Intervention Study

HEALTH PSYCHOLOGY OPEN

Health Psychology Open
January-June 2018: 1–8

DOI: 10.1177/2055102917753853
journals.sagepub.com/home/hpo
SAGE

The relationship between physical inactivity and mental wellbeing: Findings from a gamification-based community-wide physical activity intervention

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Abstract

Mental ill health accounts for 13 per cent of total global disease burden with predictions that depression alone will be the leading cause of disease burden globally by 2030. Poor mental health is consistently associated with deprivation, low income, unemployment, poor education, poorer physical health and increased health-risk behaviour. A plethora of research has examined the relationship between physical activity and mental wellbeing; however, the influence of community-wide gamification-based physical activity interventions on mental wellbeing, to the authors' knowledge, is yet to be explored. In view of this paucity of attention, the current study examined the relationship between physical activity and mental wellbeing pre/post a community-wide, gamification-based intervention. The findings revealed that increases in mental wellbeing were significantly greater for the least active prior to the intervention, and a strong, positive correlation between increase in physical activity and increase in mental wellbeing was observed.

Keywords

community health promotion, intervention, physical activity, public health psychology, wellbeing

Introduction

The World Health Organization (WHO) define health as a state of complete physical, mental and social wellbeing and not merely the absence of disease or infirmity (WHO, 2017). Mental health is defined as a state of wellbeing in which every individual realises his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully and is able to make a contribution to her or his community (World Health Organization and Calouste Gulbenkian Foundation, 2014). It is widely acknowledged that mental wellbeing is a crucial determinant of both individual functioning and societal prosperity (Diener and Chan, 2011; Field, 2009). The Centre for Mental Health (2010) estimated the total cost of mental health problems in England in 2009/2010 was £105.2 billion, a real term increase of £27.8 billion from 2002/2003. These figures are inclusive of costs related to health and social care for people with mental health problems (20%), lost output in the economy (29%) and the human costs of reduced quality of life (51%).

The Warwick–Edinburgh Mental Wellbeing Scale (WEMWBS) has been widely utilised to measure population levels of mental wellbeing for member countries of the United Kingdom. In Scotland, 14 per cent of respondents were classified as having 'good' mental wellbeing (a WEMWBS score of over one standard deviation above the mean of 51.05), 73 per cent as having 'average' mental wellbeing (a WEMWBS score of within one standard deviation of the mean) and 14 per cent as having 'poor' mental wellbeing (a WEMWBS score of more than one standard deviation below the mean; Braunholtz et al., 2007). In England, 11 per cent were defined as having 'low' mental wellbeing (a score of 39

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or less), 77 per cent had average mental wellbeing (a score between 40 and 62) and 12 per cent had high mental wellbeing (a score of 63 or above) (Bryson et al., 2011). While 11 per cent of adults were defined has having 'relatively low scores', the data were negatively skewed with frequency of distribution spread gradually between those scoring 14 (lowest possible score) and those scoring 39.

Poor mental wellbeing outcomes

Poor mental health is the largest single source of disease burden in the United Kingdom and is consistently associated with deprivation, low income, unemployment, poor education, poorer physical health and increased health-risk behaviour (Bhugra, 2010). A study by Richards and Abbot (2009) provides strong evidence for the severe impact that poor mental health at childhood could have on adulthood. The authors analysed longitudinal data from three British birth cohorts, born in 1946, 1959 and 1970 and discovered a significant association between emotional problems at adolescence and increasing severity of emotional problems in adulthood. Adolescents with emotional problems were three times more likely to have worsened symptoms than those without emotional difficulties. These data also revealed significant associations between early mental health problems and poor educational achievement, chronic economic inactivity, lower earnings, marital problems, teenage parenthood and contact with the criminal just system.

Psychosocial outcomes of positive mental wellbeing

In contrast to the detrimental impact of poor mental health, positive mental wellbeing has been associated with a breadth of biopsychosocial benefits. According to Chida and Steptoe (2008), positive psychological wellbeing is associated with reduced cardiovascular mortality in healthy and disease populations. Elsewhere, Keyes (2007) reported that 'flourishing' adults who were 'completely mentally healthy' reported the fewest absenteeism, the healthiest psychological functioning (including low helplessness, clear goals in life, high resilience and high intimacy), the lowest risk of cardiovascular disease, the lowest number of chronic physical diseases with age, the fewest health limitations of activities of daily living and lower health care utilisation. More recently, subjective wellbeing has been associated with greater health and longevity, income, productivity and organisational behaviour and a range of psychosocial benefits (including sociability, altruism, reduced risk taking and greater future time perspective) (De Neve et al., 2013).

Determinants of mental wellbeing

Social inequalities are at the forefront of inequalities in mental health and wellbeing. A recent report published by the World Health Organization and Calouste Gulbenkian Foundation (2014) outlined greater exposure and vulnerability to adverse social, economic and environmental circumstances as predisposing certain population subgroups to developing mental health problems. The report elaborated that such inequalities start before birth and accumulate throughout life (Allen et al., 2014). It has been argued that income inequality is a fundamental driver of social exclusion in England (Piachaud et al., 2009). The report published by the World Health Organization and Calouste Gulbenkian Foundation (2014) outlined that a universal approach must be taken to reduce health inequalities and improve mental health and wellbeing, arguing that inequalities in mental health exist along a social class gradient and as such, targeted services will likely miss most of these inequalities. Factors that influence mental health and wellbeing operate at the individual, family, community, structural and population level, and therefore, a multi-sector approach is required to address the scale of the problem.

Enhancing social cohesion is a potential avenue for bridging the health and social inequalities experienced throughout the world. A socially inclusive society is defined as one where all people feel valued, their differences are respected and their basic needs are met so they can live in dignity (Cappo, 2002). An early literature review by Kawachi and Berkman (2001) highlighted the well-established relationship between strong social relationships and enhanced mental wellbeing, which has been supported by more recent evidence (Cacioppo and Cacioppo, 2014; Santini et al., 2016). Social relationships influence habits which may be detrimental to health and wellbeing, they provide a social support mechanism, they can act to mitigate stress and they provide symbolic purpose and influence physiological responses to psychological distress and harm (Allen et al., 2014; Cohen, 2004; Crosnoe and Elder, 2004; Glynn et al., 1999; Thoits, 1995; Uchino, 2004; Umberson et al., 2010). As such, social inclusion policies may be a promising avenue for at least mitigating the detrimental impact of social inequalities on subsequent shortfalls in mental wellbeing (Rispel et al., 2009). Fone et al. (2007) examined population level data from 10,653 adults and discovered that poor mental health was significantly associated with area-level income deprivation and low social cohesion after adjusting for individual risk factors. Furthermore, the authors found high social cohesion significantly modified the association between income deprivation and mental health. However, no causal inferences can be made from this cross-sectional study; an alternative explanation could be that communities with individuals possessing greater mental health could be more socially connected.

Physical activity and mental wellbeing

Physical inactivity is the fourth leading risk factor for global mortality, attributed to 6 per cent of deaths globally

(WHO, 2016). According to Kruk (2007), physical activity reduces the risk of developing breast cancer by up to 75 per cent, cardiovascular and heart disease by up to 49 per cent, diabetes by up to 35 per cent and colorectal cancer by up to 22 per cent. However, effective interventions to reduce population levels of physical inactivity, which extend beyond 'standing' or 'take the stairs' campaigns, are sparse (Bauman, 2016). Furthermore, a recent Cochrane systematic review concluded insufficient evidence for current multi-component community-wide interventions citing scalability is a major weakness with many previous interventions failing to reach a substantial portion of the community (Baker et al., 2015).

The evidence base for the relationship between physical activity and mental wellbeing is well established (see Mason and Kearns, 2013). For instance, evidence has consistently shown that physical activity is positively associated with increased mental wellbeing (Bize et al., 2007; Cerin et al., 2009); however, such reviews have focused overly on 'frequent' physical activity (Mason and Kearns, 2013). Furthermore, a frequent limitation of research examining the relationship between physical activity and mental wellbeing is the abundance of small sample size investigations (Penedo and Dahn, 2005). While a plethora of research has examined the relationship between physical activity and mental wellbeing (cf. Biddle and Asare, 2011; Fox, 1999; Penedo and Dahn, 2005), the influence of community-wide gamification-based physical activity interventions on mental wellbeing is yet to be explored and with growing concerns of large geographical variations in mental wellbeing at a population level (Arora et al., 2016), the potential of this approach warrants further exploration.

The current study

The purpose of the current study was to explore the relationship between physical activity and mental wellbeing by focussing primarily on those who are inactive. The study sought to examine the cross-sectional relationship between physical inactivity and mental wellbeing from a large representative sample size, to explore the impact of a community-wide gamification-based physical activity intervention on mental wellbeing and to examine changes in mental wellbeing in relation to changes in physical activity before and after a community-wide intervention.

Methodology

Intervention

'Beat the Street' aims to increase physical activity using gamification components. Battery powered radio-frequency identification (RFID) scanners called 'Beat Boxes' are located at half mile intervals throughout a town/city and residents receive 10 points each time two consecutive 'Beat Boxes' are touched with a RFID card within 1 hour. Residents compete to see which schools, community groups and individuals can achieve the greatest physical activity over the course of the game period and highest scorers are rewarded with prizes. For example, vouchers for sports equipment are provided to schools, community groups are rewarded with active lifestyle prizes (such as bicycles), 'lucky tap' prizes offer instant gratification and there is an overall prize for total miles travelled where money is donated to a local charity. A 7-month period follows the 6-week competition and involves trained individuals supporting residents into long-term behaviour change by directing them into suitable physical activity opportunities for their age, competency level and demographic, while also working with the local authority to develop and introduce bespoke physical activities if a gap in provision is identified. For the purposes of the current study, a total of 20 Beat Boxes were situated throughout Stranraer, Scotland, which collectively received 3371 unique users (38% of the target population) completing a total of 285,380 scans. A detailed overview of the intervention has been provided elsewhere (see Coombes and Jones, 2016).

Participants

Prior to the intervention, residents of Stranraer, Scotland, were encouraged to register their RFID card online which enabled their accumulated points to be allocated to a team (school/community group). In total, $n = 1686$ people completed the primary outcome measure (mental wellbeing) in full at baseline, a response rate of 72.9 per cent and $n = 167$ people provided follow-up data immediately following the intervention. Sample characteristics are provided in Table 1.

Table 1. Sample Characteristics.

Demographic	Baseline sample, $n = 1686$	Final sample, $n = 167$ (who provided both baseline and follow-up data)
Age group (*n*, %)		
≤11 years	327 (19.4%)	12 (7.2%)
12–17 years	285 (16.9%)	15 (9%)
18–29 years	216 (12.8%)	21 (12.6%)
30–39 years	321 (19%)	35 (21%)
40–49 years	267 (15.8%)	32 (19.2%)
50–59 years	165 (9.8%)	33 (19.8%)
60–69 years	78 (4.6%)	16 (9.6%)
≥70 years	27 (1.6%)	3 (1.8%)
Female (*n*, %)	1094 (64.9%)	120 (71.9%)
Long-term medical condition (*n*, %)		
Yes	177 (10.5%)	21 (12.6%)
No	1509 (89.5%)	146 (87.4%)

Outcome measures

Participant's physical activity levels were measured using the Scottish Physical Activity Screening Questionnaire (Scot-PASQ) (Physical Activity and Health Alliance, 2012). The Scot-PASQ is a three-item measure of physical activity behaviour and attitude, although the current study only operationalised the first questionnaire element, which delineates number of days spent completing 30 minutes or more of moderate intensity physical activity in the previous week, to provide a non-subjective categorical measure of physical activity. Mental wellbeing was measured using the WEMWBS (Tennant et al., 2007). The long-form WEMWBS is a 14-item scale with five response categories, ranging from 'None of the Time' to 'All of the Time', with scores summed to provide a single score of between 14 and 70. The WEMWBS has been shown to demonstrate high levels of internal consistency, reliability and construct validity (Cronbach's $\alpha = 0.91$; test–retest reliability $r = 0.83$, goodness of fit index (GFI) = 0.91 and adjusted goodness of fit index (AGFI) = 0.87) (Tennant et al., 2007). Previous population level data in Scotland have interpreted 'good' mental wellbeing as a WEMWBS score of over one standard deviation above the mean of 51.05, 'average' mental wellbeing as a WEMWBS score of within one standard deviation of the mean and 'poor' mental wellbeing as a WEMWBS score of more than one standard deviation below the mean (see Braunholtz et al., 2007). The items are all worded positively and cover both feeling and functioning aspects of mental wellbeing (Braunholtz et al., 2007). Examples of questions included in the scale are 'I've been feeling optimistic about the Future' and 'I've been feeling close to other People'. The WEMWBS is widely regarded as a valid and reliable tool for measuring mental wellbeing in diverse populations (Stewart-Brown, 2013).

Overview of analyses

Baseline data were subjected to a one-way between subject's analysis of variance (ANOVA) to test differences in mental wellbeing across self-reported days of physical activity, and a Spearman's rank-order correlation was used to examine the relationship between physical activity and mental wellbeing. Separate within subject's ANOVAs were used to test for differences in physical activity and mental wellbeing between baseline and follow-up. Finally, a Pearson's product moment correlation was run to examine the relationship between changes in mental wellbeing and changes in physical activity between baseline and follow-up.

Procedure

Prior to the competition, residents were given a RFID card distributed via schools, council facilities, libraries, leisure centres, general practice clinics and promotional events. To participate in the competition, residents were required to activate their RFID card via an online portal. During registration, participants were invited to complete a number of optional and mandatory questions, including a range of sociodemographic questions, a validated physical activity questionnaire, a retrospective 1-week travel survey and a validated self-report measure of mental wellbeing. Immediately following the end of the 6-week competition, all registered participants who agreed to be contacted and did not unsubscribe from being contacted during the competition period (72.5%) were sent a link to a follow-up survey via email. A £50 prize draw was offered to incentivise follow-up survey completion and a total of four reminders were sent to participants.

Results

Complete responses on mental wellbeing and physical activity at baseline were collected from $n = 1686$ people, with varying levels of self-reported physical activity (see Figure 1).

Cross-sectional analysis

Data were subjected to a one-way between subject's ANOVA, with a between factor of self-reported days of physical activity. Results showed a significant main effect of self-reported days of physical activity on mental wellbeing ($F(7, 1678) = 45.948$, $p < 0.001$, partial $\eta^2 = 0.161$).

Pairwise comparisons showed that mental wellbeing was significantly lower for participants reporting 0 days of physical activity compared with those who reported all other levels of activity ($p < 0.001$). A Spearman's rank-order correlation was run to determine the relationship between physical activity and mental wellbeing. There was a weak, positive correlation between physical activity and mental wellbeing, which was statistically significant ($rs(1684) = .316$, $p < 0.001$).

Pretest/posttest analysis

Complete pretest/posttest responses on mental wellbeing were available for $n = 167$ people, with varying levels of baseline physical activity. Data were subjected to separate one-way within subject's ANOVAs and a Pearson's product moment correlation was used to examine the relationship between changes in physical activity and changes in mental wellbeing.

Changes in physical activity

There was a statistically significant increase in physical activity from baseline to follow-up, whereby average days of physical activity increased from 4.59 to 5.39 days ($F(1, 166) = 16.786$, $p < 0.001$, partial $\eta^2 = 0.92$). There was a

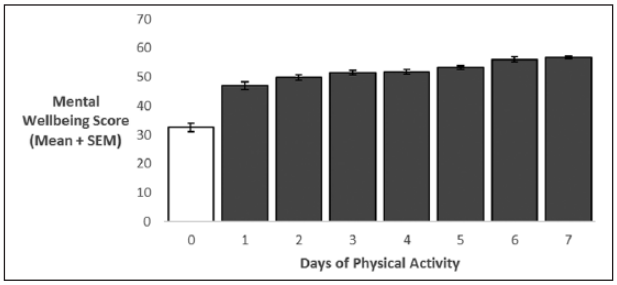

Figure 1. Showing mean mental wellbeing scores across self-reported days of physical activity (values = mean ± SEM).

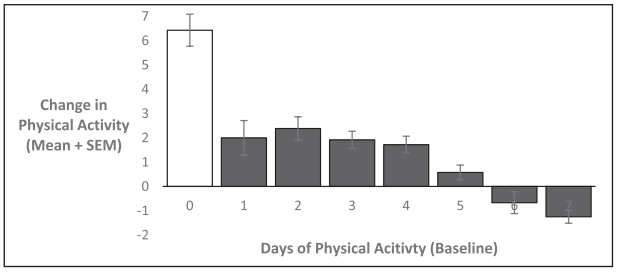

Figure 2. Showing mean change in physical activity across self-reported days of physical activity at baseline (values = mean ± SEM).

significant main effect of self-reported days of physical activity at baseline on change in physical activity between baseline and follow-up ($F(7, 159) = 25.046$, $p < 0.001$, partial $\eta^2 = 0.524$). Pairwise comparison showed that difference in physical activity between baseline and follow-up was significantly greater for participants who reported 0 days of physical activity compared to all other groups ($p < 0.001$) (see Figure 2).

Changes in mental wellbeing

There was a statistically significant increase in mental wellbeing from baseline to follow-up, whereby average mental wellbeing score increased from 51.05 to 53.28 ($F(1, 166) = 5.332$, $p < 0.05$, partial $\eta^2 = 0.031$). There was a significant main effect of self-reported days of physical activity at baseline on change in mental wellbeing between baseline and follow-up ($F(7, 159) = 10.345$, $p < 0.001$, partial $\eta^2 = 0.313$). Pairwise comparison showed that the difference in mental wellbeing between baseline and follow-up was significantly greater participants who reported 0 days of physical activity when compared to all other groups ($p < 0.001$) (see Figure 3).

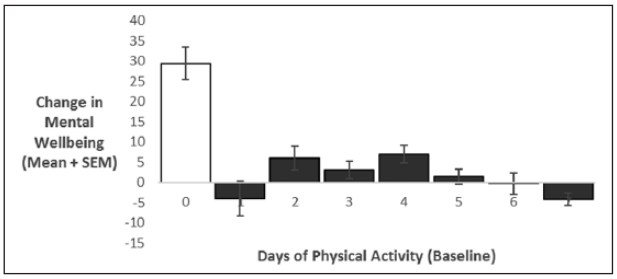

Figure 3. Showing mean change in mental wellbeing across self-reported days of physical activity at baseline (values = mean ± SEM).

Physical activity mental wellbeing relationship

A Pearson's product moment correlation was run to determine the relationship between changes in physical activity and changes in mental wellbeing. There was a strong, positive correlation between physical activity and mental wellbeing, which was statistically significant ($r(167) = 0.513$, $p < 0.0001$).

Discussion

The aim of the current study was to examine the relationship between physical activity and mental wellbeing by focussing primarily on the inactive. This investigation explored the relationship between physical inactivity and mental wellbeing using baseline data from a large representative sample size and studied the influence of a community-wide physical activity intervention on mental wellbeing. The analysis revealed a substantial and statistically significant difference between participants who reported 0 days of physical activity in the previous week, compared to those who reported all other activity levels. There was a statistically significant increase in mental wellbeing from baseline (pre-intervention) to follow-up (post-intervention). Furthermore, the increase in mental wellbeing was significantly greater for those reported 0 days of physical activity pre-intervention when compared to all other activity groups. Additionally, a positive correlation was found between change in physical activity and change in mental wellbeing from baseline to follow-up.

The current study provides three novel contributions to the current evidence base for the relationship between physical activity and mental wellbeing. First, the community-wide, gamification-based physical activity intervention examined here was found to increase mental wellbeing. Second, increase in physical activity following the intervention was positively correlated with mental wellbeing; however, no causal direction can be established. Third, increasing physical activity levels for those who reported 0 days of activity pre-intervention was associated with a substantially greater increase in mental wellbeing than was observed for all other groups. These findings provide support for the use of community-wide interventions for increasing levels of mental wellbeing at a community level and suggest that such approaches may be particularly effective for raising

levels of mental wellbeing by those with significantly lower levels of this psychological asset; the physically inactive.

The well-established link between social cohesion and mental wellbeing offers a potential avenue which may explain the findings of the current study. Previous research has provided strong evidence for the potential of social cohesion for enhancing individual wellbeing (Kawachi and Berkman, 2001). Social relationships influence health habits, provide social support, can mitigate stress, can elucidate a sense of purpose and alter physiological responses to harm and distress (Cohen, 2004; Crosnoe and Elder, 2004; Glynn et al., 1999; Kawachi and Berkman, 2001; Thoits, 1995; Uchino, 2004; Umberson et al., 2010). Research directly examining the relationship between social cohesion and mental health has found high social cohesion significantly modified the association between income deprivation and mental health (Fone et al., 2007); however, no causal direction could be established due to the cross-sectional design of this study; an alternative explanation could be that communities with individuals possessing greater mental health could be more socially connected.

A hypothesis which stems from these findings is that social cohesion may mediate the relationship between physical activity and mental wellbeing, with increased levels of social cohesion elucidating a subsequent increase in mental wellbeing, or vice versa. The Beat the Street intervention which occupied the focus of the current study provided numerous components which may have increased levels of social cohesion. First, the intervention operates at a community-wide level and is branded to the local environment, in this instance, Stranraer, which may have functioned to connect people to their local area. Second, the programme relies on the competitive nature of teams (whether school or community group based) which could have functioned to strengthen existing social networks or enable individuals without connection to an existing social group to become a part of one (for instance, their child's school, their workplace or a local charity). Finally, the intervention offered 20 local points of common interest, the 'Beat Boxes', and a common topic of conversation, the 'game'. With 3371 (38% of the population within the game boundary) recording 285,380 scans on just 20 Beat Boxes, it is highly likely that paths would have crossed on numerous occasions with familiar and unfamiliar neighbours and the game itself would have offered a convenient topic of discussion, such as what team people are a part of, how many points they have acquired and how many miles they have travelled. However, due to the novelty of both the intervention and the theory of behaviour change, gamification, these hypotheses are speculative rather than scientific and warrant further investigation.

Study limitations

There was a high drop-out rate for the second element of the study which examined changes in physical activity and mental wellbeing over time; it could be that those who remained in the study could have been a unique population compared to those who did not provide post-intervention data. Furthermore, women were more likely to engage in the intervention, provide baseline data and provide follow-up data post-intervention; therefore, the findings of the current study could be gender specific. This study also relied wholly upon self-reported measures of both physical activity and mental wellbeing, and therefore, the honesty by which participants disclose such information is questionable. However, the study utilised measurement instruments which have been validated and used extensively at population level across the country of origin of the sample.

Future directions

The Beat the Street intervention which formed the focus of the current study offers a novel way to promote physical activity and other wider psychosocial benefits, such as individual mental wellbeing and community cohesion. However, due the novelty of the intervention and its underlying theoretical basis, gamification, little is known about the precise mechanisms which support (un) successful implementation. As noted above, three potential, unique components are provided which may explain the findings of the current study; however, these are highly speculative. More research is needed which explores these elements in greater detail and such future contributions may be more suited to qualitative methodology.

Conclusion

This study provides further support for the relationship between physical activity and mental wellbeing and highlights the substantial differences in mental wellbeing between the least and most active individuals. The findings presented above provide preliminary evidence for the potential role of community-wide, gamification-based physical activity interventions in addressing mental health inequalities. Future research should explore the potential mechanisms which underpin the relationship between physical activity and mental wellbeing and seek to identify the extent to which social or psychological factors best explain this association.

Acknowledgements

The author thanks the two anonymous reviewers whose recommendations helped to improve the depth and clarity of an earlier draft.

Funding

The author(s) received no financial support for the research, authorship and/or publication of this article.

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