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Hardman, Charlotte

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INCREASING PHYSICAL ACTIVITY IN CHILDREN

Charlotte Alice Hardman

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SUMMARY

The increasing prevalence of child obesity in many developed countries emphasises the need to promote healthy eating and active lifestyles to children. Previous research indicates that a peer-modelling and rewards intervention produces substantial increases in children's fruit and vegetable consumption. The aim of the current thesis was to develop an intervention based on the same behavioural principles to increase children's physical activity.

In the first instance, it was important to identify a valid, objective measure of children's physical activity. In Study 1, the electronic pedometer distinguished between children's play activities that ranged from sedentary to very vigorous, and showed good correspondence with heart rate and self-report measures of effort.

In Study 2, children's habitual physical activity was measured over the entire day using pedometers and accelerometers. High-active children were more active than low-active children during both school-time and leisure-time, suggesting that an intervention targeting total physical activity throughout the day is most appropriate.

In Study 3, an intervention incorporating peer-modelling (i.e., the Fit n' Fun Dudes), contingent rewards, and pedometer feedback was implemented in a school-setting with 9- to 11-year-old boys and girls as participants. The intervention produced substantial increases in the physical activity of both boys and girls, which were well maintained at 12-week follow-up, particularly among the least active girls in the sample.

In Study 4, the intervention was implemented by parents in the home context and 9- to 11-year-old girls took part. They showed substantial increases in physical activity during the intervention and remained more active at follow-up relative to baseline. The physical activity of parents also increased following the introduction of pedometer self-monitoring procedures.

There is great potential for future research to combine the healthy eating and physical activity interventions to provide a two-pronged approach to preventing child obesity.

CHAPTER 1

CHANGING DIETARY AND PHYSICALLY ACTIVE BEHAVIOURS IN CHILDREN: IMPLICATIONS FOR THE PREVENTION OF OBESITY

Obesity in Children

Obesity may be defined as an unhealthy amount of body fat (Jeffrey et al., 2000). When people are obese their weight is so extreme that it seriously endangers their health. Obese individuals are more likely to suffer from several life-threatening chronic diseases including coronary heart disease, Type II diabetes, colon cancer, osteroarthritis, respiratory disease, and reproductive disorders. Obesity is additionally associated with substantial psychological penalties, such as low self-esteem, stigmatisation, and isolation. The National Audit Office report "Tackling Obesity in England" (2001) estimated that obesity cost the UK National Health Service at least half a billion pounds in 1998. The indirect costs of obesity in terms of loss of economy due to sickness or death may be around 2 billion pounds per year.

Rapidly increasing levels of obesity pose a growing threat to the health of many of the world's wealthiest nations. In 1980 just 8% of women and 6% of men in England were classed as obese. By 1998 these figures had almost tripled to 21% of women and 17% of men. The prevalence of obesity is also rising in less developed countries. The urban population of Western Samoa, for example, has one of the highest prevalence of obesity in the world, with 50% of men and 75% of women obese (National Audit Office, 2001).

The prevalence of obesity in children is also increasing at an alarming rate. In a sample of UK 5-year-olds, prevalence rates for overweight and obesity were 19% and 7% respectively (Reilly, Dorosty, & Emmett, 1999). Bundred, Kitchiner, and Buchan (2001) observed a highly significant increase in the number of overweight and obese children in a large sample of 2- to 4-year-olds from the North West of England. In 1989, 15% and 5% of these children were overweight and obese, respectively, however by 1998 the figures had increased to 24% and 9%. Comparable increases in weight however were not present in 1- to 3-month-old infants, indicating that excessive weight gain occurred during infancy and early childhood. In a more recent UK study, McCarthy, Jarrett, Emmett, and Rogers (2005) compared a cohort of 2- to 5-year-old children from a longitudinal survey conducted between 1995 and 1998 with a cohort of similar aged children measured in 1987. Central fatness, assessed by measures of waist circumference, was significantly higher in the contemporary children compared to the earlier cohort, and the greatest increases were found among girls. There is also evidence that obesity is increasing in older children in the UK. In a sample of 7- to 11-year-olds, 22% of boys and girls were overweight, and 11% of girls and 12% of boys were obese. These figures differed significantly from the expected values of 15% for overweight and 5% for obesity, relative to British children in 1990 (Rudolf, Sahota, Barth, & Walker, 2001).

Obese children are more likely to be obese in adulthood than are nonobese children (Serdula et al., 1993) and this likelihood increases among older children (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Furthermore, there are specific health costs associated with being obese as a child, for example, vascular dysfunction (Woo et al., 2004). Overweight children and adolescents are at greater risk of having cardiovascular risk factors, such as elevated levels of total cholesterol, than are normal weight children (Freedman, Dietz, Srinivasan, & Berenson, 1999). The first cases of type 2 diabetes in obese adolescents have recently been reported in the UK (Drake, Smith, Betts, Crowne, & Shield, 2002).

Evidence suggests that obesity is associated with impaired self-esteem in children and adolescents, most notably for girls. Over a 4-year period, global self-esteem decreased among obese girls such that, by 13 to 14 years of age, they had significantly lower self-esteem than their nonobese counterparts. A similar trend was observed for boys but effects were milder (Strauss, 2000). In preadolescent children, overweight and obese girls showed significantly lower physical appearance and athletic competence self-esteem and were less likely to be peer nominated as attractive compared to normal weight girls (Phillips & Hill, 1998). Additional psychosocial costs of child obesity include repeated bullying and verbal abuse (Pierce & Wardle, 1997) and negative attitudes towards obese children appear to form at a young age. In one study, 9-year-olds rated figures of obese children as having fewer friends, reduced academic success, and lower health status in comparison to thin figures (Hill & Silver, 1995).

Obesity in childhood also has implications for adult health. Must, Jacques, Dallal, Bajema, and Dietz (1992) demonstrated that mortality from all causes, and from coronary heart disease, stroke, and colorectal cancer, was greater amongst men who were overweight as adolescents compared to those who were lean. In addition, overweight in adolescence increased the risk of morbidity for several conditions in men and women. These increased risks were independent of adult weight. Therefore being obese during childhood may seriously compromise health in later life, even if excess weight is lost in adulthood.

The increasing prevalence of obesity in children and the immediate and future health costs emphasise the great importance of preventing and treating obesity at a young age. In order to do so, however, it is important to consider the causes behind this "epidemic" of obesity.

Obesity develops because of a positive energy imbalance, where energy intake exceeds energy expenditure (Dietz, 2004; Epstein, Coleman, & Myers, 1996). Intake and expenditure comprise eating and physically active behaviours, which may be targeted through intervention. Dietz and Gortmaker (2001) thus argue that:

> The only discretionary elements of energy balance are food intake and the energy spent on activity. To prevent obesity in children and adolescents, therefore, focus must be placed primarily on factors within family, school, and community environments that affect food intake and physical activity. (p. 340)

Research reviewed by Lobstein, Baur, & Uauy (2004) indicates that an individual's chances of being obese are increased when he or she has obese relatives and thus a genetic predisposition could account for a substantial amount of the variation in obesity. Whitaker et al. (1997) found that both obese and nonobese children were at greater risk for obesity as adults if at least one parent was obese, an effect most pronounced among children under 10 years of age. However, because the gene pool has not changed substantially in recent years (Dietz, 2001), genetic factors alone are unlikely to be the primary reason for rising levels of obesity.

An alternative hypothesis is that genes for obesity are expressed when the environment allows and supports their expression (Lobstein et al., 2004). Wardle, Guthrie, Sanderson, Birch, and Plomin (2001) found that nonobese children of obese parents had higher preferences for fatty foods and sedentary behaviours than did children of lean parents. The former group represent children at high risk of obesity in later life, and it is possible that their early diet and physical activity preferences play a causal role. Wardle et al. argue that these diet and physical activity preferences may be inherited, but their expression will depend on the permissiveness of the environment. An environment that makes high-fat food and opportunities to be sedentary widely available would place susceptible individuals at risk of positive energy balance and subsequent weight gain.

However modern industrialised societies appear to have developed in exactly this way. Food and drink are readily available and extensively marketed. Eating outside of the home is becoming increasingly popular, with food eaten out tending to be higher in fat than food consumed at home. There has been a reduction in occupational exercise, an increase in energy-saving devices, and wider car ownership (National Audit Office, 2001). With relevance to young people, the amount of physical education has been reduced in many schools, cycling and walking to school are less frequent behaviours, and unsupervised playing in the street has been curtailed by safety concerns (Boreham & Riddoch, 2001). It has been suggested that such "obesogenic" aspects of the environment are not consistent with human genetic makeup. Lobstein et al. (2004) propose that:

> Human metabolism evolved under very different conditions with a sparse and erratic food supply and huge physical demands for survival, which has selected individuals with a 'thrifty' genotype. This genotype is ill-suited for the modern world. Excessive fat storage, leading to obesity, is the default situation unless specific action is taken. (p. 45)

Indeed, Egger and Swinburn (1997) propose that obesity should be regarded as a normal response to an abnormal environment.

Survey data are suggestive of adverse effects of the obesogenic environment on children's diet and physically active behaviours. For example, in the UK, children show very low consumption of fruit and vegetables. The National Diet and Nutrition Survey showed that, in a typical week, more then half the young people in the survey had not eaten any citrus fruits, any leafy green vegetables, or any raw tomatoes. Furthermore, 4- to 6-year-olds consumed an average of just two portions of fruit and vegetables a day (Gregory & Lowe, 2000). More recent figures showed that the most commonly eaten foods in a sample of British 7-year-olds were white bread, biscuits, potatoes with fat (roast, fried, chips), savoury snacks, and chocolate confectionary. Over 3 days of dietary assessment, 16% of boys ate no fruit and 10% ate no vegetables. Among girls, 12% ate no fruit and 5% ate no vegetables (Glynn, Emmett, & Rogers, 2005).

Current UK guidelines recommend that young people aged between 5 and 18 years participate in physical activity of at least moderate intensity for 1 hr per day (Biddle, Sallis, & Cavill, 1998). However, the National Diet and Nutrition Survey (Gregory & Lowe, 2000) showed that 30% of boys, and 51% of girls aged between 7 and 10 years were failing to meet these guidelines. These proportions increased to 56% of boys and 69% of girls during adolescence. Furthermore, it appears that children's free time, traditionally spent in active play, is increasingly being spent on sedentary pursuits. A decline in physical activity levels from childhood into adolescence is paralleled by an increase in sedentary behaviours, such as watching television (Department of Health, 1998). When given equal access to sedentary or physically active alternatives, children reliably chose to be sedentary (Epstein, Smith, Vara, & Rodefer, 1991). Research indicates that increased television viewing and reduced physical activity are associated with higher levels of body fat among children (Jago, Baranowski, Baranowski, Thompson, & Greaves, 2005; Janz et al., 2002). Indeed, excessive television viewing has been prospectively related to obesity (Dietz & Gortmaker, 1985), and it was recently shown that watching television for more than 8 hr per week when aged 3 years is independently associated with obesity risk in later childhood (Reilly et al., 2005).

Rising levels of obesity are therefore highly correlated with an increasingly obesogenic environment, that is, one that encourages not only a preference for high calorie foods but also sedentary behaviour. As stated previously, food intake and energy expenditure through physical activity represent two key behaviours to be targeted in the prevention and treatment of obesity. In support of this, Woo and colleagues (2004) found that obesity-related vascular dysfunction in children was partially reversed with dietary modification alone, but effects were significantly enhanced by the addition of an exercise-training programme. Children continuing to exercise over a 1-year period showed beneficial changes in body fat content and further arterial improvements. In a study on family-based treatment for childhood obesity, children who received an aerobic or lifestyle exercise programme in addition to dietary intervention showed superior maintenance of weight loss at 10-year follow-up than children who received the same dietary intervention but with a low-expenditure "placebo" exercise programme (Epstein, Valoski, Wing, & McCurley, 1994). This provides evidence that the inclusion of an exercise programme enhances the effects of diet interventions with respect to reducing and maintaining body weight (see also Yamanouchi et al., 1995). Such findings demonstrate the importance of targeting both food intake and physically active behaviours in the prevention and treatment of child obesity.

Increasing Fruit and Vegetable Consumption in Children

One mechanism by which food intake may be modified is to increase fruit and vegetable consumption, given the low consumption of these foods among children in the UK. Slyper (2004) proposed that the prevalence of child obesity could be significantly decreased by diets containing ample quantities of vegetables and fruit. Furthermore, Wardle et al. (2001) found that children at high-risk for developing obesity had a significantly lower liking for vegetables than did low-risk children; disliking and not eating vegetables may therefore represent a behavioural tendency that has implications for obesity in later life. Dietary surveys show that low consumption of fruit and vegetables among young people is associated with increased energy density of the overall diet (Lobstein et al., 2004). Increasing consumption of fruit and vegetables may therefore replace consumption of energy-dense foods. Furthermore, eating a diet rich in fruit and vegetables is correlated with a decreased incidence of several cancers, cardiovascular disease, and stroke (Gillman, 1996; Key, Thorogood, Appleby, & Burr, 1996). It is therefore of great importance that these foods are consumed as part of the daily diet, particularly given the potential beneficial effects on levels of child obesity.

A 12-year programme of research, conducted at the University of Wales Bangor, has developed a peer-modelling and rewards intervention that produces long-lasting increases in children's consumption of fruit and vegetables. The intervention has strong underpinnings in behaviour analytic theory (see Chapter 3 for further detail) and involves the manipulation of environmental contingencies so that the occurrence of target behaviour is reinforced. The peer-modelling element revolves around the "Food Dudes", a group of slightly older peers who frequently eat and extol the virtues of fruit and vegetables. Through a series of video adventures, the Food Dudes prompt children to eat these foods and thus provide social models for them to imitate. In addition, daily rewards, such as Food Dude stickers and pencils, are awarded to children for eating target amounts of the fruit and vegetables presented to them. The rationale behind the use of peer modelling and rewards in this way is provided elsewhere (e.g., Dowey, 1996; Lowe, Horne, Tapper, Bowdery, & Egerton, 2004; Woolner, 2000). Following the main intervention phase, which typically lasts for 16 days, children enter the maintenance phase during which rewards become more intermittent.

All studies evaluating the effects of the Food Dudes programme show that the combination of peer-modelling and rewards is very effective in increasing consumption of fruit and vegetables in 2- to 11-year old children, and increases are maintained up to 15 months later. Early studies employed single-case methodology and were carried out in the home with "fussy" eaters (Dowey, 1996; Horne, Lowe, Fleming, & Dowey, 1995; Lowe, Dowey, & Horne, 1998). Children aged between 5 and 7 years were presented with previously refused fruits and vegetables during the family meal. In one study, children's baseline consumption of fruit and vegetables was very low; on average, they consumed just 4% of the fruit and 1% of the vegetables that were presented. At the end of the intervention, during which children were exposed to the peer-modelling videos and rewards, fruit consumption increased to 100% and vegetable consumption was at 83%. At 6-month follow-up, fruit consumption remained at maximum levels, and vegetable consumption was 58%. Thus the intervention was associated with substantial and long-lasting increases in fruit and vegetable consumption. A school-based study with a class of 5- and 6-year-old children showed that the intervention was able to increase children's selection and consumption of fruit and vegetables even when these foods were choice options that included popular sweet and savoury snacks (Horne, Lowe, Bowdery, & Egerton, 1998).

The intervention has subsequently been applied to whole schools of children aged between 4 and 11 years. The aim here was to establish a peer group culture that actively supported the eating of fruit and vegetables. A series of evaluations conducted in primary schools across the UK show substantial increases in fruit and vegetable consumption as a result of the intervention, particularly among children who initially consumed very little (Horne et al., 2004; Lowe et al., 2004).

Furthermore these increases in consumption were maintained at 4-month follow-up. There was no evidence however of any such increases in a matched control school in which fruit and vegetables were presented but otherwise no intervention took place. In addition, these studies provide evidence for beneficial effects on consumption at home indicating that behaviour change induced in one context generalised to a different setting.

These findings clearly demonstrate that a peer modelling and rewards intervention is extremely effective in boosting fruit and vegetable consumption in varied populations of children. Although the impact on physiological indicators of obesity have yet to be studied, beneficial effects on health would be predicted to occur, particularly given that increases in consumption are maintained over time. However the intervention will become more relevant to the prevention of child obesity through the development and simultaneous application of a physical activity component.

Increasing Physical Activity

A number of studies indicate that lower levels of physical activity are related to higher levels of body fat. Rowlands, Eston, and Ingledew (1999) found an inverse relationship between daily physical activity and fatness in 8- to 10-year-old children. This association appears strongest when levels of vigorous activity alone are correlated with body composition variables (Abbott & Davies, 2004; Janz et al., 2002). Therefore high intensity physical activity may be most influential on body fatness. However given the cross-sectional design of these studies, it is not possible to determine causality; children may be overweight because they are inactive, but equally, inactivity could be a result of their overweight status.

A longitudinal study by Moore and colleagues studied the effects of physical activity on changes in body fat in children over an 8-year period. Low levels of activity during preschool years had a moderately strong effect on children's fatness levels from preschool to first grade entry, such that inactive children gained significantly more subcutaneous fat than did more active children (Moore, Nguyen, Rothman, Cupples, & Ellison, 1995). By age 11 years, the most active children in the study had lower body mass indices and much less subcutaneous fat than did less active children. Importantly, the child's mean activity level throughout childhood was related to their level of body fat in early adolescence (Moore et al., 2003). These results suggest that a child's physical activity plays a crucial role in the development of obesity and highlight the importance of establishing active lifestyles early in childhood. Although inactivity is likely to be only one of the factors linked with fatness, it may be one of the most easily modifiable (Rowlands, Ingledew, & Eston, 2000).

Additional health benefits of physical activity include a positive association with bone mineral density (Rowlands, Powell, Eston, & Ingledew, 2002). Rowlands and colleagues later showed that both vigorous physical activity and calcium intake needed to be high to obtain maximal effects on bone mineral content (Rowlands, Ingledew, Powell, & Eston, 2004). This suggests an interactive effect of diet and physical activity on bone health, and again emphasises the need for interventions to target both dietary and physically active behaviours.

There is also evidence to suggest that physical activity is positively associated with psychological wellbeing and self-esteem in children and adolescents (see Mutrie & Parfitt, 1998). In a review of intervention and cross-sectional studies, Calfas and Taylor (1994) found that participation in physical activity was associated with increases in self-esteem and decreases in anxiety, stress, and depression in adolescents. Similarly, Steptoe and Butler (1996) showed that higher participation in vigorous sport and recreational activity was associated with positive emotional wellbeing in a national sample of UK adolescents. Among 10- to 11-year-old children, Parfitt and Evans (2001) found that habitual physical activity measured over 7 days had a positive relationship with self-esteem and a negative relationship with anxiety and depression. In a meta-analysis of 27 controlled experimental studies, Gruber (1986) found that participation in a physical activity programme had a significant, positive effect on self-esteem but that the effect size was larger amongst "handicapped" children (i.e., emotionally disturbed, mentally retarded, economically disadvantaged, perceptually handicapped) compared to normal populations. Gruber suggests that this result is attributable to the lower baseline levels of self-esteem among handicapped children. Thus the greatest improvements in self-esteem as a result of physical activity participation occurred in those who most needed it.

However strong relationships between physical activity and various health parameters are often difficult to detect in children. For example, studies do not consistently show beneficial effects of physical activity on levels of body fat (see Boreham & Riddoch, 2001, for review). A meta-analysis of 50 studies suggested that there is a small to moderate relationship, with 78% of included studies reporting the expected negative relationship between activity levels and body fat (Rowlands et al., 2000). Mean effect sizes, however, differed significantly according to the mode of physical activity measurement that was employed. When physical activity was measured through either direct observation or motion counters, such as pedometers, there were stronger relationships between body fat and activity than when heart rate monitoring or questionnaires were used. Inconsistent findings concerning the health benefits of physical activity may therefore be explained by the use of different measurement tools to assess physical activity in children. Indeed, although many intervention studies in the literature have used self-reported measures of children's physical activity, there is widespread concern about the accuracy of such data (e.g., see Rowlands et al., 2000; Welk, Corbin, & Dale, 2000). It is imperative to have an accurate measure of physical activity so that behavioural changes following the introduction of an intervention may be reliably detected.

Research reviewed above provides a strong rationale for increasing physical activity in children, given its likely protective effect on development of body fat and additional health benefits. However as previously stated, weight gain prevention efforts are likely to be most effective when both dietary and physically active behaviours are targeted. Studies evaluating the Food Dudes intervention programme have consistently demonstrated the powerful and long-lasting influence of peer-modelling and rewards on children's fruit and vegetable consumption. The challenge now is to modify this intervention model to target children's physical activity.

Summary

This chapter reviewed evidence to show that the prevalence of obesity is increasing in the UK and that this upward trend is also present among children. Obesity during childhood is associated with immediate health costs and has serious implications for health in later life. The causes of such marked increases in prevalence are complex but are likely to involve both genetic and environmental factors that promote increased food intake and decreased levels of physical activity. Given that UK children appear to show low levels of physical activity and low consumption of healthful foods, such as fruit and vegetables, it is of great importance that children are helped to change both dietary and physically active behaviours. There are many health benefits of eating a diet rich in fruit and vegetables. In addition, physical activity in children appears to have beneficial effects on body fat, psychological wellbeing, and bone health. The Food Dudes programme uses a combination of peer-modelling and rewards to produce substantial, long-lasting increases in children's consumption of fruit and vegetables. It is now important to apply the behavioural principles employed in the Food Dudes programme to an intervention to increase children's physical activity. This will provide a two-pronged, and more effective, approach to preventing obesity in children.

CHAPTER 2

THE MEASUREMENT OF PHYSICAL ACTIVITY IN CHILDREN

Measurement of Physical Activity in Children

Research reviewed in Chapter 1 indicates that the strength of the relationship between physical activity and health parameters in children depends on the technique employed to measure physical activity (see Rowlands et al., 2000). Indeed, Rowlands, Eston, & Ingledew (1997) argue that the identification of relationships between physical activity and health in children may be hindered by measurement difficulties. Valid methods for the assessment of physical activity in children are therefore required to determine current activity levels and to identify beneficial effects of active lifestyles on health.

A detailed observation study by Bailey and colleagues (1995) recorded the duration, intensity, and frequency of the physical activity of 6- to 10-year-old children over 12-hr periods. High intensity activities shown by these children were consistently short in duration, and were interspersed with highly variable intervals of lower intensity activity. None of the children showed a bout of high intensity activity lasting 10 consecutive min and 95% of intense activity lasted less than 15 s. Indeed, the median duration of intense activity was just 3 s. Similarly, Trost et al. (2002) found that children performed very few sustained bouts of physical activity. Measurement tools therefore should avoid focussing on sustained exercise because this does not appear to be part of children's naturalistic physical activity.

In addition, these patterns of activity should be taken into account when devising guidelines for optimal levels of physical activity in youth. Guidelines should emphasise the accumulation of intermittent activity throughout the day, rather than being based on continuous and structured adult-patterns of activity (Welk et al., 2000). A large study by Pate and colleagues (2002) observed that less than 3% of children in Grades 1 to 12 met the requirements of the Healthy People 2010, Objective 22.6 guideline, which calls for bouts of continuous vigorous activity (20 min or more) on 3 or more days of the week. Low achievement of this guideline is not surprising on the basis of Bailey et al.'s (1995) findings; children, it seems, do not behave in this way. In contrast, the UK Expert Consensus Group guidelines recommend 1 hr per day of moderate intensity activity, which may be performed in a continuous fashion or intermittently accumulated throughout the day (Biddle et al., 1998). Pate et al. found that more than two thirds of children met the UK Group guidelines. This suggests that guidelines allowing the accumulation of physical activity over time may be most appropriate and achievable for children.

Bailey et al. (1995) developed an observation system to quantify the frequency, duration, and intensity of children's activity patterns, and direct observation of movement has been proposed as the "gold standard" for the assessment of physical activity (Sirard & Pate, 2001). As well as being able to capture patterns in physical activity, direct observation techniques may also evaluate the contextual aspects of physical activity, such as physical location, antecedents, and consequences (McKenzie et al., 1991). Such detailed assessment however is not feasible with large populations due to the substantial amount of time required for observer training and data collection, the associated costs, and the burden to both experimenters and participants.

In contrast, self-report instruments represent a cheap and convenient way to collect data on activity patterns in large populations and are therefore widely used in the literature. Adults appear able to provide reasonable estimates of their activity level through self-report (Rowlands et al., 1997), however such measures become inherently problematic when used with children. Preadolescent children may be characterised by recall skill limitations and an inability to accurately estimate time

(Welk et al., 2000). On this basis children are less likely to make accurate self-report assessments than are adults.

Welk and colleagues (2000) argue that children are likely to overestimate their activity levels through self-report, and this appears particularly true for high intensity activities (Sallis & Saelens, 2000). This overestimation may be due to an exaggerated perception of time and effort, and also to the transient nature of children's vigorous physical activity. For example, following a game of football a child may report having been very active throughout whereas he or she actually engaged in occasional bursts of activity interspersed with extensive periods of low activity.

Alternatively, Riddoch et al. (2004) argue that when moderate intensity activity is considered, children may be prone to underestimating their activity levels through self-report. As described in Chapter 1, the National Diet and Nutrition survey (Gregory & Lowe, 2000) found that, among 7- to 10-year-olds, 70% of boys and 49% of girls achieved the recommended 60 min of moderate intensity activity per day. However Riddoch et al. found these figures to be much higher with over 96% of 9-year-olds achieving this recommended level of activity. This discrepancy may be due to Riddoch et al.'s use of accelerometers, an objective measure of physical activity, in contrast to the self-report measures employed in the survey. The sporadic and nonplanned nature of moderate intensity activity may make it less memorable and quantifiable. As such it is not collected by self-report measures but is detected by time-sampling accelerometers (Riddoch et al., 2004).

Sirard and Pate (2001) cite deliberate misrepresentations and social desirability biases as other sources of error when obtaining self-report measures from children. Thus given the questionable accuracy of self-report measures, there is a need for research in this area to employ objective measurement of children's physical activity. This is particularly relevant to intervention studies so that subtle changes in behaviour may be detected. Several objective instruments, such as pedometers, accelerometers, and heart rate monitors are now widely available for the measurement of physical activity. Detailed reviews of such measurement devices are provided by Freedson and Miller (2000), Rowlands et al. (1997), Sirard and Pate (2001), and Welk et al. (2000). The remainder of this chapter will focus on the use of pedometers. In addition supplementary measures employed in the current thesis will be outlined.

That is not to say that subjective measures have nothing to contribute to the assessment of children's physical activity. Rather such measures may be used to enrich information provided by objective techniques. For example, Rating of Perceived Exertion (RPE) scales allow children to estimate the level of effort they required to perform certain activities and the use of such scales will be discussed.

Pedometers

The pedometer is a motion counter that uses vertical oscillations to provide a total count of accumulated movements or steps (see Figure 2.1). The internal mechanism is simple in design and includes a horizontal, spring suspended lever arm that moves up and down with normal movement. An electrical circuit closes with each movement detected and an accumulated step count is displayed digitally on the screen (Tudor-Locke, 2002). Pedometers are battery-powered, for example, the Yamax SW-200 model (Figure 2.1) uses an LR-44 battery that lasts approximately 3 years.

Figure 2.1. The Yamax Digiwalker SW-200 pedometer (Tokyo, Japan), on the left with the case open so that the display may be viewed, and on the right with the back removed to show the internal mechanism.

Pedometers are typically worn clipped onto the participant's waistband, directly in line with the knee. It does not matter which side of the body pedometers are worn on (Bassett et al., 1996).

The simplest pedometers measure the number of steps taken in a given time period. More sophisticated pedometers are able to convert raw step counts into distance travelled and calories burned, which requires relevant variables such as stride length and weight to be manually entered into the pedometer's programme. However, the process of manipulating step counts may introduce error; if distance travelled is the outcome variable then individuals with a smaller stride length will appear less active than individuals with longer stride lengths for the same number of steps taken (Tudor-Locke, 2002). Furthermore, stride length becomes longer as speed of walking increases and this causes pedometers to underestimate distance at faster speeds (Bassett et al., 1996). Finally a distance measure seems appropriate only during walking and running (Rowlands et al., 1997). On this basis, researchers have recommended that the number of steps taken be adopted as the standard unit of measurement for pedometer data (Rowlands et al., 1997; Tudor-Locke & Myers, 2001).

The use of pedometers as a measure of physical activity in children is advantageous is several ways. Pedometers are lightweight and unobtrusive, and are thus compatible with most daily activities of children. They provide an objective measure of children's physical activity, which is important given the many problems associated with obtaining subjective measures from children. They are also cheap (the Yamax model costs around £6 per unit when bought in bulk) and may be used repeatedly. The use of pedometers requires no additional software or expertise and data are immediately available.

Pedometers are not without their limitations however. They are not able to accurately measure physical activity during activities such as cycling and swimming, nor do they detect increases in energy expenditure due to carrying heavy objects or walking uphill. Furthermore, pedometers measure only the total amount of activity in a specified time frame and cannot assess intensity, frequency, or duration of activity patterns. However because children show highly intermittent activity patterns, it may be more meaningful to examine the total amount of physical activity that is accumulated over an entire day (Rowlands et al., 1997). This is also relevant to current health guidelines that allow the accumulation of 1 hr per day of moderate intensity activity (Biddle et al., 1998).

A study by Bassett et al. (1996) compared a number of brands of pedometer and found that the Yamax model most accurately assessed the number of steps taken and distance walked by adults on a 4.88 km course. A laboratory study with 8- to 10-

year-old children compared the ability of pedometer, heart rate monitor, and accelerometer activity measures to predict energy expenditure during both treadmill and unregulated play activities (Eston, Rowlands, & Ingledew, 1998). Energy expenditure was measured by scaled oxygen uptake (sVO_2). For treadmill activities, involving walking and running at different speeds, the pedometer showed a correlation of .78 with sVO_2. During unregulated activities, such as playing catch and hopscotch, an even higher correlation of .92 was observed between sVO_2 and the pedometer, which was significantly higher than the corresponding correlations for heart rate and the more expensive uniaxial accelerometer. These findings were replicated by Louie et al. (1999). Correlations of this magnitude indicate that the pedometer showed a strong linear relationship with $sV0_2$, the gold standard measure of energy expenditure.

In an observational study, the pedometer showed correlations of .99 with the Tritrac accelerometer and .96 with behavioural observation measures during recreational and sedentary classroom activities in children (Kilanowski, Consalvi, & Epstein, 1999). In another field study, pedometer-determined physical activity measured over 6 days was negatively correlated with fatness ($r = -.42$) in 8- to 10-year old children. Aerobic fitness was also assessed by endurance time on the Bruce maximal treadmill test, and fitness measures were positively correlated with pedometer-determined activity ($r = .59$). Thus, according to the pedometer measure, increased activity levels were related to higher levels of aerobic fitness and lower levels of body fat. Furthermore, correlations of pedometer counts with fatness and fitness were not significantly different from those provided by the Tritrac accelerometer (Rowlands et al., 1999). These findings indicate that the pedometer and the more-expensive accelerometer are measuring approximately the same total accumulated daily activity. Thus there is great potential for the pedometer as a valid and low cost measure of physical activity in children.

It is important to determine the number of measurement days that are required to obtain reliable estimates of children's habitual physical activity. People are likely to show day-to-day (i.e., intra-individual) variability in their activity levels, and this may be increased by factors such as illness and bad weather (Baranowski & de Moor, 2000). Tudor-Locke et al. (2005) found substantial intra-individual variability in adult physical activity over 7 days of pedometer measurement. As the variability in a person's activity increases across days, the more days are required to obtain stable and therefore reliable estimates of habitual physical activity.

The standard way of estimating consistency across days is the intraclass correlation coefficient. An intraclass correlation of .80 indicates a desirable level of reliability; higher correlations have little additional value in their ability to detect true relationships between variables (Baranowski & de Moor, 2000).

In the study by Tudor-Locke et al. (2005), in which adult physical activity was measured over 7 days, the intra-class correlation for any single day of pedometer measurement was .72. This indicates that approximately 72% of the variance was accounted for by using data from 1 day to represent the full 7 days of measurement. Any 3-day combination produced intra-class correlations (.86 to .91) that fell well within the desirable range. Tudor-Locke et al. thus concluded that a minimum of 3 days of pedometer data is sufficient to estimate adult habitual physical activity in a week. In children, between 4 and 5 days of accelerometer monitoring were needed to achieve an intra-class reliability coefficient of .80. Furthermore, children showed higher levels of physical activity at the weekend compared to during the week, therefore weekend days should be included in the measurement period (Trost, Pate, Freedson, Sallis, & Taylor, 2000). If only weekdays are to be included, 3 to 4 days of pedometer measurement obtained reliability coefficients of greater than .80 in children (Ozdoba, Corbin, & Le Masurier, 2004).

With respect to validity, Tudor-Locke (2002) advised that pedometers should be calibrated prior to use by simply walking a short distance whilst simultaneously counting the actual steps taken. Vincent and Sidman (2003) conducted a 100-step walk test using a total of 24 individual pedometers (all Yamax SW-200 model). The mean percent error shown by the pedometers was less than 2%. No pedometer exceeded 5% error (i.e., more than 5 steps incorrectly recorded out of 100). The low amount of measurement error provides evidence for the accuracy of pedometers in terms of detecting the number of steps taken.

When using pedometers it is often desirable to conceal the displayed step count so that the participant is unable to receive feedback on his or her activity level. This may aid in the reduction of *reactivity*, which is a change in normal activity patterns when people are aware that their activity levels are being monitored (Vincent & Pangrazi, 2002b). Vincent and Pangrazi (2002b) used sealed pedometers to monitor children's physical activity over an 8-day period to determine whether reactivity occurred. This would be indicated by a higher activity count on Day 1 followed by a pattern of decreasing activity on consecutive days. There were no significant differences in activity counts over the 8-day period indicating that a reactivity period did not occur. Importantly, two recent studies indicate that reactivity does not occur when using unsealed pedometers to measure children's daily level of physical activity (Ozdoba et al., 2004; Rowe, Mahar, Raedeke, & Lore, 2004).

In other cases however researchers may wish to use pedometers as motivational tools (e.g., see Tudor-Locke, 2002; Tudor-Locke & Myers, 2001). The pedometer enables the wearer to self-monitor his or her physical activity and to determine if specified goals are obtained (Freedson & Miller, 2000). In such cases, it may be desirable for pedometers to be unsealed so that the wearer is able to receive immediate feedback on his or her activity level. The use of pedometers as motivational tools will be discussed in further detail in Chapter 3.

In summary, pedometers provide an inexpensive, convenient, and valid method of assessing physical activity in children. They are ideally suited to large population studies (Rowlands et al., 1997). In some situations however it may be advantageous to employ multiple measures of physical activity to provide a more complete description of children's activity patterns (Welk et al., 2000). The remainder of this chapter will briefly outline the additional measures of physical activity that are employed in the studies reported in this thesis.

Additional Measures of Physical Activity in Children

Accelerometers. Accelerometers are sophisticated electronic devices that measure accelerations produced by body movement (Sirard & Pate, 2001). The underlying theory holds that acceleration is directly proportional to muscular forces and therefore is related to energy expenditure (see Freedson & Miller, 2000). Uniaxial accelerometers measure acceleration in a single plane (usually vertical), whereas triaxial accelerometers measure acceleration in the vertical, horizontal, and mediolateral planes.

A time-sampling mechanism enables the measurement of intensity, frequency, and duration of physical activity therefore accelerometers are able to capture children's sporadic activity patterns. The sampling interval of accelerometers is frequently set to 60 s and summarizes all registered counts during this period. A shorter sampling interval (i.e., 5 s) gives a more detailed picture of intensity patterns

(Nilsson, Ekelund, Yngve, & Sjostrom, 2002). However given the huge amount of data obtained and the limited capacity of the accelerometer memory, the latter sampling method may not be feasible for monitoring physical activity over several days.

Three-dimensional measures of activity provided by triaxial accelerometers are particularly important when assessing children's activities such as climbing and playing (Powell & Rowlands, 2004). The triaxial Tritrac R3D model has been validated as a measure of children's physical activity and may provide information not recorded by uniaxial accelerometers (Eston et al., 1998; Ott, Pate, Trost, Ward, & Saunders, 2000). However a limitation associated with the Tritrac is its bulky nature and weight (168 g) therefore it is not well suited for use with children.

A more user-friendly device is the RT3 triaxial accelerometer (see Figure 2.2), a battery-powered monitor weighing just 65.2 g. The RT-3 collects activity data in 1- or 60-s epochs and can store activity data for up to 21 days. Motion is measured on three orthogonal axes known as X, Y, and Z, which correspond to vertical (up and down), anterioposterior (forward and back), and mediolateral (side-to-side) motion, respectively (Powell, Jones, & Rowlands, 2003). Acceleration is measured periodically (depending on whether the 1-s or 60-s epoch is employed), converted to a digital representation, and processed to obtain an "activity count" which is stored in the memory (Powell & Rowlands, 2004). Activity data for the RT3 may also be expressed as minutes spent in varying intensities of activity using count cut-off values that correspond to the intensity of activity (e.g., low intensity, moderate intensity) (Rowlands, Thomas, Eston, & Topping, 2004).

Figure 2.2. The external appearance of the RT3 triaxial accelerometer, with an AAA battery also shown.

The RT3 is worn clipped to the waistband and has no external controls that may be manipulated. Activity data are downloaded to a PC for display and analysis following measurement, therefore participants do not receive immediate feedback on their activity levels.

There have been few studies evaluating the validity and reliability of the RT3 due to its relatively recent appearance in the field. Of studies conducted to date, RT3 accelerometer counts correlated positively with sVO_2 in both boys ($r = .87$), and men ($r = .85$) (Rowlands, Thomas, et al., 2004). The RT3 thus appears a valid tool for assessment of physical activity. Powell and Rowlands (2004) found that individual RT3 monitors were reliable over two repeated trials of activities of differing intensity (e.g., walking, running). However there was considerable inter-monitor variability within activities. The X axis (vertical) showed the least variability between monitors and was the most reliable of the three axes. An additional study showed that the X axis performed well in comparison with the other two axes (Powell et al., 2003). Until further research is conducted, it may therefore be advisable to limit use of the RT3 to the vertical axis only (e.g., Rowlands, Ingledew, et al., 2004).

Disadvantages associated with the use of accelerometers include their high cost; an individual RT3 unit is currently priced at $300 on the manufacturer's website (www.stayhealthy.com). It is also necessary to purchase a docking station to enable downloading of RT3 data to a PC and this is priced at $200. The large quantity of data obtained through the use of accelerometers is time consuming to handle and analyse.

Heart rate monitoring. Heart rate monitoring provides an indication of the relative stress placed upon the cardiopulmonary system resulting from physical activity (Rowlands et al., 1997). A number of studies have used this method to estimate daily physical activity in children (e.g., Atkins, Stratton, Dugdill, & Reilly, 1997; Gavarry, Giacomoni, Bernard, Seymat, & Falgairette, 2003; Sleap & Tolfrey, 2001; Welsman & Armstrong, 1997).

Heart rate monitoring is an indirect measure of physical activity and relies on a linear relationship between heart rate and oxygen uptake. This relationship is likely to hold during moderate intensity activity, but increasing error is introduced at higher and lower intensities (Rowlands et al., 1997). At low intensities, physical activity is not the only cause for increased heart rate; for example emotional stress will significantly elevate heart rate. Further limitations are identified by Rowlands and colleagues (1997). Heart rate tends to lag behind changes in movement therefore the use of heart rate monitoring may not capture the short, intermittent bouts of vigorous activity shown by children. Furthermore heart rate is influenced by fitness level, and fitter, more active children have lower heart rates.

One way to control for the influence of fitness is to use a measure of net heart rate, which involves subtracting the participant's resting heart rate from the heart rate observed during physical activity. Thus an estimation of the net increase in heart rate as a result of physical activity is obtained and this allows for comparison between individuals of different fitness levels (Freedson & Miller, 2000).

Heart rate monitoring is frequently included in studies attempting to validate other techniques of physical activity assessment, such as accelerometers. During treadmill and unregulated play activities in children, heart rate correlated significantly with sVO_2 ($r = .80$), and with activity measures provided by the pedometer ($r = .62$), uniaxial accelerometer ($r = .68$), and triaxial accelerometer ($r = .79$) (Eston et al., 1998). Similarly, during several 5-min "free-play" activities carried out by children, Ott et al. (2000) found that heart rate was significantly correlated with uniaxial and triaxial accelerometer measures ($r = .64$ and $.73$, respectively). Correlations of a similar magnitude were found between heart rate and Metabolic Equivalent (MET) values ($r = .70$), and between heart rate and the intensity classification of the activity as light, moderate, vigorous, or very vigorous ($r_s = .68$). MET values are an indicator of the rate of energy expenditure; a 2-MET activity requires two times the metabolic energy expenditure of sitting quietly (Ainsworth et al., 1993).

In order to obtain the true heart rate during a given activity, Ott et al. (2000) emphasise the importance of allowing sufficient time for heart rate to reach "steady-state". This is because heart rate tends to lag behind movement (Rowlands et al., 1997). In their study, Ott et al. found stable heart rates over 3 min of measurement during play activities indicating that steady state had been reached. They conclude that heart rates may be used a measure of physical activity as long as the activity is sustained over a number of minutes.

Rating of Perceived Exertion (RPE) scales. Perceived exertion is defined as the act of detecting and interpreting sensations arising from the body during physical exertion (see Eston & Lamb, 2000). Ratings of Perceived Exertion (RPE) may be used to assess and regulate the intensity of exercise. In typical RPE scales, verbal descriptors of effort are assigned to an increasing numerical scale. The participant may indicate the level of exertion associated with exercise by selecting the appropriate number on the scale. A number of methods for assessing perceived exertion have been devised, and more recently child-specific scales have been developed.

When using RPE scales with children, Eston and Lamb (2000) emphasise the need to consider age, reading ability, experience and conceptual understanding; for example, 7- to 10-year-old children may find it easier to understand and interpret pictures rather than words. A recently developed children's scale, the Bug and Bag Effort (BABE) Scale (Eston & Lamb, 2000; Shepherd, 2002), may be seen in Figure 2.3. This scale shows a character from the Walt Disney film "A Bug's Life" carrying a backpack that is increasingly loaded with bricks to denote increasing intensity levels. Verbal descriptors of effort are assigned to the scale, which ranges from 1 (*very easy*) through to 10 (*so hard I'm going to stop*). Children are frequently asked to use such scales to estimate their perception of effort, in response to a request from the experimenter to indicate how "hard" the exercise feels; this is known as *estimation* mode (Eston & Lamb, 2000). In the case of the BABE scale, an activity that was perceived by a child as having required a high level of exertion would receive a high score, and conversely an activity with low perceived exertion would receive a low score. An alternate use for this type of scale is to request children to produce a specific RPE during exercise and this is known as *production mode* (Eston & Lamb, 2000).

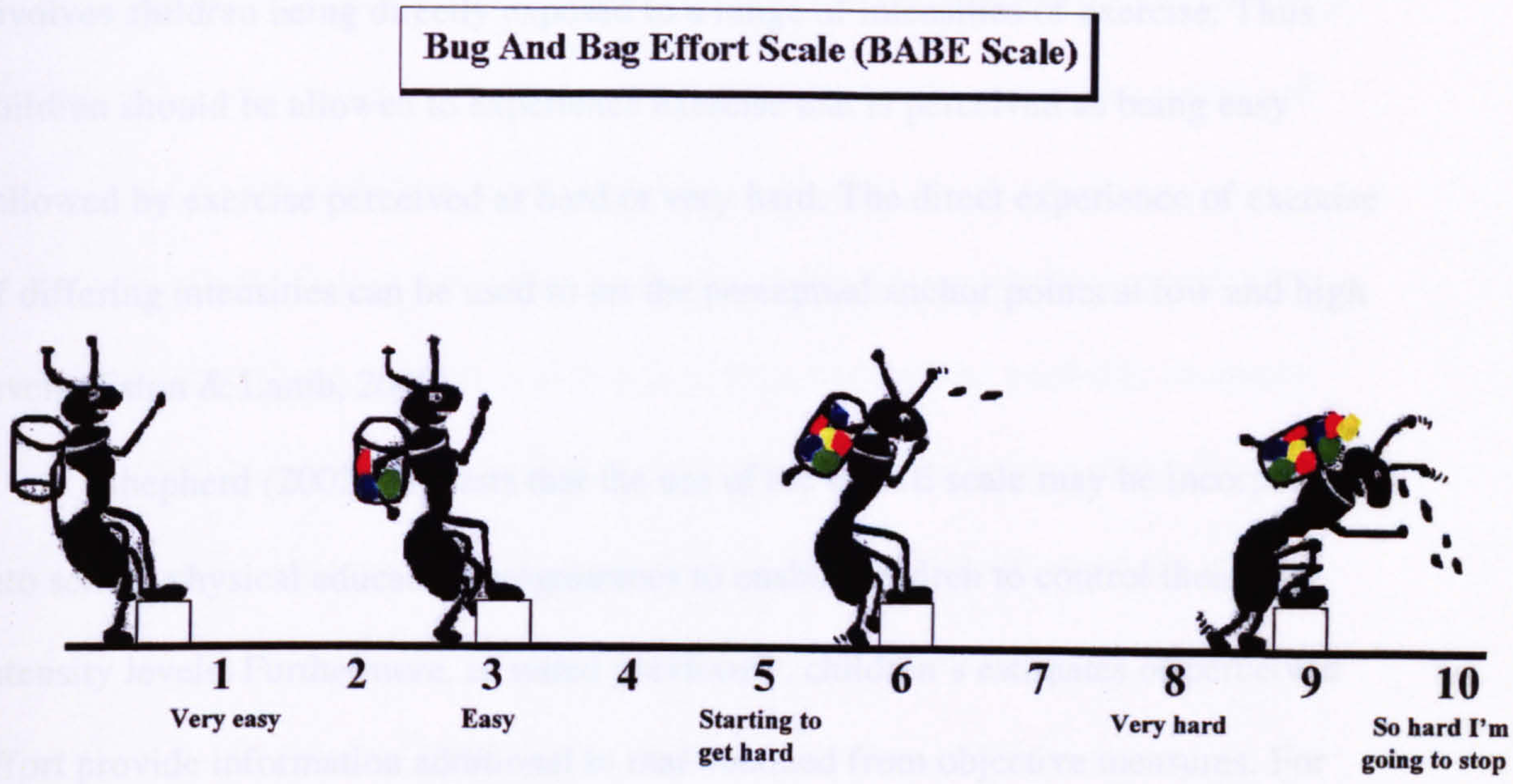


Figure 2.3. The Bug and Bag Effort (BABE) scale (Eston & Lamb, 2000, reproduced with permission).

Children's estimates of perceived effort have been validated against objective measures of physiological strain such as heart rate and oxygen uptake, and studies reviewed by Lamb and Eston (1997) consistently show high levels of validity. For example, Eston, Lamb, Bain, Williams, and Williams (1994) found a correlation of .76 between heart rate and estimates of perceived exertion in 8- to 11-year-old children. More recently, Shepherd (2002) found that 8- to 11-year-old children did significantly more pedometer counts when instructed to produce Level 8 (*very hard*) on the BABE scale compared to when they were instructed to produce Level 3 (*easy*). Thus children were able to use their effort perception to alter their production of exercise (pedometer counts) and this provides evidence for the validity of the BABE scale.

To enable children to effectively use RPE scales, it is important that they fully understand the range of sensations that correspond to the categories of effort shown by the scale. This may be achieved through a process of *perceptual anchoring* which involves children being directly exposed to a range of intensities of exercise. Thus children should be allowed to experience exercise that is perceived as being easy followed by exercise perceived as hard or very hard. The direct experience of exercise of differing intensities can be used to set the perceptual anchor points at low and high levels (Eston & Lamb, 2000).

Shepherd (2002) suggests that the use of the BABE scale may be incorporated into school physical education programmes to enable children to control their own intensity levels. Furthermore, as stated previously, children's estimates of perceived effort provide information additional to that obtained from objective measures. For example, it would be interesting to determine whether activities that produce a high number of pedometer steps are associated with estimates of increased perceived effort, in comparison to more sedentary activities.

Summary

In order to determine current activity levels, to identify relationships between physical activity and health, and to evaluate the behavioural effects of interventions, it is imperative that valid measures of children's physical activity are employed. Children's physical activity may be characterised by very short, intermittent bouts of vigorous activity and this may make it difficult for children to use self-report measures to accurately recall their level of physical activity. Pedometers are low-cost, convenient, and valid tools for the objective measurement of physical activity in large populations of children. They are ideally suited to studies which require a measure of total daily physical activity. If a more detailed breakdown of activity patterns is required then accelerometers provide a feasible alternative, most notably the user-friendly RT3 triaxial model. However the need to obtain a detailed picture of children's activity patterns must be balanced against the substantially higher cost of accelerometers in comparison to pedometers. In addition, data provided by activity monitors may be enriched by measures of heart rate, and by subjective ratings of perceived intensity associated with exercise.

On a final note, each technique for the measurement of physical activity possesses advantages but also limitations. On the basis of the available literature, researchers engaged in studies of children's physical activity must select the technique that most appropriately answers the specific research question.

CHAPTER 3

INCREASING PHYSICAL ACTIVITY IN CHILDREN: A BEHAVIOUR ANALYTIC APPROACH

Where Should We Intervene?

In order to target children's physical activity most effectively, it is important to measure variations in children's habitual physical activity during the day, and from day to day, to identify particular time periods or environments in which children tend to show low levels of physical activity.

Vincent and Pangrazi (2002a) conducted a large-scale monitoring study of the physical activity patterns of 6- to 12-year-old children. Children wore pedometers over 4 complete weekdays to assess levels of physical activity. Results showed that children's daily step counts were stable from 6 to 12 years of age, although boys took more steps per day than girls at all ages. However mean step counts had sizeable standard deviations, indicating substantial variability in activity levels among children of the same gender and age. Indeed, when the sample was collapsed for age and converted into quintiles, girls in the highest activity quintile averaged more than double the step counts of girls in the lowest quintile (14,764 vs. 7,279 steps per day, respectively). The trend was similar for boys in the highest and lowest quintiles (17,529 vs. 9,030 steps per day, respectively).

These findings are of great interest because they highlight the substantial variability in children's activity levels. When considering activity over entire days it is clearly not the case that all children are sedentary. Rather it appears that children's activity levels, in terms of steps per day, are on a continuum; some children average a very high number of steps whereas children at the other end of the continuum are less than half as active. It is this latter group of "low-active" children who are most likely to benefit from interventions to increase physical activity.

Vincent and Pangrazi (2002a) note that the amount of variability is particularly surprising because the children's activity levels would have been restricted during the school day, with the exception of short amounts of free time at playtimes. Because the structured school environment may limit individual variability, Vincent and Pangrazi suggest that major differences between children's activity levels occur outside of the school environment. Therefore, in order to increase activity levels among low active children, it may be preferable to focus on out-of-school activity.

The need to promote physical activity in out-of-school contexts has been suggested by other studies. In an observational study, Sleap and Warburton (1992) found that although preadolescent children were substantially involved in moderate to vigorous activity during school playtimes, they were much less active during free time at home. Lower activity levels in the home environment may reflect the increased availability of sedentary activities such as watching the television and using a computer. Indeed, the use of after-school time for active rather than sedentary pursuits has been shown to be a consistent correlate of total physical activity in large samples of children (Sallis, Prochaska, Taylor, Hill, & Geraci, 1999; Sallis, Taylor, Dowda, Freedson, & Pate, 2002). Furthermore, some studies have shown that children are less active on weekend days than on school days (Gavarry et al., 2003; Rowlands et al., 1999), although this has not been found consistently (e.g., Trost et al., 2000).

Such results indicate that children do not necessarily compensate with increased physical activity once the constraints of school are removed. Indeed a study by Dale, Corbin, and Dale (2000) suggests quite the opposite. In this study, children's activity at school was restricted for 2 days (restricted days); the children did not take part in physical education classes and remained indoors during playtimes. On another 2 days, physical activity opportunities were not restricted during school (active days); the children participated in their normal physical education classes and spent playtime periods outdoors. The children wore uniaxial accelerometers for the duration of the 4 days to assess the effects of restricting school activity on activity levels after school. Results showed that, following a restricted school day, the children did not compensate by increasing their physical activity levels after school. In fact, the children were significantly more active after school following an active school day than they were following a restricted-activity school day. Children, it seems, do not voluntarily "make up" for denied opportunities to be active.

Given that low activity in school tended to be followed by low activity after school, targeting in-school activity may be one way to raise activity levels in both contexts. Schools present an ideal setting to reach large numbers of children with health promotion efforts (Goran, Reynolds, & Lindquist, 1999). Increasing levels of physical activity during school physical education classes represents an obvious intervention target. Sleap and Warburton (1992) found that sustained periods of moderate to vigorous physical activity were rare during physical education lessons and that children spend almost a quarter of the lesson time standing, sitting, listening, and queuing.

School playtime can provide an ideal context for children to be physically active. Stratton (1999) used heart rate monitoring to measure the activity levels of children during morning playtimes ranging from 15 to 25 min in duration. On average, children spent only a small proportion (3.5 min) of playtime in moderate to vigorous physical activity, although wide individual differences in activity level were observed. Another study found that 6- to 7-year-old children were most active at the beginning of playtime but that activity levels showed a marked decline as time on the playground elapsed. This study also observed that children spent the majority of playtime being sedentary (McKenzie et al., 1997). School playtime thus provides opportunities to increase children's activity levels.

Intervention efforts may also focus on the mode of children's transportation to and from school. Active commuting to school by means of walking or bicycling is a potential source of moderate intensity activity (Tudor-Locke, Ainsworth, & Popkin, 2001). However, as noted in Chapter 1, cycling and walking to school have become less frequent behaviours. Adolescents who walked to school showed significantly greater daily energy expenditure than did adolescents using motorised transport; an additional 44.2 and 33.2 kilocalories per day for males and females, respectively, appeared due to active commuting (Tudor-Locke, Ainsworth, Adair, & Popkin, 2003). However findings in this area differ. Another study with 5-year-olds found that although children who walked to school were more active during the school journey than children who travelled by car, these differences completely disappeared when total weekly activity was examined using accelerometry (Metcalf, Voss, Jeffery, Perkins, & Wilkin, 2004). The researchers thus concluded that active commuting to school makes no difference to overall levels of activity in young children.

An alternative approach to focussing on one time period or context is to increase the total amount of physical activity that is accumulated throughout the day. This is consistent with current health guidelines for children that emphasise the accumulation of 1 hr per day of moderate intensity activity. A number of large-scale interventions have aimed to increase children's physical activity both during and after school. These will be reviewed in the following section.

Multicomponent Interventions to Increase Physical Activity in Children

In the physical activity literature, many interventions to increase physical activity amongst children are *multicomponent*; they incorporate a number of different behaviour change techniques, such as classroom health curricula and physical education programmes. A review of school-based interventions by Stone, McKenzie, Welk, and Booth (1998) concluded that, while improvements in children's knowledge and attitudes related to physical activity were generally found, few positive findings were reported on measures assessing out-of-school physical activity. For example, the Sports, Play, and Active Recreation for Kids (SPARK) project involved a 2-year physical education programme for elementary school children that was designed to promote high levels of physical activity, teach movement skills, and be enjoyable (Sallis et al., 1997). In addition, a self-management curriculum taught skills such as self-monitoring and goal setting to help children increase physical activity outside of school. Students who participated in this intervention spent more time in moderate to vigorous physical activity during physical education classes than control children (assessed by direct observation). There were, however, no significant effects on out-of-school activity measured objectively by accelerometers. It is therefore of great importance that interventions teach behavioural skills that children may use to be active outside of formal programmes to stay active over time (Sallis et al., 1992).

A number of intervention studies have focused on reducing the prevalence of obesity in large populations of school children through the promotion of healthy eating and physically active behaviours. The Pathways study (Caballero et al., 2003) evaluated the effectiveness of a school-based, multicomponent intervention to prevent and reduce excess weight gain in elementary children over a 3-year period. The intervention consisted of four components; classroom curricula to promote healthy eating and physical activity, a reduction in fat content of school meals, a physical education programme (three 30-min sessions per week of moderate to vigorous physical activity plus classroom physical exercise breaks), and family involvement (family action packs and events at school). Following 3 years of the intervention, knowledge related to diet and physical activity had increased significantly. There was significantly lower fat intake in the intervention schools compared to control schools (assessed by direct observation and 24-hr recall), but accelerometer data indicated no significant effects on physical activity. In addition, percentage body fat did not change significantly indicating that the intervention had no effect on the prevalence of obesity in this population of children.

To date, the only study of this kind conducted in the UK is the Active Programme Promoting Lifestyle in Schools (APPLES) (Sahota et al., 2001a, Sahota et al., 2001b), a 1-year multidisciplinary programme designed to influence physical activity and diet in 8- to 10-year-old schoolchildren. The intervention involved modification of school meals, teacher training, and the development of school "action plans", which included incorporation of nutrition education into the school curriculum and a "Fit is Fun" programme into physical education lessons. The intervention was successfully implemented in all schools with excellent cooperation by teachers and children (Sahota et al., 2001a). Self-reported measures of dietary behaviours (by 24-hr recall and food diaries), and physical activity (by questionnaire) were taken at baseline and 12 months later. Effects of this intervention are similar to those reported by Caballero et al. (2003). There was no difference in body mass index (BMI) between intervention and control children at the end of the 12-month intervention. Children's knowledge about the health benefits of diet and physical activity increased significantly as a result of the intervention. Despite this, behavioural differences between intervention and control children were minimal (slightly higher intake of vegetables in the intervention group), and in some cases undesirable (e.g., increased sedentary behaviour and higher consumption of high-sugar foods and drinks among overweight children in the intervention group). Such results have led to the conclusion that "most school based intervention programmes increase knowledge about nutrition, but they rarely produce significant changes in behaviour or favourable short to intermediate term health outcomes" (Atkinson & Nitzke, 2001, p. 1019).

Other school-based prevention studies have obtained more promising results. The largest to date is the Child and Adolescent Trial for Cardiovascular Health (CATCH), which involved 96 elementary schools at four sites in the United States (Luepker et al., 1996). The intervention consisted of school food modifications, enhanced physical education, classroom curricula, and a home curriculum. It began while children were in the third-grade of elementary school (8- to 9-year-olds) and ran for 3 years, by which time the students had progressed to the fifth-grade. At the end of the intervention a number of significant behavioural changes were reported, such as a reduction in fat intake, greater energy expenditure during physical education lessons, and a higher level of daily vigorous physical activity in intervention students compared to controls (assessed by 24-hr recall, direct observation, and a self-administered physical activity checklist, respectively). However there were no effects on measures of body size, blood pressure, or cholesterol, and the authors themselves acknowledge that the magnitude of the self-reported behavioural changes whilst statistically significant were modest.

Planet Health (Gortmaker et al., 1999) is a 2-year intervention to reduce obesity among older students in grades 6 to 8 (11- to 13-year olds). The intervention promoted reductions in television viewing, increases in physical activity, decreased consumption of high-fat foods, and increased consumption of fruit and vegetables through a classroom curriculum incorporated into major subject areas (maths, science, language arts, and social studies) and physical education. In addition, a 2-week campaign was introduced to reduce television viewing in households ("Power Down"). Classroom lessons consisted of behavioural and learning objectives relating to each of the four behavioural targets of the intervention, student resources, and homework activities. Obesity prevalence among female students in the five intervention schools was significantly reduced compared to female students in the control schools, however this effect was not observed for males. Both boys and girls in the intervention schools showed a significant reduction in self-reported television viewing time compared with controls and intervention girls reported an increase in fruit and vegetable consumption. There was no effect on the time per day spent in moderate to vigorous activity, assessed by questionnaire.

Collectively, the CATCH and Planet Health studies suggest that large scale interventions of this type are able to produce changes in eating and physically active behaviours, and in the latter case, show an impact on the prevalence of obesity (in girls only). However both studies employed self-report measures of dietary intake and physical activity, which are of "limited validity" (Gortmaker et al., 1999, p. 417). Indeed, research reviewed in Chapter 2 indicates that children are unlikely to produce reliable and valid self-reports of physical activity. Interventions that are evaluated solely through self-report measures should therefore be treated with caution. Only two studies reviewed here employed objective measures of physical activity (SPARK and Pathways) and interestingly, in both cases, the respective interventions were found to have no effect on daily physical activity. The behavioural effects of school-based prevention programmes thus appear highly inconsistent.

Lowe et al. (2004) note that many of the behaviour change techniques that make up multicomponent interventions, such as skills development and provision of nutritional information, have not been shown to reliably influence eating behaviour.

For example, a review by Contento, Manning, and Shannon (1992) showed that while school-based nutrition education programmes frequently had positive effects on nutrition knowledge, diet-related skills, behavioural expectations, and self-efficacy, the impact on actual behaviour was minimal. In order to promote changes in health behaviours, interventions should consist of well-specified, empirically-supported behaviour change techniques that are based on an underlying theoretical model (Michie & Abraham, 2004). Lowe et al. (2004) thus argue that a more effective way of developing interventions is to focus on techniques that have been shown to have a reliable effect on children's health behaviours.

There is substantial evidence that "peer-models" and rewards exert a strong influence on children's food preferences and consumption (see Dowey, 1996; Lowe et al., 2004; Woolner, 2000, for review). Empirical research and theoretical underpinnings in behaviour analysis have thus informed the development of a peer-modelling and rewards intervention that produces substantial, long lasting increases in children's fruit and vegetable consumption, as shown in Chapter 1. It is now important to determine whether this intervention model is likely to be effective in increasing children's physical activity.

Behaviour Analysis

The behaviour analytic perspective holds that behaviour is selected and changed through continuous interaction between the behavioural repertoire of an organism and its environment. Operant conditioning is the key process of psychological change whereby behaviours that are functionally effective for an individual become more frequent in the corresponding environment while other behaviours decline in frequency (Leslie, 2002, p. 5). Both overt, observable behaviours and "private" behaviours, such as thinking, are influenced by environmental consequences.

In contrast to the older methodological behaviourism, the philosophy of Radical Behaviourism holds that a science of behaviour must deal with events which take place within the private world and are not directly observable. The following quotation from Skinner (1974) emphasises the central role of language in human behaviour:

> Relatively late in its history, the human species underwent a remarkable change: its vocal musculature came under operant control.... vocal operant behavior made a great difference because it extended the scope of the social environment. Language was born, and with it many important characteristics of human behavior. (p. 98)

Skinner (1974) saw language as something a person acquires and possesses. Verbal behaviour on the other hand is behaviour that has a special character because it is reinforced by its effects on people. The reinforcing consequences of opening a door may be achieved by a person grasping the knob, turning it, and pulling the door open. Alternatively, the person may say "Please open the door" and, providing that the listener responds appropriately, the same reinforcing consequences will occur (p. 99).

Talking is an obvious and important type of verbal behaviour and enables the emission of various types of operant with different functions. For example the person saying "Shut the door" in the previous example, is emitting a *mand* (this term is derived from "demand"), which may be reinforced by the removal of a cold draught from the door. Another verbal operant is a *tact*, a descriptive act (e.g., "What a beautiful day") which is often followed by social approval. In this way, members of the verbal community routinely talk and reinforce each other's verbal behaviour (Leslie, 2002, p. 196-197).

Verbal behaviour enables humans to describe contingencies of reinforcement and to produce rules for responding. With the advent of verbal behaviour, Skinner (1974) states that:

> People began to talk about what they were doing and why they were doing it. They described their behavior, the setting in which it occurred, and the consequences. In other words, in addition to being affected by contingencies of reinforcement, they began to analyse them. (p. 132)

When the speaker responds as a listener to his or her own speech as well as to the speech of others (Skinner, 1974) subsequent learning is transformed because verbal behaviour can control one's own behaviour as well as the behaviour of others. Models of human conditioning that do not take into account the controlling role of verbal behaviour must therefore prove to be inadequate (Lowe, Horne, & Higson, 1987).

Much of human behaviour is *rule-governed* where verbal behaviour, in the form of a rule, is acquired either through verbal instruction or through direct experience of reinforcement contingencies, and then determines other behaviour (Leslie, 2002). A rule points to a contingency and has been defined by Skinner (1969) as a *contingency-specifying discriminative stimulus.* In contrast, *contingency-shaped behaviour* is shaped and maintained directly by contingencies of reinforcement and punishment:

> We refer to contingency-shaped behavior alone when we say that an organism behaves in a given way with a given probability because the behavior has been followed by a given kind of consequence in the past. We refer to behavior under the control of prior contingency-specifying stimuli when we say that an organism behaves in a given way because it expects a similar consequence to follow in the future. (p. 147)

To illustrate the difference between rule-governed and contingency-shaped behaviour, Skinner (1969) compared the behaviour of a baseball outfielder catching a fly ball to that of a ship commander taking part in the recovery of a re-entering satellite. In both cases the goal is to catch a falling object. The outfielder's ball-catching behaviour involves following the ball's trajectory, moving under it, and grasping it with his glove. It is controlled by the consequences of past ball catching behaviour and is thus contingency-shaped behaviour. In contrast, the ship commander's satellite "catching" behaviour involves detailed analysis of the trajectory of the satellite using complex mathematical models. This behaviour is not controlled directly by past satellite-catching behaviour; it is controlled by rules.

While the topography of rule-governed and contingency-shaped behaviour is often similar, the latter depends upon "genuine" consequences. The control exerted by rules however is primarily verbal and the contingencies specified have frequently never been contacted. In this way, human verbal behaviour allows behaviour to be controlled by descriptions of contingencies, in the verbal behaviour of others, as well as by direct contact with the contingencies themselves (Catania, 1998).

The advantage of following rules is that we can acquire new behaviours much more rapidly than if we were to allow contingencies to shape our behaviour. Much behaviour begins with instruction and shifts to being shaped by contingencies. Skinner (1974) provides the example of a person learning to drive a car who responds to the verbal behaviour, in the form of direction and instruction, of the driving instructor. The driver's behaviour will eventually come under the control of the natural, nonverbal contingencies of driving a car. As Skinner (1974) notes "To learn to drive simply through exposure to those contingencies would take a very long time" (p. 134).

Rule-governed behaviour may be particularly effective in controlling behaviour when the natural contingencies are "defective" (Skinner, 1969, p. 167). The reinforcing consequences of a behaviour may be long-deferred or very rare and would thus have a negligible effect in shaping that behaviour. Rules however bring these consequences to bear upon the individual; for example, many people wear seatbelts and obey speed limits not because they have avoided or escaped from serious accidents by doing so. Furthermore, rules may be used to control behaviour when the natural contingencies shape undesirable behaviour.

However, rule-governed behaviour can be insensitive to its consequences (Catania, 1998). According to experimental research, when human subjects are exposed to different schedules of reinforcement, they frequently show a rigidity of performance in the face of altered reinforcement contingencies which may be attributed to their having formulated verbal rules concerning what is required of them (Lowe et al., 1987). A series of studies from a developmental perspective found that preverbal infants showed performance on reinforcement schedules that was directly contingency-controlled and thus indistinguishable from the performance of animals. Children aged 5 years and older, however, showed insensitivity to alterations in the reinforcement schedule similar to adult patterns of responding. Importantly, this age group of children would have had the necessary verbal skills to describe contingencies to themselves and to form rules for responding. Finally, children in an intermediate age range of 2.5 to 4 years showed elements of both adult-like and animal-like patterns of responding (Bentall, Lowe, & Beasty, 1985).

The behaviour of being physically active may be initiated, shaped, and maintained by natural contingencies in the environment. Some consequences may provide immediate sources of reinforcement for physical activity, for example, a child may contact positive social interactions through participation in a game of football. As a result, the child may behave in this way in the future – an example of contingency-shaped behaviour. Other reinforcing consequences of physical activity may be less immediate but nevertheless effective in controlling the behaviour. Participation in physical activity may enhance mood and lead to a feeling of increased energy, clearer thinking, better social relationships, and better work achievement. In time, the individual may feel fitter and become more flexible and toned. Such positive changes may enhance body image and lead the individual to feel better about him or herself.

Other beneficial consequences of being physically active, such as losing weight, obtaining cardiovascular health benefits and perhaps living longer, are likely to be more delayed in time. Indeed, research reviewed in Chapter 1 emphasises the importance of additionally targeting diet in order to promote weight loss through physical activity. These ultimate consequences, however, may be brought to bear upon the individual by the following of verbal rules that specify the outcomes of being physically active. In this sense, physically active behaviour may be under the control of rules.

Behaviour analytic studies. In sedentary individuals the naturally-occurring consequences of physical activity may not function as effective reinforcers. Indeed, these individuals may never contact the contingencies because of their sedentary behaviour. In order to effectively increase physical activity in these individuals it will be important to provide immediate sources of reinforcement that are contingent on increased physical activity.

A study by Epstein, Kilanowski, Consalvi, & Paluch (1999) examined whether the relative reinforcing value of physical activity, measured in a laboratory-based computer game, predicted levels of physical activity in the natural environment among 6- to 11-year-old children (as measured by the Tritrac accelerometer). The computer game assessed how hard each child would work to obtain points that earned access to concurrently available sedentary activities or physically active alternatives. Points were earned by matching shapes and participants could switch back and forth between either of two screens, with one screen being associated with sedentary activities and the other screen being associated with vigorous activities. The sedentary activities were playing a Nintendo computer game, watching videos, reading from children's books and magazines, or colouring. The physically active alternatives were using a bicycle ergometer or a stepper machine. Concurrent reinforcement schedules were implemented by varying how many responses, on average, would be required to earn a point towards the sedentary or physically active alternatives (i.e., variable ratio [VR]). The reinforcement schedule associated with the physical activities was kept constant at VR2 across all four trials of the experiment. In contrast, the response requirements for the sedentary activities were set at VR2, VR4, VR8, and VR16 so that they became progressively more difficult to access. The relative reinforcing value of physical activity was determined by the number of points that were earned towards the physically active alternatives, with a higher number of points indicating greater reinforcing value. The results indicated that children who found physical activity more reinforcing in the laboratory computer game were more physically active in the natural environment, whereas children who did not find physical activity to be very reinforcing were less active. Consistent with the discussion so far, Epstein and colleagues concluded "interventions that can increase the reinforcing value of physical activity may help children be more physically active" (p. 602).

Participation in sedentary behaviours may provide more immediate sources of reinforcement, such as relaxation and spending time with friends, than participation in physical activities. Several studies have shown that both obese and nonobese children choose to be sedentary when they have equal choice between sedentary and physically active behaviours (Epstein, Saelens, Myers, & Vito, 1997; Epstein, Saelens, & O'Brien, 1995; Epstein et al., 1991). The reinforcing value of sedentary activities appears particularly strong for obese children. In a study by Epstein et al. (1991), lean, moderately obese, or very obese children played a computer game to earn points that were later exchanged for time spent in either a sedentary activity (watching videos) or a physical activity (riding an exercise bicycle). The reinforcement schedule associated with access to the physical activity remained at VR2 across five trials whereas the schedule for the concurrently available sedentary activity was set at VR2, VR4, VR8, VR16, to VR32. When both schedules were VR2 (i.e., equal access to the sedentary or physical activity), both obese and nonobese children chose to work for the sedentary alternative. When the response requirement for sedentary activities was increased however, lean and moderately obese children reallocated their time to working for the physical activity. In contrast, very obese children continued to work for the sedentary activity irrespective of the response requirement relative to the physical activity, and this suggests that access to the sedentary activity functioned as a stronger reinforcer for these children. Indeed, participation in physical activity may be punishing due to immediate negative consequences, such as soreness, fatigue, and performing poorly during exercise. However individuals may become less sensitive to these contingencies by following verbal rules that specify the beneficial but delayed outcomes of physical activity.

In the area of child obesity treatment, interventions derived from behaviour analytic theory consist of techniques designed to directly influence eating and physically active behaviours. In a study by Epstein, Wing, Woodall, et al. (1985), obese 5- to 8-year-old girls received one of two treatments for obesity over a 1-year period: either a behaviourally-oriented programme or an educational programme without behavioural principles. Both treatment groups received equal therapist attention and identical information on diet and lifestyle exercise. They were both given a daily caloric limit, and were instructed to exercise six times a week and to meet weekly activity goals. The behavioural group however were taught several techniques that directly targeted changes in eating and exercise behaviour. Firstly, families were taught to self-monitor food intake and exercises performed on a daily basis. Secondly, parents and children were instructed to praise each other for performing appropriate behaviours and to act as role models for each other and for other family members. Finally, parents were instructed to draw up contracts whereby the child could earn points for staying within the caloric range and for meeting exercise and weight goals daily. Points earned were exchanged for nonmonetary reinforcers such as spending time in special activities. Following 1 year of treatment, children in the behaviourally-orientated programme significantly improved their eating habits and lost more than twice the amount of weight than did children in the educational programme. This study, along with others reviewed by Epstein and Wing (1987), demonstrates the superiority of the behavioural approach in the treatment of child obesity. As noted by Epstein, Roemmich and Raynor (2001), "Many people know what they should be doing, but knowledge often is insufficient to change behavior" (p. 983).

Another important component of behavioural treatment for child obesity is *stimulus control*, or arranging the environment to be conducive to increased performance of the target behaviour (Epstein, 1996). Stimulus control procedures for physical activity involve increasing the salience of stimuli that promote physical activity (e.g., keeping exercise clothes and equipment easily available) and reducing the prominence of cues associated with competing sedentary behaviours (e.g., moving the television to a less prominent location, restricting access to computer games).

Subsequent studies have shown that the behaviourally-oriented family-based treatment consistently produces significant weight loss in obese children (e.g., Epstein, Paluch, Gordy, & Dorn, 2000; Epstein, Valoski, et al., 1995; Epstein, Wing, Koeske, Ossip, & Beck, 1982; Epstein, Wing, Koeske, & Valoski, 1985; for reviews see Epstein, 1996; Epstein et al., 2001). Importantly, weight loss shown by treated children was maintained at 10-year follow-up, by which point 30% of children were no longer obese (Epstein et al., 1994). However, because measures of physical activity and food intake were not reported, the behavioural mechanism for this impressive weight loss and maintenance is unknown. Nevertheless, the magnitude and persistence of weight loss indicates that behavioural changes in physical activity and diet must have occurred. Such results suggest that the behaviour change techniques employed by the treatment (e.g., self-monitoring, praise, contingency contracting, modelling, stimulus control) were extremely effective in helping obese children to change physically active and dietary behaviour.

In addition, behaviourally-orientated interventions appear more promising than other intervention approaches in terms of increasing levels of physical activity. Dishman and Buckworth (1996) conducted a quantitative synthesis of physical activity interventions and found that effect sizes were significantly larger for behaviour modification interventions, compared to other approaches, such as health education. (Interventions were classified as "behaviour modification" if they consisted of techniques such as reinforcement, stimulus control, and behavioural contracts).

The above studies provide substantial support for a behaviour analytic approach to increasing children's physical activity. Research reviewed in the remainder of this chapter will focus on the key independent variables, as derived from the fruit and vegetable intervention model, namely social factors (to include peer-modelling) and rewards. This will determine whether there is appropriate empirical support for the inclusion of these variables in an intervention to increase children's physical activity.

Given that pedometers may be used for both measurement and motivational purposes (see Chapter 2), the effect of feedback provided by the pedometer on physical activity levels will also be discussed.

Social Influences on Children's Physical Activity

Modelling: imitation and observational learning. There is considerable evidence that children may learn new behaviours simply by observing the actions of others (Bandura, 1972).

In imitation, the observer's behaviour corresponds to that of the organism that has been observed (Catania, 1998). From a behaviour analytic perspective, imitation is defined as a higher-order class of behaviour learnt through early social interaction (Baer & Deguchi, 1985). Provided that some imitations are directly reinforced within an observer's imitative repertoire, the observer will imitate apparently novel behaviours in the absence of direct reinforcement for doing so. This phenomenon is known as *generalised imitation.* According to Baer and Deguchi (1985) the response class of imitation is initially established through direct reinforcement by caregivers. However over time, the similarity of the model's behaviour and the observer's imitative responses becomes a conditioned reinforcer for new imitations. As long as some members of the response class are directly reinforced, generalised imitation will be maintained.

Imitation is selective, however, and does not occur all of the time. Baer and Deguchi (1985) argue that the reinforcing value of imitation is relative to the value of other available activities. Thus the occurrence of imitation depends on the availability of alternative responses in the natural environment.

In everyday life, people continually observe the actions of others and the consequences that follow each action, that is, whether it is rewarded, ignored, or punished. Observational (vicarious) learning is learning based on observing the behaviour of another organism. Catania (1998) provides the example of rhesus monkeys reared in the laboratory who do not show the fear of snakes that is displayed by wild monkeys. If the laboratory monkeys observe a wild monkey behave fearfully towards a snake however (e.g., by screaming and other agitated behaviour) they too become fearful. This learning is based solely on observing the wild monkey's behaviour towards the snake. Observational learning is distinct from imitation because the observer can observe the consequences of the model's actions, to see whether that behaviour is rewarded or punished. If the latter is true, then the observer may learn *not* to do something.

In a classic study by Bandura (1965), children watched a video in which an adult model's aggressive behaviour towards an inflatable plastic doll was followed by reinforcement (receiving candy and soda), punishment (being hit with a rolled-up magazine), or no consequences (control group). When subsequently exposed to the same doll, children who had observed the model being punished performed significantly fewer matching aggressive responses compared to children who had seen the model rewarded and control children. In the next phase of the experiment, children were offered rewards for imitating what the model has done in the video. Modelled behaviour then increased and was observed to be equivalent across groups. Thus performance of the modelled behaviour was influenced by the observed consequences for the model, but to a greater extent by the consequences available to the participant.

Modelling appears less effective over time if there is no direct reinforcement of the observer's imitation. In a study by Ollendick, Dailey, and Shapiro (1983), children who observed another child being praised for performance on a puzzle task (vicarious reinforcement) initially showed increased performance on that task as if they too were being praised. However the observing children's performance deteriorated with time and it appeared that they were being implicitly punished (i.e., they were not being praised for performance that was similar, at least initially, to that of the praised children). In contrast, when the observing children received intermittent reinforcement their performance on the task was comparable to performance of children receiving continuous reinforcement.

On this basis, we would expect modelling to be most effective in promoting behaviour change when it is used in combination with direct reinforcement. In line with this research, the Food Dudes programme consists of video-based peers who model the target behaviour (i.e., eating fruit and vegetables) and a reward scheme to ensure that the imitative responses of the observing children are reinforced. Research has also shown that children are more likely to imitate a model who they like or admire (see Lieberman, 1990), a model who is of the same age or slightly older than themselves (Brody & Stoneman, 1981), and behaviour observed in several models (see Leslie, 2002). Thus, there are four Food Dude characters who are slightly older (12 to 13 years of age) than the target audience of primary school children.

Parental and peer influences on children's physical activity. Children and adolescents may learn physical activity behaviours through observation and modelling of influential characters in their lives, such as parents, peers, and media figures. For example, the desire to look like figures in the media was associated with higher self-reported levels of physical activity in 9- to 16-year old youth (Taveras et al., 2004).

Potential modelling effects within families may be inferred by examining familial trends in physical activity. Research reviewed by Taylor, Baranowski, and Sallis (1994) indicates that "studies with children of different ages, with families of different ethnic backgrounds, and with different methods of assessing physical activity consistently found significant familial resemblance in activity habits" (p. 320). It is therefore likely that family members influence one another's activity behaviours. Using an accelerometer measure of physical activity, Moore et al. (1991) showed that 4- to 7-year-old children with active parents were significantly more likely to be active than were children with sedentary parents, particularly those children for whom both parents were physically active. There are a number of possible mechanisms for the strong association between parent and child activity levels; parents may act as role models for physical activity, parents may support children's participation in physical activity, parents and children may engage in shared activities, or there may be a genetic predisposition towards being more active (Moore et al., 1991).

Research has shown that family support for physical activity is strongly correlated with child physical activity (Sallis, et al., 1999). This indicates that having a supportive family helps children to be active. Family support for physical activity can take a variety of forms; parents may discuss physical activity with the child, purchase sports equipment, or provide transportation to sporting facilities.

Observational studies have shown that prompts and encouragement from parents for their child to be physically active were associated with higher levels of child physical activity, most notably vigorous intensity activity (Elder et al., 1998; Klesges, Malott, Boschee, & Weber, 1986).

Findings from the developmental psychology literature indicate that, as children get older, peers may exert a stronger influence on behaviour than parents. Buhrmester and Furman (1987) found that parents were important companions for 7- to 11-year-old children, however 13- to 14-year-olds perceived same-sex friends as their greatest source of companionship. On this basis, peers may be more instrumental than parents in influencing physical activity, particularly for older children (Goran et al., 1999). Adolescents who perceived that their peers were exercising frequently reported more frequent exercising themselves (Luszczynska, Gibbons, Piko, & Tekozel, 2004). Peer and parental influences to be thin in girls and peer influences to be fit in boys were associated with greater hours of physical activity per week among 9- to 16-year olds (Taveras et al., 2004). Finally peer support, comprising modelling and encouragement from peers, was a significant correlate of both parent-reported and objectively-measured vigorous physical activity in children and adolescents (Sallis et al., 2002). Influences of peers on physical activity thus appear strong even for younger children.

In support of this, a playground observational study by McKenzie et al. (1997) found that 4- to 6-year-old children were highly compliant to prompts to be active from peers and teachers during school playtime. Recorded prompts for the child to engage in physical activity were both verbal (e.g., “Will you play catch with me?”) and nonverbal (e.g., throwing a ball to a child). As the children aged, they received more prompts to be active from peers, whereas prompts from teachers decreased. On this basis, prompts and encouragement to be active delivered by peer models would be expected to have a beneficial effect on the recipient children's physical activity. This technique is employed in the Food Dudes programme, in which the Food Dude peer-models frequently prompt the children to eat fruit and vegetables during each of the video episodes and through letters.

Effects of modelling and prompting on children's physical activity. A number of intervention studies have incorporated modelling and prompting of physical activity as a behaviour change strategy. Recall that, as part of Epstein and colleagues' family-based treatment for child obesity, parents were instructed to model behaviour that they wanted their child to repeat, such as being physically active (e.g., Epstein, Wing, Woodall, et al., 1985). Epstein and Wing (1987) note that it may be unrealistic to intervene with an obese child while other family members are modelling and supporting behaviours that may counteract the treatment's effectiveness. Due to the simultaneous application of a number of behavioural change techniques as part of the child obesity treatment (e.g., self-monitoring, praise, contingency-contracting), it is not possible to determine the isolated effects of parental modelling on children's physical activity.

There is evidence that including parents in child obesity treatment enhances the long-term maintenance of the child's weight loss. Obese children significantly maintained their weight loss at 5-year follow-up when their parents were also targeted for weight loss and behaviour change, whereas children treated without their parents returned to baseline levels (Epstein, Wing, Koeske, & Valoski, 1987). Despite significant short-term weight change, targeted parents had returned to their baseline weight at follow-up and thus probably did not continue to model appropriate behaviour. This suggests that parent support contributed to the child's maintenance of weight loss to a greater extend than parent modelling. Nevertheless, this highlights the value of including parents in interventions to promote long-term maintenance of the child's behaviour change.

An intervention study by Katz and Singh (1986) used fictional characters as models to increase recreational play in a group of children with developmental disabilities. The intervention involved a sign being displayed in the playground that showed two cartoon frogs, "Freddie and Freena", engaging in the two target behaviours of ball play and jungle gym play. Children were told that exercise is good for them and that they could become members of Freddie and Freena's club by doing what the frogs were doing. Additional intervention components involved praise and members of staff taking photographs of children who were participating in the targeted activities. A Polaroid camera was used so that reinforcing feedback was immediately available to the child as a finished picture. There was an immediate increase in children's activity levels when the treatment was introduced. During the subsequent 12-week maintenance phase, modelling cues and pictorial feedback were gradually faded out, but teachers continued verbally reinforcing the children's participation in the target behaviours. Maintenance data showed that children continued to participate in the target behaviours at a rate approximately three times higher than baseline. This study provides strong evidence for the potent influence of modelling in increasing children's physical activity and, importantly, physical activity was measured by direct observation, considered to be the gold standard for measurement (see Sirard & Pate, 2001). The prompting procedure (e.g., signs, cartoons, teacher reminders) was intended to be the key mediator of behaviour change, however it is not known whether similar increases in activity would have been obtained in the absence of either teacher praise or pictorial reinforcement.

Prompting procedures have been employed to increase levels of physical activity in adults. Frequent telephone prompts were effective in increasing and maintaining levels of walking in women (Lombard, Lombard, & Winett, 1995). Furthermore, it is possible to increase activity levels using simple sign-posting procedures. In a study by Brownell, Stunkard, & Albaum, (1980), a sign was placed at the choice point between the escalator and stairs in a shopping centre, train station and bus terminal. The sign stated "Your heart needs exercise... here's your chance" and was illustrated by cartoon drawings of an unhealthy-looking heart using the escalators and a fit and healthy-looking heart using the stairs. The sign markedly increased the number of people using the stairs, and effects persisted as long as 1 month after its removal.

No studies have experimentally investigated the isolated effects of modelling on physical activity. Nevertheless, parents' level of physical activity and support from parents and peers appear important correlates of children's physical activity, furthermore intervention studies indicate that modelling and prompting procedures are effective in increasing physical activity. Previous intervention studies have employed either parent or cartoon character modelling, however peers may be even more instrumental in influencing physical activity (Goran et al., 1999). Research, in contexts other than that of physical activity, has also shown that modelled behaviour is more likely to occur and be maintained over time if the observer's imitations of that behaviour are directly reinforced.

Rewards

The effects of rewards on children's physical activity. In line with research reviewed above, studies have shown that children's physical activity may be increased by the application of positive reinforcement techniques, whereby presentation of a reinforcing stimulus is made contingent on increases in physical activity. A study conducted at a morning day camp for obese 5- to 8-year-olds aimed to increase levels of activity during a 30-min free play period (Epstein, Woodall, Goreczny, Wing, & Robertson, 1984). Following 4 days of baseline assessment of free play activity (by direct observation), the physical activity treatment was introduced. For 2 days children received a sticker if, at the random sounding of a whistle, they were "caught" engaging in physically active behaviours. A 2-day reversal phase was then introduced during which stickers were received if children were caught sharing (i.e., playing or working with another child, sharing equipment) independent of their activity levels. Following this, the physical activity treatment was reintroduced for 1 day, followed by a second 1-day reversal phase. Stickers were used to gain access to a special privilege play period. Results showed clear effects of the sequential treatment phases; children's activity levels increased from baseline during treatment and decreased during reversal. The activity levels of a control group of children remained stable throughout the study.

In a laboratory-based study by Epstein, Saelens, et al. (1995), obese 8- to 12-year-old children played individually in a room. They had access to four active and four sedentary activities during 45-min experimental sessions over 6 days (adaptation, prebaseline, 3 days of experimental contingencies, postbaseline). During the pre- and postbaseline days, no contingencies were in effect. During the 3 days of experimental contingencies, one group of children earned a point for every minute they spent engaged in one of the four active behaviours. Points were totalled over the three experimental sessions and were subsequently exchanged for a choice of reinforcers, including book tokens and baseball tickets, depending on the number of points that were earned. Children exposed to this contingency were significantly more active on experimental days than were control children for whom no contingencies were in effect (they were provided with 35 points for each session regardless of their behaviour). In a third group, children earned points for every minute they did not engage in sedentary behaviours. This group showed similar increases in activity as the group in which active behaviours were reinforced. This was a brief experiment however and neither group maintained their increased activity at postbaseline.

Positive reinforcement techniques have been used to increase the physical activity of children with developmental disabilities in naturalistic contexts. In the study by Katz and Singh (1986), reviewed in the previous section, members of staff administered praise and took photographs of children who were being physically active. Children's activity showed a significant increase during the intervention, and such increases were maintained at 12-week follow-up. As stated previously, the design of the study did not permit separate assessment of each of the treatment components. The efficacy of social reinforcement alone is demonstrated in a study by Fujita (1995) which also aimed to increase children's activity levels during free play periods. In this study social reinforcement (applause by experimenter, class teacher, and peers) increased pedometer-assessed walking rates by 52% and 24% in 5-year-old boys and girls, respectively. These increases disappeared in a subsequent return to baseline phase, but were reinstated when the reinforcement procedures were reintroduced thus demonstrating that children's walking rates were under control of the social contingencies.

Contingency contracting. A contingency contract (or behavioural contract) is a document that specifies a contingent relationship between the completion of specified behaviour and delivery of a specified reward (Cooper, Heron, & Heward, 1987). Recall that contingency contracts are a key component of the previously described family-based treatment for obese children (Epstein, 1996; Epstein et al., 2001) and have been used to contract for weight loss, and for meeting dietary and exercise goals (e.g., Epstein, Wing, Woodall, et al., 1985). In a study with university students, the use of contingency contracts increased exercise participation in 7 out of 8 participants, and these increases were maintained at 1-year follow-up (Wysocki, Hall, Iwata, & Riordan, 1979).

In a home-based study to increase activity levels of low-fitness children, (Taggart, Taggart, & Siedentop, 1986) a family contingency contract was negotiated between the parents and child. In the contract, the child agreed to increase daily activity levels to meet a preset number of points in return for an agreed-upon reward (e.g., money, social outings, food, etc). A provided list showed examples of activities and their respective point values; higher intensity activities were assigned the highest number of points. In a changing-criterion design (Kazdin, 1982), the number of activity points each child had to earn to receive reinforcers became progressively greater each week. Following implementation of the intervention, 11 out of 12 subjects systematically began to increase their activity levels (according to parental recordings) and 88% of reinforcement criteria were accomplished. This is a strong indication that the children's physical activity was under the control of the contracting-based intervention.

In most contracts, the reward, although contingent, is too delayed to directly reinforce the specified behaviour (Cooper et al., 1987). It is therefore likely that rule-governed behaviour is involved in mediating the effects of contingency contracts. A contract states a strong rule that a specified behaviour will produce a specified consequence. Delayed consequences may thus exert control over behaviours performed hours or days previously if they are linked by verbal behaviour to the rule (Cooper et al., 1987).

Reinforcing increases in physical activity versus decreases in sedentary behaviour. Being sedentary and being physically active are incompatible response classes. In the study by Epstein, Saelens, et al. (1995), children who received reinforcement for not engaging in sedentary behaviours showed similar increases in active behaviours to the group in which active behaviours were reinforced. This suggests that an intervention designed to increase children's physical activity could either reinforce *increases* in physical activity or alternatively reinforce *decreases* in sedentary behaviour. Epstein, Valoski, and colleagues (1995) compared the effects of these two approaches on child weight loss and behaviour change. As part of family-based treatment for child obesity, children received reinforcement for either decreasing sedentary activity or for increasing physical activity. At 1-year follow-up, the "decrease sedentary" group lost significantly more weight and reported lower caloric intake than did the "increase activity" group, although both groups equally improved fitness.

The implication from this study is that reinforcing reduced sedentary behaviours leads to better weight loss in obese children than reinforcing increased physical activity. The authors interpret the apparent superiority of the former approach in terms of perceived control and choice. Reinforcing a reduction in sedentary behaviours allows children the opportunity to choose how to allocate their newly available time. Providing individuals with choice-making opportunities may produce reinforcement effects that are relatively independent of the consequences associated with each response option (Fisher & Mazur, 1997). As a result of the opportunity to choose among alternative activities, children may also perceive increased control over their activity options and this may increase the reinforcing value of the substituted behaviours (Epstein, Valoski, et al., 1995). Targeting reductions in sedentary behaviours may also reduce conditioned cues for eating, and this is consistent with the observed lower caloric intake in the "decrease sedentary" group.

There are several reasons however for preference to be given to the approach of reinforcing increases in physically active behaviours. If rewards are contingent on the absence of a particular behaviour, although the child is provided with choice, he or she is given no guidance as to how best to reallocate his or her behaviour. Research indicates that rewards are more effective when their presentation is explicitly tied to performance standards (Cameron, Banko, & Pierce, 2001; Dickinson, 1989). Although children in the "decrease sedentary" group are provided with explicit instruction for how *not* to behave (e.g., "spend less than 35 hr per week in sedentary activities"), they are not provided with performance standards that specify the appropriate way *to* behave.

Furthermore, in order to be of maximum effectiveness, rewards should signal to the child that they are for behaviour that is both high status and enjoyable (e.g., see Horne et al., 2004; Lowe et al., 2004). This message will not be conveyed by contingencies that specify a decreased level of (undesirable) behaviour. In addition, rewards should signify the individual's competence or ability at the task (Cameron et al., 2001). The Food Dudes programme avoids giving negative messages about less healthy foods and focuses instead on the intrinsic virtues and enjoyment of eating fruit and vegetables. Rewards are presented as indicators of the children's positive achievement and success in eating these foods. The symbolic context of reward delivery is thus entirely positive (Horne et al., 1995; Lowe et al., 1998). When using rewards to promote physical activity, it is therefore preferable to focus on the positive, health-enhancing consequences of being active, rather than conveying negative messages about being sedentary.

Finally, a more recent comparison found that the two approaches (targeting decreased sedentary behaviours vs. increased physical activity) were associated with similar weight loss and increases in fitness over 2 years of observation (Epstein et al., 2000).

The importance of choice in physical activity interventions. If interventions focus on increasing levels of physical activity, it is clearly important that children are given the opportunity to choose how this activity is accumulated. Adults who perceived choice in selecting exercises showed better adherence to an exercise programme than did a control group who did not perceive any choice (Thompson & Wankel, 1980). Research by Epstein and colleagues (Epstein et al., 1982; Epstein, Wing, Koeske, et al., 1985) compared the outcomes of a *programmed* exercise regime, with a more flexible, *lifestyle* exercise programme, as part of family-based treatment for child obesity. In Epstein et al. (1982), parents arranged point economies with their children and drew up contracts stating rewards that the child could receive for earning exercise points. Children in the programmed exercise group were required to do one aerobic exercise at the same time each day and all exercise points had to be earned within this one daily session in order to promote continuous, high-intensity exercise. In contrast, children in the lifestyle programme could earn their exercise points in any way they liked, they did not have to earn all their points in one session but could break up their exercising.

Both groups showed significant and similar weight loss during the 8-week intensive treatment. At 18-month follow-up only the lifestyle exercise group had maintained their weight loss whereas the programmed exercise group showed weight gain that returned almost to baseline. Both exercise groups showed an improvement in fitness at the end of treatment, although superior fitness changes were produced by programmed exercise. Better fitness changes would be expected in the programmed exercise regime because it involved greater intensity exercise than did the lifestyle exercise. During maintenance, however, fitness levels of the programmed group deteriorated whereas the lifestyle group maintained their improved fitness. These results indicate that better long-term adherence to the exercise schedule was achieved in the lifestyle group compared to the programmed exercise group.

The long-term superiority of lifestyle exercise was again demonstrated by Epstein, Wing, Koeske, et al. (1985). In this study, the lifestyle exercise group had maintained relative weight changes at 24-month follow-up, whereas the programmed exercise group and a control group had returned to baseline levels. Exercise programmes that emphasise lifestyle changes (e.g., using stairs, walking or cycling instead of taking the car) thus appear to produce better adherence and maintenance of weight loss than those involving structured, aerobic activity.

The lifestyle exercise programme provided the opportunity to make more varied behavioural changes which may have been better incorporated into the child's routine than the rigid schedule of programmed exercise (Epstein et al., 1982). Reward contingencies that specify an increase in activity level should therefore allow choice and flexibility in terms of how the additional activity is accumulated. Furthermore, given the highly intermittent activity patterns of children (Bailey et al., 1995), it may be beneficial for reward contingencies to allow increased activity to be accumulated over time.

Pedometer Feedback

In Chapter 2 it was noted that a pedometer has been used as a motivational tool in addition to serving as an objective measure of physical activity. A pedometer provides immediate information on the wearer's activity level and may be used as a feedback tool and as a cue to be active (Tudor-Locke, 2002).

Pedometers were first used as motivational tools in Japan. In 1965, a pedometer appeared on the Japanese commercial market under the name of "Manpo-kei" which translates to "10,000 steps meter" (Tudor-Locke, 2002, 2003). The goal of 10,000 steps was widely accepted by the Japanese public and was promoted as a slogan by walking organisations and health promotion efforts. In Japan today people continue to be aware of the slogan and most households own at least two pedometers (Tudor-Locke, 2003). Publication in English-language journals meant that Japanese research on pedometers (e.g., Yamanouchi et al., 1995) became accessible to English-speaking societies.

Although 10,000 steps seems a reasonable estimate for a desirable level of physical activity in healthy adults, there is currently little empirical evidence to suggest that this threshold is related to health outcomes (Tudor-Locke, 2002). Nevertheless, in a study with adults with type 2 diabetes, Tudor-Locke et al. (2002) found that individuals who averaged more than 8,645 steps per day had significantly lower BMI than individuals who took fewer steps.

The effects of pedometer interventions on adult physical activity. A number of intervention studies have used pedometers to increase activity levels above the 10,000 steps per day threshold. In an 8-week pedometer-based study by Croteau (2004), adult participants set activity goals and self-monitored the number of steps taken using a daily personal activity log. A counselling session prior to beginning the intervention advised participants in terms of setting appropriate goals. Participants who completed more than 10,000 steps per day at baseline were recommended to maintain this level of steps. Participants who completed between 8,000 and 10,000 steps per day were advised to increase their daily steps by 5% every 2 weeks. Finally, participants who averaged fewer than 8,000 steps per day were advised to increase daily steps by 10% every 2 weeks. The 5% and 10% goals were used so that most of the participants would meet or exceed the 10,000 steps goal by the end of the intervention. There was a significant increase in steps per day from a mean of 8,565 at baseline to 10,538 after the intervention. Consistent with the set goals, the largest increases in activity were shown by the group who showed the lowest number of daily steps at baseline.

In a similar intervention, adult women were encouraged to wear pedometers and to walk 10,000 steps per day. At 8-week follow-up, improvements in the amount of physical activity were predicted by setting daily step goals, keeping a log of steps walked, and wearing the pedometer all of the time (Rooney, Smalley, Larson, & Havens, 2003).

The 10,000 steps per day goal is likely to be too high for sedentary individuals (see Tudor-Locke, 2002) and too low for children. Vincent and Pangrazi (2002a) suggested standards of 11,000 and 13,000 steps per day for girls and boys, respectively, on the basis of their large monitoring study of children's activity levels conducted in the southwest United States. However Vincent and Pangrazi found great individual variability in steps per day among children of the same age, and acknowledge that a single standard is likely to be too low for the most active children yet too high for the least active children. Rowlands et al. (1999) found substantially higher activity levels among 8- to 11-year-old Welsh children, with average daily step counts of 16,035 and 12,729 for boys and girls, respectively. The difference in step counts between these two studies may be attributable to different geographical locations. This research suggests that one universal step goal for all children may not be appropriate.

When using pedometers to increase physical activity, an alternative approach is to set personally relevant goals that specify an increase from individual baseline levels of activity (Tudor-Locke, 2002). This approach was used in the First Step Program, in which pedometers were used to establish baseline levels of physical activity and to facilitate personal goal-setting, self-monitoring, and feedback. During the initial 4-week adoption phase, participants attended weekly group meetings with a facilitator. Participants wore pedometers daily, set individual steps per day goals, and self-monitored their progress using a personal calendar. At weekly meetings, participants were assisted by the facilitator in setting new goals. During the subsequent 12-week adherence phase, participants continued to self monitor their progress and reset goals as required, but contact with the facilitator was limited. Participants were not given instruction about the number of steps that should be achieved, and goals for increasing physical activity were entirely self-determined. As a result of taking part in the programme, sedentary, but otherwise healthy, workers increased their steps per day from 7,029 at baseline to a plateau of 10,480 during the intervention. Participants also experienced significant reductions in BMI, waist girth, and resting heart rate (Chan, Ryan, & Tudor-Locke, 2004). In another evaluation of the First Step Programme, adults with type II diabetes increased their daily steps from 5,754 at baseline to 9,123 at the end of the adherence phase, whereas control participants showed no change in steps per day (Tudor-Locke, Bell, et al., 2004).

At present it appears that the only published intervention studies using pedometers in this way are with adults (see also review by Tudor-Locke & Myers, 2001). It is yet to be determined whether the use of the pedometer with goal-setting and self-monitoring procedures would be sufficient to increase physical activity in children. Because children show highly variable levels of activity, it may be more appropriate to select individualised step goals on the basis of each child's baseline level of activity.

With relevance to the previous section, when used in combination with a reward system, pedometers may be particularly effective in terms of establishing physical activity goals and providing feedback. For example, reward contingencies could specify the accumulation of a criterion number of pedometer counts (steps) within a specified time period. There are a number of advantages associated with using pedometers in this way in the natural environment. For example, it would be possible to allow the child to choose how additional steps are accumulated thus promoting flexibility. The reward contingency could specify an increase in total steps over the course of an entire day which would allow for the intermittent activity patterns of children. Finally, the use of the pedometer enables both the child and the individual who administers the rewards to monitor the child's progress with accuracy. This is important because rewards appear most effective when their delivery is contingent upon actual performance (e.g. see Cameron et al., 2001; Dickinson, 1989).

The following section will review two recent studies that have used activity monitors to specify the level of physical activity required to obtain access to reinforcement.

Rewards and Pedometer Feedback

In a laboratory-based study by Goldfield, Kalakanis, Ernst, and Epstein (2000), 34 obese 8- to 12-year-old children played individually in a room containing various physical and sedentary activities during a 20-min "activity phase". All children wore pedometers, were taught to check their pedometer counts during the session, and were told “the higher the number of pedometer counts, the more active you are” (p. 890).

Prior to beginning the activity phase, children were randomly assigned to one of three groups. In the “Contingent 1,500 group” children were required to accumulate 1,500 step counts during the activity phase in order to earn 10 min of time for television activities (i.e., playing video games or watching films) during a subsequent “reinforcement phase”. In the “Contingent 750 group” children were required to accumulate 750 step counts during the activity phase to earn 10 min of television activities during the reinforcement phase. In the control group there were no contingencies in place.

The three available physical activities were a step machine, a trampoline, and a ski machine. Children in the control group had access to television activities during both phases of the experiment whereas children in the two experimental groups had access only during the reinforcement phase. Reading materials were freely available to both groups during both phases.

In addition to the pedometers, all children wore Tritrac accelerometers for experimenter measurement of physical activity. Results showed that, during the activity phase, children in the Contingent 1,500 group were significantly more active than children in the Contingent 750 group, who in turn, were significantly more active than control children. This study demonstrates that when pedometer-based reward contingencies are in operation, significant increases in physical activity occur. The higher activity goal led to higher levels of activity in comparison to a lower goal, indicating that physical activity behaviour was under control of the experimental contingencies.

Unfortunately, however, data are presented as accelerometer counts so it is not possible to determine the extent to which observed pedometer counts matched the levels specified by the contingencies. It would have been useful to include a baseline phase to determine activity levels in the experimental setting prior to the introduction of the contingencies. Furthermore, children in the control group may have been less active during the activity phase simply because they had access to television activities which were not available to the two experimental groups at this point.

These results were obtained by a one-session laboratory study. It is important to determine whether pedometer-based reward contingencies may be used to increase physical activity over time in naturalistic settings. Roemmich, Gurgol, and Epstein (2004) adapted the Goldfield et al. (2000) study to increase the physical activity of 18 nonobese sedentary children in the home environment. In this study, children (aged between 8 and 12 years) wore accelerometers rather than pedometers to receive feedback on their activity levels, and the accelerometer also provided an objective measure of physical activity. The study commenced with 1 week of baseline monitoring, during which all children wore accelerometers with the display turned off to prevent them from receiving feedback on their activity levels.

For the following 6 weeks of treatment, in the experimental group only, physical activity during the current week was used to determine the amount of television time for the following week. Children were given a goal of 400 activity counts per day and were told that 400 counts were equal to 60 min of television time. (The aim was to set a ratio of 1 min of moderate intensity activity to earn 1 min of television time. Pilot testing by the experimenters indicated that 1 hr of moderate to vigorous physical activity in children accrued an average of 371 activity counts. This was rounded up to 400 counts to simplify the conversion of activity counts to television time for the child). The accelerometer display showed tallied counts so children received immediate feedback on their activity levels, similar to that provided by the pedometer in the Goldfield et al. (2000) study. Children were required to reset the accelerometer display to zero at the end of each day, although the data remained stored in the accelerometer. Accelerometers were downloaded in the laboratory each week and activity counts were converted to weekly television time by dividing the total number of counts by 400. Television hours could be used by the child at any time during the week but once the allowance had run out, television was not available for the remainder of the week.

In the control group, the accelerometer display was turned off, although the monitor was still recording data, children were given a goal of 60 min of moderate to vigorous activity per day, but there were no contingencies on television time in place.

Roemmich et al. (2004) found that children in the experimental group increased their physical activity counts per day to 24% above baseline over the 6-week study whereas the control group did not increase. Change in total physical activity was correlated with increased time spent in moderate and vigorous intensity physical activity, suggesting that the children increased participation in higher-intensity activities. This is important because children were not given specific instructions concerning activities they should engage in. Reward contingencies based on the accumulation of a specified number of activity counts therefore appear effective in increasing children's physical activity in the natural environment over a 6-week period.

In this study, similar to the study by Goldfield et al. (2000), access to television was restricted in the experimental group as part of the intervention whereas it was not restricted in the control group. Therefore higher activity levels in the experimental group may be at least partly due to the limited television access. To control for this, it would have been useful to include an additional control group in which television access was restricted to the same degree as in the experimental group. Roemmich et al. (2004) also note that the inclusion of a group that wore an accelerometer to gain feedback and had an activity goal of 400 counts per day would have been useful to determine the effects of accelerometer feedback without reinforcement.

Roemmich et al. (2004) do not present the mean activity counts per day at baseline. Therefore it is not possible to tell how active the children were prior to beginning the intervention, and whether the goal of 400 counts per day was obtainable. Furthermore, the more activity counts that the child accumulated the greater their television allowance (because total weekly counts were divided by 400 to obtain the television allowance, see above). This may have encouraged children to accumulate as many counts as possible to obtain maximum reward, and the resultant activity counts may have greatly exceeded the daily activity count goal. This is merely speculative however because Roemmich et al. present only the mean change in activity counts from baseline at each week of treatment and baseline data are not given. It would have been useful to know the actual number of counts per day that children were obtaining, to determine how well their level of physical activity matched the experimental contingency.

Nevertheless, the above studies do indicate that pedometers and accelerometers may be used to effectively increase children's physical activity by making access to a reinforcer contingent upon achieving a specified number of steps or activity counts. If contingencies are arranged in this way then the step count itself should acquire conditioned reinforcing properties, at least in the short term.

Summary and the Current Studies

Research reviewed in this chapter shows that children's activity levels are highly variable; while some children are undoubtedly highly active, others are much less so. It is the low-active children who are most likely to be in need of intervention. Interventions to increase children's activity levels may be restricted to particular contexts such as school-time, or applied to total levels of physical activity throughout the day. Several school-based, multicomponent interventions have attempted to increase children's physical activity both during and outside school. They have not, however, enjoyed consistent success in terms of increasing levels of habitual physical activity.

Interventions to increase physical activity should be based on an appropriate theoretical model and should consist of components that have been shown to reliably influence physically active behaviours. Research indicates that social influences, from peers and parents, exert a strong influence on children's physical activity. The introduction of positive peer models, who engage in frequent physical activity and extol the virtues of being active, may therefore prompt children to imitate physically active behaviours. There is a body of evidence indicating that children's physical activity increases when the occurrence of physically active behaviour is rewarded. It is argued that it is preferable to reinforce increases in physical activity rather than decreases in sedentary behaviour, and that the reward contingency should allow choice and flexibility in terms of how additional activity is accumulated. Pedometer-based interventions, involving goal-setting and self-monitoring, increase levels of daily physical activity in adults. In children, pedometers appear particularly effective in increasing physical activity when the accumulation of a specified number of steps allows access to a reinforcer.

Drawing on this literature, the current thesis aimed to develop a peer-modelling, rewards, and pedometer feedback intervention to increase levels of daily physical activity in children.

Study 1 aimed to provide further validation of the pedometer as a measure of children's physical activity during naturalistic play activities. It was important to determine the pedometer's ability to distinguish between children's activities that differ in the level of physical activity required (according to heart rate and RPE measures).

Study 2 aimed to determine the most appropriate context in which to implement an intervention to increase children's physical activity. Pedometers and accelerometers were used to measure children's habitual physical activity, segmented into school-time and leisure-time activity. The activity levels of high-active and low-active children were compared during the two time periods to determine the location of any significant differences. If low-active children were significantly less active than high-active children during both school- and leisure-time then an intervention targeting total daily activity would seem most appropriate.

Studies 3 and 4 aimed to implement and evaluate a peer-modelling, rewards, and pedometer feedback intervention to increase children's physical activity. In brief, participating children were given personalised pedometer step targets that they were instructed to reach on each day of the intervention. Targets specified an increase in total daily activity of between 1,500 and 2,000 steps per day from baseline. Children were introduced to positive peers ("the Fit n' Fun Dudes") via letters and a song, and they received daily Fit n' Fun Dude rewards for achieving the number of step specified by their target. In Study 3, the intervention was implemented in a school-setting primarily by the experimenter. In Study 4, the intervention targeted low-activity girls and was implemented by a parent.

CHAPTER 4

STUDY 1:

VALIDATION OF THE PEDOMETER AS A MEASURE OF PHYSICAL ACTIVITY DURING CHILDREN'S PLAY ACTIVITIES

INTRODUCTION

Research reported in Chapter 2 indicates that pedometers are valid and convenient tools for the objective measurement of physical activity in children. Pedometer measures of physical activity have been validated against energy expenditure during treadmill and unregulated play activities in the laboratory (Eston et al., 1998). In an observational study, pedometer measures were highly correlated with accelerometer and behavioural observation measures during children's recreational and classroom activities (Kilanowski et al., 1999).

The aim of the current study was to provide further validation of the pedometer as a measure of children's physical activity. In a similar procedure to that employed by Eston et al. (1998), but in a non-laboratory context, children took part in a series of unregulated play activities that ranged from sedentary (e.g., colouring) to vigorous (e.g., running). Pedometer and heart rate measures were taken during each activity and children were additionally asked to provide a rating of perceived exertion (RPE) at the end of the activity.

The pedometer measure was predicted to show significantly higher levels of physical activity during the vigorous activities compared to activities designed to be less vigorous. It was anticipated that the heart rate and RPE measures would also show significant differences between vigorous and less vigorous activities, and that these would mirror the differences between activities that were shown by the pedometer.

Children wore two pedometers during each activity and an additional aim of the study was to compare readings provided by pedometers worn on opposite sides of the body. On the basis of literature reviewed in Chapter 2 (Bassett et al., 1996), no significant differences were expected to occur.

METHOD

Participants

Participants were 30 children (16 boys, 14 girls), aged between 7 and 8 years, recruited from three local primary schools. Following verbal consent to participate from the respective headteachers, recruitment letters were sent home to parents of all children in the target age group (Year 3). The letter invited children to participate in a study looking at ways to measure physical activity (see Appendix A1). Parents were requested to sign an attached consent form to indicate that they agreed to their child's participation in the study. Completed consent forms were returned to the experimenter via the school.

For each school, the number of consent forms returned by parents of male and female pupils is shown in Table 4.1. The number of children comprising the final sample is also shown.

Table 4.1

For the three schools, the gender distribution of children whose parents consented to their participation, and in the final sample selected for inclusion in the study.

Schools	Returned consent forms	Final sample ($N = 30$)
School A	9 boys, 6 girls	5 boys, 5 girls
School B	8 boys, 5 girls	6 boys, 4 girls
School C	12 boys, 8 girls	5 boys, 5 girls

Table 4.1 shows that in all cases (with the exception of girls in School B) the study was over-subscribed. In these cases, the final sample of 10 participants was selected by the experimenter on a random basis with the constraint that, as far as possible, it included an equal number of boys and girls. Children who were not

selected were kept on a reserve list. In a small number of cases, children who were originally selected to take part in the study were absent on the day of testing. In these cases, they were replaced with a child of the same gender from the reserve list. The only exception to this was in School B where only five consent forms for girls were returned. In this case, an additional male participant was included from the reserve list.

Ethical approval for the study was granted by the School of Psychology Ethics Committee, University of Wales, Bangor.

Measures

The Yamax Digiwalker SW-200 pedometer (Tokyo, Japan) was used to measure the number of steps taken during each activity. Previous research has shown that the Yamax model most accurately measured distance walked and the number of steps taken in adults (Bassett et al., 1996). In the current study, pedometers were worn clipped onto the front of the child's waistband directly in line with the knee. Two pedometers were worn simultaneously for each activity, one on the right hip and the other on the left hip. The dependent variables for the pedometer measure were the total number of steps taken per activity, as measured by the pedometer positioned on the right hip and the pedometer positioned on the left hip.

A Polar Beat heart rate monitor (Polar Electro, Oy, Kempele, Finland) was used to monitor heart rate. A transmitter was attached to the child's chest via a belt and a watch worn on the child's wrist contained the receiver that displayed the heart rate reading. There were two dependent variables relating to heart rate. The first dependent variable was the net increase in heart rate from resting level that was associated with each activity. This was calculated by subtracting the participant's resting heart rate from the observed post-activity heart rate for each activity. This variable will hereafter be referred to as net increase in heart rate. As stated in Chapter 2, a measure of net heart rate allows for comparison between individuals of different fitness levels by controlling for differences in resting heart rate (Freedson & Miller, 2000). The second dependent variable was the child's heart rate at the end of each activity. This recording represented the average of a few successive beats at the time the reading was taken. Because the activities were carried out at a constant intensity for 3 min, it was assumed that heart rate had reached steady state by the end of the activity and was therefore stable. This variable will hereafter be referred to as post-activity heart rate.

Following each activity, participants used a Rating of Perceived Exertion (RPE) scale to estimate how much effort they had expended during the task. The Bug and Bag Effort (BABE) scale (Eston & Lamb, 2000; Shepherd, 2002) was employed and this scale has been described in detail in Chapter 2. The BABE scale was designed for use with children aged 7 to 11 years (P. Shepherd, personal communication, September 16, 2002) and was therefore developmentally appropriate for the current age group. Research reviewed in Chapter 2 provides evidence for validity of the BABE scale.

Design

The study employed a repeated measures design. Each participant was tested individually in the school playground at a time when it was not otherwise in use. Participants were required to carry out five different play activities for 3 min at a time. To control for order effects, each participant received a different sequence of activities. Counter-balancing was used to create 30 sequences that varied the order of the five different activities.

Procedure

The study took place in the school playground during the months of October and November 2002. Sessions were conducted during the school day and teachers consented to the participants leaving the classroom for the duration of the test session. The same experimenter implemented all procedures.

One day prior to the commencement of testing, the participants in each school took part in a group pre-study training session in which they were trained to use the BABE scale. As explained in Chapter 2, the process of perceptual anchoring involves directly exposing participants to a range of exercise intensities to set perceptual anchor points at high and low levels. In the current training session, children were instructed to walk around the playground and to select a walking pace that produced an exertion level of 3 (*easy*) on the BABE scale. Children were then instructed to quicken their pace to produce an exertion level of 5 (*starting to get hard*). Finally, participants were instructed to run around the playground to produce an exertion level of 8 (*very hard*) on the scale. At the end of the training session, participants were each given a copy of the scale to take home and keep.

The remainder of the study procedures were carried out on an individual basis. On the day assigned to testing, the experimenter fetched each individual participant in turn from the classroom. Before beginning the activities, the participant's resting heart rate was assessed in a quiet room on the school premises. The experimenter fitted each participant with the chest transmitter and receiver. The participant lay still for 5 min and heart rate was recorded at 1-min intervals. The mean of the five interval recordings was taken as the resting heart rate.

Standardised instructions were verbally communicated to each participant by the experimenter (see Appendix A2). Participants were required to carry out five different play activities that were designed to be of varying intensity. Each activity was carried out for 3 min. The experimenter used a stopwatch to monitor time. Before beginning the activities, the experimenter attached the two pedometers, one onto the left hip and the other onto the right hip of the participant. Pedometers were reset to zero before each activity began. The participant was instructed to start each activity when the experimenter said, "Go!" and to rest when the experimenter said, "Stop!". Participants were instructed to maintain a constant level of movement for the duration of the activity and the experimenter emitted verbal encouragement where necessary. The experimenter also ensured that participants did not tamper with the pedometers during the activity. At the end of the 3-min activity period, post-activity heart rate and the total pedometer counts shown by both the right and left pedometers were recorded by the experimenter. At this point, participants were also given a copy of the BABE scale and the experimenter asked, "How hard did the exercise feel?". Participants pointed to the number on the scale that best described the level of exertion they experienced during the activity. Each activity was followed by a rest period of between 5 and 10 min to allow the participant's heart rate to return to the resting level recorded at the beginning of the procedure.

The same heart rate monitor and two pedometers were used for all participants. Pedometers were labelled as either "left" or "right" to ensure that the placement of each unit was consistent across participants. However after testing 20 participants, the left pedometer appeared to malfunction and was replaced with another pedometer that was used for the remainder of the participants.

The five activities were as follows:

Running. Participants were requested to run as fast as they could between two colourful bowls that were approximately 4.5 m apart. The task was to move a collection of six colourful juggling balls from one bowl to the other, however participants were only allowed to carry one ball at a time.

Skipping. Participants skipped around the playground using a skipping rope that was 2.2 m in length. In some cases, participants preferred to skip without the rope.

Football. Participants were instructed to kick a football into a goal that was 1.5 m wide. The goal area was marked using two metal bowls. Participants started from a marked spot that was approximately 4.5 m from the goal. They were instructed to try to kick the football into the goal, with the aim of scoring as many goals as possible. After each attempt, participants retrieved the football and returned to the start for a further attempt.

Throwing. Participants played catch with the experimenter using a colourful foam ball. The participants and the experimenter stood approximately 2 m apart.

Colouring. Participants sat down and coloured a picture of their choice using colouring pencils and a colouring book provided by the experimenter.

The full procedure lasted between 30 and 40 min per child.

RESULTS

The mean (*SD*) resting heart rate for the 30 participants was 85.9 (8.3) beats per min.

Descriptive statistics were calculated for the dependent variables on each of the five play activities. These are shown in Table 4.2.

Table 4.2

Means (with standard deviations in parentheses) for each measurement technique during the five 3-min activities.

	Running	Skipping	Football	Throwing	Colouring
Left pedometer (total counts) (*N* = 29)	441.9 (38.0)	330.7 (78.9)	335.6 (74.9)	84.3 (36.5)	1.5 (1.8)
Right pedometer (total counts) (*N* = 29)	433.1 (40.8)	325.9 (80.6)	323.5 (69.7)	78.2 (33.7)	1.0 (1.3)
RPE (1-10 scale) (*N* = 30)	8.0 (2.1)	6.9 (2.8)	4.6 (2.5)	1.8 (1.2)	1.4 (0.9)
Post-activity heart rate (beats/min) (*N* = 30)	195.4 (9.0)	188.3 (16.3)	178.8 (16.2)	126.9 (11.9)	106.7 (10.3)
Net increase in heart rate (beats/min) (*N* = 30)	109.5 (12.1)	102.4 (17.8)	92.8 (16.1)	41.0 (13.0)	20.8 (8.5)

All participants had complete data for all measurement techniques and activities, with the exception of 1 male participant who lacked a data point for the left pedometer on the running task due to pedometer malfunction. For this participant all remaining pedometer data points, for both the left and the right pedometer, were excluded from the analysis. Thus means shown in Table 4.2 for the two pedometer measures represent data from 29 participants, while all other dependent variables represent the full 30 participants.

Table 4.2 shows that, on all dependent measures of physical activity, scores were higher on the running task than on the colouring task. However the two pedometer measures did not show a consistent difference between the skipping and football tasks. As would be expected, the colouring task was associated with a very low number of pedometer counts in comparison to the other activities. On the RPE measure, participants did not seem to differentiate between throwing and colouring.

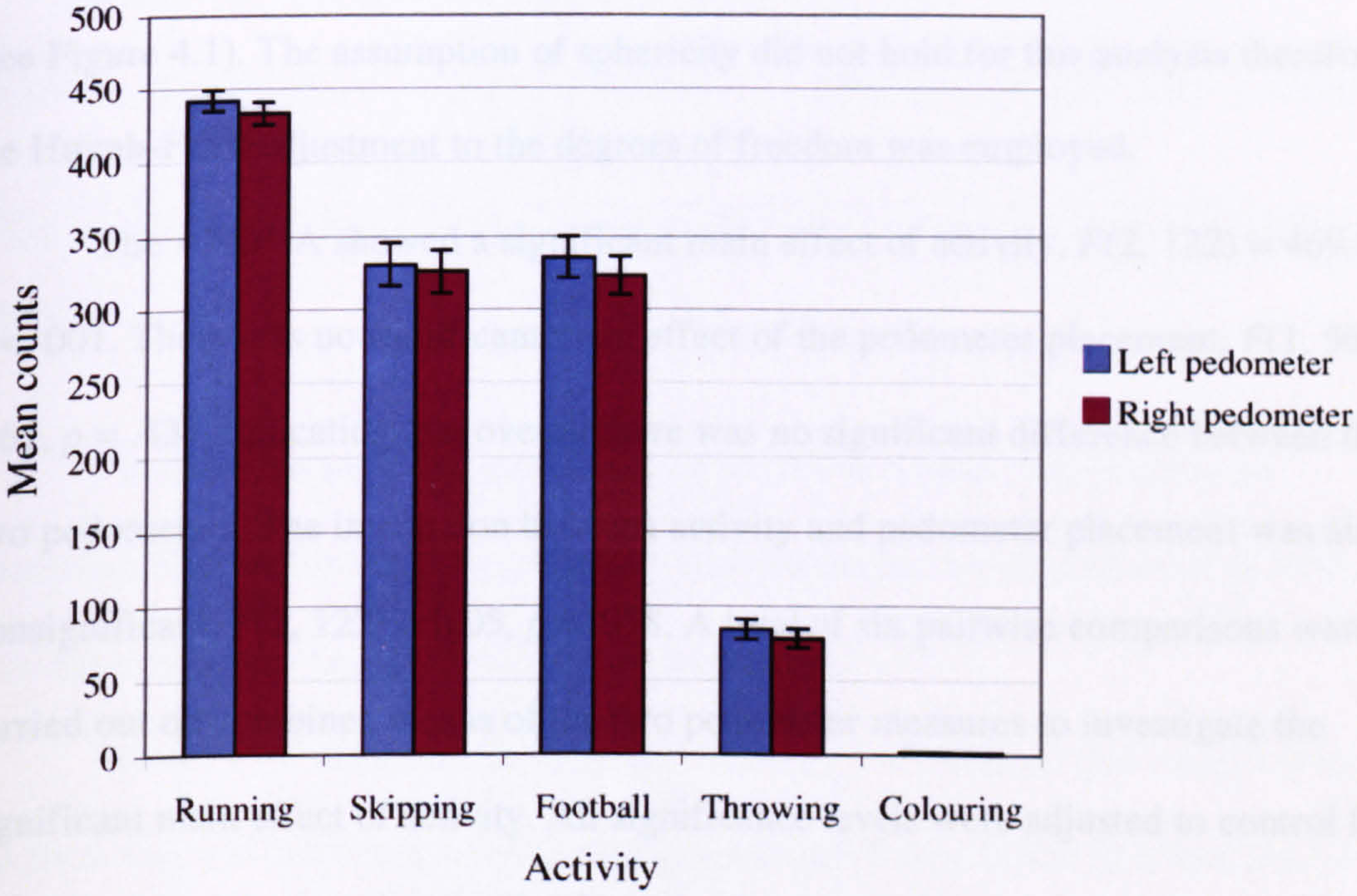


Figure 4.1: Mean counts recorded for the left and right pedometers during the five different activities. Bars represent ± 1 *SE* of the mean.

Mean pedometer counts that were recorded for the five activities for both the left and the right pedometer are shown in Figure 4.1. A 2 × 4 mixed ANOVA was carried out to determine whether the pedometers were able to discriminate between the different activities and to determine whether there were significant inter-monitor differences depending on the side of the body that the pedometer was worn. The between-subjects factor was the pedometer placement (left, right) and the within-subjects factor was the activity (running, skipping, football, throwing). Kolmogorov-Smirnow tests were used to ensure that means were drawn from normally distributed populations. The data from the colouring activity were not included in the ANOVA due to departure from the assumption of normality and noticeably smaller standard deviations compared to the other pedometer measures, indicating that homogeneity of variance was not present. Given that both pedometers recorded a mean count that was close to zero, the colouring activity was clearly different from the remaining activities (see Figure 4.1). The assumption of sphericity did not hold for this analysis therefore the Huynh-Feldt adjustment to the degrees of freedom was employed.

The ANOVA showed a significant main effect of activity, $F(2, 122) = 469.87$, $p <. 001$. There was no significant main effect of the pedometer placement, $F(1, 56) = 0.61$, $p = .437$, indicating that overall there was no significant difference between the two pedometers. The interaction between activity and pedometer placement was also nonsignificant, $F(2, 122) = 0.05$, $p = .958$. A total of six pairwise comparisons were carried out on combined means of the two pedometer measures to investigate the significant main effect of activity. All significance levels were adjusted to control for multiple comparisons using the Bonferroni adjustment. The results of the pairwise comparisons are shown in Table 4.3. The pedometers showed significant differences in physical activity between all activities, with the exception of skipping and football which were not significantly different from one another.

Table 4.3

Results of pairwise comparisons of pedometer means (left and right combined) between the four activities.

Comparison	Mean pedometer counts (*SDs*)	Mean difference (95% confidence intervals)	*p*-value
Running – Skipping	437.5 (37.2) – 328.3 (79.5)	109.2 (80.6 – 137.8)	$p < .001$*
Running – Football	437.5 (37.2) – 329.5 (70.5)	108.0 (85.1 – 130.8)	$p < .001$*
Running – Throwing	437.5 (37.2) – 81.2 (33.4)	356.2 (340.4 – 372.1)	$p < .001$*
Skipping – Football	328.3 (79.5) – 329.5 (70.5)	-1.2 (-37.7 – 35.3)	$p = 1.0$
Skipping – Throwing	328.3 (79.5) – 81.2 (33.4)	247.1 (217.0 – 277.1)	$p < .001$*
Football – Throwing	329.5 (70.5) – 81.2 (33.4)	248.3 (225.3 – 271.2)	$p < .001$*

* indicates significant differences between activities following Bonferroni adjustment for multiple comparisons.

Further analyses were carried out to determine whether the pedometer-determined differences between activities were supported by the measures of RPE, post-activity heart rate, and net increase in heart rate.

For the RPE analysis, Kolmogorov-Smirnov tests showed that mean values for the throwing and colouring activities were not drawn from normal distributions ($p < .05$ in both cases). Transforming the data did not revolve the problem, therefore Friedman's rank test for correlated samples was carried out to compare RPE scores across the five activities. This showed a significant difference across activities, $\chi^2_F(4,$

$N = 30) = 91.66, p < .001$, which was followed-up using Wilcoxon signed ranks tests. A total of 10 comparisons were carried out (see Table 4.4), with the significance level adjusted to .005 in accordance with the Bonferroni adjustment. The RPE measure did not show significant differences between the running and skipping activities, or between the throwing and colouring activities. All other activities were significantly different from one another.

Table 4.4

Results of Wilcoxon signed ranks tests for RPE between the five activities (means and standard deviations may be seen in Table 4.2).

Comparison	Wilcoxon z and p-value
Running – Skipping	-1.72, $p = .085$
Running – Football	-3.89, $p < .001$*
Running – Throwing	-4.80, $p < .001$*
Running – Colouring	-4.81, $p < .001$*
Skipping – Football	-2.93, $p < .005$*
Skipping – Throwing	-4.64, $p < .001$*
Skipping – Colouring	-4.64, $p < .001$*
Football – Throwing	-4.01, $p < .001$*
Football – Colouring	-4.31, $p < .001$*
Throwing – Colouring	-2.10, $p = .036$

* p <. 005 (required significance level after Bonferroni adjustment).

For the heart rate analysis, a one-way repeated measures ANOVA was conducted with the within-subjects factor as activity (running, skipping, football, throwing, colouring) and the dependent variable as post-activity heart rate. This analysis was subsequently repeated with net increase in heart rate as the dependent variable. In both analyses, Kolmogorov-Smirnov tests showed that means were drawn from normally distributed populations. The colouring task was included in both analyses, given that standard deviations did not show such marked differences as were seen for the pedometer data (see Table 4.2 for these values).

For post-activity heart rate, there was a significant main effect of activity, $F(4, 116) = 405.23$, $p < .001$. The ANOVA using net increase in heart rate also showed a significant main effect of activity, $F(4, 116) = 406.24$, $p < .001$. Main effects were followed up using pairwise comparisons. Given that these comparisons produced identical results for post-activity heart rate and net increase in heart rate, only results for the latter measure are shown in Table 4.5. There were no significant differences between the running and skipping activities, or between the skipping and football activities. All other activities were significantly different from one another.

Table 4.5

Results of pairwise comparisons of means for net increase in heart rate between the five activities (means and standard deviations may be seen in Table 4.2).

Comparison	Mean difference (95% confidence intervals) in beats per minute	*p*-value
Running – Skipping	7.1 (-1.7 – 16.0)	$p = .205$
Running – Football	16.7 (9.1 – 24.3)	$p < .001$*
Running – Throwing	68.5 (61.2 – 75.8)	$p < .001$*
Running – Colouring	88.7 (81.8 – 95.7)	$p < .001$*
Skipping – Football	9.6 (-0.04 – 19.2)	$p = .052$
Skipping – Throwing	61.4 (52.5 – 70.3)	$p < .001$*
Skipping – Colouring	81.6 (73.1 – 90.1)	$p < .001$*
Football – Throwing	51.8 (41.7 – 61.9)	$p < .001$*
Football – Colouring	72.0 (62.1 – 81.9)	$p < .001$*
Throwing – Colouring	20.2 (14.1 – 26.3)	$p < .001$*

* indicates significant differences between activities following Bonferroni adjustment for multiple comparisons.

DISCUSSION

The aim of Study 1 was to provide further validation of the pedometer as a measure of physical activity during children's unregulated play activities. This was determined by the ability of the pedometer to discriminate between five play activities that were selected to differ in the level of physical activity required. Measures of heart rate and RPE were additionally taken to enable comparisons with the pedometer measure. The study also aimed to determine whether there were significant differences between pedometer counts depending on the side of the body on which the pedometer was worn.

All measures were able to discriminate activities designed to be of vigorous nature (i.e., running, skipping, football) from activities designed to be less vigorous (i.e., throwing, colouring). Pedometer counts, RPE, and heart rate were all significantly higher during the running, skipping, and football activities compared to during the throwing activity. RPE and heart rate were significantly higher during running, skipping, and football compared to during colouring. Similarly, the pedometer measure showed that the colouring task was associated with a very low number of pedometer counts in comparison to the other activities. In addition, pedometer counts, RPE, and heart rate were all significantly higher during the running activity compared to the football activity. The consistent differences between activities that were shown by the three activity measures provide evidence for the validity of the pedometer as a measure of physical activity during children's play activities.

The results of the current study concur with previous research reviewed in Chapter 2 which indicates that the pedometer is a valid measure of physical activity in children (e,g., Eston et al., 1998; Kilanowski et al., 1999; Louie et al., 1999;

Rowlands et al., 1999). In the study by Eston et al. (1998) the pedometer was significantly correlated with energy expenditure (scaled oxygen uptake [sVO_2]), most notably during unregulated activities, such as playing catch and hopscotch. In the current study, activities were also unregulated and were selected to be representative of children's activities under normal, free-living conditions. In the natural environment, Kilanowski et al. (1999) found significant correlations between pedometer, accelerometer, and behavioural observation measures of physical activity and all three measures showed that children were significantly more active during recreational activities compared to classroom activities. Collectively, these findings indicate potential for the pedometer as a measure of habitual physical activity in children.

In the current study, the pedometer did not find a significant difference in steps accumulated between the skipping activity and football activity, and this lack of difference between activities was supported by the heart rate measure. On this basis, it appears that the skipping and football activities did not differ significantly in the level of physical activity they required. The RPE measure, however, indicated that perceived exertion was significantly higher during the skipping activity compared to the football activity.

In addition, the RPE measure did not significantly discriminate between the throwing and colouring activities. Heart rate, however, was significantly higher during throwing compared to colouring and this difference was supported by the mean step counts recorded for the left and right pedometers. Similarly, in the study by Eston et al. (1998), sVO_2 and heart rate were higher and the pedometer recorded a higher number of steps during the catching activity compared to the colouring activity. This suggests that children are less able to make accurate effort discriminations at the low end of the physical activity scale.

Despite these discrepancies, the current study indicates that the RPE measure was able to discriminate between vigorous and less vigorous activities and thus provides evidence for the validity of the BABE scale. Furthermore, the current study is one of the first to examine RPE in relation to pedometer measures in children. Activities which accrued a higher number of pedometer counts (e.g., running, skipping, football) received higher perceived exertion estimates compared to activities such as throwing and colouring, which accrued fewer steps and received low perceived exertion estimates. Similarly, Shepherd (2002) found that children did significantly more pedometer counts when they were instructed to produce Level 8 (*very hard*) on the BABE scale compared to Level 3 (*easy*). The current study used RPE scales via estimation mode, whereas Shepherd employed production mode (see Chapter 2), but nonetheless, the results of the two studies are in agreement. As stated in Chapter 2, children's estimates of perceived exertion may be used to enrich information provided by objective measures and to gain a "snapshot" of the subjective experience of physical activity participation.

Pedometer counts were significantly higher during the running activity compared to the skipping activity, however this difference was not supported by the heart rate and RPE measures. This was the only occasion that the pedometer and heart rate measures did not show agreement in the ability to discriminate between activities. The lack of consistency here may be due to the nature of the two activities. Sustained running over a 3-min period would be expected to significantly raise an individual's heart rate and to accrue a high number of steps because the pedometer is sensitive to ambulatory activity. However the jumping motion that is required to skip using a rope uses more energy per movement than walking or running but would be likely to accrue fewer steps.

In the study by Eston et al. (1998), a comparison between hopscotch (which involved alternatively hopping and jumping) and running at a speed of 8 km per hr indicated that sVO_2 remained fairly constant. The two activities also elicited similar mean heart rates (173.9 and 158.6 beats per min, respectively). The pedometer counts were very different however, with means of 124.3 counts per min during hopscotch and 197.7 counts per min during running. Eston et al. thus found that the energy cost of hopscotch was accurately assessed by heart rate but not by the pedometer. As stated in Chapter 2, heart rate monitoring provides an indication of the relative stress placed on the cardiopulmonary system during physical activity (Rowlands et al., 1997). Because pedometers measure accumulated steps rather than the intensity of activity, it is likely that pedometer and heart rate measures will not always concur because they are not measuring the same dimension of physical activity.

Children in the present study may have used their heart rate to gauge the level of exertion that was required for each activity. Because the skipping activity raised heart rate to a level that was not indistinguishable from that during the running activity, children may have attributed higher ratings of exertion to the skipping activity. This may explain the lack of significant difference between the running and skipping activities on the RPE measure.

The current study examined the validity of the pedometer to assess physical activity during isolated activities that were sustained over 3-min periods. While this is no doubt useful for validation purposes, in the context of the present thesis it is more important that the pedometer provides an accurate picture of children's habitual physical activity in the natural environment. As stated previously, the pedometer has great potential to be used it this way. Therefore, Study 2 of this thesis will use pedometers to measure the total amount of physical activity shown by children on weekdays and weekend days. The additional use of the RT-3 triaxial accelerometer in a subsample of children will enable validation of the pedometer as a measure of physical activity over longer periods of time.

An additional aim of the current study was to compare pedometer counts obtained by a pedometer worn on the right side of the body to those obtained by a pedometer worn on the left side during each activity. Results showed no significant difference between counts obtained by the left and right pedometers. Similarly, in a study with adult participants, Bassett et al. (1996) found that pedometers worn on the left side of the body did not differ significantly from those worn on the right and thus concluded that it does not matter which side of the body they are worn on.

In summary, the pedometer measure showed that five different play activities produced significantly different levels of physical activity in children, and these differences were, in the majority of cases, supported by additional measures of heart rate and RPE. This indicates that the pedometer is able to distinguish between sedentary activities and more vigorous activities that are likely to be common in the natural environment of children. Along with previous research reviewed in Chapter 2, this study provides further evidence for the validity of the pedometer as a measure of physical activity in children.

CHAPTER 5

STUDY 2:

SCHOOL- AND LEISURE-TIME DIFFERENCES IN THE HABITUAL PHYSICAL ACTIVITY OF CHILDREN: WHERE SHOULD WE INTERVENE?

INTRODUCTION

According to research reviewed in Chapter 3, levels of physical activity vary substantially among children of the same age and gender. Vincent and Pangrazi (2002a) found that children's daily activity levels appear to be on a continuum, with some children averaging a very high number of steps per day while others are less than half as active. It is the latter group of children who are most likely to benefit from increasing their level of physical activity.

The current study aimed to determine the most appropriate context in which to implement a physical activity intervention for children. Children's habitual physical activity was measured by pedometry during the day (i.e., during school-time and leisure-time), on weekdays and weekend days, to identify particular time periods in which children showed low levels of physical activity. In addition, children were classified as "high-active" or "low-active" on the basis of their overall level of physical activity, and activity levels between these two groups were compared during school- and leisure-time to determine the location of any significant differences.

Vincent and Pangrazi (2002a) note that the structured environment of school may limit individual variability in activity levels. On this basis, differences between high- and low-active children may be expected to occur outside of the school environment, which would point to the appropriateness of an intervention targeting leisure-time physical activity. However, school playtimes and physical education classes provide children with opportunities to be differentially physically active (see McKenzie et al., 1997; Sleap & Warburton, 1992; Stratton, 1999); therefore it may be the case that differences between high- and low-active children are also present during school.

In addition to the pedometers, a subsample of children wore RT-3 accelerometers to obtain a detailed breakdown of the intensity and duration of physical activity during school-time and leisure-time. The contribution of mode of transport to school to overall levels of physical activity was also examined to determine whether children who walked to school were more active than children who used motorised transport. To obtain a measure of child psychological wellbeing, parents completed the Strengths and Difficulties Questionnaire (SDQ). On the basis of literature reviewed in Chapter 1, which suggests that physical activity is psychologically beneficial for children, it was predicted that a high level of physical activity would be positively related to strengths on the scale (i.e., prosocial behaviour), and negatively related to difficulties (i.e., emotional symptoms, conduct problems, peer relationship problems) with the exception of the hyperactivity/inattention scale which was predicted to be positively correlated with physical activity.

METHOD

Participants

Participants were 104 children (43 boys, 61 girls) recruited from two primary schools in Bangor and Anglesey. Boys and girls were aged between 7.8 and 11.7 years. Mean ages (*SDs*) were 9.9 (1.4) years for boys and 9.9 (1.2) years for girls.

The experimenter contacted the schools by telephone and the respective headteachers gave verbal consent to take part in the study. Recruitment letters were subsequently sent home to the parents of all 7- to 11-year-old children in both schools (Years 3 – 6). The letter invited children to participate in a study looking at their levels of physical activity (see Appendix B1). Parents were requested to complete and sign an attached form either indicating that they gave consent for their child to participate (positive response) or that they did not give consent to participate (negative response). Completed consent forms were returned to the experimenter via the school.

From the Bangor school, parental consent was given for 28 children (10 boys, 18 girls) and from the Anglesey school, for 76 children (33 boys, 43 girls).

Ethical approval for the study was granted by the School of Psychology Ethics Committee, University of Wales, Bangor.

Measures

Pedometer. Physical activity was measured over complete days using Yamax Digiwalker SW-200 pedometers (Toyko, Japan). Children wore the pedometers for 4 weekdays and 2 weekend days. Pedometers were labelled with each child's name and subject number and were worn on the hip, clipped onto the participant's waistband. If no waistband was available, then the monitors were attached to a small belt. In addition, pedometers were sealed with cable ties to prevent the children from viewing the activity count. Vincent and Pangrazi (2002b) found that little reactivity occurs when sealed pedometers are used.

Prior to measurement, all pedometers ($N = 34$) were calibrated. An experimenter wore each pedometer and walked a distance of 50 steps whilst simultaneously counting the number of steps taken. The mean percent error shown by the pedometers was 1.47%, with no pedometer exceeding 5% error (i.e., more than 2 steps incorrectly recorded out of 50). This level of error is similar to that reported elsewhere in the literature (Vincent & Sidman, 2003).

Dependent variables were mean steps per day on weekdays and mean steps per day on weekend days. Additional dependent variables relevant to weekday activity were mean steps per hour during school-time and mean steps per hour during leisure-time.

To calculate steps per hour during school-time, the pedometer count recorded at the beginning of the school day (9:00 a.m.) was subtracted from the pedometer count recorded at the end of the school day (3:00 p.m.). Thus a total pedometer count was obtained for each child for the 6 hr spent in school. This total count was subsequently divided by 6 to calculate the steps per hour during school.

To calculate steps per hour during leisure-time, the school-time total pedometer count was first subtracted from the pedometer count that was recorded by the parent at the child's bedtime (i.e., the total count for the whole day). This represented the total number of steps accumulated during leisure-time for each child. To calculate steps per hour, each child's total leisure-time pedometer count was divided by the length of time (in hours) that they had worn the pedometer (this information was obtained from the parent, see *Procedure* for detail). This procedure thus controlled for the variable time intervals during leisure-time.

Accelerometer. A subsample of 40 children (21 boys, 19 girls) was randomly selected to wear an RT3-triaxial accelerometer (Stayhealthy, Inc., Monvovia, CA, USA) in addition to the pedometer. As described in Chapter 2, the RT3 measures motion along three orthogonal axes (X, Y, and Z), which correspond to vertical (up and down), anterioposterior (forward and back), and mediolateral (side-to-side) motion, respectively (Powell et al., 2003). The present study used Mode 3 on the accelerometer, which samples and stores accumulated activity counts on the three individual axes over 60-s epochs. Although it stores less detail about activity than modes that employ 1-s epochs, Mode 3 is more economical in its use of memory thus allowing for longer duration of measurement.

Children wore the accelerometers for 4 weekdays and 2 weekend days, on the same days that the pedometers were worn. Accelerometers were labelled with the child's name and subject number and were worn clipped onto the child's waistband on the opposite hip to the pedometer. Despite having no external controls to manipulate, RT3 accelerometers were sealed using masking tape to prevent the batteries from being removed. Following completion of measurement, data were downloaded to a PC and exported into Statistical Package for the Social Sciences (SPSS; version 11 for Macintosh OS X) for analysis. The resulting data files displayed minute-by-minute activity counts for each axis for 6 days.

It has recently been shown that the X axis (vertical activity) on the RT3 was associated with the lowest inter-monitor variability, as compared to either the Y and or Z axes (Powell & Rowlands, 2004). Therefore only data recorded on the X axis were used in the analysis. Dependent variables were mean summed counts on the X axis for weekdays and for weekend days (counts per day, respectively). Additional dependent variables were mean summed counts on the X axis during school-time and during leisure-time.

The number of minutes spent at different intensities of activity was computed using accelerometer cut-off points that correspond to various intensities of activity (e.g., low intensity, moderate intensity; see Rowlands, Ingledew, et al., 2004, Rowlands, Thomas, et al., 2004). The cut-off points are shown in Table 5.1.

Table 5.1

Cut-off points for accelerometer counts that correspond to different intensities of activity.

Activity intensity	Accelerometer Count	MET value[a]
Low	0 – 635	0 – 2.9
Moderate	636- 1,645	3 – 5.9
Vigorous	1,646 – 2,320	6 – 8.9
Hard	2,321 – 2,825	9 – 11.9
Very hard	2,826+	12+

[a] Metabolic equivalent; higher MET values indicate greater intensity of activity.

Additional dependent variables were mean time spent in moderate intensity activity and mean time spent at an intensity of vigorous and greater (≥ vigorous activity) on weekdays and on weekend days, and during school-time and leisure-time.

Anthropometric Assessment. Body mass was measured to the nearest 0.1 kg using a Hanson electronic scale. Height was measured to the nearest 0.1 cm using a tape measure that was attached to a vertical wall. Participants removed their shoes to allow these measures to be taken.

Psychological Wellbeing. Psychological wellbeing was measured using the Strengths and Difficulties Questionnaire (SDQ). This is a brief behavioural screening questionnaire for children from 3 to 16 years of age. The SDQ has acceptable levels of reliability and validity as a measure of adjustment and psychopathology in children (Goodman, 1997, 2001). In the present study, the parent-completed version of the SDQ for 4- to 16-year-old children was employed.

The questionnaire contains 25 items which are divided between five scales; Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems, and Prosocial Behaviour. Of these 25 items, 10 are positively-worded (e.g., "Generally obedient, usually does what adults request", from the Conduct Problems scale), and 15 are negatively-worded (e.g., "Often unhappy, downhearted or tearful" from the Emotional Symptoms scale). Respondents are requested to mark each item as *Not True, Somewhat True,* or *Certainly True* on the basis of the child's behaviour over the last 6 months.

There are five items for each of the five scales. Each item is scored as either 0, 1, or 2 depending on the response selected. *Somewhat True* is always scored as 1. *Not True* and *Certainly True* are scored as either 0 or 2 depending on whether the item is positively- or negatively-worded. For each of the five scales, the minimum score is 0 and the maximum score is 10. On the Prosocial scale, a high score is indicative of high levels of prosocial behaviour. However, on the four remaining scales (i.e., Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems), a high score indicates a high level of difficulty in that area. These four scales are combined to compute the Total Difficulties score, which has a range of scores from 0 through to 40. Copies of the questionnaire and scoring instructions may be downloaded from http://www.sdqinfo.com/.

Procedure

Data collection was staggered over an 8-week period from late March until early June, 2003. On each week, data were collected from a group of between 10 and 18 participants. Data were collected only during the school-term. There was a 2-week break in data collection for the Easter holiday in April and a further 1-week break in May for the school half-term holiday.

Up to 6 days prior to the commencement of measurement, an experimenter visited each parent at home to explain the procedures in more detail. Parents were shown how a pedometer works and they were provided with a pack containing written instructions, a pedometer count recording form, a physical activity checklist, a copy of the SDQ, and six cable ties. Parents were instructed to use a cable tie to seal the pedometers. A contact mobile telephone number was included with the instructions so that parents could contact the experimenter in the case of any queries. The written instructions, pedometer count recording form, and physical activity checklist may be viewed in Appendix B2.

One day prior to the commencement of measurement, anthropometric measurements were taken in a quiet room in the school. Following these measurements, children were given verbal instructions concerning wearing the pedometer (and accelerometer if applicable). Participants were told to put the monitors on while dressing in the morning and to wear them all day until bedtime with the exception of swimming or bathing. In addition, children were told that they should not open or tamper with the monitors. Following these instructions, pedometers (and accelerometers) were distributed for participants to take home. The experimenter telephoned all parents that evening to remind them of the procedures and to deal with any queries that may have arisen. Day 1 of measurement began the following day and participants started to wear the monitors from the time they got up in the morning.

On each of the 4 weekdays of measurement, the experimenter recorded the pedometer counts for the participants upon their arrival at school at 9:00 a.m. and again at the end of school at 3:00 p.m. At both recording times, participants were instructed to "check-in" with the experimenter who was stationed in a quiet room in the school. For each participant, the experimenter removed the cable tie from the pedometer, recorded the displayed pedometer count, resealed the pedometer with a new cable tie, and returned it to the participant. Pedometer counts were not revealed to the child at any point. A small number of participants forgot to put their pedometers on while dressing in the morning and thus arrived at school without a pedometer. In these cases, the experimenter issued a replacement pedometer that was returned the following day.

At the child's bedtime the parent opened the pedometer and recorded the displayed count on the recording form provided in the pack (see Appendix B2). The parent then reset and resealed the pedometer using a cable tie ready for the next morning. Parents were asked to not reveal the pedometer counts to the child. In addition, the parent recorded the time that the pedometer was taken off at bedtime, and the time it was put on the following morning. These data were used to determine the length of time that the pedometer was worn during leisure-time. If the pedometer was temporarily removed during the day, the parent was asked to record the length of time that the pedometer was not worn and the reason for its removal. If the pedometer was not worn at all on a particular day, the parent was asked to indicate this on the form.

On the 2 weekend days, only total activity for the day was recorded. As during weekdays, the parent recorded the displayed pedometer count at the child's bedtime. The pedometer was then reset and resealed, and parents made a note of the time it was removed and the time it was put on again the following morning.

For the 6 days of measurement, parents also recorded any physical and sedentary activities that the child did during leisure-time. A physical activity checklist consisting of a list of common children's activities was included in the pack and parents ticked the appropriate boxes to indicate activities that had been carried out by the child (see Appendix B2). Parents also recorded the child's mode of transport to and from school on the 4 weekdays. The SDQ was completed at a convenient time during the measurement period.

On Day 6 of measurement, the experimenter telephoned all parents to thank them for their participation and to determine whether there had been any deviations from the standard procedure. In addition, parents were reminded to send the pack containing the completed recording forms and the pedometer (and accelerometer) into school with their child the following morning. These materials were collected by the experimenter upon the participants' arrival at school at 9:00 a.m. Later that day, all participants received written personalised feedback showing their pedometer counts for the 6 days of measurement. Parents and teachers received a written report of the overall findings some weeks later. Personalised feedback for those children who had worn accelerometers was also given at this point.

RESULTS

Pedometer Data

The parent recording forms were used to ensure that children had worn the pedometers for complete days. In cases where the pedometer was not worn for more than 2 consecutive hours, the data point for that day was excluded from the analysis. In addition, any days where the child was absent from school, due to illness or any other reason, were excluded.

There was a total of 4 days of weekday measurement. Only participants for whom there were at least 3 complete days of weekday data were included in the analyses. Research reviewed in Chapter 2 indicates that 3 days of weekday pedometer measurement are sufficient to obtain reliable estimates of children's physical activity (Ozboba et al., 2004). In addition, on each of these days, data points for both school- and leisure-time activity were required. A total of 9 participants (5 boys, 4 girls) were excluded due to missing data for either entire days or for the school- or leisure-time segments. Reasons for missing data included illness, pedometer loss, pedometer malfunction, and children not being present when pedometer readings were taken at school (for example, due to visits to the dentists or doctors, or attendance at a special education unit). Excluded boys ($N = 5$) did not differ significantly from the included sample on age, height, mass, or BMI. Excluded girls ($N = 4$) were significantly younger than the included sample, but there were no significant differences on height, mass, or BMI.

Descriptive characteristics of the final sample ($N = 95$) are shown in Table 5.2. Also shown is the percentage of overweight or obese participants on the basis of published international cut-off points (Cole, Bellizzi, Flegal & Dietz, 2000).

Table 5.2

Means (*SDs*) showing descriptive characteristics of the final sample.

	Boys ($N = 38$)	Girls ($N = 57$)
Age (years)	9.8 (1.4)	10.0 (1.2)
Height (cm)	138.4 (10.0)	139.0 (9.7)
Mass (kg)	35.8 (8.8)	37.0 (11.2)
BMI (kg/m^2)	18.4 (2.3)	18.8 (3.6)
Percentage of overweight/ obese participants	21% (8/38)[a]	28% (16/57)[a]

[a] Participant numbers are shown in parentheses.

Independent *t* tests conducted on age, height, mass, and BMI showed that there were no significant differences between boys and girls on any of these variables. Furthermore, boys and girls did not differ significantly in the frequency of overweight and obese children ($\chi^2 = 0.6$, $df = 1$, $p = .441$).

For all analyses, means were computed using pedometer data from the final 3 weekdays of measurement. Any missing data were replaced with data from the previous measurement day. This procedure ensured that mean scores were comprised of the same number of observations across participants.

School-time and leisure-time physical activity. Means were computed for total steps, steps per hour, and the length of time that the pedometer was worn (in hours) during school- and leisure-time respectively (see Table 5.3).

Table 5.3 shows that on average pedometers were worn for a longer period of time during leisure-time compared to school-time. To control for the unequal time periods, steps per hour was used as the dependent variable in the analyses.

Table 5.3

Means (*SDs*) for pedometer variables during school- and leisure-time

	School-time		Leisure-time	
	Boys ($N = 38$)	Girls ($N = 57$)	Boys ($N = 38$)	Girls ($N = 57$)
Total steps	7,312.4 (1,815.6)	5,782.2 (1,747.6)	9,742.2 (2,994.5)	7,308.8 (2,258.7)
Time pedometer worn in hour	6.0 (0)	6.0 (0)	7.0 (0.7)	7.1 (0.8)
Steps per hour	1,218.7 (302.6)	963.7 (291.3)	1,406.4 (462.4)	1,027.5 (293.5)

A 2 × 2 mixed ANOVA was carried out to determine whether levels of activity differed between school- and leisure-time for boys and girls. The within-subjects factor was measurement time (school-time, leisure-time) and the between-subjects factor was gender (boys, girls). The dependent variable was mean steps per hour. Kolmogorov-Smirnov tests indicated that means were drawn from normally distributed populations. Levene's test however indicated that variances were not homogeneous therefore a log10 transformation was carried out on the data to correct for this.

There was a significant main effect of measurement time, $F(1, 93) = 10.78$, $p = .001$, indicating that, overall, physical activity (steps per hour) was higher during leisure-time compared to school-time. There was a significant main effect of gender, $F(1, 93) = 28.90$, $p <. 001$, indicating that boys were more active than girls. The interaction between measurement time and gender failed to reach significance, $F(1, 93) = 0.96$, $p = .329$.

For separate genders, each participant was classified as either high- or low-active using a median split on the mean weekday steps per day. Participants with a weekday mean of equal to or less than the median were classified as low-active and those with a mean that exceeded the median were classified as high-active. For girls, the mean and median for weekday activity were 13,091.0 and 13,310.7 steps per day, respectively. For boys, the mean and median for weekday activity were 17,054.6 and 16,619.5 steps per day, respectively.

To determine the location of differences in activity between high-active and low-active children, 2 × 2 ANOVAs were carried out for separate genders with measurement time (school-time, leisure-time) as the within-subjects factor and activity group (high-active, low-active) as the between-subjects factor. The dependent variable was mean steps per hour. As before, Kolmogorov-Smirnov tests and Levene's test were used to check the respective assumptions of normality and homogeneity of variance. The analysis of the boys' data indicated that homogeneity of variance was not present therefore a log10 transformation was carried out on the data prior to analysis.

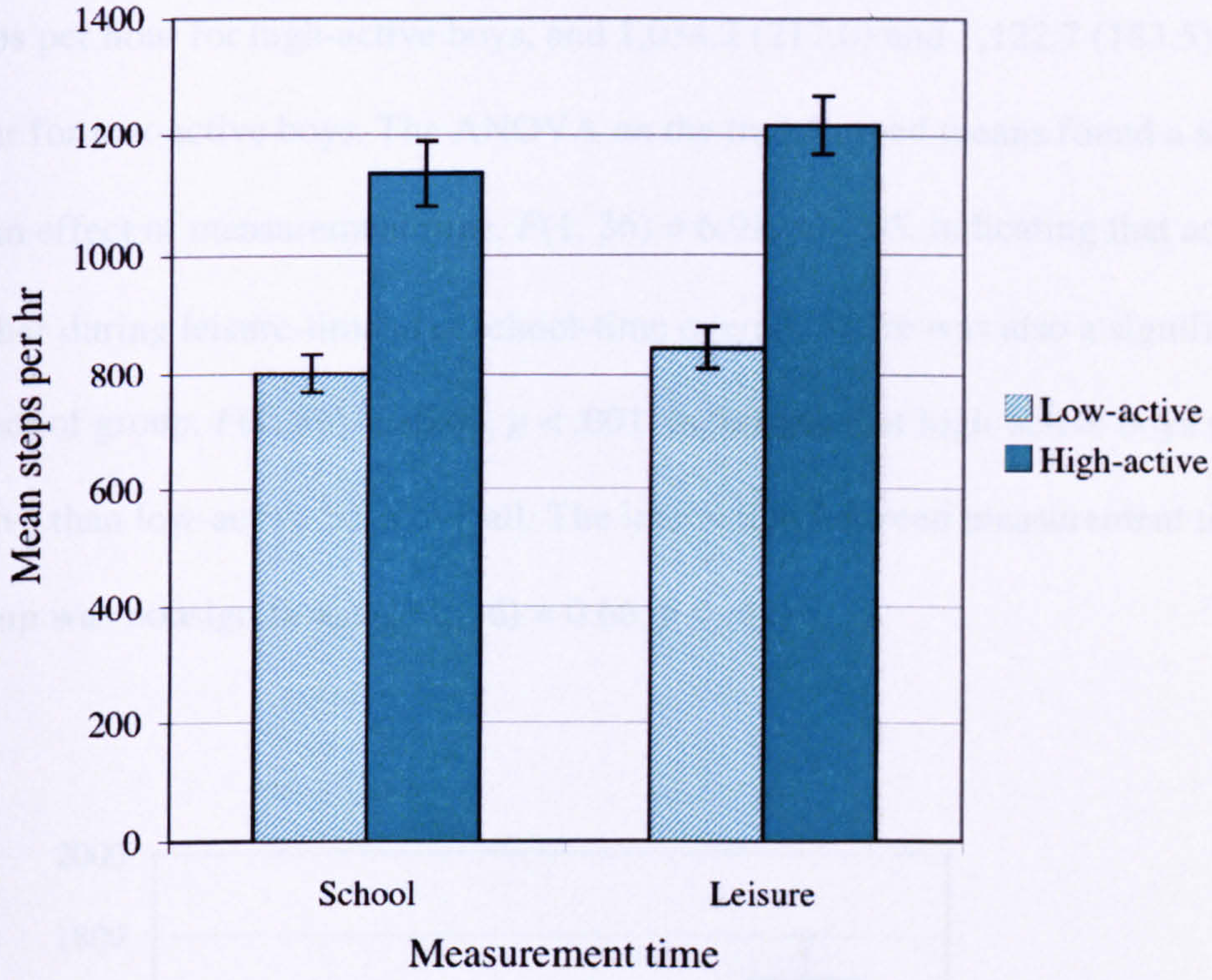


Figure 5.1. Mean steps per hour for high- and low-active girls during school-time and leisure-time. Bars represent ± 1 *SE* of the mean.

Figure 5.1 shows the mean steps per hour for high- and low-active girls at the two measurement time periods. High-active girls averaged 1,134.1 and 1,217.3 steps per hour during school-time and leisure-time, respectively (*SD*s = 285.5 and 263.1). The comparable figures for low-active girls were 799.2 and 844.2 steps per hour (*SD*s = 184.4 and 186.4, respectively). The ANOVA found a significant main effect of group, $F(1, 55) = 53.24$, $p < .001$, indicating that overall, high-active girls were more active than low-active girls. There was no significant main effect of measurement time, $F(1, 55) = 2.79$, $p = .100$, and the interaction between measurement time and group was nonsignificant, $F(1, 55) = 0.25$, $p = .621$.

The mean steps per hour for high- and low-active boys at the two time periods may be seen in Figure 5.2. Means (with standard deviations in parentheses) for school-time and leisure-time, respectively, were 1,403.3 (263.1) and 1,690.1 (485.8) steps per hour for high-active boys, and 1,034.2 (217.0) and 1,122.7 (183.5) steps per hour for low-active boys. The ANOVA on the transformed means found a significant main effect of measurement time, $F(1, 36) = 6.93, p < .05$, indicating that activity was higher during leisure-time than school-time overall. There was also a significant main effect of group, $F(1, 36) = 46.42, p < .001$, indicating that high-active boys were more active than low-active boys overall. The interaction between measurement time and group was nonsignificant, $F(1, 36) = 0.66, p = .423$.

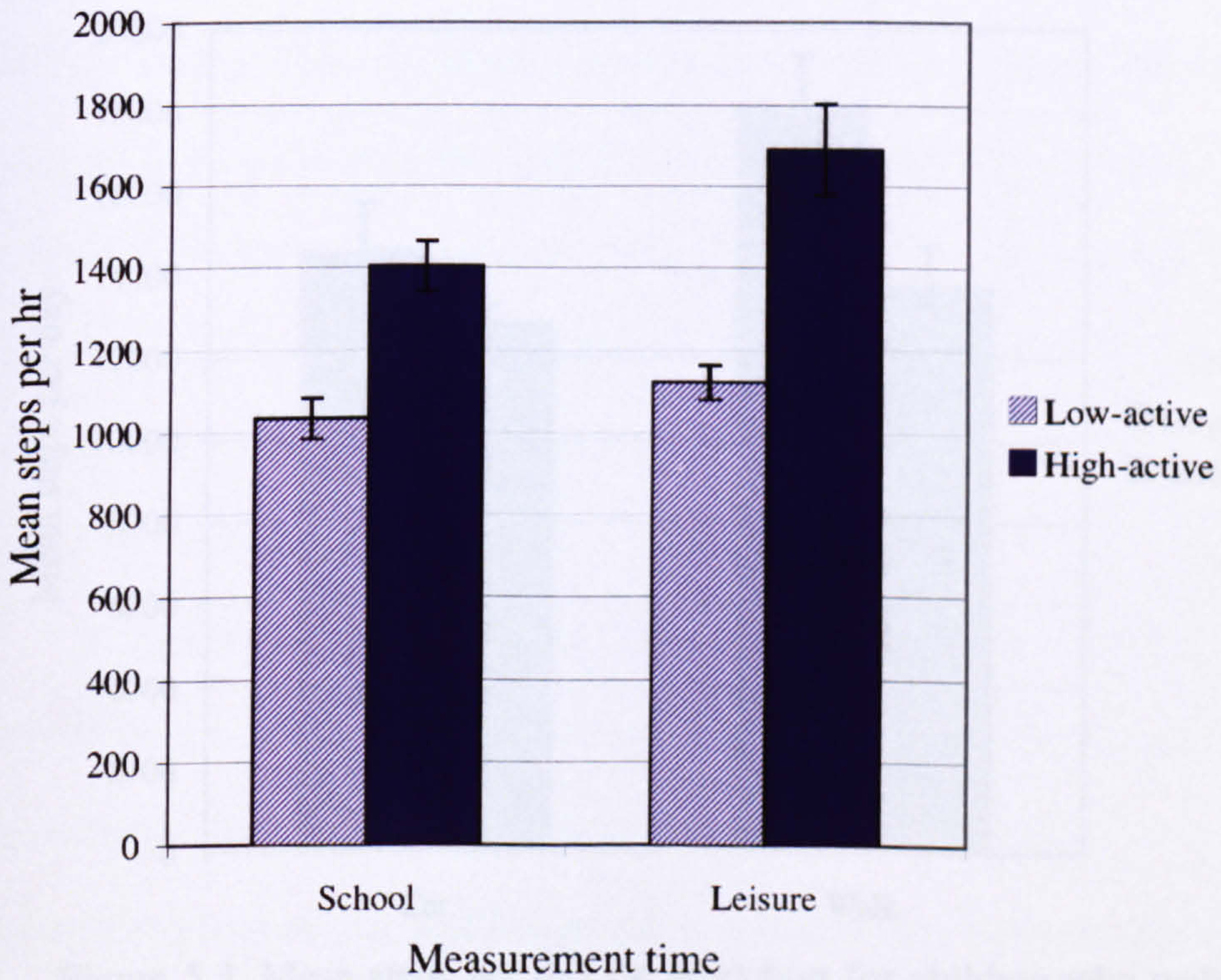


Figure 5.2. Mean steps per hour for high- and low-active boys during school-time and leisure-time. Bars represent ± 1 *SE* of the mean.

Mode of transport to school. Among girls, 26 participants travelled to school by car, 20 walked, 10 used a combination of the car and walking, and 1 used a combination of the car and cycling. Among boys, 7 participants travelled to school by car, 17 walked, 8 used a combination of the car and walking, and 4 travelled by bus. The remaining 2 boys used combinations of the car, walking and cycling.

Given that participant numbers were low for modes of transport such as cycling and travelling by bus, only children who consistently walked or used the car were included in the analysis. Mean steps per day on weekdays by method of transport are shown below in Figure 5.3.

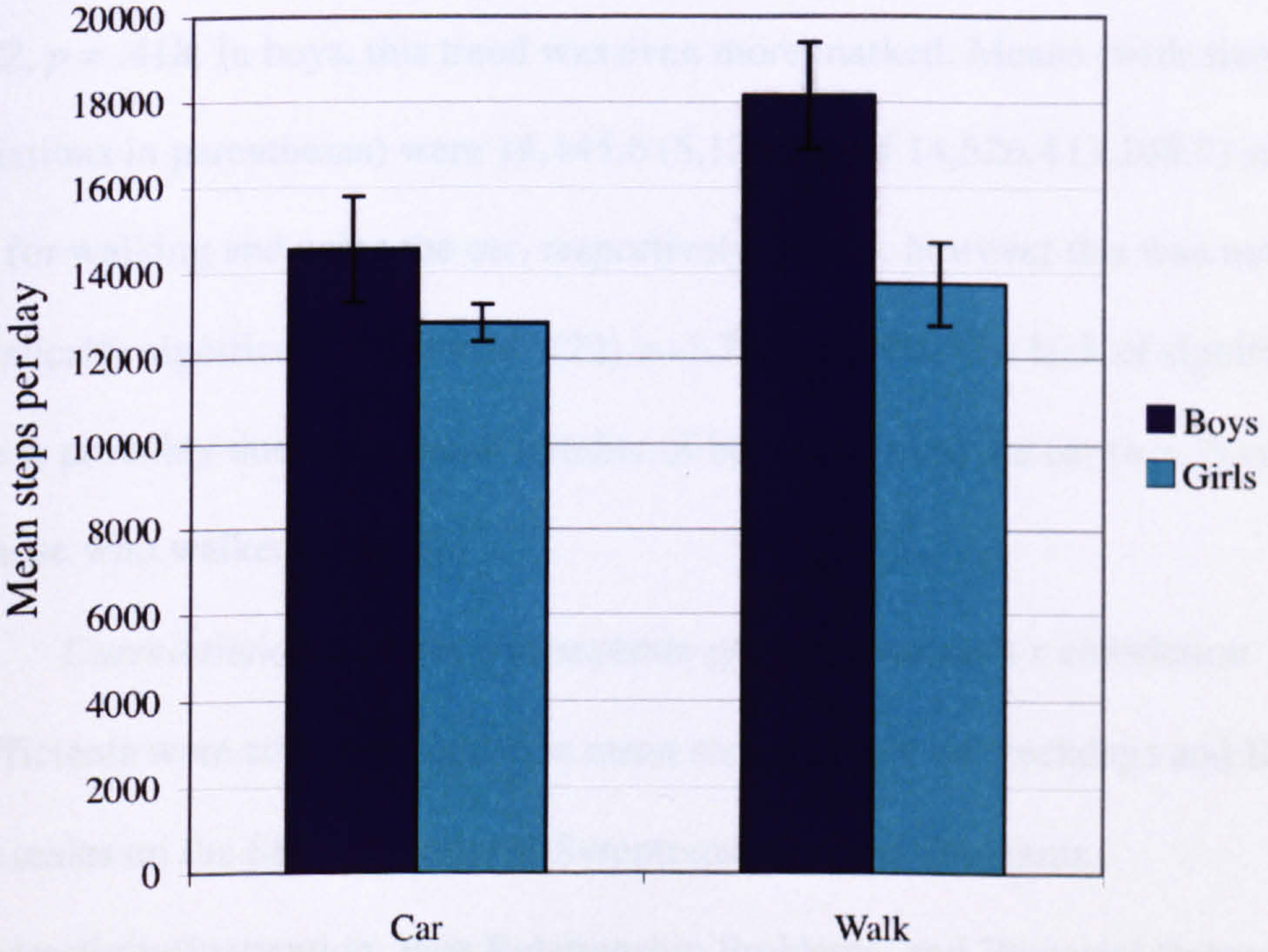


Figure 5.3. Mean steps per day on weekdays for children who walked to school and children who travelled by car. Bars represent ± 1 *SE* of the mean.

For separate gender, independent *t* tests were carried to determine whether there were differences between mean steps per day on weekdays depending on whether the participant walked or travelled by car to school. The presence of normality and homogeneity of variance were verified using Kolmogorov-Smirnov tests and Levene's tests, respectively. The analysis of the girls' data showed that homogeneity of variance was not present therefore the appropriate correction to the degrees of freedom and the significance were employed here.

For the girls, there was a trend for those who walked to school to be more active during the day than those who travelled by car. Means (with standard deviations in parentheses) were 13,705.8 (4,415.2) and 12,820.5 (2,193.8) steps per day, respectively. This was not, however, a statistically significant difference, $t(26) = -0.82$, $p = .418$. In boys, this trend was even more marked. Means (with standard deviations in parentheses) were 18,145.6 (5,136.4) and 14,526.4 (3,248.7) steps per day for walking and using the car, respectively. Again, however this was not a statistically significant difference, $t(22) = -1.72$, $p = .100$. The lack of significance here is probably due to the small number of boys who used the car ($n = 7$) compared to those who walked ($n = 17$).

Correlational analysis. For separate gender, Pearson's r correlation coefficients were computed between mean steps per day on weekdays and BMI, the five scales on the SDQ (Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems, and Prosocial Behaviour), and the composite Total Difficulties score. In cases where the assumption of normality was not met, Spearman's r_s rank correlation coefficients were computed. Prior to calculating correlation coefficients, scatterplots were examined and any outlying data points were removed.

In girls, mean steps per day on weekdays did not correlate significantly with any of the SDQ scales (see Appendix B3 for correlation coefficients). There was a significant negative correlation between BMI and weekday steps per day, $r = -.33$, $N = 57$, $p < .05$, indicating that a higher BMI in girls was related to a lower number of steps.

In boys, mean steps per day on weekdays did not correlate significantly with any of the SDQ scales (see Appendix B3). The correlation between BMI and weekday steps per day was nonsignificant.

In addition, BMI was positively correlated with Total Difficulties in both girls, $r = .28$, $N = 57$, $p < .05$, and boys, $r = .39$, $N = 38$, $p < .05$. This indicates that a higher BMI was related to a higher level of difficulties as reported by the parents. In boys only, there was a positive correlation between BMI and Emotional Symptoms, $r_s = .35$, $N = 38$, $p < .05$, and a positive correlation between BMI and Peer Relationship Problems, $r = .39$, $N = 38$, $p < .05$. This indicates that a higher BMI in boys was related to a higher level of emotional and peer relationship problems as reported by parents.

Weekday and weekend physical activity. In addition to the 3 days of weekday measurement required for previous analyses, this analysis required participants to have data for 2 weekend days. A further 11 participants (5 boys, 6 girls) were excluded on this basis. Thus the subsequent analysis was carried out on a total of 84 participants (33 boys, 51 girls). The 5 boys and 6 girls who were excluded did not differ significantly from the included sample on age, height, mass, or BMI.

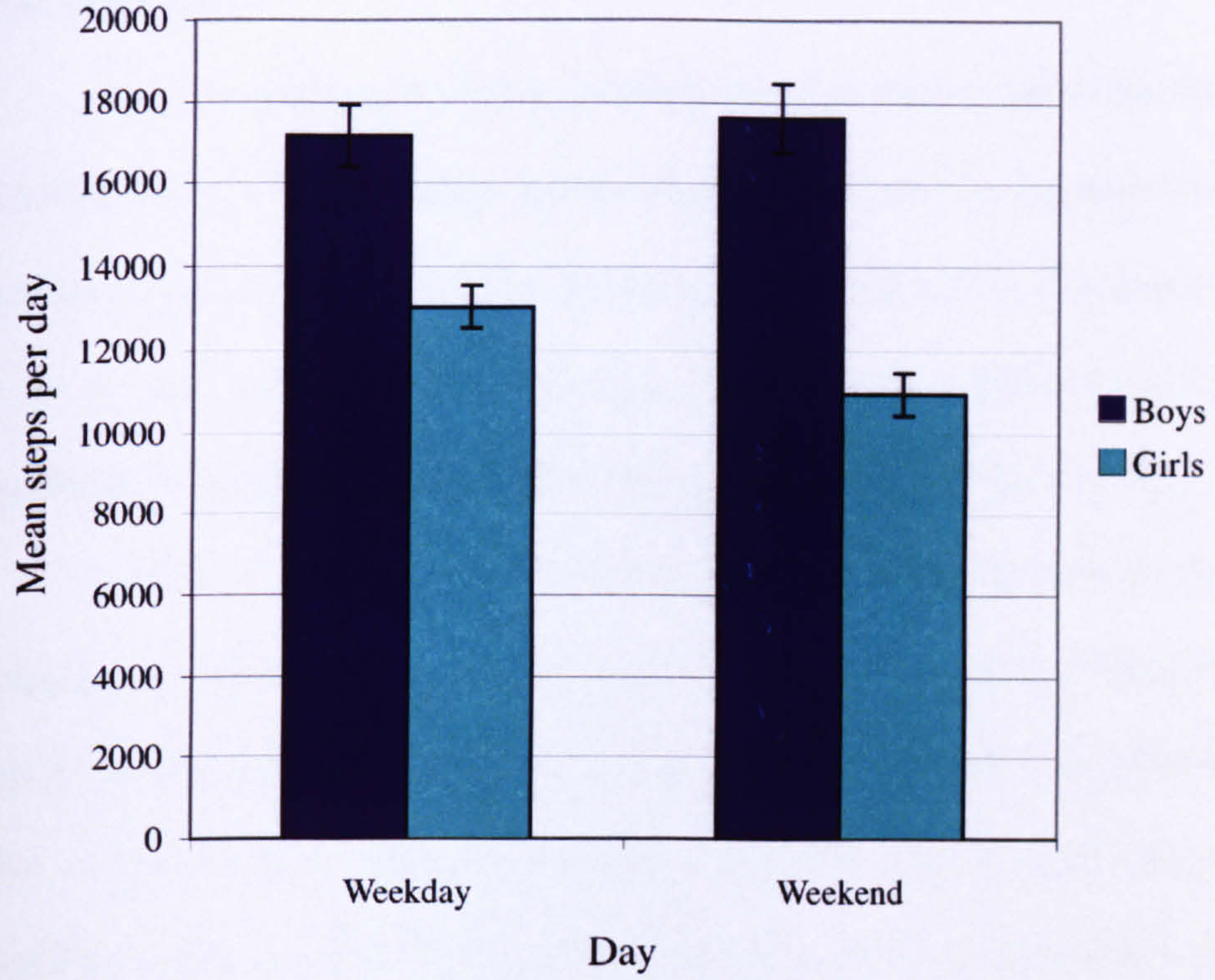


Figure 5.4. Mean steps per day on weekdays and weekend days. Bars represent ± 1 *SE* of the mean.

Mean steps per day for weekdays and weekend days for girls and boys may be seen in Figure 5.4. Girls showed means (*SDs*) of 13,026.8 (3,550.7) and 10,944.2 (3,749.0) steps per day on weekdays and weekend days, respectively. Boys averaged 17,150.7 (4,402.3) and 17,608.0 (4,867.9) steps per day on weekdays and weekend days, respectively.

A 2 × 2 mixed ANOVA was carried out to determine whether there were significant differences between weekday and weekend steps per day. The within-subjects factor was day (weekdays, weekend days) and the between-subjects factor was gender (girl, boy). The dependent variable was steps per day. The presence of normality and homogeneity of variance were verified using Kolmogorov-Smirnov tests and Levene's tests, respectively. Weekend means did not show equality of variance across gender therefore a Log10 transformation was carried out on the data prior to analysis.

On the transformed means, ANOVA showed a significant main effect of day, $F(1, 82) = 6.91, p < .05$. Means indicate that, overall, activity was higher on weekdays than on weekend days. There was also a significant main effect of gender, $F(1, 82) = 35.84, p < .001$, indicating that boys were more active than girls overall. There was a significant interaction between day and gender, $F(1, 82) = 8.49, p < .01$.

A total of four post hoc *t* tests were carried out to investigate the significant interaction, with significance levels adjusted to 0.01. Boys were significantly more active than girls on both weekdays, $t(82) = 4.73, p < .001$, and weekend days, $t(82) = 5.61, p < .001$. Girls were significantly less active on weekend days than on weekdays, $t(50) = 4.52, p < .001$. In contrast, boys showed no significant difference in level of activity between weekdays and weekend days, $t(32) = -0.18, p = .860$.

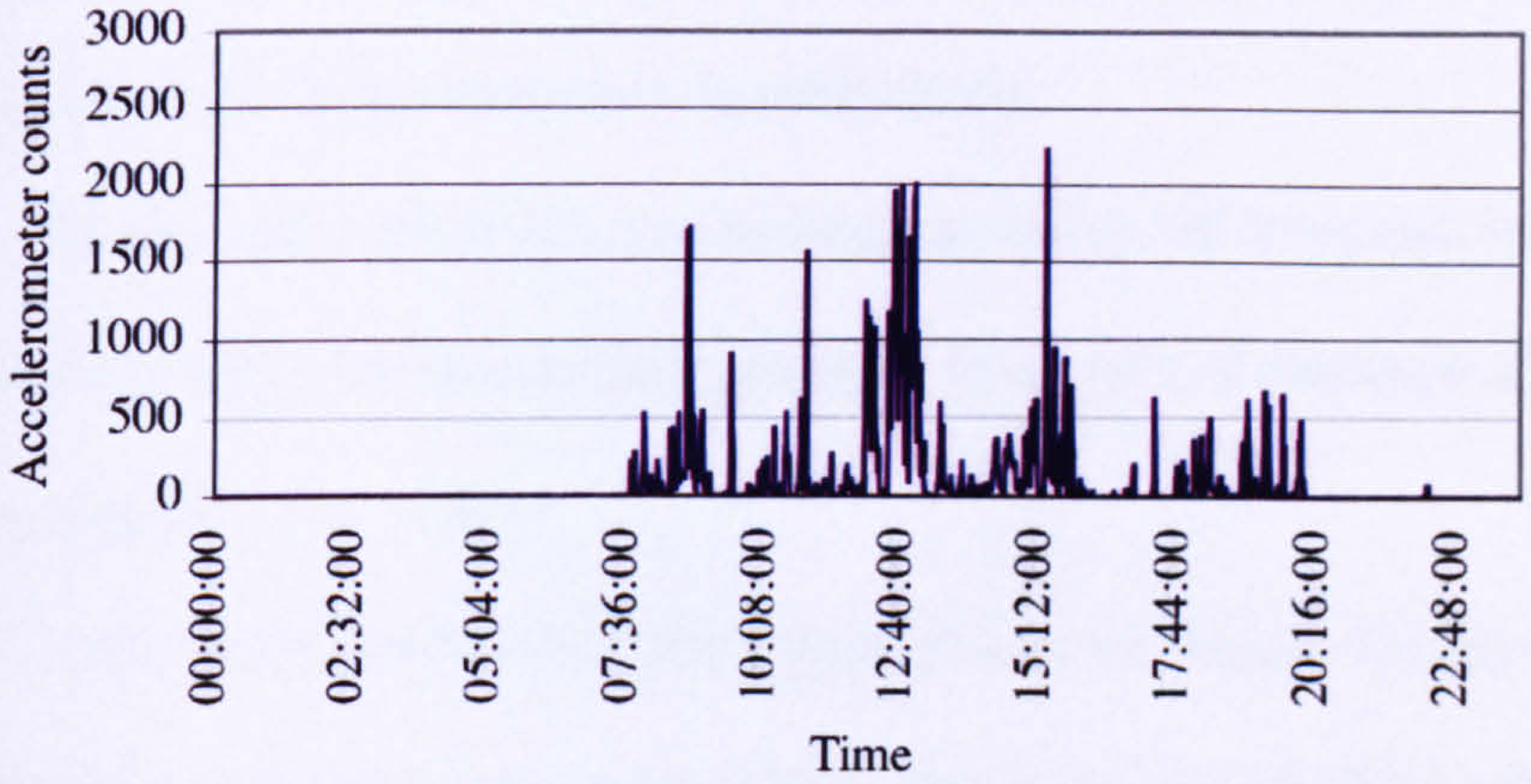
Accelerometer Data

A subsample of 40 children (21 boys, 19 girls) wore RT3 triaxial accelerometers. Data for all participants were examined to ensure that the accelerometers had been worn for complete days. Any days in which 4 consecutive 30-min blocks recorded zero were excluded from the analysis (in accordance with A.V. Rowlands, personal communication, June 2003).

As for the pedometer analysis, participants needed to have at least 3 complete days of weekday accelerometer data to be included in the analysis. On this basis, data for a total of 8 children (6 boys, 2 girls) were excluded. Of these, 4 boys and 1 girl were excluded due to accelerometer failure, 1 boy and 1 girl did not wear the accelerometer for a sufficient number of days, and 1 boy had already been excluded from the pedometer analyses. The 8 excluded children did not differ significantly from the included children ($n = 32$) on age, height, mass, or BMI.

Independent samples t tests showed that the remaining subsample of children wearing accelerometers ($n = 32$) did not differ significantly from children who wore pedometers but not accelerometers ($n = 57$) on age, height, mass, BMI, or weekday steps per day.

The daily activity patterns of 2 female participants, as obtained by the accelerometers, are shown in Figure 5.5 for descriptive purposes. The data shown in the upper panel are from a participant who typically showed low levels of activity with respect to the rest of the group (classified as low-active in the previous pedometer analysis). In contrast, the data in the lower panel are from one of the most active participants (classified as high-active in the pedometer analysis). Differences in activity between these 2 participants appear to be present throughout the course of the day.



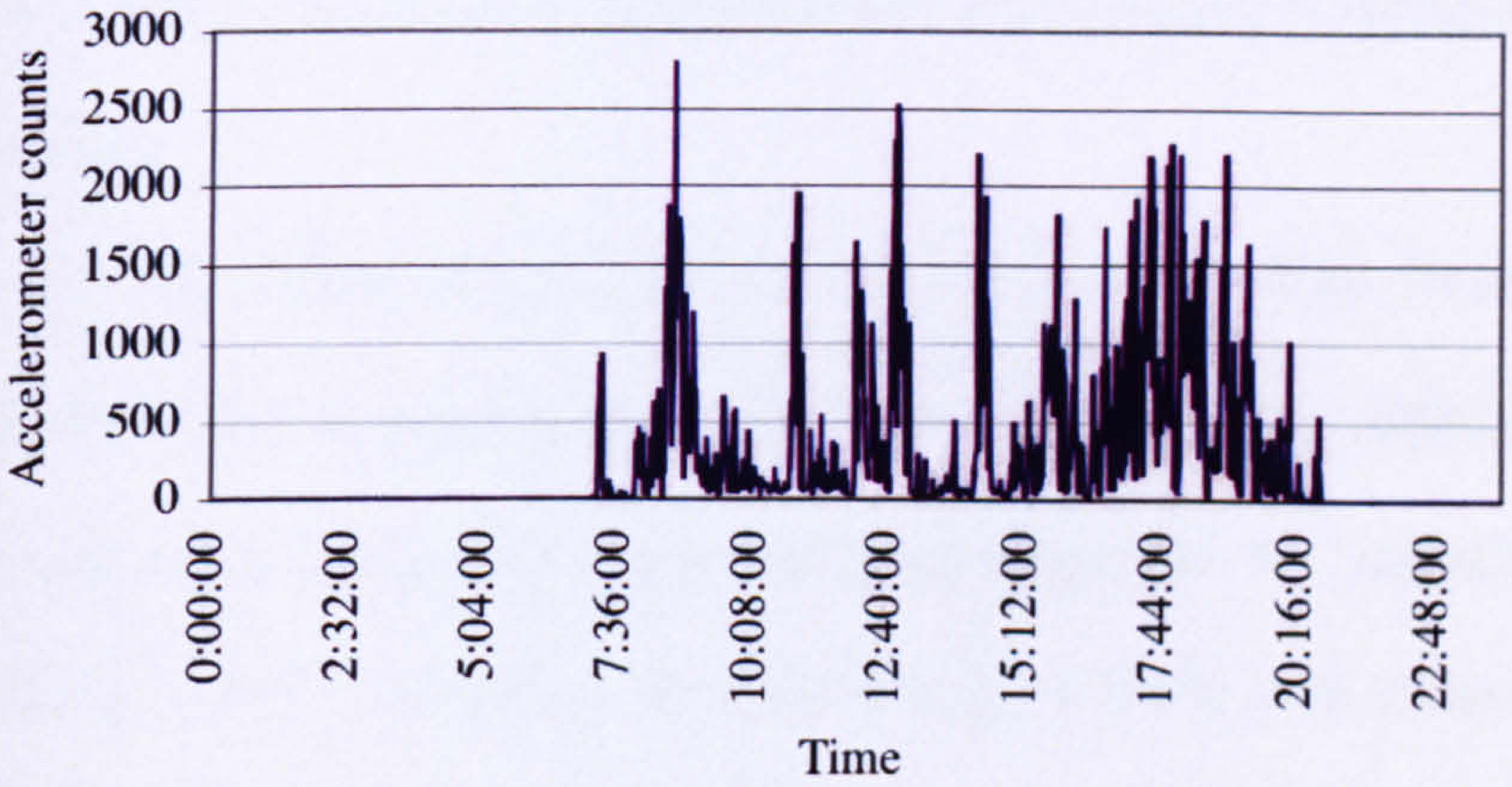


Figure 5.5. Typical plots of daily activity (accelerometer counts on the X axis) for a low-active (upper panel) and a high-active (lower panel) female participant.

For all analyses, means were computed using data from the final 3 weekdays of measurement. Any missing data were replaced with data from the previous measurement day. This procedure ensured that mean scores were comprised of the same number of observations across participants.

Means indicated that, on an average weekday, all boys and 16 out of 17 girls achieved the UK's recommended guidelines of 60 min of moderate physical activity per day (Biddle et al., 1998).

School-time and leisure-time physical activity. Figure 5.6 shows descriptive statistics for summed counts on the X axis (upper panel) and time spent in moderate activity (middle panel) and ≥ vigorous activity (lower panel) during school-time and leisure-time.

A total of three mixed 2 × 2 ANOVAs were carried out. In each case, measurement time (school-time, leisure-time) was the within-subjects factor and gender (boys, girls) was the between-subjects factor. For the respective ANOVAs, dependent variables were mean summed counts on the X axis, mean time in moderate activity, and mean time in ≥ vigorous activity. The presence of normality and homogeneity of variance were verified using Kolmogorov-Smirnov tests and Levene's tests, respectively. Means relating to time spent in ≥ vigorous activity did not have equal variances therefore a square route transformation was carried out on these data prior to analysis.

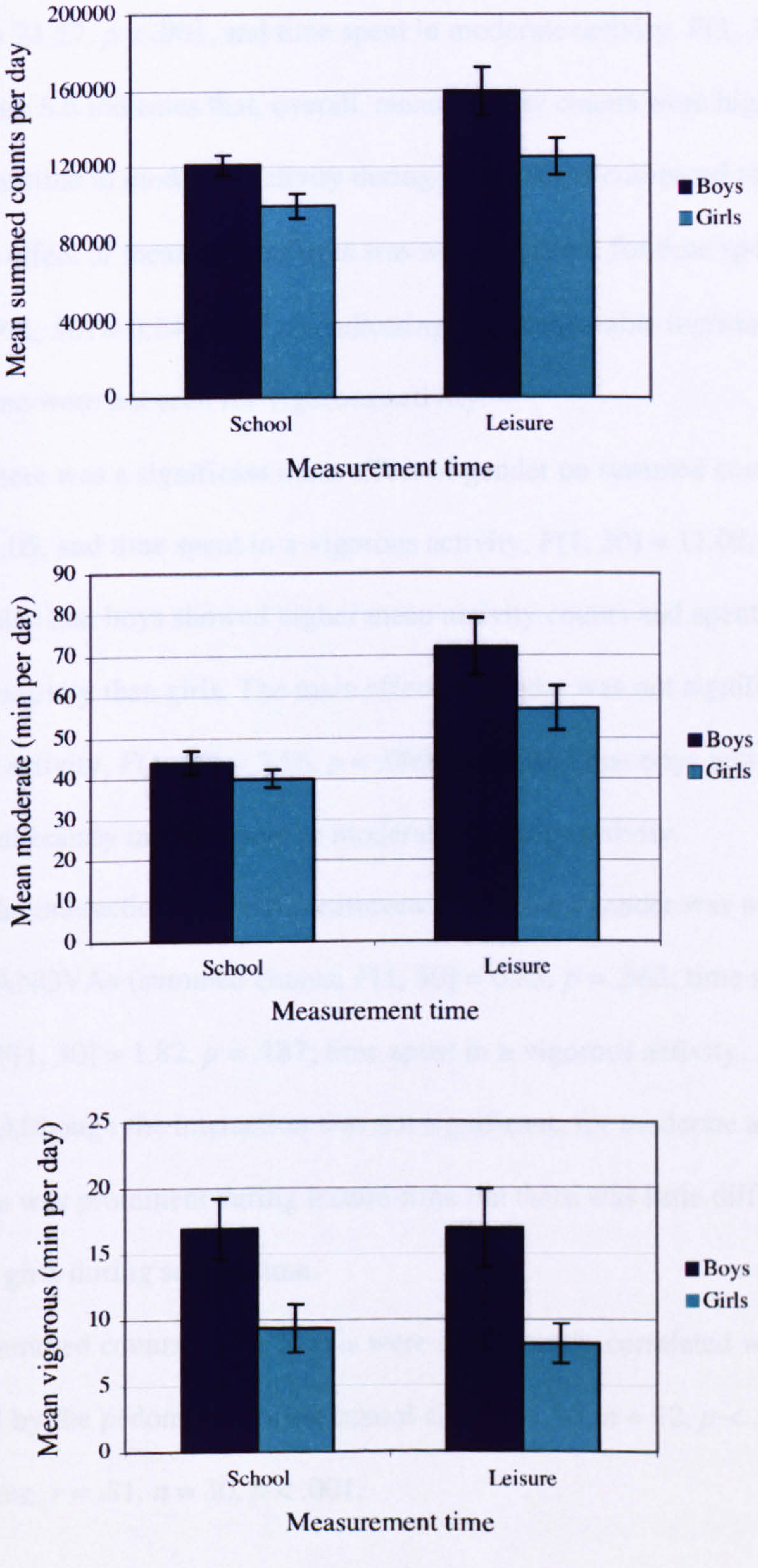


Figure 5.6. Mean summed counts (upper panel), minutes spent in moderate intensity activity (middle panel), and minutes spent in ≥ vigorous activity (lower panel) during school-time and leisure-time. Bars represent ± 1 *SE* of the mean.

There was a significant main effect of measurement time on summed counts, $F(1, 30) = 21.27, p < .001$, and time spent in moderate activity, $F(1, 30) = 31.39, p < .001$. Figure 5.6 indicates that, overall, mean activity counts were higher and children spent more time in moderate activity during leisure-time compared to school-time. The main effect of measurement time was not significant for time spent in ≥ vigorous activity, $F(1, 30) = 0.14, p = .713$, indicating that comparable increases during leisure-time were not seen for vigorous activity.

There was a significant main effect of gender on summed counts, $F(1, 30) = 7.27, p < .05$, and time spent in ≥ vigorous activity, $F(1, 30) = 11.02, p < .005$. Figure 5.6 indicates that boys showed higher mean activity counts and spent more time in vigorous activity than girls. The main effect of gender was not significant for moderate activity, $F(1, 30) = 3.56, p = .069$, indicating that boys and girls did not differ significantly in time spent in moderate-intensity activity.

The interaction between measurement time and gender was nonsignificant in all three ANOVAs (summed counts, $F[1, 30] = 0.85, p = .363$; time spent in moderate activity, $F[1, 30] = 1.82, p = .187$; time spent in ≥ vigorous activity, $F[1, 30] = 0.01, p = .928$). Although the interaction was not significant, for moderate activity the gender difference was prominent during leisure-time but there was little difference between boys and girls during school-time.

Summed counts on the X axis were significantly correlated with total steps measured by the pedometer during school-time, $r = .83, n = 32, p < .001$, and during leisure-time, $r = .81, n = 30, p < .001$.

Weekday and weekend physical activity. In addition to the 3 days of weekday measurement required for previous analyses, this analysis required participants to have data for 2 weekend days. A further 5 participants (4 boys, 1 girls) were excluded on this basis. Thus the subsequent analysis was carried out on a total of 27 participants (11 boys, 16 girls). The 5 excluded participants did not differ significantly from the remaining sample on age, height, mass, or BMI.

Descriptive statistics for summed counts, time spent in moderate activity, and time spent in ≥ vigorous activity on weekdays and weekend days are shown in Table 5.4.

Table 5.4

Means (*SDs*) for summed counts, minutes spent in moderate activity, and minutes spent in ≥ vigorous activity on weekdays and weekend days

	Weekdays		Weekend days	
	Boys (n = 11)	Girls (n = 16)	Boys (n = 11)	Girls (n = 16)
Summed counts (counts per day)	281,228.5 (72,467.3)	225,035.7 (55,971.7)	277,225.6 (72,444.7)	187,840.2 (64,084.3)
Moderate intensity (minutes per day)	116.7 (37.8)	95.9 (26.9)	126.0 (46.1)	86.4 (41.3)
≥ Vigorous intensity (minutes per day)	34.9 (18.5)	18.1 (11.7)	29.8 (20.4)	8.3 (9.1)

A total of three mixed 2 × 2 ANOVAs were carried out. In each case, day (weekdays, weekend days) was the within-subjects factor and gender (boys, girls) was the between-subjects factor. Dependent variables were mean summed counts on the X axis, mean time spent in moderate activity, and mean time spent in ≥ vigorous activity for the respective ANOVAs. The presence of normality and homogeneity of variance were verified as previously. Means relating to time spent in ≥ vigorous activity did not have equal variances therefore a square route transformation was carried out on these data prior to analysis.

Analyses showed a significant main effect of day for time spent in ≥ vigorous activity, $F(1, 25) = 11.62, p < .005$. Means indicate that, overall, children spent less time in ≥ vigorous activity on weekend days compared to weekdays. The main effect of day was not significant for summed counts, $F(1, 25) = 3.07, p = .092$, or for time spent in moderate activity, $F(1, 25) = 0.00, p = .985$.

There was a significant main effect of gender on summed counts, $F(1, 25) = 10.25, p < .005$, time spent in moderate activity, $F(1, 25) = 5.57, p < .05$, and time spent in ≥ vigorous activity, $F(1, 25) = 17.20, p < .001$. Means indicate that boys showed higher activity counts and spent more time in moderate and ≥ vigorous activity than girls.

The interaction between day and gender was nonsignificant in all three ANOVAs (summed counts, $F[1, 25] = 1.99, p = .170$; time spent in moderate activity, $F[1, 25] = 1.55, p = .224$; time spent in ≥ vigorous activity, $F[1, 25] = 2.57, p = .121$). However it should be noted that boys showed a trend to increase time spent in moderate activity on weekend days compared to weekdays whereas girls showed the opposite trend.

Summed counts per day on the X axis were significantly correlated with steps per day on the pedometer on weekdays, $r = .80$, $n = 26$, $p < .001$, and weekend days, $r = .82$, $n = 26$, $p < .001$.

DISCUSSION

The aim of the current study was to determine the most appropriate context in which to implement a physical activity intervention. Children wore pedometers, and in some cases RT-3 accelerometers, and physical activity was measured during school-time and leisure-time and on weekdays and weekends days. The physical activity levels of high-active and low-active children were compared during school-time and leisure-time to determine the location of significant differences between groups.

A clear gender difference was observed with boys significantly more active than girls in almost all of the analyses conducted. The only instance when this gender difference was not observed was time spent in moderate-intensity activity during school-time (44.4 min vs. 40.0 min for boys and girls, respectively) for the subsample of children who wore RT-3 accelerometers. The finding that boys are more active than girls is consistent with the literature (Riddoch et al., 2004; Rowlands et al., 1999, 2002; Sallis, Prochaska, & Taylor, 2000; Trost et al., 2002; Vincent & Pangrazi, 2002a). On weekdays, boys and girls averaged 17,054.6 and 13,091.0 steps per day, respectively. These values are somewhat higher than the mean daily step counts reported by Vincent and Pangrazi (2002a), of 13,162 for boys and 10,923 for girls. These differences may be attributable to different geographical locations of the current study (North Wales) and the study by Vincent and Pangrazi (southwest United States). Indeed mean steps per day in the current study are similar to those reported by another study carried out in North Wales of 16,035 and 12,729 for boys and girls, respectively (Rowlands et al., 1999). Consistent with Vincent and Pangrazi, the sizeable standard deviations in the current study indicate substantial inter-individual variability in activity levels. This suggests that while some children exhibited high levels of activity, other children were more sedentary.

For both girls and boys, high-active children were significantly more active than low-active children, regardless of the measurement period. Thus, differences in activity level between highly active and less active children were present both at school and during leisure-time. Due to the structured environment of school, Vincent and Pangrazi (2002a) postulated that inter-individual differences in activity level would be expected to occur predominantly outside of school. This was not supported by the current study which indicated that high-active children were more active than low-active children during both leisure-time and school-time. This suggests that interventions to increase the physical activity of low-active children are needed in both contexts.

As stated in Chapter 3, school-time presents a number of opportunities to increase children's physical activity, such as physical education classes (Sleap & Warburton, 1992) and playtime (McKenzie et al, 1997; Stratton, 1999). However an alternative approach to focussing on one time period or context is to increase the total amount of physical activity that is accumulated throughout the day. Research reviewed in Chapter 3 indicates that pedometers may be used to increase physical activity in children by making access to a reinforcer contingent upon achieving a specified number of steps (Goldfield et al., 2000). The reward contingency could specify an increase in total steps over the course of an entire day which would enable both school- and leisure-time to be targeted. This approach is adopted in the intervention studies reported in Chapters 6 and 7 of this thesis.

The analysis of the weekday pedometer data indicated that, overall, children were significantly more active during leisure-time compared to school-time, although analyses for separate gender indicated that this increase was significant in boys only. The accelerometer data from the subsample of children were consistent with the pedometer data showing that, overall, activity counts were higher and children spent more time in moderate intensity activity during leisure-time compared to school-time. Interestingly, neither boys nor girls showed a significant change in time spent in vigorous intensity activity from school-time to leisure-time. It therefore appears that higher levels of physical activity during leisure-time are due to children increasing time spent in moderate intensity activities. Vigorous physical activity during free-time thus represents a target for future intervention efforts. It is important to remember, however, that sustained periods of vigorous activity do not appear part of preadolescent children's naturalistic activity patterns (Bailey et al., 1995; Trost et al., 2002). In relation to this, when the time sampling interval (epoch) of the accelerometer is set to 60-s, as in the current study, short time periods of high activity counts may not be detected leading to underestimation of vigorous activity (Nilsson et al., 2002).

The current study found that girls were significantly less active on weekend days compared to weekdays while boys showed no significant difference in activity level. This differential trend for boys and girls has not been shown by other studies in the literature. A study by Rowlands et al. (1999), also conducted in North Wales, indicated lower levels of objectively-measured physical activity at the weekends compared to weekdays in both boys and girls. In addition, Gavarry et al. (2003) found that French primary school boys and girls were more sedentary on free days than during school days. A study conducted in the US, however, showed the converse, that children were more active on weekend days than weekdays (Trost et al., 2000). Clearly this issue requires further research, however it is possible that differences between studies are due to the different geographical locations, characteristics, and culture of the children sampled.

In addition, the RT3 data indicated that, overall, children spent significantly less time in vigorous activity on weekend days compared to weekdays. Again this suggests the need to target levels of vigorous physical activity during children's free-time. While boys showed a (nonsignificant) tendency to increase the time spent in moderate intensity activity on weekend days compared to weekdays, girls showed the opposite trend. This indicates that the lower level of pedometer-determined physical activity on weekend days in girls was mediated by a decrease in both moderate and vigorous intensity activity.

It was interesting to observe that, unlike boys, girls were significantly less active on weekend days compared to weekdays, and they did not significantly increase their physical activity during leisure-time compared to school-time. This suggests that girls are less likely than boys to respond with increased physical activity once the constraints of school are removed. Indeed, the study by Dale et al. (2000) suggests that restricting children's opportunities to be active at school does not lead to compensatory increased physical activity outside of school. Children, it appears, do not always "make-up" for denied opportunities to be active, and this may be particularly true for girls.

In both boys and girls there was no significant difference in weekday steps per day between children who walked to school and children who to travelled to school by car. Thus the child's mode of transport to school did not have a significant effect on their total level of activity on weekdays. However the current study did not control for the distance that each child was required to walk to school. Anecdotal observations revealed that some children lived in close proximity to the school premises, therefore the walk would accrue few pedometer counts. A significant contribution of active commuting to total daily physical activity may have been found in children who had a longer distance to walk (i.e., > 0.5 miles). Tudor-Locke et al. (2003) found that daily energy expenditure was significantly greater in adolescents who walked to school compared to those who used motorized transport. However, a study with 5-year-olds found that active commuting to school made no difference to overall levels of physical activity in week (Metcalf et al., 2004). It may be the case that active commuting to school contributes to total levels of physical activity in adolescents, but not in younger children.

There was a significant inverse correlation between BMI and steps per day on weekdays in girls only (r = -.33), indicating that a higher BMI was related to a lower number of daily steps. In boys, the correlation was not significant. Rowlands et al. (1999) found a significant negative correlation (r = -.42) between pedometer-determined physical activity and fatness for the whole group of children, and this relationship was stronger among girls compared to boys. Other research reported in Chapter 1 found significantly lower BMIs and less subcutaneous fat among active children compared to less active children (Moore et al., 1995, 2003).

The current study also found a number of significant correlations between the child's BMI and variables assessed by the SDQ. These indicate that, in both genders, a higher BMI was related to a higher level of difficulties as reported by parents. In boys only, a higher BMI was related to a higher level of emotional and peer problems. It is important to note that the measure of child psychological wellbeing was provided by the parent, and furthermore, SDQ variables were correlated with actual rather than perceived BMI. Children who perceive that they are overweight and are dissatisfied with their body weight may be more likely to exhibit psychological problems, regardless of whether they are actually overweight. It has been shown that body dissatisfaction is not restricted to overweight girls (Sands & Wardle, 2003) and that body image concerns are related to higher levels of depression and lower levels of global self-worth among preadolescent children (Phares, Steinberg, & Thompson, 2004). Nevertheless, findings of the current study are consistent with the substantial psychological penalties that are associated with obesity, such as stigmatisation, social isolation, and depression (National Audit Office, 2001; Pierce & Wardle, 1997).

There were no significant correlations between weekday physical activity and any of the SDQ variables in boys or girls. It is possible that the lack of significant relationships was due to the majority of children (86.3%) falling within the *normal* range for scores on the Total Difficulties scale as opposed to *borderline* (10.5%) or *abnormal* (3.2%). This was also true for each of the SDQ scales (i.e., Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems, and Prosocial Behaviour). Thus there was less variability in scores on the SDQ in comparison to the substantial variability observed in children's physical activity. Interestingly, Parfitt and Evans (2001) found that pedometer-determined daily physical activity was negatively associated with anxiety and depression, in a study with 10- to 11-year-old children also conducted in North Wales. The lack of agreement here may be due to the use of different measures; whereas Parfitt and Evans used questionnaires that specifically focused on anxiety and depression (the State-Trait Anxiety Inventory for Children [Spielberger, 1973] and the Children's Depression Inventory [Kovacs, 1985], respectively), the SDQ provides an overview of psychological wellbeing that taps into a number of variables. Despite the lack of significant correlations in the current study, the relationship between habitual physical activity and the SDQ variables merits further investigation. In addition, there is considerable evidence that physical activity is positively associated with self-esteem in children (e.g., Calfas & Taylor, 1994; Gruber, 1986; Parfitt & Evans, 2001; see Mutrie & Parfitt, 1998, for review), and this relationship will be further investigated in Study 3.

As stated in the previous chapter, it is important that the pedometer provides an accurate measure of children's habitual physical activity in the natural environment. In the current study, pedometer counts were highly correlated with summed counts on the RT-3 during school-time ($r = .83$) and leisure-time ($r = .81$), and on weekdays ($r = .80$) and weekend days ($r = .82$). Correlations of this magnitude indicate a strong linear relationship between the measures of total physical activity provided by the pedometer and the RT-3. Similarly, Rowlands et al. (1999) found significant correlations between Tritrac accelerometer counts and pedometer counts in both boys ($r = .85$) and girls ($r = .88$) for up to 6 complete days of wearing the monitors. On the basis of the current findings, the results of Study 1, and previous literature cited in this thesis, the pedometer may be used with confidence as the exclusive measure of habitual physical activity in the remaining studies of this thesis.

In summary, the current study found that low-active children showed lower levels of physical activity than high-active children during both school-time and leisure-time. This suggests that an intervention to increase the physical activity of low-active children is needed throughout the day in both contexts. As well as being less active than boys overall, girls appeared less likely to respond with increased physical activity during leisure-time and at the weekend, once the constraints of school were removed. This emphasises the need for physical activity interventions that are specifically aimed at girls.

CHAPTER 6

STUDY 3:

A PEER-MODELLING, REWARDS, AND PEDOMETER FEEDBACK INTERVENTION TO INCREASE PHYSICAL ACTIVITY IN CHILDREN

INTRODUCTION

Research reviewed in Chapter 1 indicates that a peer-modelling and rewards intervention, the Food Dudes Programme, substantially increases fruit and vegetable consumption in children (Horne et al., 1995, 1998, 2004; Lowe et al., 1998, 2004). The increasing prevalence of obesity, however, emphasises the need to promote both healthy eating and physical activity to children. Therefore, the aim of the current study was to develop a new intervention to target children's physical activity based on the same behavioural principles as those employed in the Food Dudes Programme.

Research reviewed in Chapter 3 suggests that children are influenced to be physically active by significant others in their social environment (e.g., peers, parents). There is a body of evidence showing that children's physical activity increases when the occurrence of physically active behaviour is rewarded (Epstein, Saelens, et al., 1995; Epstein et al., 1984; Fujita, 1995; Katz & Singh, 1986; Taggart et al., 1986). Furthermore, pedometers have been used to increase children's physical activity by making access to a reinforcer contingent upon achieving a specified number of steps (Goldfield et al., 2000).

Drawing on this literature, the current intervention consisted of three behaviour change components;

1). Peer-modelling. The Fit 'n' Fun Dudes, a group of fictional physically active peers were introduced to participants via a song on CD, letters, and personal activity recording materials.

2). Rewards. Participants needed to reach or exceed a personalised pedometer step target (see below) on each day of the intervention in order to receive a daily reward (e.g., sports bottle, ball).

3). Pedometer feedback. Each participant was given a daily pedometer step target which was set to be higher (by 1,500 steps per day) than his/her baseline level of activity. Participants were instructed to accumulate the number of steps specified by their target throughout the entire day (i.e., during both school- and leisure-time).

Two schools participated in the study, with children from one school randomly allocated to receive the intervention and children from the other school serving as the control group. The intervention lasted for 8 school days, and this was followed by a 14-week maintenance phase in which procedures were implemented to help participants maintain their increased activity. Measures of physical activity were taken at baseline, during the intervention, and at 12-week follow-up.

It was predicted that the intervention would increase levels of physical activity in experimental participants, relative to their baseline level of activity and that these increases would be maintained at 12-week follow-up. In contrast, levels of physical activity in control participants were predicted to show no significant change across the three study phases.

Measures of BMI were taken at baseline, at the end of the intervention, and at follow-up to explore potential effects of the intervention on children's body weight. Measures of self-esteem were taken at baseline and at the end of the intervention, and child psychological wellbeing was assessed at baseline using the SDQ. High levels of physical activity at baseline were predicted to be positively correlated with positive self-image, self-esteem, prosocial behaviour, and hyperactivity, and negatively correlated with negative self-image, emotional symptoms, conduct problems, and peer relationship problems. On the basis of literature reviewed in Chapter 1 (Calfas & Taylor, 1994; Gruber, 1986), it was predicted that increasing physical activity as a result of the intervention would significantly enhance children's self-esteem.

METHOD

Participants

Two primary schools in the Llandudno area of North Wales were asked to participate in the study. Following verbal consent to participate from the respective Headteachers, the schools were randomly assigned to either the experimental or the control condition.

Schools were matched in terms of number of pupils, deprivation levels in their catchment areas, and physical education provision (see Table 6.1 below). Both schools were located in residential areas.

Table 6.1
Characteristics of the two schools used for matching.

	Experimental	Control
Total number of children aged 4 to 11 years	281	240
Percentage taking free school meals	14%	15-16%
Number of Physical Education (PE) sessions per week for 7- to 11-year-olds	2	2
Extra-curricular sports offered	Football, rugby, netball	Football, rugby, netball, athletics

All junior-aged children (7- to 11-year-olds) were given a recruitment letter to take home to their parents or guardians. The letter invited children to take part in a research project concerned with encouraging children to adopt healthy lifestyles (see Appendix C1). The letters for the control and experimental schools were kept as similar as possible and parents from the experimental school were given minimal information about the intervention at this stage. Parents were requested to sign a tear-off slip to indicate that they gave consent for their child to participate in the study.

These were returned to school. Initially the study was over-subscribed (Control school, 89 positive responses out of 124, 72% response rate; Experimental school, 87 out of 150, 58% response rate), therefore for practical reasons, a decision was made to limit the study to the oldest children (i.e., those in Year 5 and 6 only). The parents of children who were not invited to participate were sent a letter explaining the reasoning behind this.

In total, 100 boys and girls were invited to participate in the study. There were 47 children from the experimental school, of which 21 were boys and 26 were girls. Experimental boys were aged between 9.0 and 11.1 years (*M* [SD] = 9.8 [0.7] years), and experimental girls were aged between 9.0 and 11.1 years (*M* [*SD*] = 10.0 [0.7] years).

There were 53 children from the control school, of which 29 were boys and 24 were girls. Control boys were aged between 9.2 and 11.1 years (*M* [*SD*] = 10.2 [0.6] years), and control girls were aged between 9.2 and 11.0 years (*M* [*SD*] = 9.9 [0.6] years).

Ethical approval for the study was granted by the School of Psychology Ethics Committee, University of Wales, Bangor.

Measures

Physical activity. Electronic pedometers (Yamax Digiwalker SW-200, Tokyo, Japan) were used to measure each participant's daily level of physical activity. For each week of measurement, physical activity was measured over four consecutive 24-hr periods from Monday until Friday. The pedometer data were recorded by the experimenters at the beginning of the school day therefore measurement was limited to weekdays only. The output measure for physical activity was steps per day.

Pedometers were worn clipped onto the child's waistband on the right-hand side of the body directly in line with the knee. Each pedometer was labelled with the participant's name and subject number.

Throughout the measurement period in the control school, and during the baseline phase only in the experimental school (see *Procedure*), pedometers were sealed with cable ties. This was to prevent the participants from tampering with the unit or viewing their pedometer count. Research reviewed in Chapter 2 suggests that little reactivity occurs when sealed and unsealed pedometers are used (Ozdoba et al., 2004; Rowe et al., 2004; Vincent & Pangrazi, 2002b).

Prior to the commencement of baseline measurement, a total of 130 pedometers were calibrated. A researcher wore each unit and walked a distance of 50 steps whilst simultaneously counting the number of steps taken. The mean percent error shown by the pedometers was 0.57%. No pedometer exceeded 2% error (i.e., more than 1 step incorrectly recorded out of 50). A total of 99 pedometers were re-calibrated prior to the commencement of follow-up measurement. At this stage, one pedometer exceeded 5% error and was thus discarded. The mean percent error shown by the remaining pedometers was 0.96%. One pedometer showed 4% error, however none of the remaining 97 pedometers exceeded 2% error.

Anthropometric assessment. Body mass was measured to the nearest 0.1 kg using a Hanson electronic scale. Height was measured to the nearest 0.1 cm using a tape measure that was attached to a vertical wall. Participants removed their shoes to allow these measures to be taken.

Psychological Wellbeing. Psychological wellbeing was measured using the Strengths and Difficulties Questionnaire (SDQ) (see Chapter 5, *Method* for full description of the SDQ). The parent-completed version of the SDQ for 4- to 16-year-old children was employed.

Self-image and self-esteem. The Butler Self Image Profiles for Children (SIP-C) (Butler, 2001) was used to measure self-image and self-esteem. The SIP-C is a brief self-report measure for children aged between 7 and 11 years. It may be administered to groups of children as well as on an individual basis. The SIP-C has been validated against the Self-Perception Profile for Children (Harter, 1985), and it appears to be reliable for use with this population (Butler, 2001).

The SIP-C conceptualises self-image as the *actual self*, or the way in which an individual describes or construes himself or herself. Self-esteem is conceptualised as the way in which individuals gauge themselves along dimensions considered by them to be important. Self-esteem is thus characterised by the individual's perceived distance between "where I am" (the actual self) and "where I would like to be" (the *ideal self*) (Butler, 2001).

There are 25 self-descriptive items on the SIP-C. Of these, 12 items are positive (e.g., "Kind", "Happy", "Friendly"), 12 items are negative (e.g., "Lazy", "Moody", "Mess About in Class"), and 1 item is neutral ("Feel Different from Others"). For the assessment of self-image (the actual self), respondents are requested to consider each item and to shade the box according to how they rate themselves on that particular attribute on a 0 to 6 scale (where 0 means *not at all like the description*, and up to 6 means *very much like the description*). For the subsequent assessment of the ideal self, respondents are requested to consider the same items and to put a star in the appropriate box according to how they would like to be, again using the 0 to 6 scale. The discrepancy between the actual self and the ideal self scores is used as an estimate of the individual's self-esteem.

To calculate the respondent's Positive Self-Image (SI+ve) score, the scores on each of the 12 positive items are summed (the range of scores is 0 to 72). A high score indicates that the respondent has a positive self-image. The Negative Self-Image (SI-ve) score is calculated by summing the scores on each of the 12 negative items (again, the range of scores is 0 to 72). A high score indicates that the respondent has a negative self-image. The Self-Esteem score is calculated by summing the discrepancy scores on all 25 items (the range of scores is 0 to 150). A high Self-Esteem score reflects a large discrepancy between the actual self and the ideal self and is therefore indicative of low self-esteem.

Participant responses to the intervention. Feedback questionnaires were sent to parents of experimental participants to obtain their views of the intervention (see Appendix C2). There were five items on the questionnaire. Four of the items were closed-ended and required a *yes* or *no* response (e.g., "Did your child enjoy taking part in the Fit n' Fun Dudes project?"). In addition, parents who answered *yes* to the item "Do you feel that your child has benefited from taking part in the Fit n' Fun Dudes project?" were requested to say how they thought their child had benefited. The fifth item was open-ended and requested parents to make any other comments about the Fit n' Fun Dudes project. An identical questionnaire was sent to control parents however items referred to the research project in general. Parents were requested to return the completed questionnaires to the University using a provided freepost envelope and these were entered into a £25 prize draw. The questionnaires were resent to both experimental and control parents at the end of the follow-up phase.

During the follow-up, a questionnaire was administered to experimental children to further explore their experiences of participating in the intervention (see

Appendix C2). There were seven items on the questionnaire. Five of the items were closed-ended and required either a *yes*, *no*, or *not sure* response (e.g., "Do you think that the Fit n' Fun Dudes programme helped you to be more physically active?"). In addition, children who answered *yes* to the item "Did you like the Fit n' Fun Dude prizes?" were requested to name their favourite prize. Two items were open-ended. The first open-ended item requested children to list the activities that they did at home and at school to help reach the pedometer target. The second open-ended item requested children to make any other comments about the Fit n' Fun Dudes project.

Materials

All intervention materials and letters were presented in both English and Welsh. Welsh translations were produced by the University Translation Unit.

Rewards. A reward was available on each day of the intervention, contingent on the participant having reached or exceeded their pedometer target. These were presented in the following order; sports bottle, wallet, frisbee, snap band, beaker, straw, slinky spring, ball. All prizes were brightly coloured and were customised with the distinctive Fit n' Fun Dudes logo. There were also two "mystery" prizes, Fit n' Fun Dude T-shirts, that were available for the boy and girl who showed the greatest increase in steps at follow-up relative to baseline. Fit n' Fun Dude certificates were awarded to all children who completed their maintenance diaries (see Appendix C3).

Fit n' Fun Dude song. Prior to the commencement of the study, a group of 10- to 13-year-old children were recruited from a local performing arts school to sing the "Fit n' Fun Dude song", which was professionally recorded onto compact disc. The song was intended to introduce the participants to the four Fit n' Fun Dude characters. The names of the characters were derived from words that are associated with physical activity; "P.D." (speed), "Lexy" (flexibility), "Ren" (strength), and "Mina" (stamina). Each Dude has skills and interests that represent the attribute from which their name is derived (for example, Lexy is very flexible and is thus a keen gymnast). During the Fit n' Fun Dudes song, each character sings a verse to introduce himself or herself. A distinctive chorus, in which the Dudes urge the participants to join them in being physically active, is repeated (Appendix C4).

Fit n' Fun Dude letters. All intervention instructions were given via letters in order to imply to the participants that the intervention was administered by the Fit n' Fun Dudes rather than by the experimenters or teachers. The first group letter from the Fit n' Fun Dudes contained general encouragement to be physically active as well as instructions for the participants concerning the intervention procedures (see Appendix C5). Participants were told to try to reach their step target every day and that they would receive a daily prize for doing so. They were instructed to open their pedometers and to check their progress towards the target as frequently as they wished. Each child also received a personalised letter from the Fit n' Fun Dudes which reiterated the intervention instructions and reminded them of their target (Appendix C5).

During the maintenance phase, participants received three further letters that prompted them to continue wearing the pedometers. In addition, participants were encouraged to try and reach their targets on as many days as possible. The letters reminded participants of the certificates and mystery prizes that would be awarded at the end of the phase.

Homepack and maintenance diary. The Homepack was for each participant's use at home during the intervention. It included a picture of each Fit n' Fun Dude character and the lyrics of the song. It also contained a chart for participants to record the number of times that they did some form of physical activity on each day of the intervention (see Appendix C6). There were also suggestions and ideas of ways to be more active. A letter to parents that explained the intervention procedures was included with the Homepack.

The maintenance diaries were designed so that participants could record their daily pedometer data continuously for the duration of the maintenance phase (Appendix C7). Each participant's target step count was clearly shown in his or her diary as a reminder. A covering letter was included with the diaries to inform parents of the maintenance procedures. The letter also contained ideas that could be used by parents to continue encouraging the participants to be physically active.

Design

A between-groups experimental design was employed, whereby comparisons were made between the experimental school and the control school on the dependent variables. The design employed a number of experimental phases that spanned a 20-week period (see Figure 6.1). Thus, within-subject comparisons over time were also made.

Beginning in November 2003, prebaseline measurements were carried out prior to beginning the baseline/baseline 1 phase (see Figure 6.1). The baseline/baseline 1 phase was 8 days in duration but in total it spanned 2 weeks. This was because although there were 5 school days each week, it was only possible to collect data in complete 24-hr cycles on 4 of these days.

Following completion of the baseline/baseline 1 phase, the experimental school participated in the 8-day intervention phase whilst the control school remained under baseline conditions (i.e., baseline 2; see Figure 6.1). As before, the intervention/baseline 2 phase spanned 2 weeks.

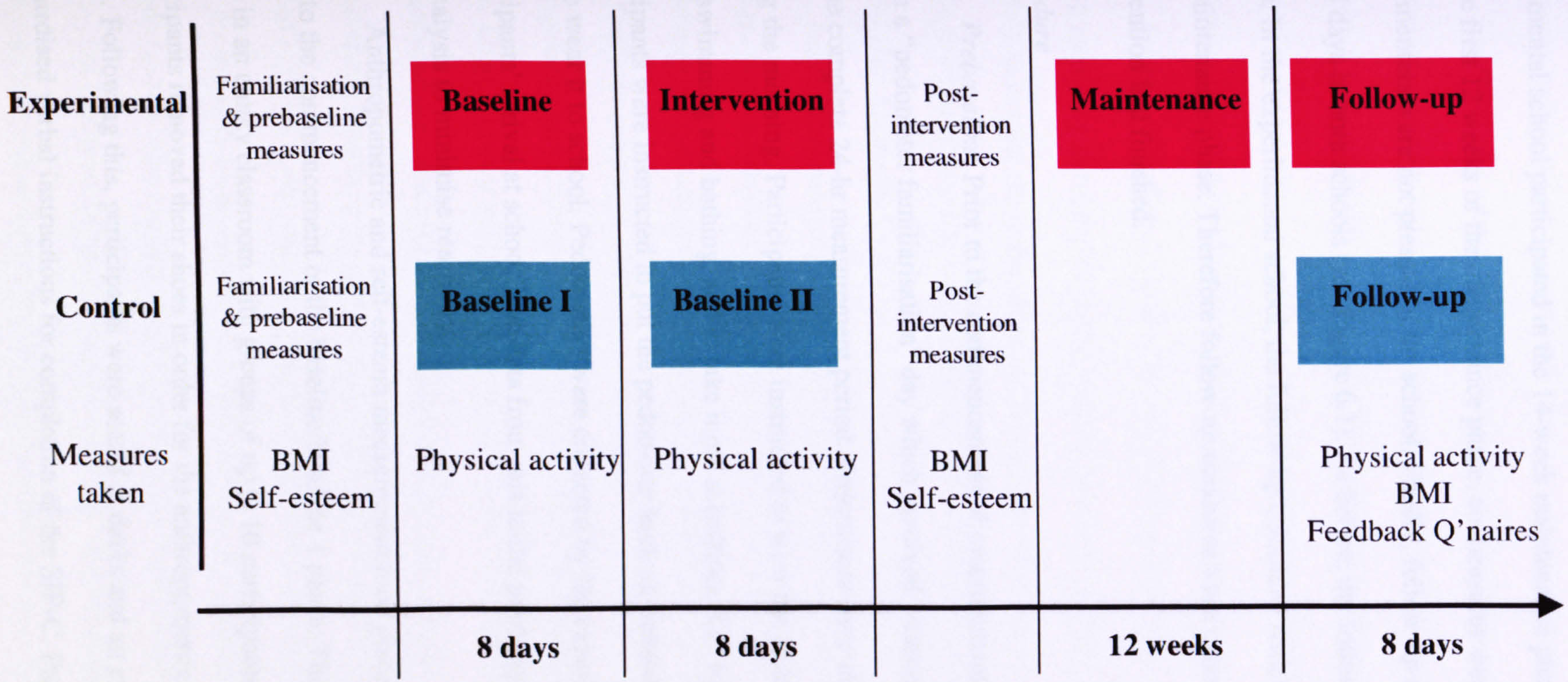


Figure 6.1. Overview of the study design

Following completion of the intervention/baseline 2 phase, only the experimental school participated in the 14-week maintenance phase (see Figure 6.1). For the first 12 weeks of the maintenance phase, no measures were taken and the experimenters were not present in the school. Finally, follow-up measures were taken over 8 days in both schools (see Figure 6.1). As before, the follow-up spanned 2 weeks. In the experimental school, the follow-up coincided with the final 2 weeks of the maintenance phase. Therefore follow-up measures were taken 12 weeks after the intervention had finished.

Procedure

Prebaseline. Prior to the commencement of measurement, all participants took part in a "pedometer familiarisation" day which involved wearing sealed pedometers for one complete 24-hr measurement period. Pedometers were distributed at school during the morning. Participants were instructed to wear the pedometer all day, apart from swimming and bathing, and to take it off at bedtime. The following morning, participants were instructed to put the pedometer back on immediately after dressing and to wear it to school. Pedometers were collected by the experimenters upon the participants' arrival at school. The data from this initial pilot day were discarded from the analysis to minimise reactivity.

Anthropometric and self-esteem measurement took place at school, 1 week prior to the commencement of the baseline/baseline 1 phase. These measures were taken in an empty classroom with groups of up to 10 participants at a time. Participants removed their shoes in order for the anthropometric measurements to be taken. Following this, participants were seated at desks and an experimenter read out standardised verbal instructions for completion of the SIP-C. Participants subsequently read the checklist and indicated their responses independently and in silence. Up to four experimenters were present at all times to supervise the participants and to answer any queries.

The SDQ was sent to the parents of all participants by mail. Parents were requested to complete and return the questionnaire to the University using a freepost envelope. The deadline for returning the SDQs was the final day of the baseline/baseline 1 phase. In addition, parents received a letter that contained written information about the baseline/baseline 1 phase of the study.

Baseline/Baseline 1. On the first day of baseline/baseline 1, children were given a recording sheet and covering letter to take home to their parents. Parents were requested to use the recording sheet for the duration of the study to record any times that the pedometer was not worn, including the length of time and the reason for its removal (see Appendix C8).

Pedometers were distributed to the participants on Monday morning at around 9:15 a.m. For the remainder of the week, a team of between two and four experimenters visited the schools at 8:45 a.m. to record each participant's pedometer count from the preceding 24-hr measurement period. Experimenters waited outside the classrooms and collected pedometers from the participants as they arrived at school. Once all pedometers had been collected, the experimenters opened the units and recorded the counts for each participant. At no point did the experimenters reveal the pedometer counts to the participants. After recording, pedometers were reset and resealed with cable ties, and they were returned to the participants within 30 min ready for the next 24-hr measurement period. Thus, on Tuesday, Wednesday, Thursday, and Friday mornings, activity data were recorded for complete 24-hr periods. On Friday morning, pedometers were not returned to the participants following recording and were kept by the experimenters over the weekend.

Pedometers were redistributed to the participants on the following Monday morning and the same procedure was repeated for the second week of baseline/baseline 1 measurement.

Every Tuesday for the duration of the study, 35 of the experimental participants went swimming for the first lesson of the day. This meant that, during baseline, the experimenters did not have sufficient time to do the recording and return the pedometers before the participants left for the swimming baths. On these days, the experimenters returned the pedometers to the participants upon their arrival back at school at around 10:30 a.m. prior to morning playtime. Given that the participants had been swimming and would have removed the pedometers anyway, it was assumed that they would have accrued minimal steps during this period. Physical activity on the swimming day was not significantly different from physical activity averaged over the other days of the week for either boys or girls, $t(15) = -0.23$, $p = .823$, and $t(17) = -0.29$, $p = .774$, respectively.

Intervention/Baseline 2. For experimental participants only, a daily pedometer step target was computed using the baseline data. For each participant, the mean pedometer count (steps per day) during baseline was computed using the pedometer data from the last 3 days of the baseline phase (if a participant had missing data for any of these days then the datum from the previous day was used). Pedometer step targets for each day of the intervention were computed by adding 1,500 steps per day onto each participant's mean baseline pedometer count. Research suggests that 1,500 steps correspond to approximately 15 to 20 min of moderate intensity activity (Goldfield et al., 2000; Tudor-Locke, 2002). To aid participants' understanding and recall of their targets, these were rounded up to the nearest hundred step counts. Thus for a participant who averaged 10,230 steps per day during baseline, the intervention target would be 11,730, which would be rounded up to 11,800 steps per day. As a result participants had their own targets that were individually tailored to their baseline level of activity.

On the first day of the intervention, pedometers were distributed to the participants at around 9:15 a.m., as in baseline. However, pedometers were no longer sealed with cable ties and a label was stuck onto each unit that clearly showed the participant's name and individualised step target. The Headteacher read a group letter to the participants from the Fit n' Fun Dudes. Participants also received a Homepack and a copy of the Fit n' Fun Dudes song on compact disc.

On each day of the intervention, the experimenters were present at school at around 8:45 a.m. each morning to record pedometer counts. However, because pedometers were no longer sealed and participants were actively encouraged to monitor their own pedometer count, recording was done in the participant's presence. Following recording, the pedometers were reset, and the experimenters handed out rewards and administered verbal praise to all participants who had reached their target. Children who had not reached their target were encouraged to keep trying.

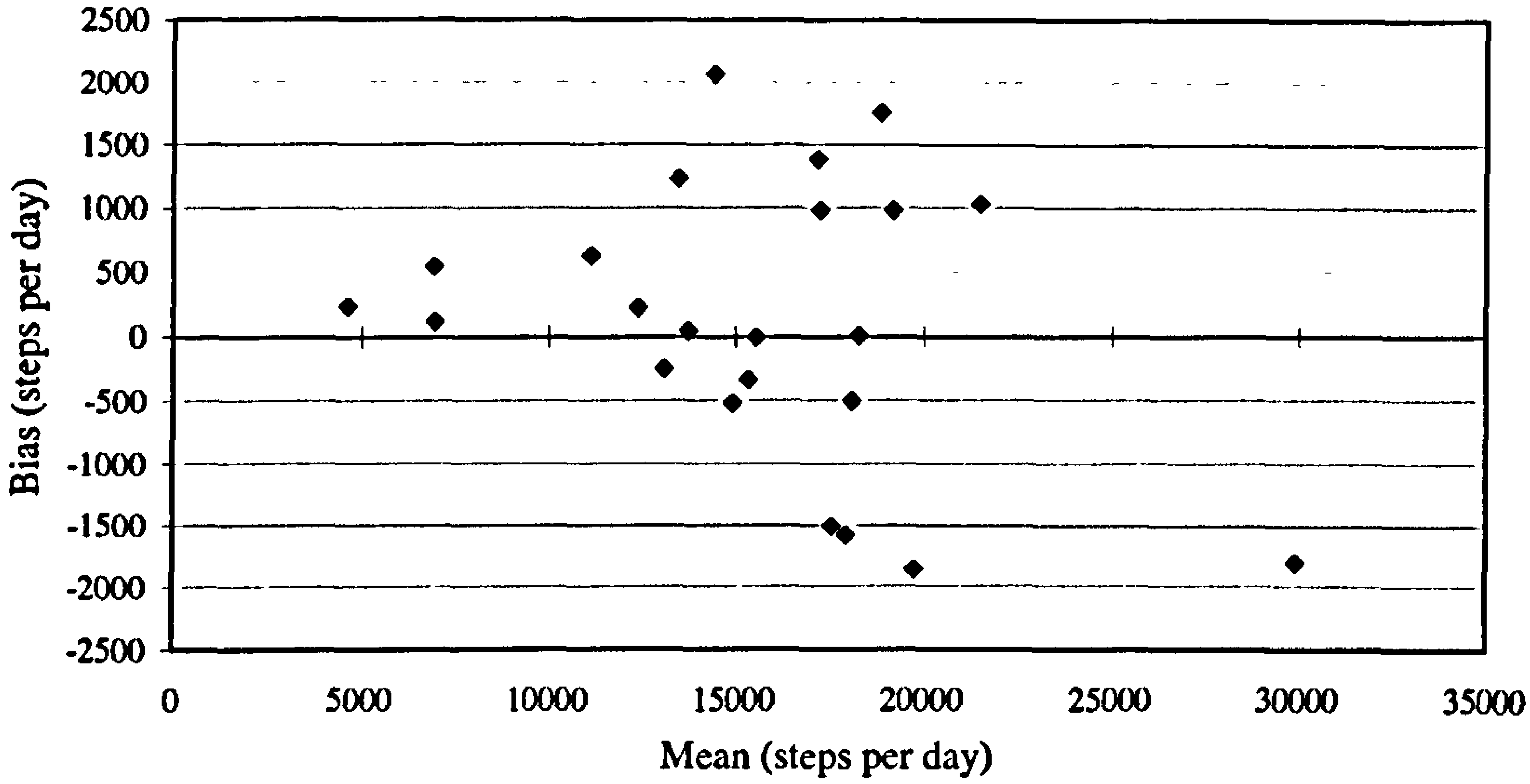


Figure 6.2. Mean bias between sealed and unsealed pedometers plotted against the mean of the two units during intervention

In addition to the unsealed pedometer, a subsample of participants from the experimental group ($n = 23$) also wore a sealed pedometer on the opposite side of the body for 1 day. Previous research (Bassett et al., 1996) and the results of Study 1 indicate no significant differences in recorded step counts between pedometers worn on the right side of the body and pedometers worn on the left. The aim of the sealed pedometer was to validate the measure provided by the unsealed pedometer, in particular to determine whether participants were "cheating" by shaking the unsealed pedometer to gain extra counts. The bias between the two units was calculated by subtracting the sealed pedometer reading from the unsealed reading. If the unsealed pedometer was higher than the sealed pedometer, a positive bias was obtained. A consistent positive bias would suggest that unsealed pedometers were consistently higher than sealed pedometers as would be expected if cheating were occurring. Figure 6.2 shows that no systematic trend was observed in the distribution of bias plotted against the mean of the sealed and unsealed units. In some cases the unsealed reading was higher than the sealed but in other cases the reverse was true. The Bland and Altman 95% Limits of Agreement (LoA) analysis calculated the mean bias as 126.5 ± 2,149.9 steps per day (an interval within which 95% of differences between the measurements are expected to lie; Bland & Altman, 1999). Differences between the sealed and unsealed pedometers may have been caused by interunit variations, although Bassett et al. (1996) found that the Yamax pedometer was very consistent between units.

While the intervention took place in the experimental school, the control school remained under baseline conditions (baseline 2). There was no Fit n' Fun Dudes intervention and pedometers continued to be sealed in order to blind participants to their level of physical activity.

Anthropometric and self-esteem measures were retaken 5 to 6 days after the final day of the intervention/baseline 2 phases, following exactly the same procedure as during baseline. At this point, parental feedback questionnaires were also distributed to participants to be taken home to parents.

Maintenance. The maintenance phase began 5 days after the completion of the intervention phase in the experimental school, and ran for 14 weeks. Participants in the experimental school were given their pedometers to keep, and they were also given a Fit n' Fun Dude diary to record their pedometer count each day for the full 14 weeks. The participants reset their own pedometers following each recording and were instructed to try to reach their target on as many days as possible. Instructions were communicated to the participants via personalised letters from the Fit n' Fun Dudes sent during Weeks 1, 7, and 11 of the maintenance phase.

Fit n' Fun Dude certificates were awarded to all children who completed their diaries and brought them into school at the end of the phase. The two mystery prize winners (i.e., the boy and girl who had increased by the most number of steps at follow-up compared to baseline) were also announced at the end of the phase. Certificates and mystery prizes (Fit n' Fun Dude T-shirts) were awarded in the school assembly by the Headteacher.

No maintenance procedures took place in the control school. Pedometers were collected from control participants at the end of the baseline 2 phase, and these were returned on the first day of the follow-up phase.

Follow-up. Anthropometric measures were taken on the first day of follow-up in both schools.

In the experimental school, the children continued to wear their (unsealed) pedometers and these were additionally used for measurement, as during the intervention phase. Children were instructed to continue with their own recording of pedometer counts (see *Maintenance procedures*, above), but they were told to not reset their pedometers. On each day of the follow-up, the experimenters were present at school at around 8:45 a.m. each morning to record pedometer counts. This was done in the presence of the participant, and verbal praise was administered if targets were achieved. Following recording, experimenters reset each pedometer to begin the next measurement period.

In addition to the unsealed pedometer, a subsample of participants from the experimental group (n = 12) also wore a sealed pedometer on the opposite side of the body for 1 day, as during the intervention. The Bland and Altman 95% LoA analysis calculated the mean bias between the two units as -493.1 ± 1,592.1 steps per day. Figure 6.3 shows that no systematic trend was observed in the distribution of bias plotted against the mean of the sealed and unsealed pedometers. In some cases the unsealed reading was higher than the sealed but in other cases the reverse was true.

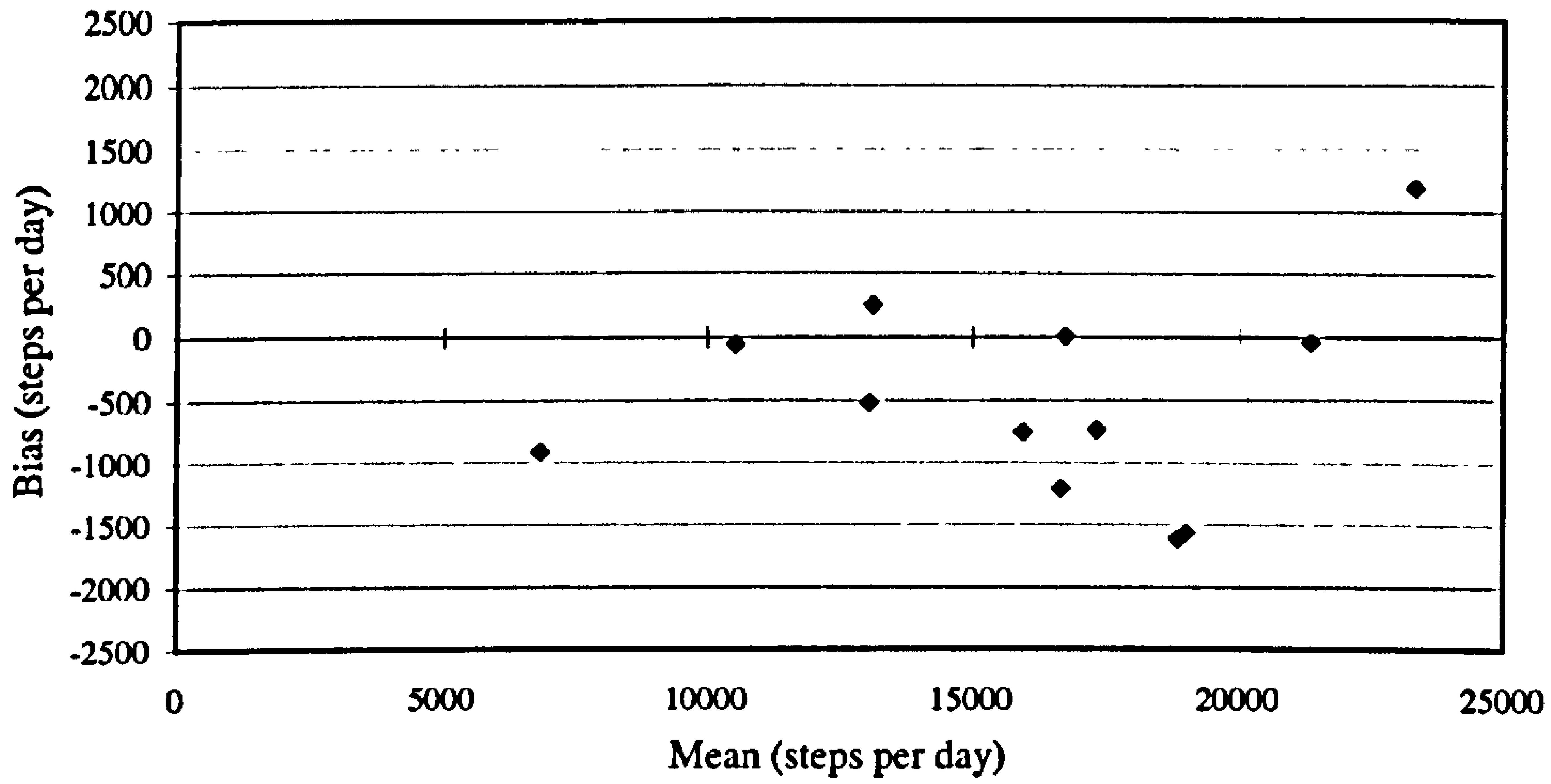


Figure 6.3. Mean bias between sealed and unsealed pedometers plotted against the mean of the two units during follow-up.

Follow-up measures of physical activity were taken concurrently in the control school. Follow-up procedures in the control school were identical to those employed during the baseline 1 and baseline 2 phases.

Approximately 3 weeks after the follow-up had finished, parents in both schools were sent a written report of the research findings by post. A copy of the parental feedback questionnaire was enclosed and parents were asked to complete and return this to the University.

RESULTS

Inclusion Criteria

Only participants for whom there were at least three physical activity data points in each of the three study phases were included in the analysis. Data for a total of 9 participants (6 boys, 3 girls) from the experimental school were excluded on this basis. Of these, 3 children (1 boy and 2 girls) left the school before the follow-up began, 2 boys missed entire experimental phases due to their being on holiday, and the remaining 4 children (3 boys and 1 girl) regularly forgot to wear the pedometers at follow-up. The 9 excluded children did not differ significantly from the remaining experimental group sample on baseline age, height, mass, or BMI. Similarly, the data for 2 participants (1 boy and 1 girl) from the control school were excluded because these children regularly forgot to wear their pedometers. The 2 excluded children did not differ significantly from the remaining control group sample on baseline 1 age, height, mass, or BMI,

The parental recording forms were used to ensure that children had worn the pedometers for the entire day. If, according to the recording form, the pedometer was not worn for more than 2 consecutive hours, then the data point for that day was excluded from the analysis.

Following these exclusion procedures, the mean number of full days that pedometers were worn was computed for the two groups during the three study phases (Table 6.2). Each phase consisted of 8 days. Between-group comparisons were carried out to determine whether there were significant differences between the experimental and control groups on the number of days that pedometers were worn. Given that mean values were not drawn from normal distributions, nonparametric

Mann-Whitney *U* tests were employed. During baseline/baseline 1 and intervention/baseline 2 there were no significant between-group differences. At follow-up, control children wore their pedometers on significantly more days than experimental children.

Table 6.2

Mean number of full days (*SD*) that pedometers were worn and between-group Mann-Whitney *U* comparisons.

	Experimental ($N = 38$)	Control ($N = 51$)	Mann-Whitney *U* and *p*-value
Baseline/Baseline 1	7.0 (1.3)	7.1 (1.2)	925.0, $p = .696$
Intervention/Baseline 2	6.9 (1.3)	6.9 (1.3)	919.0, $p = .661$
Follow-up	5.8 (1.5)	6.8 (1.6)	597.5, $p < .005$*

* $p < .02$ (required significance level after Bonferroni adjustment).

Unless otherwise specified, an alpha level of .05 was used for all statistical tests.

Physical Activity

Three scores were computed for each participant; mean physical activity during baseline/baseline 1, mean physical activity during intervention/baseline 2, and mean physical activity during follow-up. In all cases, physical activity was measured as steps per day. To minimise the effects of novelty and reactivity, mean scores were computed using the pedometer data from the last 3 days of each experimental phase. Any missing data were replaced with data from the previous days of measurement. This procedure ensured that the mean scores comprised the same number of observations across participants. Previous research indicates that 3 days of weekday pedometer measurement are sufficient to obtain reliable estimates of children's physical activity (Ozdoba et al., 2004).

Baseline characteristics of the sample are shown in Table 6.3 for age, anthropometric variables, and physical activity. In addition, participants were categorised as overweight/obese using international cut-off points (Cole, et al., 2000). The percentage of overweight/obese participants in the sample was subsequently computed and is shown in Table 6.3.

Table 6.3

Baseline descriptive statistics by gender and school (standard deviations and participant numbers are shown in parentheses).

	Boys		Girls	
	Experimental	Control	Experimental	Control
Age (years)	9.9 (0.7) (15)	10.2 (0.6) (28)	10.0 (0.7) (23)	9.9 (0.6) (23)
Height (cm)	139.3 (5.9) (15)	140.4 (6.4) (27)	138.7 (7.1) (22)	140.9 (6.1) (20)
Mass (kg)	37.2 (7.4) (15)	35.7 (6.3) (27)	34.4 (7.2) (22)	38.2 (7.5) (20)
BMI (kg/m^2)	19.1 (3.5) (15)	18.0 (2.5) (27)	17.7 (2.4) (22)	19.1 (2.7) (20)
Percentage of overweight/obese participants	27% (4/15)	22% (6/27)	14% (3/22)	25% (5/20)
Physical activity (steps per day)	13,452.0 (3,258.4) (15)	12,318.2 (3,474.2) (28)	10,864.0 (2,481.2) (23)	10,264.9 (2,049.9) (23)

Note. Missing data are due to participant absenteeism when measures were taken.

For both genders, independent *t* tests showed no significant differences between experimental and control participants on any of the above variables. Fishers exact test showed that, for both genders, the experimental and control groups did not differ significantly in the frequency of overweight and obese children (Fisher exact probability = .445 for girls, and 1.00 for boys, two-tailed tests).

Pearson's *r* correlation coefficients were computed between baseline/baseline 1 physical activity (steps per day) and baseline/baseline 1 BMI. As there were no significant differences between experimental and control participants on mean physical activity or BMI at this point, these data were combined for the subsequent computation. In girls, there was a significant negative correlation between physical activity and BMI at baseline/baseline 1, $r = -.31$, $N = 42$, $p < .05$. This indicates that having a higher BMI was related to a lower number of steps per day. In boys, following the removal of one outlying data point, the correlation was not significant, $r = -.24$, $N = 41$, $p = .133$.

Mean physical activity for the two groups during baseline/baseline 1, intervention/baseline 2, and follow-up may be seen in Figure 6.4 (girls) and Figure 6.5 (boys).

Figure 6.4 shows almost no difference between experimental and control girls at baseline/baseline 1 (*M* [*SD*] = 10,864.0 [2,481.2] cf. 10,264.9 [2,049.9] steps per day, respectively). However during the intervention/baseline 2, experimental girls increased their activity (*M* [*SD*] = 14,686.1 [2,539.6] steps per day) whilst controls showed little change (*M* [*SD*] = 9,752.2 [2,160.0] steps per day). At follow-up, experimental girls remained higher than their control counterparts (*M* [*SD*] = 13,736.6 [3,287.7] cf. 10,857.1 [2,168.3] steps per day).

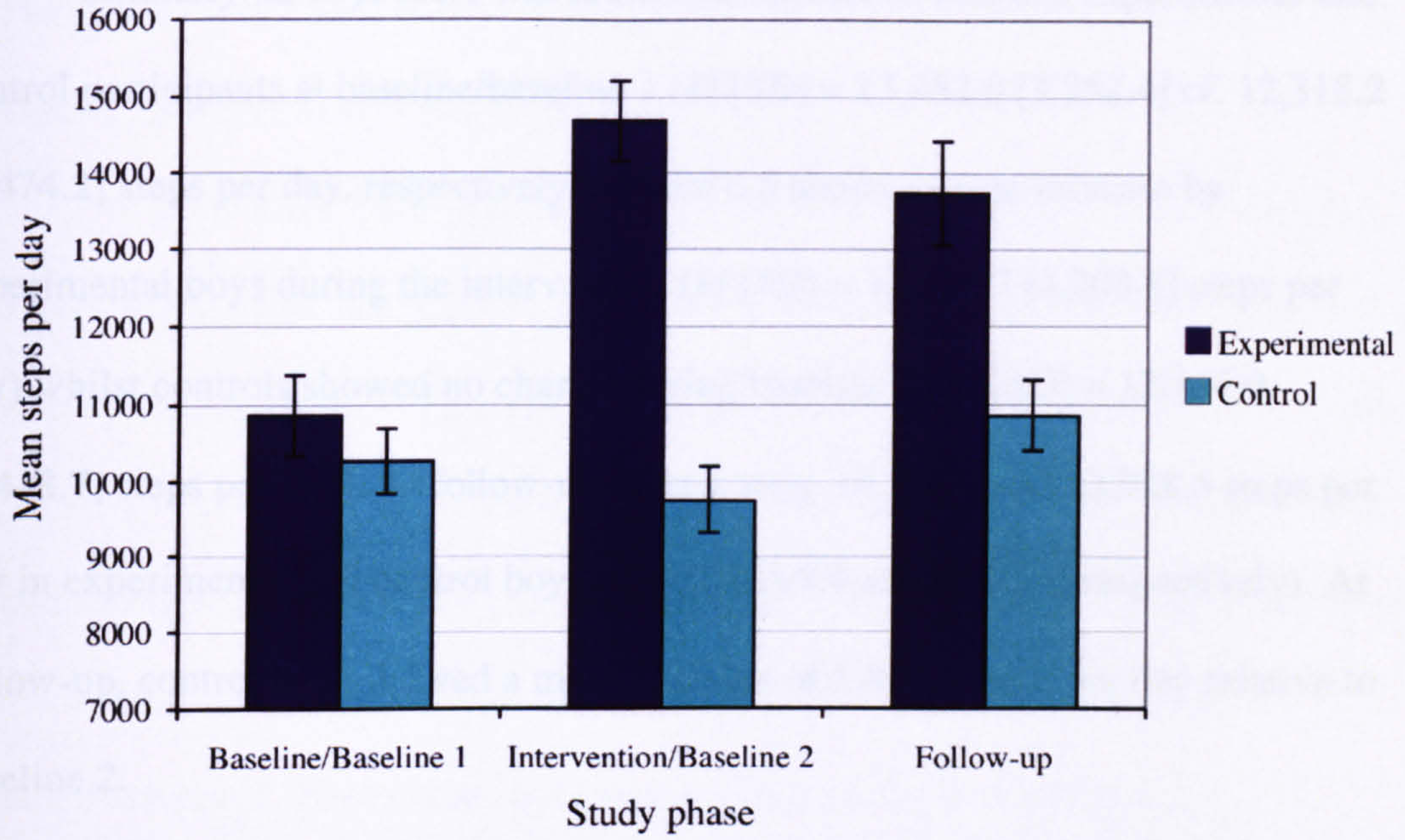


Figure 6.4. Mean physical activity (steps per day) at the three time points in girls. Bars represent ± 1 *SE* of the mean.

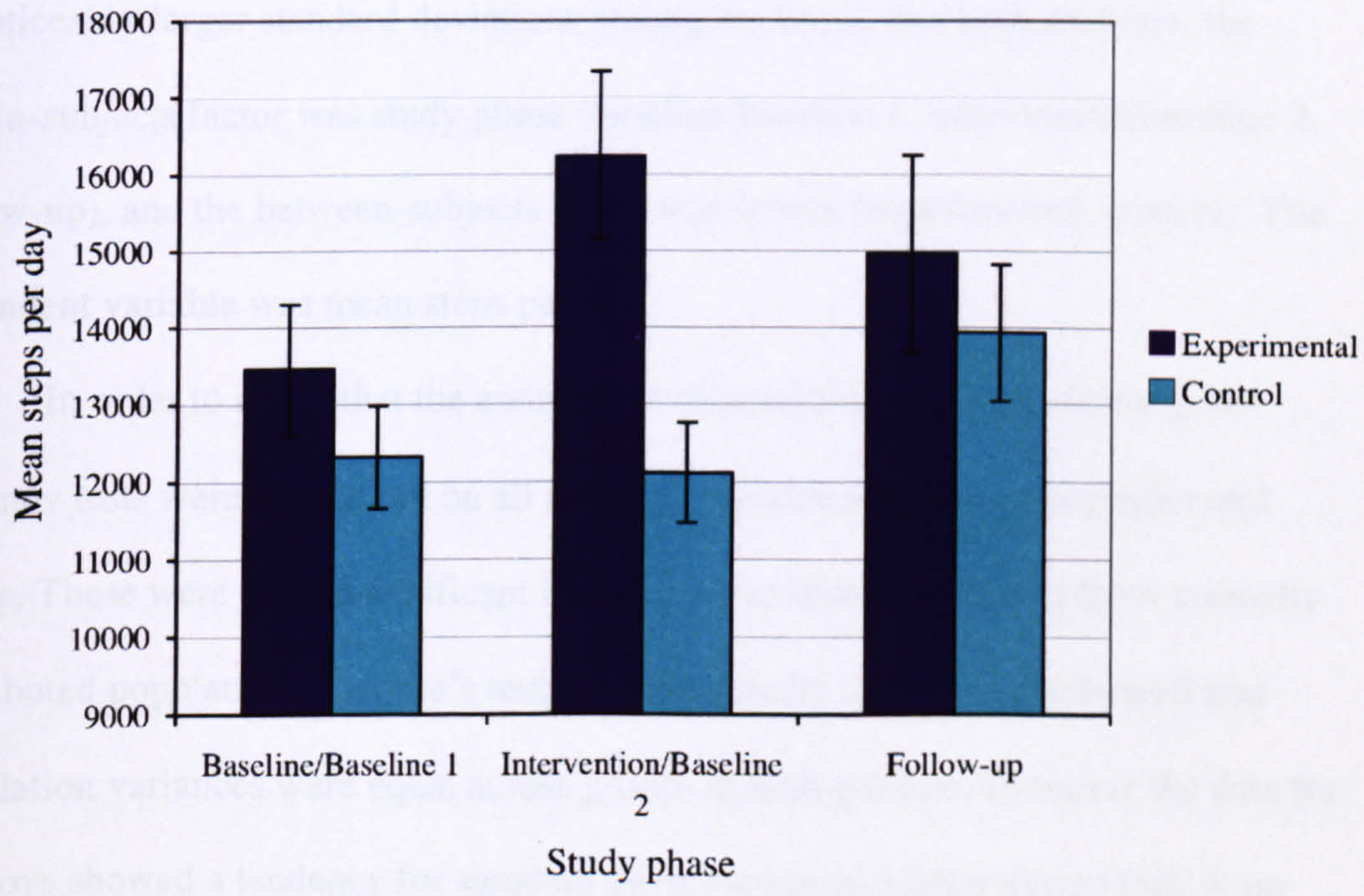


Figure 6.5. Mean physical activity (steps per day) at the three time points in boys. Bars represent ± 1 *SE* of the mean.

Similarly, in boys there was almost no difference between experimental and control participants at baseline/baseline 1 (*M* [*SD*] = 13,452.0 [3,258.4] cf. 12,318.2 [3,474.2] steps per day, respectively). Figure 6.5 shows a large increase by experimental boys during the intervention (*M* [*SD*] = 16,236.7 [4,203.8] steps per day) whilst controls showed no change during baseline 2 (*M* [*SD*] = 12,116.0 [3,418.7] steps per day). At follow-up, means were 14,955.6 and 13,928.5 steps per day in experimental and control boys (*SDs* = 4,999.4 and 4,733.1, respectively). At follow-up, control boys showed a mean increase of 1,812.5 steps per day relative to baseline 2.

Figures 6.4 and 6.5 show that, in both experimental and control groups, boys showed higher activity levels than girls at all time points.

Two-way mixed ANOVAs were carried out for boys and girls separately (due to noticeably larger standard deviations among the boys). For both analyses, the within-subjects factor was study phase (baseline/baseline 1, intervention/baseline 2, follow-up), and the between-subjects factor was school (experimental, control). The dependent variable was mean steps per day.

In order to check that the assumption of normality was met, Kolmogorov Smirnov tests were carried out on all activity measures separately for gender and group. These were all nonsignificant indicating that data were drawn from normally distributed populations. Levene's test for homogeneity of variance indicated that population variances were equal across groups in both genders. However the data for the boys showed a tendency for standard deviations to be higher during follow-up compared to the other two phases, in both the experimental and the control school. To correct this, log10 transformations were carried out on the boys' data prior to carrying out the analysis. Finally, Mauchly's test was significant in the analyses for both genders indicating a lack of sphericity. To correct this, the Huynh –Feldt adjustment to degrees of freedom was employed.

For girls, there were significant main effects of phase, $F(2, 78) = 17.44, p < .001$, and school, $F(1, 44) = 20.18, p < .001$. There was a significant interaction between phase and school, $F(2, 78) = 21.41, p < .001$. A total of nine post hoc t tests were carried out to investigate the significant interaction, with the significance level adjusted to .006. Results of the post hoc tests are reported in Table 6.4. In brief, there were no significant differences in steps per day between the two schools at baseline/baseline 1, however at both intervention/baseline 2 and follow-up, experimental girls had significantly higher step counts compared to control girls. Experimental girls had significantly higher step counts at intervention and at follow-up compared to baseline, but there was no significant difference between intervention and follow-up step counts. In control girls, there were no significant differences in step counts between any of the three phases.

For boys, there was a significant main effect of phase, $F(2, 74) = 3.69, p < 05$, and there was a significant interaction between phase and school, $F(2, 74) = 4.78, p < .05$. There was no significant main effect of school, $F(1, 41) = 3.33, p = .075$. A total of nine post hoc t tests were carried out to investigate the significant interaction, with the significance level adjusted to .006. Results of the post hoc tests are reported in Table 6.5. In brief, experimental boys had significantly higher steps per day than control boys during the intervention/baseline 2 phase, however the two groups did not differ significantly at baseline/baseline 1 or at follow-up. Experimental boys had significantly higher steps per day during the intervention relative to baseline, however follow-up activity was not significantly different from baseline activity or from intervention activity. In control boys, there were no significant differences in steps between the three phases.

Table 6.4

Results of between-group and paired-sample post hoc *t* tests for girls (*N* = 23 in experimental school; *N* = 23 in control school).

Comparison	Means (*SD*)	*t* value (*df*)
	Between-group comparisons	
Experimental baseline cf. control baseline 1	10,864.0 (2,481.2) 10,264.9 (2,049.9)	-0.89 (44)
Experimental intervention cf. control baseline 2	14,686.1 (2,539.6) 9,752.2 (2,160.0)	-7.10 (44)*
Experimental follow-up cf. control follow-up	13,736.6 (3,287.7) 10,857.1 (2,168.3)	-3.51 (44)*
	Experimental school	
Baseline cf. intervention	10,864.0 (2,481.2) 14,686.1 (2,539.6)	-9.41 (22)*
Intervention cf. follow-up	14,686.1 (2,539.6) 13,736.6 (3,287.7)	1.64 (22)
Baseline cf. follow-up	10,864.0 (2,481.2) 13,736.6 (3,287.7)	-4.59 (22)*
	Control school	
Baseline 1 cf. baseline 2	10,264.9 (2,049.9) 9,752.2 (2,160.0)	1.80 (22)
Baseline 2 cf. follow-up	9,752.2 (2,160.0) 10,857.1 (2,168.3)	-2.65 (22)
Baseline 1 cf. follow-up	10,264.9 (2,049.9) 10,857.1 (2,168.3)	-1.43 (22)

* $p <$ .006 (required significance level after Bonferroni adjustment).

Table 6.5

Results of between-group and paired-sample post hoc t tests for boys ($N = 15$ in experimental school; $N = 28$ in control school).

Comparison	Untransformed means (SD)[a]	t value (df)[b]
	Between-group comparisons	
Experimental baseline cf. control baseline 1	13,452.0 (3,258.4) 12,318.2 (3,474.2)	-1.07 (41)
Experimental intervention cf. control baseline 2	16,236.7 (4,203.8) 12,116.0 (3,418.7)	-3.25 (41)*
Experimental follow-up cf. control follow-up	14,955.6 (4,999.4) 13,928.5 (4,733.1)	-0.76 (41)
	Experimental school	
Baseline cf. intervention	13,452.0 (3,258.4) 16,236.7 (4,203.8)	-6.53 (14)*
Intervention cf. follow-up	16,236.7 (4,203.8) 14,955.6 (4,999.4)	1.52 (14)
Baseline cf. follow-up	13,452.0 (3,258.4) 14,955.6 (4,999.4)	-1.36 (14)
	Control school	
Baseline 1 cf. baseline 2	12,318.2 (3,474.2) 12,116.0 (3,418.7)	0.40 (27)
Baseline 2 cf. follow-up	12,116.0 (3,418.7) 13,928.5 (4,733.1)	-2.20 (27)
Baseline 1 cf. follow-up	12,318.2 (3,474.2) 13,928.5 (4,733.1)	-2.07 (27)

[a]Displayed means are untransformed values (steps per day). [b]t test results are for log10 transformed means.

* $p < .006$ (required significance level after Bonferroni adjustment).

In order to examine the effects of the intervention on subgroups, participants were divided into low-active or high-active groups depending on their baseline level of activity. Within each school and gender group, a median split was performed on the baseline/baseline 1 physical activity data; participants with a baseline mean steps per day that was below the group median were classified as "low-active", and those who were above the median were classified as "high-active". Among girls, medians were 10,668.0 and 10,139.0 steps per day in experimental and control schools respectively. Among boys, medians were 13,709.0 and 11,817.7 steps per day in experimental and control schools respectively.

Mean steps per day at the three study phases were then calculated for the high- and low-active groups to examine how physical activity in these different groups was affected by the intervention. These data are shown in Figure 6.6 (girls) and Figure 6.7 (boys).

Figure 6.6 shows that, in the experimental school, both low- and high-active girls showed substantial increases in steps per day during the intervention (mean increases of 4,323.2 and 3,275.3 steps per day, respectively). At follow-up, both groups maintained increased levels of activity relative to baseline (mean increases of 3,050.0 and 2,679.0 steps per day for low- and high-active, respectively). Thus, low-active girls maintained a 34% increase and high-active girls a 21% increase in activity at follow-up. In the control group, high- and low-active groups showed little change in activity from baseline 1 to baseline 2. At follow-up, however, low-active control girls showed a 17% increase relative to baseline 1 (mean increase of 1,484.7 steps per day). It should be noted that this increase from baseline is less than half of that observed in the low-active experimental girls. At follow-up low-active experimental girls averaged 12,034.1 (*SD* = 2,124.4) steps per day, whereas low-active control girls averaged 10,122.8 (*SD* = 1,969.6) steps per day. Thus the low-active experimental girls remained almost 2,000 steps per day higher than their control counterparts.

Figure 6.7 shows that, among experimental boys, both low- and high-active groups showed increases in steps during the intervention (mean increase of 2,493.8 and 3,117.2 steps per day, respectively). At follow-up, the high-active group maintained an increase of 2,449.7 steps per day from baseline (15% increase). However, the low-active boys had almost returned to their baseline level of activity, maintaining an increase of just 675.8 steps per day. In the control group, low- and high-active boys showed little change in activity from baseline 1 to baseline 2. Both groups showed an increase in steps per day at follow-up relative to baseline 1 (mean increase of 1,542.1 and 1,678.5 steps per day for low- and high-active boys, respectively).

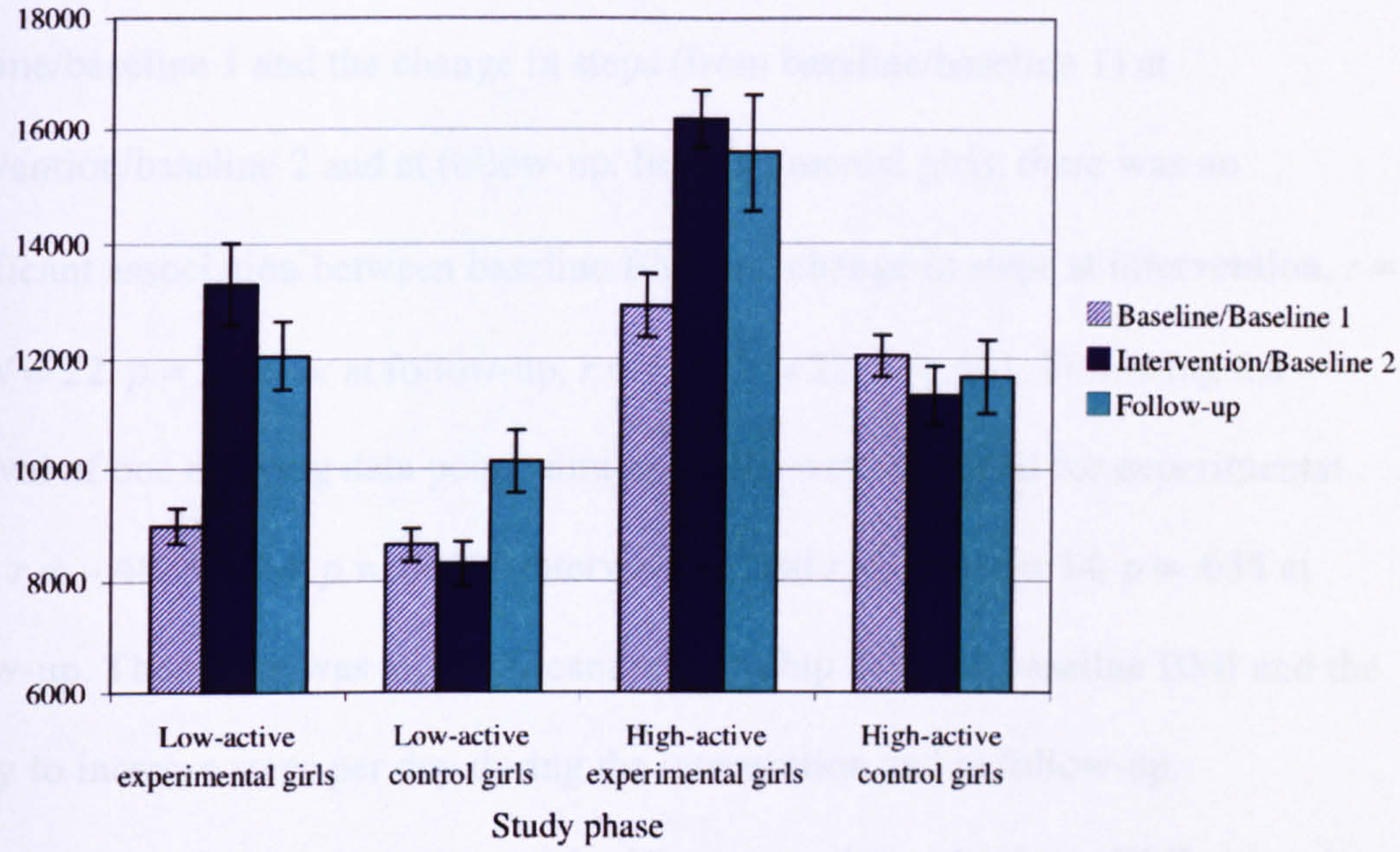


Figure 6.6. Mean physical activity (steps per day) in low- and high-active girls at the three time points. Bars represent ± 1 *SE* of the mean.

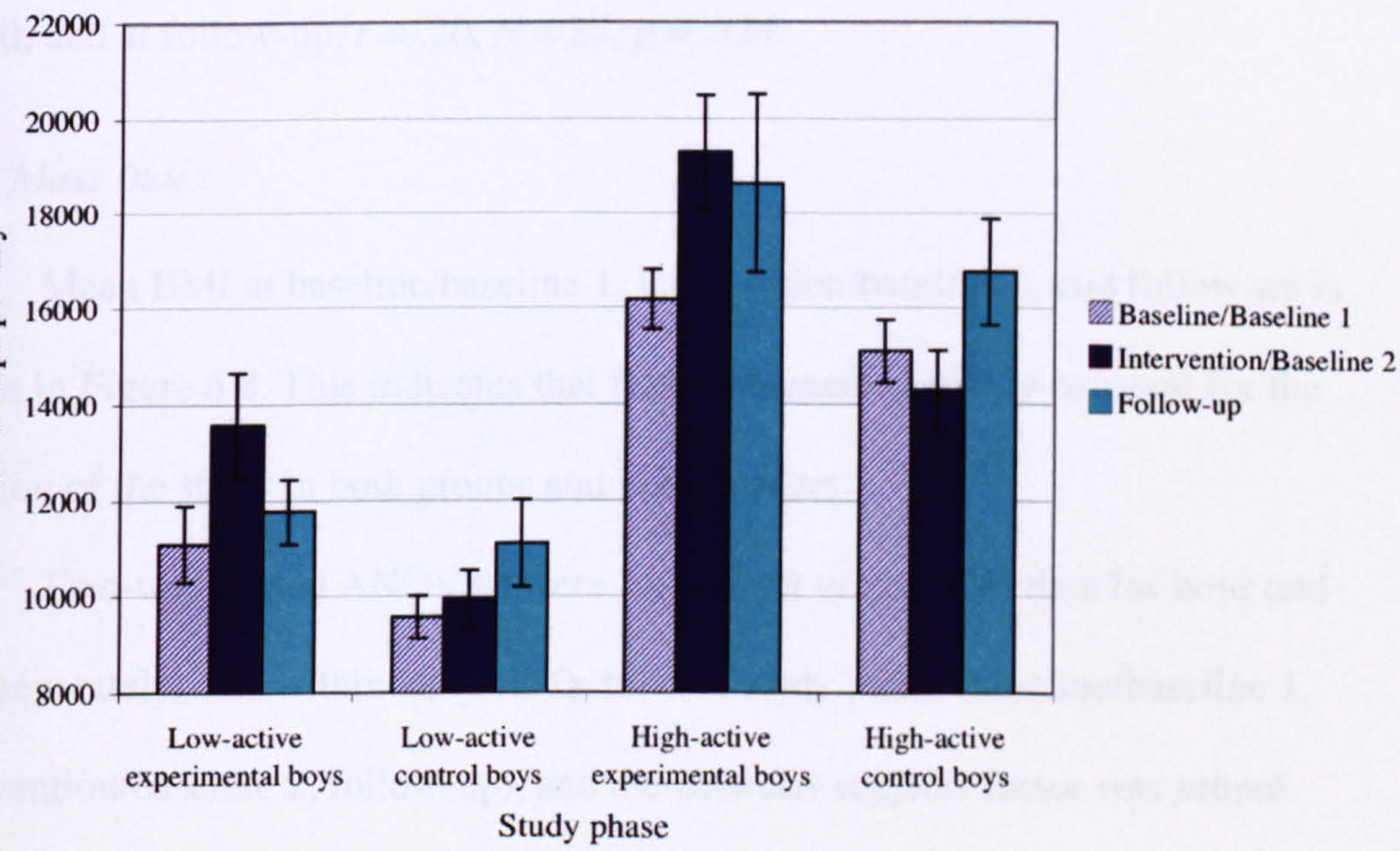


Figure 6.7. Mean physical activity (steps per day) in low- and high-active boys at the three time points. Bars represent ± 1 *SE* of the mean.

In order to examine whether participants' BMI was related to changes in their level of physical activity, correlations were computed between BMI at baseline/baseline 1 and the change in steps (from baseline/baseline 1) at intervention/baseline 2 and at follow-up. In experimental girls, there was no significant association between baseline BMI and change in steps at intervention, $r = .04$, $N = 22$, $p = .877$, or at follow-up, $r = -.10$, $N = 22$, $p = .661$. Following the removal of one outlying data point, similar results were obtained for experimental boys, $r = -.48$, $N = 14$, $p = .084$ at intervention, and $r = -.14$, $N = 14$, $p = .635$ at follow-up. Thus there was no significant relationship between baseline BMI and the ability to increase steps per day during the intervention and at follow-up.

In control girls, there was no significant association between BMI at baseline 1 and change in steps at baseline 2, $r = .05$, $N = 20$, $p = .838$, or at follow-up, $r = -.11$, $N = 20$, $p = .660$. The same was true for control boys at baseline 2, $r = .15$, $N = 27$, $p = .460$, and at follow-up, $r = .20$, $N = 27$, $p = .324$.

Body Mass Index

Mean BMI at baseline/baseline 1, intervention/baseline 2, and follow-up is shown in Figure 6.8. This indicates that BMI remained relatively constant for the duration of the study in both groups and both genders.

Two-way mixed ANOVAs were carried out on the BMI data for boys and girls separately. The within-subjects factor was study phase (baseline/baseline 1, intervention/baseline 2, follow-up), and the between-subjects factor was school (experimental, control). The dependent variable was mean BMI (kg/m^2).

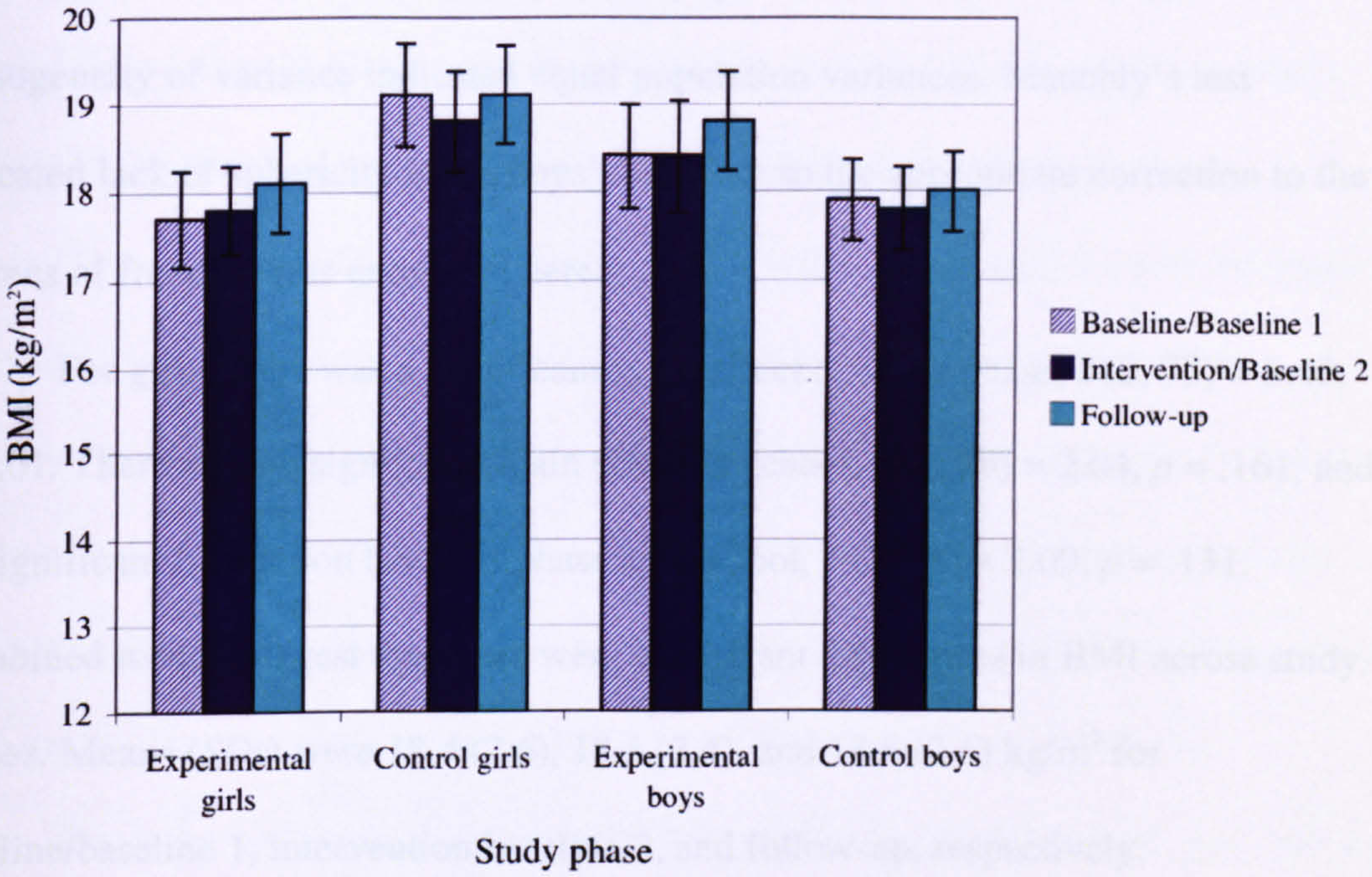


Figure 6.8. Mean BMI (kg/m^2) for the experimental and control girls and boys at the three time points. Bars represent ± 1 *SE* of the mean.

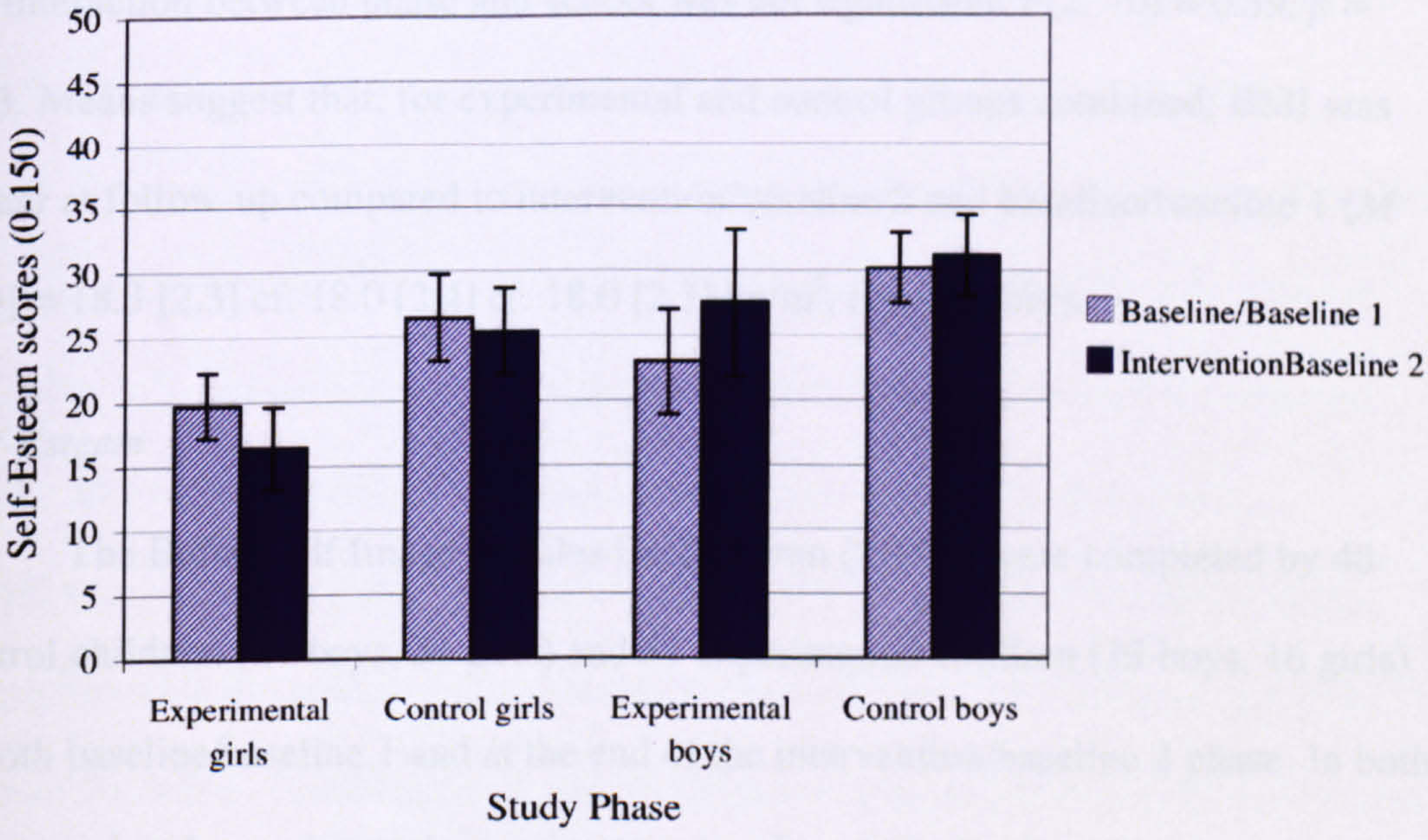


Figure 6.9. Mean Self-Esteem scores on the SIP-C for experimental and control boys and girls at baseline/baseline 1 and intervention/baseline 2. Bars represent ± 1 *SE* of the mean.

Kolmogorov Smirnov tests, carried out on all BMI measures, indicated that data were drawn from normally distributed populations. Levene's test for homogeneity of variance indicated equal population variances. Mauchly's test indicated lack of sphericity in the boys' data only so the appropriate correction to the degrees of freedom was employed here.

For girls, there was a significant main effect of study phase, $F(2, 78) = 5.40$, $p < .01$. There was no significant main effect of school, $F(1, 39) = 2.04$, $p = .161$, and no significant interaction between phase and school, $F(2, 78) = 2.09$, $p = .131$. Combined means suggest that there were significant differences in BMI across study phases. Means (*SDs*) were 18.4 (2.6), 18.3 (2.4), and 18.6 (2.6) kg/m^2 for baseline/baseline 1, intervention/baseline 2, and follow-up, respectively.

For boys, there was a significant main effect of study phase, $F(2, 70) = 4.26$, $p < .05$. There was no significant main effect of school, $F(1, 38) = 0.73$, $p = .399$, and the interaction between phase and school was not significant, $F(2, 70) = 0.59$, $p = .543$. Means suggest that, for experimental and control groups combined, BMI was higher at follow-up compared to intervention/baseline 2 and baseline/baseline 1 (*M* [*SD*] = 18.3 [2.3] cf. 18.0 [2.4] cf. 18.0 [2.3] kg/m^2, respectively).

Self-Esteem

The Butler Self Image Profiles for Children (SIP-C) were completed by 48 control children (27 boys, 21 girls) and 31 experimental children (15 boys, 16 girls) at both baseline/baseline 1 and at the end of the intervention/baseline 2 phase. In both the control and experimental schools, steps per day at baseline/baseline 1 did not differ significantly between children who completed the SIP-C at both time points and children who did not.

Mean self-esteem scores at baseline/baseline 1 and intervention/baseline 2 are shown in Figure 6.9. Recall that a high Self-Esteem score reflects a large discrepancy between the actual self and the ideal self and is therefore indicative of low self-esteem. Given that the range of scores on the SIP-C is 0 – 150, Figure 6.9 indicates that groups showed little change in Self-Esteem scores between study phases.

Two-way mixed ANOVAs for separate genders were carried out to determine whether the intervention had any significant effect on self-esteem. The within-subjects factor was study phase (baseline/baseline 1, intervention/baseline 2), and the between-subjects factor was group (experimental, control). The dependent variable was mean Self-Esteem score. The presence of homogeneity of variance and normality were verified by Levene's test and Kolmogorov Smirnov tests, respectively.

For girls, there was no significant effect of phase, $F(1, 35) = 1.75, p = .194$, or school, $F(1, 35) = 3.37, p = .075$. The interaction between phase and school was not significant, $F(1, 35) = 0.47, p = .496$. For boys, there was no significant main effect of phase, $F(1, 40) = 1.90, p = .176$, or school, $F(1, 40) = 1.17, p = .287$. There was no significant interaction between phase and school, $F(1, 40) = 0.79, p = .381$.

Pearson's r correlation coefficients were computed between baseline/baseline 1 physical activity and baseline/baseline 1 SIP-C measures of Positive Self-Image, Negative Self-Image, and Self-Esteem. Independent t tests conducted for separate gender showed no significant differences between experimental and control participants on any of these variables. Group data were therefore combined within each gender for the computation of correlation coefficients. In both boys and girls, none of the SIP-C variables correlated significantly with physical activity (correlation coefficients may be seen in Appendix C9).

Correlation coefficients were also computed between baseline/baseline 1 BMI and baseline/baseline 1 SIP-C measures of Positive Self-Image, Negative Self-Image, and Self-Esteem. There were no significant differences between experimental and control participants on any of these variables. Group data were therefore combined within each gender. In both boys and girls, none of the SIP-C variables correlated significantly with baseline/baseline 1 BMI (correlation coefficients may be seen in Appendix C9).

Psychological Wellbeing: Correlations with Baseline Physical Activity and BMI

The response rate for the parent-completed SDQ was 76% for the control school; questionnaires were received for 21 boys and 18 girls out of a total of 51 participants. The response rate in the experimental school was 71%; questionnaires were received for 9 boys and 18 girls out of a total of 38 participants. In both the control and experimental schools, children with completed SDQs did not differ significantly from children without SDQ data on baseline/baseline 1 age, height, mass, BMI, or steps per day.

Independent t tests conducted for separate gender showed that at baseline/baseline 1 there were no significant differences between experimental and control participants on physical activity, BMI, or any of the SDQ variables. Therefore data were analysed for the two groups combined within each gender.

Pearson's r correlation coefficients were computed between baseline/baseline 1 physical activity, BMI, and the six SDQ variables (Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems, Prosocial Behaviour, Total Difficulties). In cases where the assumption of normality was not met, Spearman's r_s rank correlation coefficients were computed.

In girls, there was a significant positive correlation between baseline/baseline 1 physical activity and the Prosocial Behaviour scale, $r_s = .57$, $n = 36$, $p < .001$. This indicates that, in girls, higher activity levels were related to higher levels of parent-reported prosocial behaviour. None of the remaining SDQ variables were significantly correlated with physical activity. There was a significant positive correlation between baseline/baseline 1 BMI and the Peer Problems scale, $r = .44$, $n = 33$, $p < .05$. This indicates that, in girls, a higher BMI was related to a higher level of peer problems, as reported by parents. No other SDQ variables correlated significantly with BMI (correlation coefficients may be seen in Appendix C9).

In boys, there were no significant correlations between baseline/baseline 1 physical activity and any of the SDQ variables. There was a significant negative correlation between baseline/baseline 1 BMI and the Conduct Problems scale, $r_s = -.37$, $n = 28$, $p < .05$. This indicates that a higher BMI in boys was related to fewer reported conduct problems by parents. No other SDQ variables correlated significantly with BMI (correlation coefficients may be seen in Appendix C9).

Parent and Child Responses

Parental questionnaires. Responses to the five-item questionnaire that were received from experimental and control parents at the end of follow-up are shown in Table 6.5. Response rates were 29% (11 out of 38) in the experimental group, and 27% (14 out of 51) in the control group.

Table 6.5

Percentage of parents who responded in each category to closed items on the questionnaire at the end of follow-up.

Item	Experimental (n = 11)		Control (n = 14)	
	Yes	No	Yes	No
Did your child enjoy taking part?	100% (11/11)[a]	-	100% (14/14)	-
Has your child benefited from taking part?	82% (9/11)	18% (2/11)	79% (11/14)	21% (3/14)
Has your child started to be more physically active?	64% (7/11)	36% (4/11)	46% (6/13)	54% (7/13)
Did you receive enough information?	100% (11/11)	-	92% (12/13)	8% (1/13)

[a] the number of respondents in each category are shown in parentheses.

Table 6.5 shows that parental responses were very positive in both groups. Chi-square tests showed that control and experimental parents did not differ significantly in the frequency of their responses on any of the items.

The following represents a brief summary of comments made in response to the open-ended questions at the end of follow-up. A full transcript of parental quotes is shown in Appendix C10 (for the experimental parents, responses received at the end of the intervention are also shown in Appendix C10 for descriptive purposes).

Of the experimental parents, almost half made enthusiastic comments about the programme and also commented on how much their children had enjoyed taking part. Five parents (45%) described changes in their children's physical activity as a result of taking part, and examples given were increased outdoor play instead of playing on the computer, walking to school and swimming. Two of these parents, however, commented on the difficulty of maintaining increased activity now that the programme had finished. Six parents reported that their children had become more aware of their own activity levels, more conscious of the importance of physical activity, and that they were enthusiastic to be more active. Two parents suggested that the project be continued by the school.

Among control parents, three parents made enthusiastic comments mainly relating to the importance of promoting physical activity, and a further two parents commented on their children's interest in and enjoyment of the research project. Four parents (28%) reported changes in their children's physical activity, for example being more willing to walk to school and go for bike rides. One of these parents commented that her child was more active during the project but that this diminished with time. Six parents reported that their children had become more aware of their own level of activity and the associated health benefits, and that they were keen to do more. Two parents suggested that the project be continued and that the Fit n' Fun Dudes programme be implemented in the school. One parent would have liked additional information detailing both schools' involvement. Finally two parents made general comments relating to promoting children's physical activity in school, for example, increasing sporting activities, and implementing walking chains.

Child questionnaires. A subsample of 29 children (76% of the sample) from the experimental school completed the seven-item questionnaire during the follow-up. The responses to the closed items are shown in Table 6.6.

Table 6.6

Percentage of children who responded in each category to closed items on the questionnaire

Item	Boys (n = 12)			Girls (n = 17)		
	Yes	No	Not Sure	Yes	No	Not Sure
Did you enjoy taking part?	92% (11/12)[a]	-	8% (1/12)	100% (17/17)	-	-
Did the programme help you be more active?	58% (7/12)	-	42% (5/12)	76% (13/17)	-	24% (4/17)
Did you like wearing the pedometer?	91% (10/11)	-	9% (1/11)	88% (15/17)	-	12% (2/17)
Did you like the prizes?	82% (9/11)	-	18% (2/11)	100% (17/17)	-	-
Did you like the song?	-	20% (2/10)	80% (8/10)	70% (12/17)	12% (2/17)	18% (3/17)

[a] the number of children who responded in each category are shown in parentheses.

There was a significant association between gender and preference for the Fit n' Fun Dudes song (Fishers exact probability < .001, two-tailed test). Table 6.6 indicates that girls were more likely to report liking the song. Boys were more likely to report being unsure or not liking the song. Girls and boys did not differ significantly in the frequency of their responses on any of the other items.

Among boys, the most popular prizes were the frisbee, the snap band, and the slinky spring. For girls, the most popular prize was the sports bottle, followed by the ball, the beaker, and the straw.

Children were also requested to list the types of activities that they undertook to help reach their target. The most commonly reported activity among boys was football, which was reported by 92% of the sample (11 out of 12). Other popular activities were bike riding, playing outdoors, outdoor games (e.g., Tig, Manhunt), and walking. Among girls, the most commonly reported activity was also football (reported by 94% of the sample, 16 out of 17), followed by running, walking, netball, badminton, playing out, and outdoor games (e.g., Tig, Stuck in the Mud, Polo).

Finally, children were asked whether they had any other comments to make about the Fit n' Fun Dudes programme. Of the children who responded in this section, the comments were extremely positive, for example, "its (*sic*) perfect no room to improve" (9-year-old boy), and "it was very fun and helthy (*sic*)" (9-year-old girl). Two children suggested setting up a pedometer club to help increase step counts.

DISCUSSION

The results of this study suggest that a peer-modelling, rewards, and pedometer feedback intervention, the Fit n' Fun Dudes programme, significantly increased levels of physical activity in 9- to 11-year-old children.

At baseline, experimental and control participants did not differ significantly on any of the measured variables. The introduction of the intervention in the experimental school was associated with significant increases in physical activity in both boys and girls. At the end of the 8-day intervention phase, when daily rewards were contingent upon meeting pedometer step targets, girls showed an increase of 3,822 steps per day and boys of 2,785 steps per day (35% increase and 21% increase from baseline, respectively). Both boys and girls in the experimental school were significantly more active than their control counterparts at this point. Importantly, at 12-week follow-up, experimental girls continued to do significantly more physical activity than at baseline, maintaining an increase of 2,873 steps per day (26% increase), and they remained significantly more active than control girls. At follow-up, there was a trend for experimental boys to be more active than control boys, however this was no longer significant.

The pedometer targets required each child to increase by 1,500 steps per day relative to their baseline level of activity, however average increases shown by the children during the intervention were much higher. It is therefore possible that targets were not sufficiently challenging for the children. In future studies it may be beneficial to raise the step increment that is required during the intervention.

The results of the current study are consistent with previous research that shows increases in children's activity levels when physically active behaviours are rewarded (Epstein, Saelens, et al., 1995; Epstein et al., 1984; Fujita, 1995; Katz &

Singh, 1986; Taggart et al., 1986). Previous studies with adults demonstrate that pedometers may be used to increase physical activity, in combination with goal-setting and self-monitoring strategies (Chan et al., 2004; Croteau, 2004; Rooney et al., 2003; Tudor-Locke, Bell, et al., 2004). The current study further adds to this literature by showing that pedometers are very effective in increasing children's physical activity when rewards are made contingent on accumulating a target number of pedometer counts. This is consistent with the laboratory study by Goldfield et al. (2000), however the current study shows that this approach may be used to increase total levels of physical activity throughout the day.

Similarly, Roemmich et al. (2004) showed that children significantly increased their level of daily physical activity when they were given a goal of 400 accelerometer counts per day in order to earn access to a reinforcer (i.e., 60 min of television time). Roemmich et al. found that children who took part in the intervention increased their physical activity by 24% above baseline over the 6-week study, an increase of similar magnitude to that shown by experimental children in the current study.

In addition, the current study employed fictional characters, the Fit n' Fun Dudes, who were designed to be role models for the children to imitate. Regular letters sent to the children from the Fit n' Fun Dudes represented prompts to be physically active. Previous research indicates that prompting and modelling procedures are effective in increasing physical activity in children and adults (Brownell et al., 1980; Katz & Singh, 1986; Lombard et al., 1995). On the whole, girls in the experimental group responded positively to the Fit n' Fun Dudes song, the main peer-modelling component and this may have contributed to their increased physical activity during the intervention. Boys, in contrast, did not respond positively and this suggests that the peer-modelling component had a minimal influence on their activity levels.

At present, it is not possible to estimate the relative contribution to success of individual components of the intervention. For example, it would have been interesting to determine the effects of the pedometer target and feedback on children's physical activity in the absence of rewards. This issue, which is typical of a number of other studies in the literature (e.g., Katz & Singh, 1986; Roemmich et al., 2004), will be further discussed in Chapter 8.

In contrast to girls, experimental boys did not maintain significant increases in activity at follow-up. It is possible that girls were more likely than boys to adhere to the maintenance procedures. During maintenance, children were provided with diaries to record and self-monitor their pedometer counts every day. At follow-up, just under half of girls and a third of boys returned their diaries to the experimenter, which indicates that diaries were not used by all children, particularly boys. Furthermore diaries from only 2 boys showed any sustained periods of recording whereas nine of the 11 diaries from girls showed recording for the duration of the maintenance phase. It is possible that the daily recording procedure was more appealing to girls; boys may have more quickly tired of wearing the pedometers in the absence of the daily rewards. Fewer boys than girls participated in the intervention so girls may have received greater support and encouragement from friends to continue with the maintenance procedures. In addition, it was of great importance that pedometers were worn regularly. In an intervention study with adult women, wearing the pedometer all the time was associated with significant improvements in the amount of physical activity (Rooney et al., 2003). In the current study, however, a number of boys and girls reported losing their pedometers during the maintenance phase. Whatever the explanation may be, it seems clear that children need continual support and encouragement with regard to maintaining increases in physical activity.

Both high- and low-active girls in the experimental school increased their physical activity during the intervention and maintained increases of 21% and 34% at follow-up, respectively. Results thus suggest that girls who were less active at baseline maintained proportionally greater increases in activity at follow-up than did girls who were more active. This is an important finding because it is this group of low-active children who are most in need of increasing their physical activity. Similarly, evaluations of the Food Dudes Programme showed that the largest increases in fruit and vegetable consumption were obtained by those children who ate the least at the outset (Horne et al., 2004; Lowe et al., 2004). At follow-up, low-active boys had relapsed almost to their baseline level of activity, whilst high-active boys maintained a 15% increase, although both groups showed comparable increases in physical activity during the intervention. This indicates that, in contrast to girls, boys who were less active initially were not able to maintain the increases in physical activity that occurred during the intervention. Again this emphasises the importance of effective maintenance procedures.

As predicted, there were no significant changes in the physical activity of control children over the course of the study. There was however a nonsignificant trend for activity levels to be higher during follow-up, compared to the baseline phases of the study, most notably in boys. Recall that follow-up measures were taken in March, while baseline 1 and baseline 2 measures were taken during November and December of the previous year. It is possible that the higher activity levels of control children at follow-up reflect the warmer temperature and lighter evenings in March, which are likely to be more conducive to outdoor play. Indeed, observational studies indicate that spending time outdoors is associated with higher levels of physical activity in children (Baranowski, Thompson, DuRant, Baranowski, & Puhl, 1993; Klesges, Eck, Hanson, Haddock, & Klesges, 1990). Matthews et al. (2001) found increased levels of moderate-intensity activity in adults during summer compared to winter. In addition, Baranowski et al. (1993) found substantial monthly variation in children's activity levels, which they suggest are related to seasonal changes in temperature and humidity. Time of year is therefore an important consideration when conducting research on children's physical activity levels.

Higher activity levels at follow-up in the control school may additionally reflect a novelty effect to the reintroduction of the pedometers; recall that control children had not worn pedometers since the end of baseline 2. In contrast, experimental children had been in possession of their pedometers during the 12-week maintenance phase, from the end of the intervention until the beginning of follow-up measurement. At follow-up control children wore their pedometers on significantly more days than did experimental children which is suggestive of a novelty effect. This may have been reduced by leaving control children with their pedometers for the duration of the 12-week period, however this approach presents practicality issues; pedometer loss would be likely to be high and pedometers would need to remain sealed to prevent contamination effects.

The finding that boys were more active than girls is consistent with Study 2 and with the literature (Riddoch et al., 2004; Rowlands et al., 1999, 2002; Sallis et al., 2000; Trost et al., 2002; Vincent & Pangrazi, 2002a). This further emphasises the need for physical activity interventions that are specifically aimed at girls.

In girls only, a higher BMI was related to a lower level of physical activity at baseline and this finding is consistent with Study 2 and with previous research

(Rowlands et al., 1999). In experimental girls and boys, there was no significant association between BMI at baseline and the ability to increase steps per day. This suggests that participants who were overweight did as well as lean participants during the intervention, an encouraging finding because it is important that overweight individuals are not alienated by physical activity interventions. However, the current study did not find any effects of the physical activity intervention on BMI. It is possible that the anthropometric measures employed were not precise enough to detect subtle changes in BMI; it would have been preferable to use a stadiometer to obtain measures of height. In addition, it is possible that the intervention was not of sufficient length to promote weight loss. The lack of effect of increasing physical activity on BMI will be further discussed in Chapter 8.

The SDQ data indicated that a higher level of physical activity at baseline was related to a higher level of prosocial behaviour in girls, as predicted by the hypothesis that physical activity is psychologically beneficial for children. However there were no other significant correlations between physical activity and the SDQ variables in girls or boys. The lack of association is consistent with the findings of Study 2 and, again, may be due to the majority of the children falling within the *normal* range for scores on the scale.

There were no significant associations between physical activity at baseline and the measures of self-image and self-esteem as provided by the Butler SIP-C. In addition, participation in the physical activity intervention did not significantly enhance children's levels of self-esteem. These findings are surprising in light of previous research suggesting that participation in physical activity is associated with increased self-esteem in children (e.g., Calfas & Taylor, 1994; Gruber, 1986; Parfitt & Evans, 2001). The lack of effect in the current study may be because the participants were drawn from a nonclinical population therefore the vast majority obtained self-esteem scores that fell outside of the *cause for concern* range on the SIP-C (97% and 100% of girls and boys, respectively). Gruber (1986) found stronger effects of physical activity on self-esteem for "handicapped children" (i.e., emotionally disturbed, mentally retarded, economically disadvantaged, perceptually handicapped), who showed lower levels of self-esteem at the outset. Furthermore, physical activity and fitness programmes may enhance self-esteem through positive changes in more specific elements such as body image and sense of physical mastery (Fox, 1988). Of the 25 items on the SIP-C, however, only one item was concerned with physical appearance ("Like the way I look") and one other item was concerned with liking sport. It is therefore possible that the global measure of self-esteem provided by the SIP-C was too general to identify change within specific domains that might be relevant to physical activity.

Additional correlations indicated that a higher BMI at baseline was related to fewer conduct problems in boys, but to a higher level of peer problems in girls. BMI did not correlate significantly with any other SDQ scales or with any of the SIP-C variables. As discussed above, an examination of specific domains of self-esteem may have revealed significant associations with BMI. Phillips and Hill (1998) found significantly lower physical appearance and athletic competence self-esteem among overweight and obese preadolescent girls compared to normal weight girls but there were no statistically significant differences on global self-worth. Furthermore, as discussed in Chapter 5, a measure of body dissatisfaction may have elucidated further significant associations with self-esteem and mental health variables, rather than focusing on the child's actual BMI.

Parents and children responded positively to the intervention. Responses from the control school were also positive and interestingly, several parents in the control school also believed that their children had done more physical activity during the study. Despite a trend to increase at follow-up, the pedometer data show no significant increases in activity. Such findings are suggestive of a "halo effect" as a result of taking part in the study and indicate that parents' estimations of their children's activity levels should be treated with caution.

In the current study, the physical activity intervention was implemented by experimenters. In order to enhance ecological validity, it is now important to show that the intervention may be effectively implemented and managed by individuals in the child's natural environment. Study 4 of the current thesis will therefore evaluate the effects of the physical activity intervention delivered exclusively by the child's parent. The involvement of a parent in the intervention may serve to support the child's increased physical activity, and will additionally enable the inclusion of procedures that specifically target parental physical activity.

In summary, the current study suggests that a peer-modelling, rewards, and pedometer feedback intervention, the Fit n' Fun Dudes programme, was effective in increasing levels of habitual activity in 9- to 11-year-old girls and boys. At 12-week follow-up, girls maintained their increased level of physical activity however a relapse was observed in the group of low-active boys. Future research is needed to identify effective maintenance strategies. The next study will explore the effect of including parents in the intervention on children's ability to increase physical activity, and to maintain these increases over time.

CHAPTER 7

STUDY 4:

A HOME-BASED PEER-MODELLING, REWARDS, AND PEDOMETER FEEDBACK INTERVENTION TO INCREASE PHYSICAL ACTIVITY IN GIRLS AND PARENTS

INTRODUCTION

Research reviewed in Chapter 3 indicates that family support for physical activity is associated with higher levels of activity in children (Sallis et al., 1999). Furthermore, Epstein et al. (1987) found that obese children showed significant maintenance of weight loss at 5-year follow-up when their parents were also targeted for weight loss and behaviour change, whereas children treated without their parents returned to baseline levels. This suggests that involving parents in child interventions enhances the long-term maintenance of the child's behaviour change.

In accordance with this literature, the current study investigated the effectiveness of the physical activity intervention delivered exclusively by the child's parent. It was predicted that the involvement of a parent would support the child in increasing physical activity and maintaining these increases over time. The current study also included procedures to specifically target the physical activity of parents; in brief, parents were given their own daily pedometer target to reach each day and they were encouraged to self-monitor their progress alongside the child. Pedometers may be used to effectively increase physical activity in adults, in combination with goal-setting and self-monitoring strategies (Chan et al., 2004; Croteau, 2004; Rooney et al., 2003; Tudor-Locke, Bell, et al., 2004). It was therefore predicted that parents would also show increased physical activity once the parent intervention procedures were initiated.

Consistent with the literature, previous studies in this thesis indicate that girls show significantly lower levels of habitual physical activity than boys, and this emphasises the need to increase physical activity among girls. Accordingly, the current study included girls only and implementation in the home context meant that physical activity on weekend days could be targeted in addition to weekdays. This is important because Study 2 showed that girls were significantly less active on weekend days compared to weekdays.

The structure of the physical activity intervention and the study design was similar to that employed in Study 3. Girls, aged 9 to 11 years, were recruited from four primary schools. Together with one parent from the household, girls from two of the schools were assigned to the experimental group and girls from the remaining two schools formed the control groups. During the 8-day baseline phase, both children and parents wore pedometers to measure their level of physical under normal conditions. Following this, only the experimental girls took part in the 8-day intervention, which was implemented by the parent, while physical activity of the control girls and both groups of parents was not targeted. The intervention was followed by the maintenance phase for the experimental girls only, and at this point the parent intervention procedures were introduced to experimental parents. Follow-up measures were taken from both groups of children and parents at 12 weeks.

In addition, child and parent BMI was measured at intervals during the study to further explore the effects of the intervention on body weight.

METHOD

Participants

Four primary schools in the Gwynedd and Anglesey areas of North Wales were contacted by the experimenter. In all cases, the Headteacher gave verbal consent for recruitment letters to be distributed among girls from Years 4, 5, and 6 (9- to 11-year-olds). The letter was addressed to parents or guardians. It invited children and one parent in the family to take part in a research project, which would be looking at ways to promote physical activity. The letter advised that the research project would be most suitable for girls who engaged in little or no leisure-time physical activity or sport. No specific information about the intervention was given at this stage (see Appendix D1).

The parents were requested to sign a form to indicate that they gave consent both for their own and their child's participation in the study. The form also asked for the child's and participating parent's date of birth, the participating parent's occupation, and the number of times that the participating parent and child each took part in leisure-time sporting activities on an average week (Appendix D1). Completed consent forms were returned to school, and these were collected by the experimenter approximately 2 weeks after distribution.

Children. In total, 33 girls volunteered to participate. The average age was 10.6 years (SD = 0.7, range = 9.1 – 11.7 years). An individual breakdown for the four schools may be seen in Table 7.1. The response rate was similar in all four schools ranging from 19 to 23%. Overall, children reported taking part in an average of 2.4 (SD = 1.6) sessions of leisure-time sporting activities per week, with participation ranging from zero to seven weekly sessions. Schools A and C reported slightly higher participation in such activities compared to schools B and D. Commonly reported leisure-time sporting activities among children included swimming, netball, gymnastics, dancing, cycling, rounders, walking, and football.

Two of the participants from School C were nonidentical twins and in this case one parent participated alongside both children. In all other households, one child and one parent participated.

Table 7.1

Response rates and information obtained from children and parents who agreed to participate in the study.

	School A	School B	School C	School D
Response rate (%)[a]	23% (8/35)	23% (6/26)	22% (9/41)	19% (10/53)
		Children		
Mean age (*SD*) (range) in years	10.5 (0.6) (9.8 - 11.5)	10.9 (0.5) (9.8 – 11.4)	10.2 (1.0) (9.1 – 11.7)	10.7 (0.7) (9.2 – 11.7)
Mean sessions of leisure-time sport per week (*SD*) (range)	2.9 (2.0) (0.0 – 7.0)	1.8 (1.1) (0.0 – 3.0)	2.8 (2.0) (0.0 – 7.0)	1.9 (1.0) (0.0 – 3.0)
		Parents		
Mean age (*SD*) (range) in years	39.7 (2.8) (36.7 – 44.0)	43.2 (4.5) (36.8 – 49.1)	38.5 (6.3) (31.2 – 48.4)	42.6 (3.8) (38.2 – 52.1)
Percentage male[b]	25% (2/8)	17% (1/6)	13% (1/8)	10% (1/10)
Mean sessions of leisure-time sport per week (*SD*) (range)	1.3 (1.6) (0.0 – 3.5)	2.8 (2.8) (0.0 – 7.0)	1.5 (2.1) (0.0 – 5.5)	2.2 (2.7) (0.0 – 7.0)

[a]Participant numbers are shown in parentheses. [b]Number of male parent participants is shown in parentheses.

Parents. Thirty-two parents participated alongside their children and 84% of the parent participants were female. The average age of parent participants was 41.0 years (*SD* = 4.7, range = 31.2 – 52.1 years). Five of these parents (16%) did not work. Of the remaining parents, the following occupations were reported: teacher/classroom assistant (6 parents), secretary/receptionist (5 parents), civil servant (3 parents), nurse (3 parents), sales advisor/manager (3 parents), lecturer (2 parents), aerobics instructor (1 parent), cleaner (1 parent), kitchen assistant (1 parent), policeman (1 parent), and self-employed (1 parent).

On average, parents reported taking part in 1.9 (*SD* = 2.3) sessions of leisure-time sporting activities per week, with participation ranging from zero to seven weekly sessions. Parents from School B reported the highest level of participation, averaging 2.8 sessions per week. This may be because one of the parents from this school worked as an aerobics instructor (see above). Activities commonly reported among parents included walking, cycling, going to the gym, swimming, golf, and yoga.

Ethical approval for the study was granted by the School of Psychology Ethics Committee, University of Wales, Bangor.

Measures

Physical activity. Physical activity was measured as the mean number of steps taken per day. As in previous studies, pedometers (Yamax Digiwalker SW-200, Tokyo, Japan) were used to measure the number of steps taken by parents and children over complete days. For each experimental phase of the study, physical activity was measured over 6 weekdays and 2 weekend days.

Pedometers were worn clipped onto the waistband on the right-hand side of the body directly in line with the knee. Parents and children were instructed to put the pedometers on while dressing in the morning, to wear them all day with the exception of swimming and bathing, and to take them off at bedtime.

With respect to adult physical activity, Tudor-Locke et al. (2005) found that a minimum of 3 days of pedometer measurement are needed to estimate habitual physical activity in a week at a desirable level of reliability (see Chapter 2).

Children wore pedometers that were sealed with cable ties, however children in the experimental group wore unsealed pedometers during the intervention and follow-up phases (see *Procedure*). As stated previously, research reviewed in Chapter 2 suggests that little reactivity occurs when sealed and unsealed pedometers are used (Ozdoba et al., 2004; Rowe et al., 2004; Vincent & Pangrazi, 2002b). Both control and experimental parents wore unsealed pedometers for the duration of the study.

Prior to the commencement of baseline measurement, a total of 70 pedometers were calibrated. An experimenter wore each pedometer and walked a distance of 50 steps whilst simultaneously counting the number of steps taken. The mean percent error was 0.96%. No pedometer exceeded 2% error (i.e., more than 1 step incorrectly recorded out of 50). A total of 54 pedometers were recalibrated prior to the commencement of follow-up measurement. The mean percent error was 0.48%. Again, no pedometer exceeded 2% error.

Anthropometric assessment. Body mass was measured to the nearest 0.1 kg using a Hanson electronic scale. Height was measured to the nearest 0.1 cm using a tape measure that was attached to a vertical wall. Participants removed their shoes to allow these measures to be taken.

Feedback Questionnaires. Feedback questionnaires were completed by parents and children.

The questionnaire completed by experimental parents had eight items which referred to both the child's and the parent's experience of participating in the intervention (see Appendix D2). Seven of the items were closed-ended and required a *yes, no,* or *not sure* response (e.g., "Did your child enjoy taking part in the Fit n' Fun Dudes project?" and "Did you enjoy taking part in the Fit n' Fun Dudes project?"). In addition, parents who answered *yes* to the item "Do you feel that your child has benefited from taking part in the Fit n' Fun Dudes project?" were requested to say how they thought their child had benefited. Parents who answered *yes* to the item "Do you feel that you have benefited from taking part in the Fit n' Fun Dudes project?" were requested to say how they thought they themselves had benefited. The eighth item was open-ended and requested parents to make any other comments about the Fit n' Fun Dudes project. An identical questionnaire was completed by control parents, however items referred to the research project in general.

The questionnaire for experimental children had eleven items that referred to the child's experience of participating in the intervention and asked for feedback on the intervention materials (see Appendix D2). There were eight closed-ended items that required either a *yes, no,* or *not sure* response (e.g., "Do you think that the Fit n' Fun Dudes programme helped you to be more physically active?"). In addition, children who answered *yes* to the item "Did you like the Fit n' Fun Dude prizes?" were requested to name their favourite prize. A ninth closed-ended item asked children to indicate how often they had used the Fit n' Fun Dude diary from the following options; *every day, most days, some days, a few days, never.* Two items were open-ended. The first open-ended item requested children to list the activities that they did at home and at school to help reach the pedometer target. The second open-ended item requested children to make any other comments about the Fit n' Fun Dudes project.

The questionnaire for the control children had four items that referred to the child's experience of participating in the research project. Three items were closed-ended and required a *yes, no,* or *not sure* response (e.g., "Did you do more physical activity while wearing the pedometer?"). The fourth item was open-ended and requested children to make any other comments about the research project.

Parents were requested to return the completed questionnaires to the University using a provided freepost envelope.

Materials

All materials were presented in both English and Welsh. Welsh translations were produced by the University Translation Unit.

Recording Forms. Parents were provided with two recording forms that were completed on each day of the three experimental phases (see Appendix D3). On the first recording form parents were requested to record (a) the time that the child put the pedometer on in the morning, (b) the time that the child took the pedometer off at bedtime, (c) a list of any physical activities that were undertaken by the child, and (d) details of any days that the child was ill or absent from school. The second recording form required the parents to record (a) the time that they put their own pedometer on in the morning, (b) the time that they took their pedometer off at bedtime, and (c) their pedometer reading at bedtime. These forms were used to ensure that pedometers were worn for the duration of the day by children and parents. If the child or parent forgot to wear the pedometer for an entire day, the parent was instructed to indicate so on the form.

Rewards. A series of eight rewards were used in the study, the same as those employed in Study 3 (i.e., sports bottle, wallet, frisbee etc). The order of presentation of each reward was also the same as that used in Study 3. Fit n' Fun Dude certificates were awarded to all children who completed their maintenance diaries. In addition a family trip to a nearby zoo was awarded as a "mystery" prize to the parent and child who managed to reach the pedometer targets on the most number of days during the child maintenance/parent intervention phase.

Fit n' Fun Dude Song. The song was identical to that used in Study 3. Each child received a copy of the song on compact disc.

Fit n' Fun Dude Letters. Letters from the Fit n' Fun Dudes were personally addressed to individual children. Letters were either delivered by the experimenter during home visits or they were sent to the child's home by post.

The first letter from the Fit n' Fun Dudes contained instructions for the children concerning the intervention procedures as well as encouragement to be physically active. The child's pedometer target was clearly shown.

A further three Fit n' Fun Dude letters were sent to each child during Weeks 1, 5, and 10 of the child maintenance/parent intervention phase. These letters prompted the children to wear the pedometers and to use the maintenance diary and graph. In addition, children were encouraged to try to reach their targets and they were reminded of the certificates and the mystery prize.

The final letter from the Fit n' Fun Dudes contained instructions for the children concerning the follow-up procedures.

Intervention homepack. The homepack was designed to be used by children during the intervention. It included a colour picture of each Fit n' Fun Dude character and the lyrics of the song. It also contained a chart for children to complete on each day of the intervention (see Appendix D4). Children were asked to record (a) the number of steps on their pedometer at bedtime, (b) whether they had reached their pedometer target, (c) a list of any activities that were undertaken to help with reaching the target, and (d) whether they had worn the pedometer all day. There were also suggestions and ideas of ways to be more active.

Maintenance diary and graph. The maintenance diary was designed so that parents and children could keep a daily record of their pedometer counts (see Appendix D5). There was a space to write in the pedometer count on each day for a total of 14 weeks. One side of the diary was reserved for the child's recording and the other side was for the parent. The graph was designed to be used alongside the diaries. Children, and parents could draw a cross or a dot on the graph to mark their level of activity for each day. Each point on the x-axis represented a day, and the number of steps was shown on the y-axis. After a number of days, it was suggested that children draw a line to connect the dots thus producing a line graph of their level of physical activity over time (see Appendix D5).

Design

A between-groups design was employed, whereby comparisons were made between the experimental group and the control group on the dependent variables. The design employed a number of experimental phases (see Figure 7.1) thus within-subject comparisons over time were also made.

For practical reasons, the timing of the data collection was staggered. Participants from Schools A and B began the 8-day baseline/baseline 1 phase (see Figure 7.1) in May 2004. Three weeks later, participants from Schools C and D began the baseline/baseline 1 phase and by this time, participants from Schools A and B had moved onto the second experimental phase (intervention/baseline 2; see Figure 7.1).

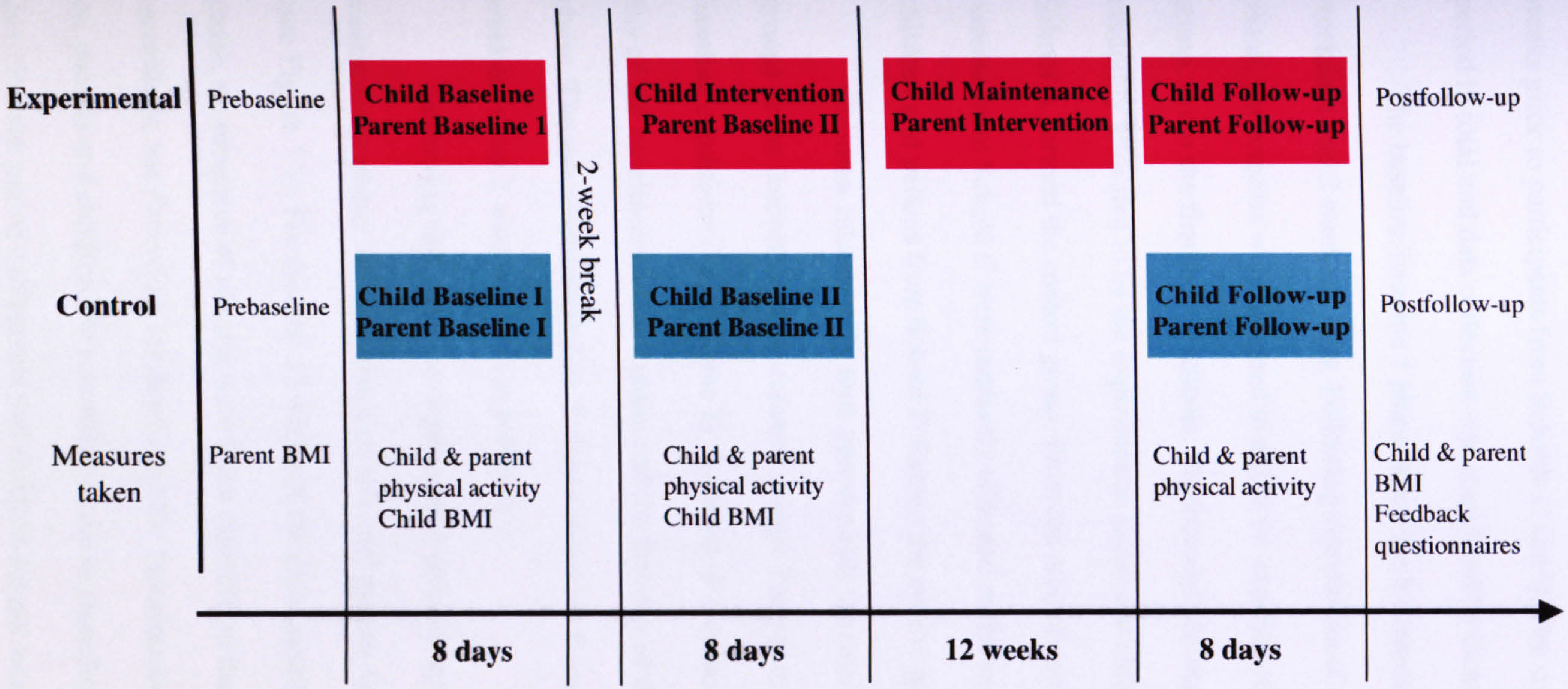


Figure 7.1. Overview of the study design

Participants from Schools A and B thus completed the final phase of the study 3 weeks prior to participants from Schools C and D. The study spanned a 22-week period in total and data collection was completed by October 2004.

The baseline/baseline 1 phase lasted for 8 consecutive days and included 6 weekdays and 2 weekend days. Following completion of the baseline/baseline 1 phase, participants were assigned to either the experimental group or the control group. From the first pair of schools, children and parents from School B were randomly allocated to be the experimental group and children and parents from School A formed the control group. From the second pair of schools, children and parents from School C were randomly allocated to the experimental group while children and parents from School D formed the control group.

Children subsequently took part in either the intervention phase (experimental group) or the baseline 2 phase (control group). Parents in both groups remained under baseline conditions (i.e., baseline 2). A period of 2 weeks elapsed between the final day of the baseline/baseline 1 phase and the first day of the intervention/baseline 2 phase. The intervention/baseline 2 phases lasted for 8 consecutive days and included 6 weekdays and 2 weekend days as previously.

Following this, only the experimental children participated in the child maintenance phase. At this point, experimental parents began the parent intervention (see Figure 7.1). For the first 12 weeks of the child maintenance/parent intervention phase, no measures of activity were taken (apart from the participants' own recordings, see *Procedure* for detail) and the experimenter had minimal contact with the parents and children. No procedures were in place for the control group during this 12-week period and parents and children did not wear pedometers.

Finally participants from both groups took part in the 8-day follow-up (see Figure 7.1). As before, this included 6 weekdays and 2 weekend days. In the experimental group, the children continued with the maintenance procedures and the parents continued with the parental intervention procedures while the follow-up measures were taken. In the control group, children and parents remained under baseline conditions.

Procedure

All procedures were implemented by the parent in the home context, following instruction from the experimenter. One or two days prior to the beginning of each experimental phase, the experimenter visited parents at home to explain the procedures. The experimenter also gave the parents a pack containing written instructions, recording forms, and pedometers (and cable ties or sticky tape, if applicable). At the end of each phase, the experimenter visited again to collect the pedometers and the completed data recording forms. Thus each household was visited six times during the course of the study.

The experimenter carried out home visits at times that were most convenient for the parent. In some cases parents preferred to be seen during the day when the child was at school. In other cases parents were seen after school, or in the evening when they had returned from work. In a small number of cases, for prephase visits only, parents either asked the experimenter to come to their work place or they came to the University themselves. Postphase visits were always arranged to take place at the participant's home. Due to restrictions on both the experimenter's and the parents' time, it was not feasible to carry out every home visit in the child's presence. If the child was at home at the time of the visit, she was invited to listen to the instructions provided by the experimenter. If the child was not at home, instructions were communicated to the parent only.

Prebaseline. The experimenter contacted all parents who expressed a wish to participate. The aims of the phone call were (a) to give the parent the opportunity to ask any questions about the research project, (b) to verify that the parent and child would be able to begin the baseline measurement on the specified day and that the 8-day period was at a convenient time, and (c) to arrange the first home visit.

During this first home visit, the experimenter delivered the pack of research materials (see above), provided verbal instructions concerning the procedure, and measured the height and body mass of the participating parents.

Baseline/Baseline 1. For the children's data collection, eight pedometers were used per child, with one pedometer allocated to each day of the phase. All pedometers were labelled with a number and the appropriate day of the week. For example, if a child began measurement on a Tuesday, on the first day she would wear the pedometer labelled "Day 1, Tuesday". On the second day she would wear the pedometer labelled "Day 2, Wednesday" and so on. Parents were instructed to ensure that the child's pedometers were set to zero at the beginning of the day and they were additionally asked to seal the pedometers using cable ties or sticky tape that were provided in the pack (see Appendix D6 for written instructions provided during this phase). In addition, children were instructed to maintain their normal level of activity. After being worn for the day, pedometers were not opened or reset and were placed in a provided envelope that was labelled "used pedometers". Parents used the provided recording form to record information relevant to the child's wearing of the pedometer (see *Materials* section for detail).

Parent data were collected by giving the parent one pedometer to be used for the duration of the baseline 1 phase. Parents did not reset their pedometer at any point thus an 8-day total pedometer count was accumulated. To obtain a breakdown for individual days, parents recorded their total pedometer count at bedtime on each day using the provided recording form. Parents were requested to maintain their normal level of activity and to avoid looking at the pedometer during the day. They were also asked to conceal their pedometer count from the child. At the end of the 8-day phase, parents placed their pedometer into the used pedometers envelope along with the child's pedometers.

Measures of height and body mass were taken for the children at school between Day 2 and Day 4 of the baseline/baseline 1 phase. The experimenter arranged a convenient time with each school and measures were taken in a quiet room on the school premises. Children were seen individually to allow these measures to be taken.

At the end of the baseline/baseline 1 phase, the experimenter collected the recording forms and the envelope containing the pedometers from the child's home. All pedometers were opened and the experimenter recorded the counts for each day. To avoid adding extra steps via movement, data were recorded prior to transporting the pedometers from the child's home.

The aim of these data collection procedures was to avoid relying on parents to record the child's pedometer data. For example, it is possible that some parents may inadvertently encourage their child to do additional steps and it would be difficult to control for such occurrences when using a group of parents.

Intervention/Baseline 2. The experimenter visited all parents 1 or 2 days prior to the start of the intervention/baseline 2 phase to deliver the pack of research materials (i.e., instructions, recording forms, pedometers). As previously, for the children's data collection, eight pedometers were used per child, with one pedometer allocated to each day of the phase. All pedometers were labelled with a number and a day of the week. Pedometers were set to zero at the beginning of the day, were worn all day until bedtime, and were placed in the used pedometers envelope at the end of the day. Pedometers were not reset at any point. Parents used the provided recording form to record information relevant to the child's wearing of the pedometer. In the control group, pedometers continued to be sealed using cable ties or sticky tape and children were instructed to maintain their normal level of activity. The control group did not take part in the Fit n' Fun Dudes intervention. In the experimental group however, pedometers were unsealed so that the count could be viewed and children were encouraged (via the Fit n' Fun Dudes letter) to increase their level of activity.

During the home visit prior to the start of the phase, the experimenter delivered to experimental participants a pack containing eight rewards, the Fit n' Fun Dudes song on compact disc, the letter from the Fit n' Fun Dudes, and the intervention homepack. In addition, all experimental parents were requested to read and sign a second consent letter to indicate that they gave consent both for their own and their child's participation in the intervention phase of the study (Appendix D7).

Each child was given a target number of steps to reach on her pedometer every day for the next 8 days in order to receive a daily reward. To compute the target, the mean steps per day on weekdays during baseline was first calculated for each child, using the pedometer counts for the last 4 weekdays of measurement (any missing data were replaced using the datum from a previous weekday). A total of 2,000 steps per day were subsequently added to the child's baseline mean. Thus each child's target throughout the intervention was determined by her baseline level of weekday activity, requiring an absolute increase of 2,000 steps per day. To aid the children's understanding and recall of their targets, these were rounded up to the nearest hundred step counts. The child's target was shown on a label that was stuck onto the front of each pedometer.

On each day at the child's bedtime, the parent looked at the child's pedometer and, if the target had been reached or exceeded, gave the child the day's reward from the pack. Parents were provided with a rewards schedule in the written instructions (see Appendix D8). Parents were also instructed to administer verbal praise in these situations. The child recorded her pedometer count and other relevant information in the homepack (see *Materials* section) on each day. If the child did not meet her pedometer target, parents were instructed to encourage her to try again the following day. If a child was consistently unable to meet her target, the parent was requested to contact the experimenter.

Procedures for the parental activity measure were identical to those employed during the baseline 1 phase for both experimental and control groups. Parents were given one pedometer to use for the duration of the phase. The pedometer was not reset and the total count was recorded each day at bedtime using the provided recording form. Parents were requested to maintain their normal level of activity, to avoid looking at the pedometer during the day, and to conceal the pedometer count from the child. At the end of the 8-day phase, parents placed the pedometer into the used pedometers envelope along with the child's pedometers.

Measures of height and body mass were taken from all the children at school on Day 8 of the intervention/baseline 2 phase.

One or two days following the end of the intervention/baseline 2 phase, the experimenter collected the pedometers and the recording forms from all participants, plus the intervention homepacks and any leftover rewards from the experimental group only. As before, pedometer data were recorded prior to transportation. In the experimental group, the experimenter used this visit to explain the procedures for the child maintenance/parent intervention phase, and to deliver the relevant materials. In the control group, the experimenter informed the parents that contact would be reinitiated in 3 months time,

Child Maintenance/Parent Intervention. During the home visit prior to the start of the phase, experimental parents and children received a pack containing two pedometers, a letter from the Fit n' Fun Dudes, the maintenance diary, and the maintenance graph.

The parental intervention consisted of each parent being given a target number of steps to reach on his or her pedometer every day. To compute the target, the mean steps per day on weekdays during the preceding intervention/baseline 2 phase was first calculated for each parent, using the pedometer data from the last 4 weekdays of measurement (any missing data were replaced using the datum from a previous weekday). A total of 2,000 steps per day were subsequently added to the parent's mean. Thus each parent's target was determined by his or her level of weekday physical activity during the baseline 2 phase, requiring an absolute increase of 2,000 steps per day. To aid the parents' recall of their targets, these were rounded up to the nearest hundred step counts. Following computation by the experimenter, targets were sent to the parents via post, along with a letter that reiterated the procedures (see Appendix D9). Experimental parents and children were also given written feedback on their pedometer counts during the baseline/baseline 1 and intervention/baseline 2 phases at this point.

On each day of the child maintenance/parent intervention phase, parents and children were instructed to wear their pedometers, to record their pedometer counts in the maintenance diary at bedtime, and to complete the maintenance graph. Pedometers were reset each day following recording. In addition, parents and children were instructed to try to reach their targets on as many days as possible. They were informed of the certificates that were available for completing the diaries. They were also told about a mystery prize that would be awarded to the child and parent who, as a pair, reached the targets on the most number of days during the phase. In this way, children and parents were encouraged to work together in trying to reach the targets to gain a mutual reward. Children also received two further letters from the Fit n' Fun Dudes that were sent by post.

If pedometers were mislaid or broken during the child maintenance/parent intervention phase, participants were instructed to contact the experimenter so that replacements could be provided.

No maintenance or parent intervention procedures took place in the control group. Pedometers were collected from control participants at the end of the baseline 2 phase, and these were returned during the visit prior to the start of the follow-up.

Follow-up. The experimenter visited all parents 1 or 2 days prior to the start of the follow-up to deliver the pack of research materials (written instructions, recording forms, pedometers). As previously the children's data were collected using eight pedometers per child that were labelled with a number and the appropriate day of the week. Pedometers were set to zero at the beginning of the day, were worn all day until bedtime, and were placed in the used pedometers envelope at the end of the day without being reset. Parents used the provided recording form to record information relevant to the child's wearing of the pedometer. In the control group, pedometers continued to be sealed using cable ties or sticky tape and children were instructed to maintain their normal level of activity. In the experimental group, pedometers were unsealed and children continued with the maintenance procedures. Experimental children were instructed to wear the eight pedometers, one per day, that were provided by the experimenter during the follow-up phase and that these were not to be reset (parents and children were asked to keep the pedometers that they had worn during the child maintenance/parent intervention phase in a safe place until after the follow-up had finished).

All parents were given one pedometer to be used for the duration of the follow-up. As before, the pedometer was not reset over the 8-day period and the total count was recorded each day using the provided recording form. Control parents were requested to maintain their normal level of activity, to avoid looking at the pedometer during the day, and to conceal the pedometer count from the child. Experimental parents were permitted to view the pedometer count and they were instructed to continue with the parental intervention procedures, but without resetting the pedometer. At the end of the 8-day phase, parents placed their pedometer into the used pedometers envelope along with the child's pedometers.

Postfollow-up. One or two days after the end of the follow-up phase, the experimenter collected the pedometers and the recording forms (all participants), plus the maintenance diaries and graphs (experimental group only). As before, the experimenter recorded the pedometer data prior to transportation. The experimenter also distributed the parent and child questionnaires to all participants with the instruction that these be returned to the University when completed using a provided Freepost envelope. Measures of height and body mass were taken from all parents and children during this home visit. Since the intervention/baseline 2 phases, a number of children from both the experimental and control groups had moved onto secondary school so, in these cases, it was no longer feasible to take the measurements at school. Therefore to maintain consistency across participants, all follow-up measures of height and mass were taken in the child's home.

Experimental parents and children were allowed to keep the pedometers that were worn during the child maintenance/parent intervention phase to enable them to continue monitoring their activity levels.

During this home visit, control participants were given a debrief that provided details of the intervention. Control participants were offered the opportunity to participate in the intervention and parents were requested to complete and sign a tear-off slip indicating their wish to participate. If parents and child did not wish to participate in the intervention they were given the opportunity to (a) each receive pedometers plus a prize for the child, or (b) opt out completely. The completed slip was returned to the University with the parent and child feedback questionnaires.

The experimenter examined all maintenance diaries that were returned from the experimental participants and computed the total number of days that each child had reached the target and the total number of days that each parent had reached the target. The child's total was then combined with the respective parent's total. The child and parent with the highest combined total were the "winners" of the mystery prize. Once identified, the experimenter contacted the parent and child to determine their preferred choice for the family day out. A cheque was subsequently sent to the participant's home that would cover the cost of admission prices and travel.

The experimenter contacted any control parents who wished to participate in the intervention and a home visit was arranged so that procedures could be explained and intervention materials delivered. Control parents and children were given one pedometer each for use during the intervention and children were given a daily step target that was based on their level of weekday physical activity at follow-up (requiring an increase of 2,000 steps per day). They were requested to send in their pedometer data to the experimenter at the University following completion of the child intervention phase. The experimenter used these data to compute the parent's target, which was subsequently sent to the participants by post to enable them to begin the child maintenance and parental intervention procedures.

All parents received a written report of the research findings. Parents and children also received written personalised feedback of their pedometer counts during the three phases of the study. These documents were sent to the participants' homes by post, approximately 6 weeks after the follow-up had finished. Certificates were also sent to experimental children at this point.

RESULTS

Inclusion Criteria

Only participants for whom there were at least four weekday pedometer data points in each of the three study phases were included in the analysis. Data for 3 children from the control group were excluded on this basis. Of these, 1 girl did not have sufficient data points during baseline 1, 1 girl did not have sufficient data points during baseline 2, and 1 girl abstained from participating in the baseline 2 phase. In the experimental group, 1 girl was excluded because she lowered her pedometer target during the maintenance phase and was therefore no longer adhering to the experimental contingencies. As a rule, if the child was excluded, then the parent was additionally excluded from all analyses.

In addition, 2 parents were excluded from the experimental group. One parent recorded no pedometer data during the follow-up, and another parent chose to opt out of the parent intervention. In both cases, however, the respective children remained in the analysis because they both had sufficient data points in all three phases. The child's data were deemed to be the main focus of the study therefore children could be included without the parent. Parents however could only be included if sufficient data were also present for the child.

Remaining sample sizes were 15 control girls and 14 experimental girls, and 15 control parents and 11 experimental parents (recall that, in the experimental group, 1 parent participated alongside 2 twin siblings). Excluded children and parents did not differ significantly from the remaining sample on baseline age, height, mass, or BMI.

The parental recording forms were used to ensure that children and parents had worn the pedometers for the entire day. If, according to the recording form, the pedometer was not worn for more than 2 consecutive hours, then the data point for that day was excluded from the analysis. Furthermore, any days where the child or parent reported illness or absenteeism from school or work were excluded.

Following these exclusion procedures, the mean number of full days that pedometers were worn by children and parents was computed for the three study phases (Table 7.2). Each study phase consisted of 8 days.

Table 7.2

Mean number of full days (*SD*) that pedometers were worn by children and parents, and between-group Mann-Whitney *U* comparisons.

	Experimental	Control	Mann-Whitney *U* and *p*-value
		Children[a]	
Baseline/Baseline 1	7.1 (0.5)	7.7 (0.5)	41.0, $p < .001$*
Intervention/Baseline 2	7.7 (0.5)	7.3 (0.9)	82.0, $p = .241$
Follow-up	6.6 (1.3)	7.0 (1.1)	87.0, $p = .410$
		Parents[b]	
Baseline 1	7.9 (0.3)	7.9 (0.4)	79.0, $p = .743$
Baseline 2	7.5 (0.9)	7.4 (0.7)	68.0, $p = .384$
Follow-up	7.5 (0.9)	7.6 (0.6)	81.5, $p = .949$

[a]$N = 14$ for experimental children, $N = 15$ for control children. [b]$N = 11$ for experimental parents, $N = 15$ for control parents.

* $p < .017$ (required significance level after Bonferroni adjustment).

Between-group comparisons were carried out to determine whether there were significant differences between the experimental and control groups on the number of days that pedometers were worn. Given that mean values were not drawn from normal distributions, nonparametric Mann-Whitney U tests were employed. These showed that control children wore their pedometers on significantly more days than experimental children during baseline/baseline 1. There were no between-group differences during intervention/baseline 2 or follow-up. There were no significant differences between the number of days that pedometers were worn by experimental and control parents during any of the three study phases (Table 7.2).

Unless otherwise specified, an alpha level of .05 was used for all statistical tests.

Children's Physical Activity

Weekdays. Three scores were computed for each participant: mean physical activity during baseline/baseline 1, mean physical activity during intervention/baseline 2, and mean physical activity during follow-up. In all cases, physical activity was measured as steps per day. To minimise the effects of novelty and reactivity, mean scores were computed using the pedometer data from the last 4 weekdays of each experimental phase. Any missing data were replaced with data from the previous days of measurement. This procedure ensured that the mean scores were comprised of the same number of observations across participants.

The maintenance diaries were used to compute a mean score for weekday physical activity during the child maintenance phase for experimental children only (these data were not available for control children). In total, 13 out of 14 experimental children completed the diaries at some point during the maintenance phase. The mean number of days that diaries were completed by children was 59.5 (SD = 22.6), with compliance ranging from 15 days to the maximum of 80 days (weekdays and weekend days). Mean scores for weekday physical activity were computed using the final 4 weekdays of pedometer data that the child recorded during the maintenance phase. In cases where pedometer data were recorded for the duration of the phase, this score represents the child's mean weekday physical activity at the end of maintenance. In cases where the children did not record for the duration of the phase, this score represents their mean weekday physical activity at the point at which they stopped recording.

Baseline characteristics of the sample are shown in Table 7.3 for age, anthropometric variables and physical activity. Children were categorised as overweight/obese using international cut-off points (Cole, et al., 2000).

Table 7.3

Baseline descriptive statistics for experimental and control children (with standard deviations in parentheses) and independent *t* test results.

	Experimental ($N = 14$)	Control ($N = 15$)	*t* value (*df*)[a]
Age (years)	10.5 (0.9)	10.7 (0.7)	0.51 (27)
Height (cm)	145.4 (7.5)	143.0 (8.8)	-0.80 (27)
Mass (kg)	41.9 (9.2)	42.0 (12.8)	0.02 (27)
BMI (kg/m^2)	19.7 (3.2)	20.2 (4.0)	0.41 (27)
Percentage of overweight/obese participants [b]	50 (7/14)	53 (8/15)	Not computed
Baseline/baseline 1 weekday physical activity (steps per day)	12,860.3 (2,242.1)	13,695.3 (3,132.4)	0.82 (27)

[a]The significance level was adjusted to $p < .01$ in accordance with the Bonferroni adjustment, however p-values obtained in all of the above *t* tests exceeded this level. [b]Participant numbers are shown in parentheses.

Independent *t* tests showed that experimental and control children did not differ significantly on age, anthropometric variables, or physical activity at baseline/baseline 1. Furthermore, experimental and control children did not differ significantly in the frequency of overweight or obese children, $\chi^2(1, N = 29) = 0.03$, $p = .858$. In both groups, approximately half of the children were overweight or obese.

A Pearson's r correlation coefficient was computed between baseline/baseline 1 weekday physical activity (steps per day) and baseline/baseline 1 BMI. Given that there were no significant differences between experimental and control children on weekday physical activity or BMI at this point, these data were combined for the subsequent computation. Following the removal of one outlying data point, there was a significant negative correlation between weekday physical activity and BMI at baseline/baseline 1, $r = -.43$, $N = 28$, $p < .05$. This indicates that, at the beginning of the study, a higher BMI was related to a lower number of steps per day.

Mean weekday physical activity for the two groups during baseline/baseline 1, intervention/baseline 2, and follow-up may be seen in Figure 7.2. Mean weekday physical activity during maintenance for the experimental children only is also shown.

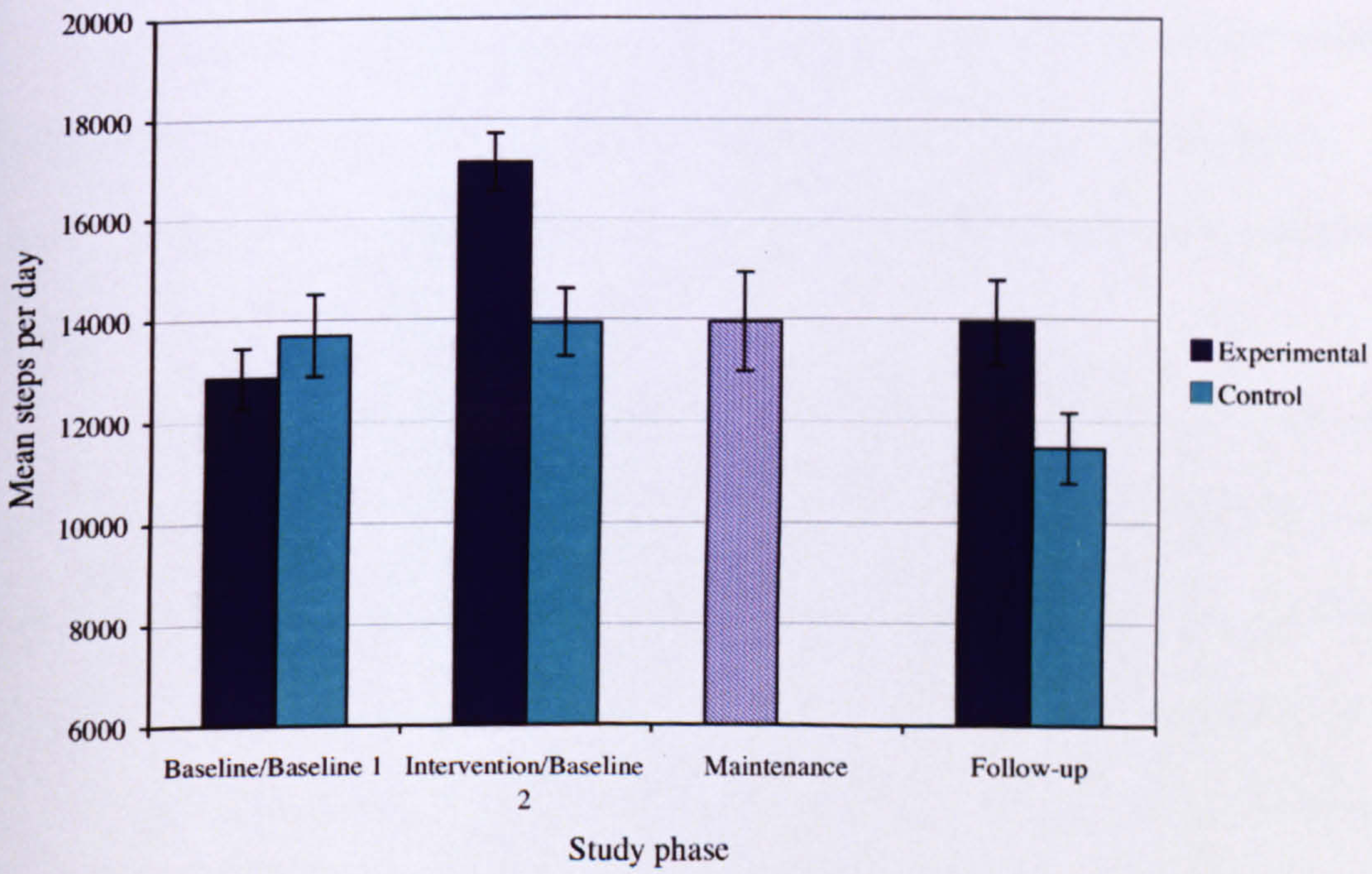


Figure 7.2. Mean physical activity (steps per day) of children on weekdays at each study phase. Bars represent ± 1 *SE* of the mean.

Figure 7.2 shows that, at baseline/baseline 1, there was a trend for physical activity to be higher in the control group compared to the experimental group (*M* [*SD*] = 13,695.3 [3,132.4] cf. 12,860.3 [2,242.1] steps per day, respectively). During the intervention/baseline 2, experimental children increased their activity level (*M* [*SD*] = 17,131.4 [2,157.4] steps per day) whilst controls showed only a marginal increase (*M* [*SD*] = 13,930.7 [2,559.3] steps per day). Experimental children averaged 13,950.4 steps per day at maintenance, and 13,941.4 steps per day at follow-up (*SD*s = 3,500.8, and 3,091.0, respectively), and thus remained higher than their baseline level of activity. In contrast, control children showed a decline in their level of activity at follow-up (*M* [*SD*] = 11,462.7 [2,659.6] steps per day).

A 2 × 3 mixed ANOVA was carried out with the within-subjects factor as study phase (baseline/baseline 1, intervention/baseline 2, follow-up), and the between-subjects factor as group (experimental, control). The dependent variable was mean steps per day on weekdays.

Kolmogorov Smirnov tests indicated that all means were drawn from normal distributions. Levene's test showed that population variances were equal across groups. Mauchly's test indicated the presence of sphericity. Thus all assumptions of repeated measures ANOVA were met.

There were significant main effects of study phase, $F(2, 54) = 15.87$, $p < .001$, and group, $F(1, 27) = 4.27$, $p < .05$. The Study Phase × Group interaction was also significant, $F(2, 54) = 8.22$, $p < .005$. A total of nine post hoc *t* tests were carried out to investigate the significant interaction, with the level of significance adjusted to .006. Results of the post hoc tests are reported in Table 7.4. In brief, there were no significant differences in steps per day between the two groups at baseline/baseline 1 or at follow-up, however experimental children were significantly more active than

Table 7.4

Results of between-group and paired-sample post hoc *t* tests for children's weekday physical activity ($N = 14$ in experimental group; $N = 15$ in control group).

Comparison	Means (*SD*)	*t* value (*df*)
Between-group comparisons		
Experimental baseline cf. control baseline 1	12,860.3 (2,242.1) 13,695.3 (3,132.4)	0.82 (27)
Experimental intervention cf. control baseline 2	17,131.4 (2,157.4) 13,930.7 (2,559.3)	-3.63 (27)*
Experimental follow-up cf. control follow-up	13,941.4 (3,091.0) 11,462.7 (2,659.6)	-2.32 (27)
Experimental group		
Baseline cf. intervention	12,860.3 (2,242.1) 17,131.4 (2,157.4)	12.55 (13)*
Intervention cf. follow-up	17,131.4 (2,157.4) 13,941.4 (3,091.0)	4.19 (13)*
Baseline cf. follow-up	12,860.3 (2,242.1) 13,941.4 (3,091.0)	1.32 (13)
Control group		
Baseline 1 cf. baseline 2	13,695.3 (3,132.4) 13,930.7 (2,559.3)	-0.30 (14)
Baseline 2 cf. follow-up	13,930.7 (2,559.3) 11,462.7 (2,659.6)	3.44 (14)*
Baseline 1 cf. follow-up	13,695.3 (3,132.4) 11,462.7 (2,659.6)	2.44 (14)

* $p < .006$ (required significance level after Bonferroni adjustment).

controls during the intervention/baseline 2 phase. Within-subject comparisons showed that experimental children had significantly higher step counts during the intervention compared to baseline and follow-up, however steps per day during follow-up did not differ significantly from baseline. Control children showed a significant decline in steps per day at follow-up compared to baseline 2, however there were no significant differences between baseline 1 and baseline 2, or between baseline 1 and follow-up.

Of the 13 experimental children for whom maintenance data were available, a paired samples t test showed that physical activity during maintenance (M = 13,950.4, SD = 3,500.8) was not significantly different from physical activity at baseline (M = 12,869.0, SD = 2,333.4), $t(12) = -1.09$, $p = .299$.

Overall group means show that experimental children were not significantly more active on weekdays at follow-up compared to baseline. However an examination of means for individual participants revealed that, at follow-up, 64% of experimental children (9 out of 14) showed a mean level of activity that exceeded their pedometer targets (recall that targets required an increase of 2,000 steps per day from baseline). Therefore the majority of children maintained the level of activity that was specified by the target and were doing, on average, an additional 2,000 steps per day at follow-up relative to baseline. The following represents a summary of the weekday physical activity patterns shown by individual children in the experimental group.

The 9 children who, at follow-up, maintained mean levels of activity above their targets will hereafter be referred to as "maintainers". Of these, 3 children passed their targets on the maximum of 6 weekdays during follow-up. An example of this pattern of behaviour may be seen in Figure 7.3. A further 5 children passed their targets on all days but one during follow-up, for between 4 and 6 recorded days of data (see Figure 7.4 for an example). Finally, 1 child passed her target on 2 out of 4 days.

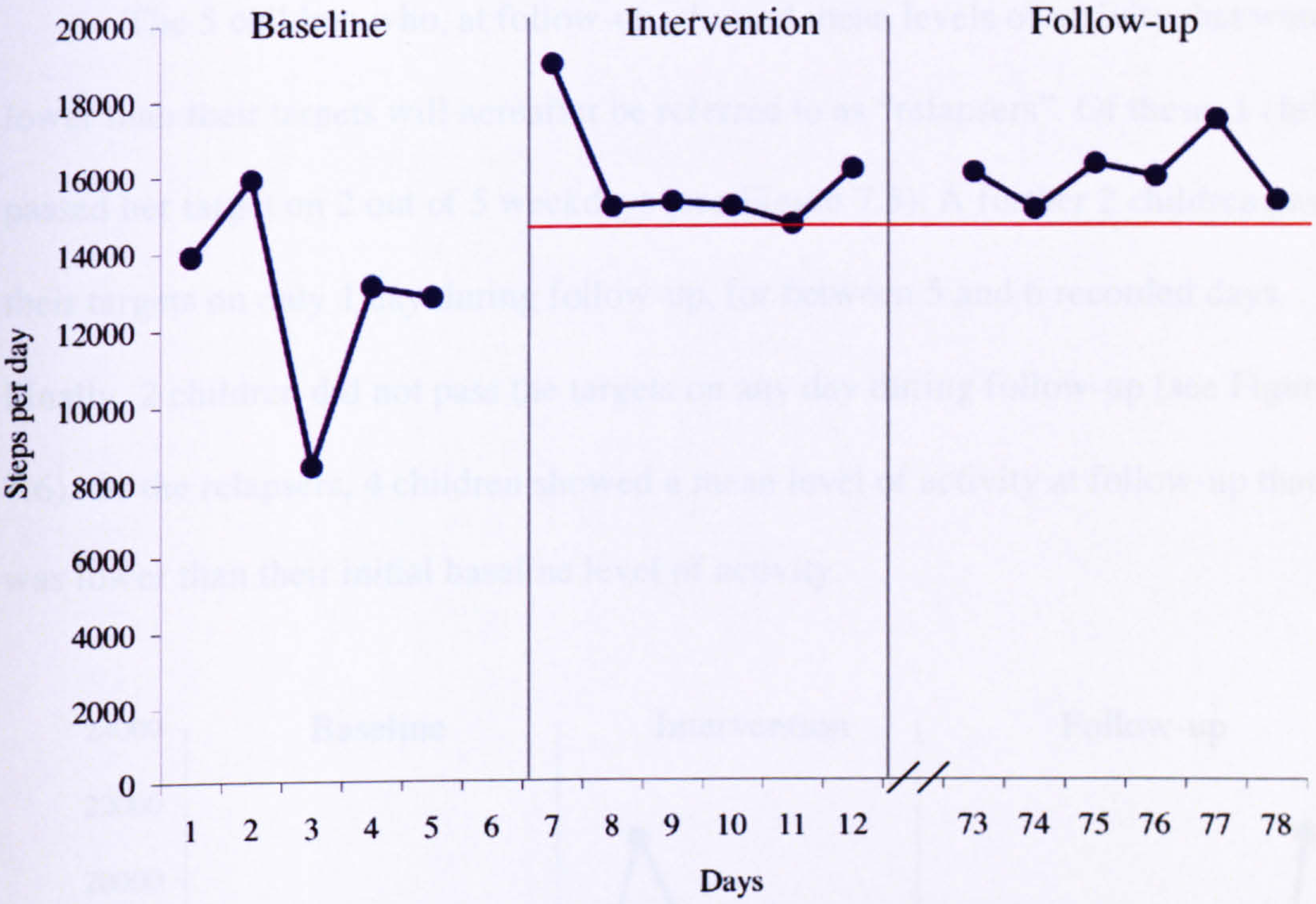


Figure 7.3. Daily physical activity on weekdays during baseline, intervention, and follow-up as shown by a maintainer who passed her target every day during follow-up. The target level of steps is indicated by the red line.

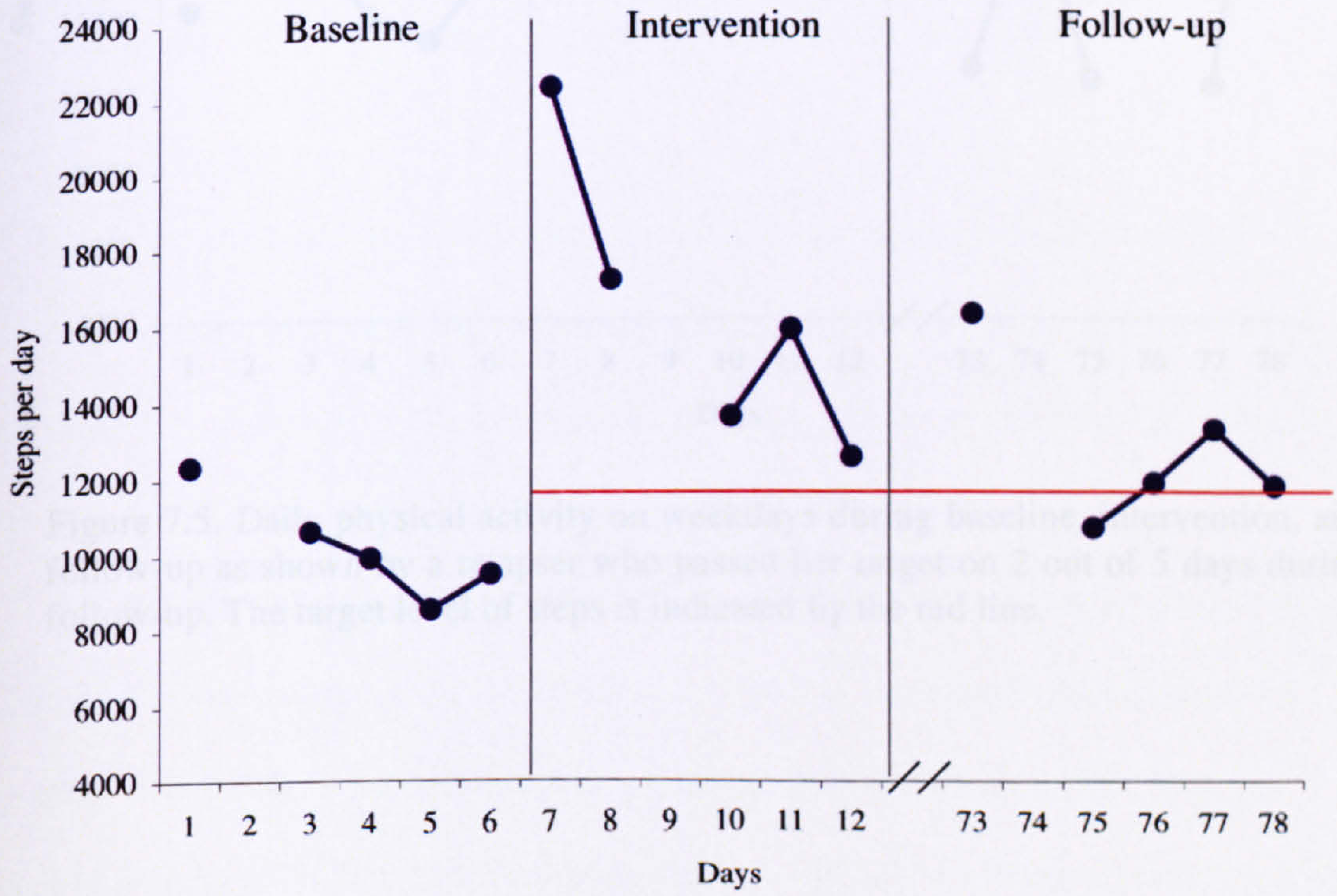


Figure 7.4. Daily physical activity on weekdays during baseline, intervention, and follow-up as shown by a maintainer who passed her target on all days but one during follow-up. The target level of steps is indicated by the red line.

The 5 children who, at follow-up, showed mean levels of activity that were lower than their targets will hereafter be referred to as "relapsers". Of these, 1 child passed her target on 2 out of 5 weekdays (see Figure 7.5). A further 2 children passed their targets on only 1 day during follow-up, for between 5 and 6 recorded days. Finally, 2 children did not pass the targets on any day during follow-up (see Figure 7.6). Of the relapsers, 4 children showed a mean level of activity at follow-up that was lower than their initial baseline level of activity.

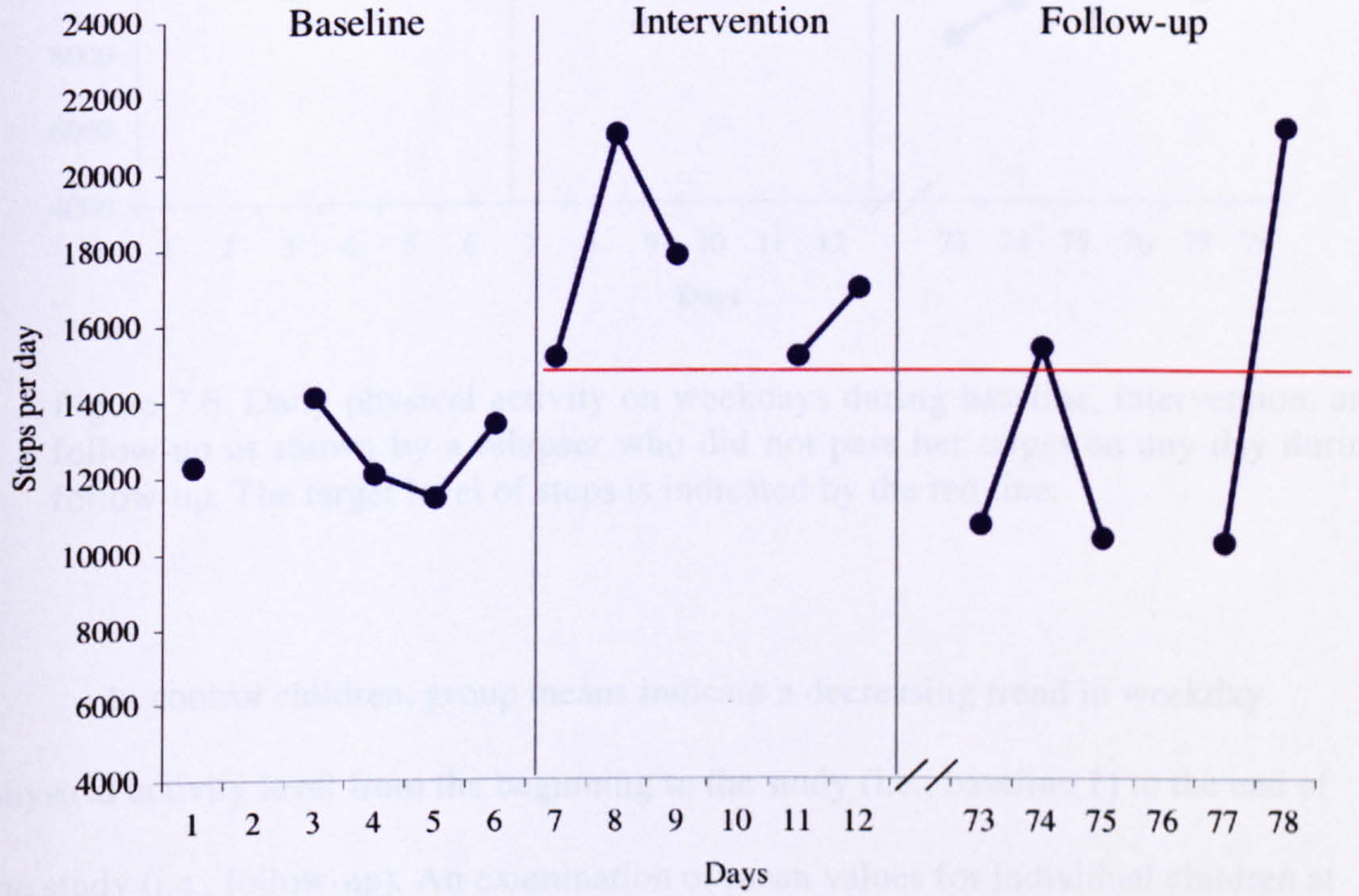


Figure 7.5. Daily physical activity on weekdays during baseline, intervention, and follow-up as shown by a relapser who passed her target on 2 out of 5 days during follow-up. The target level of steps is indicated by the red line.

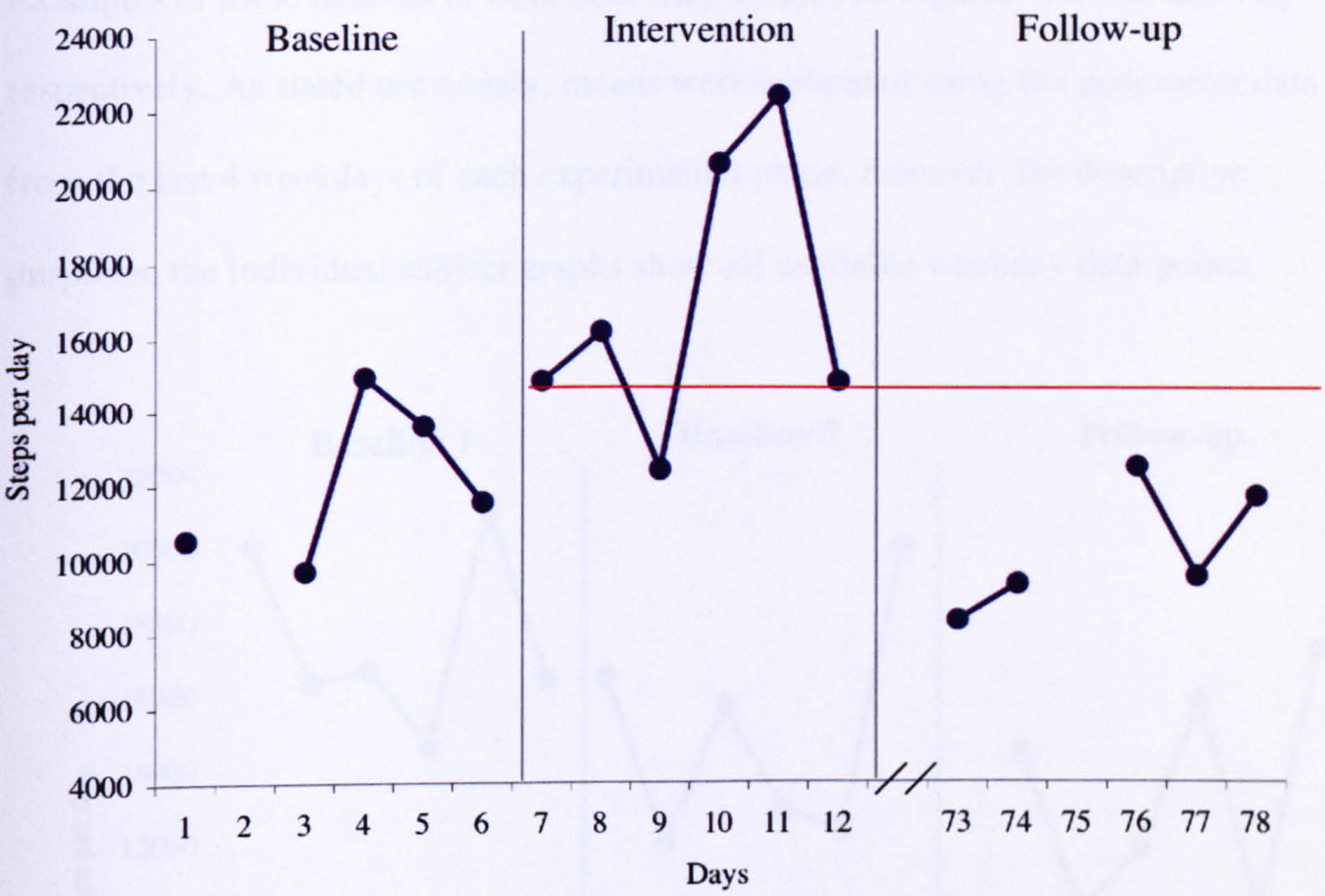


Figure 7.6. Daily physical activity on weekdays during baseline, intervention, and follow-up as shown by a relapser who did not pass her target on any day during follow-up. The target level of steps is indicated by the red line.

In control children, group means indicate a decreasing trend in weekday physical activity level from the beginning to the study (i.e., baseline 1) to the end of the study (i.e., follow-up). An examination of mean values for individual children at baseline 1 and at follow-up revealed three patterns of behaviour.

Of the 15 control children, 9 children showed a decrease in mean activity from baseline 1 to follow-up (i.e., mean activity at follow-up was lower than at baseline 1 by more than 2,000 steps per day). A further 5 children showed a relatively stable level of activity from baseline 1 to follow-up (i.e., the difference between the baseline 1 mean and the follow-up mean was less than 2,000 steps per day). Finally, 1 child showed an increase in mean activity from baseline 1 to follow-up (i.e., mean activity at follow-up was higher than at baseline 1 by more than 2,000 steps per day). Examples of these patterns of behaviour may be seen in Figures 7.7, 7.8, and 7.9, respectively. As stated previously, means were computed using the pedometer data from the last 4 weekdays of each experimental phase, however, for descriptive purposes, the individual subject graphs show all available weekday data points.

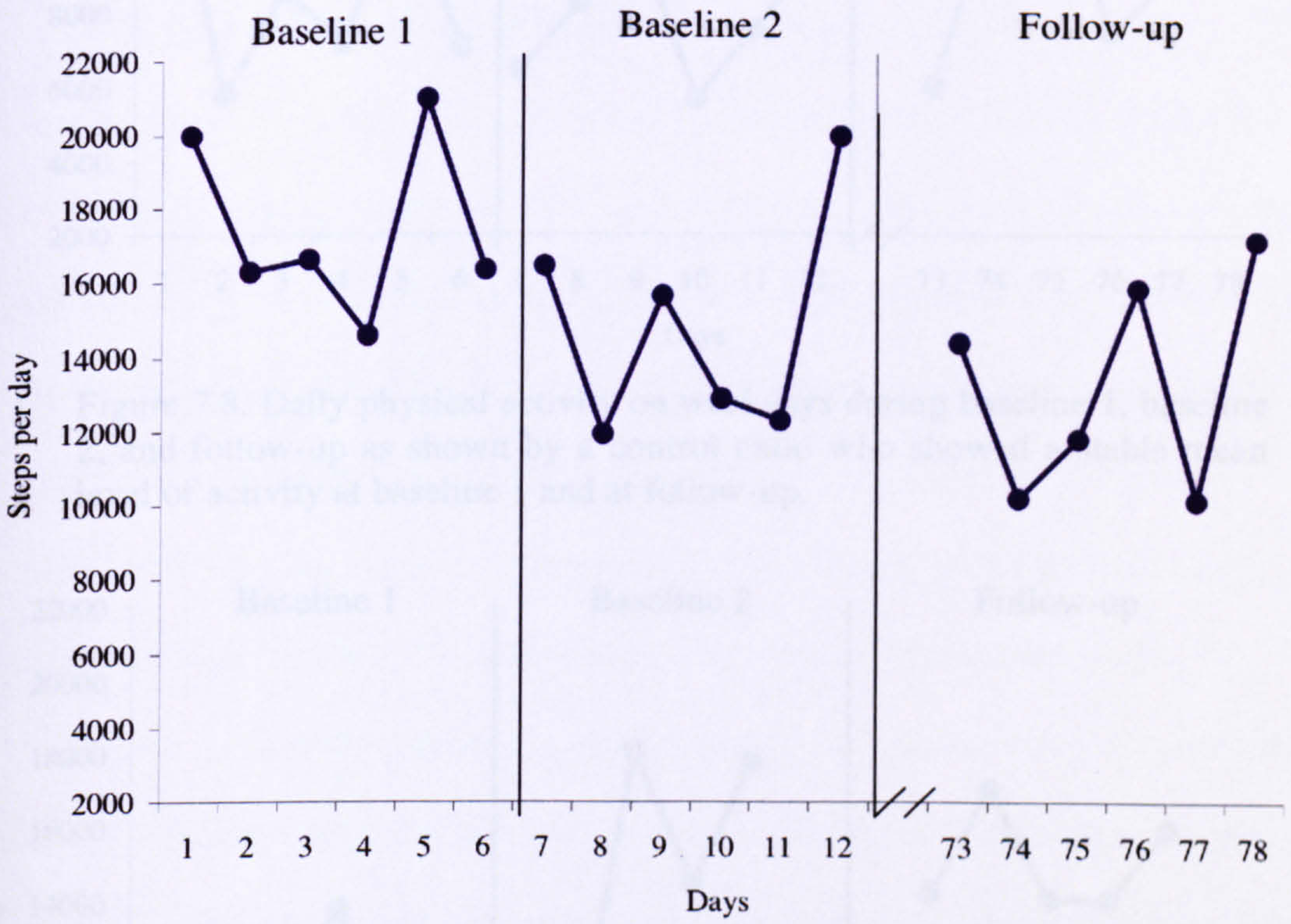


Figure 7.7. Daily physical activity on weekdays during baseline 1, baseline 2, and follow-up as shown by a control child who showed a decrease in mean physical activity from baseline 1 to follow-up.

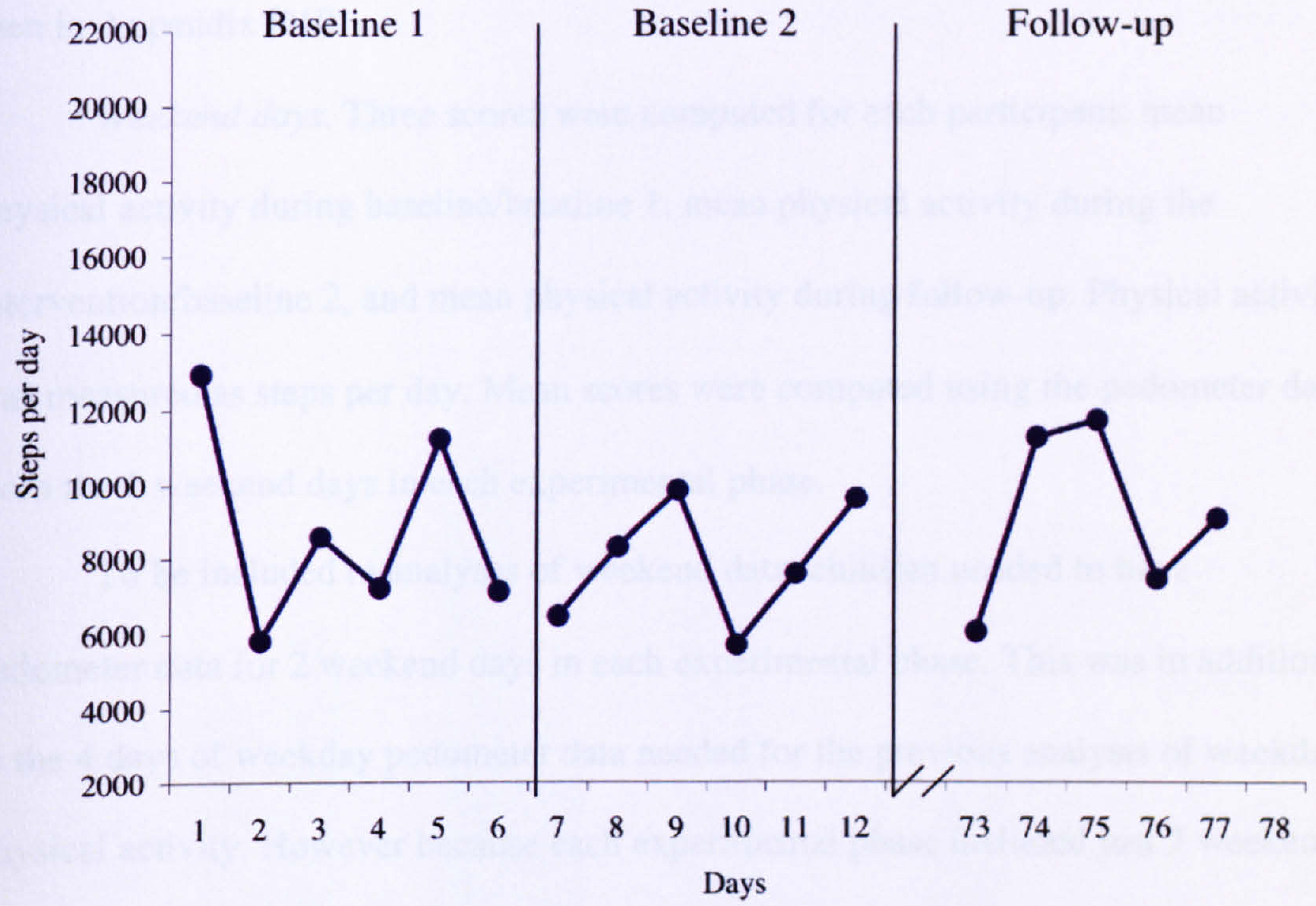


Figure 7.8. Daily physical activity on weekdays during baseline 1, baseline 2, and follow-up as shown by a control child who showed a stable mean level of activity at baseline 1 and at follow-up.

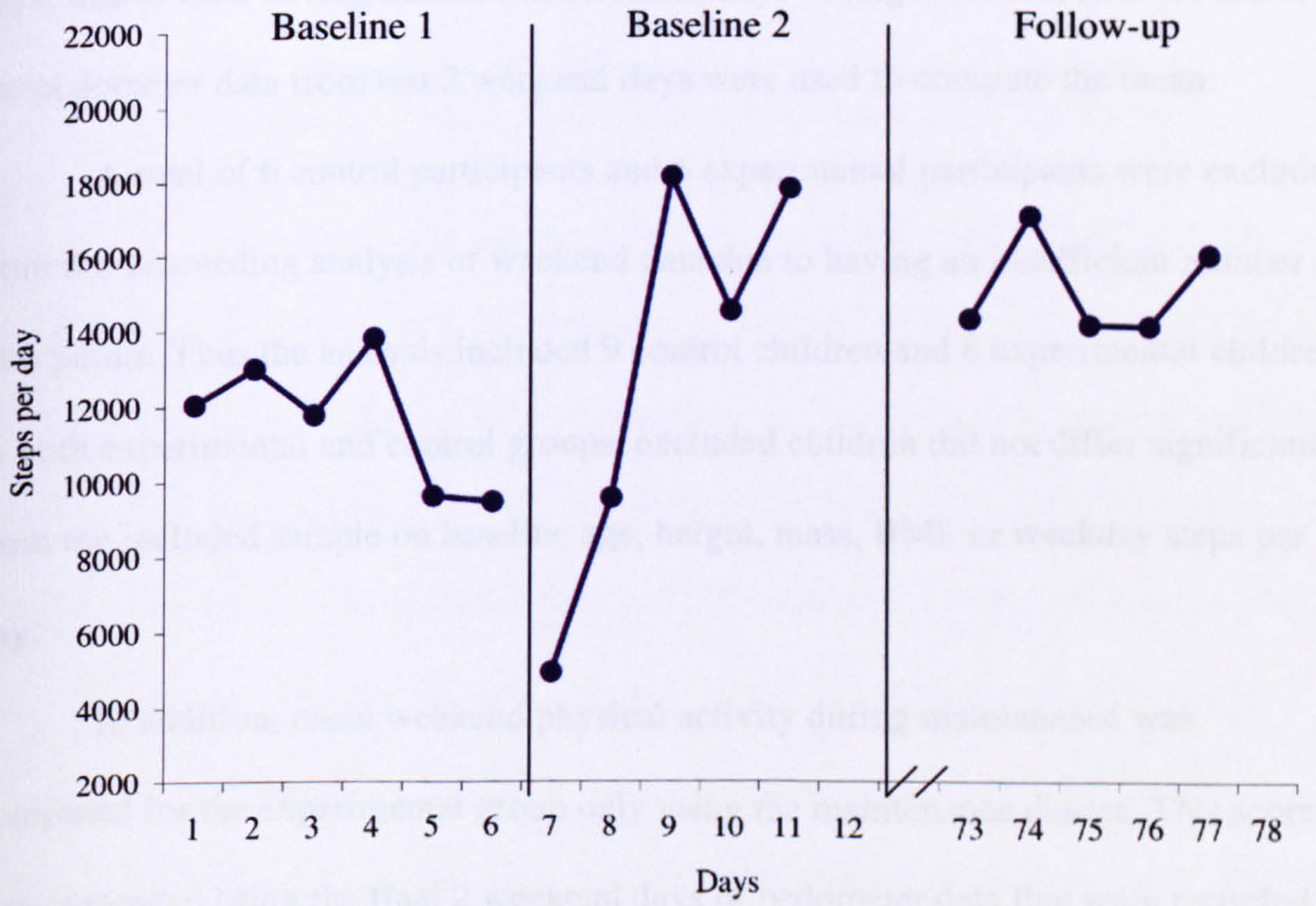


Figure 7.9. Daily physical activity on weekdays during baseline 1, baseline 2, and follow-up as shown by a control child who showed an increase in mean physical activity from baseline 1 to follow-up.

Individual subject graphs for all experimental and control children may be seen in Appendix D10.

Weekend days. Three scores were computed for each participant: mean physical activity during baseline/baseline 1, mean physical activity during the intervention/baseline 2, and mean physical activity during follow-up. Physical activity was measured as steps per day. Mean scores were computed using the pedometer data from the 2 weekend days in each experimental phase.

To be included in analyses of weekend data, children needed to have pedometer data for 2 weekend days in each experimental phase. This was in addition to the 4 days of weekday pedometer data needed for the previous analysis of weekday physical activity. However because each experimental phase included just 2 weekend days, there were no weekend data available for replacement in cases of missing data. In a very small number of cases, children recorded pedometer data for 3 weekend days, due to their having missed measurement days during the week. In these cases, the pedometer data from last 2 weekend days were used to compute the mean.

A total of 6 control participants and 6 experimental participants were excluded from the proceeding analysis of weekend data due to having an insufficient number of data points. Thus the analysis included 9 control children and 8 experimental children. In both experimental and control groups, excluded children did not differ significantly from the included sample on baseline age, height, mass, BMI, or weekday steps per day.

In addition, mean weekend physical activity during maintenance was computed for the experimental group only using the maintenance diaries. This score was computed using the final 2 weekend days of pedometer data that were recorded by the child during maintenance.

Mean weekend physical activity for the two groups during baseline/baseline1, intervention/baseline 2, and follow-up may be seen in Figure 7.10. Mean weekend physical activity during maintenance for the experimental children is also displayed.

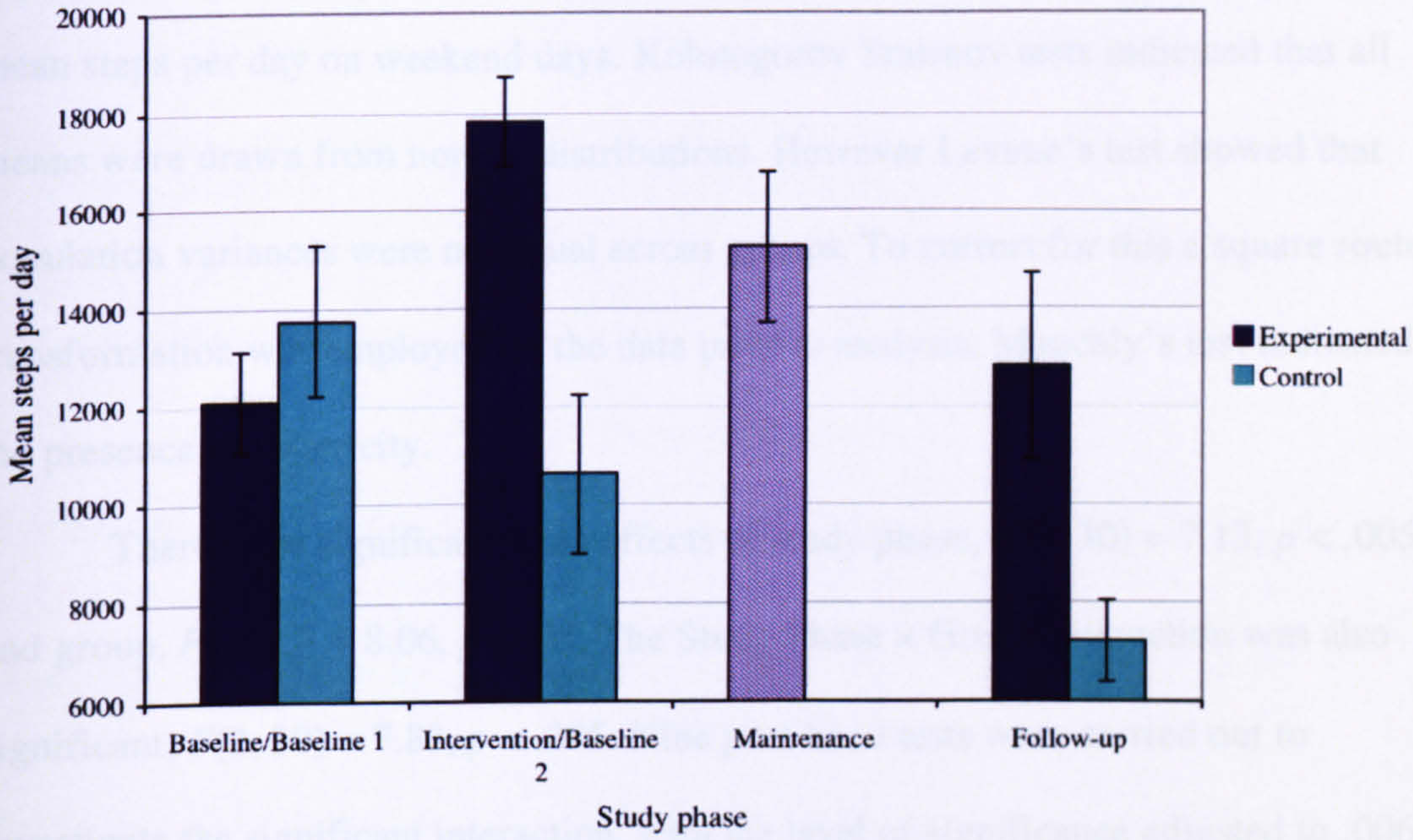


Figure 7.10. Mean physical activity (steps per day) of children on weekend days at each study phase. Bars represent ± 1 *SE* of the mean.

At baseline/baseline 1, there was a trend for physical activity to be higher in the control group compared to the experimental group (*M* [*SD*] = 13,739.3 [4,595.2] cf. 12,096.6 [2,937.5] steps per day, respectively). During the intervention/baseline 2, experimental children increased their activity (*M* [*SD*] = 17,826.8 [2,577.3] steps per day) whilst controls showed a decrease (*M* [*SD*] = 10,611.1 [4,879.0] steps per day). Experimental children averaged 15,248.0 steps per day during maintenance, and decreased to a mean of 12,811.9 steps per day at follow-up (*SD*s = 4,375.1, and 5,354.5, respectively). Nevertheless, experimental children remained slightly higher than their baseline level of activity. In contrast, at follow-up control children had declined to a mean of 7,215.9 steps per day ($SD = 2,439.6$).

A 2 × 3 mixed ANOVA was carried out with the within-subjects factor as study phase (baseline/baseline 1, intervention/baseline 2, follow-up), and the between-subjects factor as group (experimental, control). The dependent variable was mean steps per day on weekend days. Kolmogorov Smirnov tests indicated that all means were drawn from normal distributions. However Levene's test showed that population variances were not equal across groups. To correct for this a square route transformation was employed on the data prior to analysis. Mauchly's test indicated the presence of sphericity.

There were significant main effects of study phase, $F(2, 30) = 7.13, p < .005$, and group, $F(1, 15) = 8.06, p < .05$. The Study Phase × Group interaction was also significant, $F(2, 30) = 7.83, p < .005$. Nine post hoc t tests were carried out to investigate the significant interaction, with the level of significance adjusted to .006. Results of the post hoc tests are reported in Table 7.5. In brief, experimental girls were significantly more active than control girls during the intervention/baseline 2 phase, but there were no significant between-group differences at either baseline/baseline 1 or follow-up. Within-subject comparisons showed that experimental girls were significantly more active on weekend days during the intervention compared to baseline, however there were no significant differences between intervention and follow-up, or between baseline and follow-up. Control girls were significantly less active on weekend days at follow-up compared to baseline 1, however there were no significant differences between baseline 1 and baseline 2, or between baseline 2 and follow-up.

Table 7.5

Results of between-group and paired-sample post hoc *t* tests for children's weekend physical activity ($N = 8$ in experimental group; $N = 9$ in control group).

Comparison	Untransformed means (*SD*)[a]	*t* value (*df*)[b]
	Between-group comparisons	
Experimental baseline cf. control baseline 1	12,096.6 (2,937.5) 13,739.3 (4,595.2)	0.86 (15)
Experimental intervention cf. control baseline 2	17,826.8 (2,577.3) 10,611.1 (4,879.0)	-3.55 (15)*
Experimental follow-up cf. control follow-up	12,811.9 (5,354.5) 7,215.9 (2,439.6)	-2.90 (15)
	Experimental group	
Baseline cf. intervention	12,096.6 (2,937.5) 17,826.8 (2,577.3)	-7.96 (7)*
Intervention cf. follow-up	17,826.8 (2,577.3) 12,811.9 (5,354.5)	3.38 (7)
Baseline cf. follow-up	12,096.6 (2,937.5) 12,811.9 (5,354.5)	-0.35 (7)
	Control group	
Baseline 1 cf. baseline 2	13,739.3 (4,595.2) 10,611.1 (4,879.0)	1.71 (8)
Baseline 2 cf. follow-up	10,611.1 (4,879.0) 7,215.9 (2,439.6)	1.53 (8)
Baseline 1 cf. follow-up	13,739.3 (4,595.2) 7,215.9 (2,439.6)	4.65 (8)*

[a]Displayed means are untransformed values (steps per day). [b]*t* test results are for square route transformed means.

* $p <$ .006 (required significance level after Bonferroni adjustment).

A paired samples *t* test showed that experimental children were significantly more active on weekend days during maintenance (M = 15,248.0, SD = 4,375.1) compared to during baseline (M = 12,096.6, SD = 2,937.5), $t(7) = -2.81$, $p < .05$. On average, children took an additional 3,151 steps per day during maintenance, which exceeded the increase in steps that was specified by the intervention targets.

Parents' Physical Activity

Weekdays. Three scores were computed for each parent; mean physical activity during baseline 1, mean physical activity during baseline 2, and mean physical activity during follow-up. Physical activity was measured as steps/day. Mean scores were computed using the pedometer data from the last 4 weekdays of each phase and any missing data were replaced with data from the previous days of measurement.

In total, 10 out of 11 experimental parents completed the maintenance diaries at some point during the child maintenance/parent intervention phase. The mean number of days that diaries were completed by parents was 67.3 (SD = 15.0), with compliance ranging from 39 days to the maximum of 80 days (weekdays and weekend days).

Mean scores for physical activity at the beginning of the parent intervention phase were computed for experimental parents only. This was to determine whether the parent intervention had any immediate effects on parental physical activity. Scores for weekday physical activity were computed using the parents' self reported data points for the first 4 days (i.e., Monday, Tuesday, Wednesday, Thursday) of Week 2 of the phase. If a parent missed a data point on any of these days, the next available weekday data point was used. Means were computed using data from Week 2 of the parent intervention to allow sufficient time for parents to receive their intervention targets by post (see *Method* section).

Baseline 1 characteristics of the sample are shown in Table 7.6 for age, anthropometric variables and physical activity. Parents were categorised as overweight if their BMI exceeded 25 kg/m^2 (on the basis of the World Health Organisation guidelines).

Table 7.6

Baseline 1 descriptive statistics for experimental and control parents (with standard deviations in parentheses) and independent *t* test results.

	Experimental ($N = 11$)	Control ($N = 15$)	*t* value (*df*)[a]
Age (years)	39.4 (6.0)	41.3 (4.0)	0.98 (24)
Height (cm)	165.3 (5.8)	163.1 (9.0)	-0.68 (24)
Mass (kg)	68.8 (11.9)	73.6 (19.4)	0.73 (24)
BMI (kg/m^2)	25.2 (4.2)	27.7 (7.3)	1.00 (24)
Percentage of overweight/ obese participants [b]	55 (6/11)	67 (10/15)	Not computed
Weekday physical activity (steps per day)	12,092.7 (3,690.1)	9,812.9 (2,843.5)	-1.78 (24)

[a]The significance level was adjusted to $p < .01$ in accordance with the Bonferroni adjustment, however *p*-values obtained in all of the above *t* tests exceeded this level. [b]Participant numbers are shown in parentheses.

Independent *t* tests showed that experimental and control parents did not differ significantly on any of the above variables at baseline 1. Furthermore, experimental and control groups did not differ significantly in the frequency of overweight and obese individuals (Fisher exact probability = .689, $N = 26$, two-tailed test). Just over half of the experimental parents and two-thirds of the control parents were overweight or obese.

For experimental and control parent data combined, the correlation between weekday physical activity at baseline 1 and BMI at baseline 1 was not significant, $r = .17$, $N = 25$, $p = .411$. One outlying data point was removed prior to computing this correlation coefficient.

Parent weekday physical activity during baseline 1 was not significantly correlated with child weekday physical activity during baseline/baseline 1, $r = -.07$, $N = 26$, $p = .730$. Following the removal of two outlying data points, there was no significant correlation between parent BMI and child BMI at baseline/baseline 1, $r = .29$, $N = 24$, $p = .176$.

Mean weekday physical activity for the two groups of parents at baseline 1, baseline 2, and follow-up may be seen in Figure 7.11. Mean physical activity during the parent intervention is also displayed for the experimental parents only.

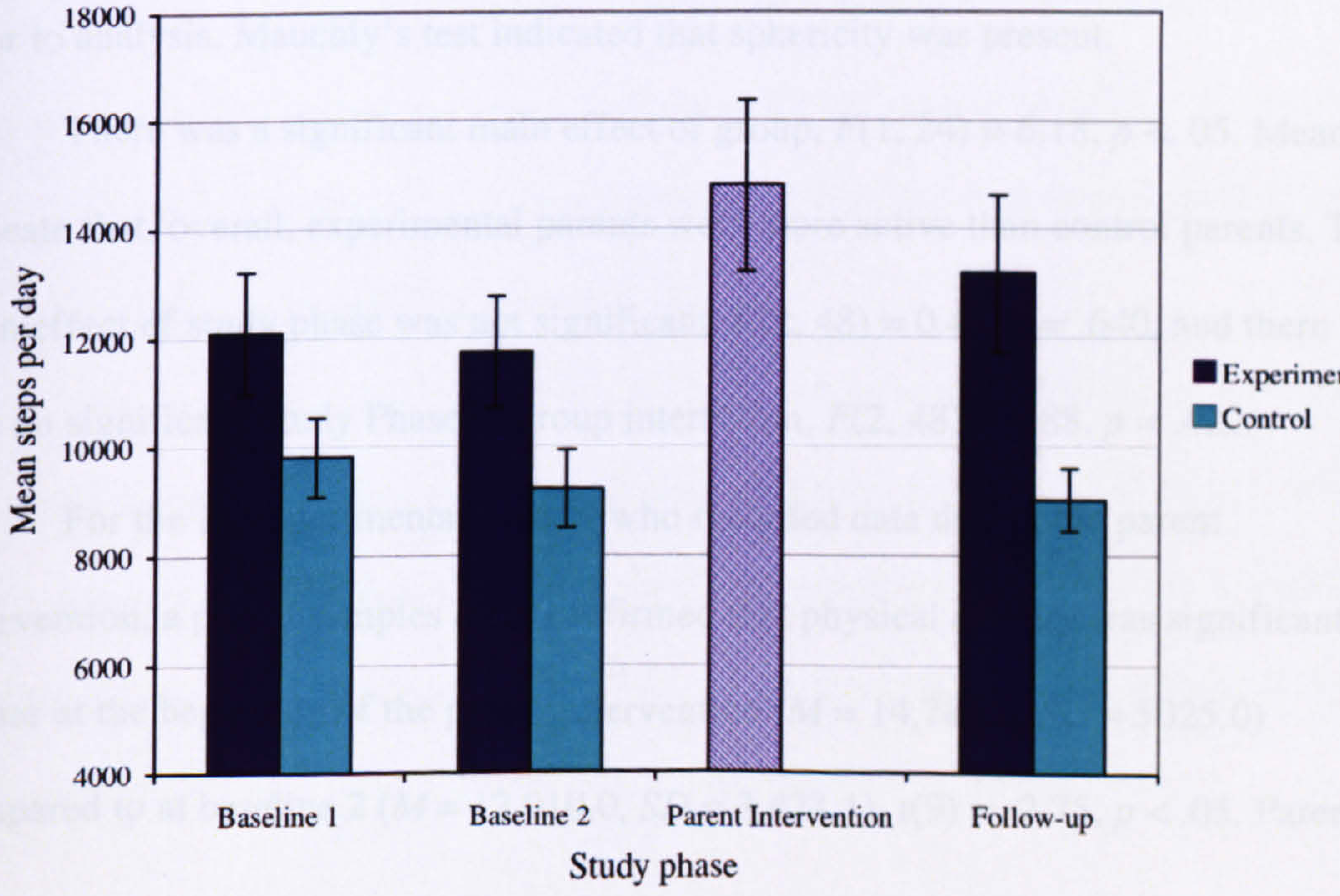


Figure 7.11. Mean physical activity (steps per day) of parents on weekdays at each study phase. Bars represent ± 1 *SE* of the mean.

Figure 7.11 shows that, at baseline 1, experimental parents were more active than control parents (*M* [*SD*] = 12,092.7 [3,690.1] cf. 9,812.9 [2,843.5] steps per day, respectively). This trend was evident during baseline 2 and at follow-up. Experimental parents averaged 11,730.4 steps per day during baseline 2 (*SD* = 3,377.2). They subsequently increased to 14,783.6 steps per day at the beginning of the parent intervention, and then averaged 13,162.2 steps per day at follow-up (*SD*s = 5,025.0, and 4,753.0. respectively). Control parents averaged 9,209.9 steps per day during baseline 2 and 9,023.3 steps per day during follow-up (*SD*s = 2,767.0, and 2,229.1, respectively).

A 2 × 3 mixed ANOVA was carried out with the within-subjects factor as study phase (baseline 1, baseline 2, follow-up), and the between-subjects factor as group (experimental, control). The dependent variable was mean steps per day on weekdays. Kolmogorov Smirnov tests indicated that all means were drawn from normal distributions. However Levene's test showed that population variances were not equal across groups therefore a log 10 transformation was employed on the data prior to analysis. Mauchly's test indicated that sphericity was present.

There was a significant main effect of group, $F(1, 24) = 6.18, p < 05$. Means indicate that, overall, experimental parents were more active than control parents. The main effect of study phase was not significant, $F(2, 48) = 0.45, p = .640$, and there was no significant Study Phase × Group interaction, $F(2, 48) = 0.88, p = .422$.

For the 10 experimental parents who recorded data during the parent intervention, a paired samples *t* test confirmed that physical activity was significantly higher at the beginning of the parent intervention ($M = 14{,}783.6$, $SD = 5025.0$) compared to at baseline 2 ($M = 12{,}010.0$, $SD = 3{,}423.1$), $t(9) = -2.75, p < .05$. Parents showed an average increase of 2,773.6 steps per day which exceeded the increase in steps that was specified by the targets (i.e., 2,000 steps per day).

Weekend days. Mean physical activity during baseline 1, baseline 2, and follow-up was computed for each parent. Physical activity was measured as steps per day. As previously, mean scores were computed using the pedometer data from the 2 weekend days in each experimental phase. To be included in the analysis of weekend data, parents needed to have pedometer data for 2 weekend days in each of the three experimental phases. This was in addition to the 4 days of weekday pedometer data needed for the previous analysis. On this basis, 2 control parents and 3 experimental parents were excluded; therefore the proceeding analysis of weekend data included 13 control parents and 8 experimental parents. In both experimental and control groups, excluded parents did not differ significantly from the included sample on baseline age, height, mass, BMI, or weekday steps per day.

Mean scores for weekend physical activity at the beginning of the parent intervention were computed for experimental parents only using the maintenance diaries. Scores were computed using the parent self-reported data points for the 2 weekend days of Week 2 of the phase (see above for the reasoning behind the use of Week 2 as opposed to Week 1). If a parent missed a data point on any of these days, the next available weekend data point was used.

Parent weekend physical activity at baseline 1 was not significantly correlated with child weekend physical activity at baseline/baseline 1, $r = .06$, $N = 15$, $p = .836$.

Mean weekend physical activity for the two groups during baseline 1, baseline 2, and follow-up may be seen in Figure 7.12. Mean weekend physical activity during the parent intervention is also displayed for the experimental parents only.

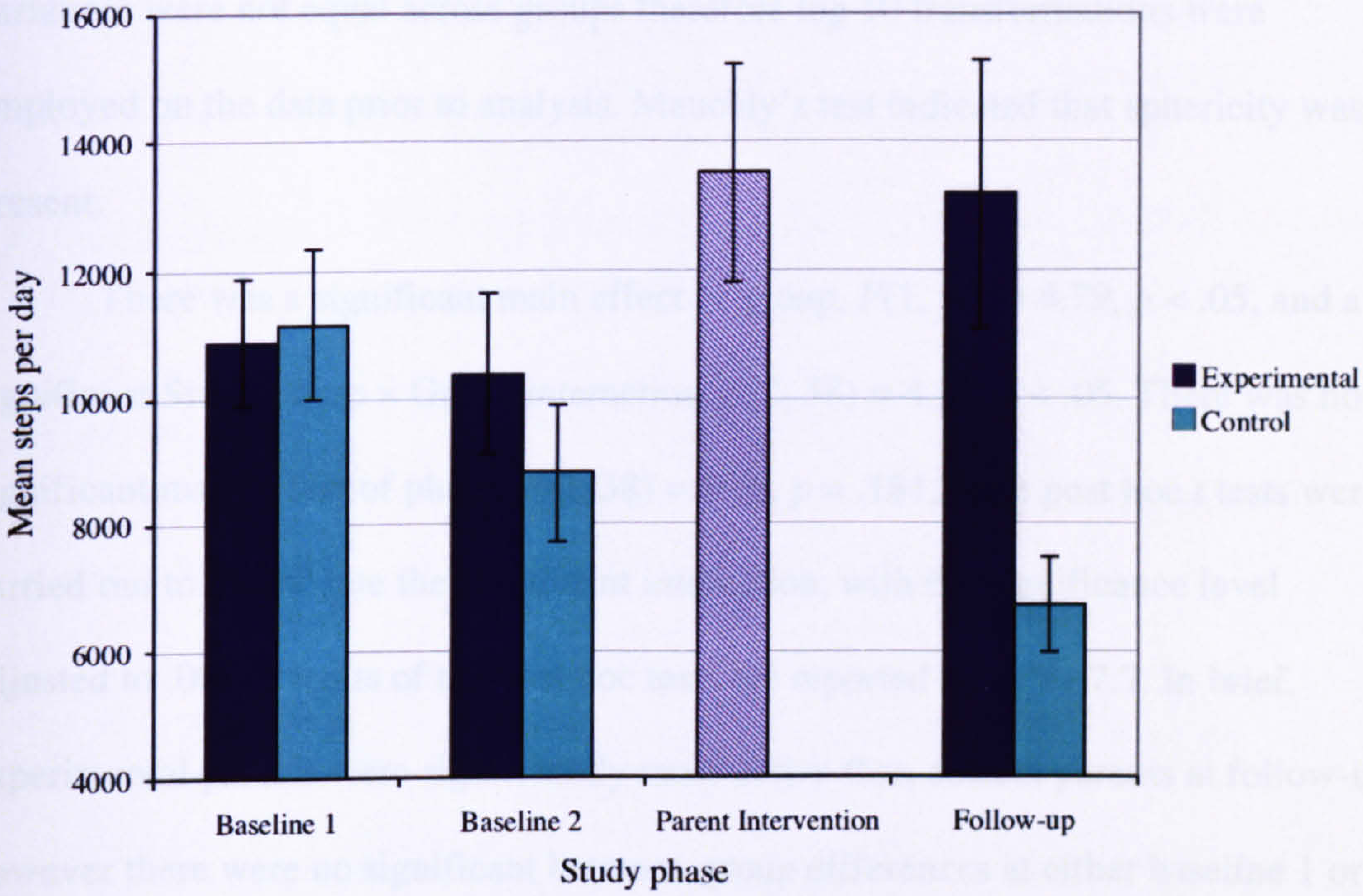


Figure 7.12. Mean physical activity (steps per day) of parents on weekend days at each study phase. Bars represent ± 1 *SE* of the mean.

Figure 7.12 shows a decreasing trend in the activity level of control parents. Mean steps per day (with standard deviations in parentheses) were 11,161.8 (4,218.9) at baseline 1, 8,816.5 (3,939.2) at baseline 2, and 6,720.0 (2,680.7) at follow-up. Experimental parents averaged 10,883.9 steps per day at baseline 1, and 10,381.6 steps per day at baseline 2 (*SD*s = 2,814.1, and 3,580.4, respectively). A subsequent increase in steps per day was observed among experimental parents to 13,508.9 at the beginning of the parent intervention and 13,184.5 at follow-up (*SD*s = 4,824.4, and 5,923.6, respectively).

A 2 × 3 mixed ANOVA was carried out with the within-subjects factor as study phase (baseline 1, baseline 2, follow-up), and the between-subjects factor as group (experimental, control). The dependent variable was mean steps per day on weekend days. Kolmogorov-Smirnov tests indicated that means were drawn from normally distributed populations. Levene's test however indicated that population variances were not equal across groups therefore log 10 transformations were employed on the data prior to analysis. Mauchly's test indicated that sphericity was present.

There was a significant main effect of group, $F(1, 19) = 4.79, p < .05$, and a significant Study Phase × Group interaction, $F(2, 38) = 4.28, p < .05$. There was no significant main effect of phase, $F(2, 38) = 1.79, p = .181$. Nine post hoc t tests were carried out to investigate the significant interaction, with the significance level adjusted to .006. Results of the post hoc tests are reported in Table 7.7. In brief, experimental parents were significantly more active than control parents at follow-up, however there were no significant between-group differences at either baseline 1 or baseline 2. Within-subject comparisons showed that, among experimental parents, there were no significant differences in level of physical activity between any of the three study phases. Control parents were significantly less active at follow-up compared to baseline 1, however there was no significant difference between baseline 1 and baseline 2, or between baseline 2 and follow-up.

Table 7.7

Results of between-group and paired-sample post hoc t tests for parents' weekend physical activity ($N = 8$ in experimental group; $N = 13$ in control group).

Comparison	Untransformed means (*SD*)[a]	*t* value (*df*)[b]
	Between-group comparisons	
Experimental baseline 1 cf. control baseline 1	10,883.9 (2,814.1) 11,161.8 (4,218.9)	-0.02 (19)
Experimental baseline 2 cf. control baseline 2	10,381.6 (3,580.4) 8,816.5 (3,939.2)	-1.05 (19)
Experimental follow-up cf. control follow-up	13,184.5 (5,923.6) 6,720.0 (2,680.7)	-3.26 (19)*
	Experimental group	
Baseline 1 cf. baseline 2	10,883.9 (2,814.1) 10,381.6 (3,580.4)	0.56 (7)
Baseline 2 cf. follow-up	10,381.6 (3,580.4) 13,184.5 (5,923.6)	-1.22 (7)
Baseline 1 cf. follow-up	10,883.9 (2,814.1) 13,184.5 (5,923.6)	-0.90 (7)
	Control group	
Baseline 1 cf. baseline 2	11,161.8 (4,218.9) 8,816.5 (3,939.2)	2.16 (12)
Baseline 2 cf. follow-up	8,816.5 (3,939.2) 6,720.0 (2,680.7)	1.31 (12)
Baseline 1 cf. follow-up	11,161.8 (4,218.9) 6,720.0 (2,680.7)	3.60 (12)*

[a]Displayed means are untransformed values (steps per day). [b]*t* test results are for log 10 transformed means.

* $p < .006$ (required significance level after Bonferroni adjustment).

All 8 experimental parents included in the above analysis of weekend physical activity had recorded data during the parent intervention. Means indicate that physical activity was higher at the beginning of the parent intervention (M = 13,508.9, SD = 4,824.4) compared to at baseline 2 (M = 10,381.6, SD = 3,580.4). Parents thus increased by 3,127 steps per day on average which is greater than the increase specified by the intervention targets (i.e., 2,000 steps per day). A paired samples t test, however, showed that this increase was not statistically significant, $t(7) = -1.65$, p = .144.

Overweight Subgroup

Physical activity in overweight and obese participants was compared at each study phase in children and parents and on weekdays and weekend days. This was to investigate whether overweight and obese individuals showed differential responses to the intervention procedures in comparison to nonoverweight individuals.

Weekday physical activity of normal weight and overweight/obese children at baseline/baseline 1, intervention/baseline 2, and follow-up is shown in Figure 7.13. During the intervention in the experimental group, overweight/obese girls increased their physical activity by 38% from baseline (i.e., mean increase of 4,627.0 steps per day) and nonoverweight girls increased by 29% (mean increase of 3,915.3 steps per day). In both cases the increase in steps per day exceeded the increase specified by the targets. At follow-up, the nonoverweight group maintained an increase of 1,981.6 steps per day relative to baseline whereas the overweight/obese group had returned to baseline. In the control group, both overweight/obese girls and nonoverweight girls showed a lower level of activity at follow-up relative to baseline 1 (mean decrease from baseline 1 of 2,432.1 and 2,004.8 steps per day, respectively).

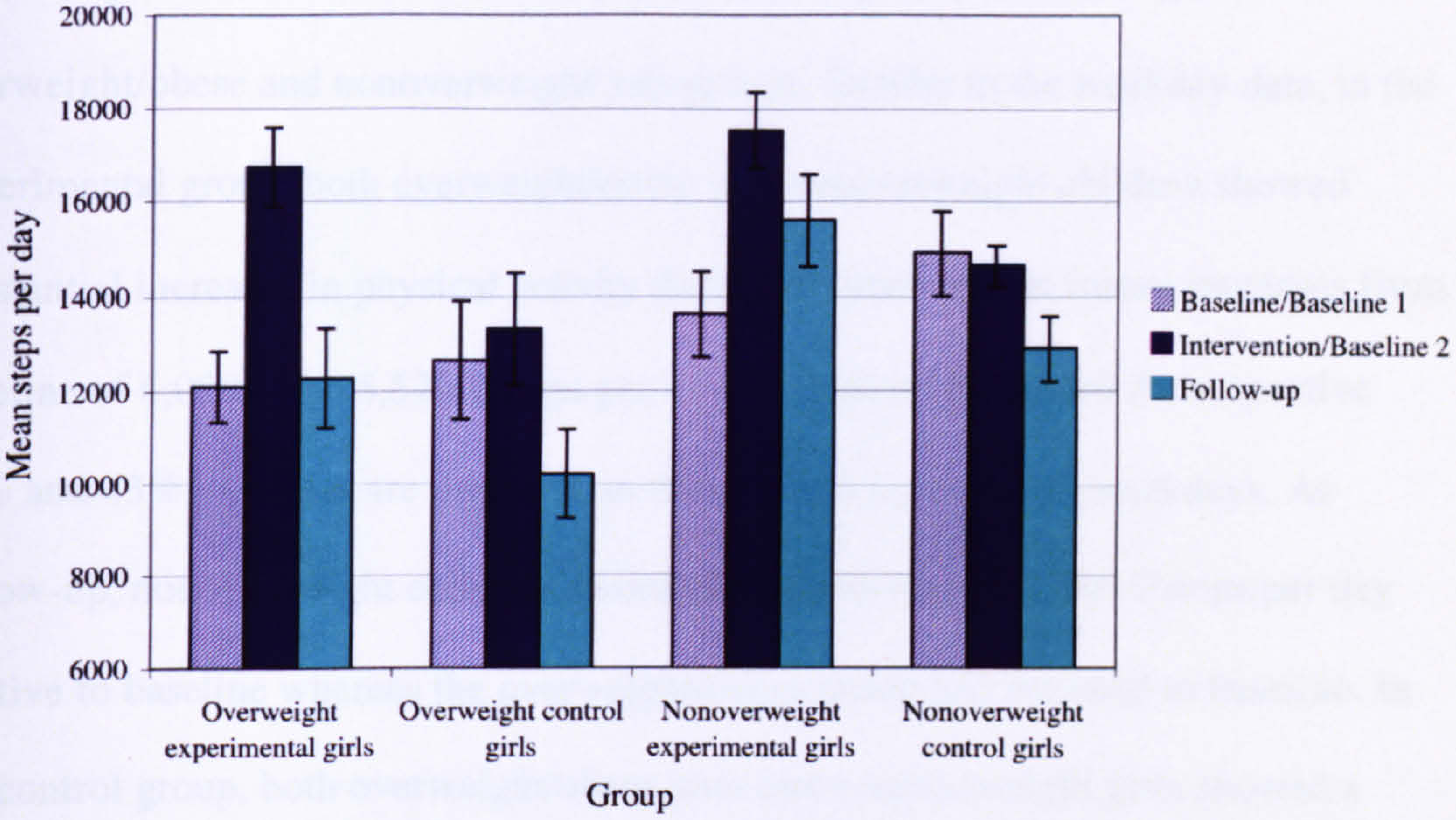


Figure 7.13. Mean steps per day on weekdays in overweight/obese (n = 7) and nonoverweight (n = 7) experimental girls and overweight/obese (n = 8) and nonoverweight (n = 7) control girls at the three time points. Bars represent ± 1 *SE* of the mean.

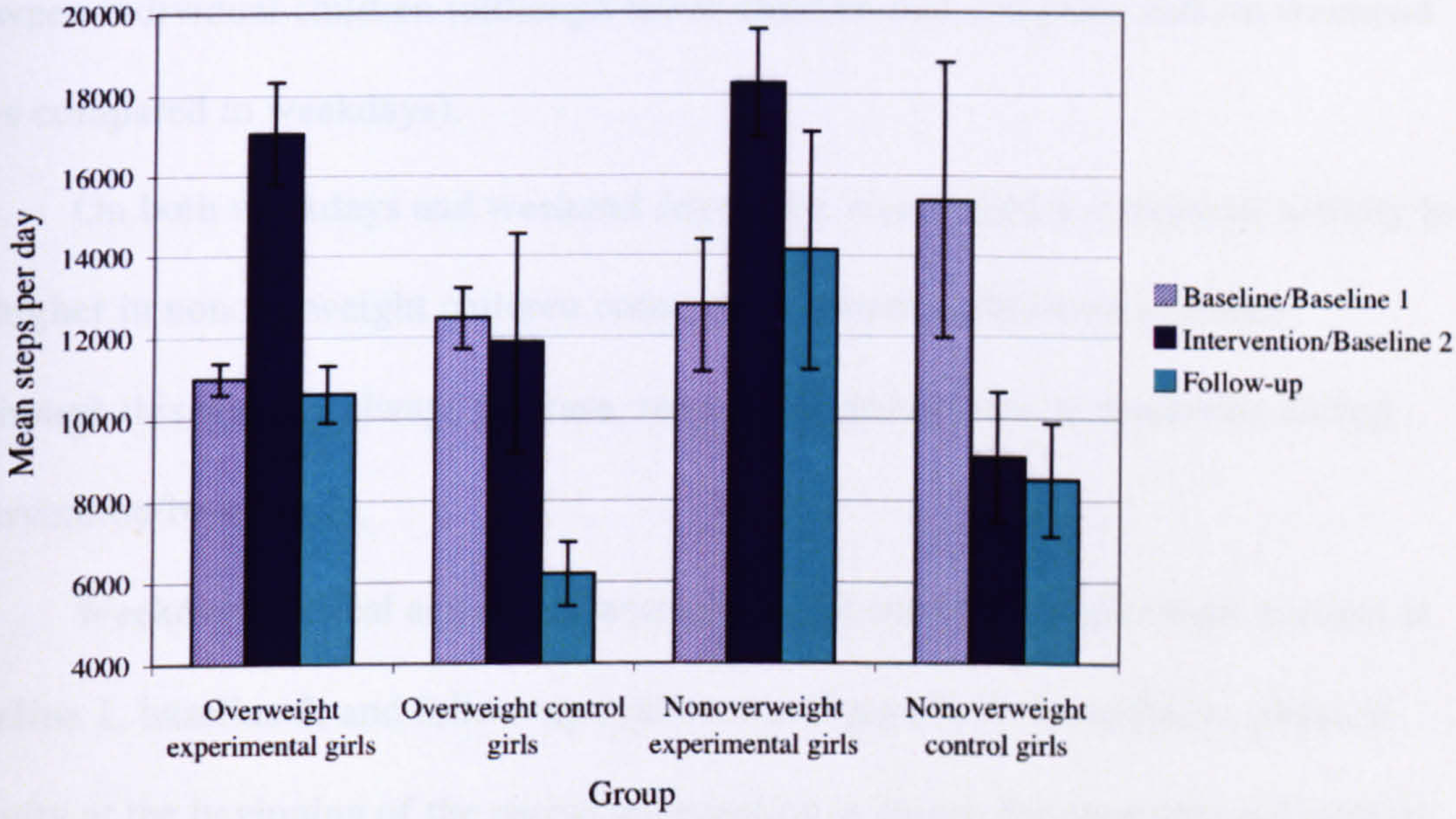


Figure 7.14. Mean steps per day on weekend days in overweight/obese (n = 3) and nonoverweight (n = 5) experimental girls and overweight/obese (n = 5) and nonoverweight (n = 4) control girls at the three time points. Bars represent ± 1 *SE* of the mean.

Figure 7.14 shows children's physical activity on weekend days for overweight/obese and nonoverweight sub-groups. Similar to the weekday data, in the experimental group, both overweight/obese and nonoverweight children showed substantial increases in physical activity during the intervention (mean increases from baseline of 6,079.1 and 5,520.8 steps per day, respectively). Indeed the respective 55% and 43% increases are greater than those which occurred on weekdays. At follow-up, nonoverweight children maintained an increase of 1,366.6 steps per day relative to baseline whereas the overweight/obese group had returned to baseline. In the control group, both overweight/obese girls and nonoverweight girls showed a marked decrease in physical activity at follow-up relative to baseline 1 (mean decrease from baseline 1 of 6,256.4 and 6,857.1 steps per day, respectively). The large standard error bars in Figure 7.14 are indicative of substantial variability between individual children (although fewer children had complete data on weekend days compared to weekdays).

On both weekdays and weekend days there was a trend for physical activity to be higher in nonoverweight children compared to overweight/obese children (although this was not always the case, see control group data on weekends during intervention/baseline 2).

Weekday physical activity of normal weight and overweight/obese parents at baseline 1, baseline 2, and follow-up is shown in Figure 7.15. In addition, physical activity at the beginning of the parent intervention is shown for experimental parents only.

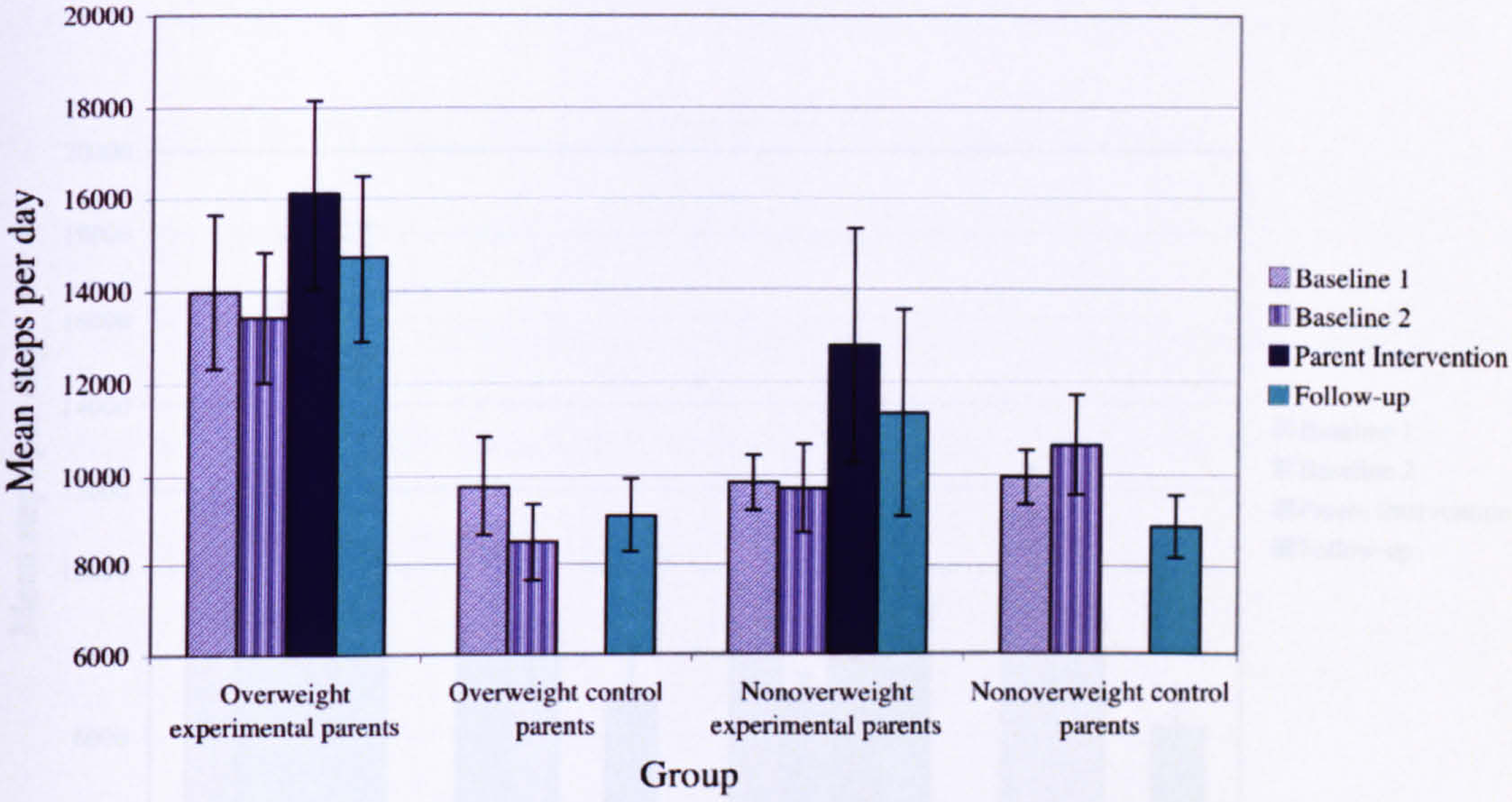


Figure 7.15. Mean steps per day on weekdays in overweight/obese (n = 6) and nonoverweight (n = 5) experimental parents and overweight/obese (n = 10) and nonoverweight (n = 5) control parents at each time point. Bars represent ± 1 *SE* of the mean.

Figure 7.15 shows that, in the experimental group, overweight/obese parents showed a 20% increase during the parent intervention from baseline 2, and nonoverweight parents showed a 32% increase (mean increases from baseline 2 of 2,687.7 and 3,096.0 steps per day, respectively). Both groups maintained a higher level of activity at follow-up relative to baseline 2 (mean increases of 1,271.1 and 1,624.6 steps per day in overweight/obese and nonoverweight groups, respectively), although the large standard error bars indicate substantial variability. In the control group, both overweight/obese and nonoverweight parents showed a lower level of activity at follow-up compared to baseline 1, although the overweight group showed a slight increase from baseline 2.

Interestingly, in the experimental parents, a trend was evident at all study phases for physical activity to be higher in the overweight/obese parents compared to the nonoverweight parents. This trend was not observed in control parents.

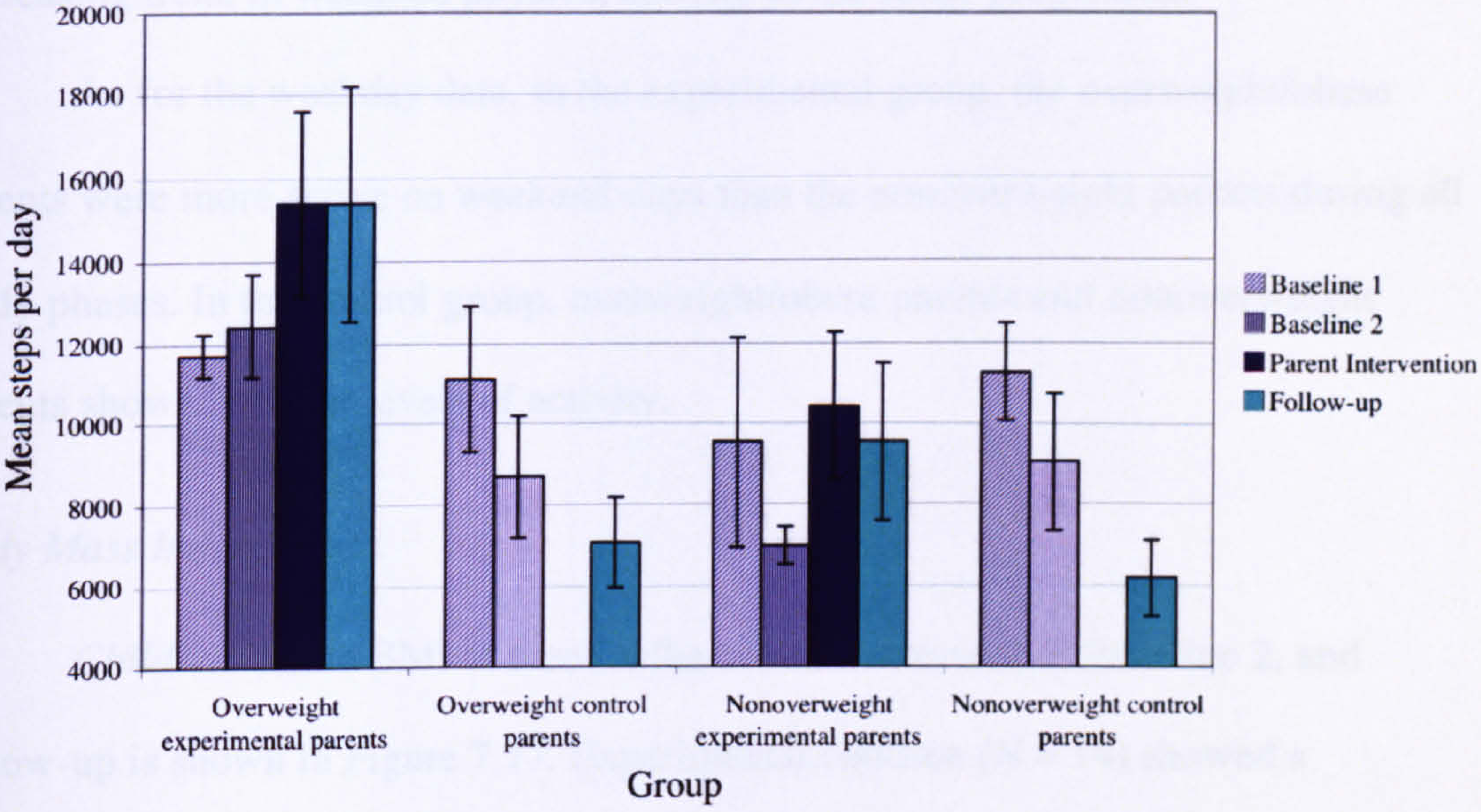


Figure 7.16. Mean steps per day on weekend days in overweight/obese (n = 5) and nonoverweight (n = 3) experimental parents and overweight/obese (n = 8) and nonoverweight (n = 5) control parents at each time point. Bars represent ± 1 *SE* of the mean.

Weekend physical activity of parents by overweight subgroup is shown above in Figure 7.16. In the experimental group, during the parent intervention overweight/obese parents increased by 24% from baseline 2 and nonoverweight parents increased by 49% (mean increase from baseline 2 of 2,936.2 and 3,446.0 steps per day, respectively). Both groups maintained a higher level of activity at follow-up relative to baseline 2 (mean increases of 2,943.1 and 2,569.4 steps per day in overweight/obese and nonoverweight groups, respectively), most notably the overweight group who showed no drop-off in activity level. As for the weekday data, however, there was substantial variability. Furthermore, due to missing data on weekend days, only 3 nonoverweight parents from the experimental group are represented in Figure 7.16. These parents showed a marked decrease in physical activity from baseline 1 to baseline 2, which was due to one of the parents showing a high level of activity during baseline 1 and a comparatively low level during baseline 2. In the control group, both overweight/obese and nonoverweight parents showed a decreasing trend in weekend physical activity as the study progressed.

As for the weekday data, in the experimental group, the overweight/obese parents were more active on weekend days than the nonoverweight parents during all study phases. In the control group, overweight/obese parents and nonoverweight parents showed similar levels of activity.

Body Mass Index

Children. Mean BMI at baseline/baseline 1, intervention/baseline 2, and follow-up is shown in Figure 7.17. Experimental children ($N = 14$) showed a decreasing trend in BMI, averaging 19.7 kg/m^2 at baseline, 19.6 kg/m^2 at intervention, and 19.5 kg/m^2 at follow-up (*SD*s = 3.2, 3.3, and 2.9, respectively). Control children ($N = 15$) averaged 20.2 kg/m^2 at baseline 1, decreased to 20.1 kg/m^2 at baseline 2, and then increased to 20.3 kg/m^2 at follow-up (*SD*s = 4.0, 4.0, and 4.2, respectively.

A 2 × 3 mixed ANOVA was carried out with the within-subjects factor as study phase (baseline/baseline 1, intervention/baseline 2, follow-up), and the between-subjects factor as group (experimental, control). The dependent variable was mean BMI (kg/m^2). Kolmogorov-Smirnov tests indicated that means were drawn from normal distributions. Levene's test indicated that population variances were equal across groups. Mauchly's test however indicated a lack of sphericity therefore the Huynh-Feldt correction to the degrees of freedom was employed here.

The ANOVA showed no significant main effect of study phase, $F(2, 43) = 0.27, p = .717$, or group, $F(1, 27) = 0.20, p = .658$. The Study Phase × Group interaction was also nonsignificant, $F(2, 43) = 1.11, p = .326$.

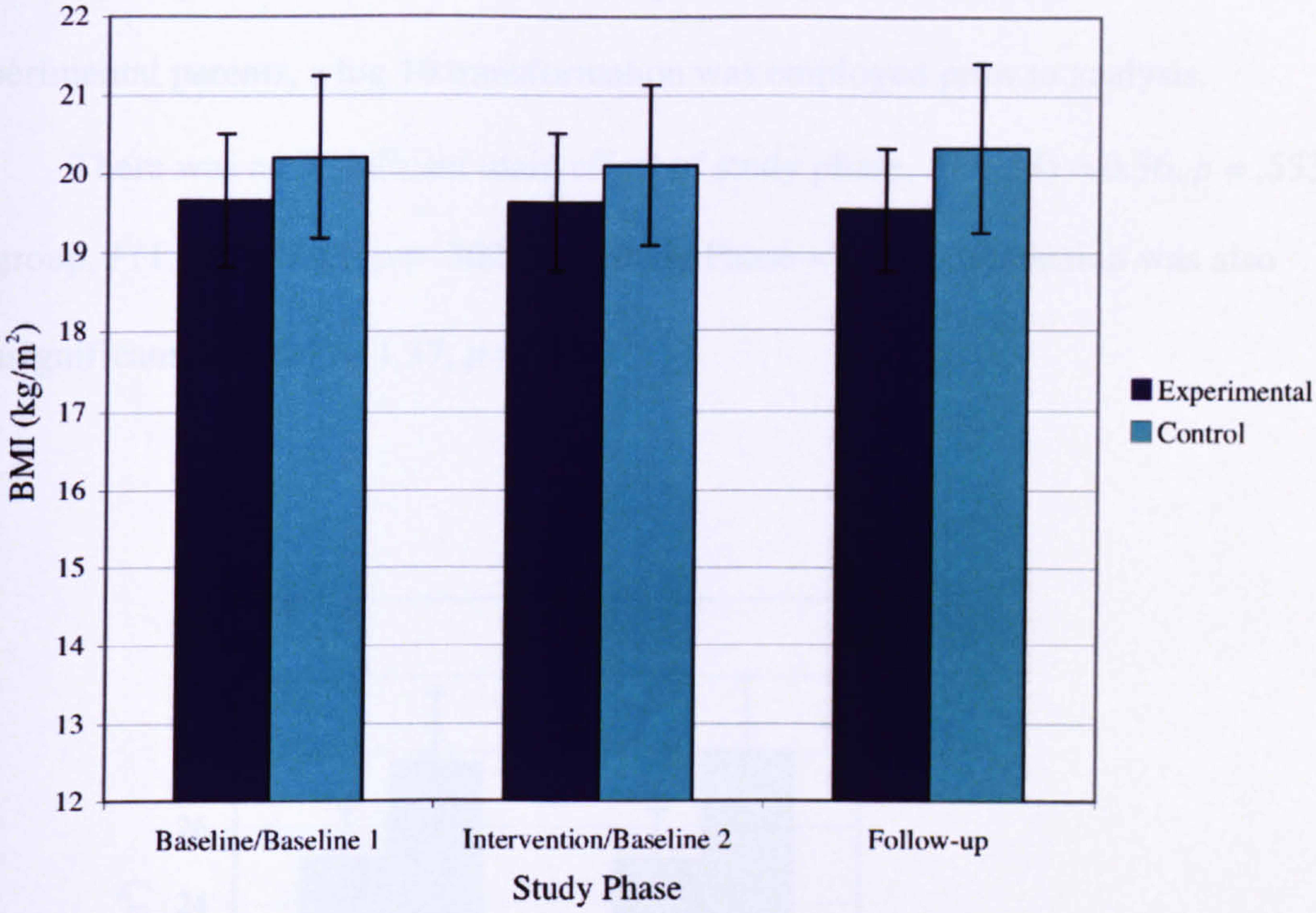


Figure 7.17. Mean BMI (kg/m^2) for experimental and control children at each study phase. Bars represent ± 1 *SE* of the mean.

Parents. Mean BMI at baseline and follow-up is shown in Figure 7.18. Experimental parents ($N = 11$) showed a slight decrease in BMI averaging 25.2 kg/m^2 at baseline 1 and 25.1 kg/m^2 at follow-up (*SD*s = 4.2, and 4.3, respectively). Control parents ($N = 15$) averaged 27.7 kg/m^2 at baseline 1 and increased to 28.0 at follow-up (*SD*s = 7.3, and 7.6, respectively).

A 2 × 2 mixed ANOVA was carried out with the within-subjects factor as study phase (baseline 1, follow-up), and the between-subjects factor as group (experimental, control). The dependent variable was mean BMI (kg/m^2). Kolmogorov-Smirnov tests indicated that means were drawn from normal distributions. Levene's test indicated equality of variances, however given the noticeably larger standard deviations among control parents compared to experimental parents, a log 10 transformation was employed prior to analysis.

There was no significant main effect of study phase, $F(1, 24) = 0.36, p = .553$, or group, $F(1, 24) = 1.11, p = .302$. The Study Phase × Group interaction was also nonsignificant, $F(1, 24) = 1.17, p = .290$.

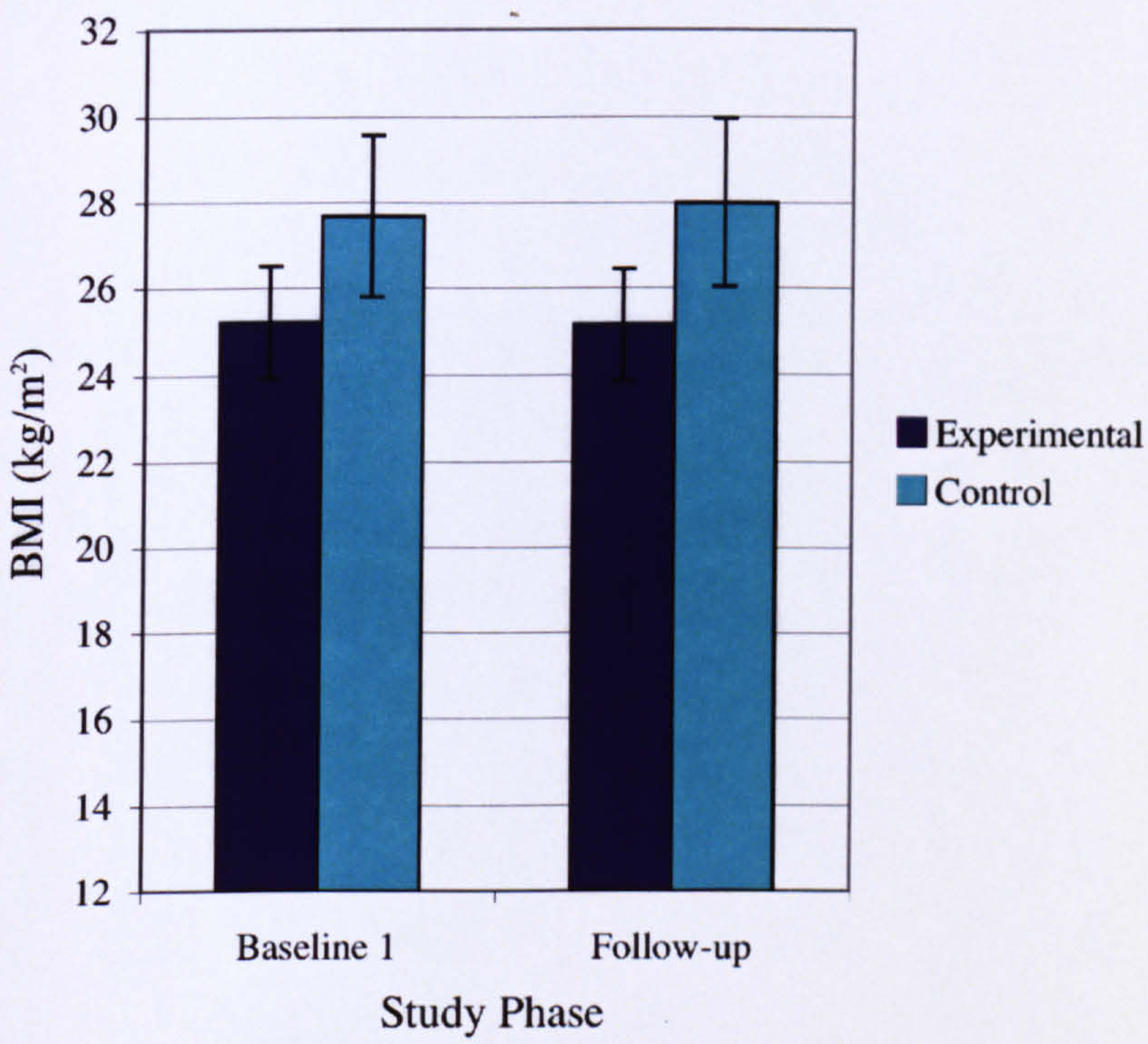


Figure 7.18. Mean BMI (kg/m^2) for experimental and control parents at baseline and follow-up. Bars represent ± 1 *SE* of the mean.

Parent and Child Responses

Parent questionnaires. Responses to the eight-item questionnaire that was sent to experimental and control parents are shown in Table 7.8. Response rates were 71% (10 out of 14) in the experimental group and 87% (13 out of 15) in the control group. One experimental parent who returned a completed questionnaire had been excluded from all preceding analyses, therefore her responses were not included in the analysis of questionnaire data.

Table 7.8

Percentage of parents who responded in each category to closed items on the questionnaire.

Item	Experimental (n = 9)			Control (n = 13)		
	Yes	No	Not sure	Yes	No	Not sure
1. Did your child enjoy taking part?	100% (9/9)	-	-	92% (12/13)	-	8% (1/13)
2. Did you enjoy taking part?	100% (9/9)	-	-	92% (12/13)	-	8% (1/13)
3. Has your child benefited from taking part?	89% (8/9)	-	11% (1/9)	62% (8/13)	15% (2/13)	23% (3/13)
4. Have you benefited from taking part?	89% (8/9)	11% (1/9)	-	69% (9/13)	23% (3/13)	8% (1/13)
5. Has your child started to be more physically active?	89% (8/9)	-	11% (1/9)	-	100% (13/13)	-
6. Have you started to be more physically active?	78% (7/9)	22% (2/9)	-	15% (2/13)	77% (10/13)	8% (1/13)
7. Did you receive enough information?	100% (9/9)	-	-	92% (12/13)	8% (1/13)	-

Note. The number of respondents in each category is shown in parentheses.

Experimental parents were significantly more likely than control parents to report that their child had become more active as a result of the programme (Fisher exact probability $< .001$, $N = 22$, two-tailed test). In addition, experimental parents were significantly more likely than control parents to report that they themselves had become more active as a result of the programme (Fisher exact probability $< .01$, $N = 22$, two-tailed test). Experimental and control parents did not differ significantly in the frequency of their responses on any of the other items.

The following represents a brief summary of comments made in response to open-ended questions. A full transcript of parental quotes is shown in Appendix D11.

Eight experimental parents believed that their child had benefited from taking part in the Fit n' Fun Dudes programme. The most frequently reported benefit to the child was increased awareness of the importance of physical activity (reported by over half of the parents). In addition, 1 parent reported that the child had become more aware of her level of physical activity. Other benefits to the child included increased physical activity and fitness (reported by 3 parents). Eight experimental parents also believed that they had benefited and the most frequently reported benefit was becoming more aware of daily levels of physical activity (reported by half of parents), and in some cases the realisation that activity levels were low. One parent reported that the programme had encouraged her to become fitter. Other reported benefits to parents included increased physical activity, health benefits (e.g., weight loss, lowering of blood pressure, improved fitness), and general interest in the data collected. In the section requesting any further comments, 1 parent commented that the programme was user-friendly, and that it could be used on a national level to improve adult fitness. One parent commented on her enjoyment of the programme, and that both she and her daughter planned to continue using the pedometers. One parent felt that she and her daughter had not been able to participate fully due to other commitments. Finally, one parent felt that the Fit n' Fun Dude characters may have been too young for near-teen girls.

Eight control parents believed that their child had benefited from taking part in the research project. The most frequently reported benefits were increased awareness of the importance of physical activity (reported by 5 parents) and the child becoming more aware of her own level of activity (reported by 4 parents). Other benefits to the child included making an effort to be more active (reported by 1 parent), and having something interesting to do and a sense of responsibility (reported by 1 parent). Nine control parents believed that they had benefited and, like the experimental parents, the most frequently reported reason was becoming aware of daily levels of physical activity (reported by 6 parents). Two parents were now encouraged to become fitter. Other reported benefits to parents included a general interest in the data collected and a shared family experience. Finally, in the section requesting any further comments, 2 parents commented on the importance and usefulness of research projects on physical activity.

Child questionnaires. Responses to the questionnaires that were sent to experimental and control children are shown in Table 7.9. Response rates were 79% (11 out of 14) in the experimental group and 87% (13 out of 15) in the control group.

Table 7.9

Percentage of control and experimental children who responded in each category to closed items on the questionnaire.

Item	Yes	No	Not sure
	Control (*n* = 13)		
Did you enjoy taking part?	100% (13/13)	-	-
Did you like wearing the pedometer?	77% (10/13)	8% (1/13)	15% (2/13)
Did you do more physical activity while wearing the pedometer?	15% (2/13)	77% (10/13)	8% (1/13)
	Experimental (*n* = 11)		
Did you enjoy taking part?	100% (11/11)	-	-
Did the Fit n' Fun Dudes programme help you to be more physically active?	82% (9/11)	-	18% (2/11)
Did you like wearing the pedometer?	91% (10/11)	9% (1/11)	-
Did you like the prizes?	100% (11/11)	-	-
Did you like the Fit n' Fun Dude song?	55% (6/11)	18% (2/11)	27% (3/11)
Did you like the Fit n' Fun Dude letters?	64% (7/11)	9% (1/11)	27% (3/11)
Did you like the Fit n' Fun Dude diary?	73% (8/11)	-	27% (3/11)
Did you use the Fit n' Fun Dude recording graph?	36% (4/11)	55% (6/11)	9% (1/11)

Table 7.9 shows that all children in the experimental and control groups enjoyed taking part. The majority of experimental and control children liked wearing the pedometer (91% and 77%, respectively). Just 15% of control children believed that they had been more active during the project. In contrast, 82% of experimental children believed that the Fit n' Fun Dudes programme had helped them to increase their level of physical activity.

The following represents a brief summary of responses to questions directed at experimental children only.

Children were asked how often they used the diary to record their pedometer count during the maintenance phase. Six children reported using the diary every day and 4 children used it on most days. One child reported never using the diary. The slinky spring was rated as the most popular prize, followed by the sports bottle and the straw. Children were also requested to list the activities that they undertook to help to reach the target. The most commonly reported activities were walking, running, and outdoor play.

Finally experimental children were asked for any other comments about the Fit n' Fun Dudes programme. Of the children who responded here, one child suggested that the programme should not be too long due to boredom, and another child felt that the Fit n' Fun Dudes were too young for her age group. Three children made positive comments about the programme, for example, "the Fit n' Fun Dudes project was really good! I liked getting the target and winning the prizes most!" (11-year-old girl).

DISCUSSION

The current study provides further evidence that a peer-modelling, rewards, and pedometer feedback intervention significantly increased levels of physical activity in 9- to 11-year-old girls. During the 8-day intervention, when daily rewards were contingent on meeting pedometer step targets, children showed substantial increases in their level of physical activity on both weekdays and weekend days (increases of 33% and 47% from baseline, respectively). These results indicate that parents were able to successfully implement and manage the intervention procedures. During the maintenance phase, children remained significantly more active than at baseline on weekend days. Parents also increased their physical activity at the beginning of the parent intervention, although this reached statistical significance on weekdays only.

On the basis of previous research (e.g., Epstein et al., 1987), it was predicted that the involvement of a parent would support the child in increasing physical activity and maintaining these increases over time. At first glance, the 12-week follow-up results for the children appeared disappointing; on neither weekdays nor weekend days were children able to significantly maintain their increased levels of physical activity relative to baseline. However an individual breakdown of the weekday data revealed that, at follow-up, 9 of the 14 experimental children (64%) maintained an increase in activity of more than 2,000 steps per day, as specified by the intervention targets. This suggests that the behaviour of these children continued to be under control of the intervention.

It is possible that children who were successful maintainers received more support and encouragement from the participating parent to continue being active. Further examination of the data revealed that, of the 9 children who maintained their increased activity at follow-up, 5 children had parents who also maintained a higher activity level than that specified by the parental target. It is possible that the joint experience of participating in the intervention and succeeding with the physical activity targets was sufficient to maintain increases in physical activity over time in this group of children and parents.

In contrast, of the 5 children who showed relapsed activity levels at follow-up, none of the parents were successful maintainers at follow-up. One child and parent pair did not adhere to the maintenance procedures, however the other parents and children showed evidence of having used the diaries for at least part of the maintenance period. It therefore appears that the maintenance procedures were not effective for all children and parents. Four of the 5 children who relapsed showed a mean level of activity at follow-up that was lower then their initial baseline level. This had an attenuating effect on the group mean which emphasises the importance of examining individual trends in physical activity.

Although intervention levels of physical activity were not maintained at follow-up, as a group the experimental children remained slightly more active relative to baseline on both weekdays and weekend days. In contrast, the group data for the control children showed a significant decline in activity level at follow-up from baseline 1 and baseline 2. At the start of the study, there was a trend for control children to be more active than experimental children on weekdays and weekend days, however by follow-up the converse was true. Indeed, on weekend days at follow-up, control children averaged just 7,215.9 steps per day while experimental children averaged almost twice as many (12,811.9 steps per day). The fact that experimental children did not show a similar decreasing trend on average is further evidence for the effectiveness of the intervention and maintenance procedures.

As noted in the previous chapter, seasonal variations in weather conditions are likely to exert a strong influence on adult and child physical activity levels (e.g., Baranowski et al., 1993; Matthews et al., 2001). In the current study, baseline and intervention measures were taken in the summer (i.e., between May and July), which may explain the higher baseline levels of activity in comparison to Study 3 of the current thesis. Follow-up measures were taken between September and October. Weather data for England and Wales obtained from the British Broadcasting Corporation (BBC) website show that, in October 2004, the average temperature was lower (10.3 °C), there was more rainfall (146.6 mm), and less sunshine (97.6 hr) compared to in June (14.9 °C, 57.6 mm, and 198.8 hr, respectively). This may explain the decline in activity at follow-up shown by control children, and by the experimental relapsers. It may therefore be unreasonable to expect the experimental children to maintain their intervention levels of activity at follow-up because, at this point, weather conditions were likely to be less conducive to outdoor physical activity.

It is possible that there was a novelty effect in response to wearing the pedometers, but this may have subsided by follow-up, which could explain the lower activity levels of the control children at this point. However this decline in activity was not apparent among control children in Study 3. Indeed, in Study 3, activity levels of control children had actually increased at follow-up and this was interpreted as reflecting more favourable weather conditions (i.e., follow-up data were collected in March) and possible novelty effects to the reintroduction of the pedometers. If novelty effects did occur among the control groups then these would be expected to operate consistently across studies. The differential trends shown by control children in Study 3 and in the current study are therefore more likely due to the timing of the data collection.

In contrast to Study 2, at baseline, there was little difference between children's weekday and weekend physical activity (13,292.2 cf. 12,966.3 steps per day, respectively, experimental and control data combined). However the decline shown by control children from baseline 1 to follow-up was largest on weekend days compared to weekdays, which suggests that girls may be vulnerable to low levels of weekend physical activity at certain times of the year. Importantly, on weekend days, the experimental group significantly increased their level of activity during the intervention and remained more active during maintenance relative to baseline.

On weekdays, experimental parents showed a significant increase of 2,773.6 steps per day at the start of the parent intervention relative to baseline 2. This increase exceeds the target increment of 2,000 steps per day and is similar in magnitude to that shown by sedentary workers (+ 3,451 steps per day) and diabetic patients (+ 3,369 steps per day) during the First Step Programme (Chan et al., 2004; Tudor-Locke, Bell, et al., 2004). In the current study, however, increased activity was not maintained to a significant level at follow-up and the analysis showed no overall effect of the parent intervention on weekday physical activity. Adult physical activity on weekdays is likely to be constrained by the nature of their employment therefore it may have been more difficult for parents to increase and maintain their level of activity on normal working days. The majority of the parents (84%) worked and several were employed in office-based occupations (e.g., secretary, civil servant), which would be likely to be highly sedentary.

On weekend days, experimental parents increased their physical activity at the start of the parent intervention and remained more active at follow-up relative to baseline 2; in both cases, increases were greater than the target increment of 2,000 steps per day. These increases, however, failed to reach statistical significance and this is most likely due to the small number of participants. Furthermore, the large standard deviations suggest that, while some parents increased and maintained a high level of activity, others were much less active. Control parents, however, showed a marked decline in weekend physical activity at follow-up relative to baseline and, at this point, were significantly less active than experimental parents (6,720.0 cf. 13,184.5 steps per day, respectively). This decrease mirrors that shown by the control children and, again, may be due to weather conditions that were less conducive to outdoor physical activity or to novelty effects of the pedometer having worn off. On average, experimental parents did not show a comparable decrease in activity at follow-up and this is suggestive of the persistence of intervention effects.

Interestingly, the decline in physical activity shown by control parents was limited to weekend days; on weekdays control parents showed a stable level of activity across the three study phases. Again this suggests that adult physical activity is constrained by work environment on weekdays and is thus less likely to be influenced by other environmental factors such as the weather.

The examination of the obese/overweight and nonoverweight subgroups revealed an interesting trend; while both groups of experimental children increased to a similar extent during the intervention, only the nonoverweight group showed evidence of physical activity maintenance at follow-up. On both weekdays and weekend days, the overweight and obese group had relapsed to their baseline level of activity. This finding suggests that, despite substantial increases in physical activity in the short-term, overweight and obese children are less able to maintain increased physical activity over time. This is consistent with a study in which obese adolescents were treated in a 10-month residential programme consisting of regular physical activity and dietary restriction (Deforche, De Bourdeaudhuij, Tanghe, Hills, & De Bode, 2004). During treatment, participants performed significantly more moderate to high intensity activities, however 6-months after treatment participation levels had relapsed and were no longer significantly different from baseline. In addition, Deforche et al. found that perceived family support for physical activity was low after treatment in these children, which again emphasises the importance of a supportive family environment for the maintenance of physically active behaviours.

It was encouraging to find that the group of physical activity maintainers consisted of 4 overweight/obese children and 5 nonoverweight children. Of the group who relapsed at follow-up, there were 3 overweight/obese children and 2 nonoverweight children. Thus over half of the overweight and obese children in the experimental group were able to maintain target increases in their level of activity over time and, again, this emphasises the importance of examining individual trends rather than exclusively focusing on group averages.

In contrast, among experimental parents, both the overweight/obese and nonoverweight groups showed a tendency to increase activity during the parent intervention and to maintain increases at follow-up relative to baseline 2. Furthermore, the overweight/obese group of experimental parents appeared more active than the nonoverweight group on both weekdays and weekend days during all study phases. This finding is unexpected and may be due to the small number of participants and to the high levels of inter-individual variability. It is possible that parents who showed a high BMI were already attempting to lose weight by increasing physical activity. This would explain their higher activity levels at baseline, leading to a higher target being set for them during the parent intervention. In future studies, it will be important to determine whether participants are already engaged in weight reductions strategies such as increasing physical activity or being on a diet.

In parents, there was no significant association between level of weekday physical activity at baseline and BMI. In children, however, a higher level of weekday physical activity was related to a lower BMI at baseline, consistent with Studies 2 and 3 and with previous research (Rowlands et al., 1999). There was a slight trend for experimental parents and children to decrease in BMI at follow-up relative to baseline, whereas control parents and children showed a slight increase, however these changes failed to reach statistical significance. The intervention's lack of effect on BMI is consistent with Study 3 and will be further discussed in Chapter 8.

At baseline, there was no significant association between child physical activity and parent physical activity on weekdays or weekend days. On weekdays this may be due to the parent and child spending a significant amount of the day in nonshared environments. However the lack of resemblance on weekend days is more surprising. Indeed Moore et al. (1991) found that children with active parents were significantly more likely to be active than were children with sedentary parents, and family resemblance in activity habits has been consistently shown in the literature (see Taylor et al., 1994). The current study measured the activity level of only one parent in the family, however Moore et al. found particularly strong effects in families where both parents were physically active. Due to the small sample size of the current study, the relationship between child and parent pedometer-determined physical activity requires further research.

Following instruction from the experimenter, parents implemented the intervention procedures with ease and no problems were reported. It was encouraging to find that the majority of experimental parents felt that they and their children had benefited from taking part in the intervention. In addition, experimental parents were more likely to report increases in physical activity as a result of the programme than were control parents. It is important to note, however, that experimental parents were aware that the aim of the intervention was to increase physical activity which may have biased their responses.

To conclude, the current study found that a peer-modelling, rewards, and pedometer-feedback intervention implemented by parents produced substantial increases in the physical activity of girls on weekdays and weekend days. Parents also increased their physical activity on commencement of the parent intervention to a greater extent than the target increment of 2,000 steps per day. At follow-up, physical activity remained higher than at baseline in both children and parents in the experimental group, and over 50% of children continued to achieve their intervention targets. In contrast, activity levels of control participants decreased substantially. It is therefore possible that the intervention protected experimental participants from showing a seasonal decline in physical activity level. The maintenance procedures did not appear effective for all children and parents and additional strategies need to be identified, with particular attention given to overweight children who may be less able to maintain increased physical activity over time.

CHAPTER 8

GENERAL DISCUSSION

Summary of Findings

It was reported in Chapter 1 that the prevalence of child obesity is increasing rapidly (Bundred et al., 2001; McCarthy et al., 2005; Reilly et al., 1999; Rudolf et al., 2001). Obesity develops because of an energy imbalance, where energy intake exceeds expenditure, therefore food intake and physical activity are key behaviours to be targeted in its prevention and treatment. It was shown that a peer-modelling and rewards intervention, the Food Dudes Programme, substantially increases children's consumption of healthful fruit and vegetables (Horne et al., 1995, 1998, 2004; Lowe et al., 1998, 2004). The aim of the current thesis was to apply the behavioural principles employed in the Food Dudes programme to an intervention to increase children's physical activity.

Various methods for the measurement of physical activity in children were outlined in Chapter 2. Given the questionable accuracy of children's self-reports, there is a need for research in this area to employ objective instruments. The electronic pedometer provides an inexpensive, convenient, and valid method of assessing physical activity in children and is ideally suited to large population studies. Study 1 demonstrated the pedometer's ability to distinguish between 7- to 8-year-old children's activities that ranged from sedentary (e.g., colouring) to moderately vigorous (e.g., football) to very vigorous (e.g., running), and that pedometer measures showed good correspondence with heart rate and self-report measures of effort (RPE).

Study 2 aimed to identify particular time periods in which 7- to 11-year-old children show low levels of habitual physical activity to determine the most appropriate context for a physical activity intervention. It was found that high-active boys and girls were more active than their low-active counterparts during both school-time and leisure-time. This suggests that an intervention to increase the physical activity of low-active children is needed in both contexts. In addition, girls were less active than boys overall and appeared less likely to increase their physical activity during free-time.

A peer-modelling, rewards, and pedometer feedback intervention was put to the test in Studies 3 and 4. Participating children, aged 9 to 11 years, wore pedometers and were each given a target number of steps to accumulate over the course of the entire day (i.e., during both school- and leisure-time). For 8 days, participants received a daily reward if they reached or exceeded their target. They were also introduced to fictional positive role models via a song and other intervention materials. Maintenance procedures were introduced following the 8-day intervention, to help children maintain their increased physical activity. In Study 3, the intervention was implemented by the experimenter in a school setting. Both girls and boys showed substantial increases in physical activity during the intervention, which were maintained at 12-week follow-up (although only girls maintained a statistically significant increase). In Study 4, the intervention was implemented by the child's parent in the home context and only girls took part. Girls showed substantial increases in physical activity on both weekdays and weekend days and remained more active at follow-up relative to baseline whereas control participants showed a marked decrease. Study 4 also included procedures to target the physical activity of parents and these appeared effective on both weekdays and weekend days.

The current study thus indicates that a peer-modelling, rewards, and pedometer feedback intervention is able to significantly increase the physical activity of 9- to 11-year-old children. Indeed, it was surprisingly easy to change children's activity levels and increases were generally well maintained over time. The following section will consider each behaviour change component in turn with respect to its effects on children's physical activity.

Social Influences on Children's Physical Activity

Research reviewed in Chapter 3 suggests that peers exert a strong influence on the physical activity of children (e.g., Luszczynska et al., 2004; Sallis et al., 2002; Taveras et al., 2004). Children are compliant to prompts to be active from peers (McKenzie et al., 1997), and a number of intervention studies have incorporated prompting and modelling of physical activity as a behaviour change strategy. In the intervention study by Katz and Singh (1986), for example, a sign was placed in the playground that displayed two cartoon frogs engaging in the target physically active behaviours and instructed children to "Do as Freddie and Freena Frog are doing". This procedure, along with praise and pictorial reinforcement using a polaroid camera, was effective in increasing the recreational behaviour of children with developmental difficulties.

In the current thesis, fictional characters called the Fit n' Fun Dudes were designed to be role models for the children to imitate. They were introduced to the children via the Fit n' Fun Dudes song, and regular letters sent to the children from the dudes represented prompts to be physically active. On the whole, girls in Studies 3 and 4 responded positively to the Fit n' Fun Dudes song and this may, in part, have facilitated their increased physical activity. In addition, the majority of girls in Study 4 (64%) indicated that they liked the Fit n' Fun Dudes letters. Boys, however, were less positive in their response to the song, which suggests that the peer-modelling element of the current intervention needs to be redesigned so that it is more appealing to boys. In the Food Dudes programme the peer-modelling element has been extensively developed and involves video-based live models presented through a series of video adventures. Future research is needed to develop a comparable peer-modelling component for use in the Fit n' Fun Dudes programme.

When interventions are conducted with groups of children (in schools, for example), it is also important to consider the impact of the child's immediate peer group. A series of studies by Woolner (2000) adapted the Food Dudes programme for use with 2- to 4-year-old children in a nursery context. During each phase of the intervention, the number of children reliably consuming fruit and vegetables increased and thus did the number of positive role models in the group. The powerful influence of these peer models was evident when new children entered the nursery once the interventions had been withdrawn; consumption of fruit and vegetables among these new attendees was substantially greater than the consumption of participating children before they were presented with the intervention. Woolner suggests that these effects are due to the development of a culture of fruit and vegetable eaters; the social environment of the nursery became one in which fruit and vegetable consumption was the norm and new members were thus likely to follow suit. Monthly consumption data continue to be collected from this nursery and many years following the original intervention the children eat around 80% of the fruit and vegetables provided each day.

In the current studies, the physical activity intervention was conducted with groups of children and it is thus likely that peer-group influences were operational. Even though Study 4 was implemented in the home context, children attended the same school and were often friends with fellow participants. Children who successfully passed their step count targets may have acted as role models and provided support for other children in the group. In addition, children appeared to compete with one another in order to obtain a high number of steps. A number of participants were keen to know how many steps they had done each day and whether they had "beaten" other children in the group (e.g., "did I do more than Ryan?"). Over time, it is possible that a culture may have developed that supported wearing pedometers and doing a high number of steps. This would be expected to exert a potent, long-lasting effect on children's activity levels. In order for this to occur, it would be important for the school to take on the management of the intervention procedures in the long-term, as was the case in the nursery studies (Woolner, 2000) and in whole-school studies of the Food Dudes programme (Horne et al., 2004; Lowe et al., 2004).

Parents are also likely to exert a significant influence on their children's physical activity by acting as role models, supporting physical activity participation, and engaging in shared activities. Indeed family resemblance in activity levels has been consistently found (Moore et al., 1991; see Taylor et al., 1994) and family support is correlated with higher activity levels in children (Sallis et al., 1999). In Study 4 of the current thesis, the intervention was implemented by the child's parent and was designed to additionally target parental physical activity. Among the experimental group, several of the children who were successful maintainers at follow-up had parents who also maintained target increases in their physical activity. Reciprocal support and modelling effects may have occurred in this group of children and parents, and this may have helped to maintain increased physical activity over time.

While it is clearly important to include parents in child interventions (e.g., see Epstein et al., 1987), the advantages of peer group interventions are highlighted above. Furthermore, as children get older, peers may exert a stronger influence on behaviour than parents (Buhrmester & Furman, 1987; see Goran et al., 1999). One approach would be to implement the physical activity intervention in the school-setting but to additionally provide parents with information and ideas to encourage their children to be active in the home context. This may be easily achieved in the current physical activity intervention given that children wear their pedometers during leisure-time as well as school-time. In addition, other family members could be given pedometers to encourage their involvement and procedures such as within-family pedometer competitions could be introduced.

Rewards and Pedometer Feedback

According to research reported in Chapter 3, children who found physical activity to be reinforcing in a laboratory choice test engaged in more physical activity in the natural environment (Epstein et al., 1999). This suggests that increasing the reinforcing value of physical activity should help children be more physically active.

Consistent with this, and with previous studies in the literature (Epstein, Saelens, et al, 1995; Epstein et al., 1984; Fujita, 1995; Katz & Singh, 1986; Taggart et al., 1986), the current studies showed substantial increases in children's activity levels when physically active behaviours were rewarded. During the 8-day intervention when rewards were available each day, girls and boys in Study 3 showed respective increases of 35% and 21% in their level of total physical activity per day. Similarly in Study 4, girls increased by 33% on weekdays and 47% on weekend days.

Rewards appear most effective when their delivery is contingent upon actual performance (e.g., see Cameron et al., 2000; Dickinson, 1989). For this reason, it is of great importance that both the child and the individual who administers the rewards are able to monitor the child's progress with accuracy. This was achieved in the current intervention by making reward delivery contingent upon the accumulation of a target number of steps on a pedometer. In the laboratory-based study by Goldfield et al. (2000), obese children were required to accumulate either 750 or 1,500 pedometer counts during the experimental session to gain access to a reinforcer (time watching television). The current thesis shows that this approach may be applied to effectively increase total levels of physical activity throughout the day. This is of great importance because Study 2 indicated that physical activity interventions should target activity levels throughout the day. In contrast, a number of previous intervention studies have focussed on one context only, for example, free play periods (e.g., Epstein et al., 1984; Fujita, 1995; Katz & Singh, 1986). Furthermore, school-based multicomponent interventions have not had great success in increasing out-of-school physical activity (e.g., Caballero et al., 2003; Sahota et al., 2001b; Sallis et al., 1997; see Stone et al., 1998, for review).

By targeting physical activity over the course of the entire day, the current intervention allowed for the intermittent activity patterns of children. It seems unreasonable to expect children to perform sustained periods of physical activity because they do not appear to behave in this way under natural conditions (see Bailey et al., 1995). In addition, the current intervention allowed children to choose how, when, and where their additional steps were accumulated. Research reported in Chapter 3 suggests that better long-term adherence to exercise schedules may be achieved through exercise programmes that emphasise lifestyle changes (e.g., using stairs, active transport) and allow choice and flexibility (Epstein et al., 1982; Epstein, Wing, Koeske, et al., 1985).

In the current study the pedometer provided immediate feedback on activity level in relation to the target that had been set for each participant. In addition, during the maintenance phase, participants were encouraged to continue wearing the pedometers and to keep a daily log of their step counts in provided Fit n' Fun Dude diaries. A number of intervention studies with adults demonstrate that pedometer goal-setting and self-monitoring strategies may be used to increase physical activity (Chan, et al., 2004; Croteau, 2004; Rooney et al., 2003; Tudor-Locke, Bell, et al., 2004). The current thesis suggests that such strategies are effective in increasing and maintaining levels of physical activity in children when used in combination with a reward scheme. In addition, in the current intervention, each child's daily step target was individualised to his or her baseline level of activity, requiring an increase of 1,500 to 2,000 steps per day over baseline. This procedure was well accepted by children, parents, and teachers, and is preferable to the use of a universal step goal (e.g., 10,000 steps), which would be too easy for highly active children but less feasible for more sedentary children.

In the study by Goldfield et al. (2000), the group instructed to accumulate 1,500 steps were significantly more active than the group instructed to accumulate 750 steps, and this suggests that the participants' step counts closely matched the experimental contingencies (although activity data are presented as accelerometer counts rather than step counts). In contrast, in both Studies 3 and 4 of the current thesis, children increased their activity to levels that greatly exceeded the intervention targets. In Study 3, targets required children to increase by 1,500 steps per day from baseline, however during the intervention, average increases of 3,822 and 2,785 steps per day were found for girls and boys, respectively. As a result, in Study 4 the target step increment was raised to 2,000 steps per day, however children continued to over-shoot the target (average increases of 4,271 and 5,730 steps per day on weekdays and weekend days, respectively). This may reflect a novelty effect to the introduction of the pedometer targets and rewards. The intervention was only 8 days in duration and it is possible that the over-shoot effect would have subsided with time. A longer intervention period may show that children's step counts do begin to match the contingencies.

In addition, the previous section highlighted the strong influence of the child's immediate peer group in intervention contexts. In the current studies, the tendency to compete with other children is likely to have encouraged participants to do as many steps as possible regardless of their intervention targets. This may explain the apparent lack of sensitivity to the experimental contingencies.

Physical Activity Maintenance

In order to obtain maximum health benefits of increasing physical activity, Sallis (1995) emphasises the importance of maintaining regular activity over time. The current thesis has shown that, at 12-week follow-up, experimental girls in Study 3 remained significantly more active than at baseline and over 50% of girls in Study 4 continued to achieve their intervention targets. During the maintenance phase, no extrinsic rewards were delivered so other factors appear to have maintained the behaviour of increased physical activity. Children may have "felt better" due to their increased activity. Furthermore, being active may have entailed being more social, which has its own rewards.

Wearing the pedometers and engaging in the self-monitoring procedures during the maintenance phase were likely to assist in the maintenance of increased activity levels. In an 8-week intervention with adult women, setting daily step goals, keeping a log of steps walked, and wearing a pedometer all of the time were most likely to predict improvements in the amount of physical activity (Rooney et al., 2003).

The self-monitoring procedures employed during the maintenance phase may have produced self-evaluative statements that served to reinforce increased physical activity (e.g., see Cooper et al., 1987). For example, a child who recorded a daily number of steps that exceeded her target may have emitted covert verbal responses (e.g. "I am a good girl, I passed my target today"). Such verbal responses may have served to reinforce achieving target increases in physical activity. Conversely, self-monitoring undesirable behaviours, such as not passing the target, may have emitted covert guilt statements. Negative affect associated with guilt statements may be escaped only by better performance, thus establishing negative reinforcement for increasing physical activity (Lombard, et al., 1995). Another possibility is that the rules maintaining the behaviour may have changed over time from "I must pass my target" to "I always pass my target".

Not all children, however, were successful in maintaining their increased physical activity. In Study 3, experimental boys did not maintain significant increases in activity at follow-up, and further breakdown of the data revealed that this was particularly true for boys who were least active at baseline. Possible explanations, suggested in Chapter 6, include poorer adherence to the maintenance procedures and reduced peer support due to the smaller number of male participants.

In Study 4, there were 5 children in the experimental group who did not maintain target increases in their pedometer counts at follow-up. The importance of family support for physical activity has been stated previously and, of interest, the children who relapsed also had parents who were unsuccessful in maintaining increased physical activity. The poor performance of both the child and the parent suggests that modelling, support, and encouragement for increasing physical activity may have been low or nonexistent in these cases.

Study 4 also indicated that, as a group, the overweight and obese children did not maintain their level of physical activity at follow-up, despite showing similar increases during the intervention as the nonoverweight children. Excess weight is a barrier to physical activity (Dishman, 1990) and research reviewed in Chapter 3 indicates that access to physical activity does not function as an effective reinforcer for very obese children (Epstein et al., 1991). An obese child who engages in physical activity may contact punishing consequences, such as being sore or out of breath, which would be likely to discourage extended participation in physical activity. Overweight and obese children may thus require a longer period of extrinsic rewards to ensure that physical activity is followed by positive consequences. In addition, more gradual increases in pedometer step targets may be beneficial to minimise the aversive features of increased physical activity. If this activity is continued over time, then naturally-occurring benefits of being physically active may eventually be contacted.

In contrast, Study 4 suggested that overweight and obese parents were able to maintain their increased activity at follow-up. This finding, however, should be treated with caution given the small number of participants and large inter-individual variability. Research reviewed by Dishman (1990) indicates that the obese are more likely to drop out of exercise programmes within 6 to 12 months than are normal-weight individuals. In addition, obese people were less responsive to sign-posting procedures that were aimed at promoting stair versus escalator use in public places (Brownell et al., 1980).

The current thesis has shown that not all children were able to maintain their increased level of activity over a 12-week period. This emphasises the need to explore additional maintenance procedures that may be incorporated into future trials of the intervention. Adult research suggests that goal setting and feedback strategies are effective in increasing and maintaining levels physical activity but only when used in combination with high-frequency telephone prompting (Lombard et al., 1995). In the current intervention, letters from the Fit n' Fun Dudes, sent at intervals during the maintenance phase, served as prompts to be more active. Sending letters more frequently and providing additional prompts may have enhanced their effectiveness. Several studies have used signs as prompts to be active (e.g., Brownell et al., 1980; Katz & Singh, 1986) and such procedures could easily be incorporated into the current intervention. For example, colourful signs showing the Fit n' Fun Dudes could be placed in strategic locations round the school.

Furthermore, older children in the school could be nominated as Fit n' Fun Dude "leaders" in order to act as immediate role models for the younger children. One of their roles could be to encourage and prompt other children to be active in the school playground. Previous research indicates that 4- to 6-year-old children are highly compliant to prompts from peers to be active in this context (McKenzie et al., 1997).

It may also be beneficial to use intermittent reinforcement during the maintenance phase, whereby rewards contingent on increasing physical activity are gradually phased out over time. For example, at the beginning of the maintenance phase there could be one reward per week, awarded to children who pass their intervention targets on each day that week. An alternative strategy would be to employ "surprise" rewards whereby class teachers covertly nominate a particular day upon which all children who have passed their targets receive an on-the-spot reward.

Finally, it would be possible to capitalise on the observed peer competitiveness by introducing inter-class pedometer competitions. The pedometer counts of each class member could be entered into a computerised spreadsheet on a regular basis. This would enable class total and average counts to be calculated. A pedometer trophy could be awarded to the class who have the highest number of pedometer counts at the end of the school year.

Physical Activity Patterns

Children. A reliable finding of the current thesis was the higher level of total daily physical activity among boys compared to girls. This gender difference has been consistently shown in the physical activity literature and emphasises the need for interventions that are specifically aimed at girls. In addition, girls have shown greater increases in waist circumference, a measure of central fatness, than have boys over the past 10 to 20 years (McCarthy, Ellis, & Cole, 2003; McCarthy et al., 2005). Accordingly, in Study 4 the intervention targeted girls only. It was reassuring to find that girls showed significant increases in physical activity as result of participation in the intervention. Moreover girls in Study 3 showed better maintenance of physical activity than boys.

In their large-scale pedometer monitoring study, Vincent and Pangrazi (2002a) found substantial inter-individual variability in the daily step counts of 6- to 12-year-old children. A similar effect was found in the current studies, evidenced by the sizeable standard deviations in relation to the mean values for steps per day. For example, in Study 2 girls and boys averaged 13,091.0 and 17,054.6 steps per day on weekdays but the respective standard deviations were 3,534.8 and 4,165.4. In addition, among boys in Study 3, the highest reported mean daily step count at baseline was 20,002.3 while the lowest was 6,616.3. The current thesis thus provides further evidence that children's activity levels are on a continuum; while some children average a very high number of steps per day, others are much less active. Indeed, Sleap and Tolfrey (2001) argue that it is inappropriate to talk generally of children engaging in high or low levels of physical activity. It is of great importance that interventions are able to reach the least active children in the population and Study 3 showed that low-active experimental girls increased and maintained their level of physical activity to a greater extent than the more active girls in the sample (although the low-active boys fared less well, as discussed above). As with the poorest eaters in the food studies (Horne et al., 2004; Lowe et al., 2004), at least in the case of girls, the most needy showed the greatest gains in physical activity.

The level of physical activity exhibited by children appears to vary depending on the time of year and related weather conditions (e.g., Baranowski et al., 1993). In the current thesis, seasonal variations in children's habitual physical activity are highlighted when pedometer counts recorded at baseline in Study 3 are compared to those recorded in Study 2 and in Study 4. In Study 3, baseline measures were taken in November and boys and girls averaged 12,713.7 and 10,564.5 steps per day, respectively (experimental and control data combined). In Study 2, measurements were taken between March and June and, on weekdays, boys and girls averaged 17,054.6 and 13,091.0 steps per day, respectively. Similarly, in Study 4, baseline measures were taken in May and June and girls averaged 13,292.2 steps per day on weekdays (experimental and control data combined). Thus levels of habitual physical activity were substantially higher in Study 2 and Study 4 compared to Study 3. This is likely due to weather conditions that were more favourable to spending time outdoors, which has been shown to be associated with higher levels of physical activity in children (Baranowski, et al., 1993; Klesges et al., 1990). Given these discrepancies in step counts, it is crucial that researchers report the time of year that physical activity data were collected to enable comparisons across studies. In addition, the substantially higher activity levels during the summer months suggest that UK children may be most in need of physical activity interventions during autumn and winter when days are shorter and the weather is less favourable to outdoor physical activity. To encourage physical activity participation during these times, children need to be provided with opportunities to be active indoors. Computer games depending on physical activity, for example, virtual dance, fighting, and running, represent one way of achieving this.

In the two intervention studies of the current thesis, the control groups showed differential trends in their level of physical activity over time. In Study 3, control children showed a nonsignificant trend to increase in activity at follow-up (taken in March) relative to baseline and intervention measurement (in November and December). In Study 4, however, the control showed the converse and decreased in activity at follow-up (in September and October) relative to baseline and intervention (in May to July). As stated in Chapter 7, the most likely explanation is the different timing of the data collection. Such results highlight the importance of including control groups in intervention studies because children's level of habitual physical activity is clearly dependent on seasonal factors.

Parents. In Study 4, the parents also showed substantial inter-individual variability in their daily pedometer counts. On weekdays, at baseline, the mean daily step count was 10,777.4 with a standard deviation of 3,360.7 (experimental and control group data combined). The most active parent in the sample averaged 19,657.5 steps per day, and the least active parent averaged just 3,073.0 steps per day.

Previous pedometer studies with adults have tended to find lower mean daily step counts. For example, in the study by Chan et al. (2004) the mean steps per day at baseline was 7,029.0 (SD = 3,100.0), however the participants were "sedentary workers" recruited from government-funded departments or agencies. In Study 4 of the current thesis, not all parents worked and those who did were employed in a variety of occupations. The parent who recorded the highest mean step count (see above) did not work and engaged in a high amount of walking each day. In contrast, the parent who recorded the lowest step count was a receptionist and was likely to be highly sedentary while at work.

In addition to variability between individuals, a person's occupation type may lead to substantial day-to-day (i.e., intra-individual) variability in his or her activity level. There were a number of parents in Study 4 for whom this appeared the case. One parent worked as a nurse and her employment alternated between days on the ward and in the office. On the postfollow-up feedback questionnaire, this parent commented that "[the project] made me more aware of how comparatively few steps I do in a day when I am working in the office as opposed to a day working on the ward". The recorded weekday step counts for this parent ranged from 5,293 to 15,447 for office and ward days, respectively. During follow-up, a parent who worked as a lecturer wrote the following note on her completed recording form, "I have been at home most of this week marking and looking after my mother from hospital so not my usual week". This parent thus averaged a fewer number of steps on weekdays at follow-up (6,673) compared to baseline (8,894). Finally, one parent worked shifts in a police call centre and this dictated substantial variations in his activity level, ranging from 2,820 steps per day on a night shift to 25,917 on a free weekend day. Clearly for some parents it will be more difficult to increase physical activity if work or other commitments require them to be sedentary for extended time periods. Indeed, employment constraints may explain why experimental parents were not able to maintain increases in weekday physical activity at follow-up.

Previous research indicates that adults engage in more moderate intensity nonoccupational activity during summer compared to winter (Matthews et al., 2001).

Consistent with this, Study 4 showed that control parents were significantly less active at follow-up (during September and October) compared to baseline (during May and June) on weekend days but not weekdays. Adult physical activity thus appears to be influenced by the weather when it is not constrained by the work environment. It was suggested that the intervention protected experimental parents from showing a similar seasonal decline in activity level.

Health Benefits of Physical Activity

BMI. Studies 2, 3, and 4 of this thesis all found an inverse correlation between steps per day and BMI among girls, indicating that a lower level of daily physical activity was associated with a higher BMI. Other research indicates that lower levels of physical activity are related to increased levels of body fat (e.g., Rowlands et al., 1999). Although it is not possible to determine the direction of causality from correlations, longitudinal research suggests that children who are active over time develop lower BMIs and less subcutaneous body fat compared to children who are less active (Moore et al., 1995, 2003).

There were, however, no significant associations between activity level and BMI in boys or parents. Paradoxically, among parents in the experimental group, overweight individuals appeared more active than those who were not overweight. It was previously suggested that high-BMI parents might have already been engaged in weight reduction strategies such as increasing physical activity. Indeed, this may have been their primary motivation for volunteering to participate in the study.

Inconsistent findings with respect to the relationship between physical activity and BMI may be due to the current thesis' exclusive focus on physical activity, which is only one factor that is likely to influence fatness. Excess body fat develops because of an energy imbalance where intake exceeds expenditure. In some cases, dietary intake may override the relationship between physical activity and body fat accumulation. For example, it would be possible for an inactive child to remain in energy balance provided that he or she eats very little. This would prevent accumulation of excess fat in the same way as in a highly active child who eats a large amount (Fox, 2004).

The current studies of this thesis did not find any effect of the physical activity intervention on BMI. In Study 4, however, there was a nonsignificant trend for experimental parents and children to decrease in BMI, while controls showed a slight increase. A greater number of participants would be needed in order for these changes to be of statistical significance.

BMI-referenced cut-off points for pedometer-determined physical activity have recently been established for children and these indicate that girls and boys taking less than 12,000 and 15,000 steps per day, respectively, are more likely to be classified as overweight or obese (Tudor-Locke, Pangrazi, et al., 2004). In Study 3, baseline activity levels of both girls and boys were lower than these cut-off points at 10,564.5 and 12,713.7 steps per day, respectively (experimental and control data combined). During the intervention, however, levels of activity in experimental girls and boys exceeded the respective 12,000 and 15,000 steps per day cut-off points, and this remained the case at follow-up for girls. Only a small proportion of children in Study 3 were overweight or obese at the time but it is possible that increasing and maintaining levels of activity above these preliminary cut-off points would help to protect them from future development of excess body fat.

The effects of previous physical activity intervention studies on BMI have been inconsistent. In the study by Roemmich et al. (2004), changes in BMI were related to reductions in television viewing but not to increases in physical activity.

Adults with type II diabetes who took part in First Step program showed slight reductions in waist and hip girth but no weight change (Tudor-Locke, Bell, et al., 2004). In contrast, Chan et al. (2004) found significant decreases in waist girth, body weight, and BMI in sedentary adults following participation in the First Step Program.

In the current thesis, the intervention lasted for just 8 days and was likely to be too short in duration to promote weight change. A longer intervention period and improved maintenance of increased physical activity may have had a significant effect in reducing or stabilising BMI. Furthermore, it may be of particular importance to encourage children to engage in vigorous intensity physical activity. Previous research indicates that the inverse relationship between physical activity and fatness is strongest when levels of vigorous activity are considered, as opposed to moderate intensity activity (Abbott & Davies, 2004; Janz et al., 2002). In addition, vigorous exercise appears to have favourable effects on percentage body fat for both obese and nonobese youth (Gutin, Barbeau, & Yin, 2004).

Research reported in Chapter 1 demonstrates the importance of targeting both food intake and physically active behaviours in the treatment and prevention of child obesity and related health conditions (Epstein et al., 1994; Woo et al., 2004). If the current intervention had additionally targeted diet, then effects on BMI may have been observed. There is great potential to combine the new physical activity intervention with the Food Dudes programme, which has been shown to produce substantial and long lasting increases in children's consumption of fruit and vegetables (e.g., Horne et al., 2004; Lowe et al., 2004).

Indeed, research reviewed by Dietz (2004) indicates that physical activity alone has a limited impact on body weight among the obese. Physical activity may instead play a much more important role in the maintenance of weight loss (see also

Lohman & Wright, 2004). Following participation in structured weight-loss programmes, participants who engaged in higher amounts of exercise were significantly more successful in maintaining their weight loss over 2 to 3 years, than were participants with lower amounts of exercise (Anderson, Konz, Frederich, & Wood, 2001). Furthermore, adults who achieved and maintained significant weight loss over a 5-year period engaged in a high amount of physical activity per week in addition to dietary restriction and weight monitoring (Klem, Wing, McGuire, Seagle, & Hill, 1997).

It is also important to consider whether BMI is the most appropriate indicator of overweight and obesity. BMI provides a measure of total fatness, but gives no information about body fat distribution. Research has shown that waist circumference, representing central fatness, is significantly greater among contemporary British children compared to earlier cohorts; however, over the same time periods, increases in BMI are modest in comparison (McCarthy et al., 2003, 2005). The increase in waist circumference remains after adjusting for height differences between the contemporary and earlier cohorts. Because central fatness appears more relevant to health outcome than total fatness, McCarthy et al. (2005) argue that the use of BMI may mask true obesity-related risk in children. In the current studies, measures of waist circumference may therefore have revealed effects of physical activity on levels of central body fatness that were not detected by BMI.

Self-esteem and psychological wellbeing. There is a body of research to suggest that physical activity is psychologically beneficial for youth and that taking part in physical activity interventions may boost self-esteem and psychological wellbeing (Calfas & Taylor, 1994; Gruber, 1986; Parfitt & Evans, 2001; Steptoe & Butler, 1996; see Mutrie & Parfitt, 1998 for review). In the current thesis, total daily physical activity was not significantly associated with psychological variables assessed by the SDQ (i.e., Emotional Symptoms, Conduct Problems, Hyperactivity/Inattention, Peer Relationship Problems, and Prosocial Behaviour), with the exception of a positive relationship between high levels of physical activity and prosocial behaviour in Study 3 girls. Moreover, in Study 3, baseline physical activity was not significantly associated with self-image or self-esteem and there was no effect of the physical activity intervention on self-esteem levels. It is possible that the intervention was not of sufficient length to produce improvements in self-esteem. In the review by Calfas and Taylor (1994), physical activity interventions that had beneficial effects on psychological variables lasted 12.8 weeks on average.

Much research in this area has been carried out with adolescents (e.g., Calfas & Taylor, 1994; Steptoe & Butler, 1996), which suggests that the beneficial effects of physical activity on self-esteem and psychological variables may be stronger in older children. Nevertheless, in preadolescent children, Parfitt and Evans (2001) found that physical activity was positively associated with self-esteem and negatively associated with anxiety and depression. The lack of agreement between the current study and the findings of Parfitt and Evans may be due to the use of different measures to assess self-esteem and wellbeing. Furthermore, the examination of specific domains of self-esteem, such as body image, may have been informative in the current thesis. Phillips and Hill (1998) found that overweight and obese girls had significantly lower appearance and athletic competence self-esteem compared to their normal weight peers.

In the current thesis, participating children were drawn from a nonclinical population however the beneficial effects of physical activity on self-esteem appear larger among "handicapped" children (i.e., emotionally disturbed, mentally retarded, economically disadvantaged, perceptually handicapped) compared to normal populations (Gruber, 1986). In addition, while the current research measured total daily physical activity, other studies have specifically focused on sports participation (e.g., Hawkins & Gruber, 1982; Steptoe & Butler, 1996). Participation in organised sport may allow children to contact positive experiences, such as skill mastery and successes (e.g., winning a match), which may be instrumental in improving self-esteem. They may also benefit from the social contact that is integral to most sporting activities, such as team approval and encouragement.

Regular physical activity and sports participation thus has great potential to promote self-esteem and psychological wellbeing among children and adolescents. Given that overweight and obese youth are vulnerable to low self-esteem (Strauss, 2000), it seems particularly important to encourage their participation.

Limitations of the Current Research

In order to participate in the current research, children required the consent of a parent. Participation rates ranged from 19% to 72% so a substantial number of children per school did not receive parental consent to take part. The child and adult participants thus represent a self-selecting sample which may not be representative of the wider population. The parents who volunteered their children to take part were likely to be highly interested in physical activity and aware of the benefits of healthy lifestyles. Indeed, in the feedback questionnaires, a number of parents commented on the value of physical activity projects for children, for example "[the project was] a great way to approach awareness of the importance of health and fitness" and "although as a family we eat healthy [*sic*] and take regular exercise, it is more important in my view that as a nation we reach the people who need the education for their future health". Such parental attitudes may have motivated the child to perform well during the intervention or to obtain a high number of steps during baseline or control conditions.

As previously suggested, parents' concerns relating to their own or their child's weight status may have additionally motivated participation. The project may have been viewed by some parents as a useful way to increase physical activity and lose weight. For example, on the initial consent and participant information form, one parent commented:

> I have just started to attend a gym once a week for approx 1 hr, however I have only been once – otherwise no exercise, I do a lot of driving and a lot of talking and would love to feel fit enough to be active with my children.

In an alternative scenario, an overweight parent or child may have declined to participate due to a strong dislike of physical activity. The reasons for participation or nonparticipation are likely to vary from individual to individual but in future school-based research it will be beneficial to encourage maximum participation.

As shown in Chapter 2, the pedometer represents an objective, valid, low-cost, and convenient tool for the measurement physical activity in children. However, pedometers are not able to accurately assess energy expenditure during activities such as cycling, walking uphill, or carrying heavy objects. Swimming and other water-based activities are omitted from the measurement frame. This would have led to the underestimation of physical activity in children who frequently performed such activities; for example, a female participant in Study 3 took part in four sessions of swimming per week for an hour each time.

When pedometers are used for personal activity monitoring in a nonresearch context, Tudor-Locke (2003) suggests the addition of "bonus steps" to account for activities such as cycling, swimming, and resistance training (e.g., weight lifting). She advises individuals to first determine the number of steps that they take in 10 min of continuous walking (e.g., 1,000 steps). Then, for every 10 min of resistance training, or swimming or cycling at a moderate intensity, the individual is advised to add this number of steps to his or her total step count at the end of the day. In this way, a 30 min swim would accrue an additional 3,000 steps per day.

Pedometers measure the total amount of activity in a specified time frame so in the current study it was not possible to determine the location, time duration, or intensity of additional physical activity from the dependent variable of steps per day. Tudor-Locke (2002) proposed that 3,100 to 4,000 steps are equivalent to 30 min of moderate intensity walking in adults, and increases shown as a result of the current intervention were within this region and higher. However, given the intermittent nature of children's naturalistic activity patterns (Bailey et al., 1995; Trost et al., 2002), it seems unlikely that the increase in steps per day was achieved in one bout of continuous moderate to vigorous intensity physical activity. Additional steps could be achieved by high intensity activities such as bursts of running around the playground, however the same increment could be achieved over time by carrying out more continuous but lower intensity activities (e.g. walking around the playground).

It would have been interesting to identify the types of physical activity that children engaged in to help reach the target and whether increases in physical activity took place during school-time, leisure-time, or in both contexts. This could have been achieved in the two intervention studies by taking additional pedometer readings at the end of school (i.e., 3:00 p.m.), as was the case in Study 2. Alternatively, a subsample of children in the intervention studies could have worn accelerometers in addition to pedometers, however practicalities curtailed their use. Accelerometers are high cost and only five units were available for the experimenter to use. This was not a problem in Study 2 because the data collection was staggered over an 8-week period, however Study 3 was a large group study in which all children participated simultaneously.

Nevertheless, qualitative data were obtained from children who took part in the intervention and in Study 3 this indicated that playing football was the most common way to increase steps. In Study 4, the most commonly reported activities were walking, running, and outdoor play.

Also, it would have been useful to identify and quantify the competing activities that children habitually engage in, for example watching television, reading, or playing computer games. Research indicates that excessive television viewing is associated with increased fatness in children, and is a risk factor for future development of obesity (Dietz & Gortmaker, 1985; Jago et al., 2005; Janz et al., 2002; Reilly et al., 2005). Studies in the literature have made access to television activities contingent on achieving target levels of physical activity (e.g., Goldfield et al., 2000; Roemmich et al., 2004). In one study, for example, children were required to pedal on a cycle ergometer to activate the television, and this effectively increased time spent pedalling and reduced television viewing over a 10-week treatment phase (Faith et al., 2001). To be of maximum benefit, however, interventions should be tailored to sociohistorical factors to ensure maintenance by the peer group culture. For example, if computer games feature prominently in children's lifestyles, then making these games physically interactive may help motivate higher activity levels, especially in boys who maintained less well in the present studies.

The current physical activity intervention consisted of three behaviour change components namely peer-modelling, rewards, and pedometer feedback. As noted previously, however, it was not possible to determine the relative contribution of each component to intervention success. Future studies could be designed to enable such an analysis. For example, one group of children who receive the full physical activity intervention could be contrasted with a second group who receive the peer-modelling and pedometer feedback elements (i.e., introduction to the Fit n' Fun Dudes, pedometer targets) but without the use of contingent rewards. Finally, a third group could wear sealed pedometers for measurement only, as was the case for the control groups in the current research. Given the potent influence of contingent rewards on children's physical activity, maximum effects would be expected to occur in the group with the rewards intervention, with lower increases in the peer-modelling and pedometer feedback-only group, and no significant increases in the control group.

Dowey (1996) conducted a component analysis to investigate the individual contribution of the video peer-modelling and reward elements of the Food Dudes programme. This showed that the combined procedure of video peer-modelling and rewards was most effective in increasing children's consumption of fruit and vegetables. The reward-alone intervention had a moderate effect on consumption of fruit but not vegetables, however the video-alone intervention was the least successful of all (see also Lowe et al., 1998). Such findings indicate that each of the two elements potentiated the other, however video-modelling appeared effective only when supported by rewards.

The likely impact of the child's immediate peer group has already been highlighted however this element would have been lacking in Dowey's (1996) research because it was conducted with individual children in the home context. This may explain the apparent ineffectiveness of the video-modelling. Greater effects would be likely to occur when the child is surrounded by a peer group who actively model and support the target behaviour.

Future Directions and Wider Implications

The discussion so far has highlighted a number of areas for future research relating to the current physical activity intervention. It is of utmost importance to develop effective maintenance strategies in order to sustain increased physical activity over time. It may also be beneficial to obtain a breakdown of children's physical activity patterns to gain a clearer picture of how extra activity is accumulated, through the use of accelerometers or by recording pedometer counts at intervals throughout the day. It will also be highly informative to conduct a component analysis of the peer-modelling, reward, and pedometer-feedback elements, similar to that conducted by Dowey (1996) for the Food Dudes programme.

The earlier discussion suggested that children may compete with one another to obtain as many steps as possible regardless of the individual targets that had been set for them. In future studies, inter-participant competition should be systematically investigated as an independent variable. This may be achieved by arranging the environment so that competition is actively encouraged; for example, the class could be divided into teams with a reward for the team with the highest combined pedometer count, or the names of children who obtain the highest counts could be read out and publicly applauded. A group of children who receive such "competition procedures" could be compared to a group who receive the standard intervention to determine the effects on activity levels.

In addition, it will be important to extend the intervention to the whole family. If the rest of the family consume high-calorie foods and model sedentary behaviours it is likely to be very difficult for the child to maintain healthy eating and physically active behaviours. Indeed, the earlier discussion emphasised the importance of establishing a supportive social environment or culture to enable the maintenance of physical activity and dietary change over time (see also Woolner, 2000). While the present studies included procedures to target the physical activity of parents, these should be extended to siblings and other individuals in the home environment.

The prevalence of child obesity in the UK is increasing at an alarming rate (Bundred et al., 2001; McCarthy et al., 2005; Reilly et al., 1999; Rudolf et al., 2001). Child obesity is associated with immediate and future serious health costs, which are both physical and psychological. Indeed, being obese during childhood may seriously compromise health in later life, even if excess weight is lost in adulthood (Must et al., 1992). This emphasises the great importance of preventing obesity from a young age through encouraging children to consume healthy diets and to engage in active lifestyles. However in the modern obesogenic environment, energy-dense foods and opportunities to be sedentary are readily available. Consequently, children show low consumption of healthful fruit and vegetables, and appear to spend increasing amounts of time engaged in sedentary behaviours, such as watching television and playing computer games.

The Food Dudes programme, a peer-modelling and rewards intervention, produces substantial and long-lasting increases in children's fruit and vegetable consumption. The current thesis has adapted the behavioural principles employed in the Food Dudes programme to develop an intervention that effectively increases children's physical activity. Ultimately, this programme of research aims to combine the healthy eating and physical activity interventions to provide a two-pronged, obesity prevention package. If implemented in primary schools throughout the UK, an intervention of this nature has great potential to prevent an "epidemic" of child obesity.

In addition to targeting younger children, obesity prevention efforts should not ignore adolescents. The prevalence of obesity becomes progressively higher as children age, such that 31% of 15-year-olds are overweight and 17% are obese (Reilly & Dorosty, 1999). In the future, it would be feasible to implement the combined Food Dudes and physical activity programme in secondary schools, provided that certain modifications are made, such as identifying effective peer-models and reward systems. Adolescents are likely to be more resistant to health behaviour change than younger children therefore the use of potent rewards will be crucial. Of relevance, according to recent news reports, a scheme is now operating in Glasgow secondary schools in which children earn points for eating healthily which may be exchanged for rewards such as iPods and Xbox games consoles (BBC website, 2005).

In conclusion, the current thesis has shown that a peer-modelling, rewards, and pedometer feedback intervention produces substantial increases in the total daily physical activity of 9- to 11-year-old children. Three months following completion of the intervention, children remained more active than at baseline and were more active than control children. The intervention shifted activity levels in boys, girls, and parents, and in obese and nonobese participants, however maintenance differed across these groups. Therefore to maintain physically active behaviours over time interventions should be tailored to meet individual needs.

Like the Food Dudes programme upon which it is based, the intervention did not convey negative messages about less healthful behaviours and focused instead on the positive aspects of being physically active. This may have contributed to the high enjoyment of the programme as reported by participating children and parents. It is thus pertinent to end with the following quotes from parents:

I enjoyed taking part in the project and feel it has been of benefit to both Lucy and myself. We will continue to use our pedometers to monitor our physical activity – especially now that the winter months are here, to try to keep motivated! (Study 4).

The project has involved our whole family – we've all become more active as a result. Could the project be used in schools in general? Obviously, it would be difficult to supply all children with pedometers, but the approach used (the characters etc) could encourage primary children to become more active (Study 3).

... Initially I thought the programme would be difficult to complete however, wearing the pedometer all day soon became second nature. In fact, when it was not there I felt something was missing. This programme should be recommended to the government as a means to improve adult health/fitness. A very cheap way to reduce the NHS budget (Study 4).

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APPENDIX A

STUDY 1

APPENDIX A1: Consent Letter

Dear Parent/ Guardian,

I am writing to tell you about a research study concerned with encouraging children to adopt healthy lifestyles, which will be taking place at (insert name of school) this term. The research is looking at ways to measure physical play and activity in children. The study is being conducted by postgraduate student, Charlotte Hardman, under the supervision of Dr. Pauline J. Horne and Professor C. Fergus Lowe, at the University of Wales, Bangor, in collaboration with (insert name of school).

The study will involve your child participating in regular play activities such as running, playing football, throwing and catching. Your child will wear a small step counter so that his or her level of activity may be measured. Your child will also wear a heart rate monitor on his or her chest for a short period of time. After each activity your child will be asked how much effort the activity required.

The study is designed to be enjoyable for the children. The research session will last for about 30 minutes and will take place during the school day at a time that is most convenient for you, your child, and the school staff.

It is University policy to obtain approval for any studies in which children participate, so we would be grateful if you would complete the slip below and return it to (insert name of head teacher).

If you are interested in learning more about the project, please ring Charlotte Hardman on (01248) 388 201 to discuss this project in further detail. It is our hope that you will consider participating in the research study. Thank you for your consideration.

Sincerely,

Professor C. Fergus Lowe
Professor of Psychology and Head of School

Name(s) of child or children ____________________________

I would like my child to take part in the study ☐ *
I would not like my child to take part in the study ☐ *
I would like more information about the study ☐ *

Name of Parent ____________________________

Telephone number ____________________________

Signed ________________________ Date ________

* Please tick as appropriate

APPENDIX A2: Instructions to Participants

Today we are going to do 5 different activities.

During each activity you will wear a heart rate monitor around your chest. The watch on your wrist tells you how fast your heart is beating. You will also wear two pedometers clipped onto your waistband. The pedometers record how may steps you have taken.

We will do each activity for three minutes. We will have a rest between each activity.

Please begin the activity when I say "Go". Try to keep going until I say "Stop". After I've said stop, please stand very still. I will record how many steps you have taken and how fast your heart is beating. I will also ask you "how hard did the exercise feel?" Please use the Bug scale to give an answer between 1 and 10.

Please make sure that the pedometers are reset to zero before beginning each activity. You can do this by pressing the yellow button.

The first activity will be............

(Afterwards) How hard did the exercise feel?

APPENDIX B

STUDY 2

Appendix B1	Recruitment letter and attached consent form
Appendix B2	Parent instructions, pedometer count recording form, and physical activity checklist
Appendix B3	Correlation coefficients between physical activity, BMI, and SDQ variables.

APPENDIX B1: Recruitment Letter and Consent Form

Dear Parent/ Guardian,

I am writing to tell you about a research project concerned with encouraging children to adopt healthy lifestyles, which will be taking place at (insert name of school) this term. The research is looking at children's levels of physical activity during the week and at the weekend. The study is being conducted by postgraduate student, Charlotte Hardman, under the supervision of Dr. Pauline J. Horne and Professor C. Fergus Lowe, at the University of Wales, Bangor, in collaboration with (insert name of school).

The study will involve your child wearing two small activity monitors for a period of one week (including two weekend days). The monitors have been widely used with children of this age group, and do not cause any discomfort.

Children will wear the monitors throughout the day apart from bathing, or swimming, from Monday afternoon until the following Monday morning. A researcher will visit the school twice a day to record the activity counts for each child. At bedtime on each day, the parent will be requested to remove the monitors and record the day's activity count. Parents will be provided with recording forms for this purpose. Every morning, children need to put the monitors back on while dressing.

In addition, parents will be provided with a brief activity checklist to indicate the leisure-time activities undertaken by their child on each day of the study.

Previous investigations of this kind have been highly enjoyable and educational for all children involved. At the end of the project, all participants will be provided with a personalised set of results showing how active they have been throughout the week.

It is University policy to obtain approval for any studies in which children participate, so we would be grateful if you would complete the slip overleaf and return it to (insert name of head teacher). If you would like to participate please include your home telephone number. You will then be telephoned by a researcher who will arrange a brief visit to your home to explain the procedures.

If you are interested in learning more about this project, please ring Charlotte Hardman on (01248) 388201 (direct line). We do hope that you will consider participating in this very worthwhile study.

Sincerely,

Professor C. Fergus Lowe
Professor of Psychology and Head of School

Name of child ____

Date of birth of child ____

I would like my child to take part in the study ☐ *
I would not like my child to take part in the study ☐ *
I would like more information about the study ☐ *

Name of Parent ____

Telephone number ____

Home Address ____

____

Signed ______________________________ Date ____________

* Please tick as appropriate

APPENDIX B2:

Parent instructions, pedometer count recording form, and physical activity checklist

Dear (insert parent's name)

Thank you for agreeing to participate in this study.

Physical activity is very important for children's health. Regular physical activity can help to:

- Promote growth and development
- Increase strength, flexibility and stamina
- Maintain a healthy weight
- Increase bone density
- Enhance positive feelings and self-esteem
- Reduce stress

In this investigation we will be looking at children's normal levels of physical activity over a period of one week. We will use small activity monitors called pedometers to measure children's activity, both at home and at school.

Please make sure that your child wears the monitors all the time, apart from sleeping, bathing or swimming.

This pack contains a **Leisure-time Activity Checklist, a Pedometer Count Recording Form** and the **Strengths and Difficulties Questionnaire.**

Please use the **Leisure-time Activity Checklist** to record the out-of-school activities undertaken by your child on each day of the week.

Please use the **Pedometer Count Recording Form** to record the number of counts shown by your child's pedometer at bedtime, on each day of the week.

Please complete the **Strengths and Difficulties Questionnaire** at any point during the measurement period. If completing this questionnaire raises any concerns about your child's emotional and behavioural development, please contact your health visitor or G.P.

If you have any questions, please don't hesitate to contact Charlotte Hardman on (01248) 388 201 (office) or 07818 032 392 (mobile). Your child's information will be kept completely confidential, and you may withdraw from the study at any point.

Thank you very much for your time. We hope that you will enjoy participating in this research.

Yours sincerely,

Charlotte Hardman Dr. Pauline Horne Prof. Fergus Lowe

Pedometer Count Recording Form

Please use this form to record the number of counts shown by your child's pedometer at bedtime. Also, please record the time the pedometer was put on in the morning, and the time it was taken off at bedtime. Please do this on every day of the week.

Once you have recorded the day's pedometer count, please reset the pedometer to zero (and reseal it using the masking tape provided).

Every morning, please ensure that your child puts the pedometer back on while they are dressing. Your child needs to wear the pedometer all day, apart from swimming and bathing.

Child's name ______________________________

Day	Time pedometer put on in the morning	Time pedometer taken off at bedtime	Pedometer Count at Bedtime
Monday	–		
Tuesday			
Wednesday			
Thursday			
Friday			
Saturday			
Sunday			
Monday		–	–

Leisure-time Activity Checklist

Think about the activities that your child did outside of school on each day of the week – that means before or after school or on weekends.

For each day of the week, please mark any activity that your child did for **15 minutes or more** with an X.

	Mon.	Tues.	Weds.	Thurs.	Fri.	Sat.	Sun.
After-school club	☐	☐	☐	☐	☐	☐	☐
Ball games: e.g. Catch, Dodge Ball	☐	☐	☐	☐	☐	☐	☐
Basketball	☐	☐	☐	☐	☐	☐	☐
Bicycling	☐	☐	☐	☐	☐	☐	☐
Computer games	☐	☐	☐	☐	☐	☐	☐
Cricket/ Rounders	☐	☐	☐	☐	☐	☐	☐
Dance	☐	☐	☐	☐	☐	☐	☐
Football	☐	☐	☐	☐	☐	☐	☐
Gymnastics	☐	☐	☐	☐	☐	☐	☐
Martial Arts: e.g. Karate, Judo.	☐	☐	☐	☐	☐	☐	☐
Netball	☐	☐	☐	☐	☐	☐	☐
Outdoor Games: e.g. Tig, Hopscotch	☐	☐	☐	☐	☐	☐	☐
Racket sports: e.g. Tennis, Badminton	☐	☐	☐	☐	☐	☐	☐
Reading	☐	☐	☐	☐	☐	☐	☐
Rugby	☐	☐	☐	☐	☐	☐	☐
Skate boarding	☐	☐	☐	☐	☐	☐	☐
Skipping	☐	☐	☐	☐	☐	☐	☐

	Mon.	Tues.	Weds.	Thurs.	Fri.	Sat.	Sun.
Swimming	☐	☐	☐	☐	☐	☐	☐
T.V./ Video	☐	☐	☐	☐	☐	☐	☐
Walking	☐	☐	☐	☐	☐	☐	☐
Other (please specify)							
	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐
	☐	☐	☐	☐	☐	☐	☐

Please indicate how your child travelled to school on each of these days (e.g. by car, walked).

	How did your child travel to school?
Monday	
Tuesday	
Wednesday	
Thursday	
Friday	

On what day of the week did your child do P.E. at school?

Mon.	Tues.	Weds.	Thurs.	Fri.
☐	☐	☐	☐	☐

APPENDIX B3

Pearson's r correlation coefficients between physical activity, BMI, and the SDQ variables in girls (upper panel) and boys (lower panel). Participant numbers are shown in parentheses

		Girls	
		Physical Activity	BMI
	BMI	-.33* (57)	-
	Emotion	-.19[a] (57)	.21[a] (57)
	Conduct	-.11[a] (57)	.21[a] (57)
SDQ	Hyperactivity	.19 (56)	.09 (57)
	Peer Problems	.04[a] (57)	.09[a] (57)
	Prosocial	-.04[a] (57)	-.01[a] (57)
	Total Difficulties	-.07 (57)	.28* (57)
		Boys	
		Physical Activity	BMI
	BMI	.13 (38)	-
	Emotion	-.02[a] (38)	.35[a]* (38)
	Conduct	-.11[a] (37)	.08[a] (37)
SDQ	Hyperactivity	.11 (38)	.27 (38)
	Peer Problems	-.01 (38)	.39* (38)
	Prosocial	.26 (38)	.03 (37)
	Total Difficulties	.05 (38)	.39* (38)

Note. Outliers were removed prior to computing correlation coefficients.

[a]Spearman's *rs* correlation coefficient was computed because the assumption of normality was not met.

*$p < .05$.

APPENDIX C

STUDY 3

Appendix C1	Recruitment letter and attached consent form
Appendix C2	Experimental school parent and child feedback questionnaires
Appendix C3	Fit n' Fun Dudes certificate
Appendix C4	The Fit 'n Fun Dudes song lyrics
Appendix C5	Group and individual Fit n' Fun Dudes letter
Appendix C6	Intervention home recording chart
Appendix C7	Maintenance diary
Appendix C8	Parent recording sheet and covering letter
Appendix C9	Correlation coefficients between physical activity, BMI, SIP-C, and SDQ variables
Appendix C10	Parental quotes

APPENDIX C1: Recruitment Letter and Consent Form

Dear Parent/Guardian,

I am writing to tell you about a research project concerned with encouraging children to adopt healthy lifestyles, which will be taking place at (insert name of school) this term. It is being conducted by postgraduate student, Charlotte Hardman, under the supervision of Dr. Pauline J. Horne and Professor C. Fergus Lowe, at the School of Psychology, University of Wales Bangor, in collaboration with (insert name of school). Participation is open to all children aged between 7 and 11 years.

The research will involve your child wearing a small pedometer (step counter) on school days for 3 weeks. The pedometer will measure your child's level of physical activity. Your child will need to wear the pedometer at all times, apart from sleeping, bathing and swimming Every morning, a researcher will visit the school to record the activity counts for each child. Pedometers have been widely used with children of this age group and do not cause any discomfort.

Researchers will visit the school to take height and weight measurements from the children at the beginning and at the end of the project. We will also assess each child's self esteem using a short questionnaire. There will be a brief questionnaire for parents to complete at the beginning of the project to assess each child's emotional and behavioural strengths and difficulties.

At the end of the three weeks, children will be given their pedometers to keep and it is hoped that they will continue to wear them and monitor their activity levels. It is anticipated that researchers will return to the school during the Spring term to take further measurements of the children's physical activity.

Previous investigations of this kind have been highly enjoyable and educational for all children involved. At certain points in the project, small rewards will be available as incentives to be physically active. All participants will be provided with a personalised set of results showing how active they have been throughout the programme. Parents will be provided with a written report of the research findings. There any many long-term health benefits of increasing physical activity, which include improved fitness and protection against obesity.

It is University policy to obtain approval for any studies in which children participate, so we would be grateful if you would complete the slip overleaf and return it to (insert name of head teacher).

Your child's information will be kept completely confidential. Participation in the research is entirely voluntary, and you are free to refuse to take part or to withdraw your child at any time without providing a reason. In the case of any complaints concerning the conduct of research, these should be addressed to Professor C. F. Lowe, Head of School, School of Psychology, University of Wales Bangor, Gwynedd, LL57 2AS.

If you are interested in learning more about this project, please don't hesitate to ring Charlotte Hardman on (01248) 388201 (direct line). We do hope that you will consider participating in this very worthwhile study.

Sincerely,

Professor C. Fergus Lowe,
Professor of Psychology and Head of School

Consent

Name of child ____

Date of birth of child ____

I would like my child to take part in this study ☐ *
I would not like my child to take part in this study ☐ *
I would like more information about the study ☐ *

Name of parent ____

Telephone number ____

Home address ____

____

Signed ______________________ Date ____________

* Please tick as appropriate

APPENDIX C2: Experimental School Parent Feedback Questionnaire

Dear Parent/Guardian,

Thank you for taking the time to complete this questionnaire.

The questions should be answered by circling the appropriate response or writing in the space provided. Please try to answer the questions as honestly and as accurately as possible.

All the information collected will be strictly confidential.

If you have any queries regarding this questionnaire or the research, please contact Charlotte Hardman on (01248) 388201, or email c.hardman@bangor.ac.uk

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1. Did your child enjoy taking part in the Fit n' Fun Dudes project?

YES NO

2. Do you feel that your child has benefited from taking part in the Fit n' Fun Dudes project?

YES NO

If you answered yes, please say how you think your child has benefited.

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3. Has your child started to be more physically active since the Fit n' Fun Dudes project began?

YES NO

4. Do you feel that you received enough information about the project?

YES NO

If you answered no, please indicate what additional information you would like to have received.

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5. Do you have any other comments you would like to make about the Fit n' Fun Dudes project?

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Thank you for your help. In order for us to enter your name into the £25 prize draw, please complete the details below and return the questionnaire in the pre-paid envelope no later than 7 May 2004.

Your name ....

Your child's name ....

Your address or telephone number ....

Date ....

APPENDIX C2: Experimental School Child Feedback Questionnaire

Your Name: ______________________ Class: ________

Thank you for taking the time to answer these questions.

Please draw a circle around your chosen answer, or write your answer in the space provided. This is not a test so try to answer the questions as honestly as you can.

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1. Did you enjoy taking part in the Fit n' Fun Dudes project?

   YES NO NOT SURE

2. Do you think that the Fit n' Fun Dudes programme helped you to be more physically active?

   YES NO NOT SURE

3. You were given a target on your pedometer, which you had to reach every day to get a prize. What sort of activities did you do at school and at home to help reach your pedometer target? Please describe these below

   Example: I played football at playtime

   ....

   ....

   ....

   ....

   ....

   ....

   ....

   ....

Please turn over ....

4. Did you like wearing the pedometer?

YES NO NOT SURE

5. Did you like the Fit n' Fun Dude prizes?

YES NO NOT SURE

If you answered yes, what was your favourite prize?

....

....

....

6. Did you like the Fit n' Fun Dude song

YES NO NOT SURE

7. Would you like to say anything else about the Fit n' Fun Dudes project? For example, you might have some ideas for how we could improve the project.

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Thank you for your help

Best Effort

Award

This is to certify that ____________________
has made an EXCELLENT effort to wear their pedometer and do loads of steps!

Well Done Dude!

P.D. Lexy Ren Mina

The Fit n' Fun Dudes Song

Chorus

Fit n' Fun are on the move
Fit n' Fun are on the move
Let's be active, do it dudes!
Let's be active do it dudes!
Ymlaen gyda'r Hwyl a Heini
Ymlaen gyda'r Hwyl a Heini
Deffra Dwd tyrd efo ni!
Deffra Dwd tyrd efo ni!

1st Verse

Hi there dude, my name's P.D.
They call me that cause I'm speedy
When I run I go so fast
And in a race I'm never last!
Football is my sport, you see
Cause I'm so quick they can't catch me.
I dribble the ball just like Paul Scholes
And I always finish with cracking goals
You should see how many steps I do
If you wear your pedometer, so can you!

Chorus

2nd Verse

Hey there dude, my name's Lexy
They call me that cause I'm flexy!
Gymnastics is my favourite thing
I do cartwheels, somersaults and hand springs.
I like to dance, you should see me groove
J-Lo's my favourite, I know all the moves.
My dance mat gets me moving my feet
I even dance while I'm in the street
I love to count all the steps I do
Wear your pedometer and you can too!

Chorus

3rd Verse

My name's Ren and I'm so strong
Stick with me and you can't go wrong!
I can move really heavy things
I like to lift weights in the gym
Cause I'm strong I can really throw
You should see how far I make the ball go
Skateboarding is the thing for me
Cause it keeps me active, don't you see!
My pedometer counts the steps I do
I wonder if I do more than you!

Chorus

4th Verse

My name's Mina and out of the gang,
I'm the brainiest, I come up with the plans!
I've got stamina, I walk everywhere
Round the park and up the stairs.
I keep going all day long
When I'm walking I go on and on.
I like to jog and I love to skip
All these things keep me really fit.
I wear my pedometer, you can too.
Let's see how many steps you do!

Final Chorus

Let's be active do it do it
Let's be active do it do it
Dudes! Let's do it Dudes!

APPENDIX C5: Group Fit n' Fun Dudes letter

Hi everyone!

We are the Fit n' Fun Dudes and we are the coolest kids around. Let us introduce ourselves. P.D. is the speediest, Lexy is the most flexible, Ren's got the most strength, and no one can beat Mina for stamina! We always wear our pedometers and we try to get as many steps as possible. This helps us to stay fit and healthy. We are always full of energy and ready to take on anyone and anything! You can find out more about us by listening to the Fit n' Fun Dudes song which you will be getting soon.

We think that you might be a cool bunch too, so we have come to your school to ask you to join us. We have sent you everything you need. There are pedometers to wear and lots of prizes to be won. We will tell you how you can win Fit n' Fun Dude prizes, so listen carefully.

Our helpers will give you a special pedometer, which you can use to check how many steps you have done. Remember to wear your pedometer all day. Try to be really active and get as many steps as you can. This will make you really fit and healthy, and very cool!

To help you be really active, we have given each of you your own Fit n' Fun Dudes step target. On each school day this week, try to get the number of steps that is shown by your target. Your target is shown on the front of your pedometer. Our helpers will be at school every morning this week to see how you are getting on. When you arrive at school, show your pedometer to a helper and if you have managed to reach your Fit n' Fun Dudes step target then you will get an amazing prize. There is a prize for each day of the week.

Please help us. Be cool, wear your pedometer, get as many steps as you can, and win a prize! It's easy!

P.D. Lexy Ren Mina

APPENDIX C5: Individual Fit n' Fun Dudes letter

Hi (insert child's name)

It's the Fit n' Fun Dudes here, the coolest kids around. We're really pleased that you're helping us by doing lots of physical activity. This will keep you fit, healthy and feeling great!

Don't forget to wear your pedometer. Its easy - put it on when you get up and wear it all day until bedtime (but remember to take it off if you have a bath or shower!).

Try to be really active and get as many steps on your pedometer as you can. To help you, we have given you your very own Fit n' Fun Dudes daily step target. Here it is!

(insert target) steps every day

On each school day this week, try to get the number of steps that is shown by your target. Our helpers will be at school every morning to see how you are getting on. When you arrive at school you will need to show your pedometer to a helper. If you are really active and you manage to reach your Fit n' Fun Dudes step target, then you will get an amazing prize. There is a prize for each day of the week.

Be careful that you don't accidentally reset your pedometer. On every morning this week, you will need to show your pedometer to our helpers to receive your prize.

Please help us. Be cool, wear your pedometer, get as many steps as you can, and win a prize! It's easy!

P.D. Lexy Ren Mina

Tell us what physical activities you have done each day, at school and at home.

Week 1

	School	Home
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		

	Home	
Saturday		
Sunday		

Week 2

	School	Home
Monday		
Tuesday		
Wednesday		
Thursday		
Friday		

	Home	
Saturday		
Sunday		

How many times have you been physically active? ☐

APPENDIX C7: Maintenance Diary

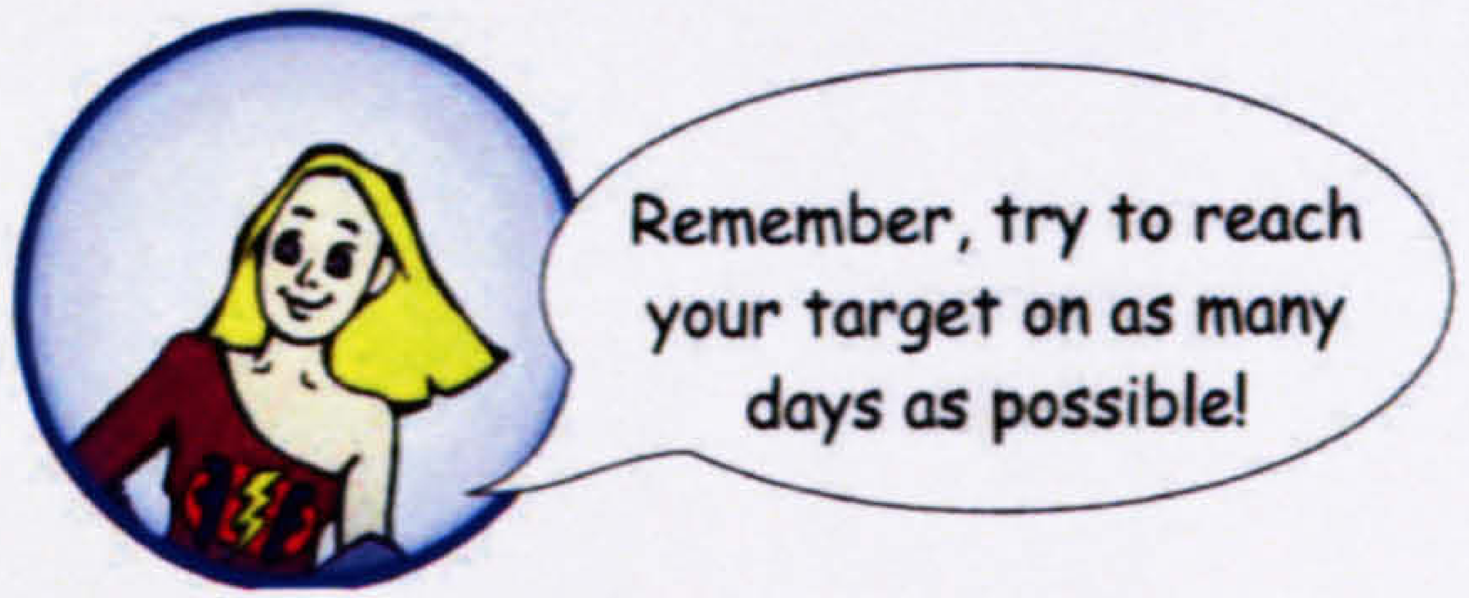
Tell us how many steps you do every day.

Your Fit 'n Fun Dudes target is ______ steps..

It's easy! Write in the number of steps that you do on each day.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week beginning 8'th December							
Week beginning 15'th December							
Week beginning 22'nd December							
Week beginning 29'th December							
Week beginning 5'th January							
Week beginning 12'th January							
Week beginning 19'th January							

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week beginning 26'th January							
Week beginning 2'nd February							
Week beginning 9'th February							
Week beginning 16'th February							
Week beginning 23'rd February							
Week beginning 1'st March							
Week beginning 8'th March							



APPENDIX C8: Parent Recording Sheet and Covering Letter

Dear Parent/Guardian,

Thank you very much for your interest in the physical activity research project. The project has now begun and, and it will last for 4 weeks until Friday 5th December. Please note that the project will now last for 4 weeks, not 3 weeks as previously stated.

As you are aware, the project will involve your child wearing a small activity monitor called a pedometer. The children need to wear their pedometers from Monday morning until Friday morning for the 4 weeks of the study.

To provide an accurate measure of physical activity, it is important that your child wears his/her pedometer at all times during the day and evening (with the exception of swimming, bathing or showering). The pedometer should be removed at bedtime and put on again while dressing the following morning.

It would be extremely helpful to us if you could make a note of any times that your child does not wear the pedometer. Overleaf is a form for you to use. For each day of the project, if your child wears the pedometer for the entire day then you just need to tick the box. If your child does not wear the pedometer for the entire day, please tell us how long the pedometer was off for and for what reason (e.g. swimming, forgot to wear it).

Thank you very much. This will help us to improve the accuracy of our measurements. If you have any further questions about the project, please don't hesitate to ring Charlotte Hardman on 01248 388201

Sincerely,

Professor C. Fergus Lowe,
Professor of Psychology and Head of School

Child's Name ______________________ School ________________

Date	Did your child wear the pedometer all day? (✓/ ✗)	Please tell us how long the pedometer was off for and for what reason.
Example	✗	***Swimming 1 hour***
Monday 10th Nov.		
Tuesday 11th Nov.		
Wednesday 12th Nov.		
Thursday 13th Nov.		
Monday 17th Nov.		
Tuesday 18th Nov.		
Wednesday 19th Nov.		
Thursday 20th Nov.		
Monday 24th Nov.		
Tuesday 25th Nov.		
Wednesday 26th Nov.		
Thursday 27th Nov.		
Monday 1st Dec.		
Tuesday 2nd Dec.		
Wednesday 3rd Dec.		
Thursday 4th Dec.		

Thank you very much. Please send this form into school with your child on **Friday 5th December**. Or if you prefer, you can send it directly to the University using the freepost address below (no stamp required).

APPENDIX C9

Pearson's r correlation coefficients between baseline physical activity, BMI, SIP-C, and SDQ variables in girls (upper panel) and boys (lower panel). Participant numbers are shown in parentheses

		Girls	
		Baseline Physical Activity	Baseline BMI
SIP-C	SI+ve	-.02 (39)	-.26 (37)
	SI-ve	-.04 (38)	.05 (36)
	Self esteem	-.00 (39)	.16 (37)
SDQ	Emotion	.01 (36)	.02 (33)
	Conduct	-.10[a] (36)	.22 (32)
	Hyperactivity	-.12 (36)	-.03 (33)
	Peer Problems	-.27[a] (36)	.44* (33)
	Prosocial	.57[a]* (36)	-.11[a] (32)
	Total Difficulties	-.16 (36)	.21 (33)
		Boys	
		Baseline Physical Activity	Baseline BMI
SIP-C	SI+ve	.18 (41)	-.21 (40)
	SI-ve	.06 (42)	-.12 (41)
	Self esteem	.00 (42)	-.02 (41)
SDQ	Emotion	-.17 (30)	.11 (28)
	Conduct	.06[a] (30)	-.37[a]* (28)
	Hyperactivity	-.13 (30)	-.26 (28)
	Peer Problems	.00 (30)	-.21 (28)
	Prosocial	-.12[a] (29)	.25[a] (27)
	Total Difficulties	-.10 (30)	-.28 (28)

Note. Outliers were removed prior to computing correlation coefficients.

[a]Spearman's r_s correlation coefficient was computed because the assumption of normality was not met.

$*p < .05$.

APPENDIX C10: Parental Quotes

The individual participant number and gender of the child is shown in parentheses following each quotation.

Experimental School

Responses at end of the intervention (*n* = 10)

2. Do you feel that your child has benefited from taking part in the Fit n' Fun Dudes project? If you answered yes, please say how you think your child has benefited.

"She has become much more active and also enjoys dancing as she understands its helping her to keep fitter" (56, girl).

"More aware of physical exercise" (58, girl).

"It has given her a definite aim and a specific interest in how much activity she is doing. Especially on quieter days she has made an effort to attain the target" (60, girl).

"She has made an effort to be more active" (61, girl).

"She has been more physically active because she wanted to increase the target each day. I have benefited because she was constantly asking for jobs to do which involved movement (70, girl).

"Aaron is now aware of how much (or little!) physical activity he does. It's encouraging him to be more active, and he's now more aware of the benefits of being more active, e.g. walking up stairs instead of taking the lift" (73, boy).

"More focus on being active – walking instead of using car" (79, girl).

"Although she was already very physically active, I have learnt the sort of things that motivate Charlotte generally. I think that she will keep wearing the pedometer to check on herself! (80, girl).

"Yes I found she wasn't sitting down a lot always on the go kept her fit" (95, girl).

5. Do you have any other comments you would like to make about the Fit n' Fun Dudes project?

" Would love to have a pedometer myself, just to see how fit I am!" (56, girl).

"Diet advice would be beneficial" (58, girl).

"It has been a good way of encouraging children to monitor their own level of activity. It has also given them a goal to aim for. By using the pedometer regularly over a period of time, they will be able to judge for themselves how much they are doing. It might be worth considering the time of year – lighter nights in the summer – more activity?" (60, girl).

"Thank you for encouraging my child who has thoroughly enjoyed taking part in this project" (70, girl).

" The project involved our whole family – we've all become more active as a result. Could the project be used in schools in general? Obviously it would be difficult to supply all children with pedometers but the approach used (the characters etc) could encourage primary children to become more active" (73, boy).

"Bethany was certainly motivated with the prizes being offered each morning! She enjoyed the Fit n'Fun CD and played it often. It has been a good project to promote fitness" (79, girl).

"Charlotte was very physically active before this project began but it has been really interesting to see which incentives have motivated her to become even more physically active. In particular, the 'prizes' seemed to motivate her greatly as did her desire to want to achieve if not exceed the target that had been set for her" (80, girl).

"I must say Leah really enjoyed it never seen her so happy in the weeks it went on for. It was like a challenge for her I found it great idea for her I would like to see this sort of thing quite often Keeps her occupied" (95, girl).

Responses at end of follow-up (*n* = 11)

2. Do you feel that your child has benefited from taking part in the Fit n' Fun Dudes project? If you answered yes, please say how you think your child has benefited.

"More conscious about importance of exercise" (58, girl).

"By attaining the target and being able to measure the level of activity" (60, girl).

"She has been more aware of how active she is being and was very conscious of meeting her target on the pedometer. Although now that it has finished she is not quite as active" (61, girl).

"It's been brought to light how fit he is and he's been made more physically active" (63, boy).

"Taking more interest in sports, but he has always been active" (69, boy).

"He is now aware of how much physical activity he does in a day and is eager to do more" (73, boy).

"Awareness of level of activity and not so, became enthusiastic to do more" (76, girl).

"He plays out more, instead of the computer all the time" (82, boy).

"She seems very happy and she does a lot for me" (95, girl).

5. Do you have any other comments you would like to make about the Fit n' Fun Dudes project

"The results are interesting and show that the project has encouraged more activity. I'm sure it came as no surprise that boys were more active than girls – they are generally more competitive. Most televised sports – football/rugby are male dominated – girls have fewer stars to look up to and emulate. If ladies football/rugby was shown more perhaps girls would be seen kicking a ball about" (60, girl).

"The idea was excellent in making children aware how fit they are and making them more active e.g. Tomos is walking to school and home since the project to name only one thing extra he's doing" (63, boy).

"Since my son took part in the Fit n' Fun Dudes project he has persuaded one of his friends to go to badminton with him every Sunday evening. This has encouraged one of his friends to become fitter as well, and also they go swimming more now" (69, boy).

"Could the project be extended so that it carries on throughout the school year? Are there any signs of schools adopting any part of the project on a permanent basis?" (73, boy).

"An excellent idea as Rhiannon actually moved a lot more whilst wearing the pedometer. The difficulty is keeping her active now the experiment is over" (75, girl).

"It certainly proved a success with the children, schools and parents alike. Therefore others would benefit perhaps target new/different aged children see how the parents would do???" (76, girl).

"I think it is a really good project to get involved with. It gives children something in common to talk about. It also gives them more exercise than they would normally do" (82, boy).

Control School

Responses at end of follow-up ($n = 14$)

2. Do you feel that your child has benefited from taking part in the research project? If you answered yes, please say how you think your child has benefited.

"Yes, Thomas thought it helped him a great deal. I thought it provide how active he is" (1, boy).

"He is understanding the reasons why we keep telling him about the food he eats and the importance of exercise" (5, boy).

"He did a little more exercise than usual! He's active anyway but he used to like to walk a little more so he could get a good result on his pedometer" (7, boy).

"She thought about her activity levels" (13, girl).

"More aware of her own fitness – although she was always active before" (15, girl).

"Tom is more willing to walk to school and seems to enjoy taking part in projects" (20, boy).

"She's more aware of what she eats and wants to exercise, asking to go on bike rides etc" (29, girl).

"Sarah was very interested in how active she was whilst being monitored" (31, girl).

"Because it has made him more aware of the importance of exercise" (36, boy).

"My daughter has (I feel!) become more aware of the amount of exercise she is doing" and "During and immediately after the programme my daughter has been more physically active, however this has diminished with time" (45, girl).

"More aware of physical activity and its health benefits. She wanted to be more active during research programme" (53, girl).

5. Do you have any other comments you would like to make about the research project?

"I was very happy for Shaun to take part in the research project because, although as a family we eat healthy and take regular exercise, it is more important in my view that as a nation we reach the people who need the education for their future health. Also this may help the promote a healthy lifestyle to some of the parents who need the advise" (5, boy).

"You should do it again!" (7, boy).

"I think the research project has been a good thing to try and bring back the focus on exercise for children. Nowadays children are carried around far too much by their parents in cars. Though I can see how parents think it's safer to take children to school in some ways, it is important to encourage exercise. I think the idea of children walking to school together i.e. meeting up with other children on their way (walking chain) in a good one. As well as exercise I think it would be beneficial for children to be taught yoga at school as may aid concentration" (36, boy).

"Having read the report, I think that the programme was a very good idea and perhaps a similar idea could be used on a permanent basis at all primary schools. I am sure that had Fit n' Fun Dudes programme been used at Deganwy school my daughter would be more conscious of exercise she was doing (my son was also keen to participate but was 12 months too young)" (45, girl).

"There should be more sport activity instead of playground after lunch which would stop the bullying and the foul mouth activity! And bad behaviour" (boy).

APPENDIX D

STUDY 4

Appendix D1	Initial recruitment letter and attached consent form
Appendix D2	Experimental group parent and child feedback questionnaires
Appendix D3	Parent recording forms
Appendix D4	Intervention home chart
Appendix D5	Maintenance diary and graph
Appendix D6	Baseline instructions for parents
Appendix D7	Intervention consent letter
Appendix D8	Intervention instructions for parents
Appendix D9	Maintenance instructions for parents
Appendix D10	Individual subject physical activity graphs
Appendix D11	Parental quotes

APPENDIX D1: Recruitment Letter and Consent Form

Dear Parent/Guardian

I am writing to tell you about a research project concerned with encouraging children to adopt healthy lifestyles, which will be taking place at (insert name of school) this term. It is being conducted by postgraduate student, Charlotte Hardman, under the supervision of Dr. Pauline J. Horne and Professor C. Fergus Lowe, at the School of Psychology, University of Wales Bangor.

Participation is open to girls in Years 4, 5 and 6 and their parents. The research is looking at ways to promote physical activity, therefore the study is most suitable for girls who do little or no leisure-time physical activity or sport. The research will take place in the home and will require the participation of a parent.

The research involves your daughter wearing a small pedometer (step counter), which will measure her level of physical activity. We are also interested in the physical activity of parents and we will ask one parent in your family to wear a pedometer. Pedometers have been widely used with adults and children and they do not cause any discomfort nor do they interfere with daily life in any way.

Starting in May, the project will run over 16 days in the first instance followed by some intermittent procedures over the course of the next few months. Before the study begins, a researcher will visit you at home to explain the project in more detail and to show you a pedometer. You and your daughter will then begin to wear the pedometers and these need to be worn at all times for two 8-day measurement periods, with the exception of sleeping, bathing and swimming. A researcher will visit you at certain points during the project to collect the pedometers and record the activity counts. The research team will also visit your daughter's school to take height and weight measurements from all participating children at the beginning and at the end of the project.

Previous investigations of this kind have been highly enjoyable and educational for all children and parents who are involved. All participants will receive feedback on how active they have been throughout the study. Parents will be provided with a written report of the research findings. There are many long-term health benefits of increasing physical activity, which include improved fitness and protection against obesity.

If you are interested in participating, we would be grateful if you could complete and sign the form overleaf and return it to (insert name of head teacher). Please ensure that you include a telephone number so that our researchers may contact you.

Your child's information will be kept completely confidential. Participation in the research is entirely voluntary, and you are free to refuse to take part or to withdraw your child at any time without providing a reason. In the case of any complaints concerning the conduct of research, these should be addressed to Professor C. F. Lowe, Head of School, School of Psychology, University of Wales Bangor, Gwynedd, LL57 2AS.

If you are interested in learning more about this project, please don't hesitate to ring Charlotte Hardman on (01248) 388201 (direct line). We do hope that you will consider participating in this very worthwhile study.

Sincerely,
Professor C. Fergus Lowe, Head of School

Consent

"On behalf of my child, ... (please insert your child's name), I agree to participate in this study. I have been given a copy of this form and had a chance to read it"

Signature of Parent: .... Date: ....

Signature of Investigator: ....

****

Participant Information Form

To assist us with our recruitment process, we would be grateful if you could provide the following information about yourself and your child. **All information you provide will be strictly confidential.**

About your child

Name of child .... Date of birth ....

School .... Class ....

On an average week, please tell us how often your child takes part in leisure-time sporting activities.

....

....

....

About yourself

Name of participating parent ....

Occupation .... Date of birth ....

On an average week, please tell us how often you take part in leisure-time sporting activities.

....

....

....

Telephone number ....

Home address ....

....

....

APPENDIX D2: Experimental Group Parent Feedback Questionnaire

Your name .... Your child's name ....
Date ....

Thank you for taking the time to complete this questionnaire.

The questions should be answered by circling the appropriate response or writing in the space provided. Please try to answer the questions as honestly and as accurately as possible.

All the information collected will be strictly confidential.

If you have any queries regarding this questionnaire or the research, please contact Charlotte Hardman on (01248) 388201, or 07818 032392

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1. Did your child enjoy taking part in the Fit n' Fun Dudes project?

YES NO NOT SURE

2. Did you enjoy taking part in the Fit n' Fun Dudes project?

YES NO NOT SURE

3. Do you feel that your child has benefited from taking part in the Fit n' Fun Dudes project?

YES NO NOT SURE

If you answered yes, please say how you think your child has benefited.
....
....
....

4. Do you feel that you have benefited from taking part in the Fit n' Fun Dudes project?

YES NO NOT SURE

Please turn over

If you answered yes, please say how you think you have benefited.

....

....

....

5. Has your child started to be more physically active since taking part in the Fit n' Fun Dudes project?

YES NO NOT SURE

6. Have you started to be more physically active since taking part in the Fit n' Fun Dudes project?

YES NO NOT SURE

7. Do you feel that you received enough information about the project?

YES NO NOT SURE

If you answered no, please indicate what additional information you would like to have received.

....

....

....

8. Do you have any other comments you would like to make about the Fit n' Fun Dudes project (please continue overleaf if necessary)?

....

....

....

....

....

....

....

....

Thank you for your help.

APPENDIX D2: Experimental Group Child Feedback Questionnaire

Your Name: ______________________

Thank you for taking the time to answer these questions.

Please draw a circle around your chosen answer, or write your answer in the space provided. This is not a test so try to answer the questions as honestly as you can.

---

1. Did you enjoy taking part in the Fit n' Fun Dudes project?

   YES NO NOT SURE

2. Do you think that the Fit n' Fun Dudes programme helped you to be more physically active?

   YES NO NOT SURE

3. You were given a target on your pedometer, which you had to reach every day to get a prize. What sort of activities did you do at school and at home to help reach your pedometer target? Please describe these below

   Example: I played football in the park

   ....

   ....

   ....

   ....

   ....

4. Did you like wearing the pedometer?

   YES NO NOT SURE

5. Did you like the Fit n' Fun Dude prizes?

   YES NO NOT SURE

If you answered yes, what was your favourite prize?

....

....

....

6. Did you like the Fit n' Fun Dude song?

YES NO NOT SURE

7. Did you like the Fit n' Fun Dude letters?

YES NO NOT SURE

8. Did you like the Fit n' Fun Dude diary?

YES NO NOT SURE

9. How often did you use the Fit n' Fun Dude diary to record your pedometer count?

EVERY DAY MOST DAYS SOME DAYS A FEW DAYS NEVER

10. Did you use the Fit n' Fun Dude recording graph?

YES NO NOT SURE

11. Would you like to say anything else about the Fit n' Fun Dudes project? For example, you might have some ideas for how we could improve the project.

....

....

....

....

....

Thank you for your help!

Child Physical Activity Diary

Please use this diary to record any physical or sporting activities that your daughter does on each day. It would also be extremely helpful if you could say how long your daughter spent doing these activities.

Please also make a note of the time that your daughter's pedometer was put on in the morning and the time it was taken off at bedtime

Name of Child ....

Day	Time pedometer put on in the morning	Time pedometer taken off at bedtime	What physical/sporting activities did your daughter do and for how long?
Example	*8.00am*	*9.00pm*	*Gymnastics (1 hour)*
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			

Please list any days that your daughter was ill or absent from school ....

....

....

....

Parent Pedometer Count Recording Form

Please use this form to record your own pedometer count at the end of each day.

After each recording, please do not press 'reset'.

Please also make a note of the time you put the pedometer on in the morning and the time you take it off at bedtime.

Name of Parent ....

Day	Time pedometer put on in the morning	Time pedometer taken off at bedtime	Pedometer Count at Bedtime
Example	*7.30 am*	*11.00pm*	*8,000 (remember, don't reset!)*
Day 1			
Day 2			
Day 3			
Day 4			
Day 5			
Day 6			
Day 7			
Day 8			

APPENDIX D4: Intervention Home Chart

Tell us how many steps you have done.

Target ☐ Steps

	Number of steps	Did you reach your target?	What physical activities did you do today, and for how long?	Did you wear your pedometer all day?
Day 1				
Day 2				
Day 3				
Day 4				
Day 5				
Day 6				
Day 7				
Day 8				

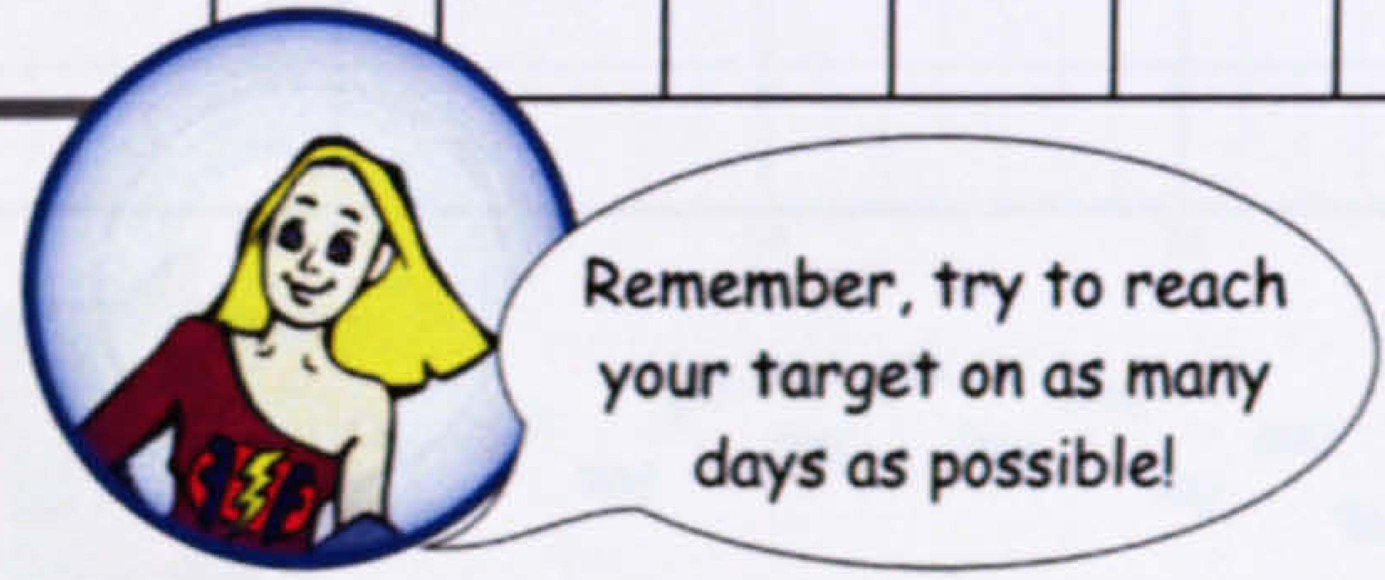
Remember, there's an amazing prize if you reach your target!

Tell us how many steps you do every day.

Your target is ☐ steps..

It's easy! Write in the number of steps that you do on each day.

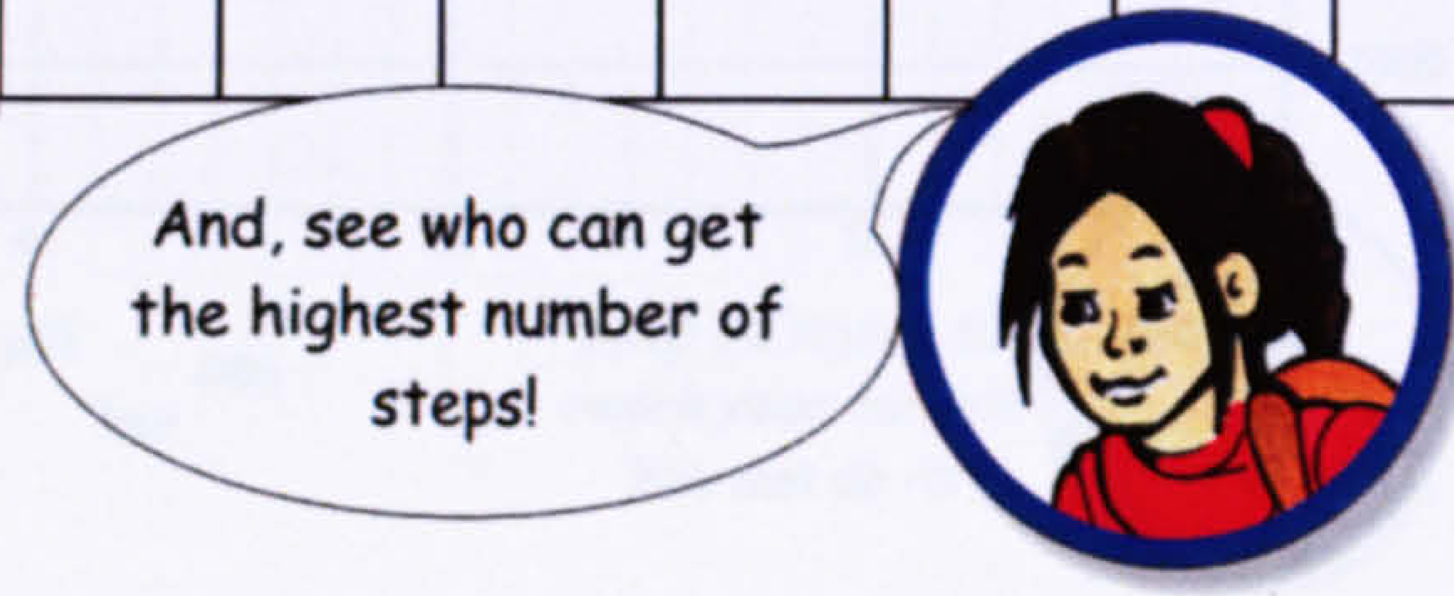
	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week beginning							
Week beginning							
Week beginning							
Week beginning							
Week beginning							
Week beginning							
Week beginning							



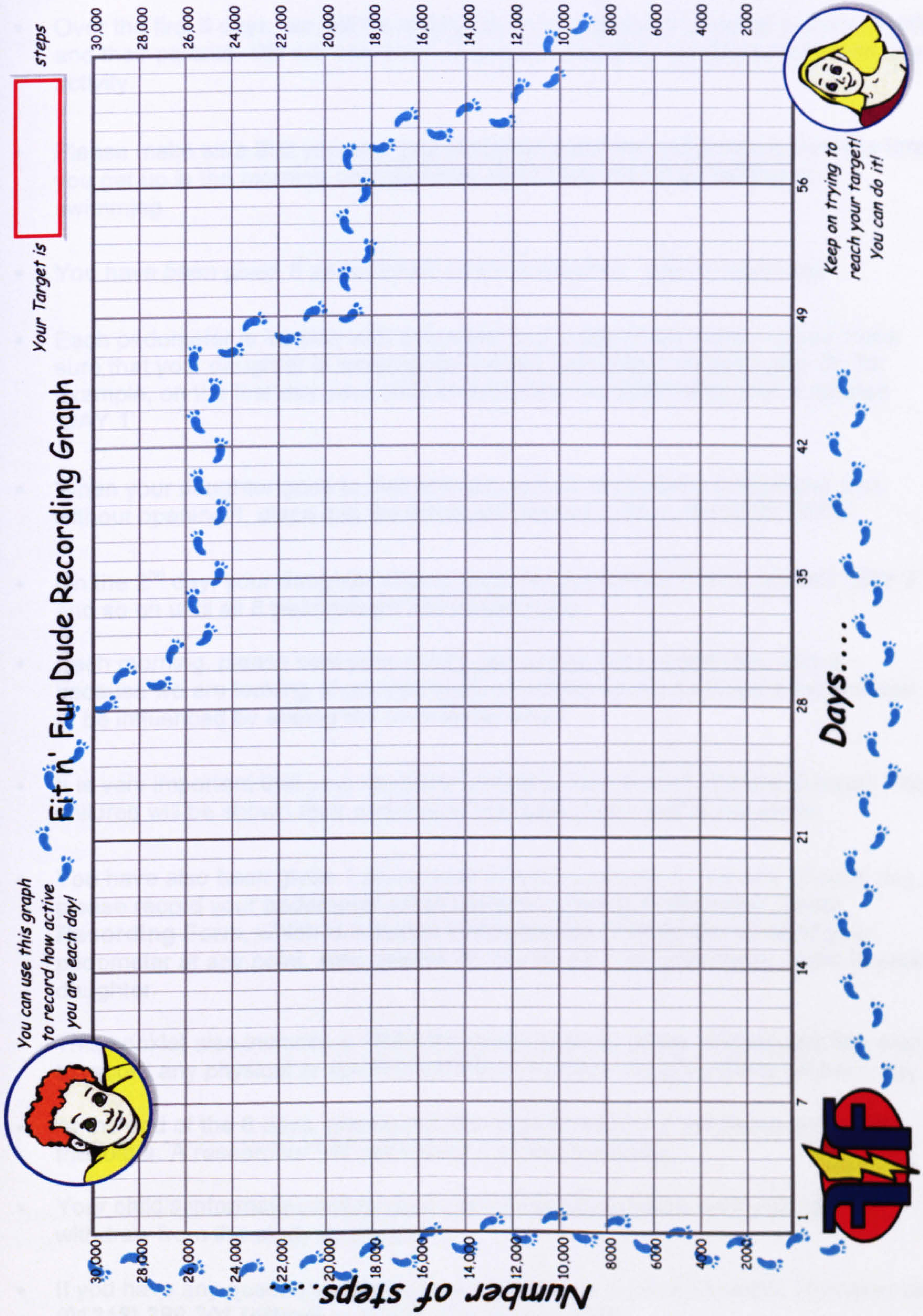
Your Parent's target is ☐ steps..

And, ask your parent to write in the number of steps that they do each day.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Week beginning							
Week beginning							
Week beginning							
Week beginning							
Week beginning							
Week beginning							
Week beginning							



APPENDIX D5; Maintenance Graph



APPENDIX D6: Baseline instructions for parents

Instructions

- Over the first 8 days, we will be looking at normal levels of physical activity in girls and their parents. We will use small step counters called pedometers to measure activity.

- Please make sure that you and your daughter wear the pedometers from the time you get up in the morning until bedtime, apart from sleeping, bathing or swimming.

- You have been given 8 pedometers for your daughter, one for each day.

- Each pedometer is labeled with a number and a day of the week. Please make sure that your daughter is wearing the correct pedometer on each day. So for example, on the first day your child should wear the pedometer that is labeled 'DAY 1'.

- When your daughter goes to bed at night, please remove the pedometer and, without opening it, place it in the envelope labeled 'USED PEDOMETERS'.

- On the 2^{nd} day, your daughter should wear the pedometer that is labeled 'DAY 2', and so on until all 8 pedometers have been worn.

- Each morning, please seal your child's pedometer with a cable tie. This is because we are looking at normal levels of activity so we don't want the children to be influenced by seeing the pedometer count.

- It is very important that your daughter's pedometers are not opened or reset. The children will be shown their pedometer readings at the end of the study.

- You have also been given 1 pedometer to wear yourself. At the end of each day, please record your pedometer count using the **Parent Pedometer Count Recording Form**, which is included in this booklet. Please do not reset your pedometer at any point. Also, please do not reveal your pedometer count to your daughter.

- This booklet also includes a **Child Physical Activity Diary**. Please use this diary to record any physical or sporting activities that your daughter does on each day.

- At the end of the 8 days, please put this booklet and all of the pedometers into the folder. A researcher will call round to collect the folder.

- Your child's information will be kept completely confidential, and you may withdraw from the study at any point.

- If you have any questions, please don't hesitate to contact Charlotte Hardman on **(01248) 388 201 (office) or 07818 032 392 (mobile).**

APPENDIX D7: Intervention Consent Letter

Dear Parent/Guardian

Thank you for your participation in the first stage of the physical activity research project.

The next stage of the research will involve you and your daughter wearing pedometers, as previously. However we will now be looking at ways to encourage your daughter to be more physically active.

You daughter will be given a daily pedometer step target. This target is a little higher than her normal level of activity, which was measured during the first stage of the research. Your daughter will be encouraged to reach this target every day. For the next 8 days, there will be a daily prize available if she is able to reach her target. We would be most grateful if you could check your daughter's pedometer at bedtime and award her with a prize as appropriate.

Your daughter will receive letters containing instructions and encouragement from the Fit n' Fun Dudes. The Fit n' Fun Dudes are a group of four fictional characters who are very physically active, and are designed to be role models for the children taking part in the programme. There will also be a diary for your daughter to record her daily pedometer count and there is a CD containing 'The Fit n' Fun Dudes song'. You will be given a pack containing all of these materials.

At the end of the 8 days, you and your daughter will be given your pedometers to keep so that you may continue to monitor your activity levels.

Previous investigations of this kind have been highly enjoyable and educational for children and parents who are involved. We have found that the Fit n' Fun Dudes programme significantly increases physical activity in children and furthermore these increases are maintained 3 months later.

Your child's information will be kept completely confidential. Participation in the research is entirely voluntary, and you are free to refuse to take part or to withdraw your child at any time without providing a reason. In the case of any complaints concerning the conduct of research, these should be addressed to Professor C. F. Lowe, Head of School, School of Psychology, University of Wales Bangor, Gwynedd, LL57 2AS.

We do hope that you will continue to participate in this very worthwhile study.

Sincerely,

Professor C. Fergus Lowe, Head of School

....

Consent

"On behalf of my child, ... (please insert your child's name), I agree to continue to participate in this study. I have been given a copy of this form and had a chance to read it"

Signature of Parent: .... Date: ....

Signature of Investigator: ....

APPENDIX D8: Intervention Instructions for Parents

Instructions

- Over the next 8 days, we will be looking at ways to encourage your daughter to do more physical activity. We will continue to use pedometers to monitor activity.

- Please make sure that you and your daughter wear the pedometers from the time you get up in the morning until bedtime, apart from sleeping, bathing or swimming.

- You have been given 8 pedometers for your daughter, one for each day. As before, each pedometer is labeled with a number and a day of the week. Please make sure that your daughter is wearing the correct pedometer on each day. So for example, on the first day your child should wear the pedometer that is labeled 'DAY 1'. On the 2nd day, your daughter should wear the pedometer that is labeled 'DAY 2', and so on until all 8 pedometers have been worn.

- You have been given a pack of materials containing: 8 Fit n' Fun Dude prizes, a letter to your daughter from the Fit n' Fun Dudes, a Homepack and recording chart for your daughter, and the Fit n' Fun Dudes song on CD.

- Firstly, please give the Fit n' Fun Dudes' letter to your daughter. This letter details the procedures and will ensure that your daughter knows what to do.

- Your daughter has been given a daily step target. This target is slightly higher than her normal level of activity. Your daughter's target is shown on her pedometers and in her letter from the 'Fit n' Fun Dudes'.

- For the next 8 days, your daughter needs to try and reach her step target every day by doing more physical activity.

- When your daughter goes to bed each night, please open the pedometer and check to see whether she has reached the target. If so, please congratulate her and award her with a prize from the Fit n' Fun Dudes pack. There is a prize for each day (a suggested schedule of prizes is shown overleaf).

- If your daughter has not managed to reach her target, please do not give out a prize. Please encourage your daughter to keep trying because there will be other prizes to win. If, after 4 days, your daughter has not managed to win a prize, please contact Charlotte.

- Please ask your daughter to record her step count in the Fit n' Fun Dudes Homepack at bedtime.

- Once your daughter has done her recording, please do not reset the pedometer. Please put the pedometer into the 'USED PEDOMETERS' envelope as before.

- The Fit n' Fun Dudes Homepack contains suggestions and ideas for being more active. It also includes the lyrics to the Fit n' Fun Dudes song, which is for your child's enjoyment!

- It is very important that your daughter's pedometers are **not** reset at any point.

- You have also been given 1 pedometer to wear yourself. At the end of each day, please record your pedometer count using the **Parent Pedometer Count Recording Form**, which is included in this booklet. Please do not reset your pedometer at any point. Also, please do not reveal your pedometer count to your daughter.

- At the end of the 8 days, please put this booklet and all of the pedometers into the folder. A researcher will call round to collect the folder. We would grateful if you could return any leftover prizes.

- Your child's information will be kept completely confidential, and you may withdraw from the study at any point.

- If you have any questions, please don't hesitate to contact Charlotte Hardman on **(01248) 388 201 (office)** or **07818 032 392 (mobile).**

Thank you very much for your time. We hope that you and your daughter will enjoy participating in this research.

Suggested Schedule of Prizes

Day	Prize
Day 1	Sports bottle
Day 2	Wallet
Day 3	Frisbee
Day 4	Snap band
Day 5	Beaker
Day 6	Straw
Day 7	Slinky spring
Day 8	Ball

APPENDIX D9: Maintenance Instructions for Parents

Dear (insert parent's name)

Thank you for supporting the Fit n' Fun Dudes programme.

Please find enclosed the daily pedometer counts that were recorded for yourself and for (insert child's name) before the Fit n' Fun Dudes programme and during the programme

Even though the main phase of the Fit n' Fun Dudes programme is now over, it is hoped that the children will continue to be physically active. In order to obtain health benefits it is important that high levels of activity are maintained over time.

(Insert child's name) has been given a diary and graph so that she may record her own pedometer count on a daily basis. We would be grateful if you could encourage her to use these materials and also to try and reach her target on as many days as possible. We have previously found that children find this very enjoyable. In September, there will be a Fit n' Fun Dudes certificate awarded to all children who have completed their diaries.

We hope that you will continue to use your pedometer to monitor your own level of physical activity. There is space in the diary for you to record your daily pedometer count. To give you something to aim for, we have given you your own daily pedometer target, which is shown overleaf. You might like to try and reach this on as many days as possible. In September there will be one special prize that will be awarded to the parent and child who have managed to reach their targets on the most number of days.

(Insert child's name) will receive letters from the Fit n' Fun Dudes over the summer, and we will contact you by telephone to see how you are getting on. There will be one further measurement period in September.

If you have any questions or comments about the Fit n' Fun Dudes programme please contact Charlotte Hardman on (01248) 388201 (office), or c.hardman@bangor.ac.uk (email). Please contact Charlotte if your pedometer is broken or mislaid and a new one will be provided.

Thank you again for your help and we hope that you are enjoying taking part.

Best wishes,

Charlotte Hardman

Parent's Target:

(insert target) **steps every day**

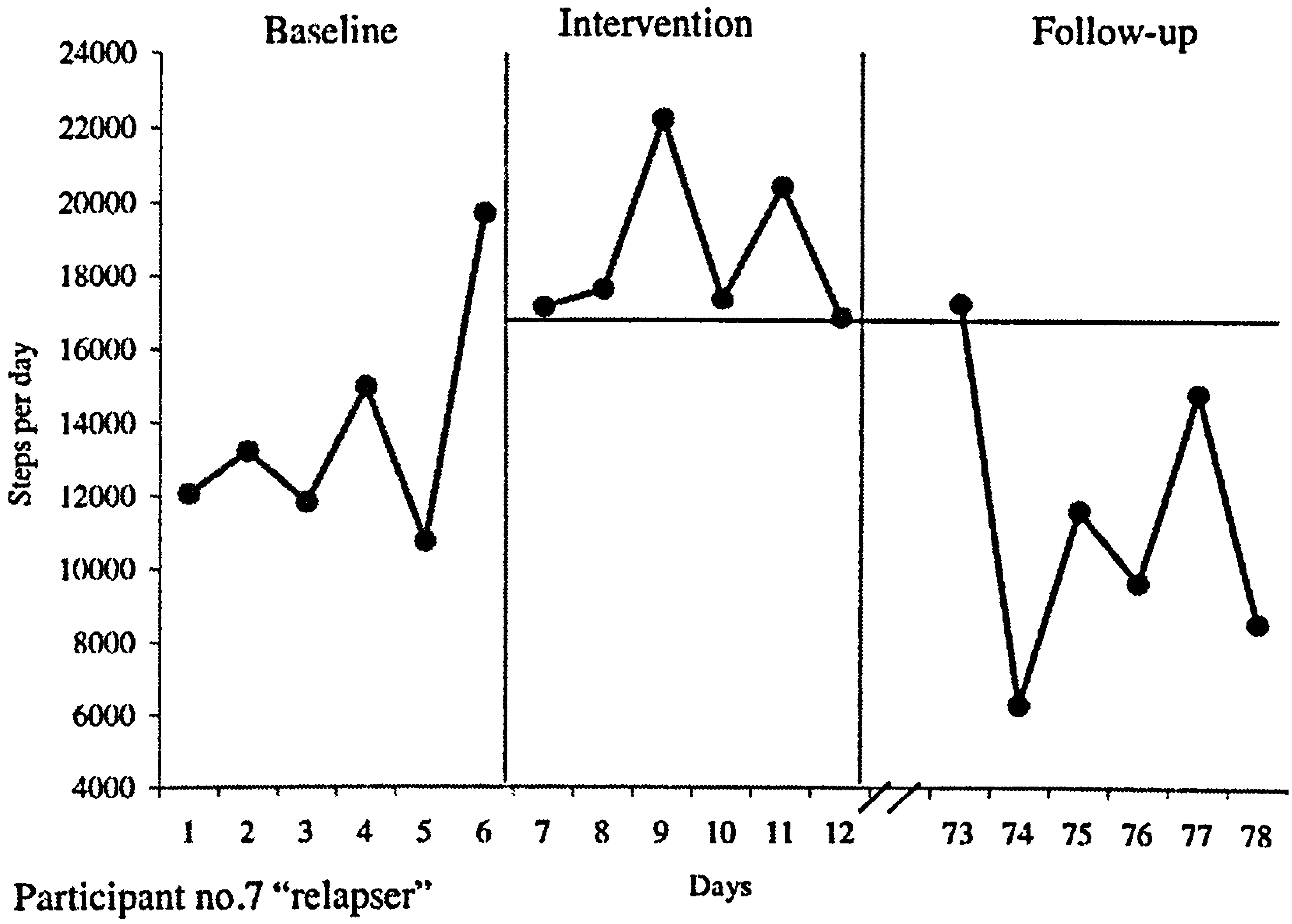
Please enter your target in the box on the right hand side of your child's Fit n' Fun Dudes Activity Diary.

How did we work out your target?

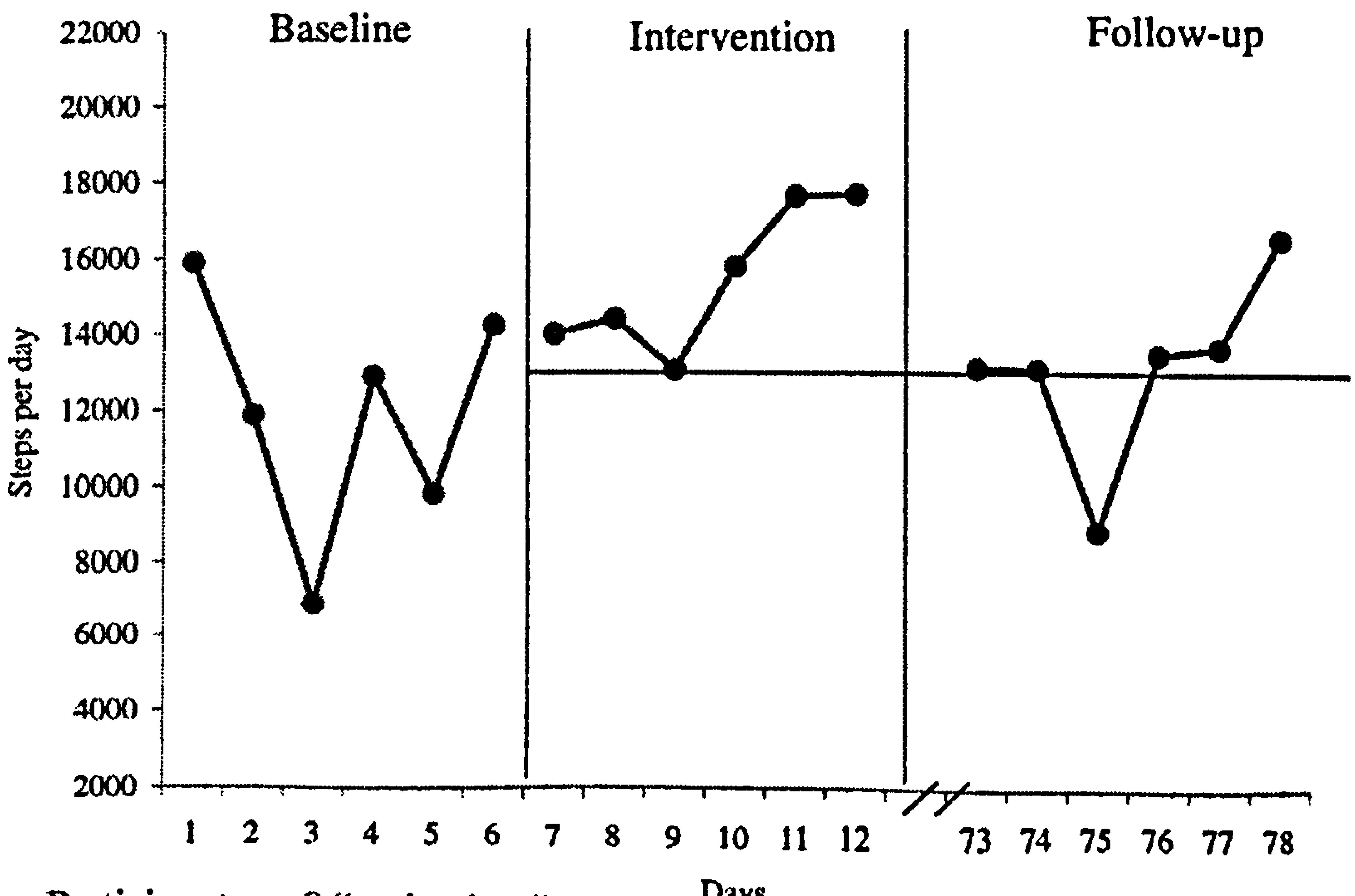
In exactly the same way as for your child. We took your weekday average pedometer count, as measured during the Fit n' Fun Dudes programme, and to this we added 2000 steps.

APPENDIX D10: Individual Subject Physical Activity Graphs

Experimental Girls (*n* = 14) The black line indicates the target level of steps



Participant no.7 "relapser"



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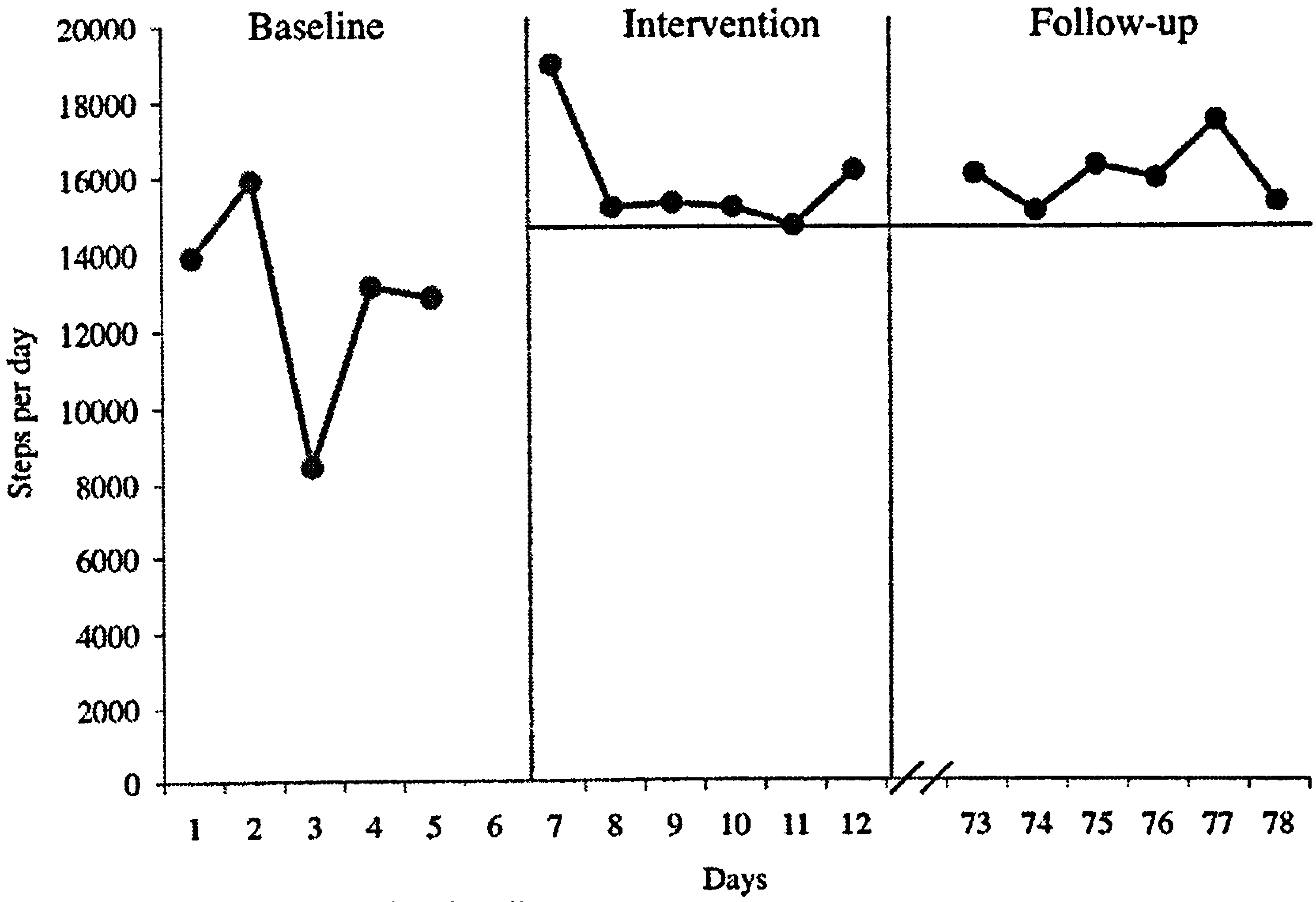

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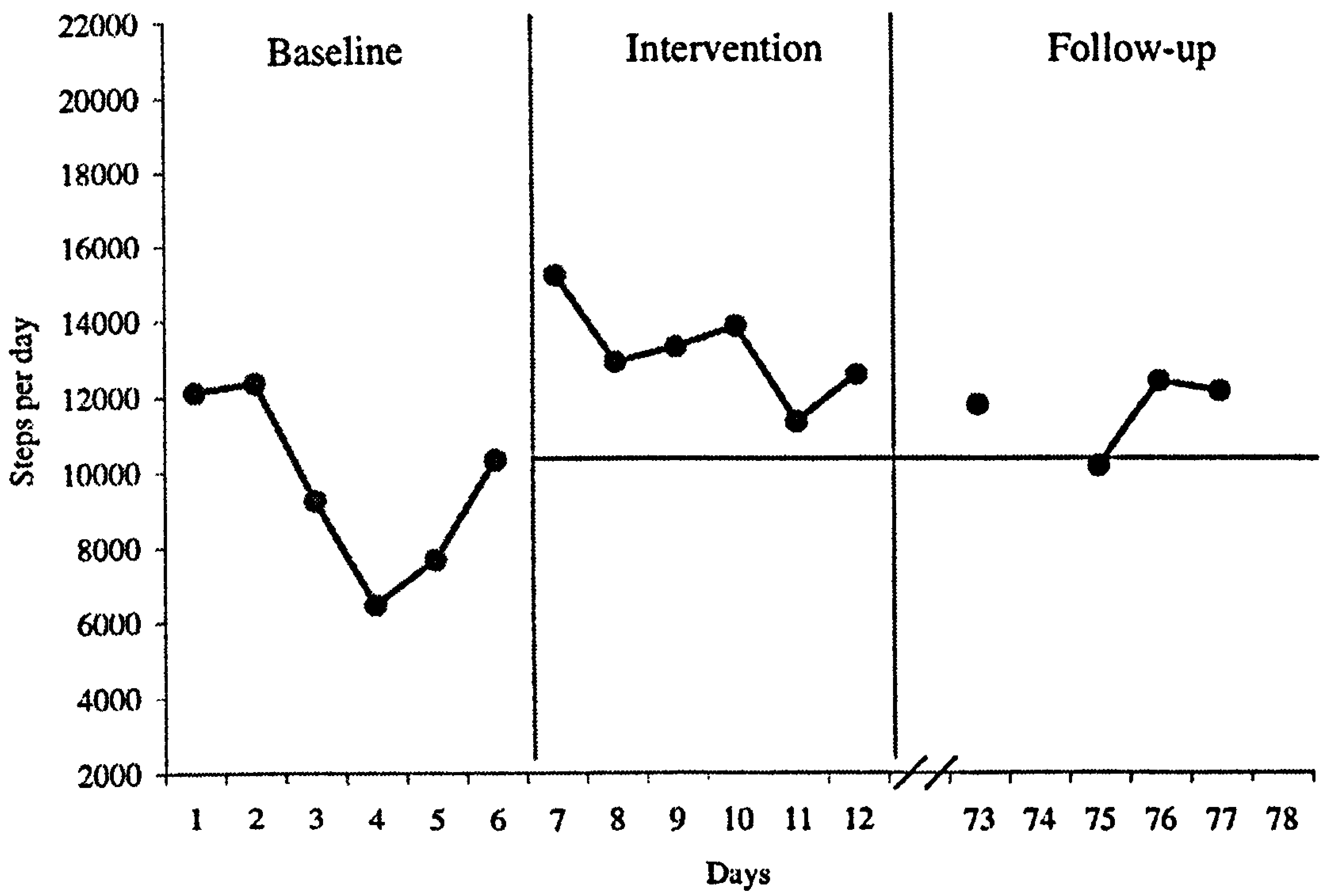

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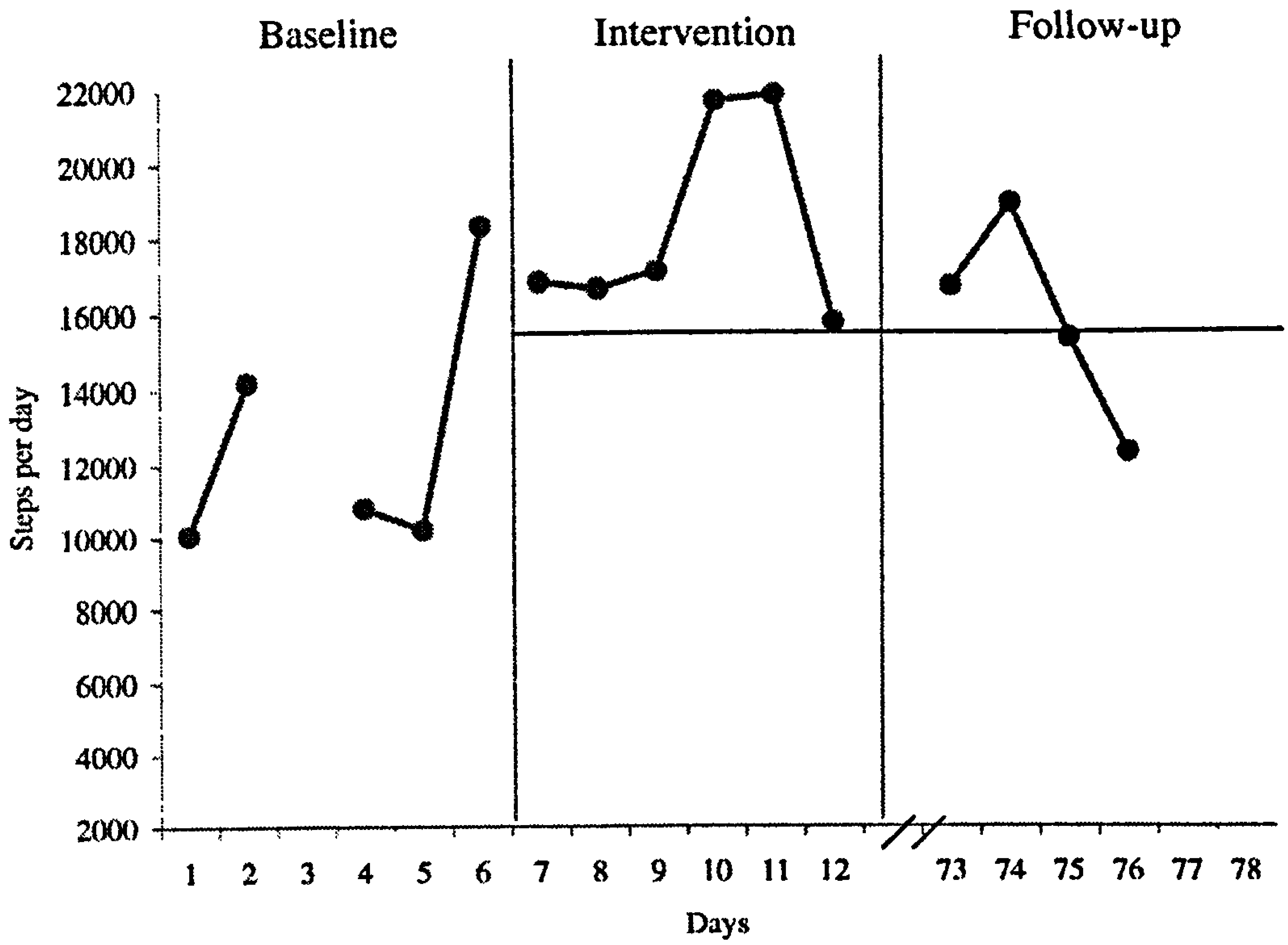

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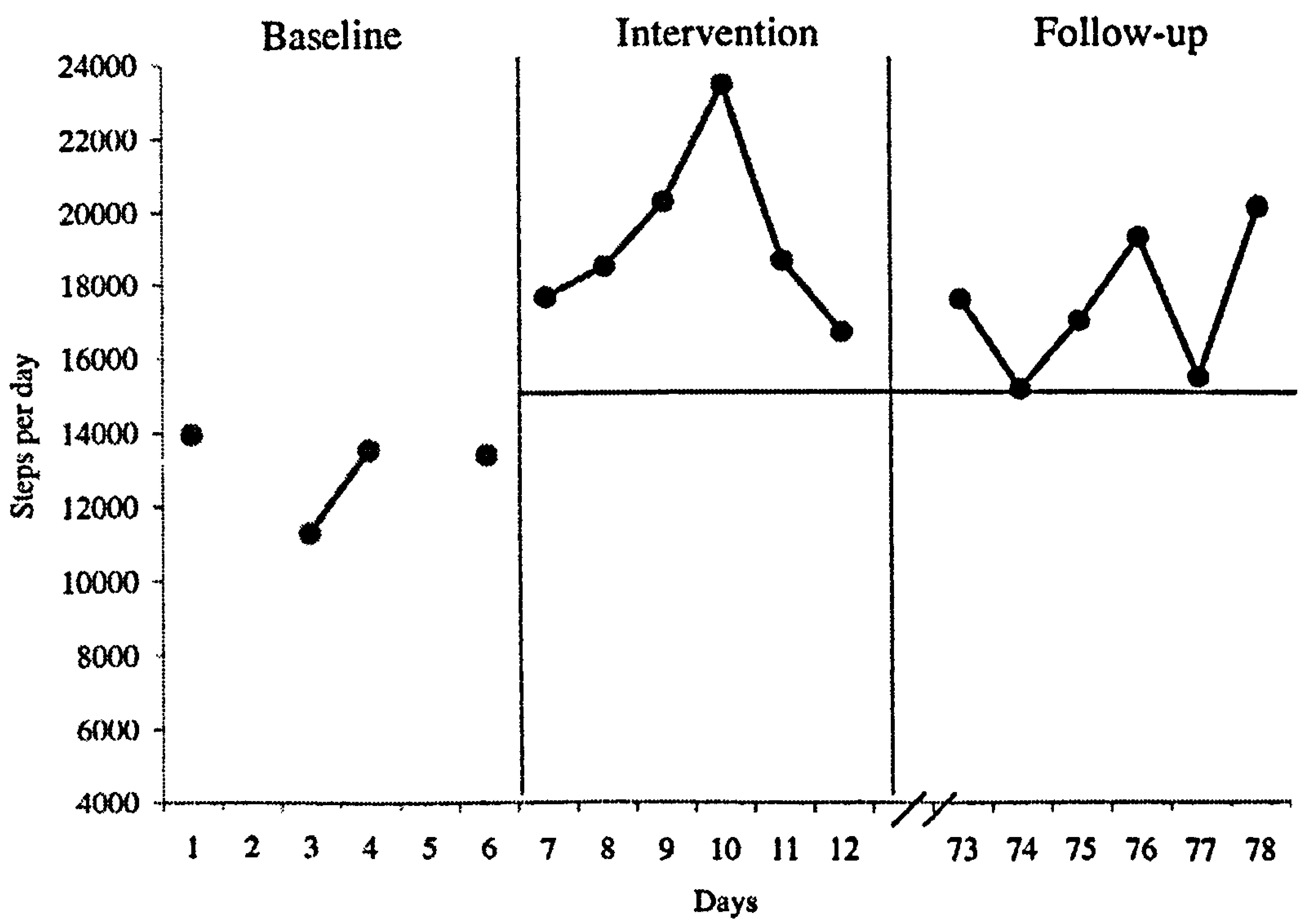

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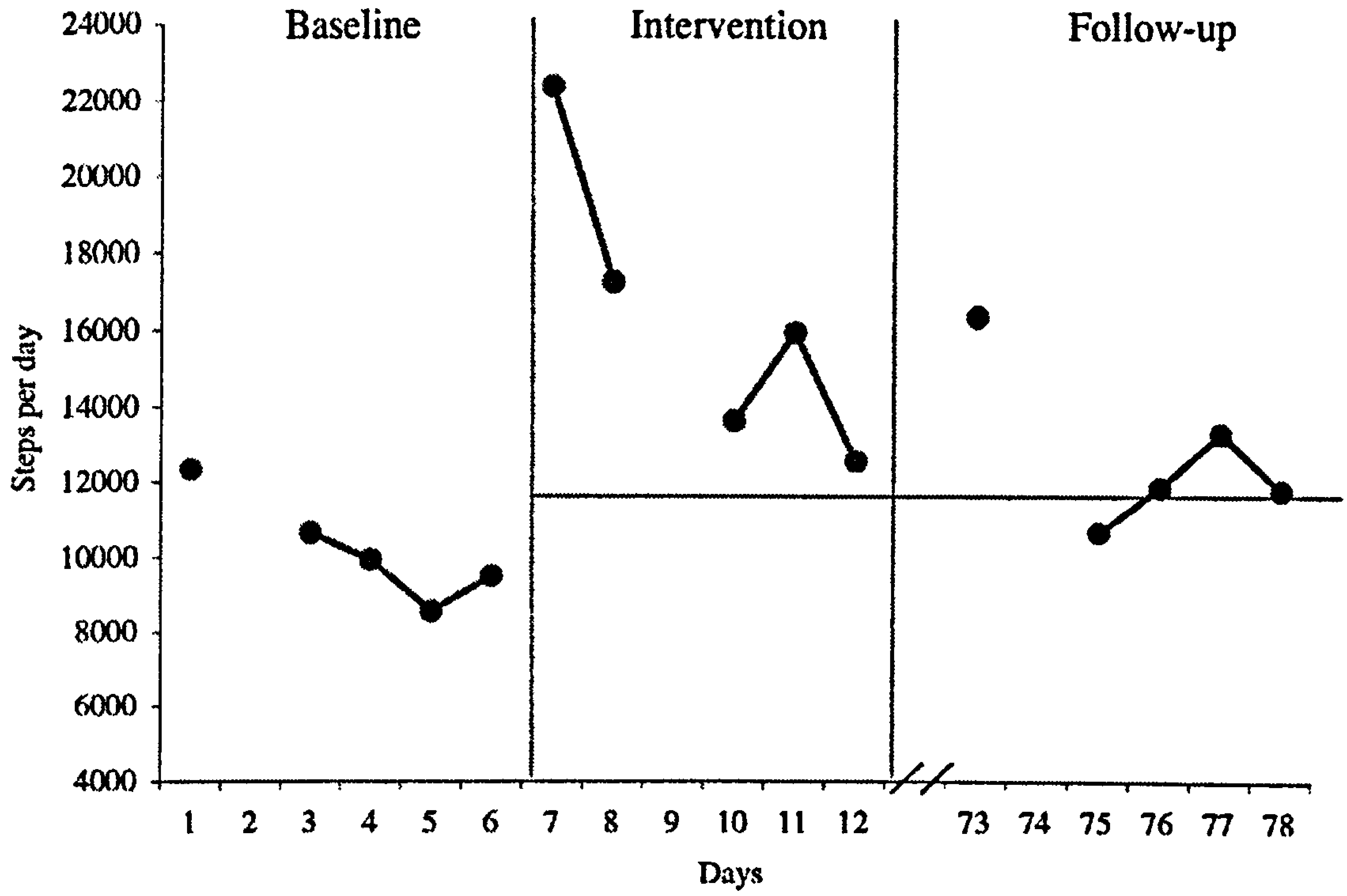

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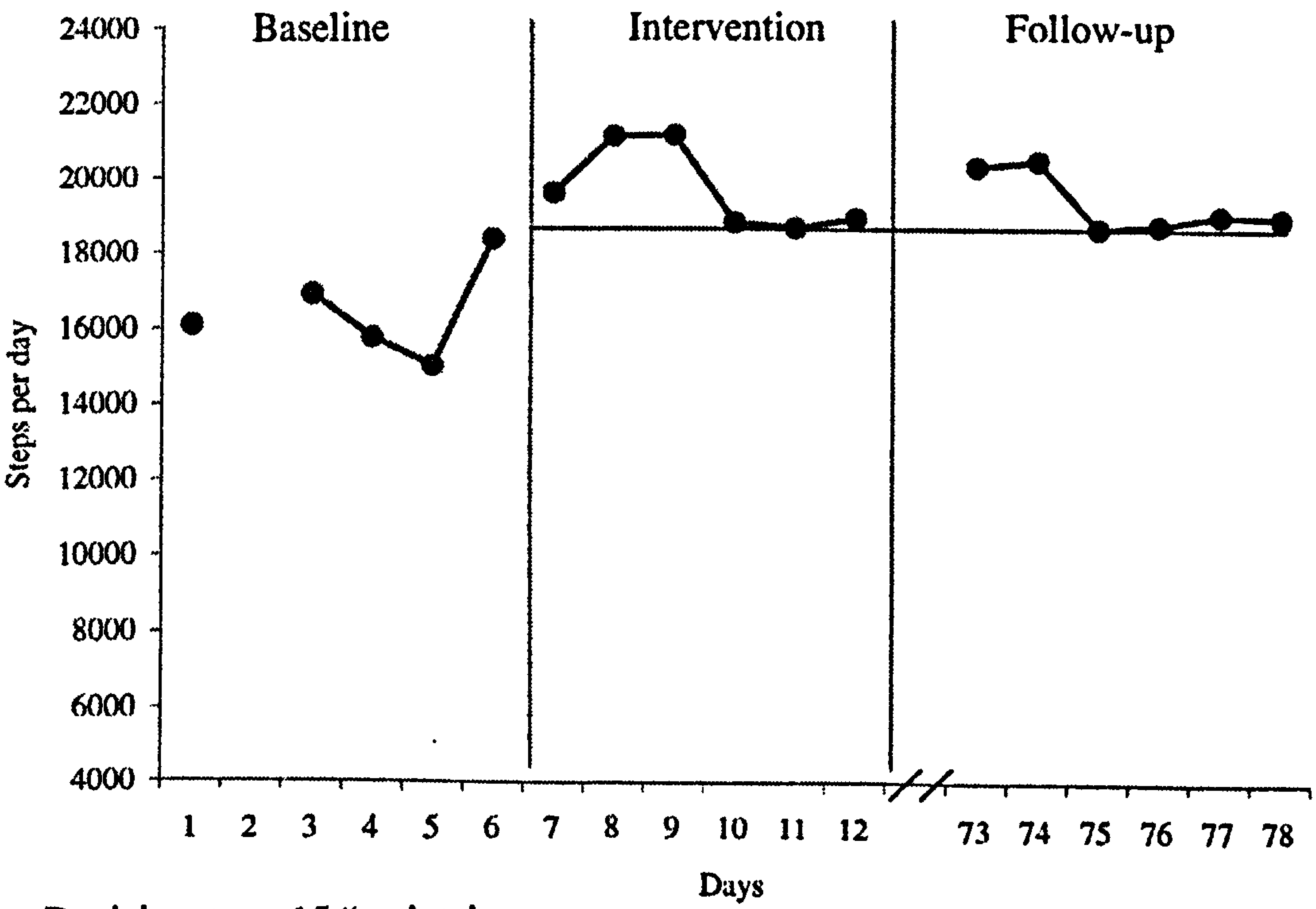

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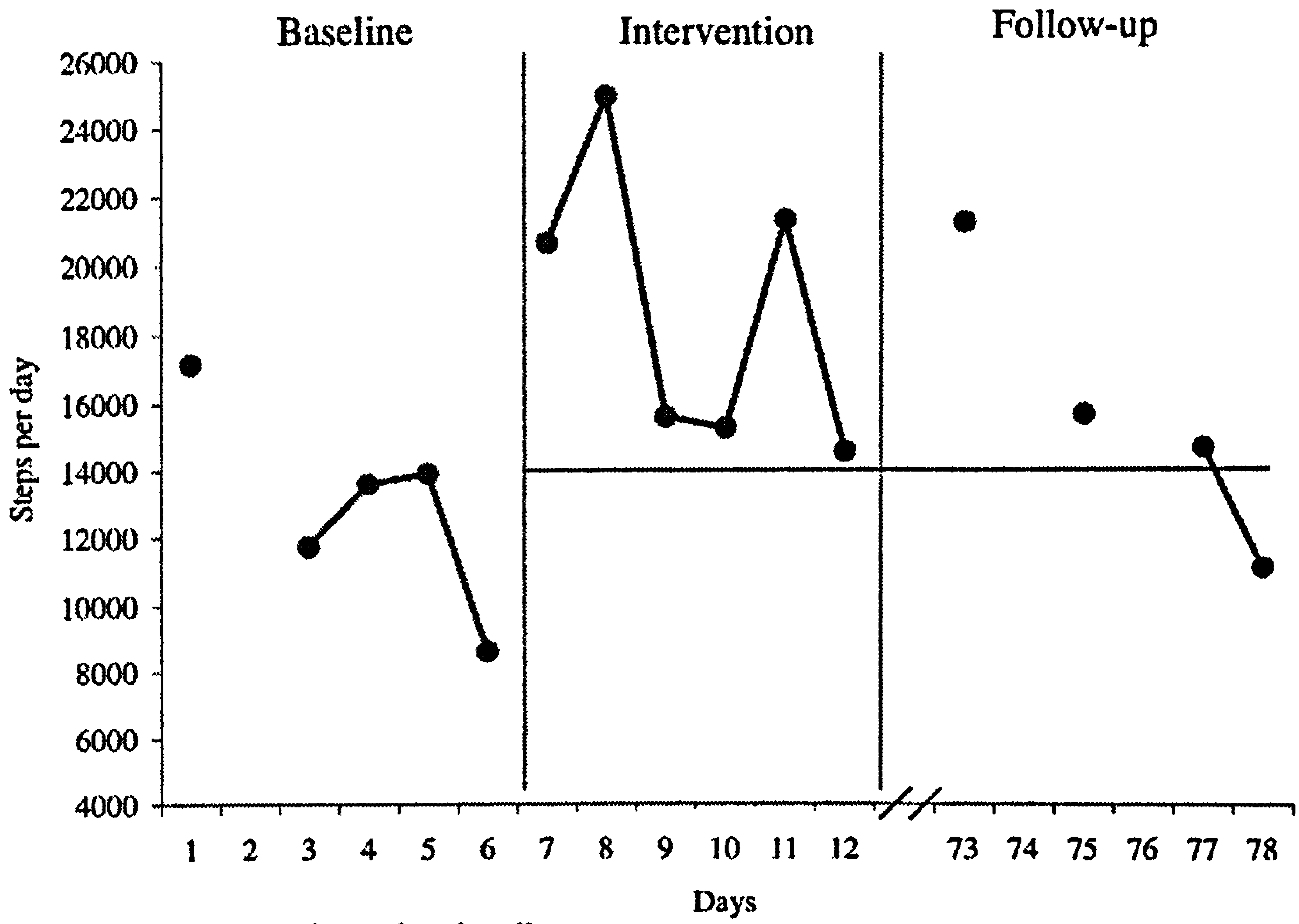

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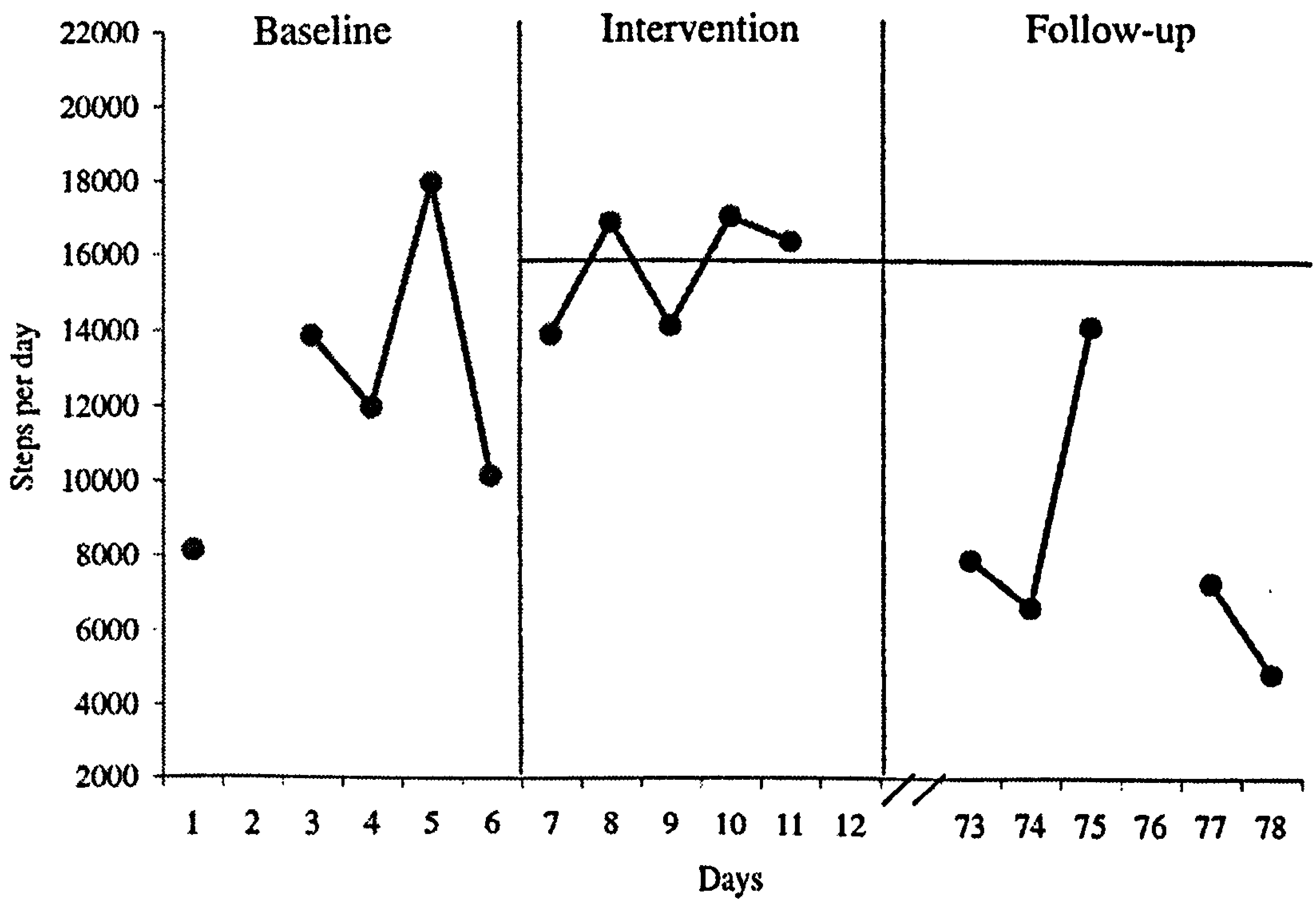

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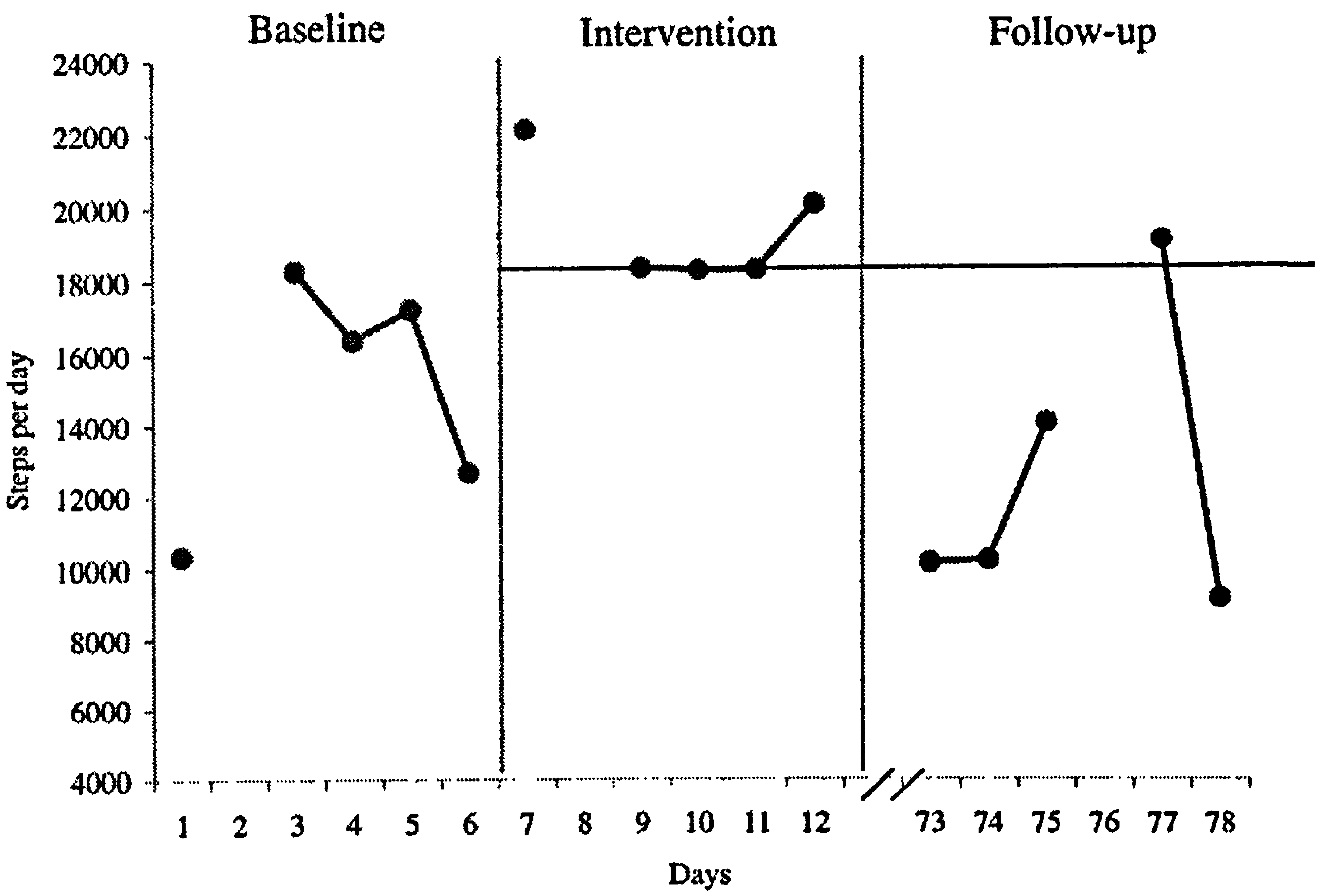

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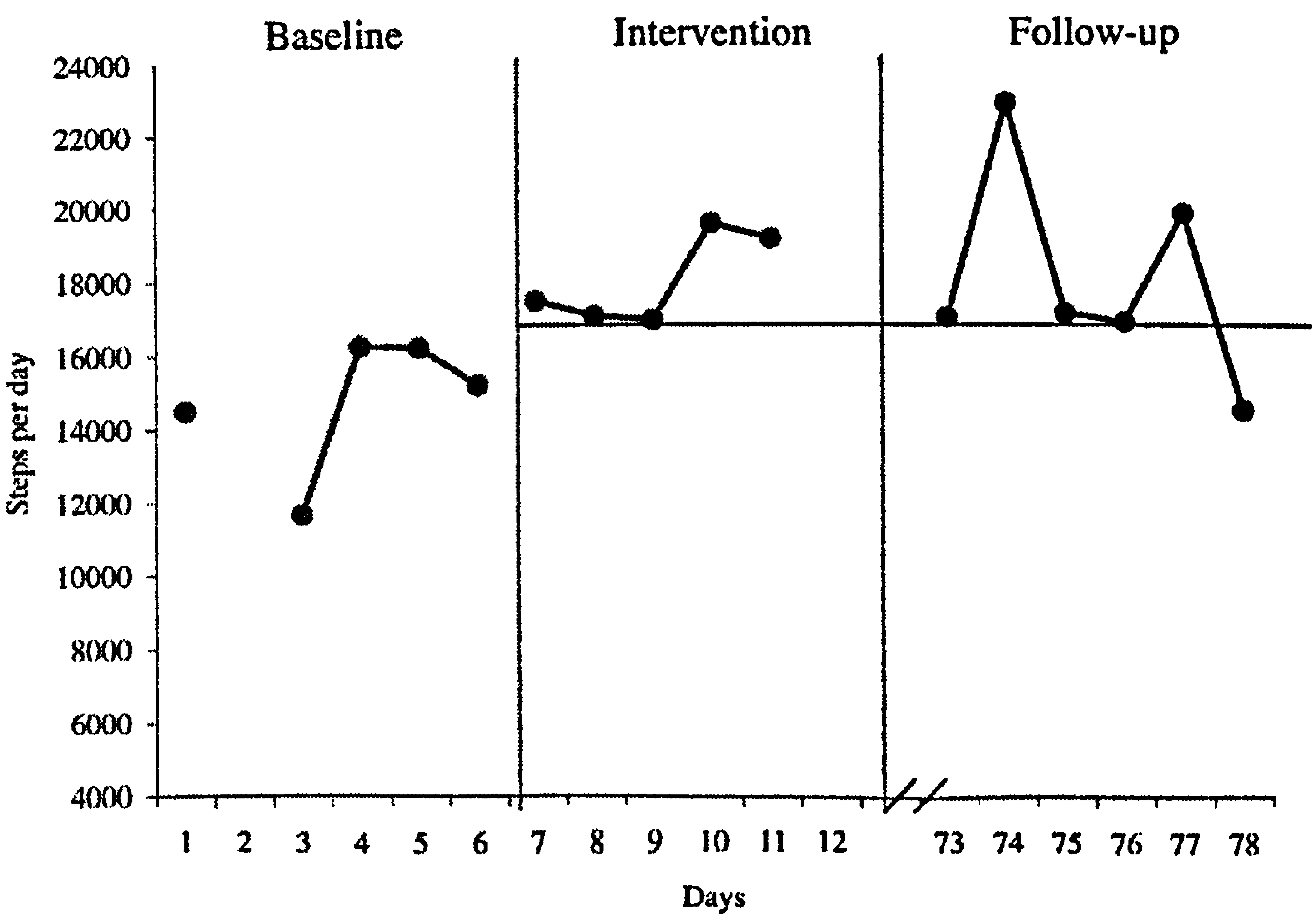

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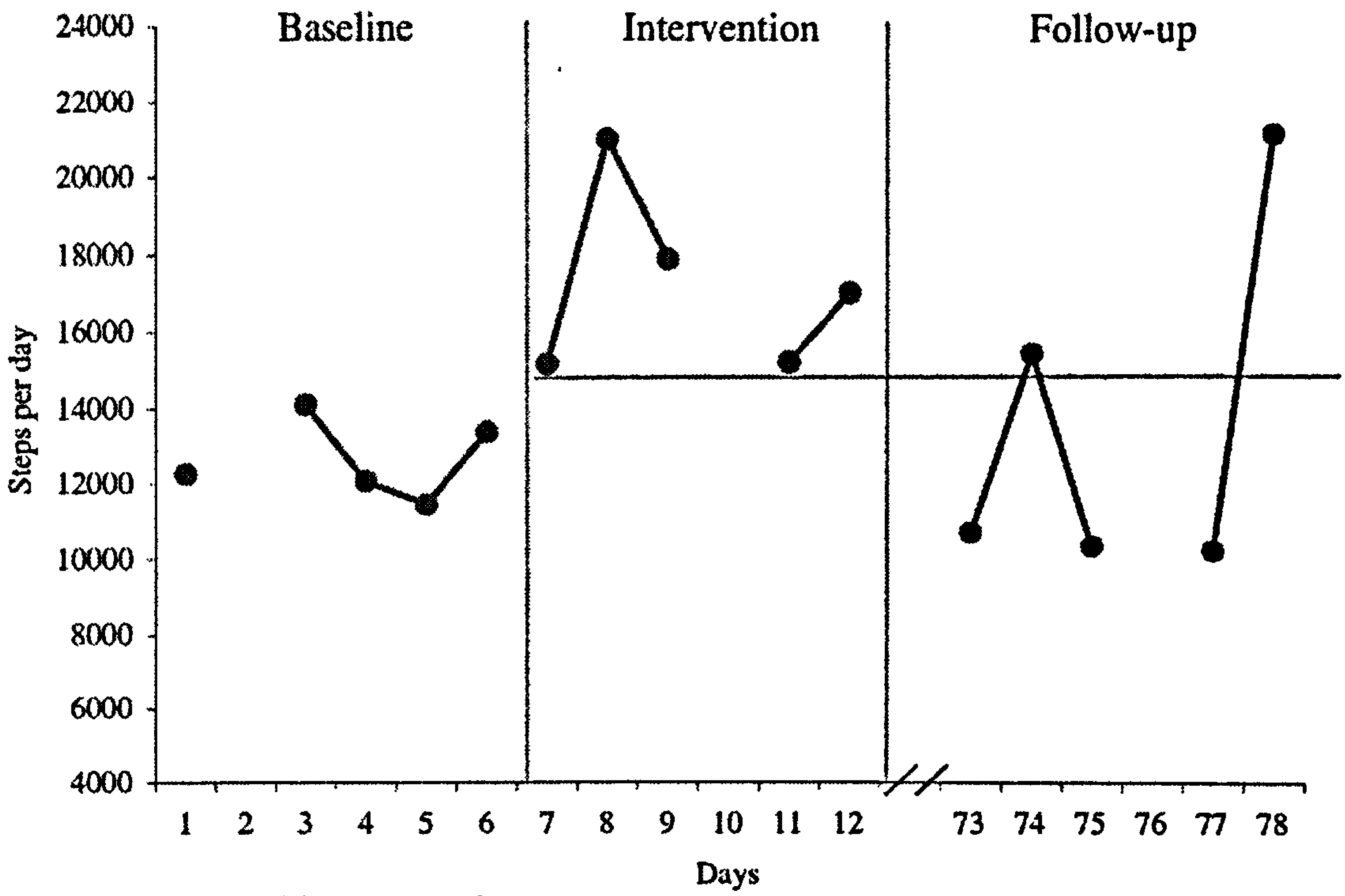

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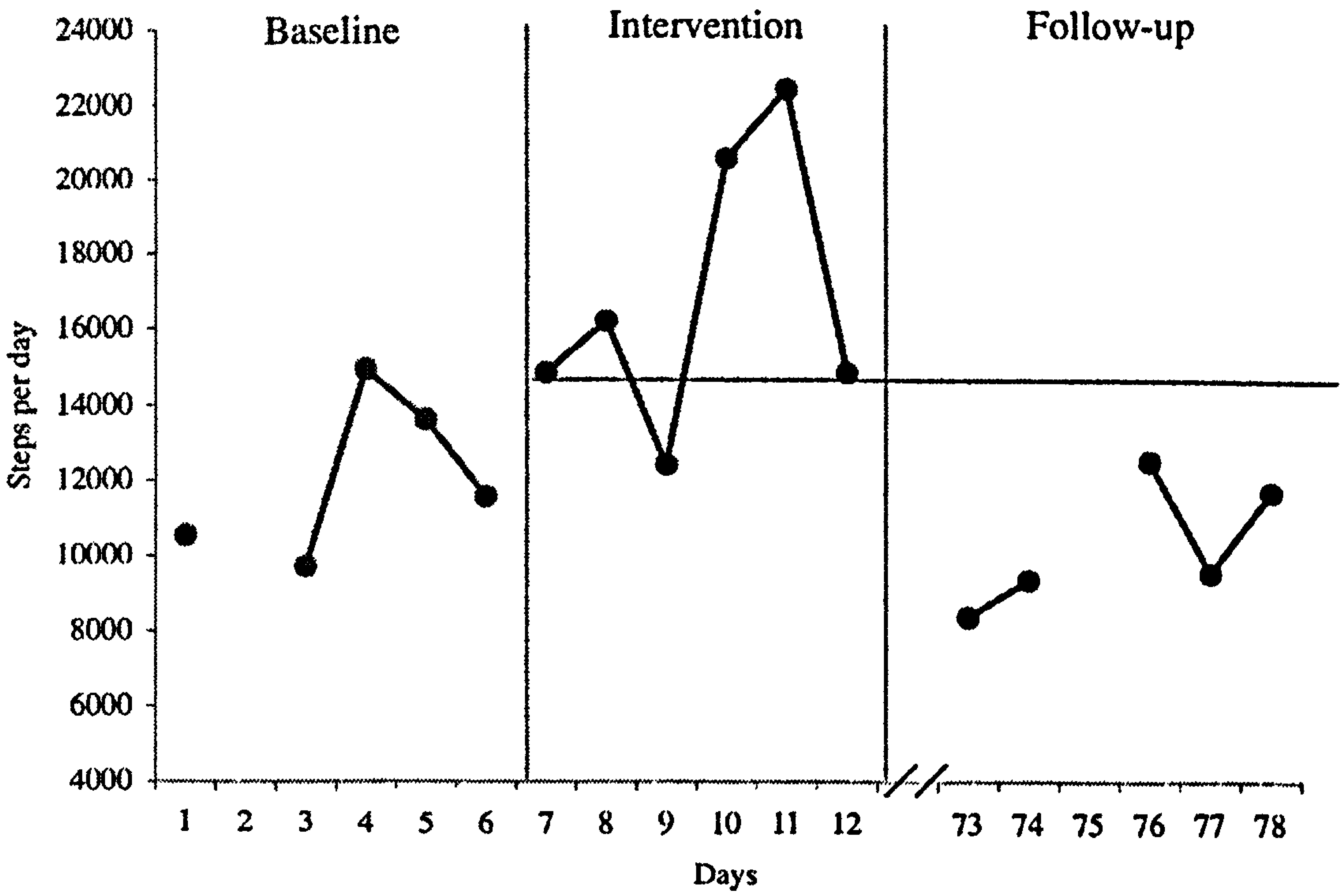

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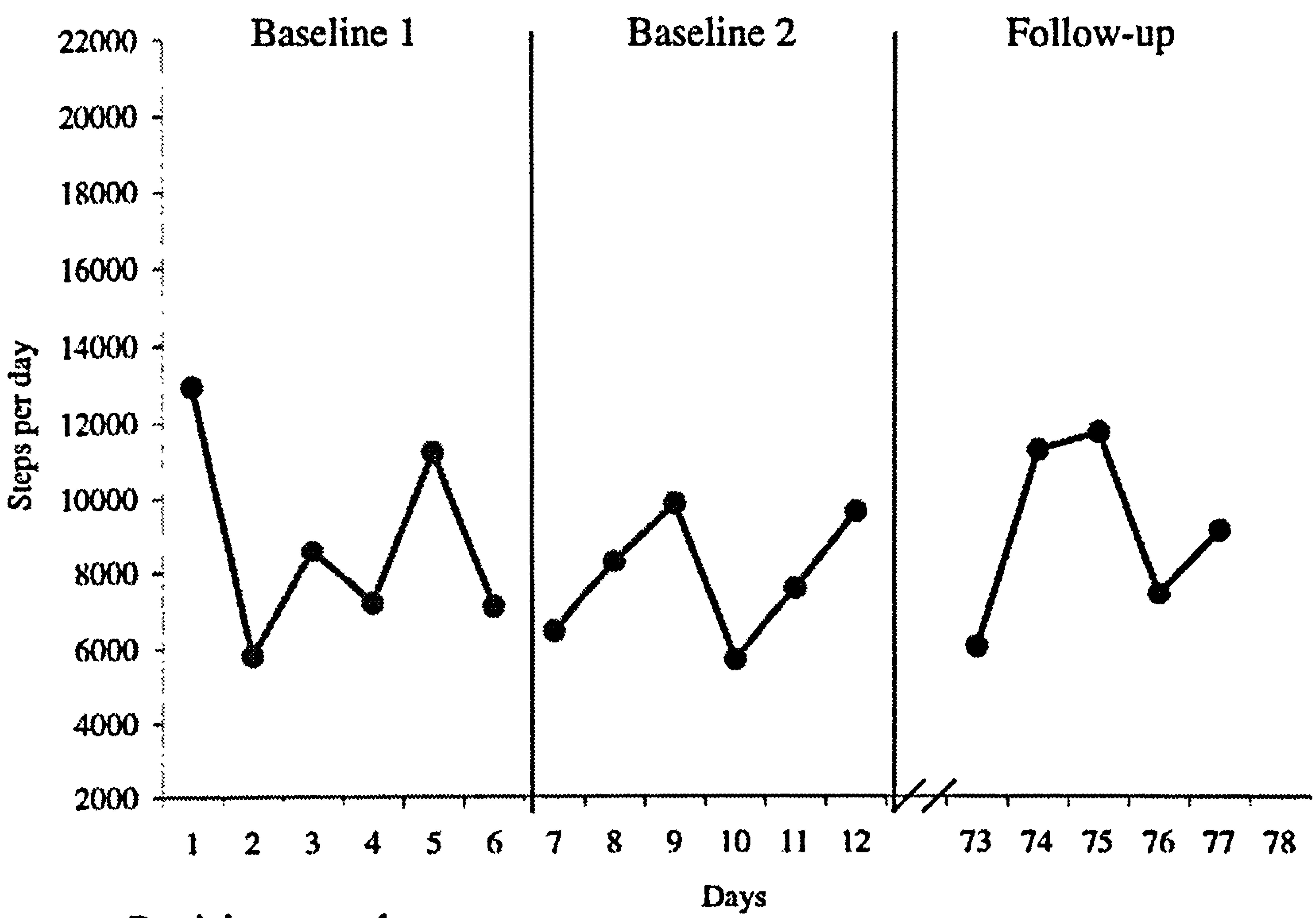
Control Girls ($n = 15$)



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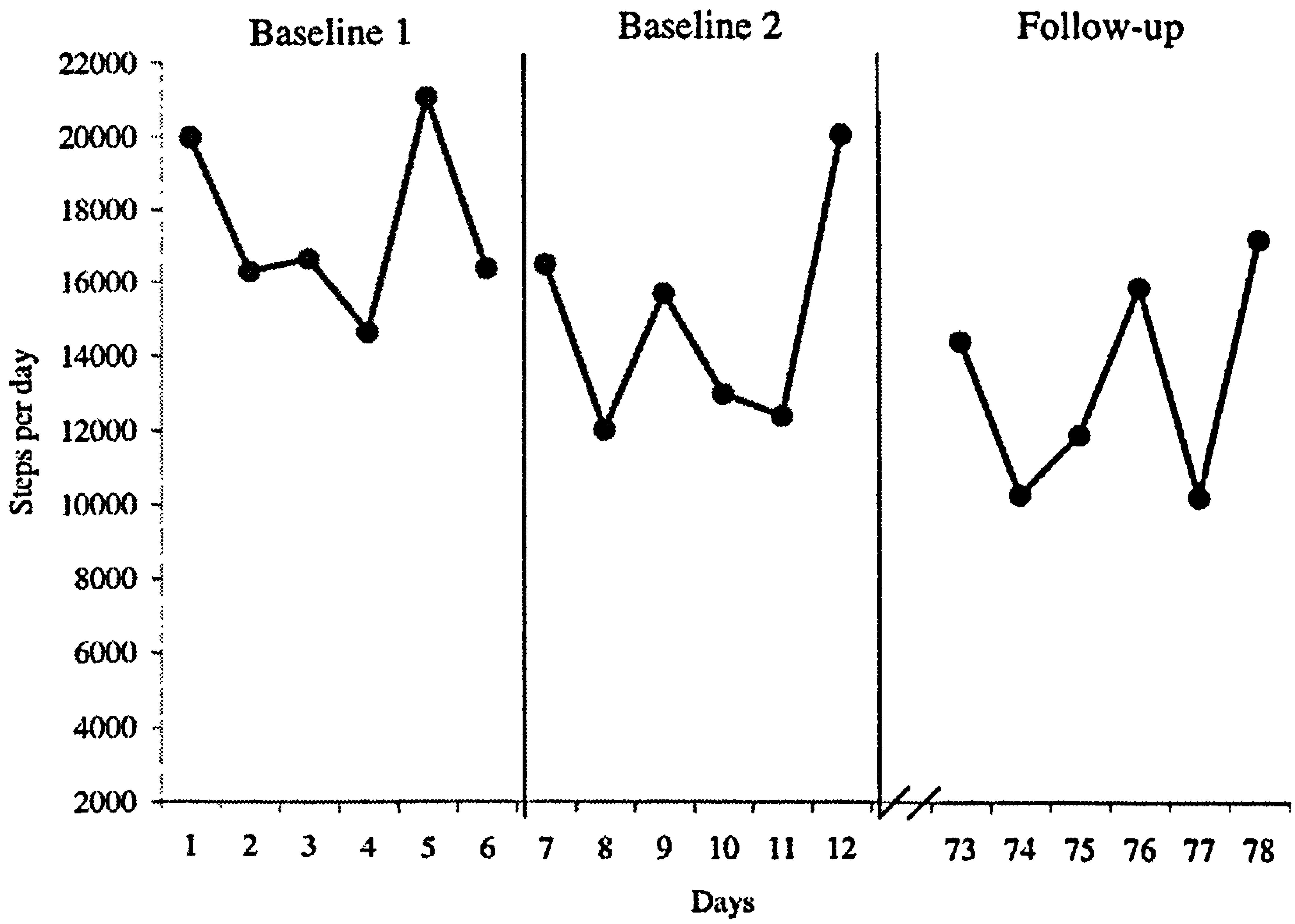

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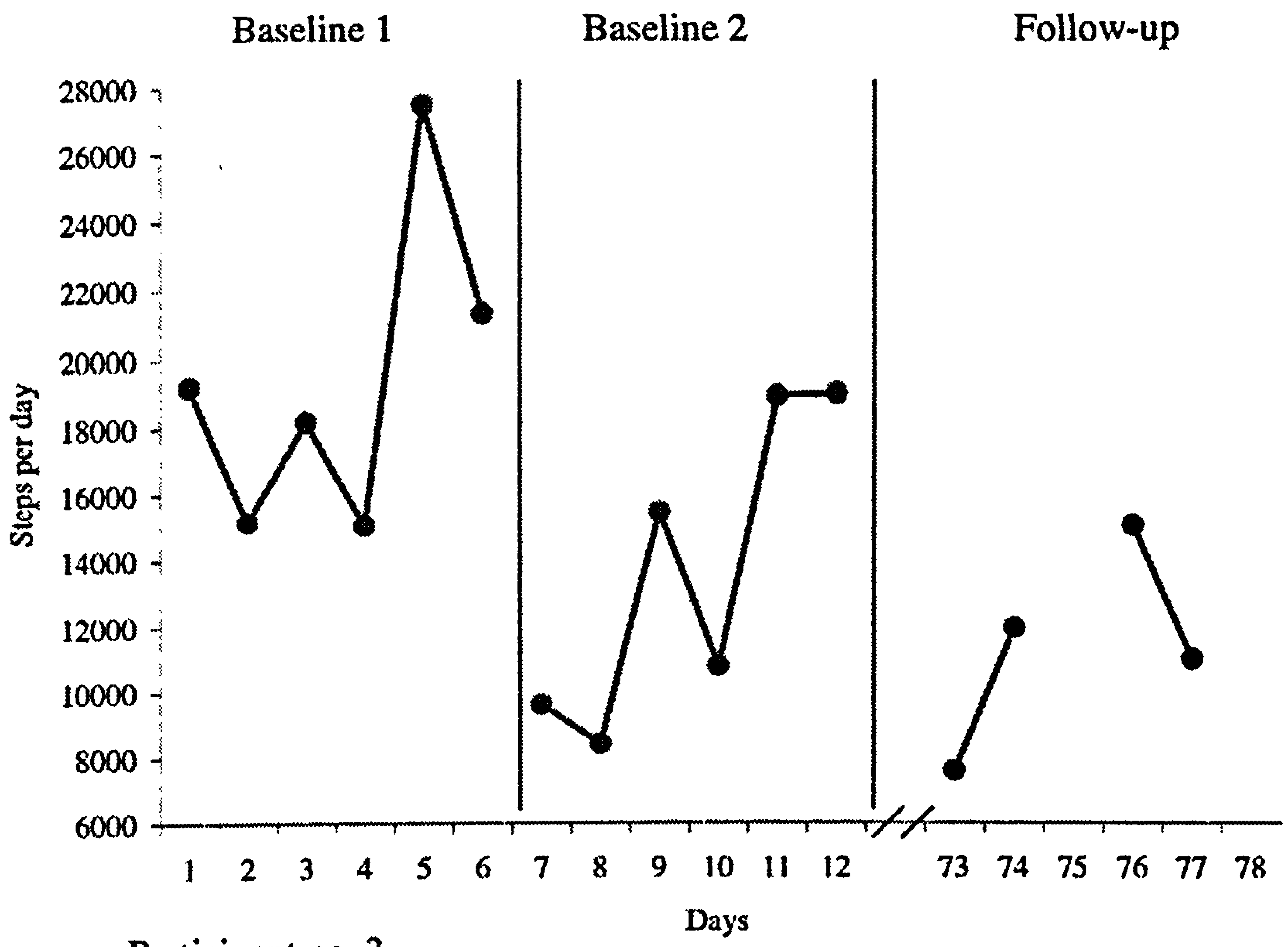

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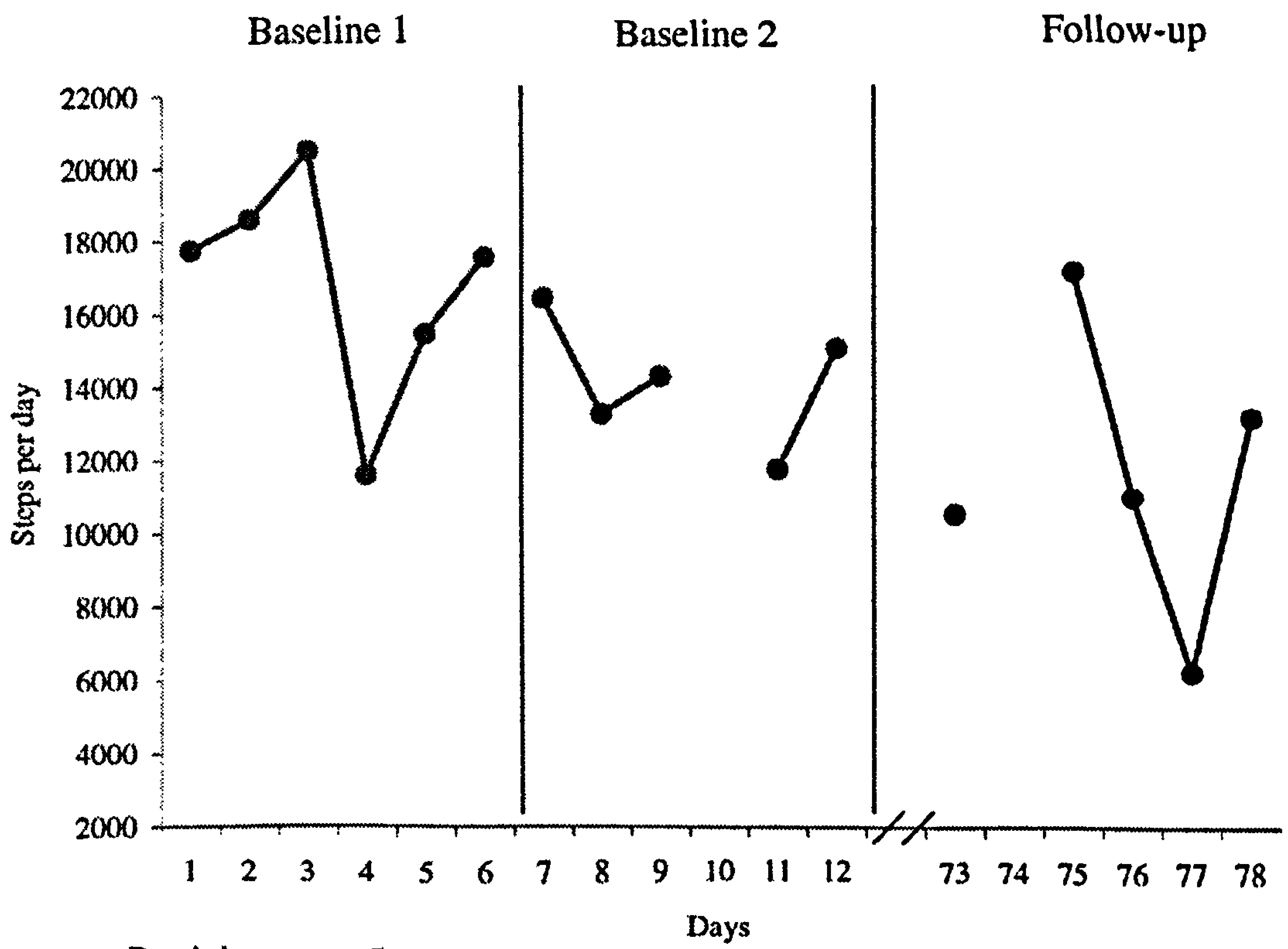

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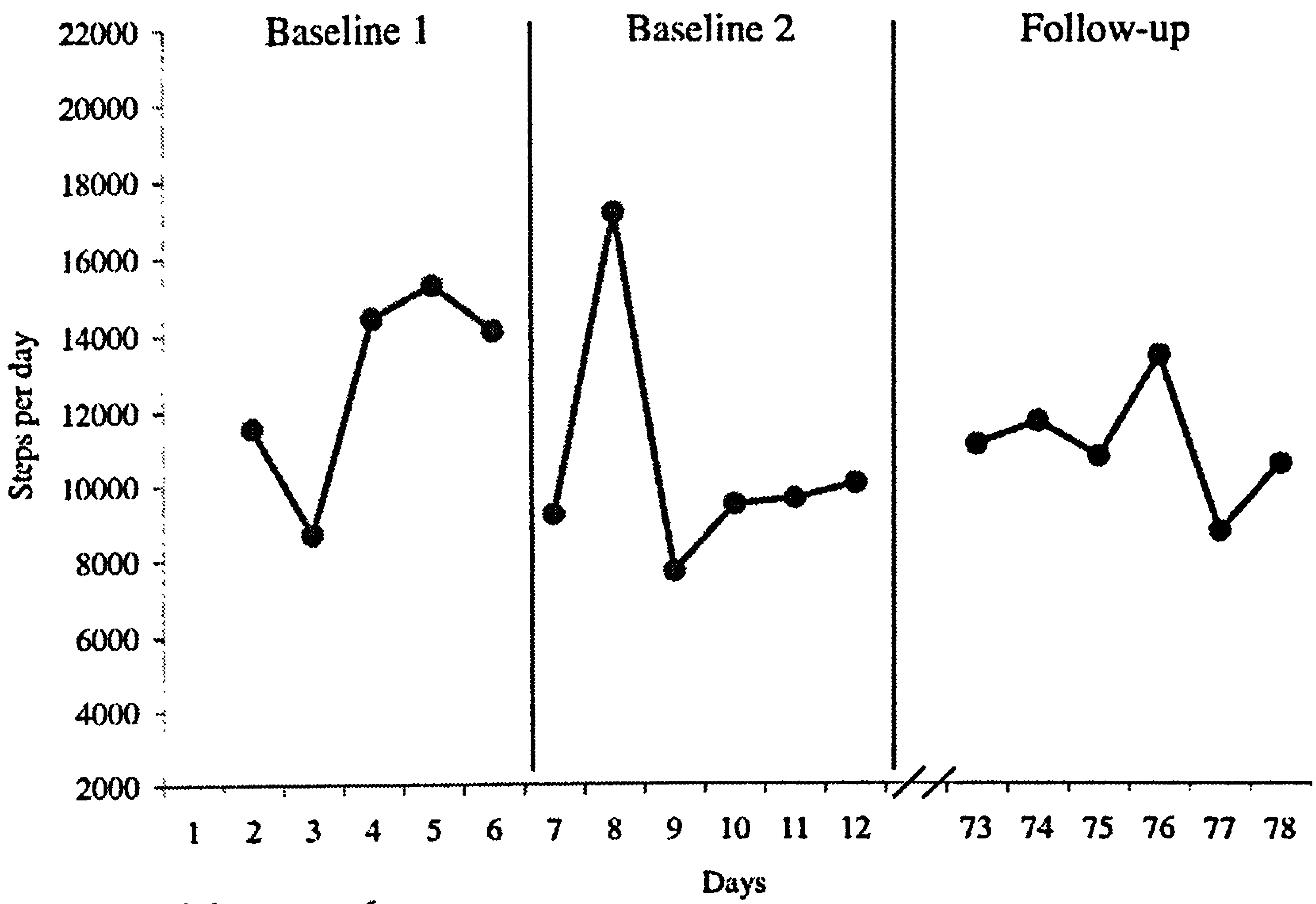

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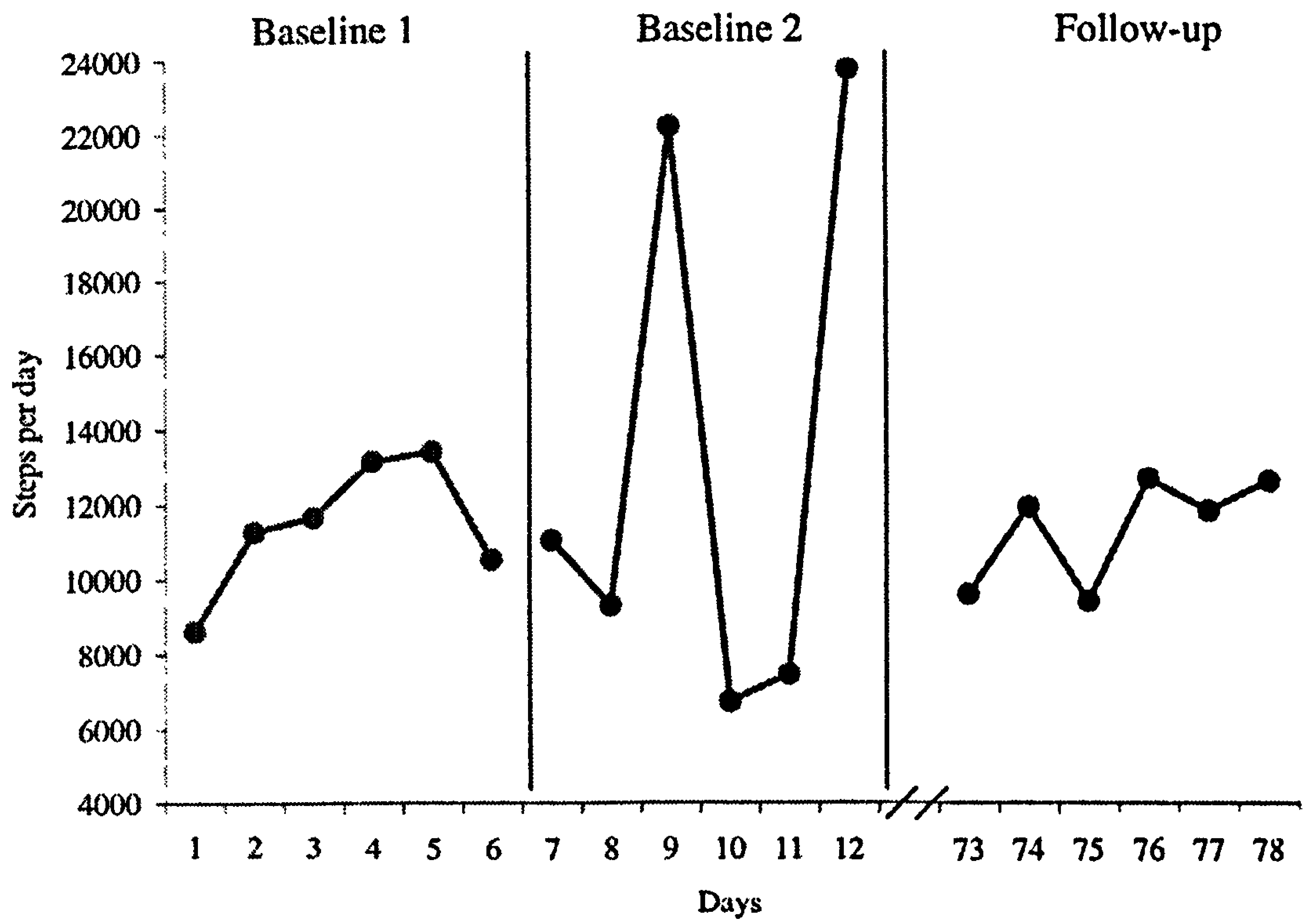

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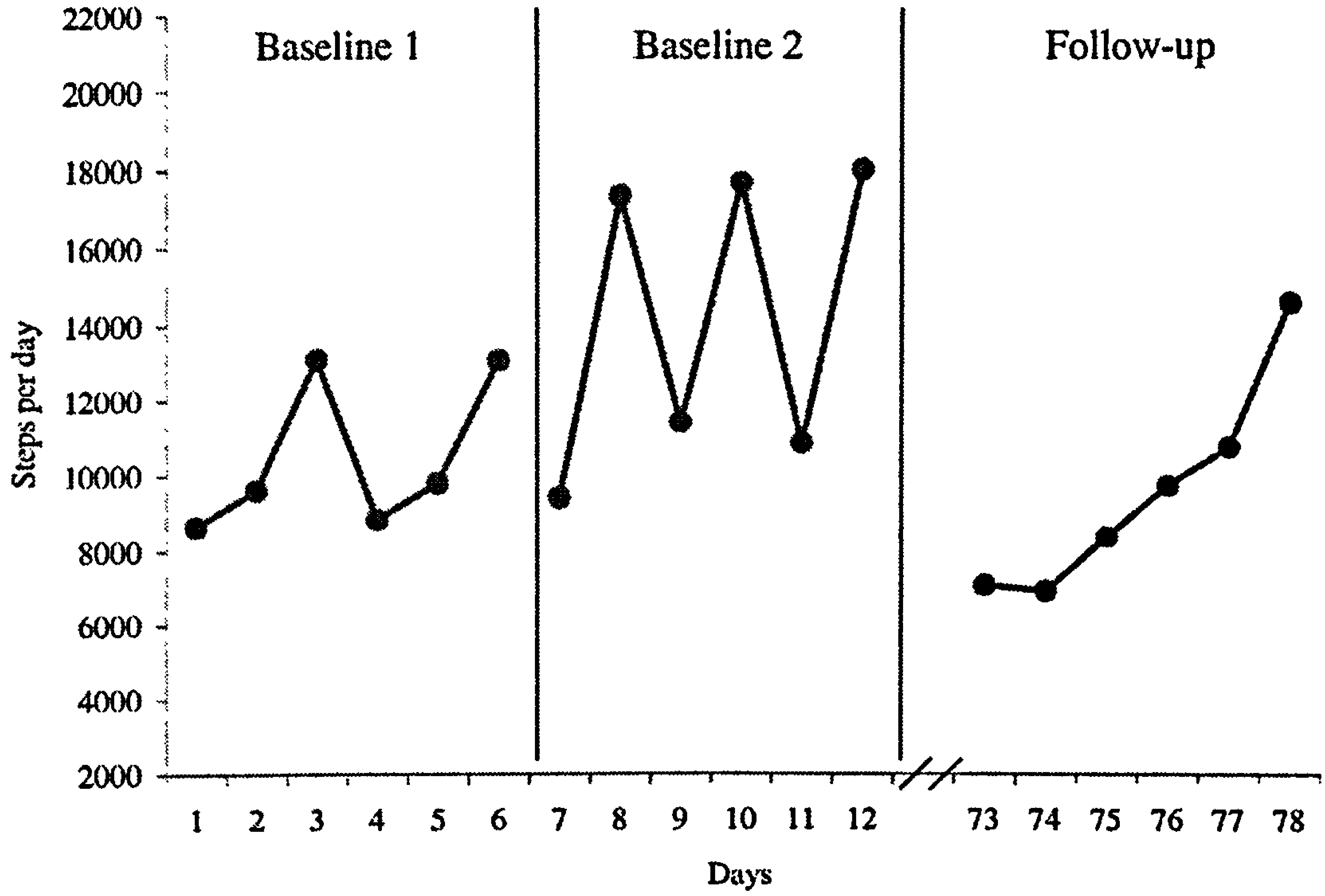

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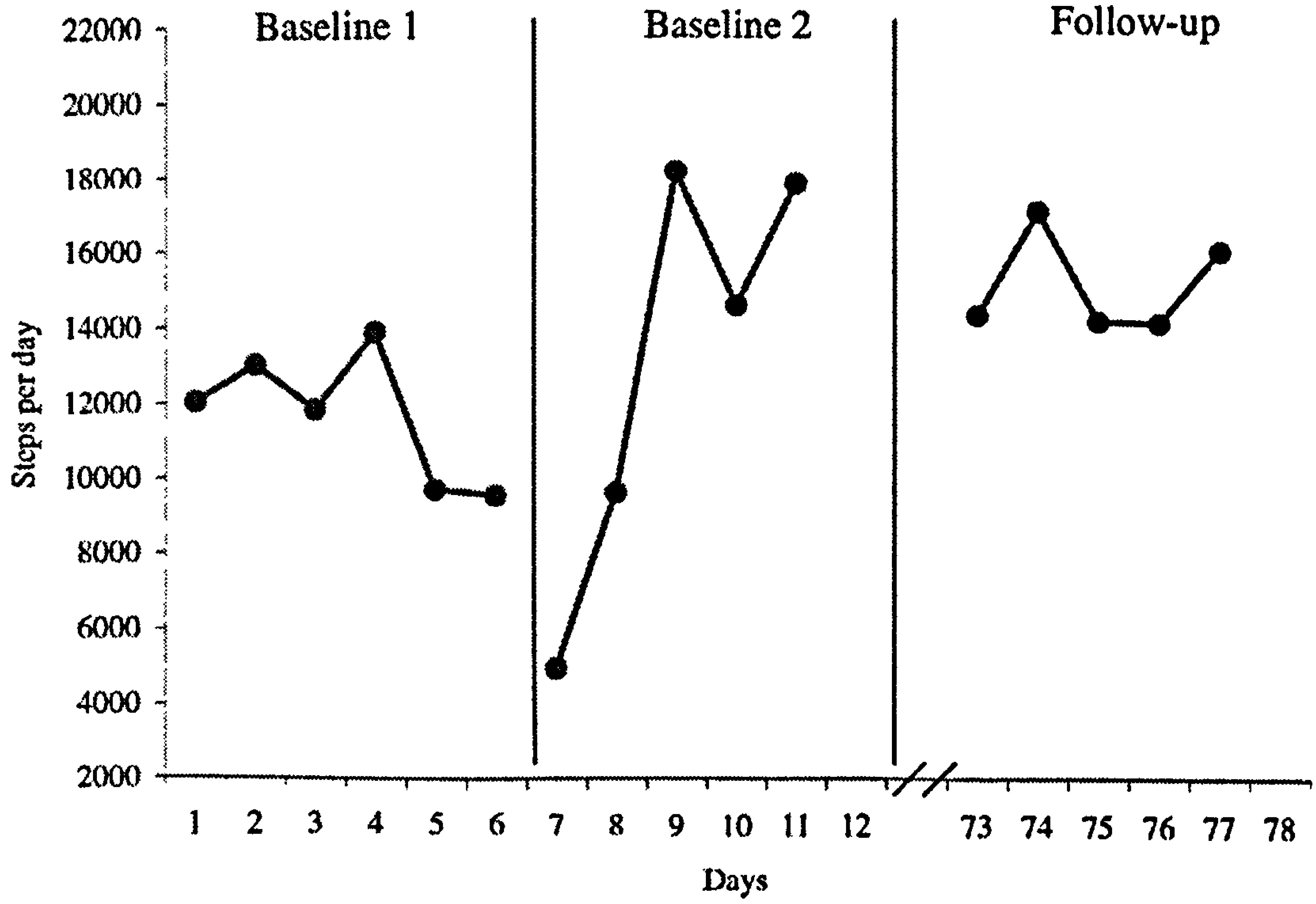

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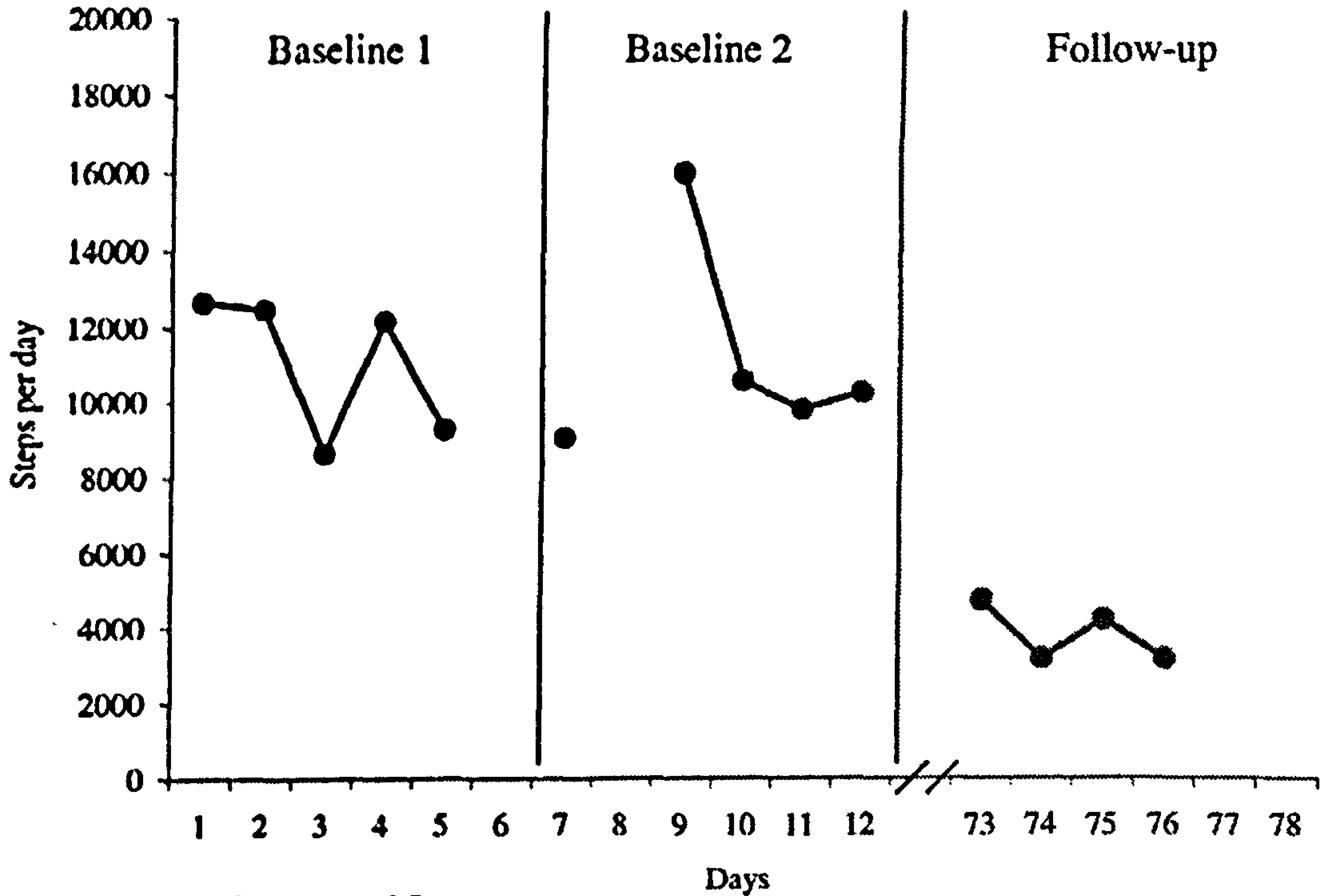

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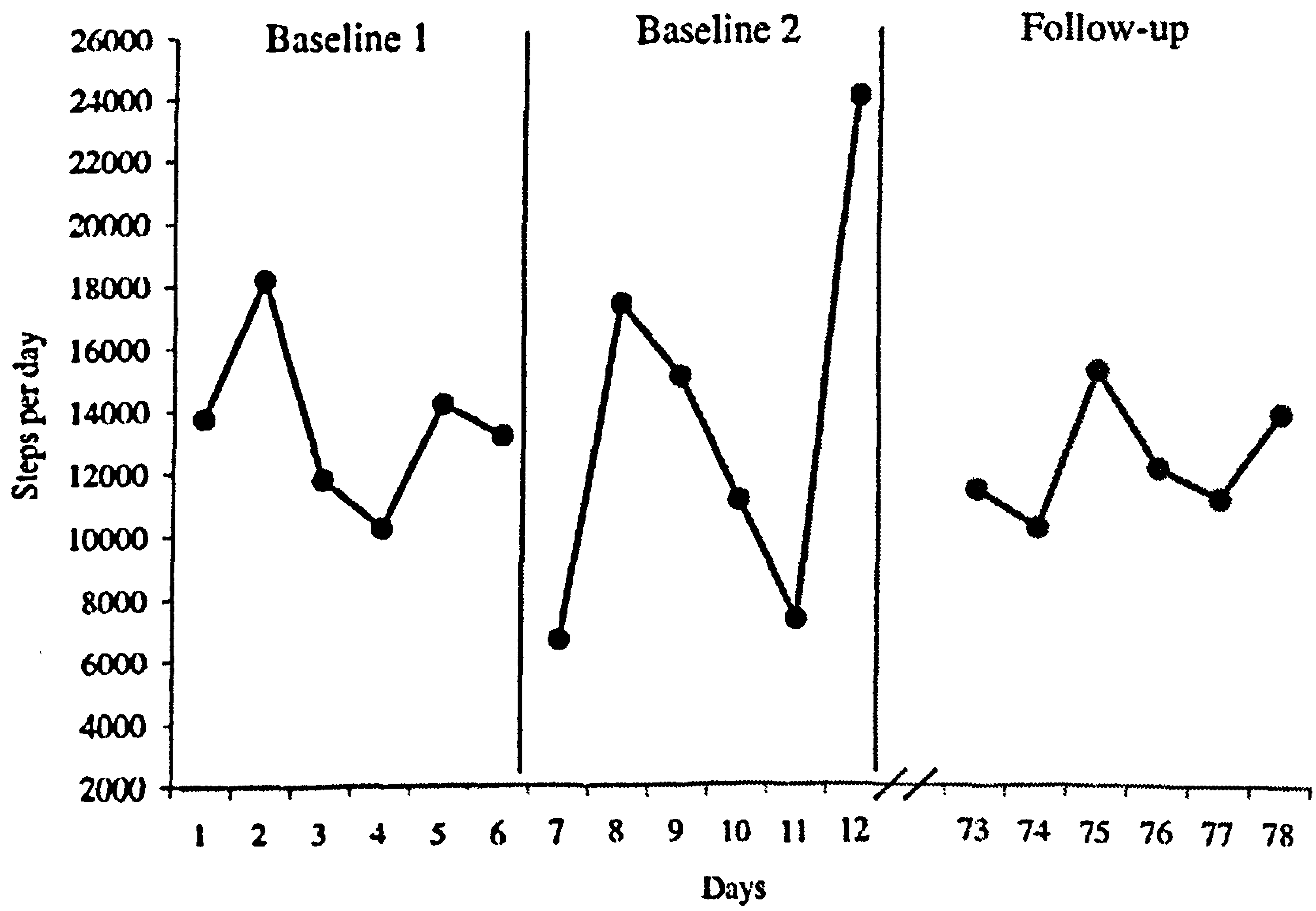

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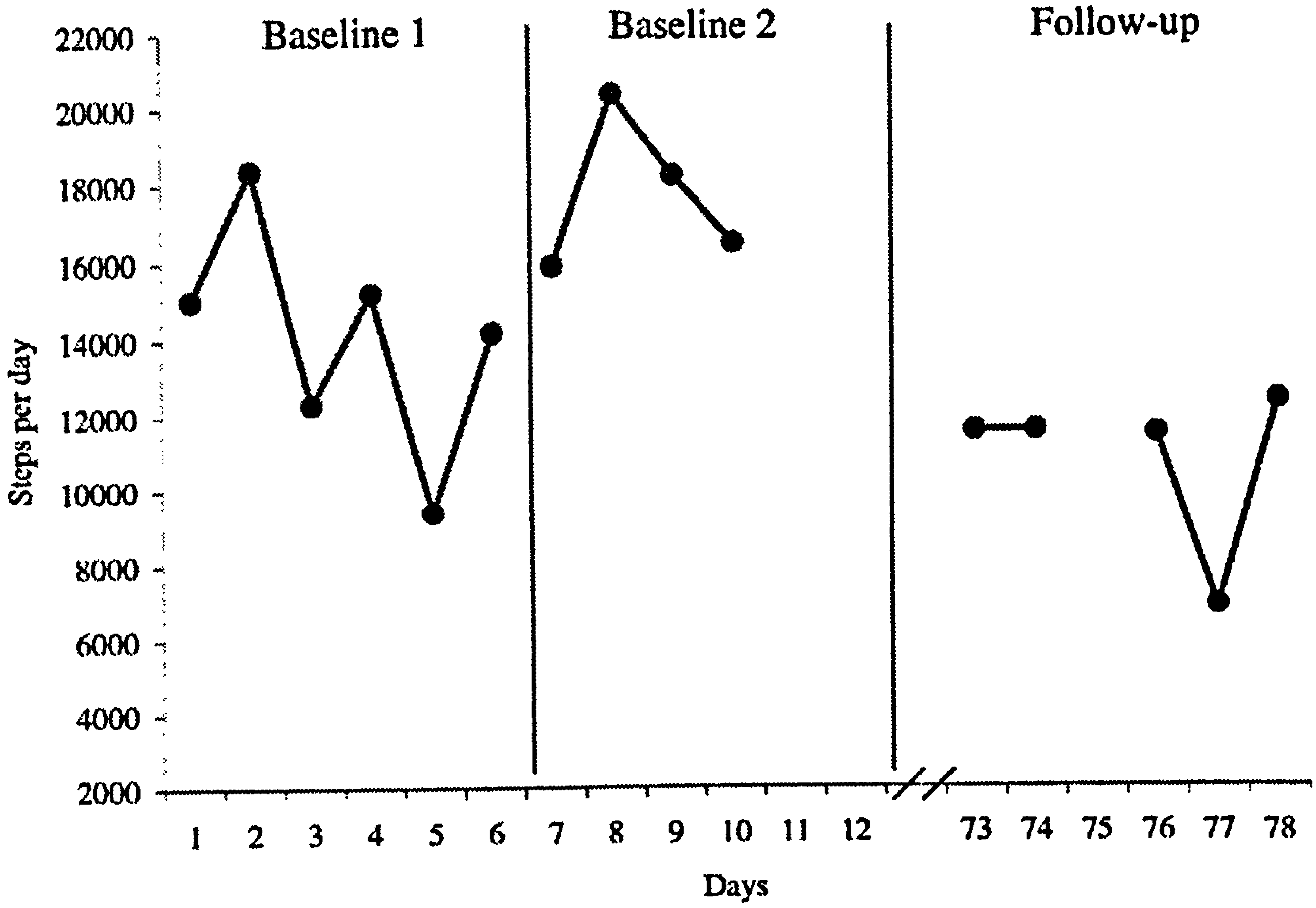

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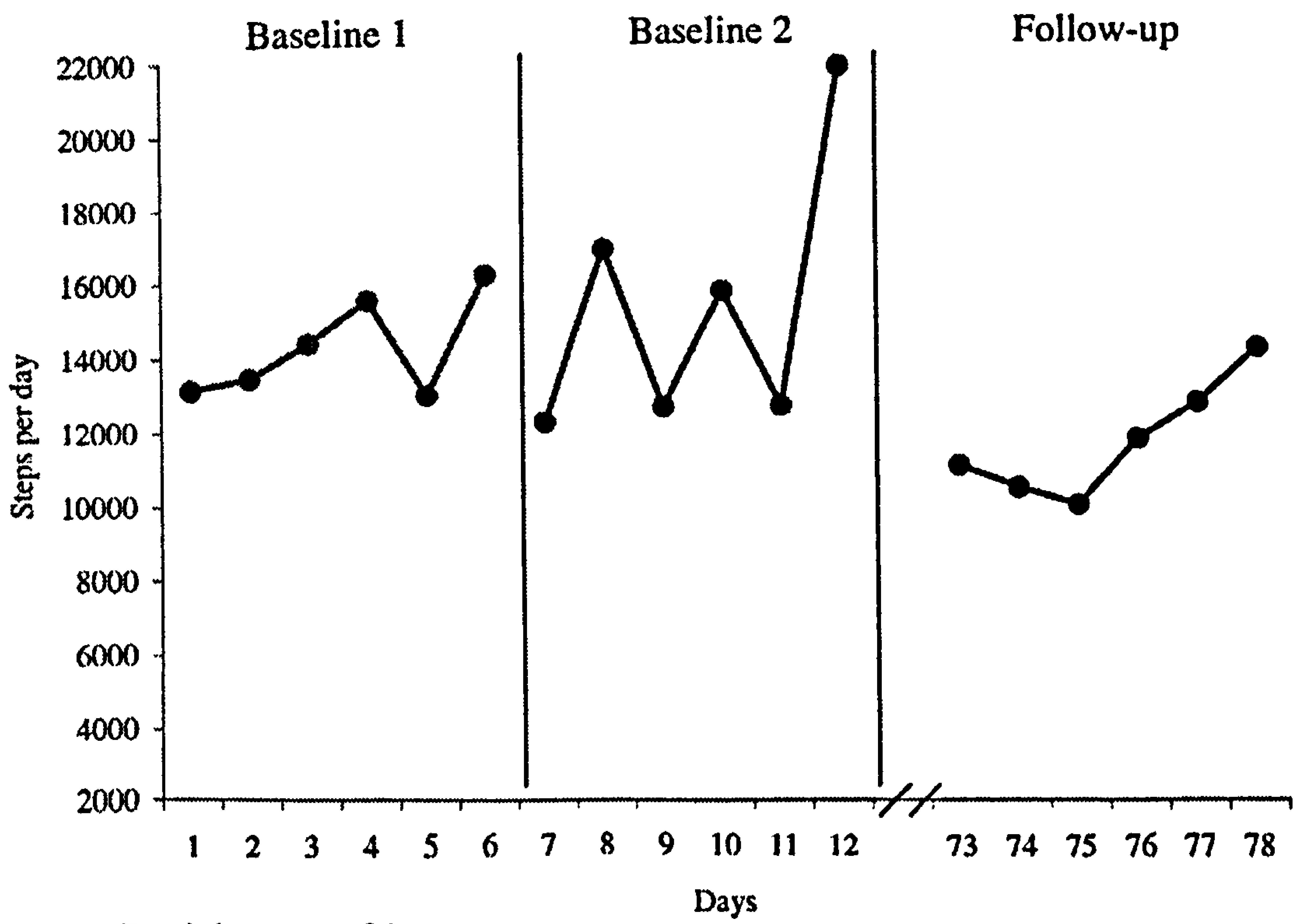

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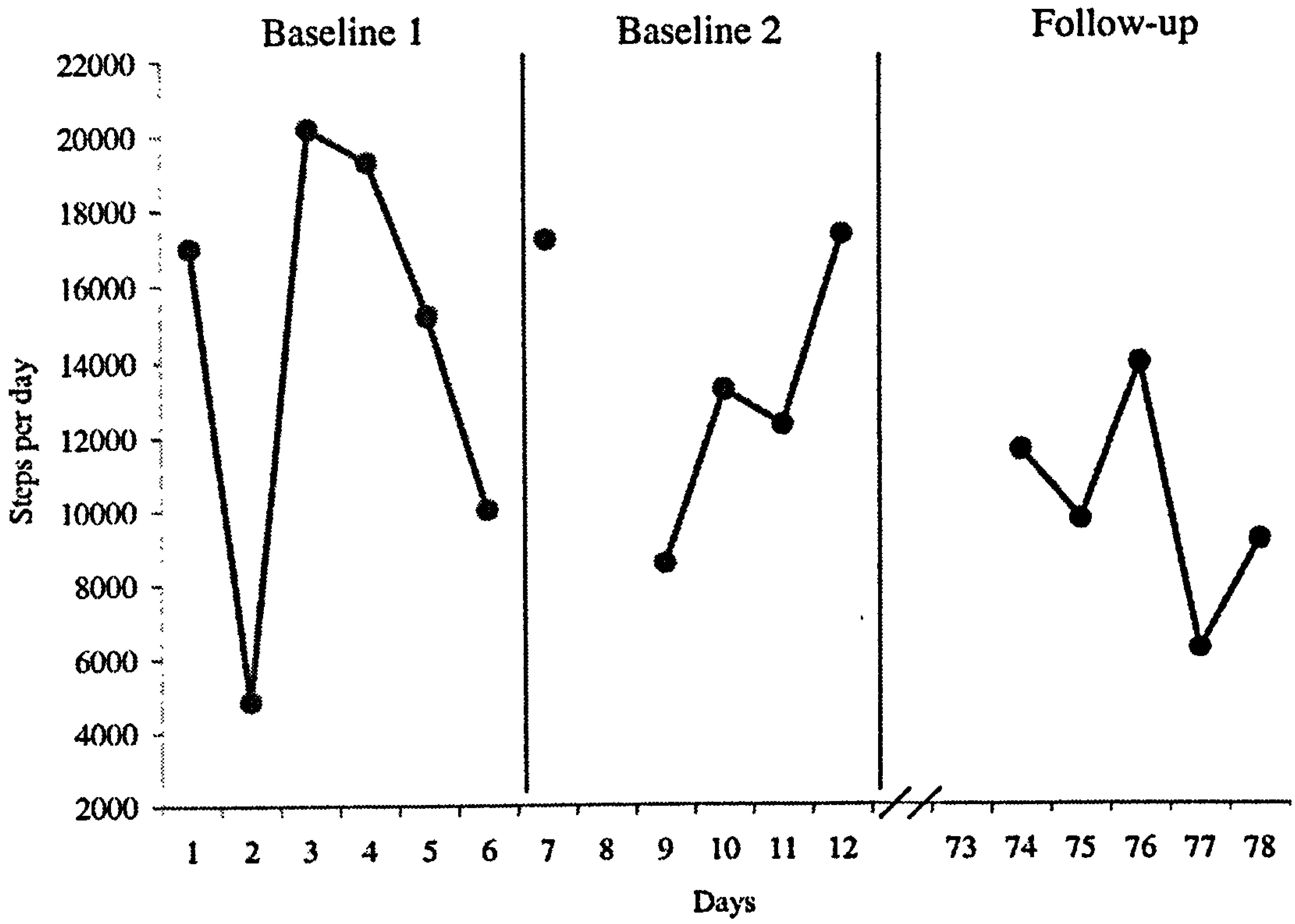

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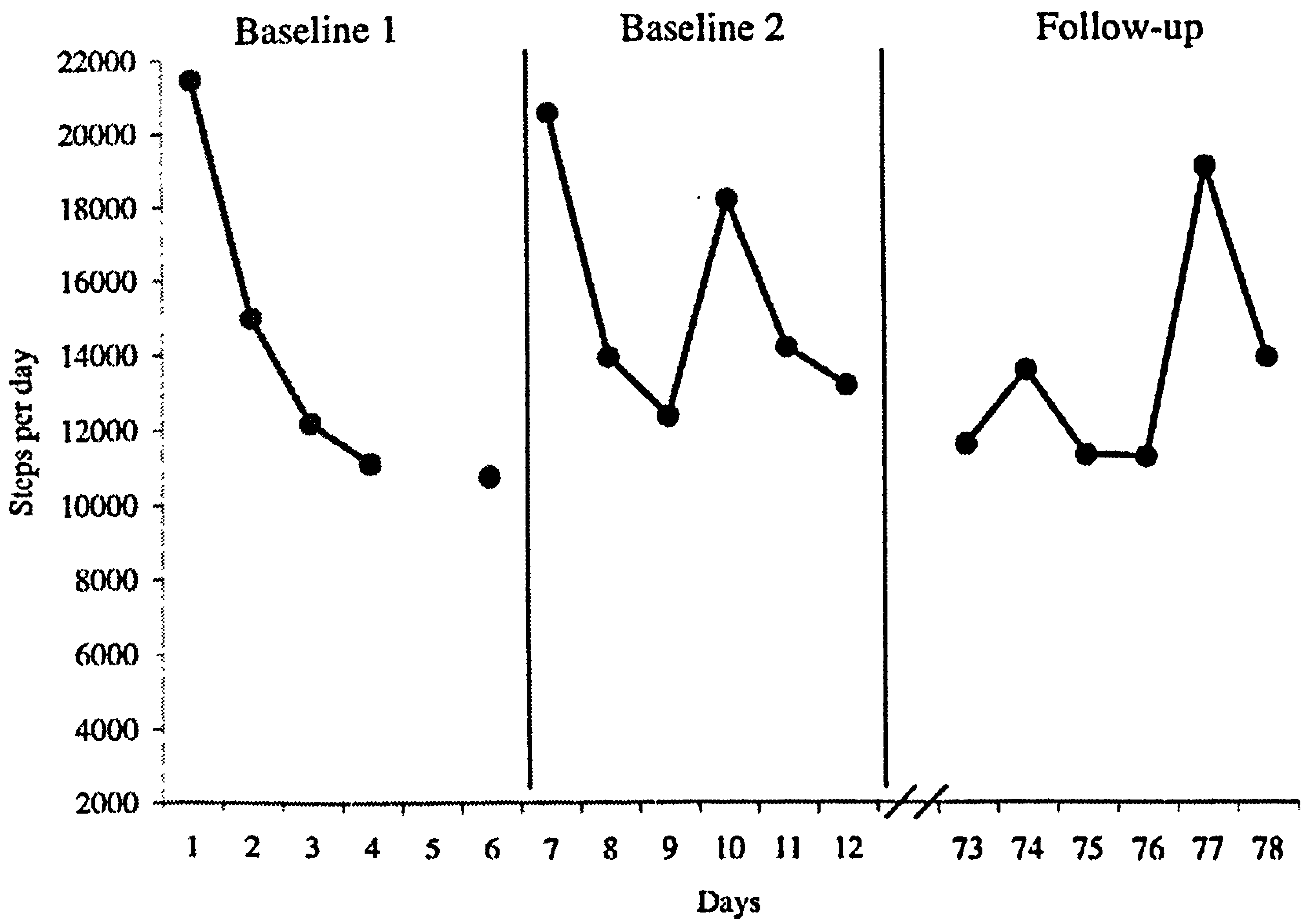

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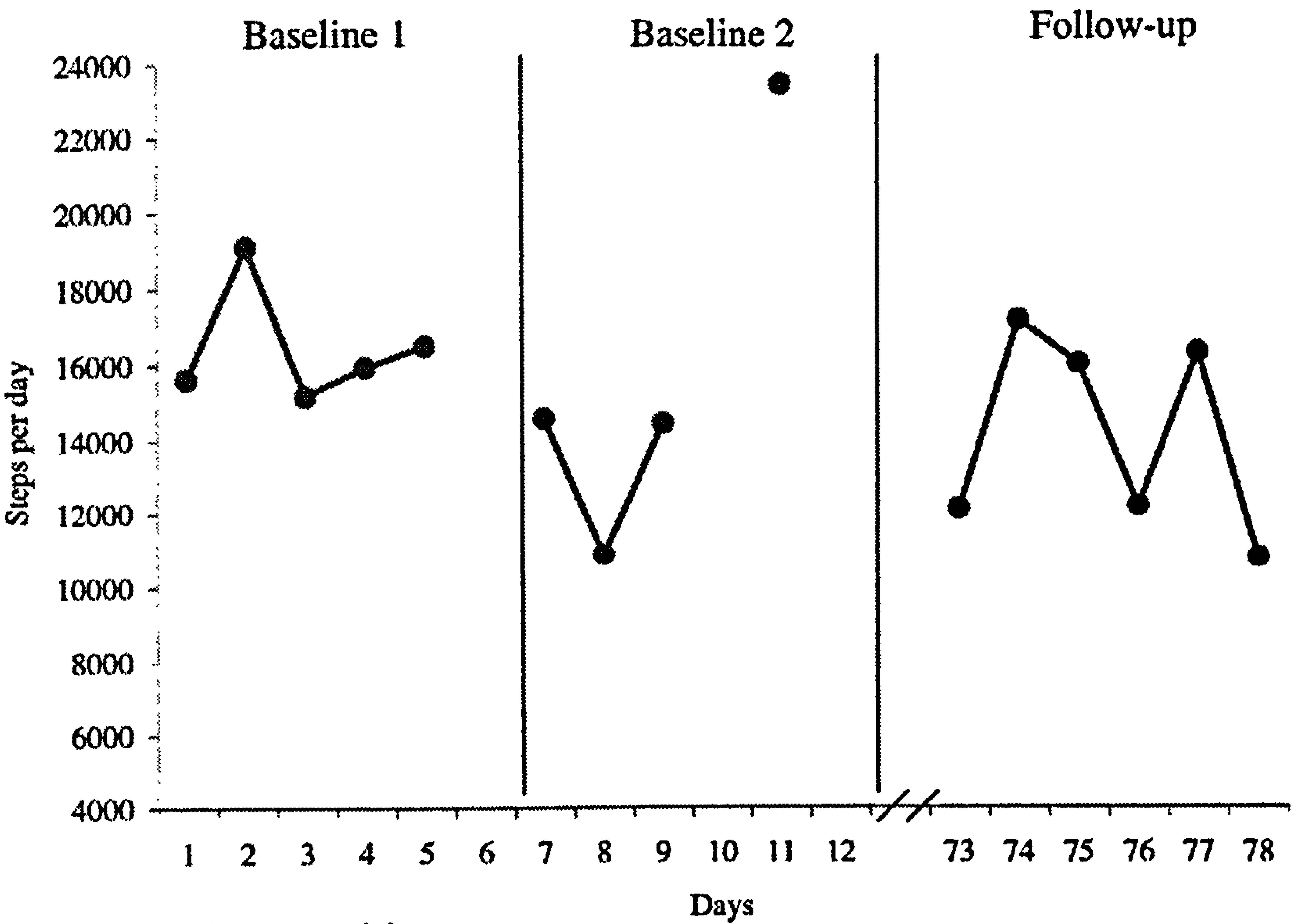

Participant no. 34

APPENDIX D11: Parental Quotes

The individual participant number of the child is shown in parentheses following each quotation.

Experimental Parents ($n = 10$)

3. Do you feel that your child has benefited from taking part in the Fit n' Fun Dudes project? If you answered yes, please say how you think your child has benefited.

"It has made Emily think about exercise and how important it is in everyday life, that walking is good for her" (7).

"Raised her awareness of the benefit of regular exercise. Also, exercise can be fun and enjoyable" (8).

"It has made her more active" (9).

"Stephanie has become more aware of how much exercise she has to participate in daily to be of benefit to her fitness and health" (10).

"More aware of need for activity which in turn has increased her general fitness" (13).

"It has made her aware of how much walking she should be doing" (14).

"Certainly made them compete against each other to see who could do the most therefore done more physical activity during the day" (17/18).

"Importance of and how to keep fit" (19).

"Has made Bethan more aware of the importance of exercise/physical activity. More aware of health issues" (21).

4. Do you feel that you have benefited from taking part in the Fit n' Fun Dudes project? If you answered yes, please say how you think you have benefited.

"I have realised that by being busy all day at work does not mean that I get enough exercise" (7).

"This has assisted in lowering my blood pressure and ensured I took daily regular exercise. The raising of the target was particularly beneficial and has improved my figure!" (8).

"It has made me take more walks than I would have done and I feel fitter for it" (9).

"It has made me more aware of how much I do exercise and move about during the day" (10).

"It has also made me more aware of my activeness (or lack of!) which in turn has encouraged me to make the effort to get fitter" (13).

"I am also now aware of how much walking I should be doing" (14).

"Made me want to reach my target therefore on some days would do a bit more to achieve this" (17/18).

"The data collected was interesting in itself, and in particular the contribution of particular activities towards the total number of steps attained and general fitness" (19).

"Made me more aware of how comparatively few steps I do in a day when I am working in the office as opposed to a day working on the ward. Also, I try to run 3 times a week and the project has encouraged me to continue" (21).

8. Do you have any other comments you would like to make about the Fit n' Fun Dudes project?

"Charlotte kept us both well informed without applying any pressure to participate. Initially I thought the programme would be difficult to complete, however, wearing the pedometer all day soon became second nature. In fact, when it was not there I felt something was missing. This programme should be recommended to the government as a means to improve adult health/fitness. A very cheap way to reduce the NHS budget" (8).

"Very good study and nice and easy to follow. Great way to approach awareness of the importance of exercise and fitness. Well done" (10).

"If the Fit n' Fun Dudes are aimed at near-teen girls, then I think they need to be a bit more grown up. Sophie didn't use the CD (although the prizes were a very good idea!). Perhaps an 'activity for the day' might be an idea i.e., to skip as much as possible, or hop, dance, etc to see which used more steps" (13).

"We would be happy to take part in any future projects" (14).

"Any feedback with regard individual performance and physical activity would be gratefully received. I would be interested in receiving a synopsis of the findings of the study if deemed appropriate" (19).

"Nicola and I weren't able to take part as well as we should have during the school summer holidays due to moving house, illness etc. I think we would have enjoyed it more without all these things going on" (20).

"I enjoyed taking part in the project and feel it has been of benefit to both Bethan and myself. We will continue to use our pedometers to monitor our physical activity – especially now that the winter months are here, to try to keep motivated!" (21).

Control Parents (n = 13)

3. Do you feel that your child has benefited from taking part in the research project? If you answered yes, please say how you think your child has benefited.

"Because she realises the importance of exercise and can see the exact amount of exercise she has done. Gives a goal to work towards" (1).

"Takes interest in her fitness" (2).

"Made her aware of keeping fit" (5).

"Has thought what exercise she needs" (6).

"Because she was taking part in the project she was more aware of the importance of exercise and walking" (23).

"Something interesting to do, a sense of responsibility, something to share with friends and a raised awareness of the need to exercise" (27).

"Increased awareness re exercising/keeping healthy" (31).

"Making more of an effort to be active! Natascha has always loved being outside playing with friends, sports etc, she can now see exactly how active she is being by wearing a pedometer, even though she hasn't seen the results, it has made her more aware" (33).

4. Do you feel that you have benefited from taking part in the research project? If you answered yes, please say how you think you have benefited.

"Recognising how little exercise I do. Fitness plan prepared and will work hard to get out of the house" (1)

"I'm aware of how many steps I've done in a day" (2).

"Makes you aware of how much you walk in a day" (5).

"Made aware that I need to start thinking about getting fit (ie) join gym" (6).

"I was very aware that I was wearing the pedometer and therefore felt obliged to go out and walk rather than to sit and read" (23).

"I could monitor the number of steps which I took daily. I thought I would have more steps taken at weekends but the monitor indicated not" (24).

"Something to share with my daughter. A reminder of how inactive I am at work" (27).

"Measurement of activity level very informative" (31).

"Like Natascha, being more aware of activity, although of course I could see activity level on pedometer every day, it shocked me to see how much inactivity I do" (33).

8. Do you have any other comments you would like to make about the research project?

"I think that these kind of projects are important especially now that kids are getting better nutrition so that they don't have problems later in life" (6).

"It's a shame that more parents and children from the school don't take part in the project" (23).

"I'm told that other children looked at their pedometers and took actions to increase the steps on them if they felt they had not taken enough exercise, which may have an effect on the data gathered" (25).

"Seems a very useful project. Certainly a good reminder to myself to be more active – even though I thought I was – and a useful way for me to encourage my daughter to maintain her level of activity" (27).