013). With the healthy eating component of the Early Years healthy eating intervention successfully tailored, the behavioural principles of role modelling and rewards were next applied to design a new physical activity intervention for pre-school children.

Prior to designing the physical activity intervention for pre-school children, it was vital to develop and validate a measurement tool to assess the effectiveness of the new intervention in the target population. Consequently, Chapter 3 investigated the reliability and validity of Fitbit Zip accelerometers when worn in custom-made tabards to measure pre-school children’s step counts, comparing their calculated step counts to observer recorded step counts during a standardised activity task. Excellent intra-class reliability and concordance reliability was found between the step counts recorded by the two devices worn by each child, and the two measurement methods, respectively. The Fitbit Zip was found to be a reliable and valid measurement tool and was therefore employed to assess all physical activity outcomes reported in this thesis.

Chapter 4 and Chapter 5 describe the process of developing the two physical activity intervention components, providing preliminary evidence that the interactive stories and exercise videos were effective means of engaging the pre-school children in physical activity. These components were then evaluated in a controlled study reported in Chapter 6 with outcomes in the intervention condition compared to those of children participating in their standard nursery curriculum (control condition). After controlling for baseline activity levels, the intervention children were found to have performed significantly more steps than the control condition during the immediate post-tests following completion of the intervention, evidencing the short-term effects of the intervention.

Chapter 7 outlined and justified modifications to the two separate behaviour change components evaluated in the studies described above, in preparation for the final study of this thesis. In Chapter 8, a controlled evaluation of the new multi-component intervention targeting healthy eating and physical activity was conducted in the nursery classroom, with extension to the home. The findings supported previous outcomes. For the Food Dudes healthy eating component, although fruit and vegetable consumption in the intervention and control conditions was matched at baseline, the intervention children increased their consumption of fruit and vegetables significantly and substantially more than the control children. Due to time constraints, the long-term effectiveness could not be evaluated.

The physical activity intervention condition showed a significantly larger increase in total in-school step counts from baseline to post-intervention than the control condition, however, there was no significant difference at 2-month follow-up. During the intervention delivery, the total in-school
step count was significantly higher in the intervention condition during block 2 and block 3, and during delivery of the intervention on the Activity days in the taper phase, suggesting that when the physical activity intervention is delivered by nursery staff, children reliably perform a greater number of steps than when it is not. The activity impacts of both intervention components compared to the standard nursery curriculum are also consistent with outcomes in the studies reported in Chapter 4–6. Engagement with the home-based physical activity intervention was also achieved, with 40% of parents visiting the site at least once.

The following chapter will consider the potential contribution of the studies reported in this thesis to theory, and the behaviour change literature. In addition to discussing the overarching strengths and limitations of this programme of research, I will outline ideas for future research before concluding the thesis.

**Contribution to Theory**

The main underpinning theory for the studies reported in this thesis is Bandura’s social learning theory (Bandura, 1977). This theory has been identified as the most commonly used in the current behaviour change literature (Campbell & Hesketh 2007). There is a clear mapping between the theory and observed change in target behaviours, as opposed to just the creation of the intervention (Michie et al., 2008). SLT specifies that individuals can either learn behaviour through direct observation of the behaviour or through the consequences of performing the behaviour themselves under a different form of stimulus control.

In the multi-component intervention, the pre-school children were introduced to fictional characters called the Super Dynamic Food Dudes who served as role models, enthusiastically consuming fruit and vegetables and collectively enjoying their signature activity skills to the full. The pre-school children were then provided with repeated opportunities to perform the target behaviours in a positive environment influenced by their peers and the nursery staff as additional role models. In the healthy eating intervention, small and inexpensive tangible rewards coupled with verbal praise were administered for actually consuming the target foods, with positive effects, however only verbal praise for being active was administered in the physical activity intervention. As this thesis is the first exploration of these particular behaviour change principles as a means of targeting pre-school children’s physical activity, it was considered inappropriate to assume that the intervention also required contingent delivery of tangible rewards given that in the Fit’n’Fun Dudes primary school intervention, children receiving modelling and verbal praise contingent on target behaviour showed slower developing, but greater long-term behaviour change than those receiving modelling, verbal praise and tangible rewards (Hardman et al., 2011). Additionally, it is important that where possible
the effectiveness of each independent variable is experimentally tested separately prior to combining with other variables (Michie & Abraham, 2004). Given the absence of long-term effects of the taste intervention reported in the present thesis, when measured in terms of total in-school steps performed at 2-month follow up, future research could explore which additional behavioural principles might help sustain the behaviour change achieved during and immediately after the intervention.

Contribution to the Literature

Healthy eating literature. An on-going dispute in the literature on changing children’s eating behaviour is whether exposure alone is sufficient to increase consumption of target foods or whether behaviour change interventions are required. Researchers continue to explore methods of exposure despite the large body of evidence demonstrating that exposure alone is a variable that is difficult to separate from other variables such as modelling, and praise (Appleton et al., 2016). In addition, governments continue to spend millions of pounds on initiatives such as the School Fruit and Vegetable scheme that has no effect (Blenkinsop et al., 2007; Hughes et al., 2012), as opposed to adopting evidence-based behaviour change interventions evaluated using objective measures such as the Food Dudes Programme (Horne et al., 2004; Horne, Hardman, Lowe, Tapper et al., 2009; Lowe et al., 2004).

A well-cited suggestion in the literature is that in order for a 2–4 year old child to learn to like a novel food, they require up to 15 taste exposures (Birch & Marlin, 1982; Birch et al., 1987; Sullivan & Birch, 1990). The food consumption outcomes of Chapter 2 and Chapter 8 illustrate that children can learn much more quickly when additional behavioural interventions accompany repeated presentations of target foods. Researchers have suggested that a rewards approach simply catalyses young children’s acceptability of novel foods (Birch & Fisher, 1995), however, there is an increasing body of literature now showing that the rewards also scaffold the learning process and that increases in the target behaviour maintain when the rewards are removed. The food consumption outcomes reported in this thesis are consistent with recent research employing either role modelling or rewards or both with pre-school children, in the short- and long-term (Anez et al., 2012; Cooke, Chambers, Anez, Croker et al., 2011; Corsini et al., 2013; Horne et al., 2011; Remington et al., 2012; Sharp, 2013). Additionally, Holley et al. (2014) explored the effects in the home environment, and found the greatest effects with repeated presentation, rewards, and role modelling (using parental models), as compared to any other combination of those principles. However, the increase achieved by Holley et al. for one target vegetable was smaller than that achieved in this thesis for four vegetables. This suggests that the modelling component administered in the current studies is stronger than the parental modelling employed in Holley et al.
The current findings provide strong evidence against the claim by both self-determination theory (Ryan & Deci, 2000) and over-justification theory (Lepper et al., 1973) that rewarding the children’s consumption will lead to a decrease in their consumption when the rewards are removed. As argued by Horne et al. (2011), the reward decrement debate is non-applicable to this target behaviour given the low intrinsic motivation at baseline to consume fruit and vegetables. Both Cooke, Chambers, Anez, & Wardle (2011) and Horne et al. point to the empirical evidence showing that contingent reward increases those low probability behaviours which are then well-maintained in the long-term (and see Cameron, Bank, & Piece, 2001).

The increase in fruit and vegetable consumption found in the control condition was not unusual; Corsini et al. (2014) also found a significant increase in their control condition from baseline to 3-months follow-up. However, it is by no means a consistent finding: for example, children in the control condition in Remington et al. (2013) showed no such change in consumption over time. Due to the range of procedural differences between the studies, such as, duration between baseline and post-intervention testing, and age range of children, it is unclear what causes the increases in consumption in some cases in the control condition in the absence of any planned intervention.

In both chapters, the greatest results were found amongst the poorest eaters (eating < 1 piece at baseline), and the highest eaters (≥ 1 piece at baseline) who increased or maintained their target behaviour, respectively. This is consistent with evaluations of the Food Dudes Healthy Eating intervention with primary school children (Lowe et al., 2004). The categorisation criteria applied were drawn from Fildes et al. (2014) who evaluated a parent-administered intervention and also found the largest increases in poorest eaters. Researchers should be encouraged to explore this extra analysis to measure the largest impact of their intervention.

This thesis adds to the literature by reporting an intervention that can be used to successfully increase consumption of multiple target fruit and vegetables in young children. A total of 430 children participated in the food consumption measures, and no child became distressed or showed a negative reaction to the foods, contrary to suggestions in the literature of possible outcomes (Holley et al., 2015). Researchers who are only targeting a single food item (Caton et al., 2014; Corsini et al., 2013 Fildes et al., 2014) should therefore design their interventions to target multiple foods from the target category.

As fruit is naturally a sweeter tasting food than vegetables, and children have an innate preference for sweet foods (Birch, 1999; Steiner, 1974) it is unsurprising that children generally consume more fruit than vegetables (Welsh Health Survey, 2016). Somewhat contradictory results were found between the evaluations of the healthy eating intervention reported in Chapter 2 (p. 62) and Chapter 8 (p. 195). In Chapter 2, both the intervention and control conditions consumed
significantly more fruit than vegetables at baseline, post-intervention, and 3-month follow-up; a finding consistent with the original evaluation of the programme (Sharp, 2013). However, in Chapter 8, there was no difference in the consumption of these target food categories at baseline, yet at the post-intervention measure, both conditions consumed significantly more vegetables than fruit. Baseline levels of consumption could explain the different findings. In Chapter 8, baseline levels of consumption were very low whereas in Chapter 2 levels were high, resulting in ceiling effects. Often researchers target foods that are ‘moderately-preferred’ (Corsini et al., 2013; Remington et al., 2012), whereas Chapter 8 successfully identified foods that the majority of children were not willing to consume at baseline. These findings should encourage other researchers to target both fruit and vegetables as the behaviour for both can be increased considerably, providing an extended repertoire of foods for the children to learn to consume.

**Physical activity literature.** The physical activity literature targeting pre-school children is not as advanced as for primary school children (McSweeney et al., 2016), or as the literature on the determinants of food preferences in pre-school children. Consequently, the increases in total in-school physical activity found consistently, in the short-term in the present multi-component physical activity intervention contributes to the literature. For example, in Chapter 8 following the completion of the Dynamic Dudes Intensive intervention phase the intervention children increased their total in-school step counts by 8.27% ($Mdn = 496.17$) steps, at face value this is not a large increase, however, it was achieved in a 118.50 minutes time period. The control condition only increased their in-school step counts by 4.71% ($Mdn = 282.33$ steps). These increases were calculated in relation to Gabel and colleagues’ (2013) step count empirical equivalent (6000 steps) of the Chief Medical Officers’ guidelines of 180 minutes (Department of Education, 2011). Direct comparison of the current findings to the existing literature is difficult due to time frames measured, however, O’Dwyer et al. (2012) found a significant increase of 4.5% of total weekday physical activity after the delivery of a 10-week family-focused intervention targeting active play. It is possible that if total daily physical activity had been measured during the Dynamic Dudes evaluation, the increase in activity achieved would have been comparable to that reported by O’Dwyer and colleagues.

During the delivery of the classroom exercise component (< 15 minutes), the maximum number of steps achieved was 636 steps. The component was an opportunity for children to practice fundamental movement skills; essential in order to develop their competence (Goldfield et al., 2012). In comparison to the recommended guidelines, the classroom exercise component alone evokes between 6.75% and 10.60% of the daily target. The intervention component was successfully administered as part of the EYFP framework (Welsh Government, 2015), as recommended by Ward et al. (2010), providing evidence to the literature that there are short periods of time in the classroom in
which to optimise activity. With this in mind, if such increases in activity level could be achieved through the day using semi-structured interventions, this could be a very promising way of making a significant contribution to the daily-recommended activity targets for children of this age (American Heart Association, 2016). To my knowledge, studies do not report the number of steps generated during specific intervention components, and so further comparison of outcomes for this section is not possible.

The research reported in this thesis has extended the findings of the Fit’n’Fun Dudes intervention designed for primary school-aged children (Horne, Hardman, Lowe, & Rowlands, 2009; Hardman et al., 2009, 2011) and the Dynamic Dudes Primary School intervention (Mitchell, 2014; Whitaker, 2016). When designing new interventions, the developmental maturity of the target population must be considered (Nixon et al. 2012), therefore the pre-schoolers intervention was tailored to their social, emotional and learning abilities.

The physical activity intervention reported here employed a strong role-modelling component. Results found in the current thesis add to the literature that on-screen role models can be a highly effective means of increasing children’s physical activity levels, in addition to parental role models as previously identified (Moore et al., 1991; Sebire et al., 2016). In line with recommendations (Ward et al., 2016), the intervention was delivered in the classroom with the pre-school children in the presence of their peers, as part of a group. All the intervention children engaged in the intervention showing that they were happy to participate whilst with their peers. This was to be expected based on Lehto et al. ’s (2012) observational research showing that children aged less than 3 years preferred single peer company and children aged 3–5 years perform more activity when in a group.

Although NICE guidelines (2015) state that parents should be motivated to participate in physical activity with their child, identifying the means of achieving this is not straightforward. In Chapter 6, parents were provided access to the interactive stories and exercise videos to complete with their child at home, but no parents engaged. In Chapter 8, we add a reward contingency and 40% of parents engaged at least once, however, it is unknown whether the parent participated with the child in doing the exercise or not. This highlights the difficulty of motivating parents and capturing their participation. One alternative approach has included a school setting with parents participating in sessions with their child. A multi-component intervention (Barber et al., 2013, 2016) administered in the school environment invited parents to attend three 30-minute outdoor play sessions over 30 weeks. Only the first 10 weeks were the sessions supervised by school staff. Authors reported no significant difference between the intervention and control children’s total physical activity at 10-week or at 52-week follow-up. Despite the common setting of the aforementioned study and the physical activity studies reported in this thesis, the outcomes are different. This suggests that depending on
parents to go to a school environment outside of school hours for their child to complete additional physical activity is not an effective approach. Based on the physical activity outcomes in Chapter 8, interventions should target both school and home environments, however, they should focus on integrating the intervention into the classroom curriculum with teachers, and at home with parents independently; further research is required in order to support this claim.

The Dynamic Dudes intervention draws on aspects of active gaming, an approach shown in the physical activity literature to be effective at increasing primary school children’s physical activity levels (Gao, Chen, Pasco, & Pope, 2015; Gao, Chen, & Stodden, 2014; Lieberman et al., 2011; Papastergiou, 2009). Mears and Hansen (2009) defined active gaming as use of a screen-based interactive interface to provide individuals with opportunities to be physically active. Active gaming has been identified as a suitable alternative to traditional means of delivering physical activity opportunities to children, although researchers have noticed smaller effects in field-based studies as compared to the laboratory-based studies that employ the technique (Gao et al., 2014, 2015). A recent systematic review of active gaming in the school setting identified 22 papers, all of which targeted primary school children and adolescents; no studies with pre-school children were identified (Norris et al., 2016).

Ridgers and colleagues (2012) and many others have found that primary school-aged boys are, in general, more active than primary school-aged girls, a finding noted earlier in Chapter 1. However, gender effects are not consistently found in pre-school children (Bingham et al., 2016; De Craemer et al., 2012; Hinkley et al., 2008; Li et al., 2005). In the present thesis, differences in gender outcomes were found between the pilot of the physical activity intervention (Chapter 6) and the final multi-component intervention (Chapter 8). In the former study, boys performed significantly more total in-school steps than girls, but no gender differences were found in the latter study. As the sample size is larger in the multi-component intervention, one could argue that the latter finding is more representative of the pre-school population. Further activity research must be conducted to explore gender effects in pre-schoolers before any firm conclusions can be drawn.

In the current thesis, the active gaming technique is embedded in the interactive story and exercise video components as the children are prompted and motivated from the screen to follow the on-screen model. Additionally, counting aloud the number of repetitions they had performed was included as a motivator. In order to quantify how much activity was generated directly by each element of the intervention components, the children’s step counts during their participation in classroom exercise or interactive story sessions alone was also captured. This detail to my knowledge is not typically presented in pre-schoolers intervention papers, despite it being a means of quantifying exactly how much activity each intervention element induces. These step counts were then compared
to the number of steps performed by control children participating in their standard nursery curriculum at the same time of day. This comparison will help to reduce the societal assumption that pre-school children are naturally active (Timmons et al., 2012).

Considering the data from the final controlled evaluation reported in Chapter 8, steps performed varied, depending on which story was presented. The intervention children completed a mean 365 steps (Charlie’s story) and a minimum of 250 (Razz’s story) steps; at the same time of days, the control children only completed between 62 steps and 76 steps. Mean steps were even higher across the board for the classroom exercise videos, ranging from 600 steps (Tom’s video) to 425 steps (Razz’s video). At the same time of day, the control children only produced 93 steps and 61 steps. Even though the physical activity guidelines do not specify a quantity of time that pre-school children should engage in MVPA, research has shown that bursts of MVPA are linked to positive health benefits (Collings et al., 2013; Janz et al., 2009) and as a result should be encouraged. The intervention is a potent means of providing daily MVPA opportunities in a supportive classroom environment. The children completed the physical activity components with their peers. The recent literature has reported children’s increased physical activity whilst completing physical activity with their peers (Barkley et al., 2014; Gubbels et al., 2011; Lehto et al., 2012).

Healthy eating and physical activity interventions literature. Interventions designed to target both of these lifestyle behaviours are becoming more prevalent, however, there are still very few such interventions for pre-school children. The new multi-component intervention reported here promises to be a feasible, highly effective and inexpensive method of teaching children to learn to like fruit and vegetables, and enjoy taking part in physical activity. This conclusion can be drawn from the food consumption and activity outcomes in children that have participated, the successful delivery of the intervention by nursery staff, and the inexpensive programme resources required. The feasibility of future implementations was a core part of the design process to ensure that the intervention could be a standalone product. In comparison to two-pronged interventions mentioned in the literature review (Chapter 1), the evaluation of the new multi-component intervention had a smaller sample size than HENRY (Roberts, 2015; Rudolph et al., 2010; Willis et al., 2016), Hip Hop to Health Jnr (Fitzgibbon et al., 2002, 2005, 2011; Kong et al., 2016; Stolley et al., 2003), and Tooty Fruity Veggie (Adams et al., 2009; Newell et al., 2001), however, the objective evaluation measurements used in the present research programme and the strong focus on the performance of target behaviours would suggest that the validity and replicability of this new intervention is greater.

Nevertheless, the anthropometric measurement of the Tooty Fruity Veggie intervention (Zask et al., 2012) found that the intervention children’s BMI z-scores had decreased more than those for the control condition by 10-month follow-up. Anthropometric measures were not reported in the other
two interventions. In the studies reported in this thesis, a trained researcher conducted the anthropometric baseline and post measures and a medical student conducted blood pressure measures. However, outcomes across studies were mixed. Medium-term change in BMI was assessed in Chapter 2 from baseline to 3-month follow-up and the intervention condition (having received the healthy eating intervention) increased their BMI while the control condition remained constant. The short-term pilot of the physical intervention found no changes in BMI for either condition. In the final multi-component intervention evaluation, no significant differences were found between the conditions at baseline or at 2-month follow-up, although within-condition analysis found that BMI increased in intervention condition, but decreased in the control condition. Waist circumference was also measured. In this instance, between-condition differences in waist circumference were found, with decrease over time in the intervention condition, and increase over time in the control condition. Regarding blood pressure, the only increases in the intervention condition were found for systolic blood pressure; decreases in diastolic blood pressure were found in the control condition. A recent school-based intervention for pre-schoolers also reported no changes in BMI (O’Dwyer et al., 2013).

Further investigation of the anthropometric and blood pressure measures is required with pre-school children, as the measures were only taken once and by one researcher due to time constraints. Future research could incorporate multiple measures to enable inter- and intra-rater reliability (Miguel-Etayo et al., 2014). However, it may be the case that with a longer duration of the intervention, as well as waist circumference, changes in BMI and blood pressure would be detected.

Strengths

A major strength of the multi-component intervention is the systematic process undertaken to achieve the end intervention. As described by Craig and colleagues (2008) it is important to complete the design and evaluation cycle advocated by the Medical Research Council. The thesis is structured to follow (a) development, (b) feasibility and piloting, and (c) evaluation; the final section (d) implementation was beyond the scope of this thesis although it has been previously achieved with the healthy eating intervention only. As the intervention is set primarily in a school environment, the decision to tailor the intervention for that setting adheres to the WHO (2004) guidance, although it is extended in scope by being designed for multiple settings (Summerbell et al., 2005); school and home have been identified as the two key locations (Lobstein et al., 2004). Small-to-large effects were found throughout the thesis dependent on the target behaviour assessed. Behaviour shift was larger and better maintained for food consumption compared to total in-school physical activity. This difference could result from the fact that children have direct control over whether or not they wish to consume a food when it is presented during measurement phases, whereas children need to be provided with
opportunities to be physically active in a nursery environment once the intervention is suspended and those opportunities are governed entirely by nursery staff.

All the primary outcome measures were conducted using valid, objective measures. For physical activity, a minimum of 3 days of data were required for a child’s data to be included in the data analyses to ensure accurate representation of the target behaviour as specified by Addy and colleagues (2014). In the present thesis, a novel method of wearing an accelerometer has been devised to reduce resistance from young children to wearing such devices around their waist on a belt (Costa et al., 2015). In addition, the children were never informed that their physical activity was being measured to prevent occurrence of the Hawthorne effect. In the final study, nursery staff were recruited to place the tabards on the children, reducing the researchers’ involvement and risk of observer-expectancy effects. In Chapter 6, the researchers achieved 115-minute recordings of the 150-minute nursery sessions; a similar time (116 – 121 minutes) was achieved in Chapter 8 despite the fact that the time the tabards were being placed on and taken off each child was out of the control of the researcher. For food consumption, visual inspection was validated as a measurement method in the school-environment (Kenney et al., 2015), and both chapters reporting food consumption yielded excellent inter-rater reliability when coding how much the children had eaten. Following the completion of an intervention, questionnaires were administered to nursery staff to gather user input, which was then implemented in subsequent evaluations.

To increase ecological validity and for the evaluation to reflect future implementation delivery, nursery staff delivered the multi-component intervention. The nursery staff’s ability and willingness to administer the programme is evident as all aspects of the school-based interventions were delivered. The interventions were anchored in the Early Years Foundation Phase Framework, and nurseries are informed of the links to the curriculum to support the administering of the intervention. This helps generalise the perceived purpose of the intervention from specific periods like snack-time, to other parts of the child’s school day, acting as a constant reminder to the children to consume their fruit and vegetables and be active.

The physical activity home intervention was initially delivered over the school holidays in Chapter 6 and received zero engagement from parents despite positive verbal responses from parents during the parent session that the resource would be valuable. In Chapter 8, the materials were made more visually appealing, in line with the healthy eating parent component, and a delayed gratification reward was offered. This resulted in 40% of parents engaging with the web-based intervention at least once. It is unknown whether parents would have completed the intervention with the children, however, this intergenerational component could be specified in future studies.
Limitations

Irrespective of the thesis strengths, limitations must be acknowledged to inform future evaluations and the literature.

Due to limited number of Fitbit Zip devices only total in-school physical activity and not whole day activity could be monitored, therefore the effects of the classroom intervention cannot be extended beyond the duration of the child’s nursery session attendance at school. In addition, we are unsure how parents would respond to the children wearing the custom-made tabards at home. This is limiting, as the study is unable to report on how the intervention influences the second half of a child’s day. Moreover, there is a similar constraint for fruit and vegetable consumption. As only the children’s consumption of target foods is measured, the effects of the healthy eating intervention cannot be generalised to other foods and other settings without further investigation. This is a consistent limitation within pre-school children food literature (Corsini et al., 2013; Horne et al., 2011; Remington et al., 2012).

As translational research conducted in school is bounded by academic time frames, studies must be designed to compliment term-time and holidays. Unfortunately, long-term follow-ups were not conducted for all primary outcomes in all of the studies, for example, physical activity intervention reported in Chapter 6, and the healthy eating intervention in Chapter 8 as the post-intervention measures were conducted just prior to the school’s summer holidays. Following the holidays, the children transition from nursery to reception where they attend all day including lunch as opposed to half a day, and having lunch with a caregiver. Such differences would make the hypothetical follow-up measures incomparable to the baseline measures collected.

Despite the range of fundamental movement skills (FMS) integrated into the physical activity intervention, and their typical initiation during pre-school years (Foweather et al., 2015), FMS development was not assessed due to time constraints and lack of research staff resources. Future evaluations should also measure these potential outcomes as large improvements could be charted and are at least as meaningful as change in total step counts and anthropometric variables (Metcalf, Henley, & Wilkin, 2012).

Further investigation is required for the healthy eating intervention at home to evaluate its effectiveness using an objective measure as no conclusive conclusions can currently be drawn. Parental responses in questionnaires administered in Chapter 2 were not always self-consistent.

As the interventions presented in this thesis were progressively developed over several chapters to produce the final multi-component intervention, this resulted in multiple variables being altered simultaneously limiting reliable identification of causal variables. In the pilot evaluation, the children performed a greater number of steps during the interactive stories, however, during the
multi-component intervention, the children performed a greater number of steps during the exercise videos. Given that the researcher also served as the onscreen presenter in the interactive stories in the pilot study it is likely that this may have induced the Hawthorne effect.

**Future Implications**

The new multi-component healthy eating and physical activity intervention for pre-school children has yielded positive and promising results, nevertheless, the intervention can be further developed to integrate additional components to increase the effectiveness and sustainability of the intervention, and collect additional outcome measures.

Following three evaluations of the healthy eating intervention, there are minimal changes now required to the school-based intervention, however, generalisation to foods beyond the target foods remains unmeasured. Horne et al. (2011) found increases in non-targeted fruit and vegetables during snack-time and lunchtime when consumption was measured following the delivery of a role modelling and rewards intervention for targeted fruit and vegetables during snack-time only. The authors drew on basic research on a determinant of categorisation in pre-school children called ‘naming’ (Horne, Hughes, & Lowe, 2006; Horne & Lowe, 1996; Horne, Lowe, & Harris, 2007; Horne, Lowe, & Randle, 2004; Lowe, Horne, Harris, & Randle, 2002; Lowe, Horne, & Hughes, 2005) to argue that as both the non-target foods and the target foods were explicitly named to the children during their presentation as “fruit” or as “vegetable”, the children consumed the non-target foods based on their food categories, demonstrating that a role modelling and rewards interventions produced extensive generalisation within categories and across contexts. During the Picnic phase of the current research, parents are asked to supply the fruit and vegetables for the session and the reward contingencies previously employed for the target foods are transferred but reduced for the picnic foods. This method presents an opportunity for children to try new fruit and vegetables but also explore whether the intervention is as successful when non-targeted fruit and vegetables are provided by their parents, as opposed to the foods presented on a cycle by the Food Dudes characters.

The intervention could introduce an award scheme. Bell, Hendrie, Harley and Golley (2015) found significant increases in a range of food categories including fruit after nurseries made menu changes, staff completed food hygiene courses, and created an encouraging environment, which earned them a ‘Start Rich-Eat Right’ award. The children’s (n = 232) consumption was measured by weighing their plate waste at baseline and post-intervention. As part of the award nursery staff could be required to present new foods to the children supported with the behavioural principles to teach the children to learn to like them. Additionally, part of the Early Years Foundation Phase Framework (Welsh Government, 2015) is that children should be taught to identify the difference between healthy
foods and non-healthy foods, ‘tasting sessions’ could be introduced with lesson’s branded by the Food Dudes characters to further help children build a broad repertoire of fruit and vegetables. To assess generalisation a selection of non-target foods would require consumption assessment at each of the measurement periods.

A second part of the healthy eating intervention is the home-intervention component. In Chapter 2 parents reported enjoying using the Home DudeKit, yet limited consistency was found in their reporting of the foods they targeted. Due to time constraints in Chapter 8 the home component was not evaluated. Researchers need to devise a data collection method, aside from questionnaires, which will provide an objective measure of the effectiveness of the booklet and Taste-Bud Training Chart to change food consumption behaviour in the home. Home-based interventions have invited parents into a laboratory to measure the child’s food consumption (Holley et al., 2015), yet this is not necessarily reflective of home consumption. However, an innovative methodology has recently been discovered. Researchers have claimed that healthy foods such as fruit and vegetables have unique biomarkers, which reside in adults’ urine (Garcia-Perex et al., 2017). This method is in its infancy and is yet to be trialled with children but has the potential to provide a non-biasing and non-invasive approach to explore in the future.

The new physical activity intervention was administered for 24 consecutive days and achieved positive short-term increases in physical activity. Following the format of the healthy eating intervention where the number of days in the Intensive phase has systematically been decreased, the physical activity intervention could be administered for a shorter period to assess if the effect is achieved in a shorter time period and then transfer the extra days from the Intensive phase into the taper phase to help maintain the achieved short-term effects. As there is very little relevant literature, the duration of the intervention could not be informed for the target pre-school population as the optimum frequency and amount of physical activity is yet to be determined (Timmons et al., 2012).

To explore if the physical activity intervention components improved more than can be assessed by measuring the pre-school children’s step counts, the children’s fundamental movements skills should be assessed given their optimum age of development (Foweather et al., 2015). Such a measure would add richness to the effect of the components as they employ a larger number of locomotor, co-ordination, and balance skills, and their development are important for health (Foulkes et al., 2015). The development of such skills would not immediately diminish as a result of the intervention being suspended for measurement periods. A commonly cited measurement tool called the ‘Test of Gross Motor Development-2’ is valid for use with pre-school children (Adams et al., 2009; Barnett et al., 2016; Cliff et al., 2009; Foweather et al.; Goldfield et al., 2012).
The Dynamic Dudes primary school intervention consists of a series of thematically-integrated classroom exercise DVDs, multi-user playground activity stations and markings, and teacher P.E. training video showing teachers how to use the activity stations and markings in a circuit-based format (Whitaker, 2016). Given the commonality of the classroom exercise components, extension of that Dynamic Dudes primary school intervention to the Dynamic Dudes intervention for pre-school children, would of course require activity stations appropriate to the developmental levels of preschoolers. For example, one approach with a positive outcome investigated lowering playground density to provide more space for the children, coupled with fixed and portable equipment plus playground markings during recess (Van Cauwenberghe, De Bourdeaudhuij, Maes, & Cardon, 2012). The authors reported that the intervention was effective in significantly increasing 4 – 6 year old children’s (N = 128) physical activity.

Conclusion

Overall, this thesis demonstrates the systematic development of a new multi-component intervention, with each intervention independently evaluated prior to its integration, producing a two-pronged intervention to teach pre-school children two requisite repertoires for a healthy lifestyle. School-based multicomponent interventions have been identified as a consistent and effective approach (Kreimler et al., 2011). Chapter 8 is the first evaluation of a healthy eating and physical activity intervention underpinned by the well-established Food Dudes behavioural principles, with implementation in the school and home environments. The success achieved in the series of studies presented in this thesis, provides a powerful foundation from which to further develop the intervention, drawing on the new research ideas, and addressing the limitations mentioned. Establishing long-term increases in consumption of fruit and vegetables and physical activity levels in pre-school children will make a strong contribution to tackling the global crisis of childhood obesity.


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