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What is the role of adherence to 24-hour movement guidelines in relation to physical fitness components among adolescents?

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Background: Physical inactivity, excessive sedentary time, and lack of sleep time have been independently associated with lower health-related physical fitness. However, little is known about the combined association between 24-h movement guidelines (i.e., physical activity, recreational screen time, and sleep duration) and components of physical fitness.

Objective: The main aim was to examine the likelihood of having high/very high levels on different components of physical fitness based on meeting with 24-h movement guidelines.

Methods: In this cross-sectional study, 1276 Spanish youths (13.07 ± 0.86; 55.88% boys), aged 11–16 years, completed self-reported questionnaires on physical activity, recreational screen time, and sleep duration. Physical fitness components were assessed by 20-m shuttle-run test, standing long jump test, handgrip strength test, and 4 × 10-m shuttle-run test. Meeting 24-h movement guidelines was defined as: 9–11 h/day (children aged 5–13) or 8–10 h/day (adolescents aged 14–17) of sleep, ≤2 h/day of recreational screen time and at least 60 min/day of moderate-to-vigorous physical activity. The probability of having a high/very high score for each physical fitness components (i.e., ≥60th centile according to the normative cut-off points for European adolescents) in relation to adherence to 24-h movement guidelines was analyzed using a series of binary logistic regressions.

Results: Participants who met the three 24-h movement guidelines were more likely to have high/very high for cardiorespiratory fitness (OR = 3.31; 95% CI: 1.79, 6.14; $p < 0.001$), standing long jump (OR = 1.91; 95% CI: 1.06, 3.45; $p = 0.031$),

muscular fitness (OR = 2.05; 95% CI: 1.09, 3.86; $p = 0.048$) and physical fitness (OR = 1.99; 95% CI: 1.08, 3.66; $p = 0.012$), but not for handgrip strength (OR = 1.15; 95% CI: 0.64, 2.01; $p = 0.636$) and speed/agility (OR = 1.65; 95% CI: 0.92, 2.96; $p = 0.093$), compared to those who did not meet all three recommendations.
Conclusion: Since meeting the three 24-h movement guidelines increased the likelihood of having higher levels in most physical fitness components, it seems necessary to promote these movement behaviors early in life, as they could serve as a gateway for improving health-related fitness in future generations.

KEYWORDS
health-related behaviors, lifestyle, movement behaviors, physical fitness, youths

1 | INTRODUCTION

Physical fitness is defined as the ability to perform physical activity and/or exercise without excessive fatigue and represents an integrated measure of all the functions and structures involved in physical activity or exercise participation.[1] Health-related physical fitness comprises a set of physical qualities such as aerobic capacity (also called cardiorespiratory fitness), muscular fitness and speed/agility.[2] Health-related physical fitness has been positively associated with several healthy indicators such as cardiovascular health and metabolic health,[3–6] motor competence,[7] as well as a lower risk of non-communicable diseases such as overweight and obesity among young people.[3,4,6,8,9] Moreover, health-related physical fitness has also been positively related to cognitive indicators (e.g., academic achievement[10]; and mental-health indicators[11]) in young people. However, some components of physical fitness such as cardiorespiratory fitness and strength have declined in recent decades.[8,12] This is a public health concern because physical fitness levels tend to track from childhood and/or adolescence to adulthood.[13]

Although there are several factors that can influence physical fitness, the adoption of a healthy lifestyle has been identified as one of the main correlates.[14,15] According to 24-h movement guidelines, it is recommended that young people aged 5–17 years spend ≥60 min per day in moderate-to-vigorous physical activity, ≤2 h per day of recreational screen time, and sleep 9–11 h per day (children aged 5–13) or 8–10 h per day (adolescents aged 14–17).[16] Previous systematic reviews and meta-analysis have reported that higher levels of physical activity,[8,17,18] lower levels of sedentary behaviors (mainly recreational screen time),[19]and adequate amount of sleep[20] have been independently associated with higher physical fitness in young people. However, a previous meta-analysis conducted among 387 437 young people from 23 countries showed that only 7.12% meet all three 24-h movement guidelines.[21] Therefore, it seems necessary to promote meeting with these recommendations to obtain adequate levels of physical fitness.

Specifically, meeting physical activity guidelines increases the likelihood of achieving healthy fitness levels of cardiorespiratory fitness,[22-24] muscular fitness,[23-26] speed/agility,[23] and flexibility.[23] Meeting recreational screen time guidelines has also been found to increase the likelihood of having greater levels of cardiorespiratory fitness,[19,27-32] and muscular fitness.[33] Similarly, meeting sleep duration guidelines has been associated with a high cardiorespiratory fitness in a sample of children and adolescents.[20,22] Moreover, a systematic review by Fonseca et al.[20] found a positive relationship between sleep duration with higher levels of muscular fitness and flexibility in adolescents. Nevertheless, a non-significant relationship between sleep duration and cardiorespiratory fitness was found in children.

There is a large body of evidence that have examined these three 24-h movement behaviors (i.e., physical activity,[34] sedentary time,[19] and sleep duration[35]) in isolation. However, these behaviors are co-dependent on each other, across the whole day (i.e., 24-h period) and, therefore, they should be examined simultaneously.[16] To our knowledge, there is only three studies that has examined the combined association between 24-h movement guidelines and physical fitness among children and/or adolescents.[22-24] The study conducted by Carson et al.[22] found that adherence to the three 24-h movement guidelines was associated with increased cardiorespiratory fitness. A limitation of this study is that only cardiorespiratory fitness was assessed, without considering other components of physical fitness. Chen et al.[23] found that adolescents meeting two or three guidelines were related with greater cardiorespiratory fitness, muscular strength, and general physical fitness. An important limitation of this study is that the fitness components were self-reported, which may lead to recall bias. On the contrary, the study conducted by Tanaka et al.[24] in children aged 6–12 years found no association between adherence to overall 24-h movement guidelines and some fitness components (i.e., muscular strength, muscular endurance, flexibility, and cardiorespiratory fitness). Due to the limitations and mixed findings found in the studies conducted by Carson et al.,[22] Chen et al.,[23] and Tanaka et al.,[24] more studies are needed to know whether adherence to the 24-h movement guidelines, compared to non-adherence to the three guidelines, is associated with higher physical fitness, as well as with higher physical fitness components. This information may be of great interest to stakeholders, teachers, and health professionals for future interventions to promote health-related fitness components. Improving movement behaviors could serve as a gateway to enhance health-related fitness, prevent associated risk factors (e.g., cardiovascular health, metabolic health, and obesity) and avoid functional limitations caused by physical inactivity, excessive recreational screen time, and lack of sleep during childhood and adolescence.[36,37]

To expand knowledge on this research question, the present study tried to examine the independent and combined association between 24-h movement guidelines and physical fitness components, as well as to analyze whether adherence to these guidelines increases the likelihood of having high levels on different physical fitness components in Spanish adolescents, compared to those who do not meet the three recommendations. Based on the results found by Carson et al.[22] and Chen et al.,[23] it was hypothesized that adherence to the three 24-h movement guidelines would be associated with a greater likelihood of having high physical fitness compared to non-adherence to the three recommendations. Similarly, consistent with previous studies, it was postulated that adherence to the three 24-h movement guidelines would be associated with a greater likelihood of having high cardiorespiratory fitness,[22] muscular fitness, and lower speed or agility scores.[23]

2 | MATERIALS AND METHODS

2.1 | Design and participants

Cross-sectional data from the physical activity and healthy habits promotion in adolescent's project was analyzed for this study.[38] Data was collected from March to June 2019, in a city in southwestern Spain. Simple random sampling was used. Twenty-two schools from this city were randomly invited to participate to ensure the representativeness of the sample (i.e., 2217 participants). Out of the total number of young people, 941 were excluded because they had missing values on physical fitness tests ($n = 404$), physical activity ($n = 6$), and recreational screen time ($n = 531$). The final sample of participants was 1276, aged 11–16 years, of which 563 were girls (13.00 ± 0.80 years old) and 713 were boys (13.07 ± 0.86 years old). This study was conducted in accordance with the Declaration of Helsinki and was approved by the Ethics Committee of the University of Extremadura (89/2016).

2.2 | Measures

2.2.1 | Physical fitness

Physical fitness was determined through the health-related fitness battery for young people (ALPHA-Fitness).[39]

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed with the 20-m shuttle-run test.[39] This test has been shown to be valid and reliable in children and adolescents.[39,40] It is a field-based test and consists of running from one line to another located 20 m away, changing the rhythm using a sound signal that increases progressively. The initial speed of the signal is 8.5 km/h and is increased by 0.5 km/h (1 min equals 1 stage). The test ends when the participant is unable to reach the line at the same point as the audio signal for a second consecutive time, loudspeaker to reproduce the sound signal and a 20-m no slippery surface. It was used the Nevil's[41] formula to calculate the maximal oxygen consumption (VO_{2max}, mL/kg/min). Participants were classified as having "very low/low/medium" or "high/very high" cardiorespiratory fitness level based on 60th centile for VO_{2max} peak in European children and adolescents,[42] which is the normative quintile-based framework cut-off for high to very high, taking into account age and sex (i.e., <60th centile: very low/low/medium or ≥60th centile: high/very high).

Lower limb strength

Lower limb strength was determined using the standing long jump test. This test has proven to be valid and reliable in young people.[39] Participants should stand behind the jump line, feet together, trying to jump as far as possible to the signal. The distance was measured from the starting line to the position of the part of the heel closest to the starting line when the participant touched the ground. The test was performed twice and the best score (cm) was retained.[39] Based on the normative cut-off points for European children and adolescents (i.e., <60th centile or ≥60th centile), participants were classified into two groups: "very low/low/medium" or "high/very high", respectively.[42]

Handgrip strength

Upper limb strength was measured by handgrip strength using a hand dynamometer with adjustable grip (TKK 5401 Grip D, Takei). This test has been showed to be valid and reliable in young people.[39,43] Before starting the test, the dynamometer was adjusted to fit the size of the participants, as recommended by Ruiz et al.[39] The test was performed in a standing position, keeping the elbow extended and the wrist in a neutral position. Participants were encouraged to squeeze as hard as possible for at least a few seconds. Two attempts were made per hand and the best result was recorded. The average of the best results obtained in each hand was recorded. The handgrip score (kg) was expressed per kilogram of body weight.[39] Adolescents were classified into two groups: "very low/low/medium" or "high/very high",[42] according to the normative cut-off points for European children and adolescents (i.e., <60th centile or ≥60th centile).

Speed/agility

Speed/agility was assessed using the 4×10-m shuttle-run test. Validity and reliability of the test was previously tested in young people.[44] It is a field test consisting of running back and forth as fast as possible between two lines located 10 m apart. The test ends when the student crosses the finish line with one foot. In this study, the test was performed twice and the fastest time in seconds was recorded. Speed/agility scores were inverted so that higher values indicated better results. Participants were classified into two groups: "very low/low/medium" or "high/very high", based on 60th centile for speed/agility in European children and adolescents (i.e., <60th centile: very low/low/medium or ≥60th centile: high/very high).[42]

Muscular fitness and physical fitness

Muscular fitness was calculated as the mean of the upper and lower limb centiles. Similarly, physical fitness was calculated as the mean of cardiorespiratory fitness, overall muscular fitness and speed/agility centiles. Participants were classified into two groups: "very low/low/medium" or "high/very high", according to the normative cut-off points for European children and adolescents.[42]

2.2.2 | 24-h movement guidelines

Physical activity

Physical activity was measured using the Spanish version of a Physical Activity Questionnaire for Adolescents (PAQ-A).[45] This instrument has proven to be a valid (a moderate relationship between total physical activity [r = 0.39] and moderate-to-vigorous physical activity [r = 0.39] was found when the questionnaire was checked against the accelerometers) and reliable tool (α = 0.79; intraclass correlation coefficient [ICC] = 0.71) for measuring physical activity levels in Spanish young people aged 12–17 years. In the present research, Cronbach's alpha in this scale was 0.89. The scale is composed of nine questions measuring participation in physical activity in the last 7 days, measured at different times of the day. To calculate a physical activity index score, the frequency of participation of a list of activities, the physical activity performed during physical education lessons, in school holidays, during the school break, at lunchtime, after school, in the evening and on non-school days was asked. Each response is scored on a 5-point Likert scale ranging from 1 to 5. Physical activity score was calculated as the average value of all responses. Higher scores indicate higher levels of physical activity. Based on the normative cut-off points established in a previous study,[46] participants were classified into two groups: active (with a score >2.75) and inactive (with a score ≤2.75 score).

Recreational screen time

Recreational screen time was assessed using the Spanish version of the Youth Leisure Sedentary Behavior Questionnaire (YLSBQ).[47] This questionnaire is valid (r = 0.36) and reliable (ICC = 0.75) to assess sedentary behaviors among Spanish youth aged 8–18 years.[47] In this study, participants self-reported usual recreational time spent on television, video games, computers, and mobile phones on both school days and non-school days. An average recreational screen time was obtained for each screen-based behavior at a ratio of 5:2 (e.g., [daily video games playing on school days × 5] + [daily video games playing on non-school days × 2]/7). The average recreational screen time was calculated by summing the daily different screen-based behaviors. Based on the 24-h movement guidelines for children and adolescents, participants were classified into two groups: meeting screen time recommendations (i.e., ≤2 h/day) or not meeting them (i.e., >2 h/day).

Sleep duration

Sleep duration was measured using a Spanish translation of a self-reported sleep questionnaire.[48] Through four questions, the usual sleep duration was calculated from the time difference between going to bed and waking up on school days and non-school days. These questions have been shown to be a valid (r = 0.45–0.90) and reliable (ICC = 0.71–0.99) to measure sleep duration in young people.[49] Average sleep duration was determined using the following formula ([sleep duration on school days × 5] + [sleep duration on non-school days × 2]/7). Based on the 24-h movement guidelines for children and adolescents, participants were classified into two groups:

meeting sleep duration recommendations (i.e., 9–11 h per day in children aged 5–13 years or 8–10 h per day in adolescents aged 14–17 years) or not meeting them.

2.2.3 | Sociodemographic characteristics

Age (in years), sex (girls/boys), socioeconomic status, and body mass index (BMI) were included as covariates in statistical analyses. Participants self-reported their age and sex. Socioeconomic status was calculated according to the average income level per household unit in each of the cities/towns where the study was carried out.[50] Weight was obtained with an accuracy of 0.1 kg using an electronic scale (model SECA 877) and height was measured with an accuracy of 1 mm using a telescopic height-measuring instrument (model SECA 217). With these measurements, BMI (kg/m^2) was determined as weigh (kg) divided by the square of height (m^2).

2.3 | Procedure

The research team contacted with school principals and teachers to explain the study aim and conduct data collection. Parents were also informed by letter about the nature and objective of the investigation. The written informed consent form was given from both adolescents and their parents or legal guardians. The questionnaires were administered in a school classroom by one member of the research team to explain in the same way the instructions of the study. Participants filled out the questionnaires in approximately 30 min, before the physical fitness and anthropometric measurements were taken. After completing the questionnaires, the participants were individually weighed and measured in a private room by a researcher of the same sex. Finally, the physical fitness tests were carried out in the school playground under suitable atmospheric conditions.

2.4 | Statistical analysis

Descriptive statistics for all measures using means and standard deviations (i.e., continuous variables) or number of participants and percentages (i.e., categorical variables) were calculated. The Kolmogorov–Smirnov test was performed to check whether the data were normally distributed. Participants were classified into one of the following categories (i.e., not meeting recommendations, meeting only with physical activity, meeting only with screen time, meeting only with sleep duration, meeting only with physical activity + screen time, meeting only with physical activity + sleep duration, meeting only with screen time + sleep duration, and meeting all three recommendations). Linear regression analyses were performed to estimate the association between 24-h movement guidelines and physical fitness components. Due to the non-normal distribution of the cardiorespiratory fitness, standing long jump, handgrip strength, and speed/agility, a nonparametric bias-corrected and accelerated (BCa) bootstrap method with 1000 samples was used (Supplementary Material 1). According to Tomkinson et al.[42] adolescents were also classified into two groups for each of the fitness components: "very low/low/medium" or "high/very high", respectively. Binary logistic regressions were also performed to predict the probability of having a high/very high score for each physical fitness component (i.e., cardiorespiratory fitness, lower limb strength, handgrip test, speed/agility test, muscular fitness, and physical fitness) in relation to the independent and combined adherence to 24-h movement guidelines compared to non-adherence to the three recommendations. Furthermore, corrections of multiple comparisons were done using the false discovery rate (FDR) *p*-value proposed by Benjamini and Hochberg.[51] All analyses were adjusted for age, sex, socioeconomic status, and BMI. Since no significant interaction was found among sex and physical activity, recreational screen time, and sleep duration in relation to physical fitness components (all, $p > 0.010$), all analyses were conducted on the entire sample. All statistical analyses were done using SPSS version 23.0 for Windows (IBM) and the level of significance was set at $p < 0.05$.

3 | RESULTS

Descriptive characteristics, prevalence of 24-h movement behaviors, and physical fitness of the participants are shown in Table 1. In addition, descriptive characteristics of included and excluded participants can be found in Supplementary Material S1. The prevalence of the participants who had a high/very high score was 50.5% for cardiorespiratory fitness, 49.8% for standing long jump, 50.3% for the handgrip test, 48.9% for muscular fitness, 50.3% for speed/agility, and 51.4% for physical fitness.

Figure 1 shows the prevalence of adolescents who met each of the 24-h movement guidelines and in combination. Overall, most of the participants (82.6%) met sleep duration guidelines, whereas 38.0% and 15.4% met physical activity and screen time guidelines, respectively. Only 5.7% met all three recommendations, while 9.9% did not meet with any of the recommendations.

The association between 24-h movement guidelines and each physical fitness component can be found in the Supplementary Material 2. The probability of having

TABLE 1 Descriptive characteristics of the participants, prevalence of 24-h movement behaviors, and physical fitness indicators.

Study variables	Total $M \pm SD$	
n (%)	1276 (100.0)	
Sociodemographic characteristics		
Age (years)	13.04 ± 0.84	
Socioeconomic status (€)	20746.58 ± 3026.86	
Height (cm)	1.60 ± 0.08	
Weigh (kg)	54.17 ± 12.11	
Body mass index (kg/m^2)	21.11 ± 3.71	
24-h movement behaviors		
Physical activity (range: 1–5)	2.54 ± 0.60	
Screen time (h/day)	4.53 ± 2.26	
Sleep duration (h/night)	8.67 ± 0.89	
Physical fitness components[a]	$M \pm SD$	n (%)
Cardiorespiratory fitness (ml/kg/min)	46.52 ± 9.46	1276 (100.0)
Very low/low/medium, n (%)	40.44 ± 5.13	631 (49.5)
High/very high, n (%)	52.47 ± 8.92	645 (50.5)
Standing long jump (cm)	157.55 ± 30.80	1276 (100.0)
Very low/low/medium, n (%)	135.79 ± 22.15	640 (50.2)
High/very high, n (%)	179.45 ± 21.32	636 (49.8)
Handgrip strength (kg)	24.89 ± 6.10	1276 (100.0)
Very low/low/medium, n (%)	22.82 ± 5.38	634 (49.7)
High/very high, n (%)	26.94 ± 6.09	642 (50.3)
Muscular fitness (z-score)	0.01 ± 1.00	1276 (100.0)
Very low/low/medium, n (%)	−0.42 ± 0.82	652 (51.1)
High/very high, n (%)	0.84 ± 0.74	624 (48.9)
Speed/Agility (sec)	13.17 ± 1.53	1276 (100.0)
Very low/low/medium, n (%)	11.98 ± 0.74	634 (49.7)
High/very high, n (%)	14.04 ± 1.41	642 (50.3)
Physical fitness (z-score)	0.11 ± 0.34	1276 (100.0)
Very low/low/medium, n (%)	−0.15 ± 0.15	817 (64.0)
High/very high, n (%)	0.32 ± 0.31	456 (36.0)

[a]Based on normative values for physical fitness in adolescents.[42]

high/very high levels on physical fitness components according to meeting 24-h movement guidelines is shown in Figure 2 and Supplementary Material 3. Participants who met the overall 24-h movement guidelines were more likely to have a high/very high score for cardiorespiratory fitness (OR = 3.31, 95% CI: 1.79, 6.14, $p < 0.001$), standing long jump (OR = 1.91, 95% CI: 1.06, 3.45, $p = 0.031$), muscular fitness (OR = 2.05, 95% CI: 1.09, 3.86, $p = 0.048$), and physical fitness (OR = 1.99; 95% CI: 1.08, 3.66; $p = 0.012$), in comparison with participants who did not meet with three recommendations. Applying FDR p-correction results were statistically significant for cardiorespiratory fitness (Benjamini-Hochberg adjusted p-value: $p < 0.001$). In addition, the Benjamini-Hochberg adjusted p-values showed a slight tendency toward significance for standing long jump (p-adjusted = 0.052), muscular fitness (p-adjusted = 0.060), and physical fitness (p-adjusted = 0.070).

4 | DISCUSSION

The objective of the present study was to examine the independent and combined association between 24-h movement guidelines and physical fitness components, as well as to analyze whether adherence to these guidelines increases the likelihood of having high levels on different physical fitness components, compared to those who do not meet the three recommendations in Spanish young people. The main findings of this study indicated that: (1) meeting the three 24-h movement guidelines was positively associated with higher levels of cardiorespiratory fitness and (2) participants who met all three 24-h movement guidelines were more likely to score high/very high levels for cardiorespiratory fitness, lower limb strength, muscular fitness, and physical fitness, compared to participants who did not meet the three recommendations. However, meeting with all three recommendations does not seem to increase the likelihood of having higher handgrip strength and speed/agility values.

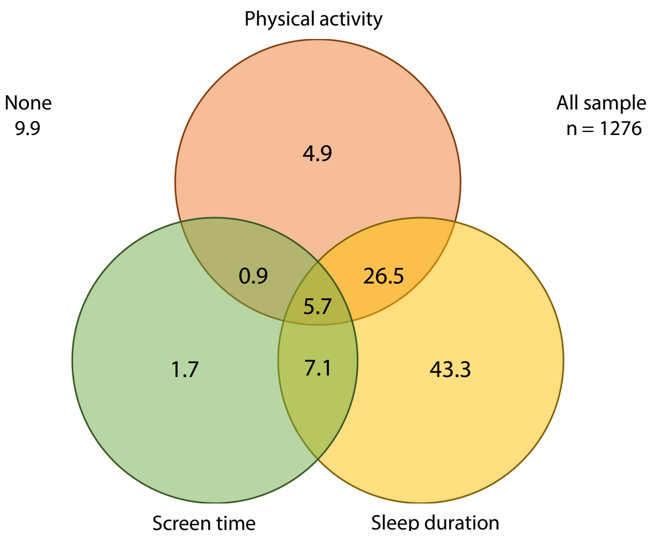

FIGURE 1 Venn diagram showing the proportion (%) of participants meeting no guidelines; physical activity, recreational screen time, and sleep duration guidelines; and combinations of these recommendations. Legend: guidelines are: ≥60 min/day of moderate-to-vigorous physical activity; no more than 2 h/day of recreational screen time; and 9–11 h/night for children, 8–10 h/night for adolescents of sleep duration. The sum of each circle is equivalent to the % meeting each individual recommendation (i.e., 38.0% for physical activity, 15.4% for screen time, and 82.6% for sleep duration).

Our results showed that meeting with overall recommendations for physical activity, recreational screen time, and sleep duration was related to higher cardiorespiratory fitness, as well as being more likely to have high levels of this component. Specifically, meeting physical activity guidelines was positively related to cardiorespiratory fitness, although this relationship was not found with screen time and sleep time. Therefore, physical activity seems to be the movement behavior that most positively affect the relationship between 24-h movement guidelines and cardiorespiratory fitness. Our results are consistent with previous studies conducted by Chen et al.[23] and Carson et al.[22] However, contrary to our study, Chen et al.[23] also revealed a positive relationship between meeting all three recommendations and physical fitness and muscular strength. The differences found in our study in comparison to the Chen et al.[23] study could be a consequence of sociodemographic differences in the population groups. The systematic review and meta-analysis by Tapia-Serrano et al.[21] found that in countries with a higher human development index, adherence to 24-h movement guidelines regions recommendations was higher. Therefore, the differences found in the relationship between the 24-h movement guidelines and physical fitness and muscular strength

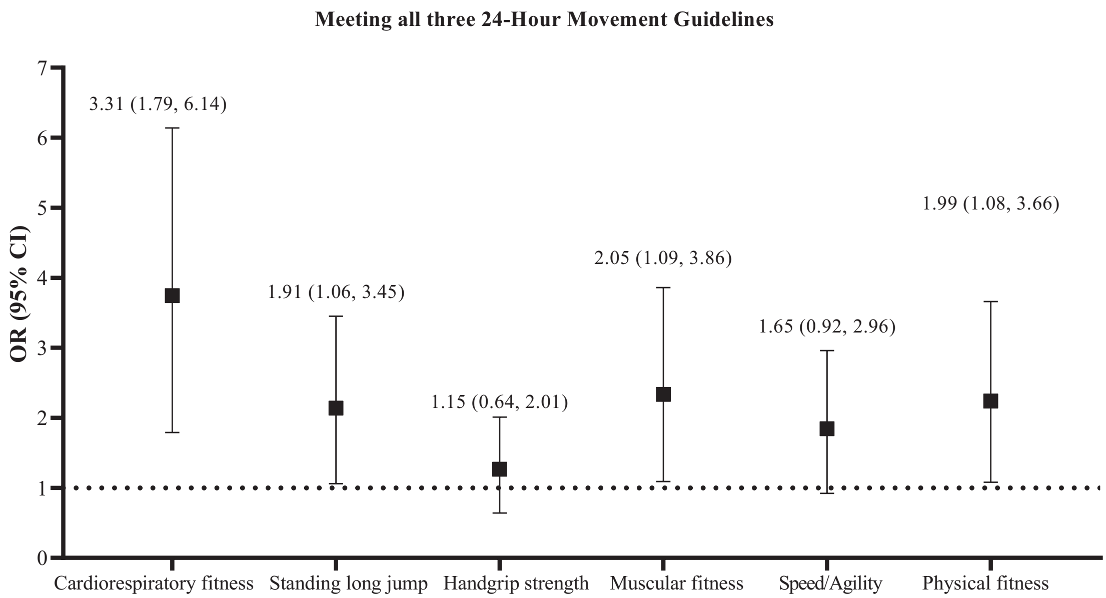

FIGURE 2 Likelihood of high/very high physical fitness indicators based on compliance with 24-h movement guidelines. *Note: OR, odds ratio; CI, confidence interval. Reference: not meeting recommendations. Muscular strength: was measured as the mean of the strength of the upper and lower limb centiles; physical fitness: was calculated as the mean of all fitness components.

could be a consequence of sociodemographic differences between the study population and the reference population. Furthermore, in the study conducted by Chen et al.[23] the physical fitness variables were self-reported by the participants, which may lead to recall bias and consequently also bias the associations with the 24-h movement guidelines. In addition, recent systematic reviews have reported that higher levels of physical activity were associated with higher levels of cardiorespiratory fitness.[34,52] Similarly, a three-year longitudinal study reported that an increase of 6.9 min of physical activity per day contributed to an increase in the mean value of distance covered in the 20 m dash test from 968 to 1070 m.[53] Therefore, it is suggested that the improvement in cardiorespiratory fitness may be the result of an increase in the cumulative amount of physical activity.[54] Regarding recreational screen time, a previous systematic review found that an excessive use of some screen-based recreational behaviors, such as video and/or computer games, had detrimental fitness consequences.[19] This could be due to the fact that an increased recreational screen time could displace other movement behaviors such as physical activity,[55] and consequently, this might promote a decrease in cardiorespiratory fitness levels.[27,28] Moreover, a systematic review by Fonseca et al.[20] showed that reduced sleep duration was associated with reduced cardiorespiratory fitness in adolescents. Despite these findings, the mechanisms involved in the relationship between sleep duration and cardiorespiratory fitness are unknown.[20] Therefore, further studies are needed to better understand these mechanisms.

Another relevant finding from our study was that adolescents who meet with the three 24-h movement guidelines were more likely to have higher muscular fitness compared to adolescents who did not meet the three recommendations. However, after applying the Benjamini-Hochberg adjustment, the result did not reach statistical significance. In a previous study conducted by Chen et al.,[23] adherence to these three guidelines was found to correlate with higher muscular fitness. Previous systematic reviews[18,25] have found that meeting physical activity recommendations was positively associated with muscular fitness. This also accords with a previous study,[26] which showed that adolescents who met with physical activity recommendations had higher levels of muscle fitness than those who did not meet. Physical activity has been shown to increase the ability of the skeletal and muscular systems to perform work requiring muscular strength and endurance.[56] These improvements allow muscles to exert higher levels of muscular tension, which translates into increased muscular fitness. Likewise, Edelson et al.[33] found that time spent watching television and time spent using the computer was inversely associated with muscle fitness in youths. Similarly, the systematic review conducted by Fonseca et al.[20] showed that a reduction in sleep duration was associated with lower levels of muscular fitness in adolescents. However, the mechanisms that explain the relationship between recreational screen time and sleep recommendations and muscle fitness are not yet fully understood; therefore, further research is needed to investigate the mechanisms that explain these possible relationships among young people.

Moreover, the results of the current study indicate that participants who met 24-h movement guidelines were more likely to have higher levels of physical fitness compared to participants who did not meet the three recommendations. Notwithstanding, using the Benjamini-Hochberg adjustment, this result reached a near-significant trend. The study by Chen et al.[23] also found that young people aged 10–17 years who met all three recommendations were more likely to have higher self-reported fitness levels than those who did not meet any of the recommendations. The systematic review by Poitras et al.[34] also indicated a positive association between physical activity levels and physical fitness in young people. This association may be explained by the fact that physical activity or exercise participation stimulates physiological adaptations that improve and maintain physical fitness.[18] Similarly, a previous systematic review has noted an inverse association between recreational screen time and physical fitness in children and adolescents,[19] which supports the results of the present study. It has been suggested that adolescents who spend a lot of time watching television and playing video games may be lower physical fitness[57] due to the displacement hypothesis.[57] This hypothesis suggests that time spent on recreational screen-based activities may replace time participating in more productive and/or active activities, especially activities involving physical movement and thus those that may affect the physical fitness of young people. In addition, the systematic review by Fonseca et al.[20] found a positive association between sleep duration and some physical fitness components in adolescents (i.e., cardiorespiratory fitness, muscular fitness, and flexibility). However, the association between sleep duration and physical fitness in adolescents has not been extensively studied, so the mechanisms that could explain this association are unclear. Therefore, further research exploring this relationship is needed before a clearer conclusion can be drawn.

This study has some limitations that open new perspectives of research. First, due to the cross-sectional design of this study, we cannot establish causality between 24-h movement guidelines and physical fitness indicators. Having high physical fitness could also serve as a gateway for improving 24-h movement guidelines (i.e., causal reversibility). Future longitudinal and experimental studies are required to determine the directionality of this relationship. Second, although all questionnaires used to assess physical activity, recreational screen time, and sleep duration are valid and reliable, they were self-reported and, therefore, may have underestimated or overestimated the results found. Future studies should use device-based physical activity, recreational screen time, and sleep duration measures. Third, in this study, only the association between the 24-h movement guidelines and physical fitness components was evaluated. Future studies should also evaluate other movement behaviors features such as sleep quality, sleep continuity, purposes of recreational screen time, type of physical activity performed, etc. Finally, the percentage of excluded participants was approximately 42%. However, this limitation does not significantly affect the results of our study, as the analysis of differences between included and excluded participants was not significant.

5 | PERSPECTIVES

Despite these limitations, the present study also has some strengths that should be highlighted. Age, sex, socioeconomic status, and BMI, were introduced as covariates in the analyses, which increased the strength of the results. In addition, this is one of the first studies that examined the association between meeting all three 24-h movement guidelines and most physical fitness components in adolescents and the first to examine this relationship using field tests to assess physical fitness components.

Given that only a small percentage of the sample met all three recommendations, efforts are needed to promote the adoption of these three guidelines. An optimal distribution of these movement behaviors across the 24 h of the day could have wider implications for health-related fitness. Therefore, it seems necessary to promote these movement behaviors early in life, as they could serve as a gateway for improving health-related fitness.

6 | CONCLUSION

The present study suggests that meeting the three 24-h movement guidelines increases the likelihood of having higher levels on most physical fitness components in Spanish young people.

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DATA AVAILABILITY STATEMENT

The datasets used and/or analyzed during the current study are available from the corresponding author upon reasonable request.

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