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Original Article

EFFECTS OF A MULTI-COMPONENT PROGRAM TO PROMOTE PHYSICAL ACTIVITY ON MENTAL HEALTH INDICATORS IN ADOLESCENTS: A PILOT RANDOMIZED CONTROLLED STUDY

EFEITOS DE UM PROGRAMA MULTICOMPONENTE PARA PROMOÇÃO DA ATIVIDADE FÍSICA NOS INDICADORES DE SAÚDE MENTAL DE ADOLESCENTES: UM ESTUDO RANDOMIZADO CONTROLADO PILOTO

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RESUMO

Os agravos à saúde mental são a principal causa de incapacidade em adolescentes do mundo todo. Intervenções de atividade física (AF) dentro do ambiente escolar tem sido promissoras quanto a melhora dos indicadores de saúde mental dessa população. O objetivo do presente estudo foi verificar os efeitos de 12 semanas de um programa multicomponente para promoção da AF nos indicadores de saúde mental de adolescentes escolares. O estudo foi conduzido em duas escolas com cinquenta e cinco adolescentes saudáveis (34% do sexo feminino; média de idade de 13,8±0,60 anos), divididos em grupo intervenção (n=31) e grupo controle (n= 24). O programa de intervenção incluiu os seguintes componentes: sessões de AF na escola; incentivo a prática de AF fora do ambiente escolar; orientações sobre estilo de vida saudável. Os indicadores de saúde mental analisados foram: sintomas de ansiedade e depressão, qualidade do sono e bem-estar psicológico. Após 12 semanas, o grupo intervenção apresentou diminuição significativa do escore do sono (diferença média: -0,96, IC 95%: -1,8; -0,09), sintomas de ansiedade (diferença média: -1,7, IC 95%: -2,9; -0,64) e depressão (diferença média: -1,5, IC 95%: -2,5; -0,56) em comparação à linha de base. Para o grupo controle, não foram encontradas diferenças significativas entre os momentos. Nas comparações intergrupos, foi observado um efeito significativo favorável ao grupo intervenção para os sintomas de depressão (-2,39; IC 95%: -4,68; -0,11). Conclui-se que 12 semanas de um programa multicomponente para a promoção da AF promoveu uma melhora significativa nos indicadores de saúde mental nos adolescentes do grupo intervenção.

Palavras-chave: Exercício físico. Bem-estar. Ansiedade. Depressão. Adolescência.

ABSTRACT

Mental health problems are the main cause of disability in adolescents worldwide. Interventions involving physical activity (PA) in school settings have shown promise in enhancing mental health outcomes in this population. The aim of the present study was to verify the effects of 12 weeks of a PA promotion program on adolescents' mental health indicators. The study was conduct in two schools with fifty-five healthy adolescents (34% female; mean age 13.8±0.60 years), allocated into an intervention group (n=31) and a control group (n=24). The intervention program included the following components: PA sessions in the school; encourage the practice of PA outside the school environment; and guidelines for a healthy lifestyle. The mental health indicators analysed were anxiety and depression symptoms, sleep quality and psychological well-being. After 12 weeks, the intervention group showed a significant decrease in sleep scores (mean difference: -0.96, 95%CI: -1.8, -0.09), and in anxiety (mean difference: -1.7, 95%CI: -2.9, -0.64) and depression (mean difference: -1.5, 95%CI: -2.5, -0.56) symptoms compared to baseline. As for the control group, no significant differences were found in mental health indicators. In intergroup comparisons, a significant effect favouring the intervention groups was observed for depression symptoms (-2.39; 95%CI: -4.68, -0.11). It is concluded that 12 weeks of intervention of a PA promotion program improved mental health indicators of adolescents in the intervention group.

Keywords: Physical exercise. Wellbeing. Anxiety. Depression. Adolescence.

Introduction

Mental health problems are the main cause of disability in adolescents worldwide[1]. One in seven teenagers suffers from a mental health problem[2], with depression and anxiety being the most common disorders in this age group[3]. A recent meta-analysis with data from 192 studies showed that the onset of a mental disorder occurs mainly during adolescence[4].

In addition, mental health problems increased during the COVID-19 pandemic[5], such as duplicate symptoms of anxiety (21%) and depression (25%)[6], and higher prevalence of sleep disturbance (44%)[7].

Physical activity (PA) practice is one of the behaviors that can improve the mental health of children and adolescents[8]. A systematic review conducted by Biddle et al.[9] showed that PA was positively associated with adolescents' mental health, presenting a direct association with cognitive functioning and symptoms of depression. Similarly, other scientific evidence supports the beneficial relationship between PA practice and mental health indicators in adolescents[10].

Schools are an ideal setting for the delivery of programs to promote PA and improve mental health indicators in adolescents, since they spend around five or more hours a day at school, making it a favorable environment for such programs[11]. School-based interventions that combined PA with other strategies, such as health literacy, have shown promising effects for reducing symptoms of mental disorders and increasing psychological well-being in adolescents[12]. In addition, previous studies suggest that to enhance the likelihood of success, school-based interventions should incorporate strategies rooted in behavior change theories, like self-determination theory[13], as well as social involvement of parents, relatives and friends[14].

Despite the benefits mentioned above, some studies have not found a positive effect of these programs on mental health outcomes[15,16], since these results depend on a variety of factors, such as the type of exercise, the duration of the intervention, and the physical and social environments of the PA[17]. Furthermore, there is a lack of school-based interventions that combine multiple components to promote physical activity, specifically targeting the enhancement of mental health indicators, especially in South American countries with low economic development, such as Brazil[18]. Therefore, the aim of this study was to analyze the effects of 12 weeks of a multicomponent program to promote PA on mental health indicators (anxiety, psychological well-being, depression and sleep quality) in adolescents aged 12 to 15 years. We hypothesized that students in the experimental group will show a significant improvement in mental health indicators after 12 weeks of intervention.

Methods

Study design

This study adopted a 12-week pilot randomized controlled trial design, with multiple strategies to promote adolescents PA, following Consolidated Standards of Reporting Trials (CONSORT) recommendations[19]. The study began in the second half of 2021, in the cities of Jacarezinho and Santo Antônio da Platina, Paraná, and data collection took place at two different times: baseline (August 2021) and post-intervention (November 2021). The trial was approved by the human research ethics committee of the State University of Northern Parana, Brazil (Registration No. 4.452.513).

Participants

Private educational institutions in the cities of Jacarezinho and Santo Antonio da Platina, both linked to the Regional Education Center of Paraná - Jacarezinho, were invited to participate. Four schools with students aged between 12 and 15 (eighth and ninth grade) were contacted. Two schools agreed to participate and were randomly assigned to either an intervention (IG) or a control (CG) group.

To calculate the sample size we used the G*Power 3.1 software, specifying a 0.20 effect size. Considering an attrition of 10%, a sample of 51 adolescents was required to achieve 90% power at a 5% level of significance. An 8th grade class and a 9th grade class

(final years of elementary school) from each school were selected to take part in the study. Both participants and their parents/guardians gave written informed consent to participate. The final sample consisted of adolescents of both sexes who met the following inclusion criteria: (I) consent to take part in the study; (II) age between 12 and 15 years. Adolescents who had some kind of physical disability that could interfere with performing the tests or their performance during the intervention program were excluded from the analyses. The number of participants involved at each phase of the study is reported in Figure 1.

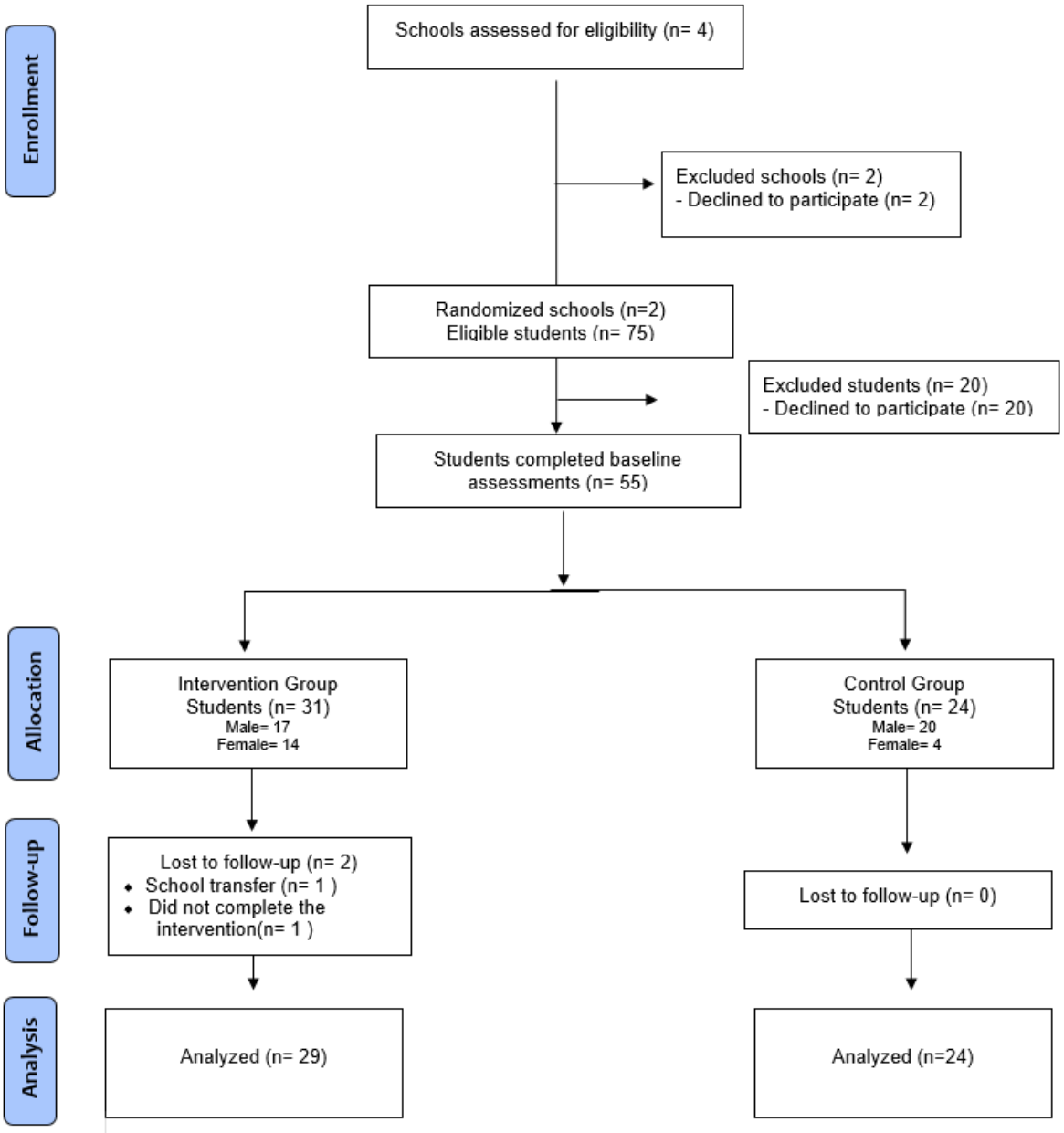

Figure 1. Flowchart of participants through the study.
Source: authors.

Intervention

The multi-component program to promote PA (*ActTeens Program*)[14] included structured PA sessions delivered within PE classes, self-monitoring associated with setting daily PA practice goals and healthy lifestyle guidance via mHealth. The strategies were guided by self-determination[13] and social-cognitive theories[20].

Strategy 1 – structured session within PE classes

The structured PA sessions were implemented over 24 weeks and delivered within PE lessons, twice a week, and 20 minutes per lesson. The structured PA sessions consisted of a combination of muscle-strengthening and aerobic exercise. The session followed a specific format including i) movement-based games and dynamic stretching warm-up; structured PA; and cool-down including static stretching. In each structured PA session, participants were able to choose their own groups (small groups of 4-5 people) and were given autonomy to choose the sequence of exercises they would like to perform (4-5 exercises), within a variety of cards, incorporating aerobic and resistance exercises. At the end of the structured PA session, the adolescents were asked to report the intensity immediately after the last exercise of the session using Borg's rating of perceived exertion scale, that varies from 0 (very, very light) to 10 (maximal effort)[21]. The PA sessions were designed to satisfy participants' basic psychological needs for autonomy, competence, and relatedness, and to promote autonomous motivation and self-efficacy for PA.

Strategy 2 – Self-monitoring of PA practice and individualized goals

YamaxSW-700 pedometers were used for the initial analysis of the number of steps and to set daily step targets to be achieved. Each participant in the IG wore a pedometer and was instructed to write down the number of steps accumulated during the day on a recording form. The students were instructed by an assistant researcher every two weeks to increase the number of steps in relation to their baseline step values. The methodology proposed by Kantanista[22] was used to progress the number of steps (Table 1).

Table 1. *Daily steps goals.*

WEEKS	***GOALS***
1st and 2nd	*B+10% minimum of 10,000 steps*
3rd and 4th	*B+15% minimum of 10,000 steps*
5th and 6th	*B+20% minimum of 10,000 steps*
7th and 8th	*B+25% minimum of 10,000 steps*
9th and 10th	*B+30% minimum of 10,000 steps*
11th and 12th	*B+35% minimum of 10,000 steps*

Note: Adapted from Kantanista[22]. *B*: Average baseline steps.
Source: authors

Strategy 3 – Healthy lifestyle guidance messages

Weekly messages (video or infographic) were sent via the WhatsApp® app (mHeath) to promote healthy behavior, to both adolescents (twice a week) and their parents (twice a month) (i.e. social support).

Control Group

Adolescents and their parents in the control group received the same messages about healthy behavior via the WhatsApp® app as the intervention group. However, the adolescents in the control condition continued with their PE classes as usual.

Instruments

Anxiety and Depression

The Depression, Anxiety and Stress Scale – Short Form (DASS-21)[23], which is

validated for Brazilian adolescents[24], was used to measure symptoms of anxiety and depression. The DASS-21 is a self-report assessment that comprises 21 questions and contains three subscales scored on a four-point scale each, ranging from 0 (not at all) to 3 (almost always). The DASS-21 questionnaire presents values that indicate reliability of the factorial structure of r=0.83 for anxiety and r=0.90 for depression.

Psychological well-being

Psychological well-being was measured using the KIDSCREEN-27 questionnaire, which is validated for Brazilian adolescents[25]. The questionnaire measures five scale dimensions but we only used the psychological well-being dimension (questions 6 to 12) in this study. For each item, participants respond using a 5-point Likert scale ranging from 1 (not at all) to 5 (very much). The KIDSCREEN-27 Intraclass Correlation Coefficient (ICC) is 0.90, and the psychological wellbeing dimension ICC is 0.81.

Sleep

Sleep was assessed by the Pittsburgh Sleep Quality Index (PSQI)[26], which is validated for Brazilian adolescents[27]. The PSQI includes 19 questions, categorized into seven groups (sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbance, use of sleeping medications, and daytime dysfunction). Each constituent question produces a score on a 4-point Likert-type scale (from 0 to 3). The PSQI presents an ICC of 0.65.

Control and sample characterization variables

The students themselves answered personal information on gender (male or female), age (date of birth) and parents' level of education. The practice of moderate to vigorous physical activity (MVPA) was assessed by the objective method, using the Actigraph model GT3X+ multiaxial accelerometer (Pensacola, Florida, USA). The adolescents were instructed on how to use the accelerometer and were asked to use it for seven consecutive days. Non-use time was defined as ≥30 minutes of continuous "0" counts[28]. Participants with at least 3 days of valid data (including 1 weekend day), i.e. > 8 hours per day, were included in the analysis. The time (minutes/day) spent on PA at different intensities (moderate and vigorous) was estimated, using the cut-off points suggested by Evenson et al.[29].

Height and body mass were measured in a private room with the participants without shoes and wearing light clothing. Based on this information, the body mass index (BMI) was calculated.

Data collection

All assessments were conducted in the school by trained research assistants. Self-report information was assessed using specific questionnaires. Anthropometric assessments were conducted by two researchers of both sexes. The data collection proceeded as follows: 1) anthropometric assessments. 2) questionnaires; and 3) delivery of the accelerometers and pedometers, along with their instructions for use.

Statistical analysis

The Shapiro Wil test was used to verify data normality. The general characteristics of the participants were presented as means and standard deviations for continuous variables and absolute and relative frequencies for categorical variables. *T-tests* were used to compare the groups at baseline. Analysis of variance for repeated measures were used to verify the effects of the intervention on the outcome variables. Analysis of covariance (Ancova), adjusted for baseline values, gender and MVPA (mean difference between pre- and post-intervention), was used to compare the effects on the primary outcome between the groups

at post-intervention. When the F-test identified an effect and/or interaction, the *Bonferroni* post hoc test was applied to locate the differences between the means. Effect sizes were determined from the *Eta Squared* values (n^2), using the following normative values: small (0.01-0.059); moderate (0.06-0.13); and large (≥ 0.14). The data was tabulated in Excel (Microsoft Windows, USA, 2013) and analyzed using the Statistical Package for the Social Sciences version 20.0 (SPSS, USA, 2012), with a significance level of $p < 0.05$.

Results

A total of 55 students (34% female; age 13.8±0.6) completed baseline assessments. Two students dropped out from the study, leaving 53 participants in the analysis. Anthropometric and socioeconomic characteristics and the time spent on MVPA of the participants are presented in Table 2. Significant differences between the groups were found for age, height and time spent on MVPA ($p<0.05$).

Table 2. Baseline characteristics of the study sample.

Variables	Intervention Group (n= 31)	Control Group (n= 24)	Total (n= 55)
Age (years)	14.0±0.63	13.5±0.44*	13.8±0.60
Weight (kg)	61.4±10.6	57.6±15	59.7±12.8
Height (cm)	166.3±5.2	161.0±8.1*	163.9±7.1
BMI (kg/m²)	22.2±3.6	22.1±5.0	22.1±4.3
Mother's educational level, n (%)			
Primary education complete	0	1 (4.2)	1 (1.9)
Secondary education complete	3 (10.3)	2 (8.3)	5 (9.4)
High school complete	3 (10.3)	8 (33.3)	11 (20.8)
Graduation complete	23 (79,3)	13 (54,2)	36 (67,9)
Father's educational level, n (%)			
Primary education incomplete	2 (6.9)	0	2 (3.8)
Primary education complete	0	1 (4.2)	1 (1.9)
Secondary education complete	2 (6.9)	2 (8.3)	4 (7.5)
High school complete	5 (17.2)	7 (29.2)	12 (22.6)
Graduation complete	20 (69.0)	14 (58.3)	34 (64.2)
MVPA (min/day)	7.2±6.3	28.3±17.1*	15.4±15.5

Note: MVPA: moderate to vigorous physical activity; **BMI:** body mass index. *Significant difference between groups at $p<0.05$.
Source: authors.

Table 3 presents intragroup comparisons for mental health indicators between baseline and post 12 weeks. Significant reductions on sleep score (mean difference: -0.96, 95% CI: -1.8; -0.09), anxiety (mean difference: -1.7, 95% CI: -2.9; -0.64) and depressive symptoms (mean difference: -1.5, 95% CI: -2.5; -0.56) were found in the IG. No significant differences for mental health indicators were found in the CG. The intergroup comparisons after 12 weeks showed a significant effect of the intervention in favor of the IG for depressive symptoms (moderate effect size) (Table 4).

Table 3. Intragroup comparisons of mental health indicators between baseline and post 12 weeks.

	Intervention Group (n= 29)			**Control Group (n= 24)**		
	Baseline	**12 weeks**	**p**	**Baseline**	**12 weeks**	**p**
Sleep	6.0 (5.1; 6.9)	5.1 (4.2; 5.9)	**0.03***	3.8 (2.8; 4.8)	4.0 (3.0; 4.9)	0.72
Anxiety	5.1 (3.7; 6.5)	3.3 (2.1; 4.5)	**0.003***	2.5 (0.96; 4.1)	1.7 (0.37; 3.0)	0.19
Normal, n (%)	22 (75.9)	26 (89.7)		22 (91.7)	22 (91.7)	
Light, n (%)	3 (10.3)	1 (3.4)		1 (4.2)	0	
Moderate, n (%)	2 (6.9)	1 (3.4)		1 (4.2)	2 (8.3)	
Severe, n (%)	2 (6.9)	1 (3.4)		0	0	
Depression	6.7 (4.7; 8.7)	5.1 (3.2; 7.0)	**0.003***	2.5 (0.37; 4.7)	2.9 (0.84; 5.0)	0.49
Normal, n (%)	20 (69.0)	22 (75.9)		22 (91.7)	22 (91.7)	
Light, n (%)	5 (17.2)	4 (13.8)		1 (4.2)	1 (4.2)	
Moderate, n (%)	3 (10.3)	3 (10.3)		1 (4.2)	1 (4.2)	
Severe, n (%)	1 (3.4)	0		0	0	
Well-being	25.0 (23.2; 26.7)	25.5 (23.6; 27.5)	0.24	28.7 (26.7; 30.6)	28.9 (26.7; 31.0)	0.70

Note:*Significant difference compared to baseline.
Source: authors.

Table 4. Intergroup comparison of mental health indicators post 12 weeks of intervention.

	Intervention Group vs Control Group Mean difference (95% CI)	η^2	**F**	**p**
Sleep	-0.16 (-2.1; 1.8)	0.001	0.029	0.86
Depression	-2.4 (-4.7; -0.11)	0.12	4.585	0.04*
Anxiety	1.2 (0.55; 2.9)	0,06	1.972	0,17
Wellbeing	0.28 (-1.7; 2.3)	0.003	0.082	0.77

Note: η^2: *etasquared* – effect size. Data are presented as mean and 95% confidence intervals; *significant differences between groups compared to post intervention at $p<0.05$, adjusted by sex, baseline values and physical activity.
Source: authors.

Discussion

The aim of the current study was to verify the effects of 12 weeks of a multicomponent program to promote PA on mental health indicators of adolescents. The results showed that there was a significant reduction on sleep score and anxiety and depressive symptoms in the IG post 12 weeks of intervention ($p<0.05$).

Sleep plays an important role on health promotion, since sleep disorders influence the risk of developing cardiovascular diseases[30] and all-cause mortality[31]. Therefore, PA practice has been considered a non-pharmacological treatment method for improving sleep quality[32].

We found a significant reduction on sleep score (-0.96, 95% CI: -1.8; -0.09) in IG compared to baseline, indicating an improvement in this mental health indicator. Other scientific evidence found similar results, in which a significant improvement in the subjective quality of sleep was observed after an intervention to increase PA, with an average increase of 1,200 steps per day over a three-week period providing a large effect size in improving the sleep of schoolchildren[33]. Our results also showed a significant increase in MVPA/day in the IG (mean difference: 10.6, 95% CI: 5.3; 15.9; $p<0.001$), which may have improved the sleep quality of adolescents (data not shown).

Baldursdottir et al.[33] carried out an intervention to increase the practice of PA outside the school environment using pedometers and found improvements in the quality of sleep of adolescents. Similarly, Santiago et al[34] analyzed the effect of resistance exercise on sleep quality and daytime sleepiness in adolescents with sleep disorders. After 12 weeks of intervention, the authors found a significant improvement in sleep quality, a significant increase in total sleep duration and a significant reduction in daytime sleepiness. Furthermore, the additional results showed in individual analyses that approximately 67% of the adolescents obtained a reduction in their sleep-related scores[34].

The mechanisms that explain the effect of regular PA practice on the sleep of adolescents are based on theories of energy conservation and body restoration, since during physical exercise there is a depletion of body energy stores and damage to tissues, which are restored during the sleep period itself[35]. Furthermore, changes in circadian rhythm, vascular, endocrine, metabolic, immunological and thermoregulatory changes can occur as a result of regular PA practice, influencing sleep quality[36].

We observed a significant reduction in anxiety and depressive symptoms in the IG after 12 weeks, and these results are in line with previous studies which also found a significant reduction in symptoms of anxiety (mean difference = -7.89, $p \leq 0.001$)[37] and depression[38]. Adding to these results, a meta-analysis of 16 studies (n=771) testing the effect of PA on symptoms of depression post-intervention compared to a control condition found significant differences in favor of PA[39].

Different mechanisms try to explain how regular PA practice can improve anxiety and depressive symptoms, such as physiological changes (decrease in cortisol levels, increase in neurotransmitter release, regulation of the HPA axis), immunological (decrease in the production of pro-inflammatory cytokines) and psychosocial (hypothesis of distraction and social interaction)[40]. We believe that psychosocial factors may be associated with the reductions in anxiety and depression scores in the IG, since the activities proposed during PE classes were carried out in groups, giving students the autonomy to choose their own groups. In addition, students had also the opportunity to choose the exercises, as well as the order in which they were to be performed.

Although regular PA practice has been shown to have positive effects on the psychological well-being of children and adolescents[41], we did not observe significant changes in this outcome in any of the groups ($p>0.05$). Contrary to our results, Lubans et al.[42] found a significant improvement in the well-being of schoolchildren after 20 weeks of intervention, and this result was associated with an improvement in their autonomy and muscular fitness.

Activities aimed at meeting individuals' basic psychological needs (autonomy, competence and relationships) make them more likely to feel that they are pursuing a purposeful life (i.e. experience greater psychological well-being)[13]. In this way, the

improvement or maintenance of psychological well-being can be mediated by increasing the satisfaction of basic psychological needs[42].

The results of this study have relevant practical implications, since the fact that students who took part in the multicomponent program to promote PA showed improvements in sleep quality, symptoms of anxiety and depression can contribute to evidence on the benefits of PA/exercise on mental health indicators in young people. On the other hand, this study has limitations that should be mentioned, such as the small sample size that limits the generalizability of our findings, as the pilot study was carried out in only two private schools. However, the restrictions imposed on public schools (remote education) due to the COVID-19 pandemic did not allow us to include other schools. Finally, the strengths of this research should be highlighted, such as conducting an intervention research within the school environment during the pandemic period, as well as using multiple strategies to increase students' PA practice.

Conclusion

Twelve weeks of a multicomponent program to promote PA proved to be effective in improving mental health indicators, increasing sleep quality and reducing symptoms of anxiety and depression in adolescents. Our results demonstrate the importance of promoting PA, especially in the school environment, where students spend a significant amount of their day. Finally, our findings are of significant relevance given the increased prevalence of mental disorders in adolescents due to the COVID-19 pandemic.

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