Toward a Mediated Model of Physical Activity in Relation to Psychological Distress

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Abstract

Leisure-time physical activity has well demonstrated benefits in mitigating symptoms of depression and, to a lesser extent, anxiety. A variety of theoretical mechanisms have been proposed as mediators of this linkage. There has been no reported attempt to develop a unified model of the relative contributions of the proposed mechanisms. To begin to fill this gap, 394 first-year university students were surveyed concerning their participation in physical activity (broadly defined), their level of depressive and anxiety symptoms as indexed by the Kessler 10, and four mediators identified as promising candidates in the literature: behavioral activation (sense of purpose and achievement), belonging (sense of social contact and inclusion), sense of flow (concentrated engagement in activity), and coaching relationship (formal or informal assistance from another person). Each of the candidate mechanisms individually mediated the relationship between physical activity and the K10 score. However, the scores for each of the mechanisms themselves were inter-correlated to a small or medium degree. When all scores were analysed as an integrated model, only behavioral activation and belonging were significant mediators. Once these two mediators had been accounted for, there was no additional direct effect of physical activity on both depression and anxiety. The next steps for refining and testing the model are discussed.

Keywords: Physical activity, Flow, Belonging, Behavioral Activation, Coaching relationship, Kessler 10
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INTRODUCTION

Vigorous physical activity, including individual exercise and competitive sport, has been demonstrated to benefit the mental health of clinical and non-clinical populations [1,2]. However, the mechanisms that may mediate this relationship have not been extensively mapped [3]. Given the huge number of mechanisms that influence mental health, building a comprehensive model of the mechanisms that may mediate the relationship between physical activity and mental health seems overly ambitious at the present time. Accordingly, the present research focused on a set of mechanisms that exemplify key classes of such mechanisms [4]. There are four key classes of potential mediating mechanisms:

First, there are "behavioral activation" mechanisms, which consist of skills for maintaining a positive perspective while minimising depression. These skills can be broadly characterised as training in behaviors that, among other things, provide a sense of purpose, self efficacy, personal control, and/or personal accomplishment [5,6]. For the present modelling, a collective measure of behavioral activation was used.

Second, there are social-cognitive mechanisms concerning a sense of belonging within a larger group. This feeling can lead to greater resilience and less vulnerability to common mental health concerns [7]. A person undertaking physical activity with others either informally, as in a fitness class or in an organised team may have an increased sense of belonging, including the social interconnections and sense of safety within the group [8,9].

Third, flow states occur when someone becomes absorbed into an activity, often losing track of time or other concerns [10,11]. Flow states have been correlated with higher levels of positive affect and performance in competitive sport [12].

Fourth, in addition to social support from a sense of belonginess within a formal team or informal group, there are also relationships in which one individual will assist one or more members of the group in improving their performance. The most familiar form of this relationship appears when there is a formally designated coach for participants in competitive sport. Less formally, training partners will often provide coach-like assistance and instruction to each other. These interactions may parallel the benefits that result from of a sound relationship between a patient and a therapist [13]. These benefits can arise from shared goals, understanding, trust, and confidence between a patient and therapist, similarly between training partners [14].

Research Rationale and Research Questions

For modelling whether the four candidate mechanisms, specifically, behavioral activation, belonging, coach relationship, and flow states, mediate the positive relationship between physical activity and mental health, we chose university students as a suitable non-clinical population. Entry into university poses an acute stressor, which may take several years to subside in its effects [15]. For example, as measured by the Kessler 10 (K10) instrument that covers both depression and anxiety, Australian university students from their first year through their final year have shown elevated scores relative to age-matched peers [15]. Among these students, 48% were classified as displaying a "high" level of psychological distress (K10 ≥ 22) as compared to 11% in age-matched peers. Depression and anxiety at a clinical level requiring treatment also appear with appreciable frequency in both American students (20%, 24%) [16] and Canadian students (19%, 24%) [17].

Based on the foregoing considerations, the following research questions were addressed in this study:

1. Do the candidate mechanisms of behavioral activation, sense of belonging, coaching relationship, and flow states have any significant correlations with each other?
2. Do the candidate mechanisms of behavioral activation, sense of belonging, coach relationship, and flow states individually mediate any relationship between physical activity and a measure of psychological distress?
3. How much variance do the candidate mechanisms account for when placed into an integrated mediation model?
4. Does the mediation model differ for symptoms of depression and anxiety?

METHOD

Participants

The sample consisted of 394 students enrolled in first-year psychology (59.9% identified as females, 39.3% identified as males, and 0.8% identified as "other"). The study received ethical approval from the University of New South Wales under relevant regulations (Approval Number 3130, 19 December 2018). After giving informed consent, the participants were administered the questionnaires outlined below. All questionnaires were administered online.

Materials

Physical Activity Measure. The participants were asked how often they undertook physical activity. Among the participants, 2% never participated, 19% reported being active 1-3 days per year, 51% reported being active 2-3 days per month, 24% reported being active once per week, 0% reported being active 2-3 times per week, and 4% undertook physical activity on at least a daily basis . For the mediation analyses, these responses were converted to an approximate number of days per year of activity (0 to 365).

Behavioral Activation for Depression Scale – Short Form (BADS-SF). For measuring behavioral activation [18], the BADS-SF contains nine items, which were developed using a university population similar to the current study. For each item, the participant was asked to read a statement and rate how often the statement was true during the past week on a seven-point scale ranging from 0 ("not at all") to 6 ("completely"). Five items concerned the frequency and quality of recent activities, e.g., "I was an active person and accomplished the goals I set out to do." The other four items, which were reverse scored, concerned avoidance and rumination, e.g., "I engaged in activities that would distract me from feeling bad." The BADS-SF is reported to have sound reliability, Cronbach's α = 0.819 (18).

Community Integration Measure (CIM). The CIM is a measure of belongingness, which concerns perceived connections within a community with respect to general assimilation, support, occupation, and independent living (19). The measure has good reliability in patient samples (Cronbach's α = 0.830) and nonclinical university samples (Cronbach's α = 0.780) [19]. The CIM contains ten declarative statements which are rated on a five-point Likert scale ranging from "always disagree" (0) to "always agree." Higher scores are interpreted as reflecting higher levels of community integration.

Short Dispositional Flow Scale (SDFS). The SDFS provides an assessment of a nine-dimensional conceptualisation of flow state (20). The scale was developed using samples from the general Australian population (Cronbach's α = 0.810). The scale contains nine statements, each being rated on a 5-point scale (never, rarely, sometimes, frequently, always) with higher scores indicating a greater sense of flow. For example, one statement is "My attention is focused entirely on what I am doing."

Coach Relationship Questionnaire (CRQ). The CRQ was developed from a list of fifteen factors identified by Stamoulos, Trepanier (21) as important to a patient-therapist relationship including, among others, rapport, trust, shared goals, and empathy between a participant in physical activity and coach or instructor. The CRQ measured corresponding factors deemed important to a participant-coaching relationship. The questionnaire used a five-point Likert scale (strongly disagree, somewhat disagree, neither agree nor disagree, somewhat agree, strongly agree)., for which higher scores indicate a stronger relationship. The questionnaire demonstrated good reliability when tested using the current university sample (Cronbach's α = 0.822).

Kessler 10 (K10). The K10 is a widely-used as measure of psychological distress based on anxiety and depressive symptoms [22-24]. It has ten items that each ask, "about how often did you feel...", for example, "nervous," "hopeless," "depressed". Four items address anxiety symptoms, and six items address depressive symptoms. The response scale consisted of a five-point rating ranging from "none of the time" to "all of the time." Thus, lower scores indicate less psychological distress. The K10 is reported to have excellent reliability (Cronbach's α = 0.930) for the general US population [23].

Statistical analyses

Correlational analyses were conducted using SPSS with the Process (V3.3) syntax [25] being used for the mediation analyses, bootstrapping 5000 samples. For zero-order correlational analyses, correlation coefficients (r) of 0.10, 0.30, and 0.50 were designated as small, medium, and large, respectively [26].

RESULTS

Pairwise Correlations

For testing the first research question, zero-order correlations were calculated among the four mechanism variables. All the variables significantly correlated with each other (ps < 0.01). Belonging had medium correlations with behavioral activation, (r = 0.49) flow state (r = 0.49), and the coaching relationship (r = 0.48). The remaining correlations were medium to small in size, ranging downward from r = 0.42 (flow x coaching relationship) to r = 0.38 (flow x coaching relationship) to r = 0.20 (flow x behavioral activation).

Individual Variable Mediation Effects

Hayes's Process V3.3 script was used to test the second research question, whether the mechanisms individually mediate the relationship between the frequency of physical activity and the K10 measure. Table 1 shows the results of the mediation analysis for each of the four variables. Each section shows the results for (a) the path between physical activity and the mediator in terms of the Beta weight, its standard error, the *t* test of the significance of the Beta weight, its *p* value, the lower limit of the 95% confidence interval of the Beta weight, and the upper limit of the confidence interval. The next four lines show the corresponding statistics for (b) the path for the mediator variable with K10, (c) the total path for the effect of activity frequency on K10, which was constant across all analyses, (d) the direct effect c' of activity on K10 subtracting the a and b paths, and (e) the indirect effect (c-c') of the mediator between activity and K10, subtracting out the direct effect.

Table 1. Individual mediation effects of Behavioral Activation, Belonging, Flow, and Coaching Relationship on the relationship between sport and psychological distress.

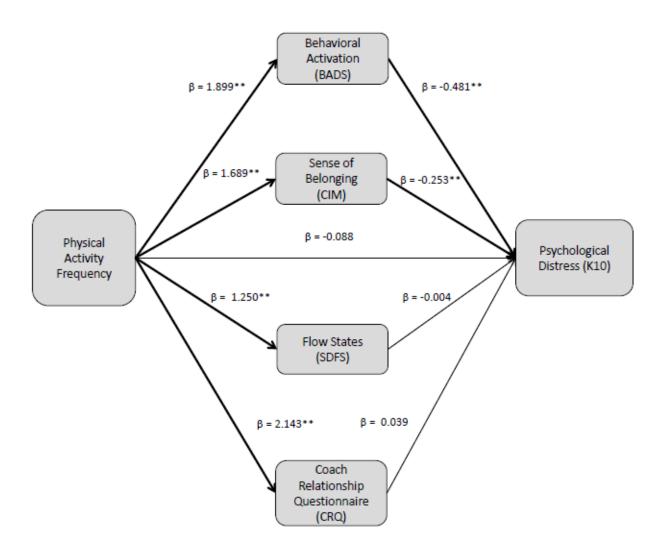| Regression paths	B	se	t	p	LLCI	ULCI
Mediation a path (Sport Frequency on Behavioral Activation)	0.027	0.005	5.864	0.000	0.018	0.037
Mediation b path (Behavioral Activation on K10)	-0.564	0.036	-15.731	0.000	-0.634	-0.493
Total effect, c path (Sport on K10)	-0.018	0.004	-4.191	0.000	-0.026	-0.009
Direct effect c' (Sport on K10 including Behavioral Activation as mediator)	-0.002	0.003	-0.665	0.507	-0.009	0.005
Mediation a path (Sport Frequency on Belonging)	0.022	0.004	6.121	0.000	0.015	0.029
Mediation b path (Belonging on K10)	-0.502	0.054	-9.340	0.000	-0.608	-0.397
Total effect, c path (Sport Frequency on K10)	-0.018	0.004	-4.191	0.000	-0.026	-0.009
Direct effect c' (Sport Frequency on K10 including Belonging as mediator)	-0.007	0.004	-1.667	0.096	-0.015	0.001
Mediation a path (Exercise Frequency on Flow)	0.018	0.003	6.334	0.000	0.012	0.024
Mediation b path (Flow on K10)	-0.413	0.072	-5.725	0.000	-0.554	-0.271
Total effect, c path (Sport Frequency on K10)	-0.018	0.004	-4.191	0.000	-0.026	-0.009
Direct effect c' (Sport Frequency on K10 including Flow as mediator)	-0.010	0.004	-2.408	0.165	-0.019	-0.002
Mediation a path (Sport Frequency on Coach Relationship)	0.020	0.007	2.861	0.004	0.006	0.034
Mediation b path (Coach Relationship on K10)	-0.077	0.030	-2.565	0.011	-0.137	-0.018
Total effect, c path (Sport Frequency on K10)	-0.018	0.004	-4.191	0.000	-0.026	-0.009
Direct effect c' (Sport Frequency on K10 including Coach Relationship as mediator)	-0.016	0.004	-3.811	0.000	-0.025	-0.008

Figure 1. An integrated mediation model of sport participation on the K10 (**$p < 0.00$).

Examination of Table 1 demonstrates that behavioral activation, belonging, and flow state each had a significant individual mediating effect. Yet, there was no significant direct effect between activity and K10 once the mediating effect of each of these three meditator variables was accounted for. In contrast, coaching relationship had an individual significant mediating effect, but there remained a significant direct effect even when the contribution of the coaching relationship was included.

Overall Mediation Model
　　　　With regard to the third research question as to whether the mechanisms collectively contribute to an overall model, all four mediating variables were placed into an analysis using Process v3.3 [25]. Figure 1 shows the Beta weights for (a) the paths of activity on each proposed mediator, (b) the paths for each proposed mediator and the K10 score, and (c') the direct path between activity frequency and the K10 score after all mediation effects had been subtracted.
　　　　Inspection of the figure reveals that physical activity had a significant simultaneous relationship with behavioral activation, belonging, flow state, and coach relationship. However, only behavioral activation and belonging had a significant relationship with the K10. Therefore, only these two variables were significant mediators in the integrated model. Together, they appeared to account for nearly all the variance. With both these variables in the model, the direct effect of activity on the K10 was not significant.

Mediation Model for Depressive and Anxiety Symptoms

For testing the fourth research question, a mediation model was again tested, however this time, the two K10 factors of depression and anxiety were entered separately as outcome variables. Consistent with the overall model shown in Figure 1, the only two significant mediators were behavioral activation and belonging. Specifically, the paths from physical activity through behavioral activation (Beta weight = 0.03, t(393) = 5.86, p <0.01) to both the depression variable (Beta weight = -0.33, t(388) = -12.55, p <0.01) and the anxiety variable (Beta weight = -0.15, t(388) = -7.70, p <0.01) were significant. Similarly, the paths from activity through belonging (Beta weight = 0.02, t(393) = 6.12, p <0.01) to both the depression variable (Beta weight = -0.16, t(388) = -4.32, p <0.01) and the anxiety variable (Beta weight = -0.94, t(388) = -3.25, p <0.01) were significant. For both models, there was no significant direct effect of activity on either depression or anxiety variables.

DISCUSSION

Major Findings

The present results provide an expanded, nuanced picture of the relationship between physical activity and psychological distress as measured by the K10. The current study revealed that four candidates as potential meditators between physical activity and psychological distress were correlated to a small or medium degree with each other (Research Question 1), and individually, they were each a mediator of the inverse relationship between physical activity and psychological distress (Research Question 2). However, when the candidate mediators were combined into an integrated analysis only the mechanisms of behavioral activation and belonging had a significant relationship with the K10, its depression component, and its anxiety component (Research Questions 3 and 4).

Implications

In connection with previous results, the present findings confirm that evidence that behavioral activation engaged by participation in physical activity helps reduce symptoms of depression and anxiety [27]. In the present case, the association between behavioral activation and reduction in anxiety was observed in a nonclinical population, rather than a clinical population. The present results also confirm the role that belonging has in alleviating depression and anxiety symptoms [9,28]. These mediation effects appeared even though the participants were not asked whether their physical activity was conducted alone, in an informal group, and/or in a formal team setting.

Limitations and Future Directions

The present research was limited in four ways that suggest avenues for future research:

First, as noted above, the sample was limited to a nonclinical population of university students. It was not feasible to source a sample of the same size suitable for a mediation analysis from a local clinical population. As a partial alternative to a clinical population, testing other nonclinical populations at risk of depression and anxiety would seem worthwhile, for example, first responders and military personnel for whom the team environment is often a central feature of their work.

Second, the questionnaires used in the present study are open to refinement. The measurement of behavioral activation in the BADS-SF could be expanded beyond goal achievement and avoidance/rumination to test an individual's use of self-talk, relaxation, skill development, and activity monitoring in warding off depression and anxiety [29]. Similarly, the belonging measure in the CIM could be expanded to identify the social context in which the physical activity occurs, including, among others, informal groups (e.g., regular training partner), formal groups (e.g., cycling club), and organised teams (e.g., basketball competition) [30]. Furthermore, the participants could be asked what type of physical activity they engaged in.

Third, the potential mediators excluded from the present model, namely, flow state and coaching relationship should receive continued testing in connection with other populations.

Fourth, the K10 is a good measure of psychological distress, but its low scores indicate only an absence of distress. In contrast, a scale for positive functioning may be worthwhile for testing potential mediators for increased wellbeing associated with physical activity [30, 31].

CONCLUSION

Beyond the well-known benefits of physical activity for cardiovascular fitness and more general physical health, the present results indicate that regular physical activity can protect against the negative impact of sustained stress on mental health in a young, nonclinical population. To achieve these benefits, the present results point particularly to the value of using physical activity to engage an individual's behavioral activation and sense of belonging. Moreover, these two mechanisms may be engaged safely and inexpensively by individuals, their peers, and/or professionals involved in physical activity, e.g., Soucy-Chartier and Provencher [32].

DATA AVAILABILITY STATEMENT

All data is stored in accordance with the requirements of the UNSW Human Research Ethics Committee. Deidentified data will be stored on the UNSW ResData system for five years following publication. Data can be provided if required with appropriate approvals.

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