



## **The Impact of Living in a Bio-Secure Bubble on Mental Health: An Examination in Elite Cricket**

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4 **The Impact of Living in a Bio-Secure Bubble on Mental Health: An Examination in Elite Cricket**

5

1 **Abstract**

2 The COVID-19 pandemic has had a profound impact on many people's lives, including the use of bio-  
3 secure environments to facilitate the continuation of professional sport. Although it is well  
4 documented that the pandemic has negatively impacted mental health, the impact of bio-bubbles  
5 on mental health is yet to be investigated. In the present study we sought to identify the impact of  
6 bio-bubbles on the mental health of those residing within, and then to explore the underlying  
7 mechanism of any such impact. Individuals ( $n = 68$ ) who resided in England and Wales Cricket Board  
8 (ECB) created bio-bubbles between March 2020 and April 2021 provided data, regarding their time  
9 inside and outside of bio-bubbles, on measures of mental health and basic psychological need  
10 satisfaction and frustration. Analysis revealed that bio-bubbles increased anxiety and depression and  
11 reduced wellbeing. Additionally, MEMORE mediation analyses revealed that autonomy frustration  
12 mediated the relationship between bubble status and all mental health markers. Furthermore,  
13 compared to men, women were more likely to experience elevated levels of anxiety and depression  
14 inside the bubble. The findings suggest that bio-bubbles negatively impact mental health and further  
15 suggest that satisfaction and frustration of basic psychological needs is a contributing factor.  
16 Findings suggest organizations tasked with creating bio-bubbles would do well to tailor their  
17 environment with an awareness of the importance of basic psychological needs and sex differences  
18 in relation to mental health. To the best of our knowledge, this research represents the first  
19 investigation of the impact of bio-bubbles on mental health.

20

21 *Keywords:* anxiety, depression, wellbeing, basic psychological needs, sex differences

## 1 The Impact of Living in a Bio-Secure Bubble on Mental Health: An Examination in Elite Cricket

2 As a consequence of COVID-19, many countries around the world entered into lockdown  
3 during 2020. To allow international cricket fixtures to be played during the pandemic and within  
4 consequent restrictions, the England and Wales Cricket Board (ECB) created bio-secure bubbles  
5 (hereafter *bio-bubbles*); the first to be created in sport. Many other sports subsequently adopted  
6 similar environments to enable the continuation of competition. People entered the ECB bio-bubbles  
7 after testing and completing a quarantine period to ensure that they were not carrying COVID-19  
8 and they then remained inside the bubble without physical contact with the “outside world”. For  
9 such bubbles to be effective, players, support staff, officials, and events management were all  
10 required to remain within the bio-bubble throughout the event. Friends and family were not  
11 permitted within the bubble and individuals were not able to leave without going through a  
12 ‘bridging’ process (quarantine period and testing) before re-entry. Given these restrictions, in  
13 addition to the other pressures of elite sport (Woodman & Hardy, 2001), there was the potential for  
14 bubble inhabitants’ wellbeing to be detrimentally affected. This research is an investigation of the  
15 impact of such an environment on mental health. Specifically, we provide the first exploration of  
16 how life in bio-bubbles influences mental health with a concomitant examination of potential  
17 mechanisms. We also explore sex differences in mental health markers in the ECB bubbles.

18 Early research suggested that COVID-19 could negatively impact mental health on a global  
19 scale (Torales et al., 2020); a prediction that has since been confirmed, with COVID-related  
20 estimated prevalence rates of mental health issues significantly higher than pre-COVID norms  
21 (Nochaiwong et al., 2021). For example, in the UK, anxiety and depression levels increased from pre-  
22 COVID norms (Jia et al., 2020) whilst subjective wellbeing decreased (Kwong et al., 2021). Although  
23 increases in anxiety and depression were observed in both men and women, symptoms were higher  
24 for women than for men during the first lockdown (Fancourt et al., 2020).

25 **Within sport, early concerns regarding the impact of COVID-19 on athlete mental health**  
26 **(Reardon, Bindra et al., 2021) have been actualized across many studies. Depression (Pillay et al.,**

1 2020), anxiety (Chandler et al., 2021), and sleep disruption (Chandler et al., 2021) all increased.  
2 Research has also looked beyond prevalence. Facer-Childs et al. (2021) suggested that changes to  
3 athlete sleep patterns were a cause of increased depression and anxiety levels, and Pensgaard et al.  
4 (2021) evidenced that financial concerns caused by the pandemic contributed to increases in anxiety  
5 and depression. Given the initial evidence that the pandemic negatively affected mental health for  
6 those in sport, and that bio-bubbles were being proposed as a solution, the current study looked to  
7 investigate the specific impact that these unique environments would have on resident wellbeing.

8 Research suggests that bio-bubbles would negatively impact mental health. For example,  
9 quarantine and isolation are known to negatively impact mental health (Henssler et al., 2021).  
10 Additionally, living in a bio-bubble for an extended period of time where close family and friends are  
11 not permitted could potentially cause loneliness, which can contribute to a range of health problems  
12 such as the development of depressive symptoms (Cacioppo et al., 2010), anxiety (Hawkey &  
13 Cacioppo, 2010), alcoholism, and aggressive behavior (Cacioppo et al., 2015). Moreover, the many  
14 restrictions on day-to-day life likely results in individuals experiencing low levels of autonomy, which  
15 has been identified within the prison setting as contributing to poor mental health (Awofeso, 2010).  
16 Whilst we are not suggesting bio-bubbles are like prisons, the social distancing, isolation, and  
17 restricted movement invite comparisons. Consequently, the possibility that bio-bubbles cause  
18 loneliness, social isolation, and reduced autonomy leads bubbles to have the potential to exert a  
19 significant negative impact on mental health.

20 With the aforementioned issues in mind, in this study we examined how mental health is  
21 impacted by residing in a bio-bubble. We focused on anxiety, depression, and subjective wellbeing  
22 as measures of mental health. Measuring anxiety and depression allowed us to quantify the  
23 prevalence of two common mental health problems in a new environment which was being  
24 proposed as the solution to the continuation of elite sport during the pandemic. Additionally,  
25 focusing on these aspects allowed us to add to the aforementioned research regarding the mental  
26 health of athletes during COVID-19, which has largely focused on anxiety and depression. Further, as

1 mental health is not merely the absence of mental illness (Westerhof & Keyes, 2010), measuring  
2 subjective wellbeing also provides insight into mental health. Due to the multitude of reasons that  
3 bio-bubbles might negatively impact mental health and a scarcity of evidence suggesting anything  
4 otherwise, we hypothesized that being within bio-bubbles would increase anxiety and depression  
5 symptoms and reduce wellbeing.

### 6 **Basic Psychological Needs and their Impact on Mental Health**

7 A cornerstone of Self Determination Theory (SDT; Deci & Ryan, 2000; Ryan & Deci, 2000) is  
8 that the satisfaction of three basic psychological needs (BPN; autonomy, competence, relatedness) is  
9 a *sine qua non* of human thriving (Deci & Ryan, 2000). Conversely, the frustration of these BPN  
10 results in maladaptive functioning (Vansteenkiste & Ryan, 2013). For example, whilst the experience  
11 of connection and intimacy with others satisfies the need for relatedness (Ryan, 1995), need  
12 frustration refers to instances where these needs are actively thwarted (Chen et al., 2015). Thus, a  
13 lack of intimacy would be regarded as low need fulfilment whilst feelings of loneliness or relational  
14 exclusion would be regarded as the need being frustrated (Chen et al., 2015).

15 Contextualizing satisfaction and frustration of BPN in the prediction of mental health, Chen  
16 et al. (2015) found that BPN satisfaction exclusively predicted subjective wellbeing whilst BPN  
17 frustration predicted immediate ill-being. Studies have previously revealed a relationship between  
18 BPN frustration and mental health in athletes (Bartholomew et al., 2011) and have also shown that  
19 long-term thwarting leads to the development of maladaptive behaviors, such as alcohol use, which  
20 in turn contributes to ill-being (Vansteenkiste & Ryan, 2013).

21 Given that part of the impact of bio-bubbles on mental health is likely to be the forced  
22 separation from close family and a lack of control over actions, thwarting of BPN is likely to act as a  
23 mechanism for the effect of bio-bubbles on mental illness. Additionally, aligning with the findings of  
24 Chen et al. (2015), changes in wellbeing are likely attributable to BPN satisfaction. Consequently, we  
25 hypothesized that BPN satisfaction would mediate the negative relationship between being in a bio-

1 bubble and subjective wellbeing and that BPN frustration would mediate the positive relationship  
2 between being in a bio-bubble and anxiety and depression.

### 3 **Sex Differences**

4 A pre-COVID investigation of mental health in the UK (McManus et al., 2016) found that  
5 symptoms of common mental disorders (CMD), including but not exclusively referring to depression  
6 and anxiety, were more prevalent for women (19.1%) than for men (12.2%). Women are twice as  
7 likely as men to suffer from anxiety or depression as an affective disorder (Altemus et al., 2014) and  
8 are more likely to experience anxiety and depression at a sub-clinical level (Hankin, 2009). **During the**  
9 **COVID-19 pandemic, research revealed that lockdown measures magnified women's greater**  
10 **susceptibility to mental health problems (see Kwong et al., 2021). This aligns with research**  
11 **conducted prior to the pandemic regarding the effects of quarantining in hospital.** Specifically, whilst  
12 quarantined, women were at greater risk of suffering from depression and were more likely to  
13 experience general mental health impairments (Henssler et al., 2021). As such, women may be more  
14 affected than men by bio-bubbles.

15 In summary, the aim of this study was to investigate whether bio-bubbles have a negative  
16 impact on mental health. Based on research conducted in similar environments (hospitals, prisons)  
17 and our predictions regarding BPN, we hypothesized that anxiety and depression would increase  
18 inside the bubble and that wellbeing would decrease inside the bubble. Following Chen et al. (2015),  
19 we also hypothesized that the frustration of autonomy, competence, and relatedness would  
20 mediate the relationship between bubble status (in or out) and anxiety/depression, and that the  
21 satisfaction of autonomy, competence, and relatedness would mediate the relationship between  
22 bubble status and wellbeing. Finally, we hypothesized that sex would moderate the relationship  
23 between bubble status and anxiety, depression, and wellbeing. Specifically, given that women are  
24 more likely than men to experience psychological impairments when quarantined (Henssler et al.,  
25 2021), we hypothesized that women would have significantly higher anxiety and depression and  
26 significantly lower wellbeing inside the bubble.

## 1 **Method**

### 2 **Participants**

3 The sample size was governed by resource constraints (cf. Lakens, 2021). Specifically, the  
4 applied implications of possible findings meant completing this research in a timely manner was of  
5 importance and prolonging the data gathering period to possibly increase sample sizes was not  
6 possible. Additionally, the population from which a sample could be gathered was relatively small.  
7 Individuals were eligible if they had spent time in at least one of the bio-bubbles associated with the  
8 England and Wales Cricket Board (ECB) between March 2020 and April 2021 and were 18 years old  
9 or older. Only individuals whose contact information was held by the ECB were invited to  
10 participate. Sixty-eight participants ( $M_{\text{age}} = 37.88$ ,  $SD = 10.52$ ; men = 36, women = 31, undisclosed =  
11 1) out of a possible 148 completed the survey. The sample comprised players ( $n = 19$ ), coaches ( $n =$   
12 11), medical staff ( $n = 11$ ), other team-specific staff ( $n = 9$ ), events management ( $n = 8$ ), umpires ( $n =$   
13 6), media (not team-specific;  $n = 2$ ), and other ECB staff members ( $n = 2$ ). Suitable *a-priori* power  
14 analysis conducted for each of our proposed analyses indicated a minimal sample size of 53 was  
15 required. In all power analyses, power was set at 0.80 and alpha set at 0.05. An effect size of 0.5 was  
16 used in the power analysis concerning *t*-tests and repeated measures MANOVA. For mediation  
17 analysis, an effect size of 0.59 was used for both the  $\alpha$  and  $\beta$  path, as per Fritz and MacKinnon's  
18 (2007) empirical estimates of sample size guide. This effect size aligns with the research findings of  
19 Šakan et al. (2020).

### 20 **Measures**

#### 21 **Anxiety**

22 We used the Generalized Anxiety Disorder Scale (GAD-7; Spitzer et al., 2006) to assess anxiety.  
23 Initially designed to screen for generalized anxiety disorder (GAD), the GAD-7 has also been  
24 identified as capable of identifying panic disorders, post-traumatic stress disorder, and social anxiety  
25 (Löwe et al., 2008). The GAD-7 has been evidenced to be effective within general and clinical



1 populations (Löwe et al., 2008) and is also widely used in sport (Reardon, Gorczynski et al., 2021).

2 The GAD-7 uses a four-point Likert scale ranging from 0 (*not at all*) to 3 (*nearly every day*).

### 3 ***Depression***

4 We used the Patient Health Questionnaire (PHQ-9; Kroenke et al., 2001) to assess  
5 depression. The PHQ-9 is a 9-item scale that can be used to establish a provisional depressive  
6 disorder diagnosis as well as to assess the severity of depressive symptoms (Kroenke & Spitzer,  
7 2002). The PHQ-9 is regarded as a reliable and valid unidimensional measure of depression within  
8 the general population (Kocalevent et al., 2013). Items are rated on a four-point Likert scale ranging  
9 from 0 (*not at all*) to 3 (*nearly every day*).

### 10 ***Wellbeing***

11 To measure wellbeing, we used the 5-item World Health Organization Index (WHO-5; World  
12 Health Organization, 1998), which is a single-factor scale (de Wit et al., 2007) that has been used  
13 extensively in a variety of domains due to its straightforward language and administration (Topp et  
14 al., 2015). The five items are positively worded on a scale of 0 (*at no time*) to 5 (*all of the time*).

15 Alpha coefficients for the PHQ-9, GAD-7, and WHO-5 can be found in Table 1.

### 16 ***Basic Psychological Need Satisfaction and Frustration***

17 To measure basic psychological needs satisfaction and frustration, we used an abbreviated  
18 version of the Basic Psychological Need Satisfaction and Frustration Scale (BPNSFS; Chen et al.,  
19 2015). The original six-factor model distinguishes between satisfaction and frustration of autonomy,  
20 competence, and relatedness, and has been validated across cultures (Chen et al., 2015).

21 In this study, we reduced each construct from four items to two. Minimizing the time  
22 commitment to complete the survey was an important ethical consideration. From a return-on-  
23 investment perspective, minimizing the length of questionnaires where possible in applied research  
24 is better for the participant, and most often does not diminish the psychometric integrity of the scale  
25 (Horvath & Röthlin, 2018). We chose item pairs taking into account Horvath and Röthlin's (2018)  
26 criteria for reducing questionnaires. Specifically, we made sure the items we chose still represented

1 the concepts that we were measuring and we ensured that the items were easy to understand and  
2 applicable to the unique setting of a bio-bubble. We used a combination of conceptual relevance  
3 and factor loadings from the original paper in making decisions about which items to use (item pairs  
4 used can be found in Supplementary Table 1). We chose not to analyze the internal reliability of the  
5 BPNSFS using Cronbach's alpha, as this method is not well suited when using item pairs (Gosling et  
6 al., 2003). Instead, we adopted a similar method to that of Rammstedt and John (2007) and analyzed  
7 the factor structure of the shortened BPNSFS to determine whether our item pairs represented the  
8 full questionnaire from which they were derived (see Rammstedt & John, 2007). Confirmatory Factor  
9 Analysis (CFA) confirmed that the item pairs for basic psychological need satisfaction and frustration  
10 had the same factor structure as the BPNSFS. We obtained substantial mean loadings on the  
11 intended factor (mean loading = .73) and negligible loadings on each of the five unintended factors  
12 (loadings less than .19). All items were scored on a five-point Likert scale from 1 (*completely untrue*)  
13 to 5 (*completely true*).

#### 14 **Procedure**

15 Following institutional ethical approval, prospective participants were invited via email to  
16 complete an online survey (Qualtrics, 2011). The survey was disseminated on February 12<sup>th</sup> 2021 and  
17 available for completion until April 14<sup>th</sup> 2021. **The time between a person residing within a bubble  
18 and their taking the survey varied across participants. Specifically, 30 participants reported spending  
19 time in bio-bubbles only in the UK during the summer of 2020, 38 participants were in later bubbles  
20 (tours abroad during the UK winter), or completed the survey whilst in a bio-bubble. Participants  
21 who had experienced multiple bubbles (27 participants were in the UK summer bubbles and part of  
22 various touring parties abroad during the 2020-2021 winter) were asked to aggregate their  
23 responses (see below for more detail).**

24 After providing informed consent and their *mental health code* (see Referral section for  
25 more details of this code), participants completed a series of demographic questions regarding age,  
26 sex, team within the bubble, ethnicity, relationship status, parental status, longest amount of time

1 spent in a bio-bubble, role in the bubble, bio-bubbles of which they had been part, and whether they  
2 were in a bubble at the time of survey completion. Following the demographics, participants  
3 completed the PHQ-9, the GAD-7, the WHO-5, and a reduced version of the BPNSFS. We changed  
4 the stem to all questionnaires so that individuals were specifically asked about their time inside bio-  
5 bubbles. Following each item, to assess their out-of-bubble experience, individuals were asked to  
6 compare their in-bubble answer to their experience outside of the bubble since the pandemic began  
7 (March 2020). This was done using a five-point Likert scale from *I have experienced this a lot less to I*  
8 *have experienced this a lot more*. For example, for the first item of the PHQ-9, individuals were asked  
9 how often during their time in-the-bubble they had “little interest or pleasure in doing things” and  
10 responded using a four-point Likert scale ranging from *not at all* to *nearly every day*. Immediately  
11 after this Likert scale they were presented with another Likert scale, this time asking them whether  
12 they had experienced “little interest or pleasure doing things” out of the bubble *a lot more, a little*  
13 *more, the same, a little less or a lot less* than they had in-the-bubble (see Supplementary  
14 Information 1 for visual representation of how this was formatted). We deemed **this approach the**  
15 **most efficient method of gathering retrospective data for two conditions. It minimized the time**  
16 **taken to complete the survey, aided memory recall, and actively encouraged comparison between**  
17 **the two conditions. Additionally, when conducting preliminary analysis, this dual Likert scale acted as**  
18 **a form of attention checking (see Results section for more details)**. When completing both the in-  
19 bubble and out-of-bubble portions of an item, participants were instructed to aggregate their  
20 experiences and refer to their total time inside and outside of bubbles, respectively. This aggregation  
21 meant it did not matter whether people were inside or outside of a bubble when completing the  
22 survey (which was varied) and allowed us to include past bubbles within our research.

23 We used this comparison process to create out-of-bubble scores for each individual for  
24 every item. For example, if a participant scored 3 for the in-bubble response to a particular item, and  
25 then answered the out-of-bubble item with *I have experienced this the same*, their out-of-bubble  
26 score for that item would also be 3. However, if they answered, *I have experienced this a little more*,

1 or, *I have experienced this a lot more*, their out of bubble score for that item was scored at 4 or 5,  
2 respectively (i.e., one and two more than their in-bubble score for the item, respectively).  
3 Conversely, if participants answered, *I have experienced this a little less* or *I have experienced this a*  
4 *lot less*, then their out-of-bubble value was scored at 2 and 1, respectively. If it was not possible to  
5 score two points less than their in-bubble score, they scored one point less. If it was not possible to  
6 score one point less (e.g., if the response was *not at all*) then their out-of-bubble score was the same  
7 as their in-bubble score – zero. Scores generated from the comparative out-of-bubble Likert scale  
8 could not be below zero or exceed the maximum limit possibly scored on the item in the original  
9 questionnaire (e.g., the PHQ-9 has a top score of three on each item; see Supplementary  
10 Information 1 for a scoring example).

### 11 **Data Analysis**

12 We used Mplus (Version 8; Muthén & Muthén, 2017) to conduct the previously discussed  
13 CFA. We analyzed all other data using the Statistical Package for the Social Sciences (SPSS, Version  
14 27). Additionally, to test the mediating role of BPN we used the MEMORE macro designed to test  
15 mediation in repeated measures designs (V2.1; Model 1; Montoya & Hayes, 2017). Prior to analysis,  
16 we checked all data for missing values and outliers and examined means and standard deviations for  
17 demographic information. We analyzed Alpha coefficients for the in-bubble scores of the PHQ-9,  
18 GAD-7, and WHO-5. We also conducted paired samples *t*-tests to examine the difference between  
19 in-and-out of bubble scores. As noted, we used the MEMORE macro, designed to test mediation in  
20 repeated measures designs, to test whether basic psychological needs satisfaction or frustration  
21 mediated the relationship between bubble status (out, in) and mental health markers (anxiety,  
22 depression, wellbeing). MEMORE allows the within-participant change in variables (e.g., autonomy  
23 satisfaction) between two conditions (e.g., being inside and outside of a bio-bubble) to be used as a  
24 mediator of within-participant change in an outcome variable (e.g., anxiety), thus enabling  
25 mediation analysis with repeated measures data. For each outcome variable we ran two models,  
26 one containing the BPN satisfaction variables as the mediators and another containing the BPN

1 frustration variables as the mediators. We used 10,000 bootstrap samples to compute 95%  
2 confidence intervals (*CI*). An effect was significant if the *CI* did not encompass zero.

3 We used repeated measures multivariate analysis of variance (MANOVA) to assess whether  
4 sex moderated the relationship between bubble status (in, out) and mental health. Alpha levels of  
5 0.05 were used. 2 x 2 repeated measures analysis of variance (ANOVA) further investigated the  
6 effect for specific mental health markers, with follow-up paired samples Bonferroni-adjusted *t*-tests.

## 7 Referral

8 Although research was the primary aim of this data collection, the study provided an  
9 opportunity to identify individuals who might need support. To make this support process possible,  
10 we pseudo-anonymized participants' data. Specifically, we gave prospective participants a unique  
11 code that they inputted at the beginning of the survey. Only the ECB employee who created the  
12 codes, the same person who distributed the survey, had access to the document linking codes to  
13 individuals. This ECB employee did not have access to the data. If a participant met referral criteria,  
14 an automatic email stating which referral criterion had been met was sent from the survey-hosting  
15 platform to the aforementioned ECB employee who then referred the individual for appropriate  
16 clinical support. Referral criteria and protocol for making a referral were devised by a governance  
17 group (consisting of medical personnel and mental health professionals), which was established by  
18 the ECB.

## 19 Results

### 20 Data Screening and Preliminary Analysis

21 The out- to in-bubble comparison response provided a form of attention check that we used  
22 to screen the data. For example, we removed participants if they responded to an item in such a way  
23 as to indicate that they had experienced a symptom of mental illness (anxiety or depression) *not at*  
24 *all* whilst inside the bubble, but then claimed that they had experienced this symptom *a little less*  
25 whilst outside the bubble. We removed seven participants who provided invalid responses.

26 Descriptive statistics and Pearson correlations are presented in Table 1.

## 1 **The Impact of Bio-Bubbles**

2 As hypothesized, paired samples *t*-tests revealed that anxiety,  $t(60) = 5.45, p < .001, d = .70$ ,  
3 and depression were significantly higher inside the bubble,  $t(60) = 4.50, p < .001, d = .58$ . Also,  
4 wellbeing was significantly lower inside the bubble,  $t(60) = 3.52, p = .001, d = .45$  (see Table 1).

## 5 **Basic Psychological Needs**

6 To test the hypothesis that basic psychological needs (BPN; autonomy, competence,  
7 relatedness) satisfaction and frustration would mediate the relationship between bubble status (out,  
8 in) and mental health markers (anxiety, depression, wellbeing), we conducted multiple mediation  
9 analyses.

### 10 ***The Effect of Basic Psychological Needs Frustration on the Bubble Status-Anxiety relationship***

11 As depicted in Figure 1.1, there was a significant positive indirect effect of bubble status on  
12 anxiety via autonomy frustration (indirect effect = 1.14,  $SE = .36$ , 95% *CI* [.60, 2.01]). Bubble status  
13 was positively associated with autonomy frustration ( $B = 1.08, SE = .18$ , 95% *CI* [.71, 1.45]), and  
14 autonomy frustration was positively associated with anxiety ( $B = 1.05, SE = .26$ , 95% *CI* [.54, 1.57]).  
15 There was no significant indirect effect of bubble status on anxiety via competence frustration ( $B =$   
16  $.35, SE = .24$ , 95% *CI* [-.07, .84]) or via relatedness frustration ( $B = -.14, SE = .15$ , 95% *CI* [-.47, .15]).  
17 Interestingly, despite the nonsignificant indirect effect via competence frustration, examination of  
18 the separate effects indicated that bubble status was significantly (and positively) associated with  
19 competence frustration ( $B = .43, SE = .14$ , 95% *CI* [.16, .71]) and competence frustration was  
20 significantly (and positively) associated with anxiety ( $B = .81, SE = .37$ , 95% *CI* [.06, 1.55]). Bubble  
21 status was associated with relatedness frustration ( $B = .42, SE = .14$ , 95% *CI* [.14, .69]) but there was  
22 no association between relatedness frustration and anxiety ( $B = -.33, SE = .30$ , 95% *CI* [-.94, .28]). The  
23 separate effects from bubble status to mediator reported in this model are the same for all models  
24 investigating bubble status on outcomes via BPN frustration and so are not reported further. The  
25 direct effect of bubble status on anxiety was significant ( $B = 1.11, SE = .41$ , 95% *CI* [.29, 1.93]).

### 26 ***The Effect of Basic Psychological Needs Frustration on the Bubble Status-Depression relationship***

1           There was a significant positive indirect effect of bubble status on depression via autonomy  
2 frustration (indirect effect = 1.58,  $SE = .51$ , 95%  $CI [.81, 2.82]$ , see Figure 1.2). Examination of the  
3 separate effects revealed a positive association between autonomy frustration and depression ( $B =$   
4  $1.46$ ,  $SE = .36$ , 95%  $CI [.74, 2.18]$ ). There was no significant indirect effect of bubble status on  
5 depression via competence frustration ( $B = .31$ ,  $SE = .27$ , 95%  $CI [-.19, .86]$ ) or via relatedness  
6 frustration ( $B = -.20$ ,  $SE = .20$ , 95%  $CI [-.63, .20]$ ). Separate effects revealed no significant relationship  
7 between competence frustration ( $B = .71$ ,  $SE = .52$ , 95%  $CI [-.33, 1.75]$ ) or relatedness frustration ( $B =$   
8  $-.47$ ,  $SE = .42$ , 95%  $CI [-1.32, .37]$ ) and depression. The direct effect of bubble status on depression  
9 was nonsignificant ( $B = .83$ ,  $SE = .57$ , 95%  $CI [-.32, 1.97]$ ).

#### 10 ***The effect of Basic Psychological Needs Frustration on the Bubble Status-Wellbeing relationship***

11           As depicted in Figure 1.3, there was a significant negative indirect effect of bubble status on  
12 wellbeing via autonomy frustration (indirect effect = -1.35,  $SE = .46$ , 95%  $CI [-2.43, -.63]$ ).  
13 Examination of the separate effects revealed an association between autonomy frustration and  
14 wellbeing ( $B = -1.25$ ,  $SE = .41$ , 95%  $CI [-2.07, -.43]$ ). There was no significant indirect effect for bubble  
15 status on wellbeing via competence frustration ( $B = -.15$ ,  $SE = .29$ , 95%  $CI [-.73, .44]$ ) or for  
16 relatedness frustration ( $B = .33$ ,  $SE = .25$ , 95%  $CI [-.12, .88]$ ). Separate effects revealed no association  
17 between competence frustration ( $B = -.34$ ,  $SE = .59$ , 95%  $CI [-1.53, .85]$ ) or relatedness frustration ( $B$   
18  $= .80$ ,  $SE = .48$ , 95%  $CI [-.16, 1.76]$ ) and wellbeing. The direct effect was nonsignificant ( $B = -.82$ ,  $SE =$   
19  $.65$ , 95%  $CI [-2.12, .49]$ ).

#### 20 ***The Effect of Basic Psychological Needs Satisfaction on the relationship between Bubble Status and*** 21 ***Mental Health Markers***

22           There was no significant indirect effect of bubble status on anxiety, depression, or wellbeing  
23 via autonomy satisfaction, competence satisfaction, or relatedness satisfaction (see Supplementary  
24 Table 2). However, there was a significant total indirect effect of bubble status on wellbeing via  
25 autonomy satisfaction, competence satisfaction, and relatedness satisfaction (total indirect effect = -  
26  $1.00$ ,  $SE = .48$ , 95%  $CI [-2.00, -.144]$ ; see Figure 1.4). For all three models concerning BPN satisfaction,

1 examination of the separate effects indicated that bubble status was negatively associated with  
2 autonomy satisfaction ( $B = -.58, SE = .12, 95\% CI [-.88, -.29]$ ) and relatedness satisfaction ( $B = -.83, SE$   
3  $= .21, 95\% CI [-1.25, -.41]$ ) but not competence satisfaction ( $B = -.22, SE = .12, 95\% CI [-.45, .02]$ ).  
4 There was no association between any aspect of need satisfaction and anxiety, depression, or  
5 wellbeing (see Supplementary Table 3). There was a significant direct effect of bubble status on  
6 anxiety ( $B = 1.95, SE = .48, 95\% CI [.98, 2.92]$ ) and depression ( $B = 1.59, SE = .63, 95\% CI [.33, 2.84]$ )  
7 but no significant direct effect of bubble status on wellbeing ( $B = -.98, SE = .63, 95\% CI [-2.25, .29]$ ).

### 8 **Sex Differences**

9         There was a significant multivariate interaction between sex and bubble status,  $F_{2,56} = 5.14, p$   
10  $< .01, \eta p^2 = .15$ ; Wilks'  $\Lambda = .85$ . To probe this omnibus effect, we conducted 2x2 repeated measures  
11 analysis of variance for each of the mental health markers, which yielded significant interactions for  
12 anxiety, ( $F_{1,58} = 6.99, p = .01, \eta p^2 = .11$ , see Figure 2), and depression ( $F_{1,58} = 9.00, p < .01, \eta p^2 = .13$ ,  
13 see Figure 2). Follow-up paired sample Bonferroni-adjusted  $t$ -tests revealed that being in the bubble  
14 had a greater detrimental effect on mental health for women than for men, consistent with the  
15 hypotheses. Regarding wellbeing, there was a significant main effect for sex,  $F_{1,58} = 5.97, p < .05, \eta p^2$   
16  $= .09$ , and for bubble status  $F_{1,58} = 14.73, p < .001, \eta p^2 = .20$ , and no interaction. WHO-5 scores were  
17 significantly lower for women ( $M = 14.41, SD = 5.01$ ) than for men ( $M = 16.84, SD = 4.88$ ) and were  
18 significantly higher outside of the bubble ( $M = 16.50, SD = 4.41$ ) than inside the bubble ( $M = 14.47,$   
19  $SD = 5.67$ ). See Supplementary Table 4 for means, standard deviations, and follow-up tests.

### 20 **Discussion**

21         The aim of the present study was to investigate the effect of bio-bubbles on mental health.  
22 We found that anxiety and depression significantly increased inside the bubble and that wellbeing  
23 significantly decreased. We also found support for basic need frustration and satisfaction as  
24 mediators of this relationship. As hypothesized, autonomy frustration significantly mediated the  
25 relationship between bubble status and anxiety and depression whilst autonomy satisfaction,  
26 competence satisfaction, and relatedness satisfaction collectively mediated the relationship



1 between bubble status and wellbeing. Additionally, autonomy frustration significantly mediated the  
2 relationship between bubble status and wellbeing, which was not hypothesized. Sex moderated the  
3 relationship between bubble status and anxiety and depression, as hypothesized. Conversely, sex did  
4 not moderate the relationship between bubble status and wellbeing.

### 5 **Impact of Bio-Bubbles on Mental Health**

6 Some research has suggested that the return to sport during the pandemic might positively  
7 impact mental health (Grimson et al., 2021; Pillay et al., 2020). The data from the present study  
8 revealed that being in a bio-bubble had a substantial negative effect on mental health. *Although a  
9 return to sport is a step toward pre-pandemic norms and sport participation benefits wellbeing (Silva  
10 et al., 2020), a return to sport facilitated by bio-bubbles creates a plethora of additional stressors,  
11 which are not typically associated with elite sport (Woodman & Hardy, 2001). Further, for bio-  
12 bubbles to exist, people other than athletes (e.g., support staff) have to reside in them. For these  
13 non-players, it is possible that bio-bubbles simply create stressors that are additional to the typical  
14 touring stressors, and without the positive benefits of sport participation. For example, in the  
15 present study, medical staff had to monitor adherence to social distancing measures – something  
16 they were only tasked with because they were in bubbles. As sample constraints in the present study  
17 made investigating such differences not viable, future research concerning restrictive environments  
18 may wish to explore possible differing impacts due to role (e.g., athlete or non-athlete). Regardless,  
19 these results demonstrate that bio-bubbles can negatively impact mental health and therefore  
20 indicate that bio-bubbles should be used with caution and only when the threat of not residing  
21 within a bio-secure environment outweighs the potential detrimental impact of bio-bubbles on  
22 mental health.*

### 23 **The Influence of Basic Psychological Needs on Mental Health**

24 Autonomy frustration emerged as the predominant mediating variable. As we hypothesized,  
25 autonomy frustration mediated the relationship between bubble status and anxiety and depression.  
26 However, it also mediated the relationship between bubble status and wellbeing. This finding aligns

1 with Awofeso's (2010) suggestion that the lack of autonomy within the prison setting is a cause of  
2 mental health problems for prisoners. This finding suggests that autonomy, as it pertains to the  
3 frustration of needs, plays a more central role for mental health than do the needs for competence  
4 and relatedness. This suggestion is also supported by Glendinning et al. (2021), who found that the  
5 importance of autonomy, competence, and relatedness varied for individuals in certain  
6 circumstances, and that satisfying the most important basic need had the strongest effects on  
7 subsequent wellbeing. Thus, it is possible that those who had the strongest need for autonomy were  
8 most affected by bio-bubbles. Specifically, our findings and those of Glendinning et al. suggest that if  
9 a person's strongest need is for autonomy, their mental health is likely to be most affected by bio-  
10 bubbles. However, those whose strongest need is for competence or relatedness may still have been  
11 able to satisfy their strongest need and consequently bio-bubbles may have had a limited impact on  
12 their mental health. Such a proposition would be worthy of future investigation.

13 More broadly, our findings regarding BPN frustration support research regarding the impact  
14 of need-thwarting environments (Vansteenkiste & Ryan, 2013). Research has predominantly focused  
15 on children within these settings (e.g., Joussemet et al., 2008) and the long-term impact of  
16 continuous BPN frustration. However, the present research demonstrates that environments  
17 indicative of need thwarting may also have immediate negative implications for mental health in  
18 adults. Although bio-bubbles are uncommon habitual environments, the present findings clearly  
19 indicate that need-thwarting environments can have a significant negative impact on mental health.  
20 As such, researchers would do well to investigate the impact of need-thwarting climates on mental  
21 health in more common environments both inside (e.g., World Cups, Olympics) and outside (e.g.,  
22 school, workplace) of sport.

23 Chen et al. (2015) previously found that frustration of BPN exclusively predicted ill-being and  
24 satisfaction of BPN exclusively predicted wellbeing. However, we also found an association between  
25 BPN frustration and wellbeing. It is possible that this finding may be due to the unique setting of bio-  
26 bubbles or the context within which they were created. It is important to remember that these bio-

1 bubbles were created in a time where the outside landscape was atypical; that is, most of the  
2 sample's nation (i.e., the UK) was in lockdown and the pandemic presented many challenges and  
3 uncertainties. Regardless, the findings suggest that BPN frustration may predict wellbeing as well as  
4 ill-being in certain circumstances. As such, further exploration regarding BPN frustration and  
5 wellbeing is warranted.

## 6 **Sex Differences**

7 Our findings regarding sex differences in the experience of mental health problems inside  
8 the bubble partially supported our predictions. Women showed substantially greater increases in  
9 anxiety and depression when inside the bubble compared to out and generally had lower wellbeing  
10 than men. Collectively, these findings are supportive of research regarding sex differences  
11 experienced during the COVID-19 pandemic (Kwong et al., 2021) and before (McManus et al., 2016).  
12 It has been suggested that one of the reasons women are more likely to experience anxiety or  
13 depression is their increased sensitivity to things such as separation and isolation (Altemus et al.,  
14 2014). Given that the purpose of a bio-bubble is to create separation and isolation (on a physical  
15 level), it is thus perhaps unsurprising that women's mental health displayed a greater susceptibility  
16 to these bio-bubble environments. Separation and isolation certainly seem to be strong mediator  
17 candidates for further exploring our understanding of the causes of sex differences in mental health.

## 18 **Applied Implications**

19 Applied implications abound from this study. First, the decision to use bio-bubbles to  
20 facilitate the continuation of events would clearly benefit from considering the potential impact of  
21 such environments on mental health. The balance of such decision-making processes is a fine one.  
22 For example, organizations may need to balance the potentially harmful mental health effects of a  
23 bio-bubble environment with the alternative risks of not residing in a bio-bubble (e.g., catching a  
24 virus or not playing sport, which carries its own concomitant potential detrimental effects on mental  
25 health). **Second, if residing within bubbles is deemed necessary, then our findings suggest that**  
26 **mental health needs to be monitored, with appropriately trained individuals on hand to provide**

1 support. Third, the extent to which a bio-bubble meets or frustrates basic psychological needs (BPN)  
2 may play a pivotal role in reducing the negative impact that bubbles might have on mental health.  
3 Thus, if bio-bubbles are seen as a necessary precaution, we suggest that those tasked with creating  
4 the bubble consider how the environment can be developed to allow those within the bubble to  
5 satisfy their psychological needs, and to explore ways in which need frustration can be prevented,  
6 on an individual-by-individual basis (see Glendinning et al., 2021). Finally, in the present study, women  
7 were more at risk than men of suffering from anxiety or depression as a result of residing within a  
8 bio-bubble. However, men's health was also affected by being in the bio-bubble. We suggest that  
9 those creating and monitoring future bubbles be conscious of sex differences in relation to the  
10 mental health consequences of bio-bubbles and provide tailored support where needed.

11 The unique socio-cultural climate that led to the creation of bio-bubbles suggests that  
12 generalizing the present findings should be done with caution. Nonetheless, it is possible that similar  
13 environments exist beyond those associated with the COVID-19 pandemic. Specifically, within sport,  
14 international events such as tours, World Cups, and the Olympics/Paralympics require people to  
15 reside in artificially-created environments for a sustained period of time. Although each  
16 environment is different and the context within which people enter is unique to them, the common  
17 trait of all these environments is they are often foreign to the residents and there are often  
18 restrictions on movement outside of hotels or training bases. This lack of familiarity and any  
19 associated restriction on movement may also be need thwarting, which, as evidenced within our  
20 research, can significantly impact mental health. Consequently, the points raised regarding the  
21 applied implications of this research may also be applicable to more common sporting environments  
22 as well as other potentially need-thwarting settings. Given this potential generalizability and the  
23 significant decreases in people's mental health, empirical research is certainly required to examine  
24 whether settings such as sporting tours abroad have a similarly detrimental impact on mental health  
25 and wellbeing.

1           It is important to note that the England and Wales Cricket Board (ECB) commissioned this  
2 research with a view to understanding the impact of bio-bubbles on the mental health of its  
3 members with a view to implementing learnings for the benefit of all players and staff. Such an  
4 initiative is itself clearly positive. Equally, the rules surrounding bio-bubbles (e.g., social distancing,  
5 family not being allowed to enter) are such that they remove autonomy. As such, it will be an  
6 ongoing challenge for all organizations to work within the societal, government, and sporting  
7 regulations while also attempting to optimize the mental health of its members. Allowing greater  
8 flexibility on the bio-bubble rules is a parsimonious implication of the current data, and the ECB have  
9 already made many changes in light of the present findings. Such a stance is a clear step forward for  
10 the mental health of ECB members. Equally, the risk of contracting a physical disease such as COVID-  
11 19 is a clear health risk of such a strategy and all organizations would do well to balance such risks  
12 and benefits in this way. We view the ECB's position as constructively evolutionary by shining a light  
13 on its members' mental health during a global pandemic and beyond.

#### 14 **Limitations**

15           It would clearly have been preferable to collect data from participants in a prospective  
16 repeated-measures in- and out-of-bubble framework. However, due to the nature of the COVID-19  
17 pandemic and the subsequent implementation of bio-bubbles, a reflective approach to data  
18 collection was the only method possible for the present study. To limit the possible negative impact  
19 of the approach taken, we asked participants to think carefully about their experience as a whole  
20 and gave them as much time as they needed to complete the survey. Although asking them to think  
21 about all their bubble experiences allowed us to gather data for multiple bubbles, comparison  
22 between bubble environments (which were not identical) may have added contextual relevance.  
23 Furthermore, we invited direct in- and out-of-bubble comparisons and we were able to identify and  
24 remove individuals who gave answers that were not possible, possibly caused by memory recall  
25 issues. Even if such a limitation impacted the in- and out-of-bubble differences, they would not  
26 explain the mediation of basic psychological needs or indeed the sex differences. Finally, we reduced

1 to item pairs each construct of the Basic Psychological Need Satisfaction and Frustration Scale, which  
2 one might view as a limitation despite the retained factor integrity across the scales. Nonetheless,  
3 given the clear importance of psychological need satisfaction/frustration, future research would  
4 benefit from retaining complete measures when assessing BPN.

## 5 **Conclusion**

6 To the best of our knowledge, the present study is the first investigation of the impact of bio-  
7 bubbles on mental health. Using established measures of anxiety, depression, and wellbeing, this  
8 study has identified bio-bubbles as a potential risk to mental health and has laid the foundation for  
9 future research in the specific domain of bio-bubbles and other domains where psychological needs  
10 might be compromised (e.g., tours, large events). Basic psychological needs appear to be key  
11 mechanisms for explaining the relationship between bubble status and mental health, offering  
12 guidance to policy makers and those wishing to create interventions aimed at mitigating the  
13 unintended risk of bio-bubbles and isolating environments. Additionally, women were identified as  
14 suffering from greater increases in depression and anxiety inside the bubbles, which requires careful  
15 consideration in preparing and monitoring isolating environments.

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