The mediating role of self-esteem in the association between physical fitness and risk of depression in adolescents: DADOS Study

Bou-Sospedra, C. [1], Adelantado-Renau, M. [1], Beltran-Valls, M. R. [1], & Moliner-Urdiales, D. [1].

[1] Universtiy Jaume I, Castellón, Spain.

Bou-Sospedra, Adelantado-Renau, Beltran-Valls, and Moliner-Urdiales are with the LIFE Research Group, University Jaume I, Castellon, Spain. Address author correspondence to Diego Moliner-Urdiales at dmoliner@uji.es

Abstract:

Background: Previous literature showed an inverse association between physical fitness and risk of depression in adolescents, but the mechanisms involved in this association remain unclear.

Aims: The primary aim of the study was to test the mediating role of self-esteem on the association between physical fitness components and risk of depression. The secondary aim was to investigate sex differences in these mediation models.

Methods: A total of 225 participants (44% girls), aged 13.9±0.3 years, from the DADOS (Deporte, ADOlescencia y Salud) study were included in the analyses. The results presented in this study belong to baseline data obtained between February and May of 2015. ALPHA-Fitness Test-Battery was used to evaluate physical fitness components. The Spanish version of the Behaviour Assessment System for Children-3 questionnaire was used to asses self-esteem and risk of depression. Boot-strapped mediation procedures were performed and indirect effects (IE) with confidence intervals (CI) not including zero were considered statistically significant.

Results: Self-esteem was revealed as a mediator in the association between cardiorespiratory fitness and risk of depression (IE= -0.059; 95% CI = -0.098 to -0.015) and in the association between speed-agility and risk of depression (IE = -1.800; 95% CI = -3.117 to -0.623). Stratified mediation analyses by sex showed similar results in girls; however, self-esteem did not act as a mediator in boys.

Conclusion: Our findings indicate that high levels of cardiorespiratory fitness and speed-agility may improve self-esteem, which could have positive effects in mental health by reducing risk of depression in adolescents, especially in girls.

Keywords: physical fitness, adolescence, risk of depression, self-esteem, mental health.

1. Introduction

According to the World Health Organization (2018), mental health is defined as a state in which the individual realizes his or her own abilities, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to his or her community. Necessarily, mental health involves the presence of psychological well-being and the absence of psychological ill-being. Some common indicators of well-being and ill-being are self-esteem (Calmeiro & de Matos, 2016) and depression (Lubans et al., 2016), respectively. Previous literature has suggested that adolescence is a critical period of life characterised by vulnerability to psychological ill-being, especially to depression (Blakemore, 2019). Therefore, it is an important time frame for the promotion of psychological well-being and the implementation of early mental health interventions when needed (Marsh et al., 2017).

Physical fitness is considered a powerful health marker during youth due to its role in disease prevention (Janssen et al., 2018; Ortega et al., 2013). The main components of physical fitness are cardiorespiratory fitness, muscular strength, and speed-agility (Ruiz et al., 2009). A growing body of evidence suggests that physical fitness may play a key role not only on physical health, but also in mental health (Kandola et al., 2019; Ortega et al., 2008). However, each physical fitness component appears to affect health in a different way (Ortega et al., 2008; Padilla-Moledo et al., 2020). Particularly, previous scientific literature suggested a positive association between cardiorespiratory fitness or muscular strength and self-esteem (Lang et al., 2017; Smith et al., 2014), and an inverse association between cardiorespiratory fitness and risk of depression in adolescents (Rieck et al., 2013; Ruggero et al., 2015). Nevertheless, the association between speed-agility and self-esteem and risk of depression remains unclear in children and adolescents (Bou-Sospedra et al., 2020; Esmaeilzadeh, 2014; Rodriguez-Ayllon et al., 2018).

To the best of the authors knowledge, the mechanisms involved in the association between physical fitness and risk of depression have not been elucidated yet. However, Dishman et al., (2006) indicated that the level of self-esteem could be a possible mechanism. In line with this idea, previous research has identified a mediating role of self-esteem on the association between physical activity and risk of depression in adolescents (Dishman et al., 2006; Pickett et al., 2012). Physical activity is often suggested as a low-cost strategy for improving children and adolescent's mental health (Biddle et al., 2019). Nevertheless, physical activity seems to be particularly difficult to

assess: self-reported measures are imprecise and may reflect other factors such as optimism or knowledge of healthy lifestyle and "objective" measures such as accelerometry, are prone to recording bias and exhibit substantial intra-individual variability (Hendelman et al., 2000; Steves et al., 2016). However, measures of physical fitness, which involve the capacity of performance physical activity through cardiorespiratory fitness, are much tractable.

Based on the previous literature about physical fitness and psychological well-being, we hypothesized that adolescents with lower levels of physical fitness presented also low self-esteem and as a consequence, higher risk of depression. Therefore, the primary aim of the study was to test the mediating role of self-esteem on the association between physical fitness components and risk of depression. Since self-esteem levels, risk of depression, and physical fitness levels were likely to differ by sex due to biological, hormonal, social, and cultural differences (Bleidorn et al., 2016; Labaka et al., 2018; Roberts et al., 2020; Tomkinson et al., 2019), the secondary aim was to investigate sex differences in these mediation models.

2. Material and Method

2.1. Study design and sample section

This study is part of the DADOS (Deporte, ADOlescencia y Salud) research project, a 3-year longitudinal study aimed to analyze the influence of physical activity on health, mental health, and academic performance through adolescence. The results presented in this study belong to baseline data obtained between February and May of 2015. A convenience sampling technique was used to recruit participants. For that purpose, advertising leaflets about the research project were sent to schools and sport clubs located in the province of Castellon (Spain), which included basic information. The inclusion criteria were to be enrolled in second grade of secondary school, and to be free of physical (i.e., locomotor system) and mental (i.e., intellectual disability) impairments. Volunteers who declared to meet the inclusion criteria contacted the research group and were included in the study. From the total DADOS study sample (n = 274), a sub-sample with 225 adolescents aged 13.9 ± 0.3 years (44% girls), with valid data for health-related physical fitness and mental health variables at baseline were included in the analyses.

Adolescents and their parents or guardians were informed about the nature and characteristics of the study, and all provided a written informed consent. The DADOS study protocol was designed in accordance with the ethical guidelines of the Declaration of Helsinki 1964 (last revision of Fortaleza, Brazil, 2013) and approved by the Research Ethics Committee of the Universitat Jaume I of Castellon (Spain).

2.2. Health-related Physical Fitness

The ALPHA (Assessing Levels of Physical fitness and Health in Adolescents) health-related fitness field-based test battery was used in order to objectively assess physical fitness components (i.e., cardiorespiratory fitness, upper limb muscular strength, lower limb muscular strength, and speed-agility) (Ruiz et al., 2009). The ALPHA fitness tests battery has shown to be valid and reliable for the assessment of health-related physical fitness in children and adolescents (Ruiz et al., 2011).

Cardiorespiratory fitness was assessed by the 20m shuttle run test. Briefly, each participant runs straight between 2 lines 20 meters apart, while keeping the pace with audio signals. The initial speed was 8.5 km/h and it was increased 0.5 km/h each minute. The test was completed when participants could not reach the end lines at the pace of the audio signals for 2 consecutive times or when they stopped because of fatigue. The number of laps (20m each) was registered and used in the analyses.

Upper limb muscular strength was measured using a hand dynamometer (TKK 5101 Grip D; Takey, Tokyo, Japan). Briefly, each participant squeezes gradually and continuously for at least 2 seconds, performing the test with the right and left hands in turn. The maximum score in kilograms for each hand was recorded, and the mean value of the scores achieved in both handgrip tests was used in the analyses.

Lower limb muscular strength was assessed through the standing broad jump test. Briefly, each participant jumps as far as possible from a starting position immediately behind a line, standing with feet approximately shoulder's width apart. The measurement is taken from the line to the nearest point of contact (back of the heels). The participants were allowed to perform the test twice. The maximum score in centimeters was used in the analyses.

Speed-agility was assessed through the 4×10m shuttle run test. Briefly, each participant runs as fast as possible 4 times between two parallel lines 10m apart. Every

time the adolescent crossed any of the lines, he or she picked up (the first time) or exchanged (second and third time) a sponge, which was previously placed behind the lines. The participants performed two trials and the minimum time taken to complete the test was used in the analyses. For analytic purposes, values were multiplied by -1, so a higher score indicates better speed-agility.

2.3. Mental health

The Behavior Assessment System for Children and Adolescents (BASC) questionnaire (Reynolds & Kamphaus, 2004), specifically, the S3 self-report Spanish version for adolescents aged 12-18 years (González et al., 2004) was used to assess self-esteem and risk of depression (reliability for the subscales ranging from 0.80 to 0.87). BASC consists of statements rated as true or false. Self-esteem score and risk of depression score were calculated by transforming raw scores into standard T-scores with an average of 50 and standard deviations of 10 points. Risk of depression was dichotomized into "non-risk" (<60) and "at risk" (≥60), and self-esteem was dichotomized into "low" (<30) and "normal" (≥30) according to the established cut off points (Reynolds & Kamphaus, 2004).

2.4.Covariates

According to previous scientific literature in adolescent population, all the analysis were adjusted by age, sex, pubertal stage, and socioeconomic status due to their associations with health-related physical fitness components (Lesinski et al., 2020; Towlson et al., 2018; Wolfe et al., 2020), self-esteem (Altintaş et al., 2014; Veselska et al., 2011), and risk of depression (Keenan et al., 2014; Pino et al., 2018).

Pubertal stage was self-reported by particiants according to the five stages described by Tanner & Whitehouse (1976). According assessment instructions, participants reported their level of maturation based on two components: pubic hair growth for boys and girls, plus breast development in girls or genital development in boys. A 5-point maturity rating was used where the stage 1 corresponds to the prepubertal state and the stage 5 corresponds to mature state. The highest rating of the 2 components was used in the analyses.

The Family Affluence Scale questionnaire developed by Currie et al., (2008) was used as a proxy of socioeconomic status. This questionnaire (ranging from 0 to 8 points),

is based on material conditions in the family such as car ownership, bedroom occupancy, computer ownership, and home internet access.

2.5. Statistical analyses

Study sample characteristics are presented as mean ± standard deviation for continuous variables or frequencies and percentages for categorical variables. All variables were checked for normality using both graphical (normal probability plots) and statistical (Kolmogorov–Smirnov test) procedures. Differences between sexes were assessed by t-test for continuous variables and chi-square test for nominal variables.

Partial correlations coefficients were used to examine the relationships between physical fitness components, self-esteem, and risk of depression, controlling for age, sex, pubertal stage, and socioeconomic status.

Mediation analyses were performed in order to elucidate whether the associations between each physical fitness component individually and risk of depression were mediated by self-esteem. The PROCESS macro version 2.16.3, model 4, with 5000 bias-corrected bootstrap samples and 95% confidence intervals was used for these analyses (Hayes, 2013). As depicted in the Figure 1, mediation was assessed by the indirect effect (IE) of the physical fitness components (independent variables) on risk of depression (dependent variable) through self-esteem (mediator). Indirect effects (paths a*b) with confidence intervals not including zero were interpreted as statistically significant (Hayes, 2013), which can be so regardless of the significance of the total effect (the effect of physical fitness on risk of depression component; path c) and the direct effect (the effect on risk of depression when both physical fitness and self-esteem are included as independent variables; path c'). These analyses were adjusted by age, sex, pubertal stage, and socioeconomic status. Furthermore, we conducted mediation models to test the mediating role of self-esteem on the association between each physical fitness component and risk of depression by sex (i.e., girls and boys), adjusting by age, pubertal stage, and socioeconomic status. Post-hoc power analyses were conducted for each association of mediation analysis. All the analyses were performed using SPSS Statistics for Windows version 22.0 (IBM Corp, New York, USA) and the level of significance was set to $p < 0.05$.

3. Results

Descriptive characteristics of the study population by sex are presented in Table 1. Overall, boys showed higher levels of all physical fitness components than girls (all $p < 0.001$). Likewise, boys showed higher levels in self-esteem ($p = 0.002$) and lower levels in risk of depression ($p = 0.037$) compared to girls.

Partial correlations between physical fitness components, self-esteem, and risk of depression, controlling for age, sex, pubertal stage, and socioeconomic status are presented in Table 2. Cardiorespiratory fitness, lower limb muscular strength, and speed-agility were positively correlated with self-esteem ($p = 0.004$; $p = 0.037$; and $p < 0.001$, respectively), whereas cardiorespiratory fitness ($p = 0.022$) and self-esteem ($p < 0.001$) were negatively correlated with risk of depression.

The results of the mediation models with the whole sample controlling for age, sex, pubertal stage, and socioeconomic status are shown in Figure 2. Self-esteem was revealed as a significant mediator in the association between cardiorespiratory fitness and risk of depression (IE = -0.059; 95% CI = -0.098 to -0.015) and in the association between speed-agility and risk of depression (IE = -1.800; 95% CI = -3.117 to -0.623). Mediation analyses of self-esteem in the association between upper and lower limb muscular strength and risk of depression were not statistically significant. Except for the analyses with upper limb muscular strength, in the whole sample the reported effects showed a statistical power ranging from 85.4% to 100%.

Additional stratified mediation analyses by sex revealed that, in girls (Figure 3), self-esteem was a significant mediator in the association between cardiorespiratory fitness and risk of depression (IE = -0.120; 95% CI = -0.239 to -0.028) and in the association between speed-agility and risk of depression (IE = -2,789; 95% CI = -4.889 to -0.512), but not in the association between upper and lower limb muscular strength and risk of depression. No significant mediation role for self-esteem was identified in boys (Figure 4). Except for the analyses with cardiorespiratory fitness (statistical power ranging over 99% for both, girls and boys), the reported effects showed a statistical power ranging from 32.2% to 100% in girls, and 23.6% to 100% in boys.

4. Discussion

The main findings of the study revealed a mediating role of self-esteem on the association between physical fitness components, specifically cardiorespiratory fitness

and speed-agility, and risk of depression in adolescents, particularly in girls. These results contribute to the scarce current knowledge by suggesting that self-esteem could partially explain the inverse association between physical fitness and risk of depression in adolescents.

In our sample, self-esteem mediated the negative association between cardiorespiratory and risk of depression (β = -0.159; CI = -0.257 to -0.052) and the negative association between speed-agility and risk of depression (β = -0.204; CI = -0.329 to -0.083). To our knowledge, this is the first study investigating the association between physical fitness components and risk of depression considering self-esteem as a possible mechanism, which hampers direct comparisons among studies. Nevertheless, we speculate that our results could be partially explained by psychological (Iwata et al., 2013; Orth & Robins, 2013) and psychosocial factors (Eime et al., 2013). For instance, this association could be supported by psychological mechanisms related with enhanced feelings of body satisfaction and self-perceptions (i.e., appearance) leading to improved adolescents' mental health (Claumann et al., 2019; Ortega et al., 2008; Ozmen et al., 2007). Additionally, with regard to psychosocial factors, our results could be related to the fact that adolescents with high levels of physical fitness are usually enrolled in sports clubs (Drenowatz et al., 2019), a context where they are more likely to experience feelings of social acceptance and less social isolation, which in turn, may improve mental health (Eime et al., 2013).

With regard to muscular strength, self-esteem seems not to mediate the association between upper and lower limb muscular strength with risk of depression. Despite the fact that this is the first study focused on the role of self-esteem in the association between muscular strength and risk of depression in adolescents, our results partially concur with previous data analysing muscular strength and depression showing null associations in children (Esmaeilzadeh, 2014; Rodriguez-Ayllon et al., 2018). However, significant inverse associations were found between muscular strength and depression in adults (Ashdown-Franks et al., 2019; Ren et al., 2020; Wu et al., 2017). We speculate that this lack of association could be explained by the fact that our participants did not achieve the highest maturity stage (i.e. 11% achieved Tanner stage V). During childhood, strength levels increase gradually and are more homogeneous than in adult population. In our opinion, low strength levels could affect daily living functioning in adults but not in

youths. Hence, it is plausible that the lack of strength during childhood and adolescence is not directly related to mental health indicators.

Regarding the results of mediation analyses stratified by sex, our results concur with previous studies highlighting that the association between physical fitness and mental health is sex-specific (Janssen et al., 2018; Olive et al., 2016). In particular, cardiorespiratory fitness (β = -0.248; CI = -0.414 to -0.082) and speed-agility (β = -0.246; CI = -0.434 to -0.049) seems to be inversely associated with risk of depression taking into account the self-esteem level such as mediator. Girls usually start puberty earlier (Hayward, 2003) and tend to present lower levels of physical fitness than boys (Tomkinson et al., 2019). These growth differences between sexes could partially explain the earlier psychological disorders found in girls (Rudolph, 2002). Indeed, girls are more likely to report negative thoughts about their body image compared to boys, which may impact girls psychological well-being (Ortega et al., 2008; Tiggemann & Zaccardo, 2015; Watson et al., 2019). It is plausible that the mediating role of self-esteem could be maturation-dependent, which could partially explain that in our sample the mediating role of self-esteem between fitness and risk of depression was only statistically significant in girls, but not in boys.

Limitations of the present study include the limited sample size and cross-sectional design, which does not allow us to draw conclusions on the causal direction of the associations. In addition, analyses performed by sex should be examined carefully due to some small to medium statistical power. Furthermore, the present study measured general self-esteem and it can be a multi-dimensional construct with specific components which were not assessed. Nonetheless, our mediation analysis strategy allowed us to provide novel data revealing the role of self-esteem in the association between physical fitness and risk of depression in adolescents. The main strengths of this study comprise the relatively large and homogeneous sample in terms of age and sex, the use of validated tests to assess health-related physical fitness components, self-esteem, and risk of depression, and the inclusion of relevant confounders in the statistical analyses (i.e., age, sex, pubertal stage, and socioeconomic status).

In conclusion, the current study revealed that self-esteem might play a mediating role in the association between physical fitness and risk of depression in adolescents, particularly in girls. Our findings indicate that adolescents girls could reduce the risk of depression through improvements on physical fitness levels or self-esteem (i.e. upgrading

self-concept and/or body image). We consider that the understanding of the association between the early identification of mental health problems and physical fitness is of great interest for families, educators, and policy makers, in order to support the promotion of psychological well-being among adolescents. Moreover, the identification of modifiable key factors involved in the association between physical fitness and psychological well-being, such as healthy lifestyles, may help shape new prevention and intervention strategies from a public health and educational perspective. Future longitudinal and interventional studies are needed in order to identify the mechanisms involved in the associations between physical fitness components and psychological well-being in adolescents. Lastly, researchers should take into account the multi-dimensional construct of self-esteem in order to establish specific links between physical fitness components and risk of depression.

Declaration of Conflicting Interests

The authors declare no conflict of interest. The funders had no role in the design of the study, in the collection, analyses, or interpretation of data; in the writing of the manuscript, or in the decision to publish the results.

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Table 1. Descriptive characteristics of the study sample.

	All	Girls	Boys	p
	(n = 225)	(n = 98)	(n = 127)	
Age (years)	13.89 ± 0.29	13.89 ± 0.29	13.89 ± 0.29	0.901
Pubertal stage II-V (%)	8.0/34.7/46.7/10.7	5.1/36.7/52.0/6.1	10.2/33.1/42.5/14.2	0.091
Socioeconomic status (0-8)	4.12 ± 1.42	3.98 ± 1.33	4.29 ± 1.51	0.583
Physical fitness components				
Cardiorespiratory fitness (laps)	68.43 ± 23.37	54.93 ± 19.95	78.85 ± 20.34	**<0.001**
Upper limb muscular strength (kg)	29.31 ± 6.06	27.20 ± 4.09	30.93 ± 6.81	**<0.001**
Lower limb muscular strength (cm)	174.52 ± 24.66	166.19 ± 23.65	180.94 ± 23.55	**<0.001**
Speed-agility (s)	12.37 ± 0.88	12.88 ± 0.85	12.02 ± 0.69	**<0.001**
Mental health				
Self-esteem score	54.10 ± 6.64	52.54 ± 8.67	55.31 ± 4.14	**0.002**
Low self-esteem; n (%)	7 (3.1)	6 (6.1)	1 (0.8)	**0.022**
Risk of depression score	45.78 ± 7.75	47.01 ± 9.69	44.84 ± 5.71	**0.037**
At risk of depression; n (%)	8 (3.6)	6 (6.1)	2 (1.6)	0.068

Data are presented as mean ± standard deviation or frequency (%). Differences between sexes were examined by t-test and chi-square test. Statistically significant values are in bold.

Table 2. Partial correlations between physical fitness components, self-esteem score, and risk of depression score, controlling for age, sex, pubertal stage, and socioeconomic status (n = 225).

	Self-esteem [a]	Cardiorespiratory fitness	Upper limb muscular strength	Lower limb muscular strength	Speed-agility
Risk of depression [a]	-0.716 ***	-0.154 *	0.002	-0.016	-0.091
Self-esteem [a]	-	0.193 **	0.081	0.140 *	0.236 ***

*p < 0.05, **p < 0.01, ***p < 0.001.

[a] Values based on standard T-scores with an average of 50 and standard deviations of 10 points.

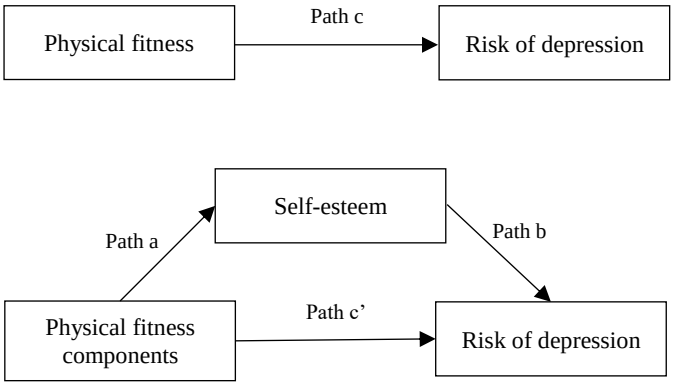
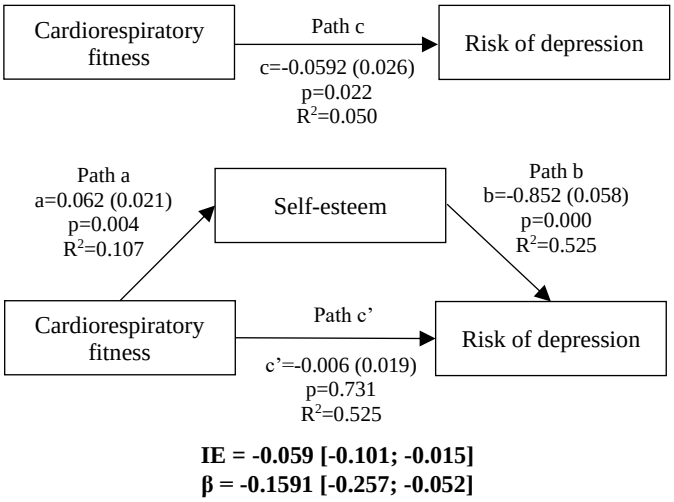
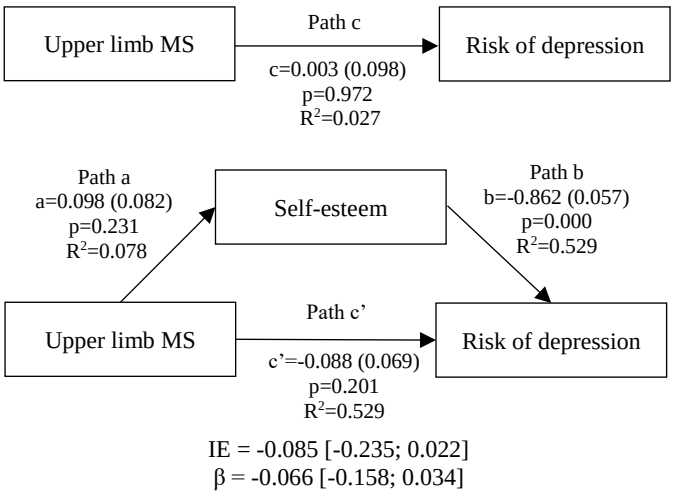


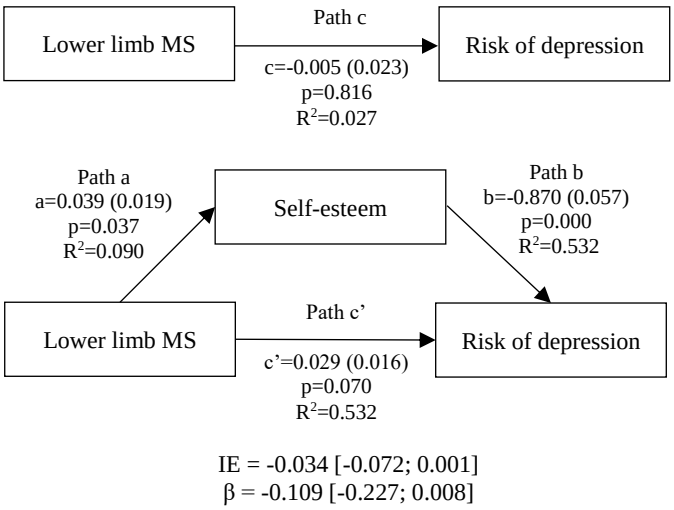
Figure 1. Simple mediation model of physical fitness components (independent variable) on risk of depression (dependent variable) through self-esteem (mediator variable). Path a, association between independent and mediator variables; Path b, association between mediator and dependent variables; Path c, overall association between independent and dependent variables; Path c', unmediated direct effect of independent variable on dependent variable.



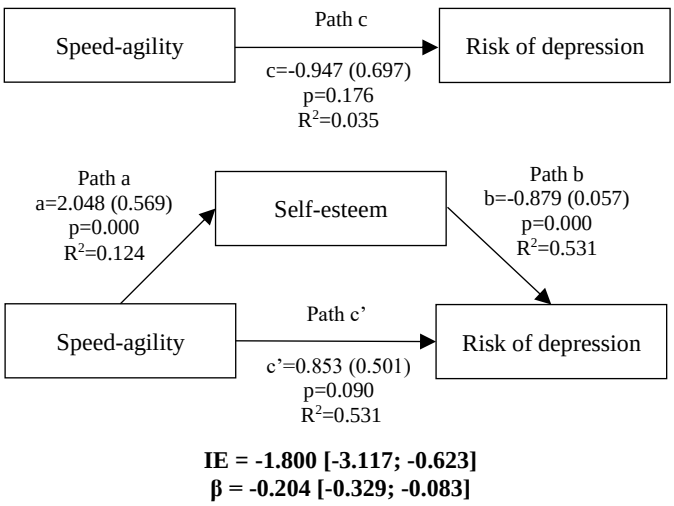
IE = -0.059 [-0.101; -0.015]
β = -0.1591 [-0.257; -0.052]



IE = -0.085 [-0.235; 0.022]
β = -0.066 [-0.158; 0.034]



IE = -0.034 [-0.072; 0.001]
β = -0.109 [-0.227; 0.008]

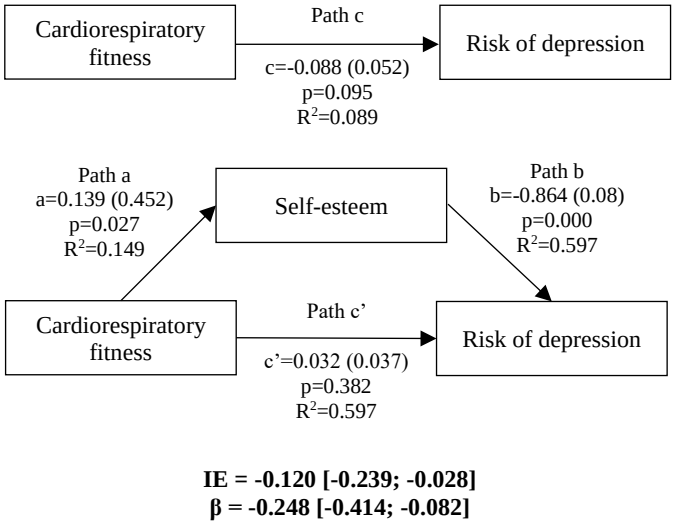


IE = -1.800 [-3.117; -0.623]
β = -0.204 [-0.329; -0.083]

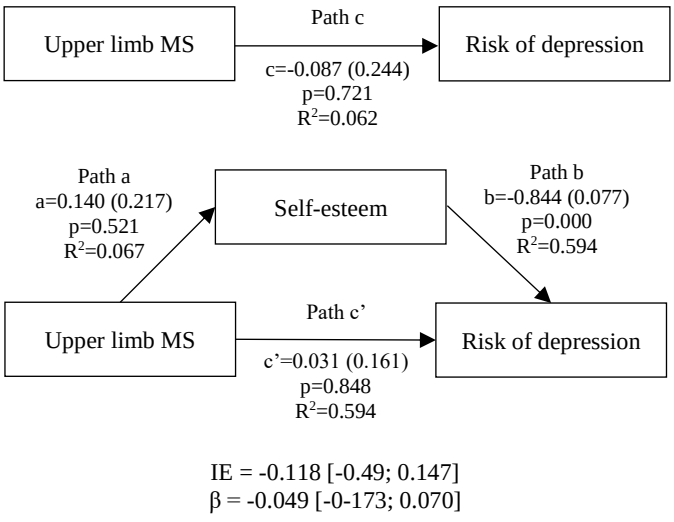
Figure 2. Self-esteem mediation models of the association between physical fitness components and risk of depression, controlling for age, sex, pubertal stage, and socioeconomic status (n = 225).

Results showed as unstandardized regression coefficients (standard error), and indirect effects in bold indicate significant mediation models.

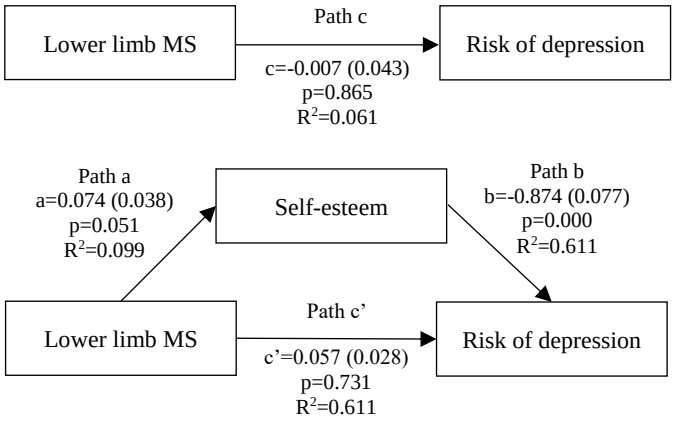
IE indicates indirect effect [lower and upper levels for 95% confidence interval of the indirect effect between physical fitness components and risk of depression]; β indicates standardized regression coefficient [lower and upper levels for 95% confidence interval]; MS indicates muscular strength.



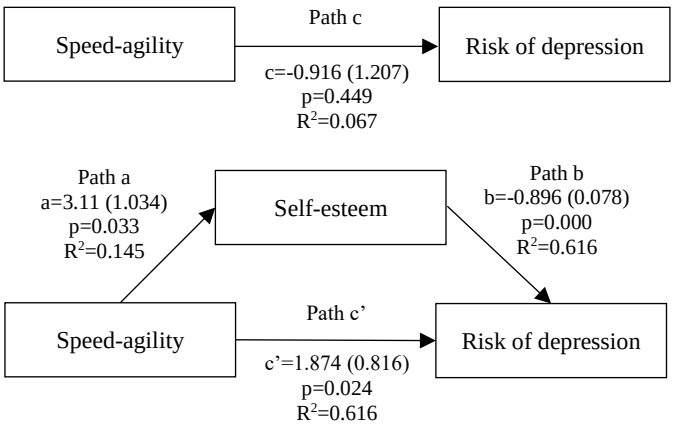
IE = -0.120 [-0.239; -0.028]
β = -0.248 [-0.414; -0.082]



IE = -0.118 [-0.49; 0.147]
β = -0.049 [-0-173; 0.070]



IE = -0.065 [-0.142; 0.013]
β = -0.158 [-0.349; 0.029]

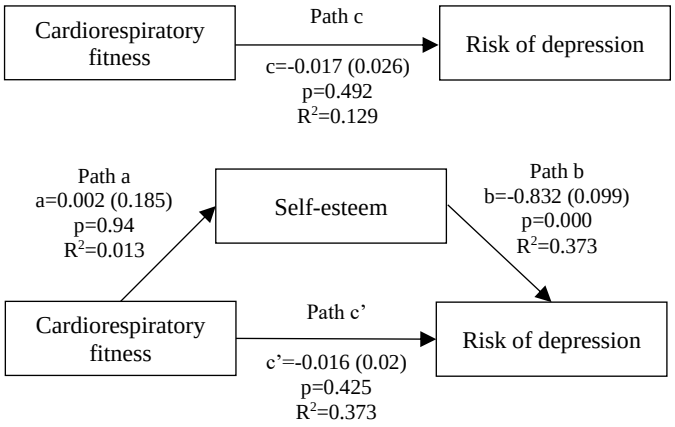


IE = -2.789 [-4.889; -0.512]
β = -0.246 [-0.434; -0.049]

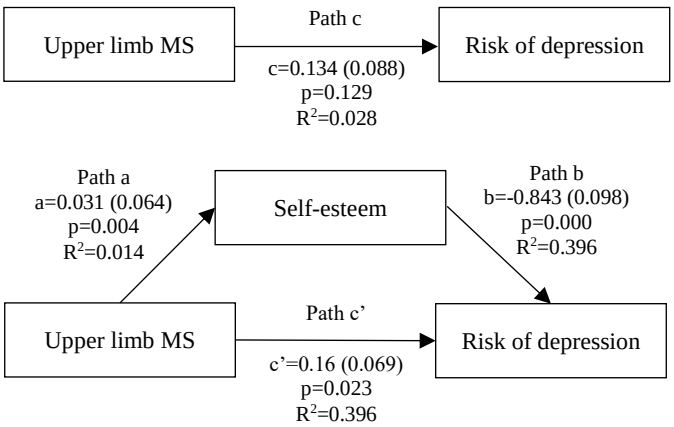
Figure 3. Self-esteem mediation models of the association between physical fitness components and risk of depression in girls, after controlling for age, pubertal stage, and socioeconomic status (n = 98).

Results showed as unstandardized regression coefficients (standard error), and indirect effects in bold indicate significant mediation models.

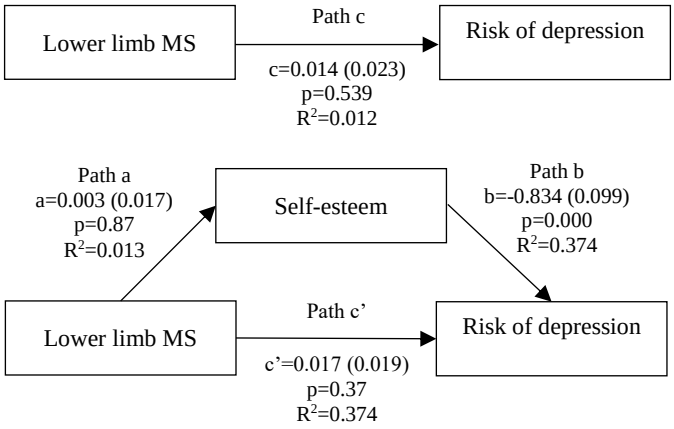
IE indicates indirect effect [lower and upper levels for 95% confidence interval of the indirect effect between physical fitness components and risk of depression]; β indicates standardized regression coefficient [lower and upper levels for 95% confidence interval]; MS indicates muscular strength.



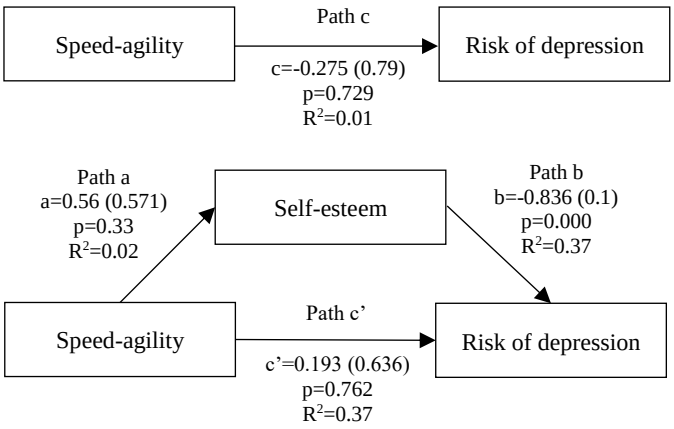
IE = -0.001 [-0.027; 0.019]
β = -0.004 [-0.083; 0.066]



IE = -0.026 [-0.142; 0.057]
β = -0.032 [-0.149; 0.069]



IE = -0.002 [-0.022; 0.023]
β = -0.009 [-0.09; 0.079]



IE = -0.468 [-1.294; 0.059]
β = -0.057 [-0.136; 0.007]

Figure 4. Self-esteem mediation models of the association between physical fitness components and risk of depression in boys, after controlling for age, pubertal stage, and socioeconomic status (n = 127).

Results showed as unstandardized regression coefficients (standard error).

IE indicates indirect effect [lower and upper levels for 95% confidence interval of the indirect effect between physical fitness components and risk of depression]; β indicates standardized regression coefficient [lower and upper levels for 95% confidence interval]; MS indicates muscular strength.