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RESEARCH ARTICLE

Examining the associations between physical activity, self-esteem, perceived stress, and internalizing symptoms among older adolescents

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Abstract

Introduction: In older adolescence, stress has been found to be prevalent. It has been seen that higher physical activity (PA) relates to lower stress levels, which, in turn, relates to fewer anxiety and depressive symptoms (internalizing symptoms). However, how these associations function is not fully understood. PA is strongly associated with greater self-esteem in adolescents. As greater self-esteem is thought to aid better coping with stress and has been seen as beneficial for mental health in adolescents, PA may be associated with lower stress and better mental health through self-esteem and more adaptive stress appraisals. Therefore, the aim of the study was to examine the relationships between PA, self-esteem, stress, and mental health.

Methods: A cross-sectional design was employed, and path analysis was implemented. PA, self-esteem, stress appraisals, distress tolerance, perceived stress, anxiety, and depression were assessed using online questionnaires from 244 adolescent participants from the United Kingdom (aged 15–19, $M = 16.75$ [$SD = 0.82$], 145 female).

Results: Path analysis revealed that PA was associated with lower perceived stress through increased self-esteem, adaptive appraisals, and higher distress tolerance (total standardized indirect effect; $p = .007$ (-0.25 to -0.11). Moreover, lower perceived stress was associated with lower anxiety (standardized direct effect; $p < .001$ [2.65 – 4.0]) and depressive symptoms (standardized direct effect; $p < .001$ [0.33 – 0.63]).

Conclusions: Findings suggest that higher PA could be effective in improving mental health among older adolescents, due to its association with perceived stress through higher self-esteem and more adaptive appraisals of stress.

KEYWORDS

adolescence, mental health, path analysis, self-esteem, stress, stress appraisals

1 | INTRODUCTION

Adolescence is an incredibly stressful time, characterized by periods of change (e.g., puberty, changing schools), academic pressures (e.g., examinations), as well as beginning the transition into adulthood (Byrne et al., 2007; Pascoe et al., 2020). Worryingly in the United Kingdom, an estimated 20%–45% of adolescents report feeling stressed (Roy et al., 2015). Older adolescence is defined by the World Health Organisation (WHO, 2018) as those adolescents who are between the ages of 15 and 19 years old. This particular age group is likely to be at risk of elevated stress levels due to added academic pressures from General Certificate of Secondary Education and A-level examinations, applying for university or posteducation employment, and establishing an identity (Chamberlain et al., 2011; Roome & Soan, 2019). Indeed, research demonstrates that older

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adolescents report higher perceived stress than their younger counterparts (Tully et al., 2009). The prevalence of stress in these adolescents has only been exacerbated in recent years by the COVID-19 pandemic (Paschke et al., 2021) due to factors such as school closures, canceled examinations, social isolation resulting from stay-at-home restrictions, as well as fear of the COVID-19 virus (Alimoradi et al., 2022; McCluskey et al., 2021; Wright et al., 2021), with older adolescents reporting higher posttraumatic stress reactions than younger adolescents (Schwartz et al., 2021).

Stress is a predictor of poor mental health such as increased anxiety (Schneider et al., 2021) and depression (Hammen, 2005), meaning the exacerbated stress experienced in older adolescence is likely a key contributor to the prevalent levels of poor mental health observed in this population. Globally approximately 14% of older adolescents are predicted to have a mental health disorder (UNICEF, 2021) and UK-based adolescents (17–19) have seen increases in probable mental health conditions from one in ten 17–19-year-olds in 2017, to as many as one in four 17–19-year-olds in 2022 (Newlove-Delgado et al., 2022). Considering it is not always possible to remove stressors, it is vital to identify ways to help older adolescents cope with stress to lead to better mental health and wellbeing such as decreased anxiety and depression.

The literature presents many theories and frameworks to explain how better coping with stress arises. One of the most prevalent and well-supported frameworks is Lazarus and Folkman (1984) transactional model of stress and coping (TMSC), which proposes that how someone copes with stress is determined by how they appraise it. The TMSC proposes that when an individual is confronted with a stressful situation, they evaluate the potential for either growth/gain or harm/loss (Lazarus & Folkman, 1984). Harm or loss is described as threat appraisal while growth or gain refers to challenge appraisal. The TMSC (Lazarus & Folkman, 1984) suggests that while challenge and threat appraisals are not mutually exclusive, the degree to which someone experiences a challenge or threat appraisal can determine how they cope, with stress appraised as a challenge leading to more adaptive coping (Nicholls et al., 2012). In contrast, a threat appraisal is associated with more debilitating coping, lower distress tolerance (i.e., lower ability to tolerate distress), and higher perceived stress (Nicholls et al., 2012). Consequently, challenge appraisals are thought to be associated with greater distress tolerance and lower perceived stress (Lee et al., 2018; Trotman et al., 2018).

The TMSC proposes an individual experiencing a challenge appraisal is likely to feel more capable of drawing on available resources (Lazarus & Folkman, 1984). The contextual model of stress and coping proposes that the appraisal of stressful events is influenced by three factors: (1) the nature of the event, (2) the social context that the event occurs, and (3) stable aspects of the self (DeLongis & Holtzman, 2005). Self-esteem (i.e., how positive a person feels about themselves; Sonstroem, 1998) is a stable aspect of the self that has been proposed to be a key resource that individuals use when exposed to stressful situations (Taylor & Stanton, 2007). In support, research has demonstrated associations between self-esteem, and secondary appraisals of stress (the extent the stress exceeds perceived resources; Juth et al., 2008). Specifically, Juth et al. (2008, p. 891) explained “self-esteem thus appears to serve to magnify the perception of available resources, their perceived effectiveness or potency, or itself functions as a resource during secondary appraisal.” Furthermore, individuals with higher levels of self-esteem are likely to possess greater confidence in their ability to succeed in a challenging situation (Pruessner et al., 1999) and a more positive sense of self or greater self-esteem has been associated with lower autonomic and cortisol stress reactivity (Seeman & Lewis, 1995)—these characteristics are reflective of appraising stressful scenarios as a challenge rather than a threat (Meijen et al., 2020). Collectively, this research suggests that adolescents displaying greater self-esteem are likely to exhibit greater perceived resources and be more likely to appraise stressful scenarios they encounter as a challenge rather than a threat, which, in turn, relates to being better able to cope with and tolerate stress. In support of this proposal, adolescent research shows that higher self-esteem is associated with a greater distress tolerance (Abdullah et al., 2020), and greater distress tolerance is associated with lower perceived stress (Ozcan, 2019). Therefore, based on the TMSC, it can be proposed that higher levels of self-esteem will be associated with lower perceived stress through more adaptive stress appraisals and greater distress tolerance. As such, identifying factors associated with greater self-esteem in adolescents appears to be highly beneficial for trying to elicit more adaptive appraisal and coping with stress. This is likely to relate to lower anxiety and depressive symptoms (Lee et al., 2018; McHugh et al., 2014).

One activity that has been consistently linked to higher self-esteem in adolescents is engagement in physical activity (PA). Lubans et al. (2016) stated that while a wealth of literature demonstrates the relationship between PA and mental health and wellbeing in children and adolescents, the underlying mechanisms have yet to be established. Consequently, they conducted a systematic review of the literature after presenting a conceptual model proposing three hypotheses for how PA could benefit adolescents and young people's mental health and wellbeing. The three proposed hypotheses were: (1) the neurobiological hypothesis (PA enhances cognition and mental health via changes in brain structural and functional composition), (2) the behavioral hypothesis (PA leads to changes in behaviors that are related to better mental health such as improved sleep), and (3) the psychosocial hypothesis (PA relates to better mental health via psychosocial determinants). Results of the systematic review showed the strongest evidence for the psychosocial hypothesis with PA being associated with greater self-esteem. Although this was in part through mechanisms such as self-perceptions and social connectedness, evidence from the review also indicated direct effects from PA to increased self-esteem independent of other mechanisms (Lubans et al., 2016). The positive relationship between PA and self-esteem has also been evidenced in another systematic reviews in adolescents (Biddle et al., 2019), with research suggesting improved self-esteem being experienced following just one single bout of

exercise (Wood et al., 2013). Therefore, PA appears an important behavior likely to be associated with greater self-esteem and better mental health and wellbeing.

Lubans et al. (2016) psychosocial hypothesis suggests adolescent PA relates to greater self-esteem which reflects better mental health and wellbeing. Drawing on the TMSC (Lazarus & Folkman, 1984), it can also be proposed that this greater self-esteem, arising from PA, may also relate to better mental health by enabling adolescents to more adaptively appraise and cope with the day-to-day stress they encounter. However, to our knowledge, research has not yet examined whether Lubans et al.'s (2016) psychosocial hypothesis of PA can be integrated with the TMSC (Lazarus & Folkman, 1984). Therefore, the aim of the present study was to integrate these two theories and examine the indirect relationship between PA, perceived stress, and anxiety and depressive symptoms in an adolescent population via self-esteem, perceived resources, challenge and threat appraisals, and distress tolerance.

1.1 | Hypothesized model

The full hypothesized model is presented in Figure 1a. Based on the aforementioned theories in the literature, physical activity was hypothesized to positively relate to self-esteem, which was in turn expected to be positively associated with perceived resources, challenge appraisal, and distress tolerance, while being negatively associated with threat appraisal and perceived stress. Resources were predicted to be negatively associated with threat appraisal and positively associated with challenge appraisal, while threat appraisal was hypothesized to be negatively associated with distress tolerance and positively with perceived stress, and challenge appraisal positively associated with distress tolerance and negatively with perceived stress. Distress tolerance was predicted to be negatively associated with perceived stress (Ozcan, 2019), anxiety, and depressive symptoms (McHugh et al., 2014), while perceived stress was expected to be positively associated with anxiety and depressive symptoms (O'Connor et al., 2010). Due to the often co-morbid nature of anxiety and depression (Aina & Susman, 2006), it is likely that there are similarities in how PA relates to both of these constructs. To examine any subtle differences in the proposed mechanisms through which PA relates to anxiety and depressive symptoms, the proposed model was tested separately with anxiety and depressive symptoms as outcome variables (see Figure 1a).

2 | MATERIALS AND METHODS

2.1 | Participants

In total, 273 participants aged 15–19 in UK school year 11 and above were recruited via emails to schools and other adolescent-targeted organizations (e.g., youth orchestras, sports clubs, youth groups, cadets, youth theaters, etc.) across the United Kingdom as well as social media posts from the research team. Emails were sent by the research team to over 300 schools and organizations throughout England and Wales with the aim of recruiting a diverse sample of adolescents that didn't focus on just one type of person (e.g., those playing sports). The study gained ethical approval from the University Ethics Committee. All participants provided consent, and where appropriate (i.e., if the participant was under 16 years old), a parent/guardian gave informed consent before participating in the study.

2.2 | Questionnaires

2.2.1 | PA

A single item was used to measure PA, whereby participants were asked to select the level which represented their usual level of PA (Jurca et al., 2005). Participants selected the level of PA from five possible levels (1–5), with higher numbers indicating higher levels of PA. Level 1 indicated “Inactive or little activity other than usual daily activities”; level 2: “Regularly (≥ 5 d/wk) participate in physical activities requiring low levels of exertion that result in slight increases in breathing and heart rate for at least 10 minutes at a time”; levels 3–5 were phrased as participation in “aerobic exercises such as brisk walking, jogging, or running at a comfortable pace, or other activities requiring similar levels of exertion” with level 3 being for 20–60 min/week, level 4: 1–3 h/week and level 5 for 3 h+/week. This item has been used as part of a test of nonexercise estimation of cardiorespiratory fitness (CRF), where it was found that it provided a good indication of CRF when compared to actual exercise testing (Jurca et al., 2005). Similar single-item measures of PA have been found to be reliable and valid assessments of PA in adolescents, including when compared with objective accelerometer data (Scott et al., 2015).

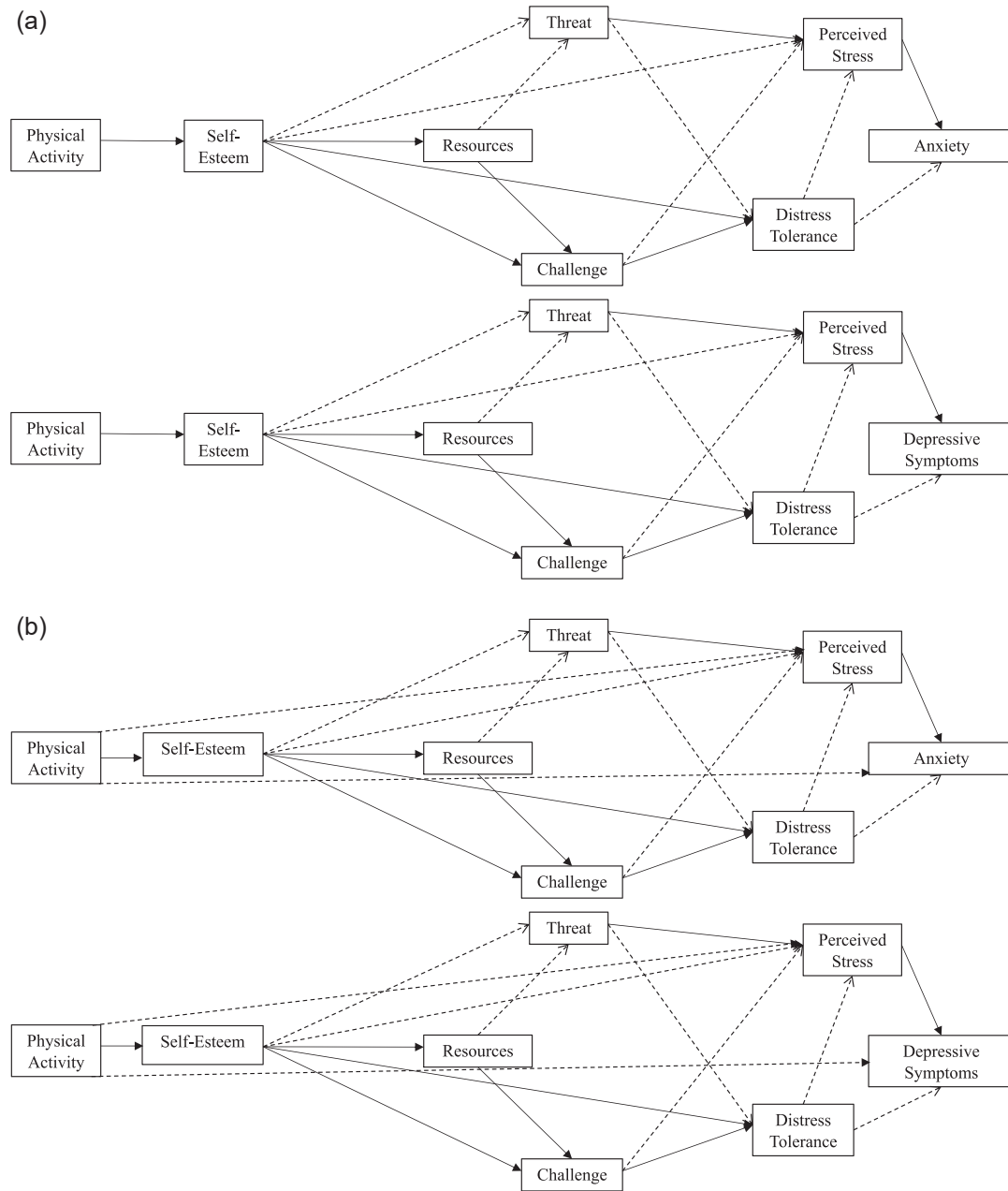


FIGURE 1 (a) Hypothesized models for the relationships between physical activity and anxiety and physical activity and depressive symptoms. (b) Hypothesized models for the relationships between physical activity and anxiety and physical activity and depressive symptoms, including direct pathways from physical activity to perceived stress, anxiety, and depressive symptoms. (a, b) Solid lines indicate a predicted positive relationship and dashed lines indicate a predicted negative relationship. For visual simplicity, age and gender control variables and the correlation between challenge and threat appraisal are not depicted.

2.2.2 | Self-esteem

A four-item version of the Rosenberg Self-Esteem Scale (Guddal et al., 2019) was used to assess self-esteem. Participants were asked to rate each item (e.g., “I have a positive attitude towards myself”) on a 4-point Likert scale from 1 (*strongly disagree*) to 4 (*strongly agree*). Two items were negatively worded so were reverse scored before summing all items to give an overall self-esteem score (range 4–16), with a higher score indicating a higher level of self-esteem. The four-item version of the Rosenberg Self-Esteem Scale has been previously used in adolescents and has good internal reliability (Guddal et al., 2019), and was strongly correlated with the full scale (Tambs & Røysamb, 2014), with the full scale having good validity (Rosenberg, 1965). In the present study, the questionnaire demonstrated good internal reliability with a Cronbach α of .78.

2.2.3 | Resources, challenge, and threat appraisals

The stress appraisal measure for adolescents (Rowley et al., 2005) was used to measure perceived resources, challenge appraisal, and threat appraisal tendencies. The measure consists of three subscales: challenge appraisal (four items, e.g., “I have the ability to overcome stress”), threat appraisal (seven items, e.g., “I perceive stress as threatening”), and resources (three items, e.g., “I have the resources available to me to overcome stress”). Participants were asked to rate the extent to which they generally think or feel each statement when encountering a stressful event. Responses were made on a 5-point Likert scale from 0 (*not at all*) to 4 (*a great amount*). Scores for each subscale were then averaged, with a higher score indicating a greater tendency toward a challenge, or a threat appraisal, and greater resources. Adequate reliability has been found for all subscales and the questionnaire has been validated for an adolescent population (Rowley et al., 2005). In the present study, the questionnaire demonstrated good internal reliability for challenge and threat with the Cronbach α being .85 and .80, respectively. The resources subscale demonstrated acceptable reliability with the Cronbach α being .67.

2.2.4 | Distress tolerance

The Distress Tolerance Scale (DTS; Simons & Gaher, 2005) is a 15-item scale, measuring individual components of an overall level of distress tolerance. The DTS is comprised of four subscales: tolerance (three items, e.g., “Feeling upset or distressed is unbearable to me”), appraisal (six items, e.g., “I can tolerate being distressed or upset as well as most people”), absorption (three items, e.g., “When I feel distressed or upset, all I can think about is how bad I feel”), and regulation (three items, e.g., “I’ll do anything to avoid feeling distress or upset”). Participants rated the extent to which they agreed with each statement. Ratings are typically made on a 5-point Likert scale from 1 (*strongly agree*) to 5 (*strongly disagree*). However, for continuity with other questionnaires in the pack, the scoring was reversed from 1 (*strongly disagree*) to 5 (*strongly agree*). Subscale means were then calculated. For the present study, a higher order (overall) distress tolerance factor was used to provide an overall representation of distress tolerance. This higher order distress tolerance subscale was calculated by taking the mean of all subscale scores. The higher order subscale and has been found to be a valid and reliable measure of general distress tolerance (Simons & Gaher, 2005). Higher scores represent higher distress tolerance. The DTS has been found to be reliable in adolescents (Wolitzky-Taylor et al., 2015). In the present study, the questionnaire demonstrated excellent internal reliability with the Cronbach α being .90.

2.2.5 | Perceived stress

The 10-item version of the Perceived Stress Scale (PSS; Cohen et al., 1983) assessed how stressed participants had felt in the past month. Participants were asked to read and respond to each item (e.g., “How often have you felt nervous and stressed?”) on a 5-point Likert scale from 0 (never) to 4 (very often). Items that were positively worded (e.g., How often have you felt that you were on top of things?) were reverse scored. A mean of all items was calculated, with a higher overall score indicating higher levels of perceived stress. In adolescent populations, the PSS has been reported to have good internal reliability (Carlozzi et al., 2010) and has been validated for both younger (Yarcheski & Mahon, 1999) and older (Cohen et al., 1983) adolescents. In the present study, the questionnaire demonstrated good internal reliability with the Cronbach α being .85.

2.2.6 | Anxiety and depressive symptoms

The 14-item Hospital Anxiety and Depression Scale (HADS; Zigmond & Snaith, 1983) was used to measure general anxiety (seven items, e.g., “Worrying thoughts go through my mind”) and depressive symptoms (seven items, e.g., “I feel as if I am slowed down”) experienced in the past month. Each item is scored from 0 to 3. Each subscale is summed, with scores ranging from 0 to 21, where a higher score indicates higher levels of anxiety and depressive symptoms. The HADS provides valid and reliable anxiety and depressive symptoms scores in an adolescent population (White et al., 1999). In the present study, the questionnaire demonstrated good internal reliability for anxiety and acceptable internal reliability for depression with the Cronbach α being .80 and .69, respectively.

2.3 | Procedures

Schools and organizations willing in supporting the research distributed information sheets explaining the nature of the study and the links to participate to adolescents and their parents to give them the opportunity to take part. Before

consenting to take part, participants were given the opportunity to contact the researchers with any questions they had. Questionnaires were completed either through an online questionnaire platform (SmartSurvey) or using paper hard copies. If participants aged 16 and above decided they wanted to take part, they could access the study consent form and questionnaire pack online directly by clicking a link from the online information sheet. Participants aged 15 also had to gain consent from a parent/guardian to take part in the study, with the link for the questionnaire being sent to the adolescent to complete via an email address provided by their parent/guardian. Participants who completed the pack via hardcopy were provided with a copy of the consent form and questionnaire pack by their school to complete in their own time before returning to the school (the consent form also contained the parental consent form to be completed by parents of adolescents under 16). The hardcopy questionnaires and consent forms were then collected from the schools by the researchers. The questionnaire pack contained items relating to demographic information, PA, self-esteem, stress appraisals, distress tolerance, perceived stress, anxiety, and depressive symptoms. The questionnaire pack took approximately 30 min to complete, and data were collected between November 2019 and March 2020.

2.4 | Data analysis

Analysis was conducted using SPSS (IBM, Version 26) and AMOS (IBM, Version 26). Data were screened and cleaned to check for missing values and outliers. Four participants were removed due to not being in year 11 or above. Three participants who had not completed at least one entire questionnaire were deemed to have not completed the study sufficiently and were removed from all analyses. A further three participants did not complete the questionnaire pack correctly and were excluded. Path analysis was used to examine the models as this allowed for the examination of both direct and indirect effects on observed data and is an approach used successfully in previous cross-sectional data (Harvey et al., 2022). Examining direct and indirect effects with cross-sectional data is appropriate in this case as the aim was to establish the existence of the hypothesized relationships and not whether they were causal (Cain et al., 2018). To examine indirect effects and obtain their confidence intervals (CIs) and significance values, a full data set is required to enable bootstrapping to provide this information (IBM, 2018). Therefore, assuming any missing data of the remaining participants was missing completely at random, this would be imputed to ensure a complete data set. To establish if missing data were missing completely at random, Little's (1988) missing completely at random (MCAR) test was run. Little's MCAR indicated that less than 5% of the data was completely missing at random, so the expectation-maximization method was used to complete the data set (Tabachnick & Fidell, 2013). Inspection of the Mahalanobis distance at $p < .05$ identified 19 multivariate outliers, which were removed from the analysis. Therefore, the final sample size was 244, with all having complete data.

Descriptive statistics on the final sample were generated, and Pearson correlations were run to examine the extent to which PA was associated with the other model variables (i.e., self-esteem, resources, challenge appraisal, threat appraisal, distress tolerance, perceived stress, anxiety, and depressive symptoms). Next, the hypothesized model predicting anxiety was tested using path analysis. The goodness of model fit was tested using the χ^2 statistic. Due to a nonsignificant value rarely being found, additional fit indices were used. The root mean square error of approximation (RMSEA) and the standardized root mean square residual (SRMR) were used to indicate absolute fit (values of 0.06 and ≤ 0.08 , respectively, indicating adequate fit). The comparative fit index (CFI) and Tucker–Lewis Index (TLI) were also used to indicate incremental fit (values >0.90 indicate adequate fit and >0.95 indicate excellent model fit (Hu & Bentler, 1999). Mediation analysis was used to explore indirect effects (Hayes, 2018). Bootstrapping was performed at 2000 samples with CIs at 95%. Subsequently, the hypothesized model for depression was tested using the same approach and fit criteria. Both models controlled for age and gender and standardized estimates were reported for direct and total indirect effects. Specific indirect effects were also examined and reported as unstandardized estimates. Estimates are unstandardized as these are measured from unstandardized path coefficients so cannot produce standardized estimates (Crowson, 2021).

To determine the extent to which the relationships between PA and stress, and between PA and anxiety/depressive symptoms were indirect via self-esteem, stress appraisals, and distress tolerance, both models were also tested with additional direct pathways from PA to perceived stress and from PA to anxiety/depressive symptoms (Figure 1b). Nonsignificant pathways between PA and stress and PA and anxiety/depressive symptoms would suggest the relationship to be operating through self-esteem, stress appraisals, and distress tolerance.

3 | RESULTS

3.1 | Participant characteristics

A final sample of 244 participants from school years 11–14 participated in the study (for the breakdown of participant characteristics, please see Table 1). Participants came from a total of 41 different schools located in the North, South, East,

TABLE 1 Participant characteristics.

| Characteristic | Frequency |
|----------------------------------|-------------|
| Age ($M = 16.5$; $SD = 0.82$) | |
| 15 | 4 (1.6%) |
| 16 | 101 (41.4%) |
| 17 | 95 (38.9%) |
| 18 | 39 (16%) |
| 19 | 5 (2.0%) |
| Gender | |
| Male | 97 (39.8%) |
| Female | 145 (59.4%) |
| Unspecified | 2 (0.8%) |
| School year | |
| 11 | 15 (6.1%) |
| 12 | 128 (52.5%) |
| 13 | 89 (36.5%) |
| 14+ | 3 (1.2%) |
| Not specified | 9 (3.7%) |

TABLE 2 Means, standard deviations, and Pearson's correlations between physical activity and model variables.

| | Mean (SD) | Coefficient (95% CI), p value of correlation with physical activity |
|---------------------|--------------|---|
| Physical activity | 3.50 (1.42) | – |
| Self-esteem | 10.98 (2.92) | 0.32 (0.20, 0.43), <.001 |
| Resources | 2.88 (0.70) | 0.15 (0.03, 0.27), .016 |
| Threat | 2.26 (0.75) | –0.21 (–0.33, –0.09), <.001 |
| Challenge | 2.25 (0.88) | 0.30 (0.18, 0.41), <.001 |
| Distress tolerance | 2.98 (0.74) | 0.14 (0.01, 0.26), .029 |
| Perceived stress | 2.24 (0.63) | –0.26 (–0.37, –0.14), <.001 |
| Anxiety | 9.73 (4.20) | –0.14 (–0.26, –0.02), .026 |
| Depressive symptoms | 5.64 (3.25) | –0.16 (–0.28, –0.04), .011 |

and West of England as well as Wales. Schools participants attended included private, state, and grammar. Means and standard deviations for PA, self-esteem, perceived resources, challenge appraisal, threat appraisal, distress tolerance, perceived stress, anxiety, and depressive symptoms are reported in Table 2. Correlation coefficients between PA and model variables were all found to be significant and are reported in Table 2 along with the p values and 95% CIs.

3.2 | Hypothesized model for anxiety

To test the hypothesized model in predicting anxiety, regression paths were drawn from PA to self-esteem, and from self-esteem to resources, challenge appraisals, and threat appraisals. Regression paths were also drawn from resources to challenge and threat appraisals. Challenge and threat appraisals then had regression paths drawn to distress tolerance and perceived stress, with distress tolerance having a regression path into perceived stress. There was also a direct pathway to perceived

stress from self-esteem. Finally, perceived stress and distress tolerance then each had a regression path to anxiety. Due to the relationship between challenge and threat appraisals, a correlation was also included between their variances similar to previous research (Williams & Cumming, 2012). The hypothesized model is displayed in Figure 1. The model was found to be a good fit to the data, $\chi^2(12) = 28.06, p = .005, CFI = 0.98, TLI = 0.93, SRMR = 0.03, RMSEA = 0.07$ (90% CI = <0.04–0.11). Furthermore, all paths within the model were significant (p 's < .05) except for the path between self-esteem and distress tolerance ($p = .074$). The model indicated that PA positively predicted self-esteem, which was positively associated with greater resources and more adaptive stress appraisals (i.e., lower threat appraisals and higher challenge appraisals). The more adaptive stress appraisals were then associated with greater distress tolerance and lower levels of perceived stress. These in turn predicted lower levels of anxiety. Furthermore, total indirect effects were identified as being significant including an indirect effect between PA and perceived stress ($p = .007$) and PA and anxiety ($p = .007$). All specific indirect effects were found to be significant. See Figure 2 for the final model and all standardized direct effects while Table 3 contains all standardized total indirect effects. The specific indirect effects through the different potential pathways when examined in isolation are also reported in Supporting Information: Table 1.

3.3 | Hypothesized model for depressive symptoms

The proposed regression pathways for the hypothesized model in predicting depressive symptoms were the same as those in the anxiety model but with depressive symptoms taking the place of anxiety as the outcome variable (i.e., the regression pathways from perceived stress and distress tolerance were drawn to depressive symptoms; see Figure 2). The model was found to be a good fit to the data, $\chi^2(12) = 22.43, p = .033, CFI = 0.99, TLI = 0.96, SRMR = 0.03, RMSEA = 0.06$ (90% CI = <0.02–0.10). Like the anxiety model, PA was a positive predictor of self-esteem which was positively associated with the more adaptive stress appraisals, which, in turn, were associated with higher distress tolerance and lower levels of perceived stress. Lower levels of perceived stress then predicted lower levels of depressive symptoms. The pathways between self-esteem and distress tolerance ($p = .074$) and distress tolerance and depressive symptoms, however, were found to be nonsignificant ($p = .243$), but all other pathways were significant (p 's < .05). Total indirect effects were found between PA and perceived stress ($p = .007$) and PA and depressive symptoms ($p = .007$) (see Figure 3, for standardized direct effects and Table 4, for all standardized total indirect effects). Specific indirect effects were also all found to be significant, except where the pathway contained a direct path between distress tolerance and depressive symptoms (see Supporting Information: Table 1, for the specific indirect effects).

3.4 | Direct pathways between PA, stress, anxiety, and depressive symptoms

Anxiety and depressive symptoms models were rerun with the addition of direct pathways from PA to perceived stress and PA to anxiety or depressive symptoms (dependent on the model being run). The models for both anxiety ($\chi^2 [10] = 26.76, p = .003, CFI = 0.98, TLI = 0.93, SRMR = 0.03, RMSEA = 0.08$ [90% CI = <0.05–0.11]) and depressive symptoms ($\chi^2 [10] = 20.60, p = .024, CFI = 0.99, TLI = 0.94, SRMR = 0.03, RMSEA = 0.07$ [90% CI = <0.02–0.11]) were found to be a good and similar fit to the data as the hypothesized models. However, the direct pathways from PA to perceived stress ($p = .792$), PA to anxiety ($p = .393$), and PA to depressive symptoms ($p = .303$) were all nonsignificant.

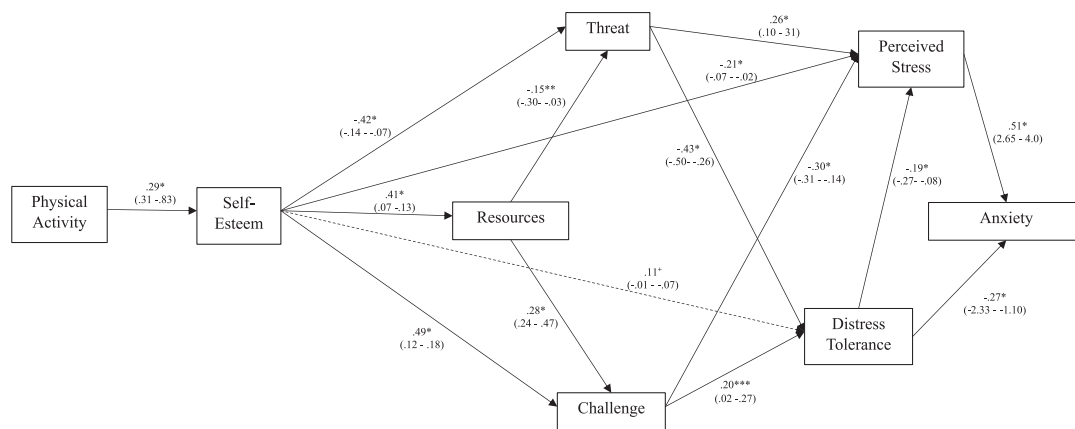


FIGURE 2 Final model for the relationship between physical activity and anxiety. Solid lines indicate a significant relationship and dashed lines indicate a nonsignificant relationship. For visual simplicity, age and gender control variables, error terms, and the correlation between challenge and threat are not presented in this model. Regression weights standardized. * $p < .001$; ** $p = .019$; *** $p = .003$; † $p = .072$.

TABLE 3 Standardized estimates (95% confidence intervals) and *p* values of the anxiety model for total indirect effects.

| | Resources | Threat | Challenge | Distress tolerance | Perceived stress | Anxiety |
|--------------------|-------------------------------------|---|--------------------------------------|-------------------------------------|---|---|
| Physical activity | 0.12 (0.09–0.19) <i>p</i> = .006 | -0.14 (-0.21 to -0.07) <i>p</i> = .006 | 0.17 (0.11–0.25) <i>p</i> = .006 | 0.13 (0.08–0.19) <i>p</i> = .005 | -0.17 (-0.25 to -0.11) <i>p</i> = .007 | -0.12 (-0.18 to -0.07) <i>p</i> = .007 |
| Self-esteem | | -0.06 (-0.12 to -0.03) <i>p</i> = .015 | 0.115 (0.08–0.17) <i>p</i> = .005 | 0.32 (0.23–0.42) <i>p</i> = .009 | -0.38 (-0.47 to -0.31) <i>p</i> = .005 | -0.42 (-0.48 to -0.33) <i>p</i> = .013 |
| Resources | | | | 0.12 (0.05–0.17) <i>p</i> = .011 | -0.14 (-0.19 to -0.09) <i>p</i> = .004 | -0.11 (-0.15 to -0.06) <i>p</i> = .009 |
| Threat | | | | | 0.08 (0.03–0.13) <i>p</i> = .005 | 0.29 (0.22–0.38) <i>p</i> = .006 |
| Challenge | | | | | -0.04 (-0.08 to -0.01) <i>p</i> = .006 | -0.22 (-0.30 to -0.15) <i>p</i> = .007 |
| Distress tolerance | | | | | | -0.09 (-0.16 to -0.04) <i>p</i> = .009 |

Note: Predictor variables are in the left-hand column, and outcome variables are across the top of the table.

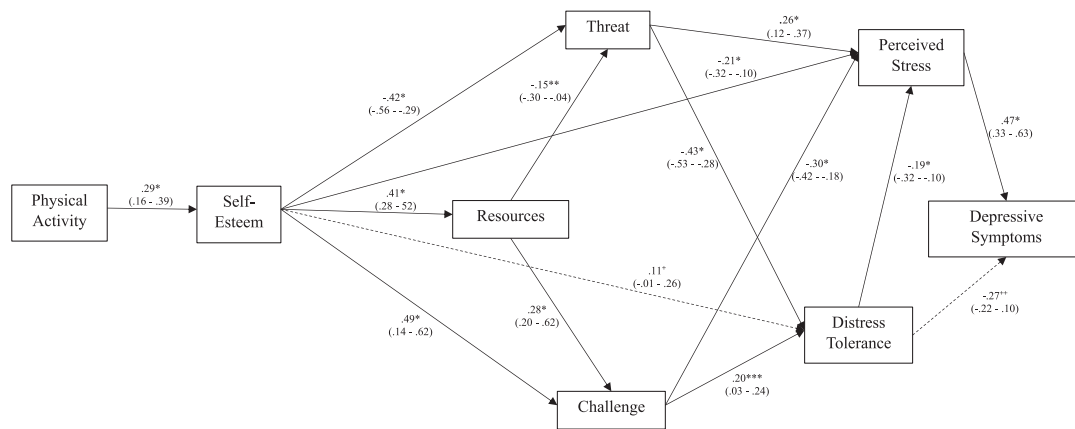


FIGURE 3 Final model for the relationship between physical activity and depressive symptoms. Solid lines indicate a significant relationship and dashed lines indicate a nonsignificant relationship. For visual simplicity, age and gender control variables, error terms, and the correlation between challenge and threat are not presented in this model. Regression weights standardized. **p* < .001; ***p* = .019; ****p* = .003; +*p* = .072; ++*p* = .246.

TABLE 4 Standardized estimates (95% confidence intervals) and *p* values of the depressive symptoms model for total indirect effects.

| | Resources | Threat | Challenge | Distress tolerance | Perceived stress | Depressive symptoms |
|--------------------|-------------------------------------|---|--------------------------------------|-------------------------------------|---|---|
| Physical activity | 0.12 (0.09–0.19) <i>p</i> = .006 | -0.14 (-0.21 to -0.07) <i>p</i> = .006 | 0.17 (0.11–0.25) <i>p</i> = .006 | 0.13 (0.08–0.19) <i>p</i> = .005 | -0.17 (-0.25 to -0.11) <i>p</i> = .007 | -0.09 (-0.14 to -0.05) <i>p</i> = .007 |
| Self-esteem | | -0.06 (-0.12 to -0.03) <i>p</i> = .015 | 0.115 (0.08–0.17) <i>p</i> = .005 | 0.32 (0.23–0.42) <i>p</i> = .009 | -0.38 (-0.47 to -0.31) <i>p</i> = .005 | -0.32 (-0.39 to -0.24) <i>p</i> = .015 |
| Resources | | | | 0.12 (0.05–0.17) <i>p</i> = .011 | -0.14 (-0.19 to -0.09) <i>p</i> = .004 | -0.08 (-0.12 to -0.05) <i>p</i> = .004 |
| Threat | | | | | 0.08 (0.03–0.13) <i>p</i> = .005 | 0.20 (0.14–0.28) <i>p</i> = .034 |
| Challenge | | | | | -0.04 (-0.08 to -0.01) <i>p</i> = .006 | -0.17 (-0.26 to -0.13) <i>p</i> = .005 |
| Distress tolerance | | | | | | -0.09 (-0.15 to -0.03) <i>p</i> = .003 |

Note: Predictor variables are in the left-hand column, and outcome variables are across the top of the table.

4 | DISCUSSION

The aim of the present study was to integrate Lubans et al. (2016) psychosocial hypothesis and Lazarus and Folkman's (1984) TMSC and examine the psychological pathways underlying the relationships between PA, stress, and mental health (in the form of anxiety and depressive symptoms) among older adolescents. The specific models tested examined the extent to which PA was associated with stress and anxiety or depressive symptoms indirectly via self-esteem, stress appraisals, and distress tolerance. All hypothesized pathways in both hypothesized models were supported (except the pathway from self-esteem to distress tolerance [both models] and distress tolerance to depressive symptoms) and the data provided a good fit for both models. PA was positively associated with self-esteem, which, in turn, was positively associated with perceived resources and challenge appraisal, and negatively associated with threat appraisal and perceived stress. Resources were positively associated with challenge appraisal and negatively associated with threat appraisal. Challenge appraisal was then positively associated with distress tolerance and negatively associated with perceived stress, with the reverse found for threat appraisal. Distress tolerance was negatively associated with perceived stress and anxiety, perceived stress was positively associated with anxiety and depressive symptoms.

Bivariate correlations in the present study demonstrated that greater levels of PA were associated with lower levels of stress, anxiety, and depressive symptoms, supporting existing literature (Biddle et al., 2019; Hammen, 2005; O'Connor et al., 2010). However, when alternate models which included direct relationships between PA and perceived stress, and PA and anxiety and depressive symptoms were tested, these relationships were nonsignificant. Collectively these findings support the notion that PA is indirectly related to perceived stress, and anxiety/depressive symptoms through self-esteem and the associations self-esteem has with stress appraisals, and perceived stress, as well as the relationship between perceived stress and anxiety or depressive symptoms.

The findings of the present study provide support for the psychosocial hypothesis presented by Lubans et al. (2016). PA was seen to be positively associated with self-esteem, suggesting PA is associated with better mental health through greater self-esteem. In addition, although the present study was cross-sectional, results appear to offer some support to the TMSC (Lazarus & Folkman, 1984). Lazarus and Folkman (1984) proposed that personal characteristics such as self-esteem are likely to influence resource appraisals which determine challenge and threat appraisals, and in turn, these can impact coping with stress. Although the findings in the present study are correlational, they do suggest the importance of self-esteem being associated with more adaptive stress appraisals in lower perceived stress and internalizing symptoms.

Collectively the results from the present study appear to support the integration of Lubans et al.'s (2016) psychosocial hypothesis and the TMSC by Lazarus and Folkman (1984). Specifically, the relationship between PA and perceived stress operated indirectly through self-esteem and stress appraisals. The direct association between greater self-esteem and lower perceived stress also supported previous literature (Abdullah et al., 2020). The fact that perceived stress was associated with lower anxiety and depressive symptoms suggests an extension of Lubans et al.'s (2016) psychosocial hypothesis. Rather than PA leading to better mental health by being associated with greater self-esteem, the present study suggests that higher self-esteem may also lead to improved mental health through more adaptive stress appraisals and lower perceived stress. Given the prevalence of stress among older adolescents and the impact that stress can have on adolescent mental health, higher levels of self-esteem arising from PA to protect against stress and the negative impact it can have on mental health seem like a logical hypothesis. The present study suggests this could be somewhat through higher self-esteem being associated with appraising stress more adaptively. However, it is important to note that this is merely a suggestion. The present findings are limited in being correlational meaning future research needs to test this hypothesis causally.

While the current study took a psychological perspective to investigate how PA relates to better mental health in adolescents, it is important to note that there are likely to be other indirect effects to consider. A wealth of literature has evidenced other benefits of PA that may play a role in improving mental health. For example, research has shown that PA interventions are associated with physiological outcomes indicative of more adaptive responses to stress such as decreased levels of the stress hormone cortisol (De Nys et al., 2022; Moraes et al., 2018) or more attenuated blood pressure (Chen et al., 2022; Farah et al., 2021). Additionally, in their systematic review, Lubans et al. (2016) provide some evidence for other avenues including neurobiological mechanisms in which PA could enhance mental health through changes in the functional composition and structure of the brain for example (Davis et al., 2011; Hillman et al., 2014). Consequently, while the present study suggests self-esteem, more adaptive stress appraisals, and lower perceived stress are one explanation for how PA is related to better mental health, it is important for future research to investigate some of the other likely indirect effects explaining the PA mental health relationship.

Additionally, the context in which PA is performed has the potential to strengthen or weaken the relationship between PA and self-esteem, perceived stress, and internalizing symptoms in different ways. For example, previous research has suggested that the increases in self-esteem post-PA are greater when PA is performed in green space (Barton et al., 2012). Additionally, individual characteristics can also influence the PA and self-esteem relationship. When examining adolescents participating in various levels of sport, individuals having a goal orientation was more beneficial than a win orientation, and more important than athletic ability level in the PA improving self-esteem (Findlay & Bowker, 2009). It has also been seen that those who are autonomously or intrinsically motivated to be physically active have higher self-esteem than those who are

more externally motivated (Wilson & Rodgers, 2002). Therefore, future work should consider the different personal and situational factors that may impact the effect of PA on self-esteem, perceived stress, and internalizing symptoms and establish how PA could be tailored best to have the most positive impact in the context of these factors.

4.1 | Strengths and limitations

One key strength of the present study was the use of path analysis to explore multiple relationships between variables and indirect pathways simultaneously. This allowed for a more comprehensive understanding of how the variables relate and contribute to each other. An additional strength of the study is the large and varied sample of adolescents recruited from various types of schools (e.g., private and state schools) and organizations (e.g., sports clubs, music societies, youth theater, cadets, etc.), with representation in the sample from across the country. It is not possible, however, to calculate an exact response rate, as many organizations or schools (e.g., school contacts) did not always respond to the researchers' contact emails, but survey responses were received from participants associated with some of these organizations or schools suggesting information about the study must have been circulated to the adolescents and their parents if under 16. The use of social media as a recruitment method also broadened the reach of the survey, but it is not possible to determine the exact number of responses gained as a result.

Limitations of the study include the use of a cross-sectional design which cannot infer causation. While the use of cross-sectional data in path analysis is often debated, as the intention of the study was to examine the existence of the relationships in the hypothesized model, not whether these relationships are causal, cross-sectional data is appropriate (Cain et al., 2018). In providing support for the proposed relationships, findings expand on existing suggestions from the literature, for example, Lazarus and Folkman (1984) and Lubans et al. (2016), laying the foundations for future research to test these associations in a more casual manner. A further limitation is the use of a self-report single-item measure of PA, however, single-item self-report measures of PA have previously been found to be a reliable and valid measure of PA in adolescent populations (Scott et al., 2015). Despite this, future research should re-examine these relationships using an objective measure of PA such as accelerometer data. An additional limitation is a slightly low-reliability score for the resources subscale in the stress appraisal measure for adolescents (0.67), and the depressive symptoms subscale from the HADS (0.69) which mean results for these scales must be interpreted with caution. However, the resources subscale only has three items which are likely to have contributed to the slightly low-reliability score and the depression subscale of the HADS has been extensively validated and previously found to be reliable in this population (White et al., 1999; Zigmond & Snaith, 1983). It must also be noted that the bivariate correlations presented between PA and other model variables are all significant, despite low effect sizes. While this demonstrates the study had sufficient power to detect significant associations, the size of some of the associations was not as meaningful as others.

4.2 | Practical implications and suggestions for future research

The findings of the present study highlight important relationships between PA, self-esteem, perceived stress, and anxiety and depressive symptoms. As PA is a relatively cheap and accessible method to potentially facilitate improvements in self-esteem and subsequent stress and mental health, it is likely to be an important tool and focus of mental health and self-esteem interventions. While there are other potential interventions available that have seen success in increasing self-esteem, such as mindfulness-based interventions (Randal et al., 2015) or therapeutic options such as rational emotive behavior therapy (Sælid & Nordahl, 2017), it is often seen that adolescents fail to access mental health support (Radez et al., 2021). This can be for a variety of reasons including perceived stigma and embarrassment, lack of access to professional services, or negative perceptions of mental health practitioners, including perceived lack of confidentiality (Radez et al., 2021). Therefore, potential interventions that do not require accessing mental health services or professionals, such as PA, that can be completed when convenient and in a way that is enjoyed, could be more easily used by adolescents to increase their self-esteem.

Addressing some of the limitations in the present study's cross-sectional design, it would be beneficial for future research to investigate how the relationships between PA, stress, and anxiety/depressive symptoms change over time and whether different types and levels of perceived stress change the relationships. Examining these relationships over time could help provide focus to potential interventions, for example, at what point before a predetermined stressor (e.g., an exam) would PA need to be implemented for best effects. Given that research has found associations between longer sedentary time and poorer mental health in adolescents, including higher depression and anxiety and lower self-esteem (Hoare et al., 2016), it is important for future research to consider the effects of sedentary behavior on these variables.

Future research could also examine if the present study findings are applicable to younger adolescents. With the WHO (2018) defining adolescence as the period from age 10–19, the current study does not address the 10–14 portion of this age group. As Rodriguez-Ayllon et al. (2019) note, PA has different associations with mental health in different developmental

periods, and UNICEF (2021) suggesting up to 13.5% of adolescents in this age group experience a probable mental health condition, it is important to see if the findings from this study among older adolescents apply to younger adolescents. Additionally, although WHO (2018), identifies older adolescence as ages 15–19 years old, this is still quite a large age range. Future research could break down this age group further to examine the relationships between smaller age brackets, or how relationships change over time within the 15–19-year-old period. Similarly, future research should look to extend the findings of the current study to young adults (18–24). Approximately, 75% of all mental health issues begin before the age of 24 (Kessler et al., 2005), with this age group experiencing numerous stress-evoking life transitions (e.g., moving away from home for the first time, whether this is to university or work, and having to take on the responsibility of becoming adults). Therefore, it is essential to extend the current research into this next age bracket, to see whether similar mechanisms are in play to explain PA's benefits on mental health.

5 | CONCLUSION

In conclusion, the present study examined the relationships between PA, stress, anxiety, and depressive symptoms among older adolescents. Findings demonstrated that PA is associated with increased self-esteem, adaptive stress appraisals, and higher distress tolerance, which were associated with reduced stress, which, in turn, was related to lower anxiety and depressive symptoms. Collectively this research provides an insight into how PA may relate to lower stress and better mental health among older adolescents through increased self-esteem which is associated with more adaptive stress appraisal. Future research should further examine these relationships assessing PA objectively and investigating how the PA/stress relationship changes over time.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request.

ETHICS STATEMENT

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki Declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study. Informed consent was also given by the parent/guardian of any participant under the age of 16.

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REFERENCES

- Abdullah, E. S. P. S., Winarsunu, T., & Yuniardi, M. S. (2020). The effect of self esteem group therapy on distress tolerance of broken home teenagers. *Journal of Psychiatry and Psychology Research*, 3(5), 266–271.
- Aina, Y., & Susman, J. L. (2006). Understanding comorbidity with depression and anxiety disorders. *The Journal of the American Osteopathic Association*, 106(5 Suppl 2), 9–14.
- Alimoradi, Z., Ohayon, M. M., Griffiths, M. D., Lin, C.-Y., & Pakpour, A. H. (2022). Fear of COVID-19 and its association with mental health-related factors: Systematic review and meta-analysis. *BJPsych Open*, 8(2), e73.
- Barton, J., Griffin, M., & Pretty, J. (2012). Exercise-, nature- and socially interactive-based initiatives improve mood and self-esteem in the clinical population. *Perspectives in Public Health*, 132(2), 89–96.
- Biddle, S. J. H., Ciacconi, S., Thomas, G., & Vergeer, I. (2019). Physical activity and mental health in children and adolescents: An updated review of reviews and an analysis of causality. *Psychology of Sport and Exercise*, 42, 146–155.
- Byrne, D. G., Davenport, S. C., & Mazanov, J. (2007). Profiles of adolescent stress: The development of the adolescent stress questionnaire (ASQ). *Journal of Adolescence*, 30(3), 393–416.
- Cain, M. K., Zhang, Z., & Bergeman, C. S. (2018). Time and other considerations in mediation design. *Educational and Psychological Measurement*, 78(6), 952–972.
- Carlozzi, B. L., Winterowd, C., Steven Harrist, R., Thomason, N., Bratkovich, K., & Worth, S. (2010). Spirituality, anger, and stress in early adolescents. *Journal of Religion and Health*, 49(4), 445–459.

- Chamberlain, S., Daly, A. L., & Spalding, V. (2011). The fear factor: Students' experiences of test anxiety when taking A-level examinations. *Pastoral Care in Education, 29*(3), 193–205.
- Chen, W. J., Mat Ludin, A. F., & Farah, N. M. F. (2022). Can acute exercise lower cardiovascular stress reactivity? Findings from a scoping review. *Journal of Cardiovascular Development and Disease, 9*(4), 106.
- Cohen, S., Kamarck, T., & Mermelstein, R. (1983). A global measure of perceived stress. *Journal of Health and Social Behavior, 24*, 385–396.
- Crowm, M. (2021). *Testing specific indirect effects in AMOS via user-defined estimands [PowerPoint Slides]*. The University of Oklahoma. Retrieved March 3, 2023, from https://drive.google.com/file/d/17KA7rBzlyD7dR_IMbXw1_KD1hrjXMKz/edit
- Davis, C. L., Tomporowski, P. D., McDowell, J. E., Austin, B. P., Miller, P. H., Yanasak, N. E., Allison, J. D., & Naglieri, J. A. (2011). Exercise improves executive function and achievement and alters brain activation in overweight children: A randomized, controlled trial. *Health Psychology, 30*(1), 91–98.
- DeLongis, A., & Holtzman, S. (2005). Coping in context: The role of stress, social support, and personality in coping. *Journal of Personality, 73*(6), 1633–1656.
- De Nys, L., Anderson, K., Oforu, E. F., Ryde, G. C., Connelly, J., & Whittaker, A. C. (2022). The effects of physical activity on cortisol and sleep: A systematic review and meta-analysis. *Psychoneuroendocrinology, 143*, 105843.
- Farah, N. M., Amran, A. D., & Che Muhamed, A. M. (2021). Attenuation of stress-induced cardiovascular reactivity following high-intensity interval exercise in untrained males. *Journal of Sports Sciences, 39*(24), 2755–2762.
- Findlay, L. C., & Bowker, A. (2009). The link between competitive sport participation and self-concept in early adolescence: A consideration of gender and sport orientation. *Journal of Youth and Adolescence, 38*(1), 29–40.
- Guddal, M. H., Stensland, S. Ø., Småstuen, M. C., Johnsen, M. B., Zwart, J.-A., & Storheim, K. (2019). Physical activity and sport participation among adolescents: Associations with mental health in different age groups. Results from the Young-HUNT study: A cross-sectional survey. *BMJ Open, 9*(9), e028555.
- Hammen, C. (2005). Stress and depression. *Annual Review of Clinical Psychology, 1*, 293–319.
- Harvey, C. M., Newell, M.-L., & Padmadas, S. (2022). Maternal socioeconomic status and infant feeding practices underlying pathways to child stunting in Cambodia: Structural path analysis using cross-sectional population data. *BMJ Open, 12*(11), e055853.
- Hayes, A. F. (2018). *Introduction to mediation, moderation, and conditional process analysis second edition: A regression-based approach*. The Guilford Press.
- Hillman, C. H., Pontifex, M. B., Castelli, D. M., Khan, N. A., Raine, L. B., Scudder, M. R., Drollette, E. S., Moore, R. D., Wu, C.-T., & Kamijo, K. (2014). Effects of the FITKids randomized controlled trial on executive control and brain function. *Pediatrics, 134*(4), e1063–e1071.
- Hoare, E., Milton, K., Foster, C., & Allender, S. (2016). The associations between sedentary behaviour and mental health among adolescents: A systematic review. *International Journal of Behavioral Nutrition and Physical Activity, 13*, 108.
- Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal, 6*(1), 1–55.
- IBM. (2018). *Will Amos report indirect effects?* Retrieved March 3, 2023, from <https://www.ibm.com/support/pages/will-amos-report-indirect-effects>
- Jurca, R., Jackson, A. S., LaMonte, M. J., Morrow, Jr., J. R., Blair, S. N., Wareham, N. J., Haskell, W. L., van Mechelen, W., Church, T. S., Jakicic, J. M., & Laukkanen, R. (2005). Assessing cardiorespiratory fitness without performing exercise testing. *American Journal of Preventive Medicine, 29*(3), 185–193.
- Juth, V., Smyth, J. M., & Santuzzi, A. M. (2008). How do you feel? Self-esteem predicts affect, stress, social interaction, and symptom severity during daily life in patients with chronic illness. *Journal of health psychology, 13*(7), 884–894.
- Kessler, R. C., Berglund, P., Demler, O., Jin, R., Merikangas, K. R., & Walters, E. E. (2005). Lifetime prevalence and age-of-onset distributions of DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry, 62*(6), 593–602.
- Lazarus, R. S., & Folkman, S. (1984). *Stress, appraisal, and coping*. Springer publishing company.
- Lee, S. Y., Park, C. L., & Russell, B. S. (2018). Does distress tolerance interact with trait anxiety to predict challenge or threat appraisals? *Personality and Individual Differences, 132*, 14–19.
- Little, R. J. A. (1988). A test of missing completely at random for multivariate data with missing values. *Journal of the American Statistical Association, 83*(404), 1198–1202.
- Lubans, D., Richards, J., Hillman, C., Faulkner, G., Beauchamp, M., Nilsson, M., Kelly, P., Smith, J., Raine, L., & Biddle, S. (2016). Physical activity for cognitive and mental health in youth: A systematic review of mechanisms. *Pediatrics, 138*(3), e20161642.
- McCluskey, G., Fry, D., Hamilton, S., King, A., Laurie, M., McAra, L., & Stewart, T. M. (2021). School closures, exam cancellations and isolation: The impact of Covid-19 on young people's mental health. *Emotional and Behavioural Difficulties, 26*(1), 46–59.
- McHugh, R. K., Kertz, S. J., Weiss, R. B., Baskin-Sommers, A. R., Hearon, B. A., & Björngvinsson, T. (2014). Changes in distress intolerance and treatment outcome in a partial hospital setting. *Behavior Therapy, 45*(2), 232–240.
- Meijen, C., Turner, M., Jones, M. V., Sheffield, D., & McCarthy, P. (2020). A theory of challenge and threat states in athletes: A revised conceptualization. *Frontiers in Psychology, 11*, 126.
- Moraes, L. J., Miranda, M. B., Loures, L. F., Mainieri, A. G., & Mármora, C. (2018). A systematic review of psychoneuroimmunology-based interventions. *Psychology, Health & Medicine, 23*(6), 635–652.
- Newlove-Delgado, T., Marcheselli, F., Williams, T., Mandalia, D., Davis, J., McManus, S., Savic, M., Treloar, W., & Ford, T. (2022). *Mental health of children and young people in England, 2022*. NHS Digital.
- Nicholls, A. R., Polman, R. C., & Levy, A. R. (2012). A path analysis of stress appraisals, emotions, coping, and performance satisfaction among athletes. *Psychology of Sport and Exercise, 13*(3), 263–270.
- O'Connor, R. C., Rasmussen, S., & Hawton, K. (2010). Predicting depression, anxiety and self-harm in adolescents: The role of perfectionism and acute life stress. *Behaviour Research and Therapy, 48*(1), 52–59.
- Ozcan, N. A. (2019). The mediator role of cognitive flexibility and mindfulness in relationship between perceived stress and distress tolerance among university students. *European Journal of Education Studies, 6*(9), 316–332.
- Paschke, K., Arnaud, N., Austermann, M. I., & Thomasius, R. (2021). Risk factors for prospective increase in psychological stress during COVID-19 lockdown in a representative sample of adolescents and their parents. *BJPsych Open, 7*(3), e94.
- Pascoe, M. C., Hetrick, S. E., & Parker, A. G. (2020). The impact of stress on students in secondary school and higher education. *International Journal of Adolescence and Youth, 25*(1), 104–112.
- Pruessner, J. C., Hellhammer, D. H., & Kirschbaum, C. (1999). Low self-esteem, induced failure and the adrenocortical stress response. *Personality and Individual Differences, 27*(3), 477–489.

- Radez, J., Reardon, T., Creswell, C., Lawrence, P. J., Evdoka-Burton, G., & Waite, P. (2021). Why do children and adolescents (not) seek and access professional help for their mental health problems? A systematic review of quantitative and qualitative studies. *European Child & Adolescent Psychiatry, 30*, 183–211.
- Randal, C., Pratt, D., & Bucci, S. (2015). Mindfulness and self-esteem: A systematic review. *Mindfulness, 6*, 1366–1378.
- Rodriguez-Ayllon, M., Cadenas-Sanchez, C., Estevez-Lopez, F., Munoz, N. E., Mora-Gonzalez, J., Migueles, J. H., Molina-Garcia, P., Henriksson, H., Mena-Molina, A., & Martinez-Vizcaino, V. (2019). Role of physical activity and sedentary behavior in the mental health of preschoolers, children and adolescents: A systematic review and meta-analysis. *Sports Medicine, 49*, 1383–1410.
- Roome, T., & Soan, C. A. (2019). GCSE exam stress: Student perceptions of the effects on wellbeing and performance. *Pastoral Care in Education, 37*(4), 297–315.
- Rosenberg, M. (1965). Rosenberg self-esteem scale (RSE). *Acceptance and Commitment Therapy. Measures Package, 61*(52), 18.
- Rowley, A. A., Roesch, S. C., Jurica, B. J., & Vaughn, A. A. (2005). Developing and validating a stress appraisal measure for minority adolescents. *Journal of Adolescence, 28*(4), 547–557.
- Roy, K., Kamath, V., & Kamath, A. (2015). Determinants of adolescent stress: A narrative review. *European Journal of Psychology & Educational Studies, 2*(2), 48.
- Sælid, G. A., & Nordahl, H. M. (2017). Rational emotive behaviour therapy in high schools to educate in mental health and empower youth health. A randomized controlled study of a brief intervention. *Cognitive Behaviour Therapy, 46*(3), 196–210.
- Schneider, R. L., Long, E. E., Arch, J. J., & Hankin, B. L. (2021). The relationship between stressful events, emotion dysregulation, and anxiety symptoms among youth: Longitudinal support for stress causation but not stress generation. *Anxiety, Stress, and Coping, 34*(2), 157–172.
- Schwartz, K. D., Exner-Cortens, D., McMorris, C. A., Makarenko, E., Arnold, P., Van Bavel, M., Williams, S., & Canfield, R. (2021). COVID-19 and student well-being: Stress and mental health during return-to-school. *Canadian Journal of School Psychology, 36*(2), 166–185.
- Scott, J. J., Morgan, P. J., Plotnikoff, R. C., & Lubans, D. R. (2015). Reliability and validity of a single-item physical activity measure for adolescents. *Journal of Paediatrics and Child Health, 51*(8), 787–793.
- Seeman, M., & Lewis, S. (1995). Powerlessness, health and mortality: A longitudinal study of older men and mature women. *Social Science & Medicine, 41*(4), 517–525.
- Simons, J. S., & Gaher, R. M. (2005). The Distress Tolerance Scale: Development and validation of a self-report measure. *Motivation and Emotion, 29*(2), 83–102.
- Sonstroem, R. J. (1998). Physical self-concept: Assessment and external validity. *Exercise and Sport Sciences Reviews, 26*(1), 133–164.
- Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics: International edition*. Pearson.
- Tambs, K., & Røysamb, E. (2014). Selection of questions to short-form versions of original psychometric instruments in MoBa. *Norsk Epidemiologi, 24*, 195–201.
- Taylor, S. E., & Stanton, A. L. (2007). Coping resources, coping processes, and mental health. *Annual Review of Clinical Psychology, 3*, 377–401.
- Trotman, G. P., Williams, S. E., Quinton, M. L., & Veldhuijzen van Zanten, J. (2018). Challenge and threat states: Examining cardiovascular, cognitive and affective responses to two distinct laboratory stress tasks. *International Journal of Psychophysiology, 126*, 42–51.
- Tully, P. J., Zajac, I. T., & Venning, A. J. (2009). The structure of anxiety and depression in a normative sample of younger and older Australian adolescents. *Journal of Abnormal Child Psychology, 37*, 717–726.
- UNICEF. (2021). *The state of the world's children 2021: On my mind—Promoting, protecting and caring for children's mental health*. UNICEF.
- White, D., Leach, C., Sims, R., Atkinson, M., & Cottrell, D. (1999). Validation of the Hospital Anxiety and Depression Scale for use with adolescents. *British Journal of Psychiatry, 175*(5), 452–454.
- Williams, S. E., & Cumming, J. (2012). Sport imagery ability predicts trait confidence, and challenge and threat appraisal tendencies. *European Journal of Sport Science, 12*(6), 499–508.
- Wilson, P. M., & Rodgers, W. (2002). The relationship between exercise motives and physical self-esteem in female exercise participants: An application of self-determination theory. *Journal of Applied Biobehavioral Research, 7*(1), 30–43.
- Wolitzky-Taylor, K., Guillot, C. R., Pang, R. D., Kirkpatrick, M. G., Zvolensky, M. J., Buckner, J. D., & Leventhal, A. M. (2015). Examination of anxiety sensitivity and distress tolerance as transdiagnostic mechanisms linking multiple anxiety pathologies to alcohol use problems in adolescents. *Alcoholism: Clinical and Experimental Research, 39*(3), 532–539.
- Wood, C., Angus, C., Pretty, J., Sandercock, G., & Barton, J. (2013). A randomised control trial of physical activity in a perceived environment on self-esteem and mood in UK adolescents. *International Journal of Environmental Health Research, 23*(4), 311–320.
- World Health Organisation (WHO). (2018). *Adolescent mental health in the European Region: Factsheet for World Mental Health Day 2018*. WHO.
- Wright, L. J., Williams, S. E., & Veldhuijzen van Zanten, J. J. C. S. (2021). Physical activity protects against the negative impact of coronavirus fear on adolescent mental health and well-being during the COVID-19 pandemic. *Frontiers in Psychology, 12*, 580511.
- Yarcheski, A., & Mahon, N. E. (1999). The moderator-mediator role of social support in early adolescents. *Western Journal of Nursing Research, 21*(5), 685–698.
- Zigmond, A. S., & Snaith, R. P. (1983). The Hospital Anxiety and Depression Scale. *Acta Psychiatrica Scandinavica, 67*(6), 361–370.

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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