Nutrición Hospitalaria

Nutr Hosp. 2009;24(2):226-232
ISSN 0212-1611 • CODEN NUHOEQ
S.V.R. 318

Original

Preliminary evidence of physical activity levels measured by accelerometer in Spanish adolescents; The AFINOS Study

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Abstract

Background: **It is necessary to know the levels of physical activity (PA) for a better understanding of the development of chronic diseases in youth. The aim of this study was to assess levels of total PA and time spent in different PA intensities in Spanish adolescents by accelerometer.**

Methods: **A sub-sample of 214 healthy Spanish adolescents (107 females), aged 13-16 years, enrolled in the AFINOS Study was selected for this study. Participants wore the ActiGraph GT1M accelerometer for 7 consecutive days. Total PA and time spent in sedentary, light, moderate, vigorous, and moderate to vigorous physical activity (MVPA) was estimated using the accelerometer. Adiposity was measured in the sample using sum of 6 skinfold thickness, waist circumference and BMI.**

Results: **Adolescent boys were engaged in higher levels of total PA, moderate PA, vigorous PA and MVPA than adolescent girls, whereas girls were engaged in higher levels of light PA. Differences between age groups showed that the 15-16 years group did more total PA (P = 0.008) than the 13-14 years group. Adolescents with highest levels of body fat were less active and spent less time in vigorous PA and MVPA than adolescents with less body fat. Among the current sample, 71.1% of the adolescents (82.2% adolescent boys and 60.7% adolescent girls) reached the recommendation of ≥ 60 min in MVPA.**

Conclusions: **Although these findings suggest that Spanish adolescents have similar PA levels than other European adolescents, further cross-sectional and longitudinal studies must assess PA levels in free-living conditions in Spanish children and adolescents using objective methods such as accelerometers, heart rate monitors and pedometers.**

(*Nutr Hosp.* 2009;24:226-232)

Key words: *Physical activity. Accelerometer. Assessment. Adolescents.*

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Recibido: 5-XI-2008.
Aceptado: 22-XI-2008.

EVIDENCIA PRELIMINAR DE LOS NIVELES DE ACTIVIDAD FÍSICA MEDIDOS MEDIANTE UN ACELERÓMETRO EN ADOLESCENTES ESPAÑOLES. ESTUDIO AFINOS

Resumen

Antecedentes: **Para comprender mejor el desarrollo de las enfermedades crónicas en los jóvenes resulta necesario conocer los niveles de actividad física (AF) que realizan. El propósito de este estudio es evaluar los niveles de AF total y el tiempo de AF a distintas intensidades medidos mediante acelerometría en adolescentes españoles.**

Métodos: **Para este estudio se seleccionó una sub-muestra de 214 adolescentes españoles sanos (107 mujeres), con edades de 13-16 años, que participaban en el Estudio AFINOS. Los participantes llevaron un acelerómetro ActiGraph GT1M durante 7 días consecutivos. La AF total y el tiempo dedicado a actividad física sedentaria, ligera, moderada, vigorosa y de moderada a vigorosa (AFMV) se valoró utilizando el acelerómetro. La adiposidad se midió en la muestra utilizando la suma de 6 pliegues cutáneos, la circunferencia de la cintura y el IMC.**

Resultados: **Los chicos adolescentes realizaron mayores niveles de AF total, AF moderada, AF vigorosa y AFMV que las chicas adolescentes, mientras que las chicas realizaron mayores niveles de AF ligera. Las diferencias entre los grupos de edad mostraron que el grupo de 15-16 años realizaba más AF total (P = 0,008) que el grupo de 13-14 años. Los adolescentes con los niveles más altos de grasa corporal eran menos activos y dedicaban menos tiempo a realizar AF vigorosa y AFMV que los adolescentes con menos grasa corporal. En esta muestra de adolescentes, el 71,1% de los adolescentes (82,2% de los chicos y el 60,7% de las chicas) alcanzó la recomendación de 60 min. de AFMV.**

Conclusiones: **Aunque estos hallazgos sugieren que los adolescentes españoles tienen niveles de AF similares a los de otros adolescentes europeos, futuros estudios transversales y longitudinales deberían evaluar los niveles de AF en adolescentes y niños españoles dentro de su estilo de vida habitual utilizando métodos objetivos como los acelerómetros, los monitores de la frecuencia cardíaca y los podómetros.**

(*Nutr Hosp.* 2009;24:226-232)

Palabras clave: *Actividad física. Acelerómetro. Evaluación. Adolescentes.*

Introduction

Rates of chronic diseases have been progressively increasing in developing countries during the last several years.[1] Cardiovascular disease, cancer, chronic respiratory diseases, and diabetes lead to a higher incidence of mortality among people between 0 and 30 years of age.[1,2] Genetic and environmental factors are involved in the development of chronic diseases,[3] but evidence suggests that modifiable lifestyle factors play a key role. The importance of regular physical activity (PA) for the prevention[4] and treatment[5] of chronic diseases has led to increased. Thus, PA monitoring and promotion must be two basic objectives in public health across the world.[6] Considerable attention has been focused on children's PA since behavior. A special focus is also needed in the prevention of chronic disease from early ages because these diseases and their associated co-morbidities often persist from childhood into adolescence, and from adolescence into adulthood.[7,8]

Higher levels of PA in school-age youth has been negatively associated to adiposity, cardiovascular health, hypertension, low physical fitness, asthma, and indicators of mental health (e.g. anxiety, depression).[9] Therefore, it is necessary to know youth PA levels for a better understanding of the development of chronic diseases in this population. In the scientific literature, there are several methods or techniques to assess PA in children and adolescents.[10] PA measures are categorized by the accuracy of assessments in primary, secondary and subjective measures. Primary measures include indirect calorimetry, doubly labeled water and direct observation. Secondary measures involve heart rate monitoring, accelerometers and pedometers. Subjective measures include self-reports, interviews, proxy report, and activity diaries. Feasibility in health-related research is inversely related with the accuracy capacity of the method.[8] For that reason, in clinical assessments with a few patients, doubly labeled water may be used to assess PA in free-living conditions, while subjective measures such as self-report are usually used in epidemiological studies. Accelerometers are often used in health-related research to assess objective PA in free-living conditions. Despite the initial-cost and limitations for large scale research applications, accelerometers have been used in longitudinal and cross-sectional studies with large samples to assess PA levels in children and adolescents.[11,12]

To date, no study has assessed habitual PA levels in a youth Spanish population using accelerometers. Therefore, the purpose of this study was to assess levels of total PA and time spent in different PA intensities in an adolescent Spanish sample by accelerometer. Differences in PA levels were analyzed by gender, age, and body fat to better understand factors that may influence adolescent's regular PA.

Methods

Participants

Participants in the present study were part of a large cardiovascular disease surveillance study called AFINOS. (La Actividad Física como Agente Preventivo del Desarrollo de Sobrepeso, Obesidad, Alergias, Infecciones y Factores de Riesgo Cardiovascular en Adolescentes Physical Activity as a Preventive Agent of the Development of Overweight, Obesity, Infections, Allergies and Factors of Cardiovascular Risk in Adolescents). The AFINOS Study has evaluated the health status and lifestyle indicators of a representative sample of adolescents and their parents in the region of Madrid (Spain). The present sample consists of 214 healthy Spanish adolescents (107 males and 107 females), aged 13-16 years currently enrolled in the AFINOS Study. Data were obtained from 2 public high schools in the region of Madrid (Spain).

Before participating in this study, all adolescents were informed of the nature of the study and gave assent and parents also provided signed written consent. Testing was conducted in accordance with the ethical standards established in the 1961 Declaration of Helsinki (as revised in Hong Kong in 1989 and in Edinburgh, Scotland, in 2000). The AFINOS Study was approved by the Ethics Committee of Puerta de Hierro Hospital (Madrid, Spain) and the Bioethics Committee from the Spanish National Research Council.

Physical examination

The anthropometry protocol in the current study was identical to the protocol used in the AVENA Study[13] (Alimentación y Valoración del Estado Nutricional en Adolescentes [Food and Assessment of the Nutritional Status of Spanish Adolescents]) with ~2,500 measurements in Spanish adolescents.[14] Skinfold thickness were measured on the left side of the body to the nearest 0.1 mm with a skinfold caliper (Caliper Holtain; Holtain Ltd., Walles, UK) at the following sites: (1) triceps, halfway between the acromion process and the olecranon process; (2) biceps, at the same level as the triceps skinfold, directly above the centre of the cubital fossa; (3) subscapular, about 20 mm below the tip of the scapula, at an angle of 45º to the lateral side of the body; (4) suprailiac, about 20 mm above the iliac crest and 20 mm towards the medial line; (5) thigh, in the midline of the anterior aspect of the thigh, midway between the inguinal crease and the proximal border of the patella; (6) calf, at the level of maximum calf circumference, on the medial aspect of the calf. Circumferences were measured with a non-elastic tape to the nearest 1 mm in the following sites: (1) biceps; (2) contract biceps; (3) waist; (4) hip; (5) calf. The complete set of anthropometric measurements was performed twice, but not consecutively. Weight and height were obtained by standardized procedures. Body mass index

(BMI) was calculated as weight/height squared (kg/m^2). Participants were categorized by weight status according the cut-off values for BMI, sex and age proposed by the International Obesity Task Force (IOTF).[15] The sum of 6 skinfolds was used as an indicator of total body fat and the waist circumference as an indicator of abdominal body fat. Blood pressure was measured using a digital automatic blood pressure monitor (Omron M6, OMRON HEALTH CARE Co., Ltd., Kyoto, Japan).

Accelerometer

Participants wore the accelerometer ActiGraph GT1M (ActiGraph™, LLC, Fort Walton Beach, FL, USA). This activity monitor is a compact, small (3.8 cm x 3.7 cm x 1.8 cm), lightweight (27 g) and uniaxial accelerometer designed to detect vertical accelerations ranges in magnitude from 0.05 to 2.00 *g* with a frequency response of 0.25-2.50 Hz. This frequency range detects normal human motion. Activity counts are summed over a user specified interval of time called an "epoch". The GT1M's rechargeable lithium polymer battery is capable of providing power for over 14 days without recharging. The ActiGraph (previously known as MTI and CSA) accelerometer has been widely validated in laboratory and free-living conditions with children and adolescents.[16]

The accelerometers were downloaded and processed according to manufacturer recommendations. Data were processed and analysed by JAVA software developed to analyze the output from this accelerometer. The monitor was initialized to record in 15-s epochs in order to capture the intermittent nature of youth's PA. [17] The software excludes bouts of 10 continuous min of zeros from the analysis output, considering these periods as non-wearing time. An inclusion criterion for this study was an activity monitor recording of at least 10 hours per day, for 4 days, one of which had to be a weekend day. Variables obtained by the ActiGraph accelerometer for this study were counts per minute (cpm) as a measure of total PA and time spent in different PA intensities. To estimate PA in different intensities, Freedson's age-specific cut-points for light PA, moderate PA and vigorous PA were used.[16] The cut-off value of < 100 cpm was used to estimate time spent in sedentary PA.[18] Time spent in moderate to vigorous activity (MVPA) was computed by summing the moderate and vigorous categories.

Procedures

Groups of participants (15 on average) were assessed during a whole week with the same procedures. Participants completed the anthropometric testing on one day during school time (Wednesday). The accelerometer was provided to the participants at the end of this testing along with instructions for use. The monitor was attached to an elastic belt and participants were instructed to keep the monitor positioned at the lower back. Participants were instructed to wear the monitor continuously for the next 7 days except for water activities and sleeping. Total data collection lasted for 4 months between 2007 and 2008 (November to February).

Data analysis

All the variables were checked for normality before analysis, and natural logarithm transformation were applied when necessary. The characteristics of participants and outcomes of the study are described as mean ± SD. Gender differences in physical characteristics were assessed by one-way analysis of variance (ANOVA). Gender, age, and body fat (sum of 6 skindfolds, waist circumference, BMI, and weight status) differences in activity indicators (total PA and PA in different intensities) were examined by analysis of covariance (ANCOVA) after adjusting for registered valid time. Bonferroni's *post hoc* for multiple comparisons was used to examine mean differences among tertiles.

The percentage (%) of compliance with youth PA guidelines was computed for the total sample and separately by gender. Differences between proportions of adolescents achieving recommendations were analyzed using chi-square test for proportions. Three different PA guidelines were evaluated in the present study. The first guideline was the Guidelines for Adolescents[19]. This recommendation suggests that adolescents should engage in at least 20 min of MVPA each day three or more times per week. The second guideline was the U.S. Centers for Disease Control and prevention (CDC) Guideline for youth[9]. This recommendation suggests that youth should engage in at least 60 min of MVPA per day. The third guideline, the Health Canada Guideline, suggests two goals for youth.[20] They recommend at least 90 minutes in MVPA each day (Goal #1) and to increase progressively the time spent on PA achieving 60 min of moderate PA plus 30 min of vigorous PA per day (Goal #2).

All statistical analyses were performed using the Statistical Package for the Social Sciences for Windows, version 14.0 (SPSS Inc., Chicago, IL, USA). The alpha level was set at 0.05 for all analyses.

Results

Physical characteristics of the sample are presented in table I. Adolescent boys were significantly taller and heavier than adolescent girls. Adolescent boys also had higher levels of systolic blood pressure, whereas basal heart rate was significantly higher in adolescent girls. According to BMI, 75% of the sample was normal-weight, 18.5% was overweight, and 6.5% was obese. Adolescent girls had significantly higher values of total body fat ($P < 0.001$), and adolescent boys had significantly higher values of abdominal fat ($P = 0.015$).

Table I
Descriptive physical characteristics of the sample

	Adolescent boys (n = 107)	*Adolescent girls (n = 107)*
Age (years)	14.65 ± 1.18	14.86 ± 1.18
Height (m)	1.70 ± 0.09	1.62 ± 0.07***
Weight (kg)	63.58 ± 14.4	57.74 ± 9.07**
Body mass index (kg m^2)	22.25 ± 6.14	21.75 ± 3.08
Sum of 6 skindfolds (mm)	87.66 ± 37.63	114.49 ± 31.68***
Waist circumference (cm)	75.25 ± 10.25	71.74 ± 8.90**
Basal heart rate (beats min^{-1})	76.94 ± 13.50	80.48 ± 11.75*
Systolic blood pressure (mmHg)	131.45 ± 13.89	119.55 ± 12.80***
Diastolic blood pressure (mmHg)	70.15 ± 11.11	70.66 ± 11.15

Values are expressed as mean ± SD.
* P < 0.05.
**P < 0.01.
***P < 0.001, denotes statistical significance between genders.

Physical Activity differences by gender and age

Differences in PA by gender are shown in Table II. Adolescent boys were more active (total PA) than adolescent girls. Adolescent boys engaged in higher levels of moderate PA, vigorous PA, and MVPA than girls. In contrast, adolescent girls spent more time in light PA than adolescent boys. On the other hand, differences between age groups showed that the 15-16 year-old group was more active (P = 0.008) than the 13-14 year-old group. Non-significant differences were found between gender and age in others PA intensities (P > 0.05).

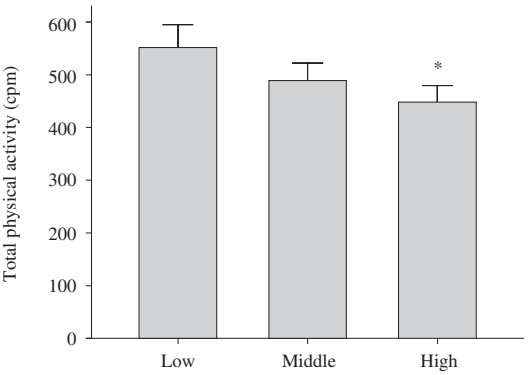
Physical Activity differences by body fat

PA differences by total body fat are illustrated in figures 1 and 2. Differences between means of total PA divided in tertiles (low, middle, and high) by the sum of 6 skinfolds showed a significant difference between the tertile with the lowest total body fat and the tertile with the highest body fat (fig. 1). Differences between means time spent in different PA intensities showed differences between the lowest tertile and the highest tertile for time in MVPA (fig. 2). Significant differences were also found in time spent in vigorous PA between adolescents with low total body fat, and other tertiles with high total body fat. Similar results were found stratifying in tertiles by BMI and waist circumference (data not shown). No significant differences between total PA and PA according to different intensities were observed among groups by weight status according to the IOTF.

Table II
Physical Activity (PA) differences between genders of the sample

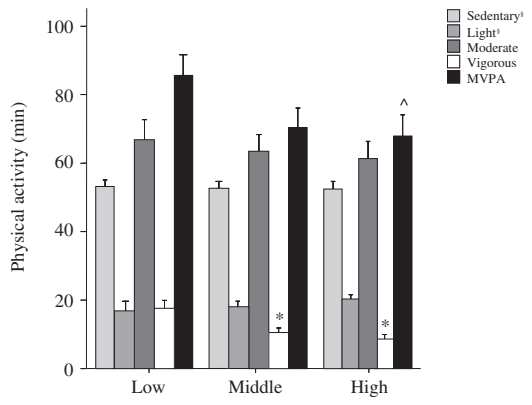
	Adolescent boys (n = 107)	*Adolescent girls (n = 107)*
Total PA (cpm)†	558.01 ± 174.67	432.52 ± 115.13*
Sedentary PA (min)†	496.12 ± 80.64	471.38 ± 84.34
Light PA (min)	164.76 ± 37.01	173.79 ± 31.55*
Moderate PA (min)	67.58 ± 21.75	56.10 ± 17.12*
Vigorous PA (min)†	17.51 ± 11.51	6.60 ± 5.66*
MVPA (min)†	85.09 ± 29.22	62.70 ± 19.64*

Values are expressed as mean ± SD. MVPA: moderate to vigorous PA. †Values were transformed (Ln) before analyses, but non-transformed values are presented in the table. Data were analyzed by analysis of covariance with Bonferroniš adjustment for multiple comparisons and were adjusted for registered valid time. *P < 0.001, denotes statistical significance between genders.



† Values were transformed (Ln) before analyses, but non-transformed values are presented in the figure. Data were analyzed by analysis of covariance with Bonferroniš adjustment for multiple comparisons and were adjusted for registered valid time. Error bars represent standard error of the mean (95% IC). *Significantly different (p = 0.003) from the low tertil.

Fig. 1.—Mean values of total physical activity divided in tertiles (low, middle, and high) by the sum of 6 skinfolds of the sample (n = 214)†.



MVPA: moderate to vigorous physical activity. §Vales presented in the figure (min) were multiplied per 10^{-2}. Values of sedentary PA, vigorous PA and MVPA were transformed (Ln) before analyses, but non-transformed values are presented in the figure. Data were analyzed by analysis of covariance with Bonferroniš adjustment for multiple comparisons and were adjusted for registered valid time. Error bars represent standard error of the mean (95% CI). *Significantly different (p < 0.001) from the low tertil. ^Significantly different (p = 0.048) from the low tertil.

Fig. 2.—Mean values of physical activity intensities divided in tertiles (low, middle, and high) by the sum of 6 skinfolds of the sample (n = 214)†.

Table III
Percentage (%) of compliance with physical activity (PA) guidelines for youth of the sample

	Guideline for Adolescents[19]	*CDC*[9]	*Health Canada*[20]	
	≥ 20 min of MVPA	*≥ 60 min of MVPA*	*≥ 90 min of MVPA*	*≥ 60 min of MVPA + ≥ 30 min of MVPA*
All (n = 214)	99.5	71.1	23.8	4.7
Adolescent boys (n = 107)	100	82.2	37.4	9.3
Adolescent girls (n = 107)	99.1	60.7*	10.3*	0*

MPA: moderate PA; VPA: vigorous PA; MVPA: moderate to vigorous PA.
* P < 0.001, denotes statistical significance between genders by the Chi-square test for proportions.

Physical Activity compliance with youth guidelines

The percentage of youth meeting PA guidelines is shown in table III. Nearly all adolescents (99.5%) achieved the recommendation of ≥ 20 min of MVPA based on the Guidelines for Adolescents. Over 70% (71.1%) of youth achieved the recommendation of ≥ 60 min of MVPA per day from the CDC but considerably fewer (23.8%) achieved the Health Canada PA Goal #1 of ≥ 90 min in MVPA per day. Even fewer (4.7%) were compliant with Goal #2 of the Health Canada PA guideline of ≥ 60 min in moderate PA plus ≥ 30 min in vigorous PA per day. The percentages of adolescent girls achieving recommendations proposed from CDC and Health Canada were significantly lower than the percentage of adolescent boys that met these guidelines.

Discussion

This study provides the first report of PA levels in Spanish children measured by accelerometer. The procedures used in the study are consistent with standard accelerometry practices used by researchers in other countries and thereby provide valuable information about the relative activity levels of Spanish youth. The results provide descriptive information about total levels of PA and also about time spent in different intensities of PA. We found that adolescent boys were engaged in higher levels of total PA, moderate PA, vigorous PA and MVPA than adolescent girls, whereas girls were engaged in higher levels of light PA, and that older adolescents were significantly more active than younger adolescents. We also found that adolescents with highest levels of body fat were less active and spend a smaller amount of time in vigorous PA and MVPA than adolescents with less body fat.

An important goal of the study was to determine the percentage of youth that meet established guidelines for PA. The Guideline recommendation for Adolescents[19] was reached by most of the Spanish participants. The U.S. CDC recommendation of ≥ 60 min in MVPA is the most commonly used for youth, and countries such as UK and Australia have adopted it. More than 70% of the Spanish adolescents reached this recommendation. The Health Canada Goals set more ambitious standards for youth (90 minutes of MVPA) and fewer (~24%) adolescents achieved this Goal #1. Fewer still achieved Goal #2 from the Health Canada PA guidelines (~5%) that targeted 60 minutes of moderate PA and 30 minutes of vigorous PA. Similar findings found in Canadian children and adolescents have caused these goals to be questioned and new goals were recently suggested of ≥ 60 min in MVPA per day[22] (Goal #1), and 45 min in moderate PA plus 15 min in vigorous PA per day (Goal #2).[23]

Rodríguez et al.[21] assessed energy expenditure using a tri-axial accelerometer in 20 healthy Spanish children and adolescents during a 24-h school day period. The main aim of the Rodríguezs study was a comparison among instruments (accelerometer, hear rate monitoring, and activity diary) to estimate total diary energy expenditure, but they did not assess the PA levels of their sample.

One limitation of this study is the difficulty to compare the PA levels found in our study with previous studies. Differences between primary, secondary and subjective measures to assess PA may be large. Despite this difficulty, we can compare results among studies that used the ActiGraph accelerometer in adolescents from other countries.

Riddoch et al.[24] assessed 2,185 children and adolescents aged 9 to 15 years from Denmark, Portugal, Estonia, and Norway. Comparing our results with their adolescents group, Spanish adolescents were involved in less total PA and MVPA than the average of these 4 countries. Spanish adolescent boys were more active (total PA and MVPA) than Denmark adolescent boys. Similarly, Spanish girls engaged in slightly more MVPA than Denmark girls. Moreover, the percentage of compliance from the CDC recommendation[9] in our study was similar than these 4 countries (81.9% boys and 62.0% girls).

Ortega et al.[25] assessed PA levels in Sweden children and adolescents. Sweden adolescent boys and girls obtained similar values of total PA to our sample (557 cpm for boys and 490 cpm for girls). However, Sweden boys spent less time in MVPA than Spanish boys (81 min), whereas Sweden girls spent more time in MVPA

than Spanish girls (69 min). Therefore, an equivalent percentage reached the CDC recommendation[9] (70.1% and 60.2%, for boys and girls respectively).

Recently, Troiano et al.[26] presented data from the 2003-2004 National Health and Nutrition Examination Survey (NHANES) in a representative U.S. sample aged 6 to 70+ years old. Results from this study in the 12-19 years old sample showed that Spanish adolescent boys and girls are more active and spent more time in MVPA than U.S. adolescents. Percentages of adolescents reaching CDC recommendation[9] were also lower (~11% adolescent boys and ~4.4% adolescent girls) than Spanish adolescents. However, the larger age range among the U.S. sample limits our ability to make comparisons between the two samples.

Several limitations should be taken into consideration in these comparisons. First, there is no consensus yet on what cut-off points are better to assess the time spent in different PA intensities using the ActiGraph accelerometer.[16] Significant differences between PA intensity cut points have been shown elsewhere[27], and the use of these cut points in our investigation would have likely resulted in different activity levels from those presented. Second, the ActiGraph was not designed to be worn in the water, and therefore, adolescents had to remove it during water activities (e.g. shower, swimming, water-polo). Third, the ActiGraph only detects vertical accelerations. Thus, activities with important movements in the horizontal axis might be underestimated (e.g. dancing, cycling, skating).[28] Fourth, different epochs have been used in previous studies in youth. Significant differences in vigorous PA using diverse epochs were found in children.[29] Thus, epochs < 60 seconds are recommended for these ages[17]. Finally, depending on the ActiGraph model used (CSA, MTI, ActiGraph 7164, ActiGraph 71256, ActiGraph GT1M) differences might exist between measurements which would limit comparison.[30] Even so, these limitations are intrinsic to all the studies using the ActiGraph accelerometer.

Differences in PA levels by gender, age and body fat were also analyzed in our study. The scientific literature contains several studies showing that boys are more active than girls in all ages.[22-24] Our study confirms these differences by gender for total PA, moderate PA, vigorous PA, and MVPA. However, our study also found that Spanish girls engaged in greater amounts of light PA than boys. Studies using accelerometers have shown that the differences by gender and age are influenced by the fact that physical maturation in girls is present two years before maturation in boys.[31] Another confirmed finding is the progressive decline of PA levels throughout the lifespan.[32] A recent longitudinal study using accelerometers showed a downward growth curve in youth between 9 to 15 years old and the estimated age at which girls crossed below the CDC recommendation per day was approximately 13.1 years for girls and 14.7 years for boys.[33] Unlike these findings, in our study the 13-14 age group was less active than the 15-16 age group and no significant differences were found in PA intensities. Further studies using objective and subjective measures must be developed to confirm or refute these results.

Moreover, differences by body fat in our study showed that the high tertile was less involved in total PA, vigorous PA and MVPA than the tertile with less body fat. In a study with 421 adolescents, Gutin et al.[34] examined the associations of moderate PA, vigorous PA and MVPA, and body fat measured by DXA. The results showed that only vigorous PA explains the variance in body fat after controlling for age, gender, race, and the gender × race interaction. Therefore, our group with higher levels of body fat should spend more time in vigorous PA. On the other hand, no differences were found according to the weight status groups (normal-weight, overweight and obesity) in our sample. A few studies have analyzed differences by weight status and PA by accelerometer in youth. For example, Ekelund et al.[35] found differences in time spent in MVPA between obese and normal weight children independently of gender. Treuth et al.[18] found significant differences in time spent in MVPA between normal-weight and overweight (including obese) girls.

In summary, this study contributes to the preliminary findings about PA levels and time spent in different PA intensities in Spanish adolescents measured by accelerometer. Differences in PA were analyzed by gender, age, and body fat, and 71.1% of the adolescents (82.2% adolescent boys and 60.7% adolescent girls) reached the recommendation of ≥ 60 min/d in MVPA. Future research directions should lead to further knowledge of PA levels in free-living conditions in youth and adults. Accelerometers, heart rate monitors and pedometers should be used to assess PA in cross-sectional and longitudinal studies, and to provide important information to future national public health policies in specific groups (girls, adolescents, and obese subjects).

Acknowledgements

The authors express their sincere gratitude to the volunteers who participated in this study. This study was supported by the DEP2006-56184-C03-02/PREV grant from the Spanish Ministry of Education and Science (MEC). DMG was supported by a scholarship from Spanish Ministry of Education and Science (AP2006-02464). None of the authors had any conflicts of interest.

*Appendix

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