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Can physical activity help explain the gender gap in adolescent mental health? A cross-sectional exploration

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ABSTRACT

Studies find that physical activity links with mental health, females engage in less physical activity than males, and females have worse mental health than males. Less attention has been paid to the intersection of physical activity, mental health, and gender. Might physical activity explain links between gender and mental health in adolescence? Or does the mental health benefit of physical activity depend on gender? In addition, while physical activity correlates with better mental health overall, it may be more beneficial for some domains than others. Using four years of cross-sectional data from students (1,756 cases over four years, ages 13–18), we (1) confirmed gender differences in physical activity and mental health, replicating prior studies; examined gender (2) as a confounding variable and (3) as a moderator of the physical activity-mental health link; and (4) tested physical activity as a mediator between gender and mental health. In addition, we considered whether associations vary for different positive and negative mental health domains. Females reported poorer mental health; males engaged in more physical activity. Physical activity was associated with all markers of mental health, having stronger correlations with Engagement and Perseverance than other positive and negative domains. Results better supported a mediational model (physical activity mediating gender-mental health associations) than a moderation model (gender moderating physical activity-mental health associations). Findings indicate the value of physical activity as an adolescent mental health intervention and suggest that barriers to females' participation in physical activity should be considered.

1. Introduction

It is a robust finding that physical activity has beneficial associations with good mental health (Biddle & Asare, 2011; Penedo & Dahn, 2005). However, physical activity participation varies by gender, as evidenced by both the scientific literature (e.g., Azevedo et al., 2007) and multiple nations' census data (e.g., Australian Bureau of Statistics, 2013), with females less likely to engage in physical activity than males. Notably, females also report poorer mental health than males, reporting both higher rates of internalising disorders and, albeit less consistently, lower levels of positive psychological functioning (Rosenfield & Mouzon, 2013; Shute, 2016). These differences in physical activity and mental health begin in adolescence and continue into adulthood (Telzer & Fuligni, 2013; Trost et al., 2002).

While evidence of these links is strong, studies that directly connect gender, mental health, and physical activity in adolescence are relatively sparse. Could females' lack of physical activity help to explain their poorer levels of mental health? Alternatively, due to a variety of biological and social factors, associations between physical activity and mental health might differ for males and females. Might males simply derive more mental health benefits from their participation in physical activity? In addition, while many studies focus on the benefit of physical activity to different types of mental illness, including depression, anxiety, and schizophrenia (e.g., Bailey, Hetrick, Rosenbaum, Purcell, & Parker, 2017; Rosenbaum, Tiedemann, Sherrington, Curtis, & Ward, 2014; Ströhle, 2009), less is known about the link between physical activity and different domains of *positive* psychological functioning, such as social connectedness, optimism, and resilience. Which domains of positive mental health might benefit the most from physical activity?

The current study explores these questions by examining associations amongst gender, physical activity, and positive and negative mental health in adolescents. Although we use a correlational research design and thus cannot fully answer the questions posed above, we examine the direction and strength of relationships amongst these variables, providing a foundation for future investigations.

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1.1. Associations between physical activity and mental health

Mental health includes both positive and negative domains of psychological functioning (World Health Organization, 2013). For our purposes here, we define positive mental health as dimensions of psychological functioning that are positive and adaptive (e.g., optimism, perseverance, engagement, resilience), whereas negative mental health refers to mental health problems, disorders, and symptoms of mental illness (e.g., depression, anxiety). We define physical activity in line with the World Health Organization (2011) as: "any bodily movement produced by skeletal muscles that results in energy expenditure". Physical activity includes the subsets of 'exercise' and 'sport' – these terms are often used interchangeably (for discussion of types, intensities and measurements of physical activity see Kern, 2015).

It is now widely acknowledged that the benefits of physical activity extend well beyond physical health, impacting mental health (Eime, Young, Harvey, Charity, & Payne, 2013), cognitive functioning (Kramer & Erickson, 2007), and social relationships (Kern, 2015). The bulk of evidence comes from cross-sectional data, making it difficult to state that physical activity *causes* better mental health, but a growing number of experimental (e.g., Christiansen et al., 2018; Oddie et al., 2014) and longitudinal studies (cf. Mammen & Faulkner, 2013) support physical activity as being beneficial across a range of domains.

Both cross-sectional and longitudinal studies demonstrate physical activity's inverse association with negative mental health, especially for depression (Daley, 2008; Morgan, Parker, Alvarez-Jimenez, & Jorm, 2013). Physical activity has been investigated as a preventative intervention (e.g., Mammen & Faulkner, 2013) and as a treatment (Paluska & Schwenk, 2000) for negative mental health, and has been found to be a less expensive, longer lasting and equally effective treatment compared to psychotherapy or medication (Dobson et al., 2008; Kern, 2015). Associations most likely are bi-directional; physical inactivity may be the antecedent and/or the result of poor mental health (Hoare, Milton, Foster, & Allender, 2016; Morgan et al., 2013).

Fewer studies have focused on positive mental health, but existing evidence again links physical activity to better positive mental health. For example, in a large representative sample of 11,110 European adolescents, physical activity levels and participation in sport were found to independently contribute to higher levels of wellbeing (McMahon et al., 2017). Physical activity has been linked with greater curiosity, exploratory behaviour, and mental toughness (Brand et al., 2017; Gerber et al., 2012). In a systematic review, Rasberry et al. (2011) linked physical activity with better cognitive skills and attitudes, academic behaviours, and academic achievement.

1.2. Gender gaps in physical activity and mental health

Notably, there are gaps between males and females in both physical activity and mental health. Across decades and cultures, males overwhelmingly report engaging in a greater amount and higher intensity physical activity than females (e.g., Armstrong & Welsman, 2006; Azevedo et al., 2007; Brand et al., 2017; Colley et al., 2011; Sallis, Prochaska, & Taylor, 2000; Trost et al., 2002; Voss, Ogunleye, & Sandercock, 2013). For example, across 17 countries (out of 20), females reported being less engaged in highly-active physical activity than males (Bauman et al., 2009). In Australia, males reported higher rates of high-level physical activity (19%, compared with 11% of females) and lower rates of low-level physical activity (31% compared with 39% of females) (Australian Bureau of Statistics, 2013). The gender gap in physical activity begins in childhood. In a review of children and adolescents 7–16 years of age, males of all ages were found to participate in more physical activity than females and this gender difference was most apparent for vigorous activities (Armstrong & Welsman, 2006).

In a parallel vein, data consistently reveals "something deeply worrying about girls' well-being" (Finch, Hargrave, Nicholls, & van Vliet, 2014, p. 8). It has been estimated that 29% of females experience depression in their lifetime, compared to 18% of males, while 34% of females versus 23% of males experience anxiety (Rosenfield & Mouzon, 2013). This likely begins in early adolescence; findings across cultures, ethnic groups, nations, socioeconomic backgrounds, point to mental health being similar before age 11, and by age 18, girls are more than twice as likely as boys to experience internalising symptoms (Telzer & Fuligni, 2013). Notably, Kessler (2003), suggested that higher rates of depression among adult females is due to a higher risk of initial onset, rather than differential persistence or recurrence, making adolescence a crucial time for intervention both for treatment and prevention.

Evidence of females' lower positive mental health is less consistent than evidence for negative mental health, but still is concerning. Adult studies have shown females measuring lower in positive mental health constructs such as self-efficacy and resilience (e.g., Bergman & Scott, 2001; Roy et al., 2018; Tomyn & Weinberg, 2018), although females often report better social relationships (e.g., Ryff & Keyes, 1995). Across 10,878 participants in 11 European countries, Lehtinen, Sohlman, and Kovess-Masfety (2005) found better positive mental health in males, but also note inconsistencies. Studies involving young people generally show females report lower positive mental health than males. For instance, a government report of 42,577 students in grades 6–9 (approximately aged 10–14 years) found that girls reported lower satisfaction with life, optimism and happiness than boys, largely due to girls reporting a greater decline as they transitioned into secondary schooling (Department for Education and Child Development, 2017). However, the size and direction of gender differences depend on the domain under consideration. For example, data collected from almost 7,000 adolescents in the UK found that, at 16 years of age, females were lower in self-esteem, emotional wellbeing, life satisfaction and resilience than males, whereas there was little difference for satisfaction with friends (Finch et al., 2014). Across 1,930 Australian middle/junior high school students, females scored significantly lower than males on measures of resilience, global self-concept, flourishing, and emotional and psychological wellbeing, but reported greater levels of cognitive and affective empathy and self-reflection (Skrzypiec, Askell-Williams, Slee, & Rudzinski, 2014).

1.3. The current study

Gender differences are clearly seen in physical activity and mental health, with males likely to be more active and experience better mental health than females, in both adolescents and adults. Notably, across studies, gender is often ignored or controlled, rather than directly investigated. The current study examines the role that physical activity might play in the relationship between gender and mental health, testing potential mediating and moderating associations amongst gender, physical activity, and mental health. We (1) replicate existing trends, testing whether boys are more physically active and report better mental health than females in these datasets; (2) test gender as a confounding variable, examining the extent to which physical activity and gender uniquely correlate with mental health; (3) test gender as a moderator of physical activity and mental health associations, assessing the extent to which associations between physical activity and mental health differ by gender; and (4) test physical activity as a mediator between gender and mental health, examining the extent to which physical activity might explain associations between them. In addition, within each set of analyses, we explore physical activity's association with different domains of positive mental health that were assessed in the study (i.e., Engagement, Perseverance, Optimism, Connectedness, Happiness or Resilience), and compare these associations with physical activity-negative mental health associations. As physical activity and mental health tend to be confounded with age (e,g., Armstrong & Welsman, 2006; Armstrong, Bauman, & Davies, 2000; Bauman et al., 2009; Corder et al., 2015; Rowland, 1999; Trost et al., 2002; Voss et al., 2013), we control for age in all analyses.

We use four years of cross-sectional data collected from adolescents annually from 2014 to 2017. Although the available data prevented us from testing prospective associations, we replicate analyses across four datasets, providing greater confidence in the pattern of results than could occur with a single cross-sectional dataset. While the correlational nature of the study does not allow causal interpretations, by exploring the size and direction of effects, it can inform future studies, causal inferences, and evidence-based practices (Curtis, Comiskey, & Dempsey, 2015; Thompson, Diamond, McWilliam, Snyder, & Snyder, 2005).

2. Method

2.1. Participants, study design and setting

An online questionnaire was completed by students during school time in 2014, 2015, 2016 and 2017 at a government (i.e., publicly funded) high school in Australia (N = 1,756, mean age = 14.5 years, SD = 1.29, 48.1% female,[1] 15.4% language other than English (LOTE) spoken at home. Students aged less than 13 years were excluded. In 2014, grade 8s, 9s and 10s were invited to complete the questionnaire. In 2015, grade 11s was also included. In 2016 and 2017, grade 12 was also included, resulting in the final sample sets. To protect student privacy, no identifying information was collected. Some students most likely completed the survey in two or more years, but it was impossible to connect responses, such that it is unknown how dependent or independent the datasets are. To avoid potential dependencies in the data, we analyse each year separately rather than combining the sets together.

The school, located in the suburbs of a major Australian city, has a similar Index of Community Socio-Educational Advantage[2] to the Australian average. Third party informed consent was gained from students' parents/guardians. Procedures were approved by the University of Adelaide Human Research Ethics Subcommittee (reference numbers 14/22, 15/15, 16/02, 17/04) and South Australia's Department of Education and Child Development Research Unit (reference numbers CS/14/511-15, CS/15/00005-1.3, CS/16/00067-1.1, CS/17/000750-1.2).

2.2. Measures

At a similar time each year, students with consent completed an online survey, which measured demographic information, physical activity and mental health. Demographic information included age, gender, LOTE, grade and pastoral care group (i.e., homeroom).

2.2.1. EPOCH Measure of Adolescent Well-Being

The 20-item measure of adolescent wellbeing (EPOCH; Kern, Benson, Steinberg, & Steinberg, 2016) provided indicators of positive mental health across five domains: Engagement, Perseverance, Optimism, Connectedness and Happiness. Respondents indicated the extent to which they agreed with each item (5-point Likert scale; e.g., 'I keep at my schoolwork until I am done with it'). Engagement refers to being interested and involved, Perseverance refers to sticking with tasks despite challenges, Optimism refers to hopefulness and confidence about the future, Connectedness refers to the presence of satisfying relationships with others, and Happiness refers to a general tendency towards feeling happy and enjoying life (Kern et al., 2016). Scores for each domain were based on the average of four items. Kern et al. (2016) found good internal consistency and adequate psychometric properties of the measure across multiple samples of US and Australian adolescents. The measure demonstrated adequate reliability in the current sample (see Appendix A for reliability data).

2.2.2. Connor-Davidson Resilience Scale

The 10-item Connor-Davidson Resilience Scale (CD-RISC 10; Davidson & Connor, 2015) was used to provide an indication of one's adaptability and ability to cope with stress. Respondents indicated the extent to which each statement described them (5-point scale; e.g., "I tend to bounce back after illness, injury, or other hardships"), then items were summed to create a total resilience score, higher scores indicate greater resilience. This scale was included only from 2016.

2.2.3. Depression Anxiety Stress Scale (DASS-21)

The Depression Anxiety Stress Scale-21 (DASS-21) was used to provide an indication of respondents' negative emotional states (Lovibond & Lovibond, 1995). The DASS-21 is a 21-item self-report measure appropriate for individuals aged 12 years or more and is comprised of scales for Depression, Anxiety, and Stress. Respondents indicated on a 4-point Likert scale the extent to which each statement described them over the past week (e.g., "I found it hard to wind down"). Tully, Zajac, and Venning (2009) found the DASS-21 to have excellent psychometric properties within an adolescent population (N = 4,039, aged 12–18 years), reporting a high internal consistency for all scales.

2.2.4. Physical Activity Questionnaire – Adolescents (PAQ-A)

The Physical Activity Questionnaire for Adolescents (PAQ-A; Kowalski, Crocker, & Donen, 2004) was employed as a standardised measure of physical activity. The measure does not discriminate between specific activity intensities, but instead assesses a general level of physical activity. The PAQ-A is comprised of nine items using a 5-point Likert-type scale and asks for physical activity in the last 7 days (e.g., "what did you normally do at lunch (besides eating lunch)? 1. Sat down (talking, reading, doing schoolwork), 2. Stood around or walked around, 3. Ran or played a little bit, 4. Ran around and played quite a bit, 5. Ran and played hard most of the time). To be culturally relevant, we adjusted a few of the items (e.g., cross-country skiing and ice hockey/ringette were omitted and replaced with football and netball). The PAQ-A is scored between 1 (low) and 5 (high). The PAQ-A has been found to have good internal consistency and moderately high concurrent validity (Janz, Lutuchy, Wenthe, & Levy, 2008).

2.3. Statistical analysis

First,[3] systematic differences in physical activity and mental health between genders were examined using independent samples t-tests, with bootstrapping of confidence intervals (CIs) using the bias-corrected and accelerated method, re-sampling 2,000 times (Efron & Tibshirani, 1994). We report effect sizes and CIs as per recommendation of Thompson (2007). Second, we tested associations of mental health variables, gender and physical activity, controlling for age, using hierarchical linear regression with simultaneous entry of variables.

[1] The 2017 questionnaire included a third answer option for gender; 'gender diverse'. Eleven individuals identified as gender diverse, some with incomplete datasets, thus this category was treated as missing data.

[2] ICSEA provides an indication of the level of educational advantage of the school's student population relative to those of other schools using the geographical location of the school, the proportion of indigenous students catered for, and the occupation and level of education of students' parents. In 2016, scores ranged from 125 for a school in remote Arnhem Land, to 1,308 for an independent inner-city Sydney school. At the time of writing, ICSEA data were available for 2014 (1,067), 2015 (1,060) and 2016 (1,068). The Australian average is 1,000 (Australian Curriculum Assessment and Reporting Authority, 2012).

[3] A mixed model analysis was used to examine the magnitude of systematic variance within pastoral care groups (i.e., homerooms) in the 2017 data, with the variance explained (< 3%) deemed unlikely to influence results (Field, 2009); thus a single level approach was taken.

Third, we examined moderation of the relationship between physical activity and mental health by gender using moderated multiple regression. Physical activity was used to predict mental health, treating gender as a dichotomous interaction term. Fourth, we examined physical activity as a mediator between gender and mental health using the PROCESS macro (Hayes, 2012). All analyses were carried out using SPSS (version 23) software.

This study uses cross-sectional data, thus, while physical activity cannot cause gender and mental health cannot cause gender, there is no way of establishing the causal ordering of the observed relationship between physical activity and mental health. Many argue that mediation should not be used with cross-sectional data (e.g., Maxwell & Cole, 2007). However, others point out that in light of real-world constraints, knowledge can still be gained from cross-sectional mediation analyses (e.g., Disabato, 2016; Hayes, 2017). By confirming that variables do relate with each other as would be expected if mediation does indeed exist, cross-sectional mediation analyses can suggest that subsequent longitudinal studies would indeed be beneficial. There are multiple approaches to mediation analyses, but we chose to take a 'test of joint significance' approach recommended by Hayes (2009), which balances Type I error with statistical power (MacKinnon, Lockwood, Hoffman, West, & Sheets, 2002). This involved (i) determining the statistical significance of path a and b, and (ii) calculating the significance of the indirect effect (the difference between path c and c') of gender on mental health via physical activity by computing the 95% CIs (Efron & Tibshirani, 1994), using a bootstrap estimation process with 5,000 samples (Preacher & Hayes, 2004). To satisfy the criteria for mediation, the 95% CIs must not cross zero. Bootstrap tests are powerful as they detect that the sampling distribution of the mediated effect is skewed away from zero (Shrout & Bolger, 2002).

3. Results

Table 1 provides descriptive statistics for the sample in each year of measurement. The samples were comparable in terms of number, gender and LOTE. Data from each year were analysed separately, due to the likelihood of repeated cases. We describe results for the 2017 dataset and, as analysis was replicated across three additional datasets, we consider consistencies and inconsistencies with prior years.

3.1. Gender differences in physical activity and mental health

Independent sample t-tests with bootstrapped CIs indicated a significant difference between genders with a small to medium effect size in physical activity and mental health, suggesting that there are indeed gender differences in physical activity and mental health, with males being more active and reporting better mental health (Table 2). In the 2017 dataset, there were significant differences in all negative mental health variables, Engagement, Optimism, Happiness and, with a smaller effect, Resilience. In previous years' datasets, there were consistent gender differences in physical activity, Depression, Anxiety and Stress with small to medium effects, though inconsistencies occurred in positive mental health variables. For instance, gender differences in Engagement and Optimism were statistically significant only in one of the past three years, and there was little evidence of gender differences favouring males for Connectedness. Across all datasets, notable gender differences in Happiness, Depression, Anxiety and Stress that favoured males were evident.

3.2. Gender as a confounding variable

To test gender as a confounding variable in the link between physical activity and mental health, we regressed age, gender and physical activity onto each mental health variable, examining the magnitude of each predictor. Results are summarised in Table 3. In 2017, gender was not a statistically significant predictor for Perseverance, Connectedness or Resilience, but was a significant predictor for all other positive mental health variables. For Engagement, Optimism and Happiness, the beta coefficient indicated that physical activity was a stronger predictor of positive mental health than gender. Gender was a significant predictor for negative mental health variables, and the beta coefficient indicated it was a stronger predictor than physical activity. Physical activity was not a significant predictor of Anxiety or Stress. Age was a statistically significant predictor only for Stress.

Data from previous years shows similar patterns. With physical activity as a predictor in the model, gender was not a significant predictor for Engagement, Optimism and Happiness in any year, but was consistently a significant predictor of all negative mental health variables in all years. Physical activity was a significant predictor for all positive mental health variables but, with one exception, was not a significant predictor of Anxiety or Stress. Physical activity significantly predicted Depression in all but one of the years. Beta weights indicated physical activity was a stronger predictor than gender for positive mental health variables, while gender was a stronger predictor for negative mental health variables. Age was significant in only six of the possible 25 calculations.

3.3. Association of mental health and physical activity by gender

Table 4 shows that gender did not moderate effects of physical activity on mental health. Out of 36 moderations calculated across the four datasets, there was only one significant statistic (physical activity

Table 1
Sample characteristics: Adolescent cross-sectional data collected across four years.

Variable		2014	2015	2016	2017
Age (years)	Mean (SD)	14.05 (.92)	14.56 (1.23)	14.77 (1.36)	14.58 (1.44)
Total n		401	454	496	405
Females	n (%)	192 (47.88)	231 (50.88)	229 (46.17)	193 (47.65)
Males	n (%)	209 (52.12)	223 (49.12)	267 (53.83)	212 (52.35)
LOTE	n (%)	56 (13.97)	77 (16.96)	74 (14.92)	66 (16.30)
Physical Activity	Mean (SD)	2.59 (.77)	2.49 (.80)	2.49 (.82)	2.55 (.84)
Engagement	Mean (SD)	3.00 (.91)	3.00 (.82)	2.96 (.87)	3.06 (.86)
Perseverance	Mean (SD)	3.15 (.85)	3.29 (.80)	3.10 (.87)	3.22 (.87)
Optimism	Mean (SD)	3.13 (.95)	3.29 (.86)	3.15 (.90)	3.26 (.92)
Connectedness	Mean (SD)	3.82 (.89)	4.02 (.80)	3.82 (.93)	3.93 (.93)
Happiness	Mean (SD)	3.46 (1.00)	3.60 (.90)	3.44 (.99)	3.59 (.93)
Resilience	Mean (SD)	–	–	23.48 (7.79)	20.89 (11.53)
Depression	Mean (SD)	4.24 (4.53)	5.25 (4.86)	4.86 (4.34)	4.14 (4.54)
Anxiety	Mean (SD)	4.17 (4.53)	5.28 (4.59)	4.92 (3.98)	4.31 (4.26)
Stress	Mean (SD)	5.14 (4.01)	6.71 (4.66)	6.21 (4.21)	5.06 (4.35)

Note. LOTE = Language other than English. Resilience was measured beginning in 2016.

Table 2
Gender differences in Physical Activity and Mental Health.

		Group Statistics				t	Effect size (Cohen's d)	CI around effect size
		Gender	N	Mean	SD			
Physical Activity	2017	Males	186	2.74	0.90	4.28***	0.45	.24, .65
		Females	176	2.37	0.74			
	2016	Males	254	2.62	0.87	3.93***	0.36	.18, .54
		Females	220	2.33	0.71			
	2015	Males	210	2.62	0.86	3.38**	0.32	.13, .52
		Females	207	2.37	0.71			
	2014	Males	201	2.72	0.84	3.46**	0.35	.15, .55
		Females	188	2.45	0.68			
Engagement	2017	Males	183	3.22	0.86	3.42***	0.36	.15, .57
		Females	174	2.92	0.82			
	2016	Males	249	3.03	0.90	1.95	0.18	.00, .36
		Females	217	2.87	0.87			
	2015	Males	217	3.02	0.84	0.40	0.04	-.15, .22
		Females	220	2.99	0.80			
	2014	Males	197	3.14	0.91	3.10**	0.31	.11, .51
		Females	186	2.86	0.89			
Perseverance	2017	Males	183	3.28	0.84	0.94	0.10	-.11, .31
		Females	174	3.20	0.87			
	2016	Males	249	3.06	0.84	−1.09	−0.10	-.29, .08
		Females	217	3.15	0.91			
	2015	Males	217	3.24	0.82	−0.10	−0.13	-.31, .06
		Females	220	3.34	0.77			
	2014	Males	197	3.21	0.85	1.44	0.14	-.06, .34
		Females	186	3.09	0.85			
Optimism	2017	Males	183	3.44	0.88	3.08**	0.33	.12, .53
		Females	174	3.15	0.91			
	2016	Males	249	3.18	0.92	0.46	0.07	-.12, .25
		Females	217	3.12	0.88			
	2015	Males	217	3.34	0.84	1.30	0.12	-.07, .30
		Females	220	3.24	0.88			
	2014	Males	197	3.26	0.90	2.78**	0.29	.09, .49
		Females	186	2.99	0.98			
Connectedness	2017	Males	183	3.91	0.91	−1.01	−0.11	-.31, .10
		Females	174	4.01	0.88			
	2016	Males	249	3.66	0.90	−4.26***	−0.40	-.58, −.21
		Females	217	4.02	0.92			
	2015	Males	217	3.94	0.79	−2.24*	−0.21	-.40, −.03
		Females	220	4.11	0.80			
	2014	Males	197	3.74	0.88	−1.77	−0.18	-.38, .02
		Females	186	3.90	0.89			
Happiness	2017	Males	183	3.78	0.91	3.14**	0.33	.12, .54
		Females	174	3.47	0.97			
	2016	Males	249	3.48	0.98	0.88	0.08	-.10, .26
		Females	217	3.40	0.99			
	2015	Males	217	3.70	0.86	2.40*	0.23	.05, .42
		Females	220	3.49	0.93			
	2014	Males	197	3.59	0.99	2.59*	0.26	.06, .46
		Females	186	3.33	1.00			
Resilience	2017	Males	212	21.65	12.40	2.69**	0.11	-.09, .30
		Females	192	20.40	10.33			
	2016	Males	249	24.18	8.07	2.09*	0.19	.01, .38
		Females	217	22.68	7.39			
	2015	Males	–					
		Females	–					
	2014	Males	–					
		Females	–					
Depression	2017	Males	212	3.11	3.80	−4.28***	−0.43	-.63, −.23
		Females	192	4.93	4.65			
	2016	Males	249	4.39	4.11	−2.49*	−0.23	-.42, −.05
		Females	217	5.40	4.53			
	2015	Males	223	4.21	4.14	−4.63***	−0.43	-.62, −.24
		Females	231	6.26	5.27			
	2014	Males	209	3.25	3.86	4.66***	−0.47	-.67, −.27
		Females	192	5.33	4.95			
Anxiety	2017	Males	212	3.23	3.53	−5.19***	−0.52	-.72, −.32
		Females	192	5.28	4.32			
	2016	Males	249	4.12	3.51	−4.71***	−0.44	-.63, −.35
		Females	217	5.84	4.29			
	2015	Males	223	4.16	3.75	−5.30***	−0.49	-.68, −.31
		Females	231	6.37	5.06			
	2014	Males	209	3.26	3.02	−5.29***	−0.53	-.73, −.33
		Females	192	5.17	4.09			

(*continued on next page*)

Table 2 (*continued*)

Stress	2017	Males	212	3.81	3.66	−5.94***	−0.60	-.79, −.40
		Females	192	6.21	4.40			
	2016	Males	249	5.19	3.74	−5.72***	−0.54	-.72, −.35
		Females	217	7.38	4.42			
	2015	Males	223	5.83	4.24	−4.04***	−0.38	-.56, −.19
		Females	231	7.56	4.89			
	2014	Males	209	4.29	3.66	−4.54***	−0.45	-.65, −.25
		Females	192	6.06	4.18			

Note. *p < .05, **p < .01, ***p < .001. Resilience measured from 2016.

Table 3
Age, gender and physical activity regressed onto mental health variables.

		2017			2016			2015			2014		
		N	β	t	N	β	t	N	β	t	N	β	t
Engagement	Age	357	-.02	-.48	466	-.05	−1.10	417	.07	1.40	383	.08	1.78
	Gender		-.11	−2.15*		-.04	-.85		.03	.67		-.07	−1.54
	Physical Activity		.31	5.95***		.28	6.11***		.26	5.17***		.38	7.93***
Perseverance	Age	357	-.10	−1.84	466	.00	-.04	417	.07	1.45	383	.10	2.05*
	Gender		.01	.10		.10	2.29*		.11	2.29*		.00	.09
	Physical Activity		.24	4.52***		.29	6.31***		.26	5.30***		.34	6.97***
Optimism	Age	357	.01	.19	466	.01	.20	417	.09	1.75	383	.10	2.03*
	Gender		-.11	−2.06*		.02	.42		-.01	-.22		-.07	−1.37
	Physical Activity		.24	4.50***		.27	5.76***		.25	4.99***		.32	6.57***
Connectedness	Age	357	.01	.21	466	-.10	−2.14*	417	.04	.74	383	.06	1.16
	Gender		.09	1.75		.22	4.76***		.15	3.07**		.14	2.62**
	Physical Activity		.18	3.33**		.12	2.60*		.21	4.20***		.20	3.88***
Happiness	Age	357	-.08	−1.63	466	-.08	−1.81	417	.01	.19	383	-.01	-.14
	Gender		-.11	−2.18*		.00	.06		-.07	−1.40		-.08	−1.52
	Physical Activity		.23	4.25***		.23	4.98***		.26	5.38***		.29	5.92***
Resilience	Age	362	.07	1.39	466	.04	.95	–			–		
	Gender		-.10	−1.91		-.06	−1.28						
	Physical Activity		.13	2.27*		.21	4.44***						
Depression	Age	362	.08	1.56	466	.21	4.52***	417	-.02	-.33	389	-.01	-.14
	Gender		.17	3.35**		.11	2.33*		.22	4.56***		.20	4.02***
	Physical Activity		-.17	−3.16**		-.03	-.73		-.13	−2.55*		-.14	−2.83**
Anxiety	Age	362	.07	1.37	466	.13	2.77**	417	-.02	-.41	389	-.01	-.26
	Gender		.25	4.81***		.23	5.07***		.26	5.46***		.24	4.85***
	Physical Activity		-.04	-.65		.09	1.98*		-.09	−1.78		-.07	−1.39
Stress	Age	362	.14	2.63**	466	.16	3.40**	417	.02	.35	389	.02	.35
	Gender		.30	5.78***		.27	5.87***		.21	4.34***		.21	4.09***
	Physical Activity		-.01	-.26		.04	.93		-.09	−1.89		-.08	−1.51

Note. * < 0.05, ** < 0.01, *** < 0.001, Resilience was measured from 2016.

and Perseverance in 2016, with 1.2% additional variance explained), suggesting no robust effects.

3.4. Physical activity as a mediator between gender and mental health

Table 5 summarises results testing physical activity as a mediator between gender and mental health. Results for the 2017 dataset supported physical activity as influential in the association between gender and positive mental health and Depression, but not Anxiety or Stress. The bootstrapped confidence intervals for the indirect effect did not cross zero for any positive mental health variables or Depression, meaning they were significant at the $p < .05$ level, such that there is a statistically significant difference between path c (the link between gender and mental health) and path c' (the link between gender and mental health through physical activity). Mediation effects were strongest for Engagement, followed by Perseverance, Optimism, Happiness and Depression.

Similar patterns emerged across the other years, supporting physical activity as a pathway linking gender and all positive mental health variables, across all four datasets. Mediation effects were strongest for Engagement, Perseverance, Optimism and Happiness. There was also evidence for partial mediation for the link between gender and Depression in all years except 2016. In contrast, results were inconsistent for Anxiety and Stress; mediation calculations were not statistically significant, except for Anxiety in 2016, in which the more physical activity an individual did, the higher their anxiety.

4. Discussion

Despite known gender differences in physical activity and mental health, studies often treat gender either as a confounding variable and control gender in models, or ignore gender, testing models for the sample as a whole. Using four years of cross-sectional data with Australian adolescent students, this study examined the role of gender in greater detail, comparing evidence for three models: physical activity and mental health controlling for gender, gender as a moderator of physical activity-mental health associations, and physical activity and a mediator between gender and mental health. The results suggest that mental health may be impacted more by what one does (e.g., physical activity) than who one is (e.g., one's gender or age). Physical activity may mediate gender and mental health associations, such that part of known gender differences in mental health could be attributed to adolescent girls engaging in less physical activity than adolescent boys. However, associations amongst gender, physical activity, and mental health also depended upon the mental health domain under consideration.

Aligned with existing studies (e.g., Armstrong & Welsman, 2006; Colley et al., 2011; Finch et al., 2014; Skrzypiec et al., 2014), across the

Table 4
Moderation of physical activity and mental health by gender.

Variable		R^2	N	
Engagement	2017	0.001	357	F(1,352) = .41, p = .522
	2016	0.000	466	F(1,461) = .04, p = *.844*
	2015	0.002	417	F(1,412) = .84, p = *.361*
	2014	0.007	383	F(1,378) = 3.29, p = *.070*
Perseverance	2017	0.002	357	F(1,352) = .71, p = .399
	2016	0.012	466	F(1,461) = .01, p = .015
	2015	0.000	417	F(1,412) = .15, p = .699
	2014	0.002	383	F(1,378) = .85, p = .357
Optimism	2017	0.000	357	F(1,352) = .01, p = .921
	2016	0.000	466	F(1,461) = .002, p = .966
	2015	0.000	417	F(1,412) = .02, p = .885
	2014	0.004	383	F(1,378) = 1.67, p = .197
Connectedness	2017	0.000	357	F(1,352) = .05, p = .829
	2016	0.000	466	F(1,461) = .009, p = .925
	2015	0.006	417	F(1,412) = 2.71, p = .100
	2014	0.000	383	F(1,378) = .10, p = .749
Happiness	2017	0.000	357	F(1,352) = .05, p = .817
	2016	0.000	466	F(1,461) = .00, p = .984
	2015	0.004	417	F(1,412) = 1.96, p = .162
	2014	0.005	383	F(1,378) = 2.05, p = .153
Resilience	2017	0.001	362	F(1,357) = .22, p = .640
	2016	0.000	466	F(1,461) = .18, p = .676
	2015	–		
	2014	–		
Depression	2017	0.000	362	F(1,357) = .05, p = .831
	2016	0.001	466	F(1,461) = .47, p = .494
	2015	0.000	417	F(1,412) = .02, p = .883
	2014	0.001	389	F(1,384) = .32, p = .573
Anxiety	2017	0.004	362	F(1,357) = 1.40, p = .238
	2016	0.000	466	F(1,461) = .12, p = .728
	2015	0.000	417	F(1,412) = .06, p = .804
	2014	0.000	389	F(1,384) = .19, p = .665
Stress	2017	0.002	362	F(1,357) = .85, p = .357
	2016	0.000	466	F(1, 441) = .16, p = .687
	2015	0.000	417	F(1,412) = .04, p = .842
	2014	0.002	389	F(1,384) = .68, p = .411

Note. Resilience measured from 2016.

four adolescent samples, females engaged in less physical activity than males. Studies consistently find gender-based differences in physical activity, with greater declines across adolescence for females than for males in both the intensity and frequency of physical activity (Armstrong & Welsman, 2006; Rowland, 1999). Yet, consistent with recent research (e.g., McPhie & Rawana, 2015), there are similar mental health benefits of physical activity between genders; moderation analyses suggest the mental health benefits of physical activity are not dependent on one's gender. The connection between mental health and physical activity is complex and involves many factors such as domains of physical activity (e.g. leisure-time, household, occupational and transport), contextual considerations, and motivation (Cerin, Leslie, Sugiyama, & Owen, 2009; Hefferon, Murphy, McLeod, Mutrie, & Campbell, 2013; White, Olson, Parker, Astell-Burt, & Lonsdale, 2018). Future research on the connection between mental health and physical activity, considering potential moderators such as these, might extend the explanations of females' low participation when there is such evidence of a benefit to their mental health.

Females also reported worse mental health than males, but the strength of associations depended on the outcome. While negative mental health variables (Depression, Anxiety, Stress) consistently demonstrated a moderate gender gap, gender differences in positive mental health were smaller and less reliable, with stronger effects for Engagement, Optimism, and Happiness, and weaker effects for Perseverance and Connectedness. This is consistent with findings that females measure higher in social domains of positive psychological functioning such as positive relations with others and emotional support (Picco et al., 2017; Ryff & Keyes, 1995). However, findings in this area are also inconsistent. For example, a study of 10,148 North American adolescents found that although females reported higher school support than males, they also reported lower family communication and lower family closeness than males (Bennefield, 2018). Gender differences in positive mental health may be connected to culturally specific gender norms and expectations; further research might consider intersection of various domains of positive mental health, gender, and culture.

Notably, when directly compared, physical activity had a greater impact on positive mental health than did gender. Further, we found little evidence for a moderating effect of gender, but instead found support for a mediational model. Physical activity may act as one pathway through which gender has differential effects on mental health. Of course, these results need to be replicated through longitudinal studies that directly test physical activity as a mediator. Yet, the pattern of results does suggest that it would be beneficial to incorporate physical activity within mental health interventions for adolescents.

Recent studies have highlighted the importance of participation in physical activity for mental health among adolescents (e.g., McPhie & Rawana, 2015). An evaluation of a large-scale mental health initiative implemented at Geelong Grammar School in Australia found the greatest benefits in year 9 students who lived together for a year in the foothills of the Victorian Alps, where students were exposed to intellectual, physical and emotional challenges under demanding environmental conditions (Vella-Brodrick, Rickard, & Chin, 2014). Brand et al. (2017) found that physical activity in adolescence had positive effects on sleep, exploratory behaviour, and mental toughness for both boys and girls, yet also found gender difference in physical activity participation. They concluded that physical activity interventions at this age might be more appropriately tailored to females. Together, our findings combined with other studies suggest the value of positive health behaviours, regardless of one's gender; the challenge moving forward is how to encourage physical activity for all adolescents.

4.1. Implications

Across four samples, physical activity had a positive association with adolescents' mental health regardless of gender, and may explain part of the gender gap in mental health. This points to the potential value that physical activity has as a school-based mental health intervention for adolescents. Physical activity has a preventative capacity, fosters positive emotions, and can help buffer individuals against the stresses of life in order to thrive (Faulkner, Hefferon, & Mutrie, 2015, pp. 207–222). Educators around the world are concerned over the growing number of mental illness problems seen in youth (e.g., Allen, Kern, Vella-Brodrick, & Waters, 2018; Kern et al., 2017.; White & Murray, 2015). There are many factors influencing mental health – behaviours, feelings and cognitions (Dobson & Block, 1988), but behaviour is easiest to target within the school context. As schools consider how to balance curricular demands with time available, continuing to include opportunities for physical activity, such as physical education classes and sport, may serve as an important tool for combatting mental illness.

Beyond preventing or dealing with mental illness, this study also shows that physical activity may have a greater impact on specific domains of adolescent positive mental health, especially Engagement (being interested or involved; Fredricks, Blumenfeld, & Paris, 2004) and Perseverance (persistence in reaching a goal; Pury, 2009). Engagement has been connected to positive behaviour and achievement at school, across the spectrum of social and economic situations (Appleton, Christenson, & Furlong, 2008). Perseverance has also been recognised by educators as a desirable quality in students. For example, Perseverance, as measured by the EPOCH scale, was found to positively influence academic achievement over and above the impact of a student's background in a large South Australian government report (Department for Education and Child Development, 2017). The same report notes the

Table 5
Model statistics for gender on mental health mediated by physical activity.

		n	Path a	Path b	Path c'	Overall Model	Indirect effect [Bootstrapped 95% CIs]
Engagement	2017	357	b = .37***, t(354) = 4.31	b = .32***, t(353) = 5.95	b = .19*, t(353) = 2.15	F(3,353) = 17.39***, R^2 = .13	b = .12 [.06, .20]
	2016	466	b = .29***, t(463) = 4.03	b = .31***, t(462) = 6.11	b = .07, t(462) = .85	F(3,463) = 22.67***, R2 = .0892	b = .09 [.04, .15]
	2015	417	b = .27***, t(414) = 3.61	b = .24***, t(423) = 5.14	b = −.05, t(413) = -.67	F(3,413) = 8.95***, R2 = .0611	b = .07 [.03, .13]
	2014	383	b = .31***, t(380) = 3.94	b = .45***, t(379) = 7.93	b = .13, t(379) = 1.54	F(3,379) = 25.16***, R2 = .1661	b = .14 [.08, .24]
Perseverance	2017	357	b = .37***, t(354) = 4.31	b = .25***, t(353) = 4.52	b = −.01, t(353) = -.10	F(3,353) = 10.14***, R2 = .08	b = .09 [.04, .16]
	2016	466	b = .29***, t(463) = 4.03	b = .32***, t(462) = 6.31	b = −.18*, t(462) = -2.29	F(3, 462) = 14.54***, R2 = .0863	b = .09 [.04, .15]
	2015	417	b = .27***, t(414) = 3.61	b = .26***, t(413) = 5.30	b = −.18*, t(413) = -2.29	F(3,413) = 10.02***, R2 = .0678	p = .07 [.03, .13]
	2014	383	b = .31***, t(380) = 3.94	b = .38***, t(379) = 6.97	b = −.01, t(379) −.09	F(3,379) = 17.72***, R2.1230	b = .12 [.06, .20]
Optimism	2017	357	b = .37***, t(354) = 4.31	b = .26***, t(353) = 4.50	b = .19*, t(353) = 2.06	F(3,353) = 10.36***, R2 = .08	b = .09 [.04, .17]
	2016	466	b = .29***, t(463) = 4.03	b = .30***, t(462) = 5.76	b = −.03, t(462) = -.42	F(3,462) = 11.69***, R2 = .0706	b = .09 [.04, .15]
	2015	417	b = .27***, t(414) = 3.61	b = .27***, t(413) = 4.99	b = .02, t(413) = .22	F(3,413) = 8.90***, R2 = .0607	b = .07 [.03, .13]
	2014	383	b = .31***, t(380) = 3.94	b = .40***, t(379) = 6.57	b = .13, t(379) = 1.37	F(3,379) = 18.02***, R2 = .1249	b = .13 [.06, .21]
Connectedness	2017	357	b = .37***, t(354) = 4.31	b = .20**, t(353) = 3.33	b = −1.7, t(353) = -1.75	F(3,353) = 4.16**, R2 = .03	b = .07 [.03, .14]
	2016	466	b = .29***, t(463) = 4.03	b = .148, t(462) = 2.60	b = −.40***, t(462) = -4.76	f(3,462) = 11.18***, R2 = .0677	b = .04 [.01,.10]
	2015	417	b = .27***, t(414) = 3.61	b = .21***, t(413) = 4.20	b = −.24*, t(413) = -3.07	F(3,413) = 7.76***, R2 = .0534	b = .06 [.02,.11]
	2014	383	b = .31***, t(380) = 3.94	b = .23***, t(379) = 3.88	b = −.24*, t(379) = -2.62	F(3,379) = 6.34***, R2 = .0478	b = .07 [.03,.14]
Happiness	2017	357	b = .37***, t(354) = 4.31	b = .26***, t(353) = 4.25	b = .22*, t(353) = 2.188	F(3,353) = 12.00***, R2 = .09	b = .09 [.04, .17]
	2016	466	b = .29***, t(463) = 4.03	b = .28***, t(462) = 4.98	b = −.01, t(462) = -.18	F(3,462) = 11.76***, R2 = .0710	b = .08 [.04, .15]
	2015	417	b = .27***, t(414) = 3.61	b = .30***, t(413) = 5.38	b = .12, t(413) = 1.40	F(3,413) = 11.82***, R2 = .0791	b = .08 [.04, .14]
	2014	383	b = .31***, t(380) = 3.94	b = .39***, t(379) = 5.92	b = .15, t(379) = 1.52	F(3,379) = 14.24*, R2 = .1013	b = .12 [.06,.20]
Resilience	2017	362	b = .36***, t(359) = 4.31	b = 1.40*, t(358) = 2.27	b = 1.93, t(358) = 1.91	F(3,358) = 4.00*, R2 = .03	b = .51 [.08, 1.10]
	2016	466	b = .29***, t(463) = 4.03	b = 2.03***, t(462) = 4.44	b = .92, t(462) = 1.28	F(3,462) = 8.09***, R2 = .0499	b = .59 [.25, 1.08]
	2015	–	–	–	–	–	–
	2014	–	–	–	–	–	–
Depression	2017	362	b = .36***, t(359) = 4.31	b = −.87**, t(358) = -3.12	b = −1.50**, t(358) = -3.35	F(3,358) = 11.14***, R2 = −.09	b = −.31 [-.65, −.11]
	2016	466	b = .29***, t(463) = 4.03	b = −.18, t(462) = -.73	b = −.93*, t(462) = -2.33	F(3,462) = 10.16***, R2 = .06	b = −.05 [-.23, .10]
	2015	417	b = .27***, t(414) = 3.61	b = −.76*, t(413) = -2.55	b = −2.12***, t(413) = -4.56	F(3,413) = 10.78***, R2 = .07	b = −.21 [-.47, −.05]
	2014	389	b = .28***, t(386) = 3.61	b = −.83*, t(385) = -2.83	b = −1.83***, t(385) = -4.56	F(3,385) = 9.82***, R2 = .07	b = −.23 [-.53, −.05]
Anxiety	2017	362	b = .36***, t(359) = 4.31	b = −.17, t(358) = -.65	b = −2.01***, t(358) = -4.81	F(3,358) = 9.67***, R2 = .07	b = −.06 [-.31, .14]
	2016	466	b = .29***, t(463) = 4.03	b = .46*, t(462) = 1.98	b = −1.85***, t(462) = -5.07	F(3,462) = 10.89***, R2 = .05	b = .13 [.02, .30]
	2015	417	b = .27***, t(414) = 3.61	b = −.50, t(413) = -1.78	b = −2.37***, t(413) = -5.46	F(3,413) = 12.51***, R2 = .08	b = −.14 [-.38, .02]
	2014	389	b = .28***, t(386) = 3.61	b = −.33, t(385) = -1.39	b = −1.79***, t(385) = -4.85	F(3,385) = 9.84***, R2 = .07	b = −.09 [-.29, .02]
Stress	2017	362	b = .36***, t(359) = 4.31	b = −.07, t(358) = -.26	b = −2.40***, t(358) = -5.78	F(3,358) = 14.73***, R2 = .11	b = −.02 [-.23, .16]
	2016	466	b = .29***, t(463) = 4.03	b = .23, t(462) = .93	b = −2.24***, t(462) = -5.87	F(3,462) = 15.23***, R2 = .09	b = .07 [-.08, .25]
	2015	417	b = .27***, t(414) = 3.61	b = −.53, t(413) = -1.89	b = −1.91***, t(413) = -4.34	F(3,413) = 8.83***, R2 = .05	b = −.15 [-.38, .00]
	2014	389	b = .28***, t(386) = 3.61	b = −.39, t(385) = -1.51	b = −1.65***, t(385) = -4.09	F(3,385) = 7.32***. R2 = .05	b = −.11 [-.33, .02]

Note. *p < .05, **p < .001 ***p < .0005. Resilience was measured from 2016.

potential benefits of developing perseverance for students, and that work is underway to determine an appropriate school-based intervention that builds it.

If physical activity is involved in such an intervention, the consistent gender gap in physical activity suggests barriers to girls' participation should be considered. Adolescence is a transitional period marked by many biological, environmental, social, and psychological factors which influence participation in physical activity (e.g., body image concerns, increase in study load) (Eime, Harvey, et al., 2013). Gender norms and stereotypes, where to be active is masculine and causes a 'femininity deficit', have been found to be important to adolescent females' attitudes to physical activity (Spencer, Rehman, & Kirk, 2015). Teasing may also contribute to their reduced rates of participation in physical activity (Slater & Tiggemann, 2011). These all present possible barriers to increasing females' engagement in physical activity and should be addressed to positively impact females' poor mental health through physical activity.

4.2. Strengths and limitations

In the current study, we replicated analyses across four years, suggesting that the pattern of results is consistent, rather than being due to chance. Still, all data came from one high school in Australia, and thus could be unique to the particular school or cultural context. As students could not be matched across time points, we employed a cross-sectional design, replicated four times, rather than tracking students across multiple time points. In our model, we specified gender as the predictor, physical activity as the mediator, and mental health as an outcome. In most cases, gender temporally precedes physical activity and mental health, and thus logically makes sense as a predictor. In contrast, the causal direction of associations between mental health and physical activity cannot be determined with these data. Although many studies investigating a mediating effect have adopted this type of design, longitudinal studies would allow a better understanding of the associations between gender, physical activity, and mental health.

We included both positive and negative mental health, providing greater insight into differential domains of adolescent mental health. The differential effect sizes support the value of distinguishing different domains, rather than looking at overall well-being or ill-being. However, the domains under consideration were specific to the measures included in the study. Numerous models and measures of mental health are available (OECD, 2013). Future studies might consider other domains or use other measures.

We used a broad definition of physical activity. We saw evidence that this low level of activity offers mental health benefits, meaning more currently socially acceptable activities to females, such as yoga, may be used as school-based mental health interventions. However, we did not specifically investigate competitive and/or team sports. There is evidence that participation in organised team sport, seems to confer an additional benefit over and above that provided by activity alone, especially in adolescent females (e.g., McMahon et al., 2017). Further, there are varying interpretations of physical activity, although we tried to limit this by including our definition immediately prior to the relevant questionnaire items.

We relied on self-report data. Despite its wide use due to its ease and low cost, self-reported data on physical activity does have limitations (see Sirard & Pate, 2001 for a full review). Young people often engage in physical activities in a less structured way compared to adults. This places considerable demands on young people's cognitive abilities in addition to their memories being filtered through biases and social desirability (Armstrong & Welsman, 2006).

At the request of the school, the 2017 measure included a gender diverse answer option alongside options of male or female. Eleven students identified as gender diverse, which was not enough to conduct meaningful statistical analyses, yet this could be an area for further qualitative research. Future studies might consider alternative gender identifications and links amongst shifting identity roles, physical activity, and mental health outcomes.

4.3. Conclusion

Physical activity plays an important role in adolescent positive and negative mental health, regardless of gender. As schools consider strategies for proactively addressing mental health issues, physical activity should be considered as a school-based mental health intervention, with the potential to impact both positive and negative mental health of all students, and at the same time may serve to close the gender gap in mental health.

Declarations of interest

None.

Data

Due to respondents' age, they were assured raw data would remain confidential and would not be shared.

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Appendix B. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.mhpa.2019.02.003.

Appendix A

Table A1
Reliability data for all variables in all years (Cronbach's alpha).

		2014	2015	2016	2017
PAQ-A	Physical Activity	.84	.85	.84	.85

(*continued on next page*)

Table A1 (*continued*)

		2014	2015	2016	2017
EPOCH	Engagement	.84	.82	.86	.84
	Perseverance	.82	.80	.82	.84
	Optimism	.87	.84	.82	.86
	Connectedness	.80	.78	.84	.85
	Happiness	.90	.87	.90	.91
CD-RISC	Resilience	–	–	.89	.93
DASS-21	Depression	.90	.91	.86	.91
	Anxiety	.78	.85	.81	.84
	Stress	.84	.86	.84	.85

Note. PAQ-A = physical activity, EPOCH = Engagement, Perseverance, Optimism, Connectedness, Happiness. CD-RISC = Resilience. DASS-21 = Depression, Anxiety, Stress. Resilience was not measured in 2014 or 2015.

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