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Original Article

Differences in nutritional status, risk factors for metabolic syndrome, physical fitness and physical activity according to hours of weekly physical education practice

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Abstract
Problem Statement: Schools have been called upon to promote healthy lifestyles. Physical education (PE) classes are the ideal instance to increase Physical Activity (PA). **Purpose**: To compare the nutritional status, the presence of risk factors for developing metabolic syndrome, insulin sensitivity, physical fitness and PA according to the number of PE scheduled hours (PESH). **Method:** The sample included 67 children aged 11±0.47 years, from schools with 2 PESH (n=28) and 4 PESH (n=39). A) Anthropometric evaluation was measured: body weight (kg), height (cm), body mass index, nutritional status, waist circumference, waist/height ratio and percentage of body fat. b) Diagnostic criteria for metabolic syndrome: 7 ml of peripheral venous blood was drawn after 8 hours of fasting to measure plasma glucose, triglycerides, HDL cholesterol and insulin, and blood pressure. c) Insulin sensitivity by HOMA-IR. d) Physical fitness: cardiorespiratory fitness estimation by VO_2max and muscular fitness evaluated by hand strength, maximum lower extremity strength and abdominal strength resistance. e) PA and sedentarism. **Statistical analysis:** According to the normal distribution, the student's t test or Wilcoxon test was used. To compare the nutritional status, a test of proportions was used. The differences were considered statistically significant when $p<0.05$. Analyzes performed by STATA 16.0. **Results:** Children who perform 4 PESH have a lower BMIz-Score (p=0.0006), waist/height ratio (p=0.0003), waist circumference (p=0.0003) and skinfolds sum (p= 0.0018). Number of risk factors for developing metabolic syndrome (p=0.0007). Insulin sensitivity (p=0.0048), fasting glycemia (p<0.0001). Higher VO_2max (p=0.0489), muscle strength expressed relative to body weight in the upper extremity (p=0.0118), in absolute lower extremity (p=0.0025) and relative to body weight (p=0, 0037), Abalakov jump (p=0.0017) and abdominal strength resistance (p<0.0001), steps (p=0.0489), Moderate PA (p=0.0159) and Moderate to Vigorous PA (p=0.0226) and they spend less time in sedentary behavior (p=0.0439). **Conclusions**: Boys and girls who participate in 4 PESH have a higher prevalence of normal weight, a better cardiovascular and metabolic health profile, a higher level of physical fitness, and during the school day a higher PA and less time spent in sedentary behavior than those who participate in 2 PESH. Schools must increase PESH to protect the health of their students.
Keywords: School, physical fitness, Nutritional status, physical activity, metabolic syndrome, school-aged child.

Introduction

Performing physical activity (PA) or physical exercise has been shown to have a significant influence on risk factors for developing metabolic syndrome, previous studies suggest that regular physical exercise, along with increases in cardiorespiratory fitness, bring about improvements in these factors (Myers et al., 2019). Compliance with the current PA recommendations in the pediatric population, that is, performing less than 60 minutes of Moderate to Vigorous Physical Activity (MVPA) daily (World Health Organization [WHO], 2020), brings with it improvements in the parameters blood pressure, dyslipidemia, glucose and insulin resistance, less adiposity, and in academic performance, executive function and fewer symptoms of depression (WHO, 2020). Despite all this evidence, the majority of children and adolescents are insufficiently active (WHO, 2022b). In

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Chile, the weighted average is 20.2% of children and adolescents who meet PA guidelines, in addition, 58.1% of boys and girls have reached a satisfactory level of cardiorespiratory fitness (Aguilar-Farias et al., 2020). Conversely, insufficient PA induces a lower level of cardiorespiratory fitness, risk of hypertension, high cholesterol and probably obesity (Masanovic et al., 2020). It has been previously shown that children with less fitness and high waist circumference have a probability of 8.5 times in adult life to develop metabolic syndrome (Schmidt et al., 2016). In Chile, a prevalence of metabolic syndrome in 10-year-old boys and girls of around 12% has been reported, this figure independent of nutritional status. However, when analyzing the prevalence in boys and girls who suffer from malnutrition due to excess, this figure reaches 38% (Sapunar et al., 2018).

Along with insufficient PA, the child population also shows a high prevalence of overweight and obesity, reaching 340 million children and adolescents between the ages of 5 and 19 worldwide, and 39 million children under 5 years of age (WHO, 2022a), in Chile it is estimated that 58.4% are overweight or obese, showing that the group with the highest prevalence are 11-year-old schoolchildren, where 3 out of 5 students present overnutrition (Ministry of Education [MINEDUC], 2022). Along with having previously reported that 95% of the population does not have healthy eating habits, and that schoolchildren who have insufficient physical activity report not having breakfast, not consuming snacks, and eating less than four meals a day, variables that have been previously correlated with malnutrition due to excess (Ibarra et al., 2019). This situation is a risk factor for suffering changes in cardiovascular and metabolic health, as well as maintaining the change in nutritional status in adult life. It is estimated that by the year 2025, approximately 167 million adults are overweight or obese (WHO, 2022a).

Increasing PA is a public health issue, and schools are ideal physical spaces (Smith et al., 2015), especially physical education (PE) classes become a curricular space to induce improvements in variables of health, demonstrating how boys and girls who regularly participate in PE classes have a lower prevalence of overweight or obesity, a lower waist circumference, as well as a lower body mass index (Learmonth et al., 2019), variables that are considered key to reducing the probability of suffering metabolic syndrome or some of its risk factors. Along with these benefits, improvements have also been observed at the cognitive level, in the competence of fundamental motor skills (Fernández-Valero et al., 2021), biopsychosocial abilities, due to the opportunity experienced by children and adolescents to achieve adequate PA (Dudley et al., 2017), decreased sedentary behavior time, adoption of healthy lifestyles (Lirola et al., 2021). In Chile, this class is called "Physical Education and Health". Being defined as Physical Education scheduled hours (PESH) per week (With a duration of 45 minutes per each scheduled hour) from 1th to 4th grade and 2 scheduled hours from 5th to 10th grade (Decrees 2960/2012). Despite the benefits previously described for the upper courses (11th & 12th), since 2019 the participation in the subject is optional, according to the differentiated subjects offered by the school.

It is interesting to know if there are differences between the number of PESH and health variables. A study carried out in Chile found that body weight, maximum oxygen consumption (VO_2max) and the level of MVPA, are positively modified by doing four hours of PE compared to two hours (Giakoni et al., 2021). However, there is no data regarding the risk factors for developing metabolic syndrome and insulin sensitivity. Therefore, the objective of this study is to compare the nutritional status, the presence of risk factors for developing metabolic syndrome, insulin sensitivity, physical fitness and PA level according to the number of PESH being compared for this purpose 2 PESH (90 minutes) versus 4 PESH (180 minutes).

Material and methods

Study design and participants:

Cross-sectional study. Probabilistic sample with a power of 90%, 67 children were recruited, where the 2PESH group was left with n=28 (39.3% men and 60.7% women) and the 4PESH group with n=39 (48.7% men and 51.3% women) with an average age of 11.0 ± 0.6 and 11.0 ± 0.3 years respectively, from 3 public basic education establishments belonging to the Commune of Ñuñoa, Santiago de Chile, all with similar socioeconomic level. Pregnancy and muscle-tendon injury were considered as exclusion criteria. All the procedures were informed to the parents and/or guardians of each child through informed consent and assent by the children. This study was approved by the Committee on Ethics and Research in Human Beings of the Faculty of Medicine of Universidad de Chile (registry 125), prepared in accordance with the Declaration of Helsinki (1961) and the current legal norm of Chile (decree of law 20.120).

Procedure

Anthropometric evaluation

The trained research personnel in the company of head teachers and/or education assistants measured body weight (kg) using a digital scale (TANITA, HD 313, USA), height (m) with a stadiometer, measured twice and in case of discrepancy of more than 0.05 kg for weight and 0.05 cm for height, it was measured again. Body mass index (BMI) (weight (kg)/[height (m)]2) was calculated and waist circumference was measured. Nutritional status was determined by age- and sex-adjusted BMI z-score (BMIz-score) according to growth standards (WHO, 2007). Sexual maturation was assessed, by self-report, using photographs of pubertal maturation stages (Matsudo & Matsudo, 1994). The waist/height ratio was calculated. To calculate the percentage of fat, 4 skin folds (bicipital, tricipital, subscapular and suprailiac) were measured using a Lange

adipometer with a precision of one millimeter (1mm), in triplicate. To calculate the percentage of fat, the recommendations proposed for the Chilean population were followed, in this way for men it was calculated by the Slaughter equation and for women it was calculated by the Ellis equation (Vásquez et al., 2012).

Diagnostic criteria for metabolic syndrome

To evaluate the metabolic parameters, after fasting for 8 hours, 7 ml of peripheral venous blood were extracted; the glucose oxidase technique was used to measure the plasma glucose level, colorimetric techniques were used for triglycerides and HDL cholesterol (HDL-C), and a radioimmunoassay technique was used to measure plasma insulin. The samples were processed in the laboratory of the Instituto de Nutrición y Tecnología de los Alimentos (INTA) of Universidad de Chile. Resting blood pressure was measured for each boy and girl with an electronic sphygmomanometer (ADC American diagnostic corporation, advantage TM plus model) with a pediatric cuff. To determine the risk factors for metabolic syndrome, the criteria proposed by Zimmet et al. (2007).

Insulin sensitivity

It was assessed by means of the homeostatic model of insulin resistance assessment (HOMA-IR).

Physical fitness

The physical fitness of the boys and girls was evaluated through the cardiorespiratory fitness and muscular fitness to be detailed:

Cardiorespiratory fitness: estimation of VO_2max (mlO2/kg/min-1): Through the 20 meter shuttle run test. For this test it was required a flat and wide space, with a surface free of obstacles, and audio equipment to reproduce a sound stimulus. This test is characterized by being progressive, multi-stage, maximum, imitating what happens in an incremental laboratory test. It ends when the subject does not arrive at the same time as the sound stimulus on two continuous occasions. Once the last completed minute is obtained, the maximum oxygen consumption in children is estimated by linear regression equation (Ruiz et al., 2009).

Muscular fitness: upper extremity; it was evaluated by determining the maximum handgrip strength (MHS), using a 100 kg Smedley brand dynamometer (TTM, Tokyo), which was squeezed with the hand and with the elbow extended for two seconds, reaching to the max. In this test, three attempts are made with both the right and left hands. For the analysis, the highest value reached by each hand was considered and the average of both hands was obtained. Dynamometry ratio: it was calculated by dividing the value in kg by the body weight in kg (WMD/kg); Lower extremity strength: measured by the standing long jump, three attempts were made considering the greatest value of the distance jumped in centimeters, long jump quotient: calculated by dividing the maximum long jump in cm, by the height in cm (SM/height). Counter-Movement Jump (CMJ), a vertical jump was performed with the hands on the waist, starting from a bipedal position, flexing the knees to 90°. Abalakov jump, consisted of a vertical jump with counter-movement and impulse of the arms, for both jumps three attempts were made and the highest height reached in meters measured with a contact platform and a microprocessor (ERGOTESTER-Globus Italia) was considered for its record; Abdominal strength resistance (ASR): it was measured with the short abdominal test, adapted by PE's SIMCE, carried by Ministry of Education of Chile, where students in a supine position performed a trunk flexion with their arms at their sides at rhythm of a sound where the execution had to be continued and controlled for five minutes. The number of sit-ups that were achieved was recorded with a limit of one hundred executions.

Physical activity

PA in boys and girls was objectively assessed using a triaxial accelerometer (Actigraph model 3GTX, Florida), which has proven to be a valid instrument for measuring PA in boys and girls (Migueles et al., 2017). The accelerometer was used for 5 continuous days, only during the school day (8 hours a day), due to the interest in knowing what happens during the school day and ensuring the daily use of the equipment in this context. Accelerometers were configured with a frequency of 100 Hz and using an epoch duration of 15 seconds, being located in the area of the right hip on the iliac crest with an adjustable elastic belt. Once the equipment was removed, the data captured by the equipment was analyzed using the Actilife-6 software (ActiGraph, USA). The number of steps, sedentary behavior, moderate physical activity (MPA) and MVPA were analyzed, which were determined by the number of counts per minute. PA was estimated using the cut-off points proposed by Freedson et al. (2005).

Data collection and analysis

Data were analyzed using Stata 16 statistical software (Stata Corporation, College Station, USA) with an a priori significance level of $p<0.05$. Normality was measured by the Shapiro Wilk test for quantitative variables. For variables with normal distribution, data are presented as means and standard deviation, and for those that do not distribute normally, as median and 25-75 percentile. To determine the differences between the groups, Student's t test or Wilcoxon test was applied according to the normal distribution of the results. To compare changes in nutritional status, the proportion test was applied.

Results

Table 1 presents the anthropometric values, nutritional status criteria, metabolic syndrome and insulin sensitivity in schoolchildren according to the number of PESH. Regarding the anthropometric variables, significant differences were observed between the 2PESH versus the 4PESH groups for the BMI Z score adjusted for age and sex (p=0.0006) according to growth standards (WHO, 2007), waist/height ratio (p=0.0003), skinfold sum (p=0.0018). No significant differences were observed between the groups in the percentage of fat (p=0.1528). In addition, Table 1 presents the diagnostic criteria for metabolic syndrome (Zimmet et al., 2007), along with insulin sensitivity by HOMA-IR. When comparing the groups, significant differences were observed, showing that the 4PESH group presented a lower waist circumference (p=0.0003), higher HDL cholesterol (p=0.0160), lower glycemia (p=0.0000) and a lower value of HOMA-IR (p=0.0048). However, no significant differences were observed for the level of plasma triglycerides (p=0.1347), SBP (p=0.1235), DBP (p=0.6129) and insulin (p=0.1574).

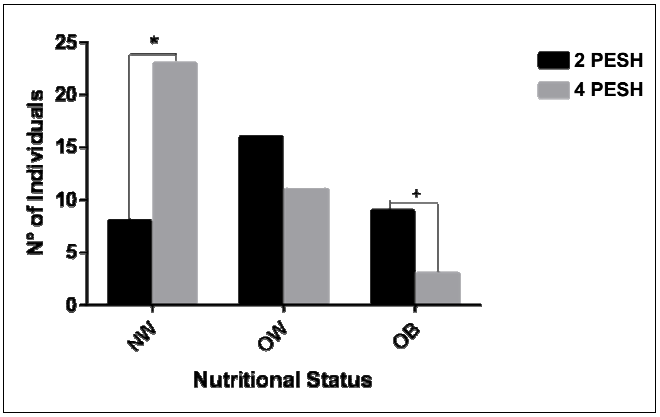
Table 1. Values of the anthropometric variables, nutritional status criteria, metabolic syndrome and insulin sensitivity in schoolchildren according to the number of physical education scheduled hours.

Variable	**2 PESH (n=28)**	**4 PESH (n=39)**	***p***
Antropometric			
IMCz-score[1]	1,71±0,78	0,96±0,96	0,0006*
Waist/Height[1]	0,50±0,04	0,46±0,05	0,0003*
Skinfold sum (mm)[2]	89(62-112)	63(48-89)	0,0018*
Body Fat (%)[2]	20,71(15,70-30,57)	16,68(12,33-31,75)	0,1528
Metabolic syndrome and insulin sensitivity			
Waist circumference (cm)[1]	71,00±5,56	65,29±7,12	0,0003*
Triglycerides (mg/dl)[1]	94,21±38,06	82,24±27,17	0,1347
HDL Cholesterol (mg/dl)[1]	51,90±12,47	59,41±12,30	0,0160*
SBP (mm/Hg)[1]	108,5±9,2	111,6±8,2	0,1235
DBP (mm/Hg)[2]	66,3(63,2-70,7)	67(62,7-72,3)	0,6129
Glycemia (mg/dl)[1]	93,33±7,31	77,79±5,87	0,0000*
Insuline (*µUI/ml)*[1]	8,41±3,65	7,26±2,94	0,1574
HOMA-IR[2]	1,75(1,28-2,32)	1,30(0,98-1,65)	0,0048*

Note. 2PESH: Two physical education scheduled hours (90 minutes); 4PESH: Four physical education scheduled hours (180 minutes); $p<0,05$*;* *: Significant differences; [1]: Arithmetic mean, standard deviation (±) and *t student* test. [2]; Median, 25th and 75th percentile and *Wilcoxon test*; BMIz-score: BMI z-score adjusted for age and sex according to WHO 2007 growth standards; Skinfolds Sum: bicipital, tricipital, subscapular and suprailiac; Fat percentage (%) for men calculated by the Slaughter equation and for women calculated by the Ellis equation (Vásquez et al., 2012); HDL: high density lipoprotein; SBP: systolic blood pressure; DBP: diastolic blood pressure; HOMA-IR: Hemostatic model for the evaluation of insulin resistance.

Regarding the nutritional status for the Z score of the BMI adjusted according to age and sex according to the growth standards (WHO, 2007) (Figure 1), significant differences are observed between the groups. Thus, the group with 2PESH presented the highest number of children with both obesity (p=0.0206), while the 4PESH group presented the highest number of children with normal weight (p=0.0181).

Figure 1. Distribution of the nutritional status of schoolchildren according to the physical education scheduled hours.



Note: 2 PESH: Two physical education scheduled hours (90 minutes); 4 PESH: Four physical education scheduled hours (180 minutes)*: significant differences NW; + significant differences OB; proportion test; Nº of individuals: number of individuals; NO: Normal weight; OM: overweight; OB: obesity.

Regarding the number of risk factors for developing metabolic syndrome according to the criteria proposed by Zimmet et al. 2007 (Table 2), it is observed for those children who perform 2 PESH, the presence of risk factors in 42.9 % of them and for those who perform 4 PESH this condition occurred in 7.7% of the children, these differences being significant (p=0.0007).

Table 2. Frequency of risk factors for developing metabolic syndrome in schoolchildren according to the number of physical education scheduled hours

Risk factors	**2 PESH (n=28)**	**4 PESH (n=39)**	**All (n=67)**
Number of children without risk factors	16 (57,1)	36 (92,3)	52 (77,6)
Number of children with risk factors	12 (42,9)	3 (7,7)	15 (22,4)
Total	28(100)	39(100)	67(100)

Note. Values expressed as a percentage in parentheses. 2 PESH: Two physical education scheduled hours (90 minutes); 4 PESH: Four physical education scheduled hours (180 minutes); *Significant differences between groups (p=0.0007) test of proportion.

Table 3 shows the values of the variables of physical fitness and PA in schoolchildren according to the number of PESH When comparing the physical fitness between the groups, significant differences were found in VO_2max (p=0.0489), dynamometry quotient (p=0.0118), long jump (p=0.0025), long jump quotient (p=0.0025), =0.0037), Abalakov jump (p=0.0017) and ASR (p=0.0000), no differences were observed in MHS (p=0.2990) and CMJ jump (p=0.0852) . Regarding the level of physical activity, significant differences were found between the groups. In this way, the group with 4PESH during the school day walks a greater number of steps (p=0.0489), spends less time in sedentary behavior during the school day (p=0.0439), performs more minutes of MPA (p=0.0159) and MVPA (p=0.0226) during the school day.

Table 3. Values of the variables of physical fitness and physical activity in schoolchildren according to the number of physical education scheduled hours.

Variable	**2 PESH (n=28)**	**4 PESH (n=39)**	***p***
Physical fitness			
VO_2max ($mlO_2/kg/min^{-1}$)[2]	40,0(36,4-42,4)	44,3(41,3-47,6)	0,0489*
MHS (kg)[1]	18,0±3,7	18,8±3,3	0,2990
Dynamometry ratio[1]	0,39±0,73	0,45±0,11	0,0118*

Standing long jump (cm)[1]	107,8±15,3	120,1±17,9	0,0025*
Standing long jump quotient [1]	0,76±0,11	0,85±0,14	0,0037*
CMJ jump (m)[1]	0,22±0,06	0,24±0,05	0,0852
Abalakov jump (m)[1]	0,23±0,05	0,27±0,49	0,0017*
ASR (number)[2]	43(38-73)	166(131-166)	0,0000*
Physical activity			
Steps (nº of steps/SD)[2]	3805(3278-4775)	4904(3690-5486)	0,0489*
Sedentary behavior (min/SD)[2]	285,6(272,4-304,3)	268,4(246,3-283,3)	0,0439*
MPA (min/JE)[2]	59,0(50,0-66,5)	75,25(58,8-89,7)	0,0159*
MVPA (min/JE)[2]	69,0±17,0	79,4±29,4	0,0226*

Note. 2PESH: two hours of PE scheduled hours (90 minutes); 4HSEF: four PE scheduled hours (180 minutes); $p<0.05$; *: Significant differences, [1]: Mean, standard deviation (+) and student's t test; [2]: Median, 25th and 75th percentile and Wilcoxon test; VO_2max (mlO2/kg/min): Maximum oxygen consumption; MHS: Maximum handgrip strength; Dynamometry ratio: corresponds to the index obtained by dividing average dynamometry (DMP) in kg, by body weight in kg (DMP/kg); Standing Long jump quotient: corresponds to the index obtained by dividing the maximum long jump in cm, by the height in cm (SM/height); ASR: Abdominal Strength Resistance (number of sit-ups); JE: school day; MPA: Moderate physical activity; MVPA: sum of the time in minutes of moderate and vigorous physical activity.

Discussion

The objective of this study was to compare the nutritional status, the presence of risk factors for developing metabolic syndrome, insulin sensitivity, physical fitness, and PA among schoolchildren who perform 2 PESH versus those who perform 4 PESH. The main findings show that boys and girls who perform 4 PESH have a lower BMIz-Score, greater sensitivity to insulin, a higher level of physical status and PA, and fewer risk factors for developing metabolic syndrome. Therefore, a greater number of PESH could have a positive impact on the health of boys and girls.

The results showed a greater number of participants with normal weight and less tendency to obesity, lower waist/height ratio, lower waist circumference and less skin adiposity in boys and girls who performed 4 PESH. These results are consistent with previous research that showed that children who work a greater number of hours show control of their nutritional status (Datar et al., 2004). A previous study even increased the frequency and intensity of PE classes over a two-year period, finding that boys and girls who attended an intensive Physical Education school (six PE classes with a total of 270 minutes a week) resulted in a lower prevalence of overweight or obesity (Learmonth et al., 2019). Another study showed changes in weight, BMI and waist circumference, in the group of students who participated in four hours a week (Giakoni et al., 2021). In this sense, and according to our findings, a greater number of PESH could contribute to the treatment of overweight or obesity in the child and adolescent population.

Boys and girls who performed 4 PESH have a lower number of risk factors for developing metabolic syndrome, greater sensitivity to insulin, and lower glycemia compared to schoolchildren who perform 2 PESH. This is in line with the evidence that higher levels of PA have a favorable effect in the treatment of metabolic syndrome and its components (Myers et al., 2019). Currently, the prevalence of metabolic syndrome is an important public health problem, with a prevalence of around 12% of Chilean boys and girls with obesity (Sapunar et al., 2018). PA and lifestyle interventions therefore constitute effective approaches to control it (Sequi-Dominguez et al., 2020), therefore the physiological stimuli that occur during a PE class at the muscular level could contribute to increasing sensitivity to insulin (Guixeres et al., 2014), consistent with the values obtained from HOMA-IR in the group that performed a greater number of PESH.

In addition, those boys and girls with 4 PESH have a higher level of physical fitness (VO_2max and muscle strength), a higher PA, number of steps MPA and MVPA, achieving compliance with the PA recommendations proposed by the WHO (WHO, 2020), finally spend less time in sedentary behavior during the school day. These results agree with previous findings, where the level of MPA and MVPA, and VO_2max are positively modified when performing four hours compared to those who perform two hours per week (Giakoni et al., 2021). Performing more scheduled PA in schools through PE classes can contribute to improving physical fitness, it could stimulate increases in plasma HDL cholesterol levels, generating a cardioprotective effect (Mayorga-Vega et al., 2018).

Therefore, it is recommended that boys and girls older than 11 years of age practice at least 225 minutes of MVPA in schools weekly, of which 50% should be done during PE classes (American Heart Association [AHA], 2015). In this way, those schools that carry out only 2 PESH (90 minutes), have an equivalence of 4.25% of the total time that children and adolescents are in educational establishments (Ministry of Education, 2020), so they are not able to meet the minimum PA requirements proposed to maintain an adequate state of health in this age group. Given this, the AHA in conjunction with the heart attack association made a call highlighting that during PE classes, students practice and learn about PA, allowing them to acquire a healthy lifestyle, preventing unfavorable conditions in this group such as alterations in the lipid profile, elevated blood pressure, hyperglycemia, cardiovascular disease and mental health problems (AHA, 2015). In Chile, work is currently underway to carry out various orientations and programs to increase the number of PESH and AF, suggesting the use of other times.

Conclusion

In conclusion, boys and girls who participate in 4 PESH have a higher prevalence of normal weight, a better cardiovascular and metabolic health profile, a higher level of physical fitness, and during the school day a higher PA and less time spent in sedentary behavior than those who participate in 2 PESH.

Our study supports the importance of PE classes in the school curriculum to protect the cardiovascular and metabolic health of boys and girls, as well as increase physical fitness and promote compliance with PA recommendations and with this achieve all the benefits of an active lifestyle in childhood and adolescence, being essential in countries where malnutrition figures due to excess exceed 50%. Finally, it is urged that the Ministry of Education and the schools decide to increase the PESH and ensure that all students participate in it, avoiding substituting it for other academic activities.

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