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TESIS DOCTORAL

PATRONES, FRACCIONAMIENTO Y DIRECTRICES DE LA ACTIVIDAD FÍSICA: LA RELEVANCIA DE LA ACTIVIDAD FÍSICA ESCOLAR SOBRE EL CONSUMO MÁXIMO DE OXÍGENO

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1. **Calahorro Cañada F**, Torres-Luque G, López-Fernández I, Santos-Lozano A, Garatachea N, Álvarez Carnero E. (2015). Actividad física y acelerometría: Orientaciones metodológicas en población escolar. Nutr Hosp, 31(1):115-128. doi:10.3305/nh.2015.31.1.7450

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6. **Calahorro Cañada, F.**, Torres-Luque, G., López-Fernández, I., Álvarez Carnero, E. Recess Sedentary time and CRF in School-Aged Children and Adolescents.

RESUMEN

Los beneficios de la realización de actividades físicas y deportivas son fundamentales para garantizar una buena la salud. Es por ello que los niveles y patrones de actividad física han sido analizados, siendo la etapa escolar un período fundamental para la prevención de enfermedades y mejora de la salud. De esta manera, el estudio y análisis de los niveles de actividad física en la niñez y adolescencia por medio de la acelerometría está siendo una línea de trabajo en auge en la presente década, así como el análisis de consumo de oxígeno máximo un importante predictor y marcador del estado de salud.

El objetivo general de esta Tesis Doctoral es describir los niveles de AF y diferentes intervalos de integración de datos (bouts) durante diferentes actividades del contexto escolar (educación física y recreo) y fuera del mismo, así como analizar la asociación entre intensidades de actividad física y el consumo máximo de oxígeno en alumnos de primaria y secundaria.

Se colocaron un total de 668 acelerómetros triaxiales GT3X a alumnos con edades comprendidas entre los 8 y 19 años para analizar los patrones, niveles de actividad física y bouts realizados. Los participantes llevaron el acelerómetro un total de 7 días en la cadera derecha con un epoch de 1 s. Se consideró válido un tiempo de registro de ≥ 10 horas/día y 5 días (4 durante la semana y 1 de fin de semana). Los puntos de corte elegidos son los propuestos por Evenson et al. (2008), correspondientes a actividad física Sedentaria ≤ 100; Ligera ≥ 100; Moderada ≥ 2296 y Vigorosa ≥ 4012 counts·min^{-1}. Se calculó la actividad física en cada una de las diferentes actividades de la semana: el total de la semana, fin de semana, de lunes a viernes (semana escolar), actividades extraescolares (desde las 14:01 ó 14:31 hasta las 23:00 horas), educación física, recreo y el resto de actividades que no incluyen el recreo ni la educación física (min/día, min/hora y %). De manera adicional, se analizaron los bouts netos y acumulados correspondientes a los intervalos de 1, 2, 4, 5, 6, 8, 10 y 12 minutos (bouts/día y min/día).

Además, se realizaron un total de 503 test con el fin de obtener el consumo de oxígeno máximo. El analizador portátil seleccionado fue Metamax 3B, el cual fue colocado durante la realización del test progresivo maximal Chester Step en un banco sueco. Se midió además la frecuencia cardiaca mediante el Polar Team^2 y la presión arterial mediante el Omron M3 Intellisense; HEM-7051-E.

Los resultados más significativos de la Tesis muestran que a) los diferentes criterios metodológicos en el empleo de acelerómetros dificultan su comparación a pesar de tener puntos en común; b) los mejores predictores del consumo máximo de oxígeno son la edad, tiempo total a intensidad sedentaria e índice de masa corporal; c) los niveles de actividad física y cumplimiento de recomendaciones son bajos; el recreo y la educación física permiten acumular una mayor cantidad de actividad física a intensidad desde moderada a vigorosa por hora que otras actividades; d) se muestran diferencias en los niveles de actividad física, así como en los bouts netos y acumulados durante el recreo, educación física y el resto de actividades diarias; los resultados sugieren diferentes patrones de comportamiento de los bouts en función de su análisis como bouts netos o acumulados; e) los alumnos deben evitar la intensidad a nivel

sedentaria durante el recreo (menos de 15 minutos) por tener mayores posibilidades de tener un consumo máximo de oxígeno catalogado como no saludable.

ABSTRACT

Benefits engaging physical activity are vital to provide a proper health. Thus, physical activity levels and patterns during school-ages have been analyzed, because this stage is essential for disease prevention and health improvement. By this manner, the analysis of physical activity levels during childhood and adolescence measured by accelerometers is an increasing issue of research this decade, and so the maximum oxygen uptake as a powerful marker and predictor of health status.

The overall aim of this Doctoral Thesis is to describe physical activity levels and different bouts during several school-based activities (recess time and physical education), and out-of-school activities, and also analyze associations among physical activities intensities and maximum oxygen uptake among elementary and secondary school students.

A total of 668 triaxial GT3X accelerometers were attached to school-aged participants from 8 to 19 years old; in order to analyze physical activity, patterns and bouts accrued. Subjects wore the accelerometer during 7 days on the right hip with an epoch of 1 s. A wear-time of ≥ 10 hours/day for ≥ 5 days was used as the criterion for a valid measurement (4 week days and 1 weekend day). Cutoffs points proposed were based on Evenson et al. (2008): Sedentary physical activity ≤ 100; Ligh ≥ 100; Moderate ≥ 2296 and Vigorous ≥ 4012 counts·min^{-1}. Physical activity was recorded during: the whole week, weekend, from Monday to Friday (school-week), out of school activities (from 2.01 or 2.31 pm to 11.00 pm), physical education classes, recess time and non-physical education or recess activities (min/day, min/hour and %). Moreover, 1, 2, 4, 5, 6, 8, 10 and 12-minute net and accumulated bouts (bouts/day and min/day) were analyzed.

Additionally, 503 tests were conducted to calculate maximum oxygen uptake. The portable breath by breath selected was Metamax 3B, which was carried during the performance of the progressive maximal Chester Step Test in a bench. Besides, the heart rate was collected by the Polar Team^2 and blood pressure by Omron M3 Intellisense; HEM-7051-E.

The most important results show that a) the different methodological criteria used with accelerometers, makes it difficult to compare methodology among papers in spite of some of them carried out similar methods; b) the main predictors of maximum oxygen uptake are age, total sedentary time and body mass index category; c) overall, subjects displayed low physical activity levels and low meeting of health guidelines; recess and physical education classes allow accruing a higher moderate to vigorous physical activity per hour than other activities; d) differences in physical activities, net and accumulated bouts were displayed during physical education, recess and non-physical education or recess activities; results suggest different pattern of behavior when using accumulated or net bout approaches; e) school-aged subjects should discourage sedentary time during recess because those who met more than 15-minute had higher likelihood of being unhealthy.

Abreviaturas [Abbreviations]

NAF	Niveles de actividad física
EF	Educación física
AF	Actividad Física
MV	Intensidad desde moderado a vigoroso
ACL	Acelerómetro
IMC	Índica de Masa Corporal
GC	Grupo Control
GI	Grupo Experimental
S	Intensidad Sedentaria
L	Intensidad Ligera
M	Intensidad Moderada
V	Intensidad Vigorosa
Pre	Preescolares
P	Primaria
S	Secundaria
1X	Uniaxial
3X	Triaxial
C	Cadera
CD	Cadera Derecha
CI	Cadera Izquierda
E	Parte baja de Espalda
Cint	Cintura
CND	Cadera no dominante
D	Días
DS	Días semanales
DFS	Días Fin de semana
ANOVA	Análisis de la Varianza
PE	Physical education classes
PA	Physical activity
PAs	Physical activities
MVPA	Moderate to vigorous physical activity
ACLs	Accelerometers
VO_{2Max}	Maximum oxygen uptake
CRF	Cardiorespiratory fitness
CVD	Cardiovascular disease
CPX-T	Indirect Calorimetry and Cardiopulmonary exercise test
H	High VO_{2Max} / Healthy
UH	Low VO_{2Max} / Unhealthy
NPERA	Non-physical education or recess activities
RT	Recess time
ST	Sedentary time
ANOVA	Analysis of Variance

INTRODUCCIÓN [INTRODUCTION]

The vital role of PA on health outcomes is widely known. Engaging PA confers several health benefits, such as prevention of hypertension, obesity and other CVD. Therefore PA has been analyzed to deepen on prevention of disease, obesity and effects on health (Chen & Bassett Jr, 2005; Janssen & LeBlanc, 2010). Childhood and adolescence have been proposed to be a vital stage in life influencing health issues (Janssen & LeBlanc, 2010), future habits and behavior. Multiple papers have underlined the importance of attain and maintain a good health status and conditioning from youth to adulthood in order to prevent diabetes, obesity and risk factors associated with CVD; on the other hand PA improves body composition and physiological parameters (Andersen et al., 2006; Carnethon et al., 2003; Janssen & LeBlanc, 2010; Janssen, Wong, Colley, & Tremblay, 2013; Kozey, Lyden, Howe, Staudenmayer, & Freedson, 2010; J.R. Ruiz et al., 2006; Sardinha et al., 2008a). Moreover, PA also has been addressed to improve cognitive functions and academic performance (Dudley, Okely, Cotton, Pearson, & Caputi, 2012).

In the light of previous findings, the influence and importance of PA has been spotlighted on kid´s health during school ages (Andersen et al., 2006; Strong et al., 2005). Several reviews shown the large health benefits that youth could achieve accruing PA (Janssen & LeBlanc, 2010; Strong et al., 2005). For this reason, the enhancement PA is a main concern in order to promote a healthy lifestyle among youth (Ortega, Ruiz, Castillo, & Sjöström, 2008a). In line with this, the current health guidelines revealed the relevance of performing 60 min of MVPA to provide a proper health status in this population (Tremblay et al., 2011; WHO, 2010). For previous reasons and because youth spend a substantial proportion of their waking hours at school, school-based activities have been a commonly used setting for analyzing PA and health outcomes in this population (Pate et al., 2006). These patterns of PA at youth ages is highly transitory and intermittent, whatever its intensity, where the mean duration of PA submitted for medium and high intensity was 6 and 3 s respectively (Bailey et al., 1995). Most children accumulate the majority of their PA in a very sporadic manner rather than consistent bouts (Armstrong, Balding, Gentle, & Kirby, 1990; Bailey et al., 1995; Baquet, Stratton, Van Praagh, & Berthoin, 2007; Berman, Bailey, Barstow, & Cooper, 1998; Sanders, Cliff, & Lonsdale, 2014).

Hence, an objective, reliable, detailed and accurate measurement of PA is a vital aim to analyze associations between health and CVD (Butte, Ekelund, & Westerterp, 2012; Chen & Bassett Jr, 2005; Freedson, Pober, & Janz, 2005; Plasqui, Bonomi, & Westerterp, 2013). Regarding PA measurement, direct and indirect methods have been used in school-based activities (Butte et al., 2012; Chen & Bassett Jr, 2005; Fairclough & Stratton, 2005). Firstly, indirect methods are prone to subjectivity and influenced by the ability to recall PA retrospectively, and do not provide a direct measurement on physiological strain (Corder, Ekelund, Steele, Wareham, & Brage, 2008; Fairclough & Stratton, 2005; Freedson et al., 2005; Reilly et al., 2008; Stratton, 1996). On the other hand, the possibility to collect objective PA information have replaced the use of indirect methods by ACLs (Cliff, Reilly, & Okely, 2009; Plasqui et al., 2013). Nowadays, despite indirect methods still remain being used, ACLs provide objectivity and several advantages such as being a small-sized device, being easy to transport, having a great accuracy and the possibility to quantify the intensity of movement (Butte et al., 2012; Freedson et al., 2005; Plasqui et al., 2013; A.V. Rowlands, 2007a).

These small portable, lightweight and compact devices collect motion data. Previous ACLs recorded information on one orthogonal axe, however, recent ones are able to record information of the three orthogonal axes´ (vertical: Y, horizontal right-left: X, and horizontal front-back axis: Z) during a specific interval of time (epoch), ranging from 1 to 60 s. Shorter epochs are usually proposed for young subjects in order to accurately capture patterns of high intensity and short duration PA (Santos-Lozano et al., 2013; Trost, Loprinzi, Moore, & Pfeiffer, 2011). Additionally, this information might be categorized into different intensities, according to specific cutoffs points.

To provide an accurate measurement of PA, several papers highlighted the importance of analyze PA registered with several instruments (Rowlands et al., 2007; Butte et al., 2012). By this manner, papers combined ACls with a portable breath by breath unit with school-aged participants (Treuth et al., 2004; Schmitz et al., 2005; Ottevaere et al., 2011; Plusford et al., 2011; Trost et al., 2011; Aadland et al., 2011). Previous papers addressed multiple aims, but the major goals have been to categorize PA patterns during school-based and out of school activities and also confirm associations between PA, health and VO_{2Max}.

VO_{2Max} is an indicator of CRF and the most important variable of a healthy physical condition, which has been shown to have a positive influence on children´s health (Ortega et al., 2008a; Ottevaere et al., 2011) and prevents from cardiovascular diseases later in life (Carnethon et al., 2003). CRF has been described as a limiting factor and the absolute capacity to engage PA (Taylor, Buskirk, & Henschel, 1955), and is dependent on multiple factors, such as genetics, growth, sexual maturation and lifestyle (Teran-Garcia, Rankinen, & Bouchard, 2008). There is no doubt about the improvements on CRF performing PA (Ruiz et al., 2006b), being the best stimulus to increase CRF. Moderate and high levels of CRF are associated to provide protection against death, and low CRF levels are a precursor of mortality (Dugmore et al., 1999; Blair et al., 1996). Previous findings have reported that PA and exercise might modify CRF during childhood and adolescence preventing obesity, diabetes and cardiovascular risk factors (Andersen et al., 2006; Carnethon et al., 2003; Janssen & LeBlanc, 2010). In line with this, several studies indicate negative association between CRF and CVD (Adegboye et al., 2011; Jonatan R Ruiz et al., 2007). With school-aged subjects, the enhancement of MVPA seems to influence CRF, which is associated to numerous health-related benefits (Janssen & LeBlanc, 2010; Strong et al., 2005). The relevance of CRF during youth as a risk factor for developing morbidities in adult life has been highlighted (Carnethon et al., 2003). Due to reasons exposed, CRF is considered one of the most important health predictors and CV markers among children and adolescents (Ortega et al., 2008).

In order to provide a better comprehension of PA levels, bouts have been analyzed. Bouts are described as a daily or weekly amount of data regarding the times that PA has been accrued at a given intensity during a specific set time. In order to analyze PA in detail and provide a better understanding of PA bouts patterns have been reported (Trost, McIver, & Pate, 2005; Trost et al., 2002). Youth have shown intermittent and sporadic intervals interspersed with high intensity PAs, so a detailed analysis of this day may be of interest. Thus, papers displayed descriptive information regarding bout-length from different intensities (Baquet et al., 2007; Ann V Rowlands, Pilgrim, & Eston, 2008); and on the other hand, authors described the number of bouts engaged regarding gender, age, duration and health status (Troiano, Berrigan, & Dodd, 2008; Trost et al., 2005). Several researchers focused on bouts effects on health outcomes with school-aged subjects (Andersen et al., 2006; Mark & Janssen, 2009; Stone, Rowlands, & Eston, 2009b; Stone, Rowlands, Middlebrooke, Jawis, & Eston, 2009a). The results were consistent, the most MVPA bouts performed, the less odds of cardiovascular risk at young ages (Andersen et al., 2006; Holman, Carson, & Janssen, 2011).

BIBLIOGRAFÍA [REFERENCES]

1. Adegboye, A. R., Anderssen, S. A., Froberg, K., Sardinha, L. B., Heitmann, B. L., Steene-Johannessen, J., . . . Andersen, L. B. (2011). Recommended aerobic fitness level for metabolic health in children and adolescents: a study of diagnostic accuracy. *Br J Sports Med, 45*(9), 722-728. doi: 10.1136/bjsm.2009.068346

2. Andersen, L. B., Harro, M., Sardinha, L. B., Froberg, K., Ekelund, U., Brage, S., & Anderssen, S. A. (2006). Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *The Lancet, 368*(9532), 299-304.

3. Armstrong, N., Balding, J., Gentle, P., & Kirby, B. (1990). Patterns of physical activity among 11 to 16 year old British children. *BMJ: British Medical Journal, 301*(6745), 203.

4. Bailey, R. C., Olson, J., Pepper, S. L., Porszasz, J., Barstow, T. J., & Cooper, D. M. (1995). The level and tempo of children's physical activities: an observational study. *Med Sci Sports Exerc, 27*(7), 1033-1041.

5. Baquet, G., Stratton, G., Van Praagh, E., & Berthoin, S. (2007). Improving physical activity assessment in prepubertal children with high-frequency accelerometry monitoring: a methodological issue. *Preventive medicine, 44*(2), 143-147.

6. Berman, N., Bailey, R., Barstow, T. J., & Cooper, D. M. (1998). Spectral and bout detection analysis of physical activity patterns in healthy, prepubertal boys and girls. *American Journal of Human Biology, 10*(3), 289-297.

7. Butte, N. F., Ekelund, U., & Westerterp, K. R. (2012). Assessing physical activity using wearable monitors: measures of physical activity. *Med Sci Sports Exerc, 44*(1), S5-S12.

8. Carnethon, M. R., Gidding, S. S., Nehgme, R., Sidney, S., Jacobs Jr, D. R., & Liu, K. (2003). Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors. *JAMA: the journal of the American Medical Association, 290*(23), 3092-3100.

9. Cliff, D. P., Reilly, J. J., & Okely, A. D. (2009). Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0–5 years. *J Sci Med Sport, 12*(5), 557-567.

10. Corder, K., Ekelund, U., Steele, R., Wareham, N., & Brage, S. (2008). Assessment of physical activity in youth. *Journal of applied physiology, 105*(3), 862-870.

11. Chen, K. Y., & Bassett Jr, D. R. (2005). The technology of accelerometry-based activity monitors: current and future. *Med Sci Sports Exerc, 37*(11 Suppl), S490.

12. Dudley, D. A., Okely, A. D., Cotton, W. G., Pearson, P., & Caputi, P. (2012). Physical activity levels and movement skill instruction in secondary school physical education. *J Sci Med Sport, 15*(3), 231-237.

13. Fairclough, S., & Stratton, G. (2005). Physical activity levels in middle and high school physical education: a review. *Pediatric Exercise Science, 17*(3), 217-236.

14. Freedson, P. S., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Med Sci Sports Exerc, 37*(11 Suppl), S523.

15. Holman, R. M., Carson, V., & Janssen, I. (2011). Does the fractionalization of daily physical activity (sporadic vs. bouts) impact cardiometabolic risk factors in children and youth? *PLOS ONE, 6*(10), e25733.

16. Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *Int J Behav Nutr Phys Act, 7*(40), 1-16.

17. Janssen, I., Wong, S. L., Colley, R., & Tremblay, M. S. (2013). The fractionalization of physical activity throughout the week is associated with the cardiometabolic health of children and youth. *BMC public health, 13*(554), 1-8.
18. Kozey, S. L., Lyden, K., Howe, C. A., Staudenmayer, J. W., & Freedson, P. S. (2010). Accelerometer output and MET values of common physical activities. *Med Sci Sports Exerc, 42*(9), 1776-1784.
19. Mark, A. E., & Janssen, I. (2009). Influence of bouts of physical activity on overweight in youth. *Am J Prev Med, 36*(5), 416-421.
20. Ortega, F., Ruiz, J., Castillo, M., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: a powerful marker of health. *Int J Obes, 32*(1), 1-11.
21. Ottevaere, C., Huybrechts, I., De Bourdeaudhuij, I., Sjostrom, M., Ruiz, J. R., Ortega, F. B., . . . De Henauw, S. (2011). Comparison of the IPAQ-A and actigraph in relation to VO2max among European adolescents: the HELENA study. *J Sci Med Sport, 14*(4), 317-324. doi: 10.1016/j.jsams.2011.02.008
22. Pate, R. R., Davis, M. G., Robinson, T. N., Stone, E. J., McKenzie, T. L., & Young, J. C. (2006). Promoting physical activity in children and youth: a leadership role for schools: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. *Circulation, 114*(11), 1214-1224. doi: 10.1161/circulationaha.106.177052
23. Plasqui, G., Bonomi, A., & Westerterp, K. (2013). Daily physical activity assessment with accelerometers: new insights and validation studies. *Obes Rev, 14*, 451–462.
24. Reilly, J. J., Penpraze, V., Hislop, J., Davies, G., Grant, S., & Paton, J. Y. (2008). Objective measurement of physical activity and sedentary behaviour: review with new data. *Arch Dis Child, 93*(7), 614-619. doi: adc.2007.133272 [pii]
25. 10.1136/adc.2007.133272
26. Rowlands, A. V. (2007). Accelerometer assessment of physical activity in children: an update. *Pediatric Exercise Science, 19*(3), 252.
27. Rowlands, A. V., Pilgrim, E. L., & Eston, R. G. (2008). Patterns of habitual activity across weekdays and weekend days in 9–11-year-old children. *Preventive medicine, 46*(4), 317-324.
28. Ruiz, J. R., Rizzo, N. S., Hurtig-Wennlöf, A., Ortega, F. B., Wärnberg, J., & Sjöström, M. (2006). Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study. *Am J Clin Nutr, 84*(2), 299-303.
29. Ruiz, J. R., Sola, R., Gonzalez-Gross, M., Ortega, F. B., Vicente-Rodriguez, G., Garcia-Fuentes, M., . . . Castillo, M. J. (2007). Cardiovascular fitness is negatively associated with homocysteine levels in female adolescents. *Arch Pediatr Adolesc Med, 161*(2), 166.
30. Sanders, T., Cliff, D. P., & Lonsdale, C. (2014). Measuring adolescent boys' physical activity: bout length and the influence of accelerometer epoch length. *PLOS ONE, 9*(3), e92040. doi: 10.1371/journal.pone.0092040
31. Santos-Lozano, A., Santín-Medeiros, F., Cardon, G., Torres-Luque, G., Bailón, R., Bergmeir, C., . . . Garatachea, N. (2013). Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points. *Int J Sports Med, 34*(11), 975-982.
32. Sardinha, L. B., Andersen, L. B., Anderssen, S. A., Quitério, A. L., Ornelas, R., Froberg, K., . . . Ekelund, U. (2008). Objectively measured time spent sedentary is

associated with insulin resistance independent of overall and central body fat in 9-to 10-year-old Portuguese children. *Diabetes care, 31*(3), 569-575.
33. Stone, M. R., Rowlands, A. V., & Eston, R. G. (2009b). Characteristics of the activity pattern in normal weight and overweight boys. *Preventive medicine, 49*(2), 205-208.
34. Stone, M. R., Rowlands, A. V., Middlebrooke, A. R., Jawis, M. N., & Eston, R. G. (2009a). The pattern of physical activity in relation to health outcomes in boys. *Int J Pediatr Obes, 4*(4), 306-315.
35. Stratton, G. (1996). Children's heart rates during physical education lessons: a review. *Pediatric Exercise Science, 8*, 215-233.
36. Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., . . . Pivarnik, J. M. (2005). Evidence based physical activity for school-age youth. *J Pediatr, 146*(6), 732-737.
37. Taylor, H. L., Buskirk, E., & Henschel, A. (1955). Maximal oxygen intake as an objective measure of cardio-respiratory performance. *J Appl Physiol, 8*(1), 73-80.
38. Teran-Garcia, M., Rankinen, T., & Bouchard, C. (2008). Genes, exercise, growth, and the sedentary, obese child. *J Appl Physiol (1985), 105*(3), 988-1001. doi: 10.1152/japplphysiol.00070.2008
39. Tremblay, M. S., Warburton, D. E., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., . . . Zehr, L. (2011). New Canadian physical activity guidelines. *Appl Physiol Nutr Metab, 36*(1), 36-46.
40. Troiano, R. P., Berrigan, D., & Dodd, K. (2008). Physical Activity in the United States Measured by Accelerometer. *Med Sci Sports Exerc, 40*(1), 181-188.
41. Trost, S. G., Loprinzi, P. D., Moore, R., & Pfeiffer, K. A. (2011). Comparison of accelerometer cut points for predicting activity intensity in youth. *Med Sci Sports Exerc, 43*(7), 1360-1368.
42. Trost, S. G., McIver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Med Sci Sports Exerc, 37*(11 Suppl), S531.
43. Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., & Sirard, J. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and science in sports and exercise, 34*(2), 350.
44. WHO (2010). *Global Recommendations on Physical Activity for Health*. Geneva, Switzerland: WHO.

OBJETIVOS

a) Los objetivos generales de esta Tesis Doctoral son los siguientes:

- Describir los niveles de AF y la contribución de cada actividad respecto a las recomendaciones de salud y el total de AFMV en escolares de primaria y secundaria.

- Analizar la asociación entre intensidades de AF medidas a través de acelerómetro y VO_{2Max} durante diferentes actividades del contexto escolar (EF y recreo) en alumnos de primaria y secundaria.

- Describir y comparar diferentes intervalos de bouts netos y acumulados durante EF, recreo y resto de actividades con niños y adolescentes.

b) Específicos:

  - Revisar aspectos metodológicos relacionados con la evaluación de la actividad física en escolares utilizando la acelerometría (Artículo I).

  - Identificar los niveles de AF por medio de acelerometría en alumnos de edad escolar y analizar el cumplimiento de las recomendaciones de AF propuestas (Artículo II).

  - Confirmar si el nivel de AF durante EF es un factor asociado a un mayor VO_{2Max} y su grado de asociación en escolares (Artículo III).

  - Describir los niveles generales de práctica de AF y el grado de cumplimiento de las recomendaciones de salud en la población escolar (Artículo II y IV).

  - Estudiar de manera fraccionada la práctica de actividad física en diferentes actividades de la semana y fin de semana, para determinar su contribución a la AFMV, tomando de referencia los niveles de AF diarios (min/día) y AF por hora (min/hora) (Artículo IV).

  - Medir niveles de AF y diferentes intervalos de bouts de AFMV durante EF, recreo y resto de actividades (Artículo V).

  - Analizar la asociación entre los niveles de AF durante el recreo y el CRF con niños y adolescents escolares (Artículo VI).

Aims

a) The overall objectives of this Thesis are described below:

- ✓ Report PA levels and its contribution to health guidelines and total MVPA with school-aged students from elementary and secondary school.

- ✓ Analyze the association between accelerometer-measured PA intensities and VO_{2Max} during different activities during the school day (PE and recess) with elementary and secondary subjects.

- ✓ Describe and compare different lengths of accumulated and net bouts among PE, recess and NPERA with children and adolescents.

b) Specific:

- Review methodological criteria regarding physical activity assessed by accelerometry with school-aged subjects. (Paper I).

- Identify PA levels among scholars and analyze PA accomplishment to health guidelines proposed (Paper II).

- Confirm if PA levels during PE is a factor associated with an improved VO_{2Max} and its level of association with school-aged children (Paper III).

- Describe PA patterns and the prevalence of meeting PA guidelines among school-aged subjects (Paper II and IV).

- Analyze the contribution to total moderate to vigorous physical activity, taking into account daily PA (min/day), such as PA per hour (min/hour) (Paper IV).

- Measure PA levels and different lengths of MVPA net and accumulated bouts during non-PE or recess activities (NPERA), Physical Education (PE) and recess (Paper V).

- Analyze associations between accelerometer-measured PA during RT and cardiorespiratory fitness (CRF) in children and adolescents. (Paper VI).

RESULTADOS Y DISCUSIÓN [RESULTS AND DISCUSSION]

El epígrafe Resultados y Discusión se presenta en el formato en el cual han los artículos científicos sido enviados o aceptados.

Results and Discussion section is displayed as papers have been previously published or submitted.

I

ACTIVIDAD FÍSICA Y ACELERÓMETRÍA: ORIENTACIONES METODOLÓGICAS EN POBLACIÓN ESCOLAR.

Fernando Calahorro Cañada; Gema Torres-Luque; Iván López-Fernández; Alejandro Santos-Lozano, Nuria Garatachea, Elvis Álvarez Carnero.

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Revisión

Actividad física y acelerometría; orientaciones metodológicas, recomendaciones y patrones

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Resumen

Introducción: **En los últimos años, ha cobrado especial importancia el empleo de acelerómetros para valorar la actividad física de niños y jóvenes. La metodología utilizada en el uso de la acelerometría determina los resultados obtenidos y condiciona la posibilidad de comparar diferentes estudios.**

Objetivo: **El objetivo de esta revisión, se centra en aspectos metodológicos relacionados con la evaluación de la actividad física en escolares utilizando la acelerometría.**

Metodología: **Se realizó una revisión de la literatura de los artículos incluidos en las bases de datos Medline/Pubmed y Scielo que utilizaran acelerómetros con participantes en edad escolar entre Enero de 2002 y Agosto de 2013, seleccionándose 133 artículos científicos.**

Resultados: **Parece existir un cierto consenso respecto a la elección del lugar de colocación, el tiempo de registro y el empleo de epochs cada vez más reducidos; sin embargo, se encuentra una gran variabilidad respecto al modelo de acelerómetro empleado y los puntos de corte seleccionados.**

Discusión y Conclusiones: **Los diferentes criterios empleados, dificultan la comparación en la metodología empleada entre estudios a pesar de que existan ciertos puntos en común entre ellos.**

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Palabras clave: *Escuelas. Promoción. Educación Física y Entrenamiento. Adolescente.*

PHYSICAL ACTIVITY AND ACCELEROMETER; METHODOLOGICAL TRAINING, RECOMMENDATIONS AND MOVEMENT PATTERNS IN SCHOOL

Abstract

Introduction: **Over the last years, the use of accelerometers has become relevant to quantify physical activity among youth. Methods used with accelerometers might modify the results and the possibility to compare different papers. These devices have been proved to be effective and valid quantifying long periods of physical activity compared to other methods.**

Objective: **To show methodological criteria regarding physical activity assessed by accelerometry with schoolars.**

Methodology: **It was conducted a review of the literature related to accelerometers and scholar-aged subjects at PubMed from January 2002 to August 2013, selecting 133 papers.**

Results: **As far as it is shown, it appears to be some tendencies related to the choice of attachment of the device, wearing time and a shorter epoch-length; however, it has been found a wide variability regarding the model of accelerometer and cutoff points used.**

Discussion and Conclusions: **The different criterion used makes it difficult to compare methodological aspects among studies in spite of some papers carried out similar methods.**

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Key words: *Schools. Promotion. Physical Education and Training. Adolescent.*

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Abreviaturas

AF: Actividad física.
ACL: Acelerómetro.
EF: Educación Física.
MV: Intensidad desde Moderada a Vigorosa

Introducción

La relación entre la práctica regular de actividad física (AF) y la salud, ha sido reconocida en diversos estudios que destacan la práctica físico-deportiva como una variable esencial asociada a una vida saludable. En este sentido, se han observado beneficios de carácter físico y psicológico, tales como la mejora de la *salud metabólica, la* prevención de la obesidad *y el control de los factores de riesgo de las enfermedades cardiovasculares*[1-4]. Es por estos motivos, que la AF ha sido estudiada con el fin de entender los patrones y características del movimiento humano y las relaciones con enfermedades crónicas, cardiovasculares y relacionadas con la obesidad[3,5]. Una valoración precisa y detallada de la AF es un requisito fundamental para entender la relación entre salud y enfermedad[5-8]. Desde la década de los años 50 y posteriormente en los 80 del siglo XX, se han encontrado estudios que hacen referencia a la evaluación de la AF medida de manera directa, además de la evaluación de parámetros cardiorrespiratorios como un indicador de la práctica de AF[9-12]. Posteriormente, alrededor de la década de los 90, han sido utilizados principalmente cardio-frecuencímetros[13,14] y podómetros[15] para la evaluación de la AF. En la actualidad, y a pesar de que éstos últimos instrumentos siguen empleándose para valorar la AF, los acelerómetros (ACLs) han comenzado a ser utilizados con más frecuencia en poblaciones escolares respecto a los anteriores instrumentos descritos, fundamentalmente desde el año 2000[6,8,16-20]. El objetivo principal de los mismos ha sido cuantificar los parámetros fundamentales de la AF: Tiempo total, intensidad y frecuencia[21]. La posibilidad de recopilar la información objetiva de la carga de la AF, ha llevado a sustituir los métodos clásicos indirectos como cuestionarios, auto-informes e informes paternos por el uso de la acelerometría[8,22]. Estos métodos no proporcionan una medición directa del estrés fisiológico y/o mecánico; y además están sujetos a gran subjetividad, pudiendo inducir a errores al estar influenciados por la capacidad para recordar la AF de manera retrospectiva, así como la percepción personal de los sujetos[6,23-26]. El ACL resuelve los problemas de la subjetividad, y además tiene como ventajas, su reducido tamaño, la facilidad de transporte y una mínima interferencia en la vida diaria; adicionalmente, poseen una alta capacidad de almacenamiento de datos (desde días a semanas), una gran precisión y la posibilidad de cuantificar la intensidad del movimiento[6-8,17.] Todo ello permite el registro objetivo de la carga asociada a la mayoría de la AF realizada por niños, jóvenes y adultos. Sin embargo, aunque su aplicación es simple y rápida, el tratamiento de los datos, su validez y su reproductibilidad son aspectos sensibles, los cuales necesitan cumplir unos criterios metodológicos precisos para obtener datos de calidad. Por lo tanto, el objetivo de esta revisión, es conocer la metodología utilizada en el uso de los acelerómetros para estimar la actividad física en población escolar.

Metodología

Se revisaron los artículos originales en inglés y castellano registrados en las bases de datos MEDLINE/Pubmed y SciELO, introduciéndose las siguientes palabras clave en sus motores de búsqueda: “accelerometers”, “children”, “adolescents”, “physical activity”, “physical activity levels”, “recess”, “physical education”, “after-school”, “school”, “high school”, “intervention”, “patterns”, “bouts”, “epoch”, “calibration”, “validation”, “accuracy”, “precision”, “cut-offs”, “cut-points”, “data analysis”. Se emplearon las conjunciones “and” y “or”. Como criterios de selección adicionales, se tuvieron en cuenta las investigaciones donde la edad de la muestra de estudio oscilase entre 3 y 19 años y que estuviesen publicados entre Enero del año 2002 y Agosto de 2013. Se excluyeron los estudios de casos, conferencias, artículos en prensa, artículos repetidos, opiniones y estudios en los que participaban personas con algún tipo de patología. En un segundo nivel de concreción, se seleccionaron los que indicasen claramente aspectos metodológicos y técnicos en el empleo de acelerómetros, como edad, población de estudio, modelo, tiempo de exposición, lugar de colocación y puntos de corte. En total se seleccionaron 133 artículos científicos.

Resultados

Se destacan a continuación los resultados más representativos de la revisión sistemática llevada a cabo, en diferentes apartados metodológicos.

Tipo de ACL

Los ACLs son pequeños instrumentos electrónicos que miden la magnitud de los cambios de la aceleración del centro de masas del cuerpo durante el movimiento[22]. Su resultado es expresado en una unidad adimensional denominada “counts”, que es el sumatorio de los valores absolutos de cambios de aceleración en un período o intervalo de tiempo específico, que va desde 1 a 60 segundos (este tiempo es conocido como Epoch)[22,27]. Este nivel de aceleración respecto al movimiento, puede ser registrado en cada uno de sus tres ejes de referencia. Al respecto, en el mercado existen una variada gama de ACLs, uniaxiales, que registran aceleraciones en un solo eje , generalmente el vertical; los biaxiales, que miden dos ejes; y los triaxiales, los cuales registran el cambio de aceleración en los tres ejes en tres planos ortogonales, midiendo por separado en cada uno de ellos, así como un sumatorio total del movimiento en los 3 ejes[5,6,17,22,28]. Hasta el 2009, los modelos de ACLs que han sido usados con mayor asiduidad en la literatura con escolares, son los uniaxiales de la marca ActiGraph (el cual también ha sido llamado CSA, MTI y WAM), Actical y Actiwatch, y el ACL triaxial RT3 que fue reemplazado por el ACL Tritrac[6,17]. El modelo Actigraph GT1M se ha validado con éxito para diferentes poblaciones y los datos de movimiento en su eje vertical siguen siendo los más utilizados[2,29]. El avance de la tecnología permitió que a partir de 2010, apareciese un nuevo modelo, el ACL triaxial Actigraph GT3X, el cual almacena el movimiento en los tres ejes ortogonales, vertical (y), horizontal izquierda y derecha (x) y, horizontal adelante y atrás (z), incluyendo además el vector magnitud de los tres ejes[30].

A pesar de que la tecnología y el paradigma del acelerómero son aspectos ampliamente conocidos, la validación de los nuevos modelos para la medición fiable y válida de los parámetros de la AF es un aspecto fulcral en la investigación. El objetivo de la validación, consiste según Strath y colaboradores[31] en establecer una relación entre las señales generadas por el ACL y la cantidad de movimiento realizado. Por ello, se precisa validar la mecánica de los ACLs que se utilizan comúnmente para la evaluación de la AF en los seres humanos[16,32], pues la complejidad de los movimientos implica equipos que consigan registrar movimiento en 3 dimensiones, además de establecer umbrales máximos y mínimos de sensibilidad acordes con las aceleraciones de los seres humanos. Actualmente el ACL triaxial Actigraph GT3X, ya ha sido validado con niños, adultos y mayores[30,33,34]. Adicionalmente, este equipo registra los datos en bruto (raw data) a una frecuencia de 30 a 100 Hz[35], lo cual aumenta las posibilidades del procesamiento de los datos; en este sentido, la gran evolución que ha experimentado el "software" permite un tratamiento de los registros mucho más rápido, simple y variable que en el pasado. Es por estos motivos que representa un instrumento de elección en la investigación con niños.

Son diversos los autores[8,17,31,32,36,37] que indican que de manera general, no aparecen diferencias respecto a la validez y fiabilidad entre modelos para estimar AF en niños y jóvenes. Por ello, la selección del mismo depende fundamentalmente del motivo del estudio, de las características de interés respecto a la población a estudiar, del grado de aplicación, la comparación de datos con otros estudios, o si se pretende calibrar y/o validar otras herramientas de evaluación de la AF (Tabla I).

Lugar de colocación

Los ACLs pueden ser colocados en diferentes localizaciones del cuerpo del sujeto a través de una banda elástica. Trost y colaboradores[36] indican que deberían estar colocados lo más cerca posible del centro de masas del cuerpo. Entre los lugares más comunes destacan: la cintura, cadera derecha, la parte baja de la espalda y, en menor medida, la muñeca, el tobillo y el muslo[8,22,36,38]. El análisis de la literatura indica que el lugar ideal con niños sería la intersección de la cadera derecha con la cintura (encima de la cresta ilíaca), ya que es el lugar más próximo al centro de gravedad, y es más cómodo que la espalda, que podría molestar al sentarse o al estar en una posición de espalda pegada a la pared o a un compañero

Tiempo de exposición/registro

El tiempo de exposición/registro del ACL hace referencia al volumen de días que el ACL estará recopilando información (normalmente se coloca el día antes de comenzar la grabación, la cual se programa/activa mediante un reloj interno desde el software). Este tiempo puede variar en función de los objetivos del estudio, desde 4 a 7 días (Tabla 1), no obstante, en jóvenes se recomienda su uso durante 7 días[8], donde existan días lectivos y fin de semana[39-46]. Una vez descargados los datos, el registro se considera adecuado si, el niño tiene lecturas válidas de como mínimo 5 días, 4 de contexto escolar y uno de fin de semana, lo cual permitirá conocer el comportamiento general del chico. Sin embargo, este no es el único requisito temporal para tener registros válidos, también es importante el cómputo total de tiempo que se tiene puesto el ACL a lo largo de un día. Para que los valores sean válidos, se debe tener puesto un mínimo de 10 horas en días lectivos y 8 horas los días no lectivos (fiesta y/o fin de semana), lo que equivale a un 41,1% y 33,1% de todo el día respectivamente[25,47]. Como el ACL se quita para actividades acuáticas o ducha y para dormir, en ocasiones, los niños olvidan colocarlo. Por ello, quienes no cumplan estos parámetros, no deben ser considerados como sujetos válidos, ni incluirse dentro de los sujetos de estudio en el posterior análisis de los datos. Dentro de las soluciones prácticas para informar de estos problemas, la utilización de un simple diario de registro es la más utilizada, en este se anota la hora a la que se lo quita y se lo pone, y el motivo (como puede ser dormir y realizar alguna actividad acuática); así, algunos de los registros pueden resultar válidos después de corregir los mismos (por ejemplo, un niño que haya pasado 2 horas en la piscina un fin de semana, puede no llegar a las 8 horas; u otro, que se ha pasado 6 horas en la playa).

Epochs

Los epochs hacen referencia al intervalo de tiempo en que el ACL almacena la información, que puede ir de 1 a 60 s[27]. Según el tipo de ACL o población al que se administre se recomienda una u otra medida. Por ejemplo, en poblaciones jóvenes o niños el epoch debe ser corta duración[22]. Durante años, el epoch más empleado ha estado en torno a los 5 – 15 s, basado en que al ser la AF de los niños mas intermitente, si fuese mayor, se perderían datos significativos[17,48]. Los alumnos de Infantil y Primaria (de 3 a 9 años), obtienen muchos picos de actividad a lo largo de un día, clasificada entre Moderada y Vigorosa, aunque estos no suceden de manera continua[49], por lo que es racional considerar un epoch próximo a 5 s. No obstante, esta recomendación ha cambiado desde que los nuevos ACLs permiten registrar con un epoch de 1 s[50]. La elección del epoch al igual que el punto de corte adecuado es fundamental, ya que pueden influenciar significativamente los niveles de AF, en este sentido la frecuencia de almacenamiento recomendada es de 1 segundo (Tabla 1).

Tabla I
Metodología de los estudios con acelerómetros en escolares

Autor	*n*	*Edad*	*Población*	*Tipo*	*Colocación*	*Días*	*Epoch*	*Puntos de Corte*
Trost y cols. (2002)	375	De 7 a 15	P y S	CSA 7164 1X	CD	7D	60 s	----
Guerra et al. (2003)	157	De 8 a 16	P y S	CSA 7164 1X	CND	3D	60 s	Freedson et al. (1998)
Ekelund et al. (2004)	1292	De 9 a 10	P	CSA WAM 7164	CD	2DS y 2DFM	----	Propios
Riddoch et al. (2004)	2906	De 9 a 15	P y S	CSA MTI 7164	C	2DS y 2DFM	60 s	Trost et al. (2002)
Stewart y cols. (2004)	71	De 6 a 11	P	CSA	C	1DS	60 s	----
Treuth et al. (2004)	74	De 13 a 14	S	Actigraph MTI 7164	CD y CI	1D	30 s	Propios
Catellier et al. (2005)	436	De 13 a 14	S	---	----	Varios D	30 s	
Ekelund et al. (2005b)	481	De 16 a 17	S	MTI Actigraph	CD	7D	15 s	Propios
Mota et al. (2005)	22	De 8 a 10	P	CSA 7164 1X	CND	3DS	60 s	----
Ridgers et al. (2005)	228	De 5 a 10	P	Actigraph MTI 7164 1X	CD	1DS	5 s	Nilsson y cols. (2002)
Schmitz y cols. (2005)	74	De 13 a 14	S	2 Actigraph MTI 7164	CD y CI	1DS	30 s	----
Andersen y cols. (2006)	1732	De 9 a 15	P y S	Actigraph 7164	C	2DS y 2DFS	60 s	
Ekelund y cols. (2006)	1921	De 9 a 16	P y S	CSA WAM 7164	CD	2DS y 2DFS	60 s	----
Rowlands et al. (2006)	25	De 7 a 11	P	RT3X	CD	1DS	1 y 60 s	Propios
Ruiz et al. (2006)	780	De 9 a 10	P	MTI WAM 7164	CD	2-3DS y 1-2DFM	----	Trost y cols (2002)
Verstraete et al. (2006)	235	De 10 a 11	P	Actigraph MTI 7164 1X	CD	1D	60 s	Trost y cols. (2002)
Wilkin et al. (2006)	522	De 6 a 10	P y Pre	CSA 1X	----	7D	60 s	----
Baquet y cols. (2007)	13	De 8 a 10	P	Actigraph 7164 1X	CD	7D	2 s	----
Nees y cols. (2007)	5500	De 11 a 12	----	MTI Actigraph 7164	---	3D	---	Propios, similares a Guinhouya y cols. (2006)
Ortega y cols. (2007)	472	De 12 a 16	S	MTI WAM 7164	E	4DS y 2DFS	60 s	Trost y cols. (2002)
Troiano et al. (2007)	6329	De 6 a 19	P y S	Actigraph 7164	CD	7D	60 s	----
Trost y cols. (2007)	147	De 6 a 10	P	Actigraph GT1M	CD	----	30 s	Freedson et al. (2005)
Wickel et al. (2007)	119	De 6 a 12	P	GT1M ActiGraph 1X	C	1DS	30 s	----

Tabla I (cont.)
Metodología de los estudios con acelerómetros en escolares

Autor	*n*	*Edad*	*Población*	*Tipo*	*Colocación*	*Días*	*Epoch*	*Puntos de Corte*
Evenson et al. (2008)	35	De 5 a 8	P y Pre	Actical y ActiGraph 1X AM 7164	Cint	2D	15 s	Propios
Frömel et al. (2008)	315	De 6 a 8	P	Caltrac 1X	CI	7D	----	----
Hagstömer et al. (2008)	248	De 12 a 17	S	Actigraph MTI, GT1M (1X)	E	7D	15 s	----
Moeller y cols. (2008)	902	De 8 a 16	P y S	Actigraph MTI, 7164 1X	----	5D	60 s	----
Roemmich y cols. (2008)	36	De 8 a 12	P	Biotrainer-Pro	C	7D	60 s	Guinhouya y cols. (2006) y Freedson y cols. (1998)
Rowlands y cols. (2008)	84	De 9 a 11	P	Actigraph GT1M 1X	CD	4DS y 2DFM	2 s	Trost y cols. (1998)
Sardinha y cols. (2008)	293	De 9 a 10	P	CSA Wam 6471 1X	CD	2DS y 2DFM	60 s	Ekelund y cols. (2004)
Corder y cols. (2009)	82	De 4 a 17	Prees y S	Actigraph MTI, 7164 1X y CSA	C	11D	60 s	Freedson et al. (1998)
Grontved et al. (2009)	146	De 3 a 6	Pre	Actigraph 7164	CD	5D	15 s	Pate y cols. (2006)
Mark y cols. (2009)	2498	De 8 a 17	P y S	Actigraph 7124 1X	CD	7D	60 s	Treuth y cols. (2004)
Martínez-Gómez et al. (2009a)	61	De 14 a 15	S	Actigraph MTI, GT1M 1X	----	3D	15 s	----
Martínez-Gómez et al. (2009b)	61	De 14 a 15	S	Actigraph MTI, GT1M 1X	----	3D	60 s	----
Metcalf et al. (2009)	307	De 5 a 8	P	Actigraph	Cint	7D	60 s	Modificado de Schmitz y cols. (2005)
Moliner-Urdiales et al. (2009)	365	De 12 a 18	S	ActiGraph MTI 1X	E	7D	15 s	Puyau y cols. (2002)
Rowlands y cols. (2009)	64	De 9 a 11	P	GT1M Actigraph 1X	CD	6D	2 s	Trost y cols. (1998)
Steele et al. (2009)	1862	De 9 a 10	P	Actigraph GT1M	CD	12 Semanas	5 s	Propios
Stone y cols. (2009a)	47	De 8 a 10	P	Actigraph GT1M	----	7D	2 s	Mattocks y cols. (2007) y Rowlands y cols. (2008
Stone y cols. (2009b)	32	De 8 a 10	P	Actigraph GT1M	----	4DS y 2DFS	2 s	Mattocks et al. (2007) y Stone y cols. (2009a)
Sveinsson et al. (2009)	270	De 9 a 15	P y S	Actigraph MTI, 7164 1X	CD	6D	60 s	----
De Bock et al. (2010)	33	De 3 a 6	Prees	Actiheart	Torax subesternal	1DS	15 s	Propios

Tabla I (cont.)
Metodología de los estudios con acelerómetros en escolares

Autor	*n*	*Edad*	*Población*	*Tipo*	*Colocación*	*Días*	*Epoch*	*Puntos de Corte*
España-Romero y cols. (2010)	3528	De 12 a 18	S	Actigraph GT1M 1X	----	----	----	Ekelund y cols. (2007) y Nilssson y cols. (2009)
Martínez-Gómez y cols. (2011)	1808	De 12 a 18	S	ActiGraph GT1M 1X	C	7D	15 s	Ekelund y cols. (2007) y Nilsson y cols (2009)
Ortega y cols. (2010)	1075	De 9 a 15	P y S	MTI WAM 7164	CD	3D	60 s	Trost y cols. (2002)
Moliner-Urdiales et al. (2010)	363	De 12 a 18	S	ActiGraph MTI 1X	E	7D	15 s	Modificados de Andersen et al. (2006)
Ridgers y cols. (2010)	98	De 9 a 12	P	Actigraph 7164 1X	C	3D	5 s	----
Silva et al. (2010)	208	De 12 a 18	S	ActiGraph MTI 7164	CD	7D	60 s	Freedson et al. (2005)
Aznar y cols. (2011)	221	De 9 a 15	P y S	ActiGraph MTI GT1M	Cint	4D (2FS y 2DS)	15 s	Andersen y cols. (2006)
Bornstein et al. (2011)	419	De 3 a 6	Prees	ActiGraph 7146	CD	14D	15 s	Pate et al. (2006); Sirard y cols. (2005); Puyau y cols. (2002); VanCauwengerghe et al. (2011); Freedson et al. (1998; 2005)
Bundy et al. (2011)	216	De 5 a 7	Pre y P	GT3X ActiGraph 3X	CD	5DS	5 s	----
Escalante et al., (2011)	783	De 6 a 11	P	Caltrac 1X	C	1 Recreo	----	----
García-Marco y cols. (2011)	373	De 12 a 18	S	Actigraph GT1M	E	7D	15 s	Andersen y cols. (2006)
Holman y cols. (2011)	2754	De 6 a 19	P y S	Actigraph 7164 1X	CD	7D	60 s	Freedson y cols. (2005)
Huberty et al. (2011)	93	De 8 a 11	P	GT1M ActiGraph 1X	----	5DS	5 s	----
Janssen et al. (2011)	1200	De 6 a 12	P	ActiGraph ActiTrainer 3X	----	15D	1 s	----
Laguna y cols. (2011)	438	Alrededor de 9	P	MTI GT1M CSA ActiGraph	CD	2DS y 2DFM	15 s	Propios
Martínez-Gómez y cols. (2011)	1808	De 12 a 18	S	ActiGraph GT1M	C	7D	15 s	Ekelund y cols. (2007)
Moliner-Urdiales et al. (2011)	363	De 12 a 18	S	ActiGraph MTI 1X	E	7D	15 s	----
Meyer y cols. (2011)	676	De 9 a 10	P	MTI/CSA 7164 y GT1M Actigraph 1X	C	4-7D	15 y 60 s	Ekelund et al. (2004)

Tabla I (cont.) *Metodología de los estudios con acelerómetros en escolares*								
Autor	*n*	*Edad*	*Población*	*Tipo*	*Colocación*	*Días*	*Epoch*	*Puntos de Corte*
Nielsen et al. (2011)	594	De 6 a 10	Pre y P	Actigraph MTI 7164	----	2DS y 2DFM	10 s	Mattocks y cols. (2007); Puyau et al. (2002); Sirard y cols. (2005); Treuth y cols. (2004); Trost et al. (1998)
Ottevaere et al. (2011)	2018	De 12,5 a 17,5	S	Actigraph MTI	E	7D	15 s	Sardinha et al. (2008)
Pulsford et al. (2011)	55	De 7 a 8	P	Actigraph GT1M 1X	CD	1D	15 s	Propios
Rigders et al. (2011)	210	De 8 a 11	P	GT1M ActiGraph 1X	Cint	7D	5 s	Freedson y cols. (1997)
Ruiz y cols. (2011)	2200	De 12 a 17	S	ActiGraph MTI GT1M	E	7D	15 s	Andersen et al. (2006)
Trost et al. (2011)	206	De 5 a 15	P y S	ActiGraph GT1M	CD	1D	1 s	Freedson y cols. (2005); Puyau y cols. (2002); Treuth y cols. (2004); Mattocks y cols. (2007); Evenson y cols. (2008)
Zaragoza y cols. (2011)	67	De 12 a 14	S	MTI 7164	Cint	7D	15 s	Treuth y cols. (2004)
Aibar y cols. (2012)	401	De 13 a 15	S	GT3X	CD	7D	15 s	Evenson y cols. (2008)
Aelterman (2012)	739	De 11 a 19	S	Actigraph 7164 1X, GT1M 3X y GT3X	C	46 clases EF	60 s	Puyau y cols. (2002)
Augustin et al. (2012)	6567	De 12 a 14	S	ActiGraph MTI GT1M	----	7D	60 s	Mattocks et al. (2007)
Bailey y cols. (2012)	100	De 10 a 14	P y S	RT3X	----	7D	----	Rowlands y cols. (2004)
Baptista y cols. (2012)	818	De 10 a 17	P y S	ActiGraph GT1M	CD	2DS y 2FS	15 s	Troiano y cols. (2008)
Ceroni et al. (2012)	100	De 10 a 16	S	ActiGraph MTI GT1M	CD	10D	60 s	Ekelund et al. (2004)
Fairclough y cols. (2012)	223	De 10 a 11	P	ActiGraph MTI GT1M	CD	7D	---	---
Kremer et al. (2012)	272	De 14 a 15	P y S	ActiGraph GT1M	Cint	218 clases EF	60 s	Propios
Martínez-Martínez et al. (2012)	32	De 11 a 12	P	ActiGraph GT1M	Cint D	7D	5 s	Andersen et al. (2006)
Perlman (2012)	69	---	S	GT1M ActiGraph 1X	CD	----	30 s	Trost et al. (2002)
Raustorp y cols. (2012)	50	De 4 a 6	Prees	GT1M ActiGraph 7164	Cint	5D	15 s	Sirard y cols. (2005)

Tabla I (cont.)
Metodología de los estudios con acelerómetros en escolares

Autor	*n*	*Edad*	*Población*	*Tipo*	*Colocación*	*Días*	*Epoch*	*Puntos de Corte*
Van Cauwenberghe et al. (2012)	573	De 5 a 6	Prees	GT1M ActiGraph 1X	CD	35 clases EF	15 s	Van Cauwenberghe et al. (2011)
Verloigne et al. (2012)	686	De 10 a 12	P y S	GT1M 1X, GT3X 3X y Actitrainer 3X	CD	4DS y 2 DFS	15 s	Treuth et al, (2004)
Adams y cols. (2013)	2217	De 6 a 17	P y S	ActiGraph 7164 1X	CD	7D	60 s	Freedson y cols. (2000); Evenson y cols (2008)
Denker et al. (2013)	167	De 7 a 13	P y S	ActiGraph MTI 7164	CD	4D	10 s	Propios
Denton y cols. (2013)	135	De 11 a 13	P	RT3X	----	7D	60 s	Rowlands y cols. (2004)
Janssen et al. (2013)	745	De 6 a 19	P y S	Actical	CD	7D	----	Puyau et al. (2000)
Jiménez-Pavón y cols. (2013)	2025	De 6 a 9	P	Actigraph 1x, MTI GT1M	CD	Al menos 3 D (2DS y 1DFS)	15 s	Propios
Lee y cols. (2013)	4069	Mayores de 6	P	ActiGraph 7164	CD	7D	60 s	----
Morris y cols. (2013)	378	De 7 a 11	P	ActiGraph 1X GT1M	----	7D	5 s	Freedson y cols. (1997)
O´Connor et al. (2013)	15	De 3 a 5	Pre	GT3X	C	1D	30 s	----
Santos y cols. (2013)	2506	De 10 a 18	P y S	Actigraph GT1M	CD	2DS y 1 FS	15 s	Trost y cols. (2002)
Santos-Lozano et al. (2013)	31	De 12 a 16	P y S	GT3X	CD	1D	1 s	Propios

AF: Actividad Física; s: Segundos; S: Intensidad Sedentaria; L: Intensidad Ligera; M: Intensidad Moderada; V: Intensidad Vigorosa; MV: Intensidad desde Moderada a Vigorosa; Pre: Preescolares; P: Primaria; S: Secundaria; 1X:Uniaxial; 3X:Triaxial; C: Cadera; CD: Cadera Derecha; CI: Cadera Izquierda; E: Parte baja de Espalda; Cintura: Cint; CND: Cadera no dominante; D: Días; DS: Días semanales; DFS: Días Fin de semana; EF: Educación Física; s: segundos.

Puntos de corte o Cutoffs Points

La información que aporta el ACL sobre la intensidad de la AF se realiza por medio de la unidad “Counts” por minuto, que permite clasificar la actividad del sujeto (*Cutoffs Points*) en Sedentaria, Ligera, Moderada y Vigorosa, siendo menos empleado el nivel Muy Vigoroso[6]. Esta clasificación va a depender del tipo de población en concreto, siendo los valores numéricos muy diferentes si se trata de adultos, jóvenes y/o niños. Sin embargo, la selección de estos valores de corte continúa en debate, pues la utilización de unos u otros puede condicionar sustancialmente los resultados del estudio. Concretamente, en el cumplimiento de las recomendaciones de AF, los valores pueden verse influenciados por el punto de corte y epoch empleado[46]. Por ejemplo, no todos los autores definen la opción de Muy Vigorosa, a pesar de ser una zona muy recomendada cuando se llevan a cabo estudios con niños, por el carácter propio de su actividad diaria. En otro estudio, comparando los diferentes puntos de corte más empleados en niños, se indica que las ecuaciones de Freedson/Trost y Evenson muestran mejor precisión que las otras, siendo especialmente interesante la propuesta por Evenson para el modelo ActiGraph en escolares[51]. Aunque la investigación con acelerometría en los últimos años[30], ha podido generar una falta de consenso[51], no es menos cierto que también ha provocado que los puntos de corte se hayan definido mejor según edades concretas[44,52-54]. En la tabla II, se indican los puntos de corte establecidos para uso en escolares.

Tabla II
Puntos de Corte empleados con escolares Puntos de Corte empleados con escolares

Autor	*AF S*	*AF L*	*Freestyle*	*AF M*	*AF V*	*AF MV*	*Unidad*
Freedson y cols. (1998)	0 - 99	100 - 759	760 - 1951	1952 - 5724	5725 - 9498	9498	counts·min^{-1}
Steele y cols. (2009)	0 - 100	101 - 1999		2000 - 3999	4000		counts·min^{-1}
Pate y cols. (2006)	0 - 799	800 - 1679		1680 3367	3368		counts·min^{-1}
Nilsson y cols. (2002)				1956 - 5759	5760 - 9479	9480	counts·min^{-1}
Puyau et al. (2002)	0 - 799	800 - 3199		3200 - 8199	8120		counts·min^{-1}
Ekelund et al. (2004)	0 - 499	500 - 1999		2000 - 2999	3000		counts·min^{-1}
Treuth y cols. (2004)		0 - 100		101 - 2999	3000 - 5200	5200	counts·min^{-1}
Freedson y cols. (2005)	0 - 149	150 - 499		500 - 3999	4000 - 8000		counts·min^{-1}
Sirard y cols. (2005)[*1]	0 - 1592	1593 - 3560		3561 - 5016	5017		counts·min^{-1}
Mattocks y cols. (2007)	0 - 100	101 - 3580		3581 - 6129	6130		counts·min^{-1}
Evenson y cols. (2008)	0 - 100	100 - 2295		2296 - 4012	4013		counts·min^{-1}
Pulsford y cols. (2011)	0 - 100	101 - 2240		2241 - 3840	3841		counts·min^{-1}
Trost y cols. (2011)	0 - 195	196 1672		1673			counts·min^{-1}
Van Cauwenberghe y cols. (2011)[*1]	0 - 1488	1489 - 2336		2337 - 3520	3521		counts·min^{-1}
Kremer y cols. (2012)	0 - 100	101 - 2000		2001 - 4999	5000 - 7999	8001	counts·min^{-1}
Denker y cols. (2013)		0 - 1000		101 - 3499	3500		counts·min^{-1}
Media	**0 - 471**	**409 - 1928**	**760 - 1951**	**1949 - 4537**	**4533 - 8035**	**8045**	

AF: Actividad Física; min:minutos; s: Segundos; S: Intensidad Sedentaria; L: Intensidad Ligera; M: Intensidad Moderada; V: Intensidad Vigorosa; MV: Intensidad desde Moderada a Vigorosa.
[*1]: Estas unidades fueron inicialmente descritas en counts·15 s^{-1} y transformadas a counts·min^{-1}.

Discusión

La revisión de los diferentes estudios revisados ha posibilitado tener una perspectiva más concreta de la medición objetiva de la AF con acelerómetros con sujetos en edad escolar. A nivel general, no se observa unos criterios metodológicos uniformes a la hora de planificar la puesta de acelerómetros, recoger o analizar los datos a través de las diferentes investigaciones[31]. No obstante, sí que aparecen ciertas tendencias o criterios similares durante los mismos. A pesar de que no existe una evidencia contrastada respecto a que una marca y modelo de acelerómetro sea más válida y fiable que otra[36], los estudios han seleccionado fundamentalmente el modelo Actigraph; apareciendo una gran gama de modelos en los estudios analizados, además del empleo de uniaxiales y triaxiales. Si, parece coherente que el acelerómetro triaxial GT3X va ser el más utilizado en un futuro a corto plazo, ya que registra la AF en los tres ejes cartesianos, aumentando la precisión en la valoración de la AF. Para el lugar de colocación del mismo, a pesar de que unos pocos estudios lo han empleado, se indica que los acelerómetros no han de colocarse en la muñeca o tobillo[36]. Los estudios indican que suele colocarse en la cintura mediante una banda elástica ajustable, en la cadera derecha, ya que parece ser un sitio adecuado para registrar las aceleraciones del centro de masas, y no impide una AF habitual. Respecto al tiempo de registro de la AF, se indica que este tipo de población necesita un mayor tiempo de exposición respecto adultos[36]. La mayoría de estudios indican que están al menos 5 días con el acelerómetro puesto (4 durante la semana y 1 de fin de semana). La idea más sensata al respecto en la mayoría de estudios, ha sido registrar la AF durante 7 días, para contemplar la AF total de la semana. De esta manera, es posible conocer patrones de AF durante la semana (contemplando la AF escolar y extraescolar) y fin de semana (posibles competiciones), permitiendo comparar entre ambos. Por otro lado, se ha sugerido que un epoch de 1 minuto de duración pueden subestimar los niveles de AFMV[36]. Al respecto, la mayoría de los estudios analizados tienden a seleccionar un epoch de 15 s o inferior, este hecho probablemente esté condicionado por el tipo de AF desarrollada por esta población, que suele ser esporádica e intermitente, registrando de manera más precisa estos cambios en los niveles de AF. No se observan estos puntos en común con los puntos de corte empleados, se aprecia una gran heterogeneidad en los mismos, llegando incluso muchos estudios a plantear sus propios puntos de corte. El motivo principal para la elección de unos u otros puntos, debería estar fundamentada en la edad concreta de la muestra de estudio.

A pesar de los avances en la medición objetiva de la AF, sería interesante incluir en futuros estudios las siguientes propuestas, ya que hay elementos que no han sido analizados de manera suficiente en las publicaciones. Entre ellos, se destacan los factores que influyen en el tiempo que los participantes llevan puesto los acelerómetros y el sesgo que puede aparecer en la muestra por la eliminación de participantes durante el procesamiento de los datos de los acelerómetros. Las futuras actuaciones deben ir enfocadas a evitar en la medida de lo posible la pérdida de sujetos por no llevar el acelerómetro o no cumplir con los criterios mínimos establecidos. Además, indagar en lo relativo al por qué esos sujetos no han cumplido con estos criterios mínimos para evitar el sesgo puede ser también interesante y no se ha contemplado en la literatura. Para ello, estudiar aspectos socioculturales y ambientales podría arrojar algo de información y ayuda al respecto. Además, en determinadas situaciones podría ser interesante combinar los acelerómetros con la observación directa con el fin de conocer el contexto y tipo de actividad realizada (si el sujeto está sentado, corriendo, etc), lo cual ha sido tenido en cuenta en algunos estudios. Adicionalmente, la literatura demanda el establecer unos criterios uniformes respecto a los puntos de corte; y en menor medida el resto de aspectos metodológicos. Para finalizar, se indica que es necesaria una planificación cuidadosa y utilizar estrategias adecuadas en función de los objetivos de estudio. Al respecto, podría ser interesante que los grupos de investigación trabajasen de manera conjunta, en ver de unilateral, para así impulsar el progreso y el uso objetivo de acelerómetros en diversas poblaciones[31].

Conclusiones

La acelerometría se presenta como una herramienta sencilla y práctica para cuantificar y conocer de una manera más detallada estos niveles y patrones de AF con sujetos en edad escolar. Durante la última década ha mejorado de forma significativa la tecnología y las aplicaciones de "software" del ACL, lo cual posibilita una mayor precisión y volumen de datos; esto ha ampliado las posibilidades de análisis pero también la necesidad de un conocimiento más profundo. Se ha observado a lo largo de los estudios analizados, que parece existir unos ciertos parámetros comunes en la metodología empleada para cuantificar la AF mediante acelerometría con escolares. Los investigadores tienen a usar acelerómetros Actigraph (en un futuro próximo el modelo triaxial), con un epoch de 15 s o menos, que se suele colocar en la cadera derecha durante al menos 5 días hasta una media de 7, incluyendo el fin de semana. No hubo criterios uniformes respecto a los puntos de corte, los cuales van a depender fundamentalmente de edad de la muestra escolar. En base a lo anterior, no existe uniformidad en los criterios técnicos empleados en cada uno de los apartados metodológicos en el uso de acelerómetros.

Referencias

1. Andersen LB, Harro M, Sardinha LB, Froberg K, Ekelund U, Brage S, et al. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *The Lancet* 2006;368(9532):299-304.
2. Kozey SL, Lyden K, Howe CA, Staudenmayer JW, Freedson PS. Accelerometer output and MET values of common physical activities. *Medicine and science in sports and exercise* 2010;42(9):1776-84.
3. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. International *Journal of Behavioral Nutrition and Physical Activity* 2010;7(40):1-16.
4. Janssen I, Wong SL, Colley R, Tremblay MS. The fractionalization of physical activity throughout the week is associated with the cardiometabolic health of children and youth. *BMC public health* 2013;13(554):1-8.
5. Chen KY, Bassett Jr DR. The technology of accelerometry-based activity monitors: current and future. *Medicine and science in sports and exercise* 2005;37(11 Suppl):S490.
6. Freedson PS, Pober D, Janz KF. Calibration of accelerometer output for children. *Medicine and science in sports and exercise* 2005;37(11 Suppl):S523.
7. Butte NF, Ekelund U, Westerterp KR. Assessing physical activity using wearable monitors: measures of physical activity. *Medicine and science in sports and exercise* 2012;44(1):S5-S12.
8. Plasqui G, Bonomi A, Westerterp K. Daily physical activity assessment with accelerometers: new insights and validation studies. *Obesity Reviews* 2013;14:451–62.

9. Taylor HL, Buskirk E, Henschel A. Maximal oxygen intake as an objective measure of cardio-respiratory performance. *J Appl Physiol* 1955;8(1):73-80. Epub 1955/07/01.
10. Ramsbottom R, Brewer J, Williams C. A progressive shuttle run test to estimate maximal oxygen uptake. *Br J Sports Med* 1988;22(4):141-4. Epub 1988/12/01.
11. Leger L, Mercier D, Gadoury C, Lambert J. The multistage 20 metre shuttle run test for aerobic fitness. *Journal of sports sciences* 1988;6(2):93-101.
12. Raven PB, Gettman LR, Pollock ML, Cooper KH. A physiological evaluation of professional soccer players. *Br J Sports Med* 1976;10(4):209-16. Epub 1976/12/01.
13. Armstrong N, Bray S. Physical activity patterns defined by continuous heart rate monitoring. *Archives of disease in childhood* 1991;66(2):245-7.
14. Simons-Morton BG, Taylor WC, Snider SA, Huang IW. The physical activity of fifth-grade students during physical education classes. *American Journal of Public Health* 1993;83(2):262-4.
15. Kilanowski CK, Consalvi AR, Epstein LH. Validation of an electronic pedometer for measurement of physical activity in children. *Pediatric Exercise Science* 1999;11:63-8.
16. Welk G, McClain J, Ainsworth B. Protocols for evaluating equivalency of accelerometry-based activity monitors. *Medicine and science in sports and exercise* 2012;44(1 Suppl 1):S39.
17. Rowlands AV. Accelerometer assessment of physical activity in children: an update. *Pediatric Exercise Science* 2007a;19(3):252.
18. Dollman J, Okely AD, Hardy L, Timperio A, Salmon J, Hills AP. A hitchhiker's guide to assessing young people's physical activity: Deciding what method to use. *Journal of science and medicine in sport / Sports Medicine Australia* 2009;12(5):518-25. Epub 2008/11/29.
19. Bornstein DB, Beets MW, Byun W, Welk G, Bottai M, Dowda M, et al. Equating accelerometer estimates of moderate-to-vigorous physical activity: In search of the Rosetta Stone. *Journal of Science and Medicine in Sport* 2011;14(5):404-10.
20. Kim Y, Beets MW, Welk GJ. Everything you wanted to know about selecting the "right" Actigraph accelerometer cut-points for youth, but…: A systematic review. *Journal of Science and Medicine in Sport* 2012;15:311-21.
21. Intille S, Lester J, Sallis J, Duncan G. New horizons in sensor development. *Medicine and science in sports and exercise* 2012;44(1 Suppl 1):S24.
22. Cliff DP, Reilly JJ, Okely AD. Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0–5 years. *Journal of Science and Medicine in Sport* 2009;12(5):557-67.
23. Reilly JJ, Penpraze V, Hislop J, Davies G, Grant S, Paton JY. Objective measurement of physical activity and sedentary behaviour: review with new data. *Arch Dis Child* 2008;93(7):614-9. Epub 2008/02/29.
24. Corder K, Ekelund U, Steele R, Wareham N, Brage S. Assessment of physical activity in youth. *Journal of applied physiology* 2008;105(3):862-70.
25. Stratton G. Children's heart rates during physical education lessons: a review. *Pediatric Exercise Science* 1996;8:215-33.
26. Fairclough S, Stratton G. Physical activity levels in middle and high school physical education: a review. *Pediatric Exercise Science* 2005;17(3):217-36.
27. Heil D, Brage S, Rothney M. Modeling physical activity outcomes from wearable monitors. *Medicine and science in sports and exercise* 2012;44(1 Suppl 1):S50.
28. Den Hoed M, Westerterp KR. Body composition is associated with physical activity in daily life as measured using a triaxial accelerometer in both men and women. *International Journal of Obesity* 2008;32(8):1264-70.
29. Ceroni D, Martin X, Lamah L, Delhumeau C, Farpour-Lambert N, De Coulon G, et al. Recovery of physical activity levels in adolescents after lower limb fractures: a longitudinal, accelerometry-based activity monitor study. *BMC Musculoskeletal Disorders* 2012;13(1):131-9.
30. Baptista F, Santos DA, Silva AM, Mota J, Santos R, Vale S, et al. Prevalence of the Portuguese population attaining sufficient physical activity. *Med Sci Sports Exerc* 2012;44(3):466-73.
31. Strath SJ, Pfeiffer KA, Whitt-Glover MC. Accelerometer use in children, older adults, and adults with functional limitations. *Med Sci Sports Exerc* 2012;44(1 suppl):S77-85.
32. Garatachea N, Torres Luque G, González Gallego J. Physical activity and energy expenditure measurements using accelerometers in older adults. *Nutrición Hospitalaria* 2010;25(2):224-30.
33. Santos-Lozano A, Marín PJ, Torres-Luque G, Ruiz JR, Lucía A, Garatachea N. Technical variability of the GT3X accelerometer. *Medical engineering & physics* 2012a;34(6):787-90.
34. Santos-Lozano A, Santín-Medeiros F, Cardon G, Torres-Luque G, Bailón R, Bergmeir C, et al. Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points. *International journal of sports medicine* 2013;34(11):975-82.
35. Rowlands A, Stiles V. Accelerometer counts and raw acceleration output in relation to mechanical loading. *Journal of biomechanics* 2012;45(3):448-54.
36. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. *Medicine and science in sports and exercise* 2005;37(11 Suppl):S531.
37. Robusto KM, Trost SG. Comparison of three generations of ActiGraph™ activity monitors in children and adolescents. *Journal of sports sciences* 2012;30(13):1429-35.
38. Matthews CE, Hagströmer M, Pober DM, Bowles HR. Best practices for using physical activity monitors in population-based research. *Med Sci Sports Exerc* 2012;44(1 suppl):S68-76.
39. Ridgers ND, Stratton G, McKenzie TL. Reliability and validity of the system for observing children's activity and relationships during play (SOCARP). *Journal of physical activity & health* 2010;7(1):17-25.
40. Ottevaere C, Huybrechts I, De Bourdeaudhuij I, Sjostrom M, Ruiz JR, Ortega FB, et al. Comparison of the IPAQ-A and actigraph in relation to VO2max among European adolescents: the HELENA study. *Journal of science and medicine in sport / Sports Medicine Australia* 2011;14(4):317-24. Epub 2011/03/30.
41. Ruiz JR, Ortega FB, Martínez-Gómez D, Labayen I, Moreno LA, De Bourdeaudhuij I, et al. Objectively Measured Physical Activity and Sedentary Time in European Adolescents The HELENA Study. *American journal of epidemiology* 2011a;174(2):173-84.
42. Aadland E, Steene-Johannessen J. The use of individual cut points from treadmill walking to assess free-living moderate to vigorous physical activity in obese subjects by accelerometry: is it useful? *BMC medical research methodology* 2012;12(1):172-80.
43. Augustin NH, Mattocks C, Cooper AR, Ness AR, Faraway JJ. Modelling fat mass as a function of weekly physical activity profiles measured by Actigraph accelerometers. *Physiological measurement* 2012;33(11):1831–9.
44. Kremer MM, Reichert FF, Hallal PC. Intensity and duration of physical efforts in Physical Education classes. *Revista de Saúde Pública* 2012;46(2):320-6.
45. Verloigne M, Van Lippevelde W, Maes L, Yıldırım M, Chinapaw M, Manios Y, et al. Levels of physical activity and sedentary time among 10-to 12-year-old boys and girls across 5 European countries using accelerometers: an observational study within the ENERGY-project. *The International Journal of Behavioral Nutrition and Physical Activity* 2012;9:34-42.
46. Ojiambo R, Cuthill R, Budd H, Konstabel K, Casajus JA, González-Agüero A, et al. Impact of methodological decisions on accelerometer outcome variables in young children. *International Journal of Obesity* 2011;35:S98-S103.
47. Yıldırım M, Verloigne M, De Bourdeaudhuij I, Androutsos O, Manios Y, Felső R, et al. Study protocol of physical activity and sedentary behaviour measurement among schoolchildren by accelerometry-Cross-sectional survey as part of the ENERGY-project. *BMC public health* 2011;11(1):182.
48. Dorsey K, Herrin J, Krumholz H, Irwin M. The utility of shorter epochs in direct motion monitoring. *Research quarterly for exercise and sport* 2009;80(3):460-8. Epub 2009/10/02.
49. (NASPE) NAfSPE. Active start: a statement of physical activity guidelines for children birth to five years. Reston, VA: NASPE Publications; 2002.

50. Sallis JF, McKenzie TL, Kolody B, Lewis M, Marshall S, Rosengard P. Effects of health-related physical education on academic achievement: Project SPARK. *Research quarterly for exercise and sport* 1999;70(2):127-34.
51. Trost SG, Loprinzi PD, Moore R, Pfeiffer KA. Comparison of accelerometer cut points for predicting activity intensity in youth. *Medicine and science in sports and exercise* 2011;43(7):1360-8.
52. Treuth M, Schmitz K, Catellier D, McMurray R, Murray D, Almeida M, et al. Defining accelerometer thresholds for activity intensities in adolescent girls. *Medicine and science in sports and exercise* 2004;36(7):1259.
53. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. *Journal of sports sciences* 2008;24(14):1557-65.
54. Laguna MLN, Hernández MTL, Laín SA. Patrones de Actividad Física en función del género y los niveles de obesidad en población infantil española. Estudio EYHS1. *Revista de Psicologia del Deporte* 2011;20(2):621-36.
55. Ekelund U, Sardinha LB, Anderssen SA, Harro M, Franks PW, Brage S, et al. Associations between objectively assessed physical activity and indicators of body fatness in 9- to 10-y-old European children: a population-based study from 4 distinct regions in Europe (the European Youth Heart Study). *Am J Clin Nutr* 2004;80(3):584-90. Epub 2004/08/24.
56. Guerra S, Santos P, Ribeiro J, Duarte J, Mota J. Assessment of children's and adolescents' physical activity levels. *European Physical Education Review* 2003;9(75):75-85.
57. Ekelund U, Neovius M, Linné Y, Brage S, Wareham NJ, Rössner S. Associations between physical activity and fat mass in adolescents: the Stockholm Weight Development Study. *The American journal of clinical nutrition* 2005b;81(2):355-60.
58. Schmitz K, Treuth M, Hannan P, McMurray R, Ring K, Catellier D, et al. Predicting energy expenditure from accelerometry counts in adolescent girls. *Medicine and science in sports and exercise* 2005;37(1):155-61.
59. Rowlands AV, Powell SM, Humphries R, Eston RG. The effect of accelerometer epoch on physical activity output measures. *Journal of Exercise Science and Fitness* 2006;4(1):52-8.
60. Frömel K, Stelzer J, Groffik D, Ernest J. Physical activity of children ages 6–8: The beginning of school attendance. *Journal of Research in Childhood Education* 2008;23(1):29-40.
61. Moeller N, Korsholm L, Kristensen P, Andersen L, Wedderkopp N, Froberg K. Unit-specific calibration of Actigraph accelerometers in a mechanical setup–Is it worth the effort? The effect on random output variation caused by technical inter-instrument variability in the laboratory and in the field. *BMC medical research methodology* 2008;8(19):1-8.
62. De Bock F, Menze J, Becker S, Litaker D, Fischer J, Seidel I. Combining accelerometry and HR for assessing preschoolers' physical activity. *Medicine and science in sports and exercise* 2010;42(12):2237-43.
63. Bundy A, Naughton G, Tranter P, Wyver S, Baur L, Schiller W, et al. The sydney playground project: popping the bubblewrap-unleashing the power of play: a cluster randomized controlled trial of a primary school playground-based intervention aiming to increase children's physical activity and social skills. *BMC public health* 2011;11(680):1-14.
64. Janssen M, Toussaint HM, Van Willem M, Verhagen EALM. PLAYgrounds: Effect of a PE playground program in primary schools on PA levels during recess in 6 to 12 year old children. Design of a prospective controlled trial. *BMC public health* 2011;11(282):1-8.
65. Nielsen G, Pfister G, Andersen LB. Gender differences in the daily physical activities of Danish school children. *European Physical Education Review* 2011;17(1):69-90.
66. Pulsford R, Cortina-Borja M, Rich C, Kinnafick F, Dezateux C, Griffiths L. Actigraph Accelerometer-Defined Boundaries for Sedentary Behaviour and Physical Activity Intensities in 7 Year Old Children. *PLOS ONE* 2011;6(8):1-9.
67. Perlman D. The influence of the Sport Education Model on amotivated students' in-class physical activity. *European Physical Education Review* 2012;18(3):335-45.
68. Stewart JA, Dennison DA, Kohl HW, Doyle JA. Exercise level and energy expenditure in the TAKE 10! in-class physical activity program. *The Journal of school health* 2004;74(10):397-400. Epub 2005/02/24.
69. Puyau MR, Adolph AL, Vohra FA, Butte NF. Validation and calibration of physical activity monitors in children. *Obesity research* 2002;10(3):150-7.
70. Freedson PS, Melanson E, Sirard J. Calibration of the Computer Science and Applications, Inc. accelerometer. *Medicine and science in sports and exercise* 1998;30(5):1-5.
71. Nilsson A, Ekelund U, Yngve A, Sjostrom M. Assessing physical activity among children with accelerometers using different time sampling intervals and placements. *Pediatric Exercise Science* 2002;14(1):87-96.
72. Sirard JR, Trost SG, Pfeiffer KA, Dowda M, Pate RR. Calibration and evaluation of an objective measure of physical activity in preschool children. *Journal of physical activity & health* 2005;9:85-96.
73. Mattocks C, Leary S, Ness A, Deere K, Saunders J, Tilling K, et al. Calibration of an accelerometer during free-living activities in children. *International Journal of Pediatric Obesity*. 2007;2(4):218-26.
74. Van Cauwenberghe E, Labarque V, Trost S, de Bourdeaudhuij I, Cardon G. Calibration and comparison of accelerometer cut points in preschool children. International journal of pediatric obesity: *IJPO: an official journal of the International Association for the Study of Obesity* 2011;6(2-2):e582.
75. Catellier DJ, Hannan PJ, Murray DM, Addy CL, Conway TL, Yang S, et al. Imputation of missing data when measuring physical activity by accelerometry. *Medicine and science in sports and exercise* 2005;37(11 Suppl):S555.
76. Moeller N, Korsholm L, Kristensen P, Andersen L, Wedderkopp N, Froberg K. Unit-specific calibration of Actigraph accelerometers in a mechanical setup–Is it worth the effort? The effect on random output variation caused by technical inter-instrument variability in the laboratory and in the field. *BMC medical research methodology* 2008;8(19):1-8.
77. Raustorp A, Söderström M, Boldemann C. Accelerometer Measured Level of Physical Activity Indoors and Outdoors During Preschool time in Sweden and United States. *Journal of physical activity & health* 2012; 9:801-808.
78. Lee PH. Data imputation for accelerometer-measured physical activity: the combined approach. *The American journal of clinical nutrition* 2013; 9:965-71.
79. Adams MA, Johnson WD, Tudor-Locke C. Steps/day translation of the moderate-to-vigorous physical activity guideline for children and adolescents. International *Journal of Behavioral Nutrition and Physical Activity* 2013;10(49):1-8.
80. Sardinha LB, Baptista F, Ekelund U. Objectively measured physical activity and bone strength in 9-year-old boys and girls. *Pediatrics* 2008;122(3):e728-e36.
81. Denton SJ, Trenell MI, Plötz T, Savory LA, Bailey DP, Kerr CJ. Cardiorespiratory fitness is associated with hard and light intensity physical activity but not time spent sedentary in 10–14 year old schoolchildren: the HAPPY study. *Plos One* 2013;8(4):e61073.
82. Aibar A, Bois JE, Generelo E, Zaragoza Casterad J, Paillard T. A cross-cultural study of adolescents' physical activity levels in France and Spain. *European Journal of Sport Science* 2013a;13(5):551-8.
83. Aibar A, Bois JE, Zaragoza Casterad J, Generelo E, Paillard T, Fairclough S. Weekday and weekend physical activity patterns of French and Spanish adolescents. *European Journal of Sport Science* 2013b(ahead-of-print):1-10.
84. Zaragoza Casterad J, Generelo E, Aznar S, Abarca-Sos A, Julián JA, Mota J. Validation of a short physical activity recall questionnaire completed by Spanish adolescents. *European Journal of Sport Science* 2012;12(3):283-91.
85. Morris JG, Gorely T, Sedgwick MJ, Nevill A, Nevill ME. Effect of the Great Activity Programme on healthy lifestyle behaviours in 7–11 year olds. *Journal of sports sciences* 2013;31(12):1280-93.
86. Janssen M, Toussaint HM, Van Willem M, Verhagen EALM. PLAYgrounds: Effect of a PE playground program in primary

schools on PA levels during recess in 6 to 12 year old children. Design of a prospective controlled trial. *BMC public health* 2011;11(282):1-9.
87. Fairclough S, Hilland T, Stratton G, Ridgers N. 'Am I able? Is it worth it?'Adolescent girls' motivational predispositions to school physical education: Associations with health-enhancing physical activity. *European Physical Education Review* 2012;18(2):147-58.
88. Rowlands AV, Pilgrim EL, Eston RG. Seasonal changes in children's physical activity: an examination of group changes, intra-individual variability and consistency in activity pattern across season. *Annals of human biology* 2009;36(4):363-78.
89. Rowlands AV, Pilgrim EL, Eston RG. Patterns of habitual activity across weekdays and weekend days in 9–11-year-old children. *Preventive Medicine* 2008;46(4):317-24.
90. Bailey DP, Boddy LM, Savory LA, Denton SJ, Kerr CJ. Associations between cardiorespiratory fitness, physical activity and clustered cardiometabolic risk in children and adolescents: the HAPPY study. *European journal of pediatrics* 2012;171(9):1317-23.
91. Moliner-Urdiales D, Ruiz JR, Vicente-Rodriguez G, Ortega FB, Rey-Lopez JP, España-Romero V, et al. Associations of muscular and cardiorespiratory fitness with total and central body fat in adolescents: The HELENA Study. *British Journal of Sports Medicine* 2011;45(2):101-8.
92. Martinez-Gomez D, Ruiz JR, Ortega FB, Casajús JA, Veiga OL, Widhalm K, et al. Recommended levels and intensities of physical activity to avoid low-cardiorespiratory fitness in European adolescents: The HELENA study. *American Journal of Human Biology* 2010;22(6):750-6.
93. Martinez-Gomez D, Ortega FB, Ruiz JR, Vicente-Rodriguez G, Veiga OL, Widhalm K, et al. Excessive sedentary time and low cardiorespiratory fitness in European adolescents: the HELENA study. *Archives of disease in childhood* 2011;96:240-6.
94. España-Romero V, Ortega F, Ruiz J, Artero E, Martínez-Gómez D, Vicente-Rodriguez G, et al. Role of Cardiorespiratory Fitness on the Association Between Physical Activity and Abdominal Fat Content in Adolescents: The HELENA Study. *International journal of sports medicine* 2010;31(10):679-82.
95. Ekelund U, Brage S, Froberg K, Harro M, Anderssen SA, Sardinha LB, et al. TV viewing and physical activity are independently associated with metabolic risk in children: the European Youth Heart Study. *PLoS medicine* 2006;3(12):e488.
96. Aelterman N, Vansteenkiste M, Van Keer H, Van den Berghe L, De Meyer J, Haerens L. Students' objectively measured physical activity levels and engagement as a function of between-class and between-student differences in motivation toward physical education. *Journal of sport & exercise psychology* 2012;34(4).
97. Gracia-Marco L, Vicente-Rodriguez G, Casajus J, Molnar D, Castillo M, Moreno L. Effect of fitness and physical activity on bone mass in adolescents: the HELENA Study. *European journal of applied physiology* 2011;111(11):2671-80.
98. Aznar S, Naylor P, Silva P, Pérez M, Angulo T, Laguna M, et al. Patterns of physical activity in Spanish children: a descriptive pilot study. *Child: care, health and development* 2011;37(3):322-8.
99. Sveinsson T, Arngrimsson SA, Johannsson E. Association between aerobic fitness, body composition, and physical activity in 9-and 15-year-olds. *European Journal of Sport Science* 2009;9(3):141-50.
100. Roemmich JN, Barkley JE, Lobarinas CL, Foster JH, White TM, Epstein LH. Association of liking and reinforcing value with children's physical activity. *Physiology & behavior* 2008;93(4):1011-8.
101. Ortega FB, Ruiz JR, Hurtig-Wennlöf A, Vicente-Rodriguez G, Rizzo NS, Castillo MJ, et al. Cardiovascular fitness modifies the associations between physical activity and abdominal adiposity in children and adolescents: the European Youth Heart Study. *British Journal of Sports Medicine* 2010;44(4):256-62.
102. Ortega FB, Ruiz JR, Hurtig-Wennlöf A, Sjöström M. Physically active adolescents are more likely to have a healthier cardiovascular fitness level independently of their adiposity status. The European youth heart study. *Revista Española de Cardiología (English Edition)* 2008;61(2):123-9.
103. Moliner-Urdiales D, Ruiz J, Ortega F, Rey-Lopez J, Vicente-Rodriguez G, Espana-Romero V, et al. Association of objectively assessed physical activity with total and central body fat in Spanish adolescents; the HELENA Study. *International Journal of Obesity* 2009;33(10):1126-35.
104. Ness AR, Leary SD, Mattocks C, Blair SN, Reilly JJ, Wells J, et al. Objectively measured physical activity and fat mass in a large cohort of children. *PLoS medicine* 2007;4(3):e97.
105. Steele R, Sluijs Ev, Cassidy A, Griffin S, Ekelund U. Targeting sedentary time or moderate-and vigorous-intensity activity: independent relations with adiposity in a population-based sample of 10-y-old British children. *American Journal of Clinical Nutrition* 2009;90(5):1185-92.
106. Treuth M, Schmitz K, Catellier D, McMurray R, Murray D, Almeida M, et al. Defining accelerometer thresholds for activity intensities in adolescent girls. *Medicine and science in sports and exercise* 2004;36(7):1259.
107. Dencker M Fau - Tanha T, Tanha T Fau - Wollmer P, Wollmer P Fau - Karlsson MK, Karlsson Mk Fau - Andersen LB, Andersen Lb Fau - Thorsson O, Thorsson O. Tracking of physical activity with accelerometers over a 2-year time period. *Journal of Physical Activity and Health* 2013;10 241-8.
108. Trost SG, Pate RR, Sallis JF, Freedson PS, Taylor WC, Dowda M, et al. Age and gender differences in objectively measured physical activity in youth. *Medicine and science in sports and exercise* 2002;34(2):350-5.
109. Guerra S, Santos P, Ribeiro J, Duarte J, Mota J. Assessment of children's and adolescents' physical activity levels. *European Physical Education Review* 2003;9(75):75-85.
110. Riddoch CJ, Andersen LB, Wedderkopp N, Harro M, Klasson-Heggebo L, Sardinha LB, et al. Physical activity levels and patterns of 9-and 15-yr-old European children. *Medicine and science in sports and exercise* 2004;36(1):86-92.
111. Mota J, Silva P, Santos M, Ribeiro J, Oliveira J, Duarte J. Physical activity and school recess time: differences between the sexes and the relationship between children's playground physical activity and habitual physical activity. *Journal of Sports Sciences* 2005;23(3):6.
112. Ridgers ND, Stratton G, Fairclough SJ. Assessing physical activity during recess using accelerometry. *Preventive medicine* 2005;41(1):102-105.
113. Ridgers ND, Saint-Maurice PF, Welk GJ, Siahpush M, Huberty J. Differences in physical activity during school recess. *Journal of School Health* 2011;81(9):545-51.
114. Ruiz JR, Rizzo NS, Hurtig-Wennlöf A, Ortega FB, Wärnberg J, Sjöström M. Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study. *The American journal of clinical nutrition* 2006;84(2):299-303.
115. Verstraete SJ, Cardon GM, De Clercq DL, De Bourdeaudhuij IM. Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *The European Journal of Public Health* 2006;16(4):415-9.
116. Pate RR, Almeida MJ, McIver KL, et al. Validation and calibration of an accelerometer in preschol children. *Obesity (Silver Spring)* 2006:14(11):2000-6.
117. Wilkin TJ, Mallam KM, Metcalf B, Jeffery AN, Voss LD. Variation in physical activity lies with the child, not his environment: evidence for an 'activitystat'in young children (EarlyBird 16). *International Journal of Obesity* 2006;30(7):1050-5.
118. Ortega FB, Ruiz JR, Hurtig-Wennlöf A, Sjöström M. Physically active adolescents are more likely to have a healthier cardiovascular fitness level independently of their adiposity status. The European youth heart study. *Revista Española de Cardiología (English Edition)* 2007;61(2):123-9.
119. Troiano RP, Berrigan D, Dodd K. Physical Activity in the United States Measured by Accelerometer. Medicine & Science in Sports & exercise: *Official Journal of the American College of Sports Medicine* 2008;40(1):181-8.

120. Trost S, Rosenkranz R, Dzewaltowski D. Physical activity levels among children attending after-school programs. *Medicine and science in sports and exercise* 2007;40(4):622-9..
121. Wickel EE, Eisenmann JC. Contribution of Youth Sport to Total Daily Physical Activity among 6-to 12-yr-old Boys. Medicine & Science in Sports & exercise: *Official Journal of the American College of Sports Medicine* 2007;39(9):1493-500.
122. Hagströmer M, Bergman P, De Bourdeaudhuij I, Ortega FB, Ruiz JR, Manios Y, et al. Concurrent validity of a modified version of the International Physical Activity Questionnaire (IPAQ-A) in European adolescents: The HELENA Study. *International Journal of Obesity* 2008;32:S42-S8.
123. Grontved A, Pedersen GS, Andersen LB, Kristensen PL, Moller NC, Froberg K. Personal characteristics and demographic factors associated with objectively measured physical activity in children attending preschool. *Pediatric Exercise Science* 2009;21(2):201-9.
124. Meyer U, Roth R, Zahner L, Gerber M, Puder J, Hebestreit H, et al. Contribution of physical education to overall physical activity. *Scandinavian Journal of Medicine & Science in Sports* 2011;23(5)600-6.
125. Martínez Martínez J, Contreras Jordán OR, Lera Navarro Á, Aznar Laín S. Niveles de actividad física medido con acelerómetro en alumnos de 3º ciclo de educación primaria: actividad física diaria y sesiones de educación física. *Revista de Psicologia del Deporte* 2012;21(1):117-23.
126. Martınez-Gómez D, Wärnberg J, Welk GJ, Sjöström M, Veiga OL, Marcos A. Validity of the Bouchard activity diary in Spanish adolescents. *Public health nutrition* 2009b;13(2):261-8.
127. Jiménez-Pavón D, Konstabel K, Bergman P, Ahrens W, Pohlabeln H, Hadjigeorgiou C, et al. Physical activity and clustered cardiovascular disease risk factors in young children: a cross-sectional study (the IDEFICS study). *BMC medicine* 2013;11(172):1-8.
128. Martínez-Gómez D, Welk G, Calle M, Marcos A, Veiga O. Preliminary evidence of physical activity levels measured by accelerometer in Spanish adolescents: the AFINOS Study. Nutrición hospitalaria: organo oficial de la Sociedad Española de *Nutrición Parenteral y Enteral* 2009a;24(2):212-218.
129. Santos R, Mota J, Okely AD, Pratt M, Moreira C, Coelho ESMJ, et al. The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. *Br J Sports Med* 2013;0:1-6.
130. Metcalf BS, Jeffery AN, Hosking J, Voss LD, Sattar N, Wilkin TJ. Objectively Measured Physical Activity and Its Association With Adiponectin and Other Novel Metabolic Markers A longitudinal study in children (EarlyBird 38). *Diabetes care* 2009;32(3):468-73.
131. Moliner-Urdiales D, Ortega FB, Vicente-Rodriguez G, Rey-Lopez JP, Gracia-Marco L, Widhalm K, et al. Association of physical activity with muscular strength and fat-free mass in adolescents: the HELENA study. *European journal of applied physiology* 2010;109(6):1119-27.
132. Huberty JL, Siahpush M, Beighle A, Fuhrmeister E, Silva P, Welk G. Ready for recess: A pilot study to increase physical activity in elementary school children. *Journal of School Health* 2011;81(5):251-7.
133. Van Cauwenberghe E, Labarque V, Gubbels J, De Bourdeaudhuij I, Cardon G. Preschooler's Physical Activity Levels and Associations with Lesson Context, Teacher's Behavior, and Environment during Preschool Physical Education. *Early Childhood Research Quarterly* 2012;27(2):221–30.

II

NIVELES DE ACTIVIDAD FÍSICA Y ACELEROMETRÍA: RECOMENDACIONES Y PATRONES DE MOVIMIENTO EN ESCOLARES.

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Niveles de actividad física y acelerometría: Recomendaciones y patrones de movimiento en escolares

Physical Activity Levels and accelerometry: Recommendations and patterns in school-aged subjects

Níveis de actividade física e acelerometria: recomendações e padrões de movimento em estudantes

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Resumen: El objetivo de esta revisión es identificar los niveles de actividad física por medio de acelerometría en alumnos de edad escolar y analizar el cumplimiento de las recomendaciones de actividad física. Se realizó una revisión de la literatura de los artículos incluidos en las bases de datos Medline/Pubmed y Scielo que utilizaran acelerómetros con participantes en edad escolar, entre enero de 2004 y mayo de 2013, seleccionándose 98 artículos científicos. Se muestran valores de referencia en diferentes etapas educativas, posibilidades de actividad física que ofrece el contexto escolar, así como programas de intervención, donde en términos generales se observa un bajo nivel de actividad física. A su vez, se observa un escaso cumplimiento del mínimo nivel de actividad física recomendada como saludable. En conclusión, esta revisión contribuye a orientar las futuras investigaciones en este campo, fundamentalmente destinadas a llevar a cabo programas de intervención.
Palabras Clave: Escuelas, Promoción, Educación Física y Entrenamiento, Adolescente.
Abstract: During school and high school stages, are proposed as beneficial aspects the ones related to the settlement and promotion of sports-habits and an increase of health and fitness through physical activity. In order to quantify that physical activity, the use of accelerometers has become important, due to several advantages related to other methods. By this manner, the purpose of this review has been focused on identify physical activity levels among scholars and analyze physical activity guidelines proposed. It was conducted a review of the literature related to accelerometers and scholar-aged subjects at PubMed from January 2004 to May 2013, selecting 98 papers, from those 19 show percentage of physical activity levels. In the assessment of physical activity with scholars, (across different school stages, school environment possibilities and intervention protocols), a low level of physical activity has been highlighted, with poor level of subjects meeting recommendations proposed.
Key Words: Schools, Promotion, Physical Education and Training, Adolescent.
Resumo: O objectivo desta revisão é identificar os níveis de actividade física através da acelerometria em alunos em idade escolar e analisar o cumprimento das recomendações de actividade física. Foi realizada uma revisão de literatura dos artigos incluídos nas bases de dados Medline/Pubmed e Scielo que utilizaram acelerómetros com participantes em idade escolar, entre Janeiro e Maio de 2013, seleccionando-se 98 artigos científicos. Apresentam-se valores de referência em diferentes etapas educativas, possibilidades de actividade física que oferece o contexto escolar, assim como programas de intervenção, onde em termos gerais se observa um baixo nível de actividade física. De igual modo, observa-se um escasso cumprimento do nível mínimo de actividade física recomendada como saudável. Em suma, esta revisão contribui para a orientação de futuras investigações neste âmbito, fundamentalmente destinadas à implementação de programas de intervenção.
Palavras-chave: Escolas, Promoção, Educação Física e Treino, Adolescentes.

Introducción

Diferentes estudios resaltan la importancia de la actividad física (AF) y la salud, considerándola una variable esencial para garantizar la misma. Hay un considerable interés social sobre los niveles de AF desarrollados por niños y adolescentes, debido al aumento de la obesidad, sedentarismo y su asociación con un bajo nivel de AF (Freedson, Pober, & Janz, 2005). Al respecto, se ha identificado que las etapas de niñez y adolescencia tienen una importancia crucial, ya que parecen influir en aspectos relacionados con la salud (Janssen & LeBlanc, 2010), asentamiento de hábitos y conductas futuras. Numerosos estudios han puesto de manifiesto la importancia de mantener un buen estado de forma durante la juventud para prevenir factores de riesgo en la vida adulta relacionados con la obesidad, la diabetes y, en general, el control de los factores de riesgo de las enfermedades cardiovasculares (Andersen et al., 2006; Carnethon et al., 2003; Janssen & LeBlanc, 2010; Janssen, Wong, Colley, & Tremblay, 2013; Kozey, Lyden, Howe, Staudenmayer, & Freedson, 2010; Ruiz et al., 2006; Sardinha et al., 2008a). Así, es interesante resaltar que la AF

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no solo mejora aspectos físicos y de composición corporal, sino que también contribuye a obtener mejores resultados en la función cognitiva y el rendimiento académico (Dudley, Okely, Cotton, Pearson, & Caputi, 2012). A la vista de los beneficios de la práctica de AF, se ha destacado la importancia de la etapa escolar como lugar idóneo de adquisición y adherencia a la práctica de AF (Andersen et al., 2006; Strong et al., 2005), estableciéndose recomendaciones de AF con el fin de garantizar la salud en esta población (Tremblay et al., 2011; WHO, 2010).

Para valorar la actividad física en la población escolar se han utilizado métodos objetivos e indirectos en este entorno (Butte, Ekelund, & Westerterp, 2012; Chen & Bassett Jr, 2005; Fairclough & Stratton, 2005). Respecto a los métodos indirectos para cuantificar la AF total, los cuestionarios, auto-informes e informes han sido muy utilizados (Colley et al., 2011; Corder et al., 2009; Ottevaere et al., 2011). Estos métodos están sujetos a una gran subjetividad, y con una alta probabilidad de inducir a errores, principalmente por estar influenciados por la capacidad para recordar la AF de manera retrospectiva, la percepción personal de los sujetos y el no proporcionar una medición directa del estrés fisiológico y/o mecánico (Corder, Ekelund, Steele, Wareham, & Brage, 2008; Fairclough & Stratton, 2005; Freedson et al., 2005; Reilly et al., 2008).

Según lo expuesto, una valoración objetiva, precisa y detallada de la AF es un requisito fundamental para entender la relación entre salud y enfermedad (Butte et al., 2012; Chen & Bassett Jr, 2005; Freedson et al., 2005; Plasqui, Bonomi, & Westerterp, 2013). La posibilidad de recopilar la información objetiva de la carga de la AF, ha llevado a sustituir los métodos indirectos por el uso de la acelerometría (Cliff, Reilly, & Okely, 2009; Plasqui et al., 2013). En la actualidad, y a pesar de que éstos métodos indirectos siguen empleándose, los acelerómetros (ACLs) han comenzado a ser utilizados con mucha mayor frecuencia que los anteriores, fundamentalmente desde el año 2000 (Bornstein et al., 2011; Dollman et al., 2009; Freedson et al., 2005; Kim, Beets, & Welk, 2012; Plasqui et al., 2013; A.V. Rowlands, 2007a; Welk, McClain, & Ainsworth, 2012). El objetivo principal de estos dispositivos es cuantificar parámetros de AF: tiempo total, intensidad y frecuencia (Intille, Lester, Sallis, & Duncan, 2012). El ACL resuelve los problemas de subjetividad, y además tiene como ventajas, su reducido tamaño, la facilidad de transporte y una muy baja interferencia en la vida diaria; adicionalmente, poseen una alta capacidad de almacenamiento de datos (desde días a semanas), una gran precisión y la posibilidad de cuantificar la intensidad del movimiento (Butte et al., 2012; Freedson et al., 2005; Plasqui et al., 2013; A.V. Rowlands, 2007a). Todo ello permite el registro objetivo de la carga asociada a la mayoría de la AF realizada por niños y jóvenes.

En general, los datos apoyan la relación entre la actividad física, la función cognitiva y el rendimiento académico. Por otro lado, se observa un menor tiempo AF semanal durante el fin de semana que durante días lectivos (Aibar et al., 2013b; Aznar et al., 2011; Godard, Román, Rodríguez, Leyton, & Salazar, 2012; Kwon & Janz, 2012; Ramirez-Rico, Hilland, Foweather, Fernández-Garcia, & Fairclough, 2013; Ann V Rowlands, Pilgrim, & Eston, 2009). En base a ello, se describe el contexto escolar como un momento esencial para la creación de estilos de vida activos y saludables, especialmente a través de las clases de Educación Física (EF), recreos y fuera del horario lectivo mediante las actividades extraescolares (Huberty et al., 2011; Kremer, Reichert, & Hallal, 2012; Martínez-Martínez, Contreras Jordán, Lera Navarro, & Aznar Laín, 2012; Meyer et al., 2011; Mota et al., 2005; Ridgers, Stratton, & McKenzie, 2010; Ridgers, Stratton, & Fairclough, 2005). Por lo tanto, el objetivo de este trabajo, es analizar las recomendaciones de AF para niños y adolescentes; y en segundo lugar identificar los patrones de AF evaluada mediante acelerometría en escolares, resaltando los patrones de movimiento en esta población, lo cual podrá ayudar como referencia para poder comparar resultados de estudios futuros.

Material y métodos

Se revisaron los artículos originales en inglés y castellano registrados en las bases de datos MEDLINE/Pubmed y SciELO, introduciéndose las siguientes palabras clave en sus motores de búsqueda: “accelerometers”, “children”, “adolescents”, “preschool”, “prescholars”, “physical activity”, “physical activity levels”, “recess”, “physical education”, “after-school”, “school”, “high school”, “intervention”, “patterns”, “data analysis”, “guidelines”, recommendations”. Se emplearon la combinación de las conjunciones “and” y “or” para un análisis más concreto. Como criterios de selección adicionales, se tuvieron en cuenta las investigaciones donde la edad de la muestra de estudio oscilase entre 3 y 19 años y que estuviesen publicados entre enero del año 2004 y mayo de 2013. Se excluyeron los estudios de casos, conferencias, artículos en prensa, editoriales, opiniones, así como los artículos repetidos. Fueron seleccionados un total de 98 artículos.

Resultados

Recomendaciones del nivel de AF.

La literatura refleja la importancia en el cumplimiento de las recomendaciones de AF para mantener un estado saludable. A continuación, se detallan estas recomendaciones, que están agrupadas por áreas temáticas y población a la cual van destinadas.

El nivel de AF varía en función de la edad del sujeto, tipo de ejercicio y el contexto en el que se realiza (Strong et al., 2005), por lo que es importante conocer las necesidades de AF que debe tener un niño a lo largo de su desarrollo. En las edades seleccionadas en este artículo, se observa cómo se recomienda acumular un mínimo de 30 min de AF estructurada y 60 min (incluso varias horas) de AF no estructurada, en niños de 0 a 3 años (NASPE), 2002). Además, sugieren que en la etapa preescolar (3 a 6 años) acumulen al día al menos 60 min de actividad estructurada y 60 min (incluso varias horas) de AF no estructurada. Estos valores irán variando hasta obtener 60 min/día de AF a intensidad MV cuando se accede a la Educación Primaria y Secundaria (Godard et al., 2012; Janssen et al., 2013; Martinez-Gomez et al., 2010b; Strong et al., 2005; Tremblay et al., 2011; Verloigne et al., 2012; WHO, 2010). Estos valores se deben incrementar progresivamente hasta los 90 min al día de AFMV, si se quiere prevenir enfermedades de riesgo cardiovascular (Andersen et al., 2006; Jiménez-Pavón et al., 2013), independientemente del tiempo empleado en el nivel sedentario (Ekelund et al., 2012).

Otros autores, proponen otras recomendaciones alternativas en caso de no poder cumplir los requisitos previamente descritos. Por un lado Laguna , Hernández, and Laín (2011) y Pate et al. (2006), indican que se debería realizar al menos un 50% de las recomendaciones de AFMV (30 min) en el entorno escolar y, por otro lado, para niños y jóvenes de hasta Secundaria realizar al menos 2 horas de AFMV semanal (Janssen & LeBlanc, 2010; Janssen et al., 2013; Laguna et al., 2011; Martínez-Gómez, Welk, Calle, Marcos, & Veiga, 2009a; Martínez-Martínez et al., 2012; Moliner-Urdiales et al., 2010; Ridgers et al., 2005; Strong et al., 2005).

Sin embargo, los estudios indican que la juventud no alcanza los niveles de AFMV recomendables para la salud (Aznar et al., 2011; Hallal et al., 2012). En relación al cumplimiento de las recomendaciones, se observa que los jóvenes españoles y europeos no suelen cumplir los 60 min diarios, realizando alrededor de 51-58 min (Fairclough, Breighle, Erwin, & Ridgers, 2012a; Martinez-Gomez et al., 2010b; Moliner-Urdiales et al., 2009; Ramirez-Rico et al., 2013). La prevalencia respecto al cumplimiento de estas recomendaciones en la población escolar española y europea es aún baja. Se observan valores que van desde el 20 al 60%, siendo mejores estos valores en chicos (Aibar et al., 2013b; Aznar et al., 2011; Janssen et al., 2013; Laguna et al., 2011; Martinez-Gomez et al., 2011; Martinez-Gomez et al., 2010a; Martínez-Martínez et al., 2012; Moliner-Urdiales et al., 2009). Del 35 al 51% de la población de 5 a 9 años no obtiene un mínimo de 60 min/día de AFMV. Este hecho se agrava aún más en edades entre 10 y 12 años y hasta los 17 años, donde la prevalencia disminuye hasta un porcentaje menor al 9% (Aznar et al., 2011; Baptista et al., 2012; Laguna et al., 2011). En cuanto al cumplimiento de que el 50% de la AFMV recomendada se desarrolle en el colegio, se observan valores inferiores al 40% en la población escolar española (Aibar, Bois, Generelo, Zaragoza Casterad, & Paillard, 2013a). Además, se detecta como el sobrepeso es un factor limitante para alcanzar estos valores mínimos recomendados (Godard et al., 2012; Laguna et al., 2011; Ridgers et al., 2010; S.G. Trost et al., 2002), lo cual es un dato preocupante ya que el sobrepeso tiende a incrementarse en la etapa en Secundaria respecto a Primaria (Tremblay et al., 2011).

Respecto a las diferencias de género, se muestra un grado de cumplimiento entre el 55 y 70% en chicos y 24 y 61% en chicas (Martínez-Gómez et al., 2009a; Moliner-Urdiales et al., 2010). La realidad de los adolescentes españoles no es muy distinta: entre el 55 y 80% de los chicos y desde el 25 hasta 60% de las chicas sí realizan la recomendación de los 60 min por día (Martınez-Gómez et al., 2009b; Martínez-Gómez et al., 2009a; Moliner-Urdiales et al., 2010).

Incluso con estos valores tan bajos, Strong et al. (2005) indican que cumplir los 60 min de AF puede ser factible durante la jornada escolar, especialmente en EF y el recreo, de manera progresiva, y en la medida de lo posible, que los jóvenes sedentarios, aumenten gradualmente su AF hacia estos niveles recomendados.

Nivel de AF en el contexto escolar y extraescolar

La jornada escolar ofrece oportunidades para aumentar los niveles de AF (Fairclough, Hilland, Straton, & Ridgers, 2012b), especialmente durante las clases de EF y los recreos. Se han descrito valores deficientes respecto a los niveles de AF desarrollados en la escuela, y a la vez, poco esperanzadores en el cumplimiento de las recomendaciones sobre la salud (Martínez-Martínez et al., 2012; Ridgers, Saint-Maurice, Welk, Siahpush, & Huberty, 2011; Ridgers et al., 2005; Jonatan R Ruiz et al., 2007). Se detallan a continuación los patrones de de AF escolar expresadas en porcentajes (Tabla 1), en las diferentes etapas educativas. Respecto a alumnos preescolares, se observan valores entre el 8 y 20% a intensidad MV, lo cual equivale a 60-70 min a intensidad Moderada y alrededor de 20 min a Vigorosa (Grontved et al., 2009; Nielsen, Pfister, & Andersen, 2011; Raustorp, Söderström, & Boldemann, 2012; Van Cauwenberghe, Labarque, Gubbels, De Bourdeaudhuij, & Cardon, 2012). En Primaria, Hoos, Kuipers, Gerver, and Westerterp (2004) muestran un 25% a Moderada y un 19% a Vigorosa. Estos valores son similares a los expresados en min con preescolares (Metcalf et al., 2009; Nielsen et al., 2011) e incluso superiores, entre 70 y 110 min (Godard et al., 2012; Troiano, Berrigan, & Dodd, 2008; Wickel & Eisenmann, 2007). Respecto a la actividades extraescolares menos del 30% de los jóvenes españoles realiza AF durante su tiempo libre (Lasheras, Aznar, Merino, & López, 2001) y, sólo el 33% de ellos acumula 60 min de AF en cinco días o más a la semana (Janssen et al., 2005).

Además, los niveles de AF también pueden incrementarse durante las actividades extraescolares. Respecto a la contribución de cada una de ellas respecto al total, se observa como el recreo y la EF contribuyen alrededor del 11-16% y del 16-18% respectivamente; las actividades extraescolares proporcionan alrededor del 55-70% del total AFMV (Meyer et al., 2011; Ridgers et al., 2011; Tudor-Locke, Lee, Morgan, Beighle, & Pangrazi, 2006; Wickel & Eisenmann, 2007). Teniendo en cuenta el volumen, las actividades extraescolares parecen ser las que más contribuyen (Trost, Rosenkranz, & Dzewaltowski, 2008), a pesar de que tienen mucha mayor duración que la EF y el recreo.

Nivel de AF en las clases de EF

La EF es considerada un período escolar que tiene el propósito de mejorar la salud a través de la AF (Fairclough & Stratton, 2005). Se enuncia que cuando la EF no se realiza de manera aislada, puede aportar niveles considerables de AF junto a otras actividades, teniendo una repercusión positiva sobre la salud y cumplimiento de las recomendaciones (Fairclough & Stratton, 2005). Por tanto, en base a las evidencias halladas respecto a la salud, y al ser una AF dirigida, la EF ha de ser un momento esencial para acumular AFMV diaria. Diversos estudios inciden en el bajo nivel de AFMV desarrollado en EF y la necesidad de aumentarlo para alcanzar los valores propuestos en las recomendaciones (Kremer et al., 2012; Van Cauwenberghe et al., 2012).

Se observa gran disparidad de datos en lo concerniente a las intensidades y volúmenes durante las sesiones de EF. Por un lado estudios presentan tiempos de entre el 8 al 10% (Martínez-Martínez et al., 2012), y en otros presentan valores que fluctúan entre 30 y 37% (Kremer et al., 2012; Meyer et al., 2011; Van Cauwenberghe et al., 2012) a intensidad MV. La AF durante las sesiones de EF, contribuye entre un 12 y 16% a la AF desarrollada durante la semana (Meyer et al., 2011; Wickel & Eisenmann, 2007). A pesar de que esta contribución no es muy notable cuantitativamente, varios autores han destacado el rol de la EF. Fairclough and Stratton (2005) enuncian que la EF no es la panacea para solventar los problemas de la salud del alumnado, pero junto a otras actividades, puede ayudar para conseguir cumplir los niveles de AF recomendados para la salud. Al respecto, se ha mostrado una correlación positiva entre la AF a intensidad desde MV en EF y la AFMV semanal (Martínez-Martínez et al., 2012). Este hecho tiene una importancia crucial desde el punto de vista del profesorado y su papel de promoción de salud y AF desde la EF.

Respecto a los valores presentados con alumnos de Primaria y Secundaria durante 218 clases, Kremer et al. (2012) han obtenido las siguientes intensidades: cerca del 1% a Muy Vigorosa, 5% a Vigorosa y 27% a Moderada. Esto ofrece un intervalo entre 60 y 110 min de AF MV (Meyer et al., 2011; Moliner-Urdiales et al., 2010). Sin embargo, son múltiples los factores que afectan a los datos según se considere etapas educativas, género y edad fundamentalmente, por ejemplo, se observa en torno a un 46% de intensidad MV en Secundaria, respecto al 33% en bachillerato (Troiano et al., 2008). Esta heterogeneidad de valores entre colegios, podrían mostrar que estas diferencias tienen un origen multidisciplinar, ya que podrían deberse a las características del contenido trabajado en EF o al hecho de que al ser una actividad dirigida, la cual pudiese implicar que todos los alumnos la realizasen a intensidades similares, motivaciones del alumnado respecto al contenido, o el nivel general de condición física de la clase. Independientemente de estos factores, lo que sí parece claro es que en escolares españoles, el tiempo en un nivel de AF adecuado está en torno a los 17 min (Martínez-Martínez et al., 2012).

Nivel de AF durante recreos

Los estudios destacan que, los recreos proporcionan una gran oportunidad de aumentar la AF para los alumnos menos proactivos hacia la AF o con sobrepeso (Ridgers et al., 2011). De esta manera y a pesar de ser una AF no estructurada, los recreos son un momento importante para la realización de ejercicio físico en el entorno escolar. Durante el mismo, se observan valores de intensidad Moderada entre el 18 y 31% (40 min) y Vigorosa desde el 5 hasta el 18% (5-25 min) (Huberty et al., 2011; Ridgers et al., 2011; Ridgers et al., 2010; Ridgers et al., 2005; Stewart G Trost & van der Mars, 2010).

En este sentido, Ridgers et al. (2011) quienes indican que a pesar de la poca duración respecto al total del día del recreo (30 minutos al día, siendo alrededor del 4%), este contribuye ampliamente a desarrollar la AF especialmente a intensidad MV, contribuyendo desde un 14 a 27% de esta intensidad diaria; e incluso Stratton and Mullan (2005) consideran que se puede conseguir el 50% de las recomendaciones diarias durante el recreo. Los estudios indican que la AF durante los recreos puede estar influenciada por motivaciones sociales, facilidad, disponibilidad y acceso a material y espacios deportivos (Ridgers, Salmon, Parrish, Stanley, & Okely, 2012a). Al respecto, se han propuesto diferentes propuestas para intentar mejorar los niveles de AF (Van Cauwenberghe, De Bourdeaudhuij, Maes, & Cardon, 2012b). Así, Verstraete, Cardon, De Clercq, and De Bourdeaudhuij (2006) resaltan aspectos para mejorar el volumen de práctica física durante los mismos, como por ejemplo, el dotar al alumnado de material para la AF. Otras propuestas podrían ser dibujar señalizaciones para juegos y entrenar a los docentes para fomentar la AF (Huberty et al., 2011).

Para finalizar, destacar el estudio de revisión durante recreos propuesto por Parrish, Okely, Stanley, and Ridgers

(2013), el cual invita a la reflexión para futuras intervenciones. En el mismo, indican que el bajo número de estudios al respecto y la falta de investigación de calidad a nivel metodológico impiden arrojar resultados concluyentes. Los autores recomiendan el uso de listas de control metodológicas a modo de guía durante la intervención.

Diferencias de AF en el contexto escolar en función del género

Además de los niveles de AF descritos anteriormente, diferentes estudios analizan la influencia del sexo respecto a la AF, lo cual es interesante conocer para poder generar intervenciones en el futuro según las características respecto al género. De hecho, son multitud los estudios que muestran mayor nivel de AF en chicos respecto a chicas (Aznar et al., 2011; Cheung, 2012; Dencker M Fau - Tanha et al., 2013; U. Ekelund et al., 2004; Escalante, Backx, Saavedra, García-Hermoso, & Domínguez, 2011; García-Artero et al., 2007; Godard et al., 2012; Grontved et al., 2009; Kremer et al., 2012; Martınez-Gómez et al., 2009b; Martínez-Martínez et al., 2012; Nielsen et al., 2011; Riddoch et al., 2004; Ridgers et al., 2010; Ridgers et al., 2005; J.R. Ruiz et al., 2011a; Scruggs, 2007; Silva et al., 2010; Tremblay et al., 2011; Troiano et al., 2008; Verloigne et al., 2012), y/o un mayor intervalo de tiempo a intensidad recomendada (Baquet, Stratton, Van Praagh, & Berthoin, 2007; Cheung, 2012; Dencker M Fau - Tanha et al., 2013; García-Artero et al., 2007; Godard et al., 2012; Grontved et al., 2009; Kremer et al., 2012; Laguna et al., 2011; Martínez-Gómez et al., 2009a; Martínez-Martínez et al., 2012; Metcalf et al., 2009; Steele, Sluijs, Cassidy, Griffin, & Ekelund, 2009; S. Trost et al., 2008; Verloigne et al., 2012; Wilkin, Mallam, Metcalf, Jeffery, & Voss, 2006). Respecto a los resultados, estas diferencias no siempre alcanzan grado de significación. Meyer et al. (2011), exponen que el género está significativamente asociado a la AFMV ($p \leq 0{,}001$); no obstante, otros estudios estos valores no alcanzan grado de significación (Martínez-Martínez et al., 2012). A pesar de ello, los resultados de la mayoría de las investigaciones sugieren la necesidad de reforzar los programas de intervención que fomenten la AF en chicas (Verloigne et al., 2012). Existen dos líneas de actuación a desarrollar, por un lado, llevar a cabo programas de intervención para las niñas inactivas, estudiar su entorno social y fomentar su participación principalmente; y por otro, enfocada a los docentes de EF, los cuales deben incidir en mejorar su percepción respecto a la AF, estudiar las motivaciones y crear un entorno cooperativo y de apoyo a las féminas (Kwon & Janz, 2012). El hecho de cumplir el principio de coeducación en EF es citado por varios autores, en el cual los profesores deben cumplir los principios pedagógicos de EF y crear un entorno propicio de AF para la mujer (Fairclough & Stratton, 2005; Kwon & Janz, 2012). Además, O'Connor et al. (2013) indican que el empleo de ACLs y GPS podría dotar de mayor información en relación al entorno de práctica de AF y quizá entender los posibles factores que limitan su práctica respecto a varones.

Programas de Intervención Escolar

Los programas de intervención para la promoción de la AF escolar, están siendo una línea de actuación en incremento, dónde el uso de la acelerometría está jugando un papel predominante para evaluar la eficacia de la modificación comportamental de los mismos. Uno de los aspectos que más preocupan en los estudios de carácter descriptivo, es que se ha observado como las clases de EF y los recreos, no están teniendo una implicación física suficiente, lo que hace necesario que exista intervención (Hoos et al., 2004; Huberty et al., 2011; Martínez-Martínez et al., 2012; Ridgers et al., 2005; Steele et al., 2009; Van Cauwenberghe et al., 2012). Verloigne et al. (2012) manifiestan la necesidad de programas de prevención contra la obesidad en niños europeos, enfocados en descender el sedentarismo y aumentar los niveles de AF, especialmente para niñas. Al respecto, se muestran cómo programas de intervención en chicas ofrecen datos esperanzadores durante la jornada escolar, produciendo incrementos en la AF (Russell R Pate et al., 2005). En relación a esto, un estudio de revisión con niños entre 5 y 18 años (Parikh and Stratton (2011) destacan que entre los estudios de intervención, se observa una disminución de la adiposidad y el aumento de la capacidad cardio-respiratoria en la mayoría de los estudios. En estudios de intervención en Primaria se reportan incrementos significativos en la AF (Ruiz et al., 2007). Concretamente, Huberty et al. (2011) a través de un programa de 6 meses de duración que fue realizado durante los recreos y una formación del profesorado relacionado con la EF, muestran un 18% de actividad Moderada en el Pre Tratamiento, y un 31% en el Post; respecto al nivel Vigoroso, este incrementó desde un 7% hasta un 17% (Tabla 1).

Tabla 1. Niveles de Actividad Física

Autor	n	Edad	Pobla-ción	Aceleró-metro	Colo-ca-ción	Días	Epoch	Niveles de AF		Puntos de Corte
Ekelund et al. (2004)	1292	De 9 a 10	P	CSA WAM 7164	CD	2DS y 2DFS	---	Chicos: AF S: 61,8±9,7% AF L: 26,1±5,8% AFMV: 12,0±5,6% AF V: 6,0±3,6	Chicas: AF S: 65,3±8,3% AF L: 26,0±5,5% AF MV: 8,7±4,2% AF V: 3,9±2,5%	Propues-tos por los autores
Hoos et al. (2004)	20	De 8 a 9	P	3X Trac-mor 2	E	14D	60 seg	L: 56% M: 25% V: 19%		Propues-tos por los autores
Mota et al. (2005)	22	De 8 a 10	P	CSA 7164 1X	CND	3DS	60 seg	AFMV Recreo: 30-40%		---
Ridgers et al. (2005)	228	De 5 a 10	P	Actigraph MTI 7164 1X	CD	1D	5 seg	Recreo Chicos: AFM: 25-30% AFV: < 5% AF MV: < 5 %	Recreo Chicas: AF M: 20-25% AF V: < del 5% AF M V: < 5 %	Nilsson et al. (2002)
Verstrae-te et al. (2006)	235	De 10 a 11	P	Actigraph MTI 7164 1X	CD	1D	60 seg	Pre Test Recreo: AF L GC:43,20±22,43% AF M GC 41,10±18,99% AF V GC 14,82±17,42% AF MV GC: 55,92±22,87% Post Test Recreo AF L GC: 54,54±26,37% AF M GC: 33,90±21,14% AF V GC: 9,57±17,10% AFMV GC: 43,47±27,62%	Pre Test Recreo: AF L GI: 42,10±28,29% AF M GI: 41,05±22,74% AF V GI: 15,53±18,40% AF MV GI: 56,58±29,37% Post Test Recreo AF L GI: 45,82 ±24,93% AF M GI: 45,16±21,55% AF V GI: 8,24±15,29% AF MV GI:53,40±25,63%	Trost et al., (2002)
Wickel et al. (2007)	119	De 6 a 12	P	GT1M ActiGra-ph 1X	C	1DS	30 seg	AFMV Deporte 23% AFMV EF: 11% AFMV Recreo: 16%		---
Pratt et al. (2008)	1458	12	P	Actigraph MTI 7164 1X	CD	6D	30 seg	AF S: 56% AF L: 41%		---
Grontved et al. (2009)	146	De 3 a 6	Pre	Actigraph 7164	CD	5D	16 seg	Chicas AFMV: 15,6±4,7% Chicos AFMV: 19,9±5,7 Total AFMV: 17,6±5,6		Pate et al. (2006)
Ridgers et al. (2010)	98	De 9 a 12	P	Actigraph 7164 1X	C	3DS	5 seg	Chicos peso nor-mal Recreo: AF S: 33,6±19,8 AF V: 24,2±16,1 AF MV: 66,4±19,8 Chicos sobrepeso Recreo: AF S: 37,7±16,7 AF V: 19,6±11,1 AF MV: 62,3±16,7	Chicas peso normal Recreo: AF S: 41,8±19,7 AF V: 17,3±13,7 AF MV: 58,3±19,8 Chicas sobrepeso Recreo: AFS: 51,6±19,4 AF V: 12,6±9,3 AF MV: 48,6±19,4	---
Huberty et al. (2011)	93	De 8 a 11	P	GT1M ActiGra-ph 1X	---	5DS	5 seg	Recreo: Pre Test: AF M: 18,1% AF V: 7,2% Post Test: M:31,2% AF V: 16,8%	Jornada escolar: Pre Test: AF M: 4,9% AF V: 1,6% Post Test: M: 9,1% AF V: 2,6%	---
Meyer et al. (2011)	676	de 9 a 10	P	MTI/ CSA 7164 y GT1M Actigraph 1X	C	4-7D	15 y 60 seg	EF MV: 32,8±15,1%		Ekelund et al. (2004)

Autor	n	Edad	Pobla-ción	Aceleró-metro	Colo-ca-ción	Días	Epoch	Niveles de AF		Puntos de Corte
Rigders et al. (2011)	210	De 8 a 11	P	GT1M ActiGra-ph 1X	Cint	7D	5 seg	Chicos: S: 34,8±16,8% L: 16,4± 4,8% M: 31± 10,8% V: 17,8± 10,9% MV:48,8± 17,4%	Chicas: S: 47,2± 14,6% L: 17,7± 4,6% M: 23,8± 8,4% V: 11,4± 7,8% MV: 35,2±13,6%	Freedson et al. (1997)
Ruiz et al. (2011)	2200	De 12 a 17	S	ActiGra-ph MTI GT1M	E	7D	15 seg	Total AF S: 71% Chicos AF S: 70% Chicas AF S: 72%		Trost et al. (2002)
Alhasan et al. (2012)	315	De 3 a 5	Pre	ActiGra-ph MTI	E	5DS	15 seg	Total: S: 74,2±9,3 L: 18,6±4,8 MV: 6,4±3,4		Pate et al. (2006)
Ceroni et al. (2012)	100	Des-de 10 a 16	S	ActiGra-ph MTI GT1M	CD	10D	60 seg	AF S: 75,3% AF L: 16,8% AF M: 3,7% AF MV: 4,2%		Ekelund et al. (2004)
Kremer et al. (2012)	272	de 14 a 15	P y S	ActiGra-ph GT1M	Cint	218 CEF	5 seg	AF S: 22,6% AF L: 44,7% AF M: 26,7% AF V: 5,1% MV: 0,8%		Propues-tos por los autores
Martínez-Martínez et al. (2012)	32	De 11 a 12	P	ActiGra-ph GT1M	CD	7D	30 seg	EF: AF S: 83% AF L: 8% AF MV: 9%		Andersen et al. (2006)
Van Cauwen-berghe et al. (2012)	573	de 5 a 6	Pre	GT1M ActiGra-ph 1X	CD	35 CEF	15 seg	AF S: 53,7±13,8% AF L: 13,3±5,9% AF M: 13,4±5,1% AF V: 19,6±9,5% AF MV: 33,0±12,1%		Van Cauwen-berghe et al. (2011)
Raustorp et al. (2012)	50	De 4 a 6	Pre	GT1M ActiGra-ph 7164	Cint	5D	15 seg	Total: AF S interior: 89,1±3,2% AF S exterior: 75,2±9,5 AF L interior: 8,5±2,6% AF L: exterior: 17,6±6,1 AF MV interior: 2,3±1,7% AF MV exterior: 7,3±5,7%	Chicos AF S interior: 89,5±3,8% AF S exte-rior: 73,6±10,3% AF L interior: 8,5±3,0 AF L: exterior: 18,6±6,5% AF MV interior:2,0±1,5% AF MV exterior: 7,5±6,3 Chicas AF S interior: 89,1±3,8 AF S exterior: 76,8±10,1 AF L interior: 8,4±3,0% AF L: exterior: 16,1±5,9% AF MV in-terior: 2,7±1,8 AF MV exterior:7,0±5,3%	Sirard et al. (2005)

AF: Actividad Física; CLF: Clases de Educación Física: EF; GC: Grupo GC; GI:: Grupo GI:; seg: Segundos; S: Intensidad Sedentaria; L: Intensidad Ligera; M: Intensidad Moderada; V: Intensidad Vigorosa; MV: Intensidad desde Moderada a Vigorosa; Pre: Preescolares; P: Primaria; S: Secundaria; 1X:Uniaxial; 3X:Triaxial; C: Cadera; CD: Cadera Derecha; CI: Cadera Izquierda; E: Parte baja de Espalda; Cintura: Cint; CND: Cadera no dominante; D: Días; DS: Días semanales; DFS: Días Fin de semana.

Conclusiones

Se observa como existe un consenso en cuanto a las recomendaciones de un mínimo de 60 min/día de AFMV en la población escolar. Se evidencia un preocupante incumplimiento de las mismas en todas las etapas educativas, siendo más acentuada en adolescentes.

Las clases de EF y los Recreos, se focalizan como momentos importantes para el incremento de los niveles de AF en el contexto escolar, aunque actualmente, contribuyen escasamente a los niveles determinados como saludables. Las niñas presentan niveles de actividad física inferiores a los desarrollados por los niños, lo que sugiere la necesidad de promover de manera especial la AF en el género femenino.

Se concluye que los estudios en el futuro deberían ir enfocados a la incipiente línea de actuación orientada a generar programas de intervención que ayuden y colaboren a incrementar los niveles de AF determinados en esta revisión.

Aplicaciones prácticas

La acelerometría se presenta como una herramienta objetiva, sencilla y práctica para cuantificar y conocer de una manera más detallada los niveles y patrones de AF con escolares. El ACL permite evaluar la AF con una gran precisión y la recogida de grandes volúmenes de datos; esto ha ampliado las posibilidades de análisis pero también la necesidad de un conocimiento más profundo. Por otro lado, hasta la fecha, la utilización de los ACLs ha permitido una mejor definición de las recomendaciones de AF para niños y adolescentes, sin embargo, parece que después de analizar los estudios transversales, la mayor parte de los escolares (entre el 20 y 60%) no cumplen estas recomendaciones de AF saludables. Además, el tiempo de práctica durante el contexto escolar es todavía insuficiente, y aunque ayuda reunir las recomendaciones, podría optimizarse aún más. A partir de estos datos, los investigadores pueden reflexionar sobre la necesidad de intervenir, ya que como se ha observado, existen muchísimos estudios en la última década orientados a describir lo que ocurre. De esta manera, las intervenciones en el contexto escolar se apuntan como una solución para resolver este problema, aunque por el momento existe una cantidad limitada de estudios a largo plazo donde se confirme un cambio sostenido del volumen y patrones de AF de los escolares.

Bibliografía

1. (NASPE), N. A. f. S. P. E. (2002). Active start: a statement of physical activity guidelines for children birth to five years *Reston, VA*: NASPE Publications.
2. Aibar, A., Bois, J. E., Generelo, E., Zaragoza Casterad, J., & Paillard, T. (2013a). A cross-cultural study of adolescents' physical activity levels in France and Spain. *European Journal of Sport Science, 13*(5), 551-558.
3. Aibar, A., Bois, J. E., Zaragoza Casterad, J., Generelo, E., Paillard, T., & Fairclough, S. (2013b). Weekday and weekend physical activity patterns of French and Spanish adolescents. *European Journal of Sport Science*(ahead-of-print), 1-10.
4. Andersen, L. B., Harro, M., Sardinha, L. B., Froberg, K., Ekelund, U., Brage, S., & Anderssen, S. A. (2006). Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *The Lancet, 368*(9532), 299-304.
5. Aznar, S., Naylor, P., Silva, P., Pérez, M., Angulo, T., Laguna, M.,... López-Chicharro, J. (2011). Patterns of physical activity in Spanish children: a descriptive pilot study. *Child: care, health and development, 37*(3), 322-328.
6. Baptista, F., Santos, D. A., Silva, A. M., Mota, J., Santos, R., Vale, S.,... Sardinha, L. B. (2012). Prevalence of the Portuguese population attaining sufficient physical activity. *Med Sci Sports Exerc, 44*(3), 466-473.
7. Baquet, G., Stratton, G., Van Praagh, E., & Berthoin, S. (2007). Improving physical activity assessment in prepubertal children with high-frequency accelerometry monitoring: a methodological issue. *Preventive medicine, 44*(2), 143-147.
8. Bornstein, D. B., Beets, M. W., Byun, W., Welk, G., Bottai, M., Dowda, M., & Pate, R. (2011). Equating accelerometer estimates of moderate-to-vigorous physical activity: In search of the Rosetta Stone. *Journal of Science and Medicine in Sport, 14*(5), 404-410.
9. Butte, N. F., Ekelund, U., & Westerterp, K. R. (2012). Assessing physical activity using wearable monitors: measures of physical activity. *Medicine and science in sports and exercise, 44*(1), S5-S12.
10. Carnethon, M. R., Gidding, S. S., Nehgme, R., Sidney, S., Jacobs Jr, D. R., & Liu, K. (2003). Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors. *JAMA: the journal of the American Medical Association, 290*(23), 3092-3100.
11. Cliff, D. P., Reilly, J. J., & Okely, A. D. (2009). Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0–5 years. *Journal of Science and Medicine in Sport, 12*(5), 557-567.
12. Colley, R. C., Garriguet, D., Janssen, I., Craig, C. L., Clarke, J., & Tremblay, M. S. (2011). Physical activity of Canadian adults: Accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. *Health Rep, 22*(1), 7-14.
13. Corder, K., Ekelund, U., Steele, R., Wareham, N., & Brage, S. (2008). Assessment of physical activity in youth. *Journal of applied physiology, 105*(3), 862-870.
14. Corder, K., van Sluijs, E. M., Wright, A., Whincup, P., Wareham, N. J., & Ekelund, U. (2009). Is it possible to assess free-living physical activity and energy expenditure in young people by self-report? *Am J Clin Nutr, 89*(3), 862-870. doi: 10.3945/ajcn.2008.26739
15. Chen, K. Y., & Bassett Jr, D. R. (2005). The technology of accelerometry-based activity monitors: current and future. *Medicine and science in sports and exercise, 37*(11 Suppl), S490.
16. Cheung, P. P. Y. (2012). Association of after-school physical activity levels and organized physical activity participation in Hong Kong children. *European Physical Education Review, 18*(2), 182-190.
17. Dencker M Fau - Tanha, T., Tanha T Fau - Wollmer, P., Wollmer P Fau - Karlsson, M. K., Karlsson Mk Fau - Andersen, L. B., Andersen Lb Fau - Thorsson, O., & Thorsson, O. (2013). Tracking of physical activity with accelerometers over a 2-year time period. *Journal of Physical Activity and Health, 10* 241-248.
18. Dollman, J., Okely, A. D., Hardy, L., Timperio, A., Salmon, J., & Hills, A. P. (2009). A hitchhiker's guide to assessing young people's physical activity: Deciding what method to use. *J Sci Med Sport, 12*(5), 518-525. doi: 10.1016/j.jsams.2008.09.007
19. Dudley, D. A., Okely, A. D., Cotton, W. G., Pearson, P., & Caputi, P. (2012). Physical activity levels and movement skill instruction in secondary school physical education. *Journal of Science and Medicine in Sport, 15*(3), 231-237.
20. Ekelund, U., Luan, J. a., Sherar, L. B., Esliger, D. W., Griew, P., & Cooper, A. (2012). Moderate to vigorous physical activity and sedentary time and cardiometabolic risk factors in children and adolescents. *JAMA: the journal of the American Medical Association, 307*(7), 704-712.
21. Ekelund, U., Sardinha, L. B., Anderssen, S. A., Harro, M., Franks, P. W., Brage, S., . . . Froberg, K. (2004). Associations between objectively assessed physical activity and indicators of body fatness in 9- to 10-y-old European children: a population-based study from 4 distinct regions in Europe (the European Youth Heart Study). *Am J Clin Nutr, 80*(3), 584-590.
22. Escalante, Y., Backx, K., Saavedra, J. M., García-Hermoso, A., & Domínguez, A. M. (2011). Relationship between daily physical activity, recess physical activity, age and sex in scholar of primary school, Spain. *Revista Española de Salud Pública, 85*(5), 481-489.

23. Fairclough, S., Breighle, A., Erwin, H., & Ridgers, N. (2012a). School day segmented physical activity patetrs of high and low active children. *BMC public health, 12*(406).
24. Fairclough, S., Hilland, T., Straton, G., & Ridgers, N. (2012b). 'Am I able? Is it worth it?' Adolescent girls' motivational predispositions to school physical education: Associations with health-enhancing physical activity. *European Physical Education Review, 18*(2), 147-158. doi: 10.1177/1356336X12440025
25. Fairclough, S., & Stratton, G. (2005). Physical activity levels in middle and high school physical education: a review. *Pediatric Exercise Science, 17*(3), 217-236.
26. Freedson, P. S., Pober, D., & Janz, K. F. (2005). Calibration of accelerometer output for children. *Medicine and science in sports and exercise, 37*(11 Suppl), S523.
27. García-Artero, E., Ortega, F. B., Ruiz, J. R., Mesa, J. L., Delgado, M., González-Gross, M., . . . Castillo, M. J. (2007). El perfil lipídico-metabólico en los adolescentes está más influido por la condición física que por la actividad física (estudio AVENA). *Revista española de Cardiología, 60*(6), 581-588.
28. Godard, C., Román, M., Rodríguez, M. P., Leyton, B., & Salazar, G. (2012). Variabilidad de la actividad física en niños chilenos de 4 a 10 años: estudio por acelerometría. *Archivos argentinos de pediatría, 110*(5), 388-393.
29. Grontved, A., Pedersen, G. S., Andersen, L. B., Kristensen, P. L., Moller, N. C., & Froberg, K. (2009). Personal characteristics and demographic factors associated with objectively measured physical activity in children attending preschool. *Pediatric Exercise Science, 21*(2), 201-209.
30. Hallal, P. C., Andersen, L. B., Bull, F. C., Guthold, R., Haskell, W., & Ekelund, U. (2012). Global physical activity levels: surveillance progress, pitfalls, and prospects. *The Lancet, 380*(9838), 247-257.
31. Hoos, M., Kuipers, H., Gerver, W.-J., & Westerterp, K. (2004). Physical activity pattern of children assessed by triaxial accelerometry. *European journal of clinical nutrition, 58*(10), 1425-1428.
32. Huberty, J. L., Siahpush, M., Beighle, A., Fuhrmeister, E., Silva, P., & Welk, G. (2011). Ready for recess: A pilot study to increase physical activity in elementary school children. *Journal of School Health, 81*(5), 251-257.
33. Intille, S., Lester, J., Sallis, J., & Duncan, G. (2012). New horizons in sensor development. *Medicine and science in sports and exercise, 44*(1 Suppl 1), S24.
34. Janssen, I., Katzmarzyk, P., Boyce, W., Vereecken, C., Mulvihill, C., Roberts, C., . . . Pickett, W. (2005). Comparison of overweight and obesity prevalence in school-aged youth from 34 countries and their relationships with physical activity and dietary patterns. *Obesity Reviews, 6*(2), 123-132.
35. Janssen, I., & LeBlanc, A. G. (2010). Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. *International Journal of Behavioral Nutrition and Physical Activity, 7*(40), 1-16.
36. Janssen, I., Wong, S. L., Colley, R., & Tremblay, M. S. (2013). The fractionalization of physical activity throughout the week is associated with the cardiometabolic health of children and youth. *BMC public health, 13*(554), 1-8.
37. Jiménez-Pavón, D., Konstabel, K., Bergman, P., Ahrens, W., Pohlabeln, H., Hadjigeorgiou, C., . . . De Henauw, S. (2013). Physical activity and clustered cardiovascular disease risk factors in young children: a cross-sectional study (the IDEFICS study). *BMC medicine, 11*(172), 1-8.
38. Kim, Y., Beets, M. W., & Welk, G. J. (2012). Everything you wanted to know about selecting the "right" Actigraph accelerometer cut-points for youth, but…: A systematic review. *Journal of Science and Medicine in Sport, 15*, 311-321.
39. Kozey, S. L., Lyden, K., Howe, C. A., Staudenmayer, J. W., & Freedson, P. S. (2010). Accelerometer output and MET values of common physical activities. *Medicine and science in sports and exercise, 42*(9), 1776-1784.
40. Kremer, M. M., Reichert, F. F., & Hallal, P. C. (2012). Intensity and duration of physical efforts in Physical Education classes. *Revista de Saúde Pública, 46*(2), 320-326.
41. Kwon, S., & Janz, K. F. (2012). Tracking of accelerometry-measured physical activity during childhood: ICAD pooled analysis. *The International Journal of Behavioral Nutrition and Physical Activity, 9*(1), 68.
42. Laguna , M. L. N., Hernández, M. T. L., & Laín, S. A. (2011). Patrones de Actividad Física en función del género y los niveles de obesidad en población infantil española. Estudio EYHS1. *Revista de Psicologia del Deporte, 20*(2), 621-636.
43. Lasheras, L., Aznar, S., Merino, B., & López, E. G. (2001). Factors associated with physical activity among Spanish youth through the National Health Survey. *Preventive medicine, 32*(6), 455-464.
44. Martinez-Gomez, D., Ortega, F. B., Ruiz, J. R., Vicente-Rodriguez, G., Veiga, O. L., Widhalm, K., . . . Kafatos, A. (2011). Excessive sedentary time and low cardiorespiratory fitness in European adolescents: the HELENA study. *Archives of disease in childhood, 96*(240–246).
45. Martinez-Gomez, D., Ruiz, J. R., Ortega, F. B., Casajús, J. A., Veiga, O. L., Widhalm, K., . . . Kafatos, A. (2010a). Recommended levels and intensities of physical activity to avoid low-cardiorespiratory fitness in European adolescents: The HELENA study. *American Journal of Human Biology, 22*(6), 750-756.
46. Martinez-Gomez, D., Ruiz, J. R., Ortega, F. B., Veiga, O. L., Moliner-Urdiales, D., Mauro, B., . . . Béghin, L. (2010b). Recommended levels of physical activity to avoid an excess of body fat in European adolescents: the HELENA Study. *American journal of preventive medicine, 39*(3), 203-211.
47. Martınez-Gómez, D., Wärnberg, J., Welk, G. J., Sjöström, M., Veiga, O. L., & Marcos, A. (2009b). Validity of the Bouchard activity diary in Spanish adolescents. *Public health nutrition, 13*(2), 261-268.
48. Martínez-Gómez, D., Welk, G., Calle, M., Marcos, A., & Veiga, O. (2009a). Preliminary evidence of physical activity levels measured by accelerometer in Spanish adolescents: the AFINOS Study. *Nutrición hospitalaria: organo oficial de la Sociedad Española de Nutrición Parenteral y Enteral, 24*(2), 212-218.
49. Martínez-Martínez, J., Contreras Jordán, O. R., Lera Navarro, Á., & Aznar Laín, S. (2012). Niveles de actividad física medido con acelerómetro en alumnos de 3º ciclo de educación primaria: actividad física diaria y sesiones de educación física. *Revista de Psicologia del Deporte, 21*(1), 117-123.
50. Metcalf, B. S., Jeffery, A. N., Hosking, J., Voss, L. D., Sattar, N., & Wilkin, T. J. (2009). Objectively Measured Physical Activity and Its Association With Adiponectin and Other Novel Metabolic Markers A longitudinal study in children (EarlyBird 38). *Diabetes care, 32*(3), 468-473.
51. Meyer, U., Roth, R., Zahner, L., Gerber, M., Puder, J., Hebestreit, H., & Kriemler, S. (2011). Contribution of physical education to overall physical activity. *Scandinavian Journal of Medicine & Science in Sports, 23*(5), 600-606. doi: doi: 10.1111/j.1600-0838.2011.01425.x
52. Moliner-Urdiales, D., Ortega, F. B., Vicente-Rodriguez, G., Rey-Lopez, J. P., Gracia-Marco, L., Widhalm, K., . . . Ruiz, J. R. (2010). Association of physical activity with muscular strength and fat-free mass in adolescents: the HELENA study. *European journal of applied physiology, 109*(6), 1119-1127.
53. Moliner-Urdiales, D., Ruiz, J., Ortega, F., Rey-Lopez, J., Vicente-Rodriguez, G., Espana-Romero, V., . . . Moreno, L. (2009). Association of objectively assessed physical activity with total and central body fat in Spanish adolescents; the HELENA Study. *International Journal of Obesity, 33*(10), 1126-1135.
54. Mota, J., Silva, P., Santos, M., Ribeiro, J., Oliveira, J., & Duarte, J. (2005). Physical activity and school recess time: differences between the

sexes and the relationship between children's playground physical activity and habitual physical activity. *Journal of Sports Sciences, 23*(3), 6.
55. Nielsen, G., Pfister, G., & Andersen, L. B. (2011). Gender differences in the daily physical activities of Danish school children. *European Physical Education Review, 17*(1), 69-90.
56. O'Connor, T. M., Cerin, E., Robles, J., Lee, R. E., Kerr, J., Butte, N., . . . Baranowski, T. (2013). Feasibility study to objectively assess activity and location of Hispanic preschoolers: a short communication. *Geospatial health, 7*(2), 375-380.
57. Ottevaere, C., Huybrechts, I., De Bourdeaudhuij, I., Sjostrom, M., Ruiz, J. R., Ortega, F. B., . . . De Henauw, S. (2011). Comparison of the IPAQ-A and actigraph in relation to VO2max among European adolescents: the HELENA study. *J Sci Med Sport, 14*(4), 317-324. doi: 10.1016/j.jsams.2011.02.008
58. Parikh, T., & Stratton, G. (2011). Influence of intensity of physical activity on adiposity and cardiorespiratory fitness in 5-18 year olds. *Sports Med, 41*(6), 477-488. doi: 10.2165/11588750-000000000-00000
59. Parrish, A.-M., Okely, A. D., Stanley, R. M., & Ridgers, N. D. (2013). The Effect of School Recess Interventions on Physical Activity. *Sports Medicine, 43*(4), 287-299.
60. Pate, R. R., Davis, M. G., Robinson, T. N., Stone, E. J., McKenzie, T. L., & Young, J. C. (2006). Promoting physical activity in children and youth: a leadership role for schools: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. *Circulation, 114*(11), 1214-1224. doi: 10.1161/circulationaha.106.177052
61. Pate, R. R., Ward, D. S., Saunders, R. P., Felton, G., Dishman, R. K., & Dowda, M. (2005). Promotion of physical activity among high-school girls: a randomized controlled trial. *Journal Information, 95*(9).
62. Plasqui, G., Bonomi, A., & Westerterp, K. (2013). Daily physical activity assessment with accelerometers: new insights and validation studies. *Obesity Reviews, 14*, 451–462.
63. Ramirez-Rico, E., Hilland, T. A., Foweather, L., Fernández-Garcia, E., & Fairclough, S. J. (2013). Weekday and weekend patterns of physical activity and sedentary time among Liverpool and Madrid youth. *European Journal of Sport Science*(ahead-of-print), 1-7.
64. Raustorp, A., Söderström, M., & Boldemann, C. (2012). Accelerometer Measured Level of Physical Activity Indoors and Outdoors During Preschool time in Sweden and United States. *Journal of physical activity & health, 9*, 801-808.
65. Reilly, J. J., Penpraze, V., Hislop, J., Davies, G., Grant, S., & Paton, J. Y. (2008). Objective measurement of physical activity and sedentary behaviour: review with new data. *Arch Dis Child, 93*(7), 614-619. doi: adc.2007.133272 [pii]
66. 10.1136/adc.2007.133272
67. Riddoch, C. J., Andersen, L. B., Wedderkopp, N., Harro, M., Klasson-Heggebo, L., Sardinha, L. B., . . . Ekelund, U. (2004). Physical activity levels and patterns of 9-and 15-yr-old European children. *Medicine and science in sports and exercise, 36*(1), 86-92.
68. Ridgers, N., Saint-Maurice, P. F., Welk, G. J., Siahpush, M., & Huberty, J. (2011). Differences in physical activity during school recess. *Journal of School Health, 81*(9), 545-551.
69. Ridgers, N., Stratton, G., & McKenzie, T. L. (2010). Reliability and validity of the system for observing children's activity and relationships during play (SOCARP). *Journal of physical activity & health, 7*(1), 17-25.
70. Ridgers, N. D., Salmon, J., Parrish, A. M., Stanley, R. M., & Okely, A. D. (2012a). Physical activity during school recess: a systematic review. *Am J Prev Med, 43*(3), 320-328. doi: 10.1016/j.amepre.2012.05.019
71. Ridgers, N. D., Stratton, G., & Fairclough, S. J. (2005). Assessing physical activity during recess using accelerometry. *Preventive medicine, 41*(1), 4.
72. Rowlands, A. V. (2007a). Accelerometer assessment of physical activity in children: an update. *Pediatric Exercise Science, 19*(3), 252.
73. Rowlands, A. V., Pilgrim, E. L., & Eston, R. G. (2009). Seasonal changes in children's physical activity: an examination of group changes, intra-individual variability and consistency in activity pattern across season. *Annals of human biology, 36*(4), 363-378.
74. Ruiz, J. R., Ortega, F. B., Martínez-Gómez, D., Labayen, I., Moreno, L. A., De Bourdeaudhuij, I., . . . Molnar, D. (2011a). Objectively Measured Physical Activity and Sedentary Time in European Adolescents The HELENA Study. *American journal of epidemiology, 174*(2), 173-184.
75. Ruiz, J. R., Rizzo, N. S., Hurtig-Wennlöf, A., Ortega, F. B., Wärnberg, J., & Sjöström, M. (2006). Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study. *The American journal of clinical nutrition, 84*(2), 299-303.
76. Ruiz, J. R., Sola, R., Gonzalez-Gross, M., Ortega, F. B., Vicente-Rodriguez, G., Garcia-Fuentes, M., . . . Castillo, M. J. (2007). Cardiovascular fitness is negatively associated with homocysteine levels in female adolescents. *Archives of pediatrics & adolescent medicine, 161*(2), 166.
77. Sardinha, L. B., Andersen, L. B., Anderssen, S. A., Quitério, A. L., Ornelas, R., Froberg, K., . . . Ekelund, U. (2008a). Objectively measured time spent sedentary is associated with insulin resistance independent of overall and central body fat in 9-to 10-year-old Portuguese children. *Diabetes care, 31*(3), 569-575.
78. Scruggs, P. W. (2007). Middle school physical education physical activity quantification: a pedometer steps/min guideline. *Res Q Exerc Sport, 78*(4), 284-292.
79. Silva, P., Sousa, M., Aires, L., Seabra, A., Ribeiro, J., Welk, G., & Mota, J. (2010). Physical activity patterns in Portuguese adolescents: The contribution of extracurricular sports. *European Physical Education Review, 16*(2), 171-181.
80. Steele, R., Sluijs, E. v., Cassidy, A., Griffin, S., & Ekelund, U. (2009). Targeting sedentary time or moderate-and vigorous-intensity activity: independent relations with adiposity in a population-based sample of 10-y-old British children. *American Journal of Clinical Nutrition, 90*(5), 1185-1192.
81. Stratton, G., & Mullan, E. (2005). The effect of multicolor playground markings on children's physical activity level during recess. *Preventive medicine, 41*, 828-833.
82. Strong, W. B., Malina, R. M., Blimkie, C. J., Daniels, S. R., Dishman, R. K., Gutin, B., . . . Pivarnik, J. M. (2005). Evidence based physical activity for school-age youth. *The Journal of pediatrics, 146*(6), 732-737.
83. Tremblay, M. S., Warburton, D. E., Janssen, I., Paterson, D. H., Latimer, A. E., Rhodes, R. E., . . . Zehr, L. (2011). New Canadian physical activity guidelines. *Applied Physiology, Nutrition, and Metabolism, 36*(1), 36-46.
84. Troiano, R. P., Berrigan, D., & Dodd, K. (2008). Physical Activity in the United States Measured by Accelerometer. *Medicine & Science in Sports & exercise: Official Journal of the American College of Sports Medicine, 40*(1), 181-188.
85. Trost, S., Rosenkranz, R., & Dzewaltowski, D. (2008). Physical activity levels among children attending after-school programs. *Medicine and science in sports and exercise, 40*(4), 622-629.
86. Trost, S. G., Pate, R. R., Sallis, J. F., Freedson, P. S., Taylor, W. C., Dowda, M., & Sirard, J. (2002). Age and gender differences in objectively measured physical activity in youth. *Medicine and science in sports and exercise, 34*(2), 350.
87. Trost, S. G., & van der Mars, H. (2010). Why we should not cut PE. *Health Learn, 67*(4), 60-65.
88. Tudor-Locke, C., Lee, S. M., Morgan, C. F., Beighle, A., & Pangrazi, R. P. (2006). Children's pedometer-determined physical activity during the segmented school day. *Medicine and science in sports and exercise, 38*(10), 1732-1738.
89. Van Cauwenberghe, E., De Bourdeaudhuij, I., Maes, L., & Cardon,

G. (2012b). Efficacy and feasibility of lowering playground density to promote physical activity and to discourage sedentary time during recess at preschool: a pilot study. *Prev Med, 55*(4), 319-321. doi: 10.1016/j.ypmed.2012.07.014

90. Van Cauwenberghe, E., Labarque, V., Gubbels, J., De Bourdeaudhuij, I., & Cardon, G. (2012). Preschooler's Physical Activity Levels and Associations with Lesson Context, Teacher's Behavior, and Environment during Preschool Physical Education. *Early Childhood Research Quarterly, 27*(2), 221– 230.
91. Verloigne, M., Van Lippevelde, W., Maes, L., Yıldırım, M., Chinapaw, M., Manios, Y., . . . Brug, J. (2012). Levels of physical activity and sedentary time among 10-to 12-year-old boys and girls across 5 European countries using accelerometers: an observational study within the ENERGY-project. *The International Journal of Behavioral Nutrition and Physical Activity, 9*, 34-42.
92. Verstraete, S. J., Cardon, G. M., De Clercq, D. L., & De Bourdeaudhuij, I. M. (2006). Increasing children's physical activity levels during recess periods in elementary schools: the effects of providing game equipment. *The European Journal of Public Health, 16*(4), 415-419.
93. Welk, G., McClain, J., & Ainsworth, B. (2012). Protocols for evaluating equivalency of accelerometry-based activity monitors. *Medicine and science in sports and exercise, 44*(1 Suppl 1), S39.
94. WHO, W. H. O. (2010). *Global Recommendations on Physical Activity for Health*. Geneva, Switzerland: WHO.
95. Wickel, E. E., & Eisenmann, J. C. (2007). Contribution of Youth Sport to Total Daily Physical Activity among 6-to 12-yr-old Boys. *Medicine & Science in Sports & exercise: Official Journal of the American College of Sports Medicine, 39*(9), 1493-1500.
96. Wilkin, T. J., Mallam, K. M., Metcalf, B., Jeffery, A. N., & Voss, L. D. (2006). Variation in physical activity lies with the child, not his environment: evidence for an 'activitystat'in young children (EarlyBird 16). *International Journal of Obesity, 30*(7), 1050-1055.
97. Ceroni D, Martin X, Lamah L, Delhumeau C, Farpour-Lambert N, De Coulon G, et al. Recovery of physical activity levels in adolescents after lower limb fractures: a longitudinal, accelerometry-based activity monitor study. BMC Musculoskeletal Disorders. 2012;13:131.
98. Alhassan S, Nwaokelemeh O, Mendoza A, Shitole S, Whitt-Glover M, Yancey A. Design and Baseline characteristics of the short bouts of exercise for preescholers (STEP) study. BMC Public Health. 2012; 12:582.

III

RELATIONSHIP BETWEEN PHYSICAL ACTIVITY LEVEL IN PHYSICAL EDUCATION CLASSES AND MAXIMUM OXYGEN UPTAKE IN CHILDREN AND ADOLESCENTS

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Abstract:

Several findings have indicated the importance of moderate and vigorous physical activity (MVPA) to improve maximum oxygen uptake (VO_{2max}). Physical education classes (PE) are considered a school period which aims to engage and increase physical activity (PA) levels. However, there are few PE data that confirm if these PA levels are associated with VO_{2max}. We described PA and its association with VO_{2max} in 150 school-aged from 3rd to 12nd grade.

A linear regression model was carried out to verify associations between VO_{2max} and PA intensities. During PE, the group with a healthy VO_{2max} engaged in higher MVPA (8.7 vs 5.7 min; $p \leq 0.001$), total PA (20.4 vs 14.3 min; $p \leq 0.001$) and better % of PA ($p \leq 0.01$; $p \leq 0.001$) than unhealthy subjects whereas no significant differences where found between sexes during PE. PA levels in PE displayed higher associations with VO_{2max} compared with other periods. The linear regression model for VO_{2max} revealed that age, total sedentary time, BMI category and moderate PA were inversely associated whereas vigorous PA in PE was positively associated ($r = 0.0484$; $p \leq 0.001$). During PE, no statistical differences were found between genders; however, great differences were shown between healthy and unhealthy participants. Main predictors of VO_{2max} were age, total sedentary time and BMI category.

Key Words: adolescents, children, physical activity, physical education and training, schools.

Main Text

Introduction

Physical education classes (PE) are considered a school period which aims to engage and increase physical activity (PA) levels, which combined with others activities would be a valuable contributor and meeting recommendations of moderate to vigorous PA (MVPA) (Fairclough & Stratton, 2005; Martínez-Martínez, Contreras, Lera, & Aznar, 2012). Although PE and PA have been assessed over the last years in order to measure their impact on health, less is known regarding the influence of PE in improving health with independence of the total daily MVPA. Maximum oxygen uptake (VO_{2max}) is an indicator of cardiorespiratory fitness (CRF) and the most important variable of healthy physical condition, which has a positive influence on children´s health (Ottevaere et al., 2011). Previous findings reported PA can modify CRF during youth preventing obesity, diabetes and cardiovascular risk factors (Carnethon et al., 2003).

With aged-children has particular relevance the issue in regard of PA intensity, so both vigorous and hard PA have been positively correlated with CRF (Denton et al., 2013). On the contrary, exceeding 69% of non sleeping hours in sedentary and not meeting health recommendations were correlated with significantly lower levels of VO_{2max} (Martinez-Gomez et al., 2011). Moreover PA levels do not decrease adverse effects of sedentary time (ST) on CRF (Santos et al., 2013). These findings are important in regard of the role of PE teachers promoting a healthy lifestyle from PE to outside school activities. This paradigm concerning PE would improve CRF with independence of total daily MVPA. Since, it seems interesting to elucidate the role of PE on health and whether the most active students in PE have also higher CRF than others less active.

Thus, the purpose of this study was to describe PA during PE; and its association with CRF in primary and secondary school students.

Methods

Participants

150 healthy children and adolescents from 3rd – 12th school Spanish grades were recruited from 8 elementary and high schools from Spain (Malaga, Orense and Jaen regions). Detailed information about procedures was exposed to parents and consent to participate was obtained prior to participation. All procedures were in accordance with the ethical principles from Helsinki declaration (Association, 2000) and approved by the Ethical Committee of the University of Malaga, Spain.

A total of 668 acelerometers were worn. Considering lost data device, lost device and not meeting Troiano, Berrigan, and Dodd (2008) recommendations, 282 ACLs were considered as valid data. Regarding CPX-T, 503 breath-by-breath tests were performed. From those, 418 hundred eighteen were considered valid (85 were discarded because of telemetry errors, non-valid data or technical issues). Additionally, only children with at least one-day of PE class registered in the ACL were selected (150 participants met the criteria for ACLs and 132 for ACLs and CPX-T with CRF status).

Accelerometry

Actigraph GT3X monitors were used to measure PA (Actigraph, Pensacola, FL, USA), which collects motion data on 3 orthogonal axes, which was reported reliability to quantify PA (Santos-Lozano et al., 2013). Participants wore accelerometers (ACLs) next to the right hip (Evenson, Catellier, Gill, Ondrak, & McMurray, 2008) and fastened with an elastic belt. Data was collected with 1 s epoch as previous studies with children between 5 and 16 years (Santos-Lozano et al., 2013), to accurately capture patterns of high intensity and short duration PA.

Students were instructed to wear the ACLs for 7 whole consecutive days (5 week-days and the whole weekend), except during water activities or while sleeping (Trost, McIver, & Pate, 2005). Information about activities during school (9.00 AM and 2.00 PM) and the rest of the day (between 2.01 PM and 12.00 PM) were recorded. A wear-time of ≥ 10 hours/day for ≥ 5 days was used as the criterion for a valid measurement (Troiano et al., 2008). The cut-off points proposed by Evenson et al. (2008) were used: Sedentary PA ≤ 100; Ligh PA ≥ 100; Moderate PA ≥ 2296 and Vigorous PA ≥ 4012 counts·min-¹.

<u>Cardiopulmonary exercise test</u> (CPX-T)

The Chester Step Test was selected as CPX-T, which is a validated incremental five-level step test (Sykes & Roberts, 2004). It consists of going up and down in a bench (from 32 to 52 cm) at a pace set by a signal sound progressively speeded up during five levels. All children engaged a previous test and they were reminded briefly what were required to do. Later, they were encouraged until exhaustion and the test was terminated either by the subject (because of dyspnea and/or leg fatigue) or by the supervisor when the student was unable to maintain properly the cadence for 15 seconds (De Camargo, Justino, De Andrade, Malaguti, & Dal Corso, 2011).

VO_{2max} was assessed using a portable breath-by-breath metabolic unit (Metamax 3B, Cortex Biophysic, Leipzig, Germany) while performing CPX-T. The gas analyzers were calibrated using as references the room air and a bottle of known O_2 and CO_2 concentrations (5.0% CO_2, 15.0% O_2). Volume calibration was conducted with a three-liter volume syringe (Calibration syringe D, Sensormedics Hans Rudolph Inc 5530) each testing day. Heart rate was also collected using a Polar Team^2 (Finland) stored every 5 seconds.

Statistical Analysis

Sample was split into a binary variable according to BMI categories (normal weight, overweight/obese) according with international cut-offs (Cole, Bellizzi, Flegal, & Dietz, 2000). Additionally, sample was classified as "High / Healthy VO_{2max}" (H) or "Low / Unhealthy VO_{2max}" (UH) according to sex and age-specific references, for children between 10 and 18 years cut-off point criteria reported in Welk and Meredith (2008). (Adegboye et al., 2011) classification was used for students under 10 years. A new variable was created (square root of vigorous PA in PE) in order to transform into a normal distributed variable.

The Kolmogorov-Smirnov test was used to confirm a non parametric distribution of the variables. U of Mann-Whitney was conducted for comparisons of PA variables, sexes and CRF. A Spearman´s correlation was carried out to analyze associations between VO_{2Max} and PA intensities among different periods registered. A general linear model was conducted to confirm factors that determine PA in PE, after controlling for total physical activity (TPA) without PE. Additionally, interactions between VO_{2max} and light, moderate and vigorous PA levels in PE and total ST, age and BMI category were analyzed. Finally, a linear regression model was performed to detect the strength of associations between VO_{2max} and PA intensities after controlling for age, total minutes of MVPA and ST. The level of significance was set at $p \leq 0.05$ for all the tests with statistics software SPSS (v. 20.0).

Results

Table 1. Descriptive characteristics of the sample.

		Total (n=150)			Girls (n=66)			Boys (n=84)			Sig.
		Mean		SD	Mean		SD	Mean		SD	
Age	*(years)*	13.0	±	2.5	13.1	±	2.4	13.0	±	2.6	
					44%			56%			
NW	*(%)*	68.7			68.2			69.0			
Healthy Status	*(%)*	51.9			36.2			63.5			
BMI	*(kg/m²)*	20.2	±	3.8	19.9	±	3.7	20.4	±	3.8	
VO_{2Max}	*(ml/kg/min)*	40.8		10.2	36.4	±	9.2	44.3	±	9.6	***
Sedentary	*(min/day)*	858.4	±	299.6	1120.6		192.4	652.4		185.7	***
MV	*(min/day)*	48.9	±	20.0	49.0	±	18.6	48.8	±	21.1	
Total PA	*(min/day)*	149.0	±	52.4	141.9	±	40.5	154.6	±	59.8	
PA Rec	*(%)*	33.30			30.3			35.7			

BMI: Body Mass Index; NW: normal weight; VO_{2max}: Maximun Oxygen uptake; MV: Moderate to Vigorous; PA: Physical Activity (Light + Moderate + Vigorous); PA Rec: Meeting PA Health 60 min Guidelines; ***: $p \leq 0.001$

Participants displayed on average a normal weight, a healthy status and a low compliance of meeting health guidelines with poor levels of MVPA. Besides, main differences between sexes were VO_{2max} (44.3 vs. 36.4; $p \leq 0.001$) and ST (652.4 vs. 1120; $p \leq 0.001$). All this values were remarkably low, especially among girls compared to boys.

Table 2. PA levels between genders and health statuses during PE.

PE																				
		Total (n=150)			**Girls (n=66)**			**Boys (n=84)**			Sig.	**UH (n=64)**			**H (n=68)**			Sig.
		Mean		SD	Mean		SD	Mean		SD		Mean		SD	Mean		SD	
Sedentary	*(min/day)*	40.8	±	12.1	43.1	±	11.5	39.1	±	12.4		46.5	±	10.6	36.8	±	11.1	***
Light	*(min/day)*	10.2	±	6.1	9.1	±	5.5	11.0	±	6.5		8.6	±	6.4	11.6	±	5.7	***
Moderate	*(min/day)*	3.5	±	2.6	3.2	±	2.5	3.8	±	2.7		2.9	±	2.4	3.9	±	2.4	**
Vigorous	*min/day*	4.0	±	3.3	3.5	±	3.1	4.3	±	3.5		2.8	±	2.9	4.9	±	3.5	***
MV	*(min/day)*	7.5	±	5.5	6.6	±	5.2	8.2	±	5.7		5.7	±	4.9	8.7	±	5.4	***
Total PA	*min/day*	17.7	±	10.7	15.8	±	9.7	19.1	±	11.2		14.3	±	10.2	20.4	±	10.3	***
Sedentary	*(%)*	70.0	±	18.4	72.9	±	17.2	67.7	±	19.1		76.3	±	16.9	65.0	±	17.0	***
Light	*(%)*	17.4	±	10.4	15.7	±	9.6	18.6	±	10.9		14.2	±	10.7	20.0	±	9.4	***
Moderate	*(%)*	6.0	±	4.4	5.4	±	4.2	6.4	±	4.5		4.8	±	4.0	6.6	±	3.9	**
Vigorous	*(%)*	6.7	±	5.9	6.0	±	5.5	7.3	±	6.1		4.7	±	4.8	8.4	±	6.1	***
MVPA	*(%)*	12.7	±	9.6	11.4	±	9.2	13.7	±	9.8		9.4	±	8.2	15.0	±	9.1	***

PE: Physical Education; MV: Moderate to Vigorous; PA: Physical Activity (Light + Moderate + Vigorous); **: $p \leq 0.01$; ***: $p \leq 0.001$.

PA differences in PE between both CRF groups and genders were displayed in table 2. No differences were found between boys and girls. Nevertheless CRF statuses revealed differences in all variables displayed. UH participants were more sedentary (46.5 vs. 36.8 min/day and 76.3% vs. 65.0%; $p \leq 0.001$) during PE whereas H students engaged more light (11.6 vs. 8.6 min/day and 20.0% vs. 14.2%; $p \leq 0.001$), moderate (3.9 vs 2.9 min/day and 6.6% vs. 4.8%; $p \leq 0.01$), vigorous (4.9 vs. 2.8 min/day and 8.4% vs. 4.7%; $p \leq 0.001$) , MVPA (8.7 vs. 5.7 min/day and 15.0 vs 9.4; $p \leq 0.001$) and TPA (20.4 vs. 14.3 min/day and 15.0% vs. 9.4% ; $p \leq 0.001$)

Table 3. Spearman´s Correlations among VO_{2max} and PA intensities.

		VO_{2max}									
		PE		TOTAL WEEK		TIPICAL DAY OF THE WEEK		DAY WITHOUT PE		DAY WITH PE	
IMC	(kg/m^2)	-0,170	*								
Sedentary	*(min/day)*	-0,399	***	-0,398	***	-0,379	***	-0,377	***	-0,380	***
Light	*(min/day)*	0,275	***	0,208	*	-		-		-	
Moderate	*(min/day)*	0,227	**	0,226	**	-		-		-	
Vigorous	*(min/day)*	0,345	***	0,224	**	-		-		-	
MV	*(min/day)*	0,302	***	0,215	*	-		-		-	
Total PA	*(min/day)*	0,283	***	0,221	**	-		-		-	
Sedentary	*(%)*	-0,314	***	-0,219	*	-0,376	***	-0,369	***	-0,373	***
Light	*(%)*	0,307	***	-0,308	***	0,335	***	0,339	***	0,338	***
Moderate	*(%)*	0,255	**	-0,209	*	0,308	***	0,311	***	0,314	***
Vigorous	*(%)*	0,367	***	-		0,210	*	0,196	*	0,228	**
MV	*(%)*	0,319	***	-		0,305	***	0,305	***	0,322	***

BMI: Body Mass Index; VO_{2max}: Maximun Oxygen uptake; MV: Moderate to Vigorous; PA: Physical Activity (Light + Moderate + Vigorous); *: p≤0,05; **: p≤0,01; ***: p≤0,001

Table 3 showed significant associations between VO_{2max} and PA for all periods analyzed. However, PE was where higher associations were observed. The best correlated variables in this school period were ST (-0.399) and vigorous time (0.345) min/day ($p \leq 0.001$).

Table 4. Linear regression models predicting VO_{2max} from ACL variables, BMI and age.

VO_{2max}	Variables	β	*Sig*	SEE	R^2
Step 1	Constant	69.885		4.497	0.250
	Age	-2.167	***	0.330	
Step 2	Constant	80.242		4.437	0.400
	Age	-2.111	***	0.297	
	T Sed	-0.013	***	0.002	
Step 3	Constant	84.599		4.610	0.433
	Age	-2.326	***	0.300	
	T Sed	-0.013	***	0.002	
	BMI Cat	-4.198	**	1.530	
Step 4	Constant	77.711		5.447	0.456
	Age	-2.079	***	0.314	
	T Sed	-0.013	***	0.002	
	BMI Cat	-4.323	**	1.506	
	Vig PA	1.753	*	0.768	
Step 5	Constant	77.013		5.334	0.484
	Age	-2.070	***	0.307	
	T Sed	-0.012	***	0.002	
	BMI Cat	-3.716	*	1.491	
	Vig PE	4.350	***	1.251	
	Mod PE	-1.299	**	0.500	

VO_{2max}: Maximun Oxygen uptake; BMI Cat: BMI Category; T Sed: Total Sedentary Time; *: $p \leq 0.05$; **: $p \leq 0.01$; ***: $p \leq 0.001$.

Regression analysis explained 50% of VO_{2max} variability after controlling for total MVPA; being age (β = -2,070; $p \leq 0.001$), total ST (β = -0,012; $p \leq 0.001$), BMI category (β = -3,716; $p \leq 0.05$) and moderate time in PE (β = -1,299; $p \leq 0.01$) inversely associated. Conversely vigorous time in PE was positively and significantly associated with VO_{2max} (β = 4,350; $p \leq 0.001$).

Discussion

We assessed the PA levels during PE and associations of PA levels with CRF. Main findings were: PA levels were different during PE between CRF statuses; and CRF was associated with age, BMI, ST and MVPA in PE.

Subjects met poorly the current recommendations of 60 min/day of MVPA (Table 1), which is reported in this population (Aznar et al., 2011; Martínez-Martínez et al., 2012); suggesting that MVPA values are low but similar to Spanish students. Students´ weekly results of ST showed that boys were less sedentary than girls, which is in line with Portuguese and Spanish (Baptista et al., 2012; Martinez-Gomez et al., 2011). Evidence revealed longitudinal inverse relationship of ST and VO_{2max} (Chinapaw, Proper, Brug, van Mechelen, & Singh, 2011), as well as is underlined that exceeding 70% of waking hours lower VO_{2max} (Martinez-Gomez et al., 2011). These were similar to our results, where UH and girls spent more ST and had lower VO_{2max} than other students. Finally, our general lineal model showed none interaction between daily ST and ST in PE, which meant that both periods acted independently on VO_{2max}. This fact mean that being at a sedentary level in PE do not let engaging higher PA intensities (associated with VO_{2max}) and the deleterious influence of ST out of school on VO_{2max}. This fact was similar to studies which revealed that PA levels did not overcome the adverse effects of high ST on CRF (Santos et al., 2013).

PA levels during PE was similar for both genders, which was supported previously (Sarkin, McKenzie, & Sallis, 1997). Additionally, a significant positive association was addressed between weekly MVPA and MVPA in PE (Martínez-Martínez et al., 2012); which meant that the more MVPA accrued in PE, the more MVPA engaged outside-school and vice versa. Due to reasons exposed, PE might be a cornerstone for promoting a healthy lifestyle. Moreover, differences in PA during PE were noticeable regarding CRF status ($p \leq 0.01$; $p \leq 0.001$), which may confirm the actual utility of PE.

PA levels´ associations on VO_{2max} revealed the importance of PA during PE, because these levels were highly correlated compared to other periods (total week, day without PE, day with PE and a usual day of the week (Table 3). The main predictors for VO_{2max} were age, BMI category, and total ST. The regression model predicted 48.5 % of the variability of the VO_{2max}, which is in line to the heritage of VO_{2max} issued (Bouchard et al., 1998). Regarding age, would be inappropriate to report changes in VO_{2max} per kilogram of body mass; because these differences would be confounded by the growth-associated changes in body mass (Teran-Garcia, Rankinen, & Bouchard, 2008), especially among girls across adolescence, whereas in boys this changes in VO_{2max} were more stable (Bouchard, 1997). Secondly, body fat has been negatively associated with CRF among schoolchildren (Ostojic, Stojanovic, Stojanovic, Maric, & Njaradi, 2011), which explained our negative influence of BMI category on VO_{2max}.

Moderate intensity ranges from 3 to 6 METs (Freedson, Melanson, & Sirard, 1998); therefore, it might be speculated that sample´s PA moderate intensity varied from 27 to 47% of their VO_{2max} workload; which would be considered as an insufficient stimulus on $VO_{2Max.}$, because the PA intensity varied from 27 to 47% of their VO_{2max} workload at moderate intensity. With animals, vigorous (85-90% of VO_{2max}) compared to moderate intensities (66-70% of VO_{2max}) provided 71 to 28% of improvement respectively on VO_{2max}, eliciting significantly higher benefits and demonstrating that those adaptations are intensity-dependent (Kemi et al., 2005). Among well trained runners, who have been reported to reach a plateau in VO_{2max}, high intensity training programs has enhanced those values developing (Billat, Demarle, Paiva, & Koralsztein, 2002; Smith, Coombes, & Geraghty, 2003; Smith, McNaughton, & Marshall, 1999). Although vigorous and moderate intensities are often recommended as equally effective, reviews refuse that fact, highlighting the particular importance of vigorous PA on VO_{2max} with school-aged subjects (Dencker et al., 2007; Ortega, Ruiz, Castillo, & Sjöström, 2008; Ruiz & Ortega, 2009). Authors emphasized on vigorous PA (9 METs) as an optimum mean to maintain or improve CRF rather than lower intensities, such as light and moderate PA, which were inversely correlated in both genders and boys respectively (Denton et al., 2013). The reasons indicated that spending time in lower intensities was detrimental for health, but not by itself, it was because represented a lack of more vigorous PA; which was very similar to our results, where more PA in PE does not decreased CRF, however low levels of PA intensity do not allow engaging a higher intensity. Furthermore, PE is a punctual period with a short weekly time where moderate PA may act differently from daily/weekly moderate PA.

Current key findings indicated no statistical differences were found regarding genders during PE, but these differences were remarkable between H and UH scholars. Concerning the prediction of VO_{2max}, age, total ST, BMI category were the main predictors. Moreover, data suggested that the behaviour conducted in PE is relevant, the advice should aimed to encourage and promote higher PA intensity (> 6 METs) because of negative effects' of lower intensities on CRF. Previous implications may be of vital importance for future policies and health promotion with school-aged subjects.

Bibliography

Adegboye, A. R., Anderssen, S. A., Froberg, K., Sardinha, L. B., Heitmann, B. L., Steene-Johannessen, J., . . . Andersen, L. B. (2011). Recommended aerobic fitness level for metabolic health in children and adolescents: a study of diagnostic accuracy. *Br J Sports Med, 45*(9), 722-728. doi: 10.1136/bjsm.2009.068346

Aznar, S., Naylor, P., Silva, P., Pérez, M., Angulo, T., Laguna, M., . . . López-Chicharro, J. (2011). Patterns of physical activity in Spanish children: a descriptive pilot study. *Child: care, health and development, 37*(3), 322-328.

Baptista, F., Santos, D. A., Silva, A. M., Mota, J., Santos, R., Vale, S., . . . Sardinha, L. B. (2012). Prevalence of the Portuguese population attaining sufficient physical activity. *Med Sci Sports Exerc, 44*(3), 466-473.

Billat, V., Demarle, A., Paiva, M., & Koralsztein, J. P. (2002). Effect of training on the physiological factors of performance in elite marathon runners (males and females). *Int J Sports Med, 23*(5), 336-341. doi: 10.1055/s-2002-33265

Bouchard, C. (1997). *Genetics of fitness and physical performance*: Human Kinetics.

Bouchard, C., Daw, E. W., Rice, T., Perusse, L., Gagnon, J., Province, M. A., . . . Wilmore, J. H. (1998). Familial resemblance for VO2max in the sedentary state: the HERITAGE family study. *Med Sci Sports Exerc, 30*(2), 252-258.

Carnethon, M. R., Gidding, S. S., Nehgme, R., Sidney, S., Jacobs Jr, D. R., & Liu, K. (2003). Cardiorespiratory fitness in young adulthood and the development of cardiovascular disease risk factors. *JAMA: the journal of the American Medical Association, 290*(23), 3092-3100.

Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *Bmj, 320*(7244), 1240.

Chinapaw, M. J., Proper, K. I., Brug, J., van Mechelen, W., & Singh, A. S. (2011). Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. *Obes Rev, 12*(7), e621-632. doi: 10.1111/j.1467-789X.2011.00865.x

De Camargo, A. A., Justino, T., De Andrade, C. H., Malaguti, C., & Dal Corso, S. (2011). Chester step test in patients with COPD: reliability and correlation with pulmonary function test results. *Respir Care, 56*(7), 995-1001. doi: 10.4187/respcare.01047

Dencker, M., Thorsson, O., Karlsson, M. K., Linden, C., Eiberg, S., Wollmer, P., & Andersen, L. B. (2007). Gender differences and determinants of aerobic fitness in children aged 8-11 years. *Eur J Appl Physiol, 99*(1), 19-26. doi: 10.1007/s00421-006-0310-x

Denton, S. J., Trenell, M. I., Plötz, T., Savory, L. A., Bailey, D. P., & Kerr, C. J. (2013). Cardiorespiratory fitness is associated with hard and light intensity physical activity but not time spent sedentary in 10–14 year old schoolchildren: the HAPPY study. *PLOS ONE, 8*(4), e61073.

Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. *Journal of sports sciences, 24*(14), 1557-1565.

Fairclough, S., & Stratton, G. (2005). Physical activity levels in middle and high school physical education: a review. *Pediatric Exercise Science, 17*(3), 217-236.

Freedson, P. S., Melanson, E., & Sirard, J. (1998). Calibration of the Computer Science and Applications, Inc. accelerometer. *Med Sci Sports Exerc, 30*(5), 1-5.

Kemi, O. J., Haram, P. M., Loennechen, J. P., Osnes, J. B., Skomedal, T., Wisloff, U., & Ellingsen, O. (2005). Moderate vs. high exercise intensity: differential effects on aerobic fitness, cardiomyocyte contractility, and endothelial function. *Cardiovasc Res, 67*(1), 161-172. doi: 10.1016/j.cardiores.2005.03.010

Martinez-Gomez, D., Ortega, F. B., Ruiz, J. R., Vicente-Rodriguez, G., Veiga, O. L., Widhalm, K., . . . Kafatos, A. (2011). Excessive sedentary time and low cardiorespiratory fitness in European adolescents: the HELENA study. *Archives of disease in childhood, 96*(240–246).

Martínez-Martínez, J., Contreras, O. R., Lera, Á., & Aznar, S. (2012). Niveles de actividad física medido con acelerómetro en alumnos de 3º ciclo de educación primaria: actividad física diaria y sesiones de educación física. *Revista de Psicologia del Deporte, 21*(1), 117-123.

Ortega, F., Ruiz, J., Castillo, M., & Sjöström, M. (2008). Physical fitness in childhood and adolescence: a powerful marker of health. *Int J Obes, 32*(1), 1-11.

Ostojic, S. M., Stojanovic, M. D., Stojanovic, V., Maric, J., & Njaradi, N. (2011). Correlation between fitness and fatness in 6-14-year old Serbian school children. *J Health Popul Nutr, 29*(1), 53-60.

Ottevaere, C., Huybrechts, I., De Bourdeaudhuij, I., Sjostrom, M., Ruiz, J. R., Ortega, F. B., . . . De Henauw, S. (2011). Comparison of the IPAQ-A and actigraph in relation to VO2max among European adolescents: the HELENA study. *J Sci Med Sport, 14*(4), 317-324. doi: 10.1016/j.jsams.2011.02.008

Ruiz, J. R., & Ortega, F. B. (2009). Physical activity and cardiovascular disease risk factors in children and adolescents. *Current Cardiovascular Risk Reports, 3*(4), 281-287. doi: 10.1007/s12170-009-0043-6

Santos-Lozano, A., Santín-Medeiros, F., Cardon, G., Torres-Luque, G., Bailón, R., Bergmeir, C., . . . Garatachea, N. (2013). Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points. *Int J Sports Med, 34*(11), 975-982.

Santos, R., Mota, J., Okely, A. D., Pratt, M., Moreira, C., Coelho, E. S. M. J., . . . Sardinha, L. B. (2013). The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. *Br J Sports Med, 0*, 6. doi: 10.1136/bjsports-2012-091610

Sarkin, J. A., McKenzie, T. L., & Sallis, J. F. (1997). Gender differences in physical activity during fifth-grade physical education and recess periods. *Journal of Teaching in Physical Education, 17*(1), 99-106.

Smith, T. P., Coombes, J. S., & Geraghty, D. P. (2003). Optimising high-intensity treadmill training using the running speed at maximal O(2) uptake and the time for which this can be maintained. *Eur J Appl Physiol, 89*(3-4), 337-343. doi: 10.1007/s00421-003-0806-6

Smith, T. P., McNaughton, L. R., & Marshall, K. J. (1999). Effects of 4-wk training using Vmax/Tmax on VO2max and performance in athletes. *Med Sci Sports Exerc, 31*(6), 892-896.

Sykes, K., & Roberts, A. (2004). The Chester step test—a simple yet effective tool for the prediction of aerobic capacity. *Physiotherapy, 90*(4), 183-188.

Teran-Garcia, M., Rankinen, T., & Bouchard, C. (2008). Genes, exercise, growth, and the sedentary, obese child. *J Appl Physiol (1985), 105*(3), 988-1001. doi: 10.1152/japplphysiol.00070.2008

Troiano, R. P., Berrigan, D., & Dodd, K. (2008). Physical Activity in the United States Measured by Accelerometer. *Med Sci Sports Exerc, 40*(1), 181-188.

Trost, S. G., McIver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Med Sci Sports Exerc, 37*(11 Suppl), S531.

Welk, G., & Meredith, M. D. (2008). *FITNESSGRAM/ACTIVITYGRAM: reference guide.* Dallas, Texas. : The Cooper Institute.

World Medical Association (2000). *Declaration of Helsinki, ethical principles for medical research involving human subjects*. Edinburgh, Scotland.

IV

ANÁLISIS FRACCIONADO DE LA ACTIVIDAD FÍSICA DESARROLLADA EN ESCOLARES.

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Análisis fraccionado de la actividad física desarrollada en escolares.

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Resumen: Se ha observado como la literatura resalta la importancia de la actividad física en la edad escolar. El presente estudio transversal pretende, por un lado, conocer los niveles generales de práctica de actividad física de la población escolar y el grado de cumplimiento de las recomendaciones de salud; y, por otro lado, estudiar de manera fraccionada la práctica de actividad física en diferentes momentos de la semana, para determinar la contribución de cada momento a la actividad física desde moderada a vigorosa, tomando de referencia tanto el volumen de diario (min/día), como el volumen por hora (min/hora). Se seleccionaron 136 escolares españoles entre 8 y 20 años, empleándose acelerómetros triaxiales para evaluar su nivel de actividad física durante una semana. La mayoría de participantes presentaron niveles bajos de actividad física, siendo también reducido el porcentaje de los que cumplían las recomendaciones de salud en relación a la práctica de actividad física. A pesar de ello, se detectaron momentos que proporcionaban una contribución elevada de actividad física de moderada a vigorosa por unidad de tiempo, como la educación física y el recreo. Estos resultados podrían ser relevantes para futuros estudios de intervención, así como para el establecimiento de estrategias y políticas de promoción de la actividad física en la población escolar.

Palabras clave: niños, acelerómetro, escuelas, educación física y entrenamiento, adolescentes.

Abstract: Several papers focused on the importance of physical activity during school ages. The objectives of this paper are two: to describe physical activity patterns among school-aged subjects and the prevalence of meeting physical activity guidelines; and secondly to describe the contribution to total moderate to vigorous physical activity, from two points of view: taking into account the volume of daily physical activity (min/day), such as the volume per hour (min/hour). The study compared 136 Spanish scholars aged 8 to 19 years who wore a triaxial in order to measure physical activity along different moments during a whole week. Most of children show a low level of physical activity, not meeting physical activity health guidelines. In spite of those low levels, there are activities, such as physical education and recess, which provide high moderate to vigorous intensity per hour. This might be essential for futures interventional studies, policies and promoting these kinds of activities.

Key words: Children, Accelerometer, Schools, Physical Education and Training, Adolescent.

Análisis fraccionado de la actividad física desarrollada en escolares.

La importancia de la Actividad Física (AF) durante la infancia y adolescencia, así como sus efectos preventivos sobre la salud han sido ampliamente descritos. Existen evidencias que indican que la AF está asociada a numerosos efectos positivos sobre la salud en niños y adolescentes (Andersen et al., 2006). La AF parece jugar un papel importante en la prevención de enfermedades cardiovasculares, incidiendo ya desde las primeras edades hasta la adolescencia, y reflejándose en la edad adulta (McGill et al., 2000). En relación a ello, varios autores indican que es muy recomendable controlar el tiempo semanal destinado a la práctica de AF a intensidades desde Moderada hasta Vigorosa (MV) para la prevención de enfermedades relacionadas con la salud y la obesidad (Andersen et al., 2006; Huberty et al., 2011).

En base a estas aportaciones, diferentes estudios y organizaciones han establecido un valor de al menos 60 min/día o más de AFMV durante las etapas educativas de Primaria y Secundaria con el fin de garantizar la salud en esta población (WHO, 2010). A nivel general, los estudios indican que los jóvenes no alcanzan las recomendaciones de salud respecto de AFMV y además, la prevalencia de la inactividad física respecto a las recomendaciones aumenta de Primaria a Secundaria (Aznar et al., 2011). Conocer el patrón de AF, niveles de AF y su variabilidad, posibilitará orientar de manera más acertada estrategias de promoción de la misma durante las primeras etapas educativas. A lo largo del día y de la semana, existen varios momentos en los que se puede practicar AF, cobrando especial énfasis, en la infancia y la adolescencia, el contexto escolar, el cual ofrece buenas oportunidades como lugar de promoción de la AF (Martinez-Gomez et al., 2013; Ridgers, Saint-Maurice, Welk, Siahpush, & Huberty, 2011). Se sugiere que la AFMV realizada en la escuela debería proporcionar la mitad de la AFMV recomendada para la salud (Pate et al., 2006). Durante la jornada escolar se destacan tres intervalos temporales idóneos para la práctica de AF y la creación de hábitos saludables: la Educación Física (EF), los recreos y las actividades extraescolares. Al respecto, estudios recientes inciden en la necesidad de conocer la contribución de las diferentes actividades semanales, como el recreo, para el cumplimiento de las recomendaciones (Martinez-Gomez et al., 2013). Los niveles de AFMV desarrollados durante la EF (Martínez-Martínez, Contreras, Lera, & Aznar, 2012; Meyer et al., 2011) y los recreos (Huberty et al., 2011) no son demasiado elevados respecto al cómputo semanal, contribuyendo en torno a un 11-16% y 16-18% respectivamente. Por otro lado, el periodo extraescolar ofrece datos en torno al 55 y 70% (Meyer et al., 2011; Ridgers et al., 2011; Wickel & Eisenmann, 2007), siendo las que contribuyen en mayor medida al volumen total

En base a lo anterior, es importante destacar no sólo el nivel y volumen de contribución de AF de cada periodo temporal, sino también la contribución de AF evaluada a nivel cualitativo (min AFMV/hora actividad). De esta manera, actividades con una reducida duración diaria, podrían contribuir notablemente a cumplir las recomendaciones de AF para la salud e incidir en la promoción de las mismas, conociendo cómo contribuye cada actividad al cumplimiento de las recomendaciones propuestas. Hasta la fecha, no se ha observado ningún estudio que contemple esta variable. Por lo tanto, los objetivos de este estudio son: a) Conocer el patrón de movimiento a lo largo de diferentes momentos durante la semana y sus posibles diferencias entre estudiantes de Educación Primaria y Secundaria, determinando el grado de cumplimiento de las recomendaciones en cuanto a nivel de AF; y, b) Conocer la contribución de diferentes períodos a la AFMV total, desde un punto de vista absoluto (porcentual respecto al volumen total) y a nivel relativo (los min de AFMV por unidad de tiempo, AFMV/hora).

Método

Muestra

En este estudio transversal participaron 136 escolares de 13,11±2,57 años, con un rango de edad de 8 a 19 años y un IMC de 20,13±3,60 kg/m^2. Todos los sujetos eran escolares de Educación Primaria (n=64) o Secundaria (n=72) y no poseían ninguna limitación física. Se les entregó a padres/tutores un documento relativo a la información detallada y procedimiento del estudio, invitándoles a participar en el mismo. Todos los procedimientos estuvieron en concordancia con los principios éticos de investigación aprobados por el Comité de Ética de la Universidad de Málaga.

Material y procedimiento

Los participantes llevaron puesto un acelerómetro durante 7 días consecutivos siguiendo las recomendaciones propuestas en estudios previos (Trost, McIver, & Pate, 2005). El dispositivo fue colocado en la cintura por medio de una banda ajustable y a la altura de la cadera derecha sobre la cresta iliaca (Treuth et al., 2004), siendo comprobado por un investigador. Un diario semanal fue entregado, y se les indicó a los participantes que anotaran el horario de Educación Física, recreo, hora de levantarse y hora acostarse. Además, fue proporcionado a cada participante una hoja explicativa del uso del acelerómetro que complementaba las instrucciones verbales proporcionadas durante la colocación, indicando que se retiraba para actividades acuáticas (ducha o natación) y para dormir. Se consideró válido un tiempo de registro de ≥ 10 horas/día y 5 días (4 durante la semana y 1 de fin de semana) (Troiano, Berrigan, & Dodd, 2008).

El acelerómetro seleccionado fue el Actigraph GT3X (Actigraph, Pensacola, FL, USA), el cual almacena información en 3 ejes ortogonales, es decir, vertical (Y), horizontal derecha-izquierda (X) y horizontal delante-atrás (Z). A su vez incluye el denominado “vector magnitud”, que es la raíz cuadrada del sumatorio de cada eje al cuadrado . Este dispositivo está validado para cuantificar la AF (Santos-Lozano et al., 2013). Todos los datos fueron tratados por medio del Software Actilife 6.0 (Actigraph) El epoch seleccionado fue de 1 s. Los puntos de corte seleccionados fueron los propuestos por Evenson, Catellier, Gill, Ondrak, and McMurray (2008): AF Sedentaria ≤ 100; Ligera ≥ 100; Moderada ≥ 2296 y Vigorosa ≥ 4012 counts·min-^{1}.

Se calculo la AF en cada uno de los siguientes momentos o actividades de la semana: Fin de Semana, de Lunes a Viernes (semana escolar), Actividades Extraescolares (desde las 14:01 ó 14:31 hasta las 23:00 horas), EF y Recreo. Todos los NAF se promediaron a min/día, dividiendo el sumatorio de cada nivel de AF entre el número de días de registro válidos, con el fin de facilitar la comparación entre los diferentes participantes. Además, se calculó para cada actividad el porcentaje de contribución en min/día a las recomendaciones de AF para la salud (AFMV de la Actividad x 100/60), correspondientes a 60 min/día con jóvenes (WHO, 2010). De manera similar, se calculó también la contribución de cada actividad en min/día respecto al total semanal (AFMV de la Actividad x 100 / AFMV Total de la semana). Para finalizar, se calcularon los min de AFMV por hora de actividad, a través del siguiente procedimiento:(AFMV de la actividad / horas de la Actividad).

Análisis estadístico

Los estadísticos descriptivos del estudio se muestran como media y desviación típica. Los alumnos fueron clasificados en base a su IMC según valores específicos internacionales para su edad (Cole, Bellizzi, Flegal, & Dietz, 2000). Las pruebas de normalidad revelaron una distribución no normal, empleándose pruebas no paramétricas para la comparación entre grupos. Concretamente, para las comparaciones en función de la etapa educativa, IMC y sexo de los sujetos, fue utilizada la prueba U de Mann Whitney. El nivel de significación se fijó a p≤0,05 para las diferentes pruebas. Los análisis fueron llevados a cabo mediante el software estadístico SPSS (v. 20.0).

Resultados

En la Tabla 1 se muestran los resultados referentes a los NAF desarrollados durante la semana y la prevalencia al cumplimiento de las recomendaciones de 60 min/día AFMV.

Tabla 1. Nivel de AF desarrollada durante la semana y cumplimiento de las recomendaciones de salud.

			Primaria 47% (N=64)			Secundaria 53% (N=72)			Total (N=136)			Sig.
			Media		D.T.	Media		D.T.	Media		D.T.	
AFMV Semanal	Sedentario	*(min/día)*	806,9	±	82,3	618,5	±	82,4	707,2	±	125,1	0,001***
	Ligero	*(min/día)*	101,4	±	26,8	108,4	±	55,2	105,1	±	44,2	0,291
	AFMV	*(min/día)*	53,7	±	18,7	50,0	±	21,7	51,7	±	20,4	0,253
AFMV F.S.	Sedentario	*(min/día)*	1.262,0	±	199,2	554,1	±	148,3	887,2	±	394,8	0,001***
	Ligero	*(min/día)*	87,8	±	48,8	101,7	±	70,0	95,2	±	61,1	0,983
	AFMV	*(min/día)*	42,1	±	29,7	43,2	±	35,4	42,7	±	32,7	0,805
AFMV L a V	Sedentario	*(min/día)*	625,0	±	84,5	644,2	±	84,4	635,2	±	84,6	0,355
	Ligero	*(min/día)*	105,4	±	29,0	109,4	±	54,9	107,5	±	44,5	0,211
	AFMV	*(min/día)*	57,4	±	20,5	51,4	±	23,2	54,2	±	22,1	0,094
AFMV Extr	Sedentario	*(min/día)*	401,4	±	66,1	328,7	±	73,6	362,9	±	78,8	0,001***
	Ligero	*(min/día)*	46,6	±	18,6	62,6	±	35,2	55,1	±	29,6	0,015*
	AFMV	*(min/día)*	29,3	±	13,4	32,2	±	16,4	30,8	±	15,1	0,292
AFMV EF	Sedentario	*(min/día)*	33,0	±	11,3	46,8	±	9,7	40,3	±	12,6	0,001***
	Ligero	*(min/día)*	12,2	±	5,7	8,2	±	5,3	10,1	±	5,8	0,001***
	AFMV	*(min/día)*	9,7	±	5,5	5,8	±	5,2	7,6	±	5,6	0,001***
AFMV Recreo	Sedentario	*(min/día)*	17,7	±	5,1	23,2	±	5,3	20,6	±	5,9	0,001***
	Ligero	*(min/día)*	7,9	±	2,4	5,8	±	3,1	6,8	±	3,0	0,001***
	AFMV	*(min/día)*	5,4	±	3,2	2,3	±	2,3	3,8	±	3,2	0,001***
Cumplimiento Recomendaciones 60 min AFMV		*(%)*	35,90			33,30			34,60			

Nota. *N* = Número total de casos; *D.T.* = Desviación Típica; *Sig* = Significación; *AFMV* = Actividad Física a intensidad desde Moderada hasta Vigorosa, *min* = minutos; *F.S.* = Fin de Semana, *L a V* = De Lunes a Viernes, *Extr* = Actividades Extraescolares, *EF* = Educación Física.
Diferencias entre Etapas Educativas = *$p \leq 0,05$; ***$p \leq 0,001$.

El análisis de U de Mann Whitney indicó a nivel general grandes diferencia entre etapas educativas, fundamentalmente en cuanto al NAF sedentario en todas los momentos a excepción de lunes a viernes (p ≤ 0,001), siendo el grupo de Primaria quienes obtienen mayores registros en todos los momentos excepto en recreo y EF (p ≤ 0,001). Los alumnos de Primaria, son a su vez los más activos en estos momentos, ($p \leq 0,01$) y en el resto a excepción de las Actividades Extraescolares y el fin de semana respecto a Secundaria. Se observa un nivel de prevalencia del cumplimiento de las recomendaciones de 60 min/día de AFMV en torno al 35%, siendo ligeramente inferior en Secundaria, pero no estadísticamente significativo.

En la tabla 2 se muestra la contribución de cada una de las actividades a las recomendaciones de 60 min/día de AFMV, el volumen de contribución a la AFMV total y los minutos de AFMV por hora de actividad.

Tabla 2. Contribución a las recomendaciones de AFMV para la Salud y a la AMVF Total.

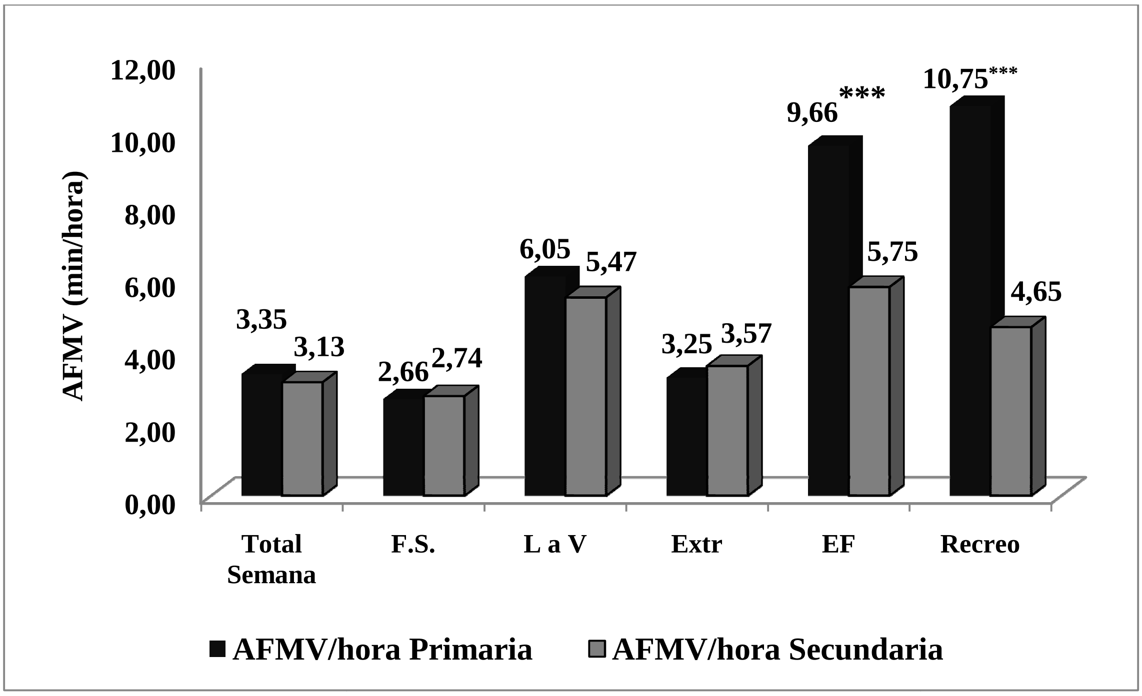
		Primaria 47% (N=64)			Secundaria 53% (N=72)			Total (N=136)			P
		Media		D.T.	Media		D.T.	Media		D.T.	
F.S.	CR 60 min (%)	70,97	±	49,40	73,06	±	58,20	72,07	±	54,05	0,795
	CT AMFV (%)	38,63	±	20,27	41,83	±	20,69	40,32	±	20,48	0,512
L a V	CR 60 min (%)	96,80	±	33,47	87,49	±	39,70	91,87	±	37,06	0,120
	CT AMFV (%)	61,37	±	20,27	58,17	±	20,69	59,68	±	20,48	0,512
Extr	CR 60 min (%)	48,78	±	22,40	53,61	±	27,40	51,33	±	25,20	0,291
	CT AMFV (%)	33,75	±	20,01	50,49	±	74,83	42,61	±	56,59	0,266
EF	CR 60 min (%)	16,09	±	9,08	9,59	±	8,59	12,65	±	9,38	0,001***
	CT AMFV (%)	10,72	±	7,07	9,38	±	22,28	10,01	±	16,88	0,001***
Recreo	CR 60 min (%)	8,96	±	5,41	3,87	±	3,90	6,27	±	5,31	0,001***
	CT AMFV (%)	5,87	±	3,99	5,54	±	19,32	5,70	±	14,27	0,001***

Nota. *N* = Número total de casos; *D.T.* = Desviación Típica; *Sig* = Significación; *AFMV* = Actividad Física a intensidad desde Moderada hasta Vigorosa, *min* = minutos; *F.S.* = Fin de Semana, *L a V* = De Lunes a Viernes, *Extr* = Actividades Extraescolares, *EF* = Educación Física; *CR 60 min* = Contribución a las recomendaciones de 60 min de AFMV; *CT AFMV* = Contribución a la AFMV Total de la actividad. ***$p \leq 0,001$.

El análisis entre niveles educativos a través de los diferentes momentos, de manera similar a la anterior tabla, muestra diferencias significativas ($p \leq 0,001$) durante el recreo y la EF para todas las variables contempladas. Respecto a la contribución a las recomendaciones de salud de 60 min/día, puede observarse como las principales son la AF durante la semana escolar, que cubre prácticamente las recomendaciones saludables, seguidas de las del fin de semana y extraescolares. Para la contribución de AFMV de cada actividad se observa la misma tendencia.

En la Figura 1, se muestran los valores absolutos de AFMV expresados en min/hora según los diferentes momentos.

Figura 1. AFMV en min/hora durante los diferentes momentos de la semana



Como puede apreciarse, cuando se tiene en cuenta la AFMV/hora, se observa como a nivel general los alumnos de Primaria realizan más AFMV por unidad de tiempo respecto a Secundaria. Además se observa como la EF y el recreo son las que contribuyen en mayor medida respecto a las otras actividades, especialmente en Primaria, mostrando diferencias significativas ($p \leq 0,001$).

Discusión

En este estudio se han analizado las diferencias en cuanto a NAF y su contribución en relación a los diferentes momentos y actividades de la semana con alumnos de Primaria y Secundaria. En base a nuestro conocimiento, éste es el primer estudio que valora la AFMV a través de diferentes momentos y su contribución por unidad de tiempo. El hallazgo más relevante a reseñar son las diferencias encontradas en todas las variables de NAF analizadas durante la EF y el recreo.

Respecto a la comparación entre la AF semanal y durante el fin de semana (Tabla 1), de manera similar a otros estudios, se observa como la AFMV es superior durante la semana respecto al fin de semana (Aibar et al., 2013; Aznar et al., 2011; Ramirez-Rico, Hilland, Foweather, Fernández-Garcia, & Fairclough, 2013). Aunque estos datos están acorde a lo expuesto en la bibliografía, los mismos podrían parecer contradictorios, ya que a pesar de que los sujetos poseen un mayor tiempo libre para la práctica de AF y competiciones deportivas, realizan mas AFMV durante la semana teniendo un menor tiempo disponible para ello. Según lo señalado, parece que el entorno escolar durante la semana es adecuado para la realización de AFMV a través de sus actividades durante el día.

Por otro lado, el patrón de movimiento en los diferentes momentos en días laborables, muestra como la AFMV Extraescolar aporta valores en torno a 30 -36 min (Aibar et al., 2013; Fairclough, Breighle, Erwin, & Ridgers, 2012; Ramirez-Rico et al., 2013). A pesar de no encontrarse diferencias significativas entre etapas, las actividades extraescolares son las únicas que indican una mayor AFMV y menos tiempo sedentario para los niños de secundaria respecto a primaria. Este hecho podría estar condicionado por la adhesión a equipos deportivos esté más consolidado a esta edad respecto a la primaria. No obstante, esta es una de las limitaciones de estudio, ya que no se ha tenido en cuenta la participación en AF extraescolar estructurada. Los valores hallados en las clases de EF y en el Recreo, están en consonancia con otros estudios (Martínez-Martínez et al., 2012; Meyer et al., 2011), marcando valores en torno a un 9 – 33% de AFMV. Al respecto, Fairclough and Stratton (2005) resaltan que la EF no es la panacea para solventar los problemas de la salud del alumnado, pero ésta puede contribuir junto a otras actividades a conseguir los NAF recomendados. Se resalta también la importancia de la EF, no sólo para aumentar los valores de AFMV, sino en la labor docente de promoción y contribución a la AF fuera del entorno escolar. Por último, durante el recreo se observan valores similares al estudio, entre 2 y 7 min de AFMV (Fairclough et al., 2012; Martinez-Gomez et al., 2013). Los estudios indican que la AF durante los recreos puede estar influenciada por motivaciones sociales, facilidad, disponibilidad y acceso a material y espacios deportivos (Ridgers, Salmon, Parrish, Stanley, & Okely, 2012), que sería interesante analizar en el futuro. A pesar de ello, en esta ocasión si existe una diferencia estadísticamente significativa en la AFMV mayor en educación Primaria frente a Secundaria, tanto en las clases de EF como en el Recreo ($p<0,001$). Se ha observado que la AF decrece con la edad (Aznar et al., 2011), lo que podría estar incidiendo en los patrones de movimientos de estos dos momentos.

Respecto al cumplimiento de las recomendaciones, se observa que los jóvenes españoles y europeos no suelen cumplir los 60 min diarios, realizando alrededor de 51-58 min por día (Fairclough et al., 2012; Ramirez-Rico et al., 2013), siendo similares a los del presente estudio (Tabla 1), denotando una baja prevalencia, entre 20 y 60%, y una tendencia a disminuir en Educación Secundaria respecto a Primaria (Aibar et al., 2013; Aznar et al., 2011; Martínez-Martínez et al., 2012). Se ha descrito que los alumnos deben realizar el 50% de las recomendaciones de salud (30 min de AFMV) durante el colegio (Pate et al., 2006). A pesar de ello no siempre se alcanza, ya que en sujetos europeos ronda entre un 40 y 50% el grado de cumplimiento (Fairclough et al., 2012), siendo ambos superiores a los datos del estudio, correspondientes a un 20% (alrededor de 12 min de AFMV). Estos NAF se consideran insuficientes dentro y fuera del contexto escolar, no cumpliéndose los mínimos recomendados de AFMV para garantizar la salud, por lo que es importante fomentarla desde Educación Primaria. Al respecto, un estilo de vida saludable empieza a desarrollarse en la niñez y se estabiliza de manera moderada o intensa desde la juventud hasta la edad adulta; indicando que una intervención temprana y la promoción de la AF en la adolescencia es necesaria, ya que puede proporcionar beneficios saludables en la edad adulta (Janz, Dawson, & Mahoney, 2000).

Para la contribución total de cada momento (Tabla 2), se observa en la bibliografía como las actividades Extraescolares suponen desde un 55 hasta un 70% de AFMV y la EF y el recreo contribuyen entre un 11-16% y 16-18% respectivamente (Meyer et al., 2011; Ridgers et al., 2011; Wickel & Eisenmann, 2007). Estos resultados son similares a la EF, pero inferiores durante el recreo y actividades extraescolares. A pesar de que estos NAF en EF son bajos, cuando la EF no se realiza de manera aislada, puede aportar importantes NAF junto a otras actividades, teniendo una repercusión positiva sobre la salud y cumplimiento de las recomendaciones (Fairclough & Stratton, 2005), y además al ser una AF dirigida, la EF ha de ser un momento esencial para acumular AFMV diaria. No obstante, puede observarse (Tabla 2) como la EF y el recreo proporcionan los niveles más bajos de contribución a las recomendaciones y volumen total de AFMV. Al respecto, se han propuesto diferentes alternativas fundamentalmente en el Recreo, como facilitar instalaciones, señalizarlas y balizarlas adecuadamente o buscar apoyo social en pos de la promoción de la AF (Blaes et al., 2013; Ridgers et al., 2012).

No aparece ningún estudio en la bibliografía que contemple la aportación de AFMV para cada actividad en unidad de tiempo (min/hora). Esta clasificación ofrece datos de relevancia para el estudio, ya que indica la contribución a la AFMV total de una manera cualitativa y relativa al tiempo de actividad desempeñada. De esta manera, puede observarse como los momentos que contribuyen en menor medida a las recomendaciones y al total de AFMV, son las que aportan una mayor cantidad de AFMV si considera su ratio por unidad de tiempo (Tabla 2, Figura 1), es decir, EF y Recreo son las que mayor AFMV aportan por hora de ejecución. En ambos, la aportación que se hace a un nivel de AFMV es de 7-8 min/hora, por encima del resto de momentos a lo largo de una semana. Es decir, las clases de EF y los recreos son los que más contribuyen a un nivel de AF saludable en unidad de tiempo. Además de lo anterior, aparecen una serie de estudios que arrojan interesantes conclusiones sobre ambas. Así, Martínez-Martínez et al. (2012) en EF muestran una relación positiva moderada ($r = 0,481$; $p < 0,01$) entre AFMV semanal y la AFMV en EF. De esta manera, los alumnos que realizan más AFMV en EF, también lo hacen fuera de la escuela y viceversa. Es interesante destacar también a Ridgers et al. (2011) quienes indicaron que a pesar de la poca duración del recreo (4% de la semana) su potencial en cuanto a contribución total es elevado. Según los datos del estudio (Figura 1), el grupo total realiza menos del 20% de la AFMV en actividades escolares, en el caso de primaria, se podría conseguir el 40% de las recomendaciones diarias solo durante dos horas. Esto puede conseguirse mediante las actividades con mayor AFMV/hora (la EF y un recreo de una hora); y además, se ha observado como es fácil aumentar la AFMV a través de diferentes propuestas. Por ejemplo, los Recreos al ser una actividad no estructurada, aparecen múltiples iniciativas docentes que puedan generar estrategias para aumentar la AFMV (Blaes et al., 2013; Huberty et al., 2011; Ridgers et al., 2012). Otro dato a destacar, es que no se encontraron diferencias en la AFMV ni AFMV/hora durante el Recreo ni EF en alumnos con sobrepeso y obesidad respecto a normopeso. Esto es similar a la bibliografía, en la cual se destaca como la EF y el Recreo proporcionan una gran oportunidad de aumentar la AF para los alumnos menos proactivos hacia la AF o con sobrepeso, siendo un momento especialmente propicio para que acumulen AF (Meyer et al., 2011; Ridgers et al., 2011). En base a estos datos, el aumento de las horas de EF a la semana o la inclusión de un segundo recreo, iniciativa que ya es una realidad en otros países europeos (Fairclough et al., 2012), pueden ser alternativas interesantes para conseguir las recomendaciones propuestas de 60 min AFMV.

Este estudio muestra los NAF a lo largo de diferentes momentos durante la semana, el grado de cumplimiento de las recomendaciones y contribución de cada una de ellas a la AFMV. Aparecen en general unos niveles acordes a la bibliografía durante los diferentes momentos, los cuales son considerados como deficientes, especialmente en secundaria, y aparece un bajo nivel de cumplimiento de las recomendaciones de 60 min AFMV/día. Por último indicar que a pesar de tener una baja contribución respecto a la AF total, hay actividades que tienen mucha menor duración durante el día, pero que permiten acumular una mayor cantidad de AFMV diaria en unidad de tiempo, como son el Recreo y la clase de EF. Esto podría ser de relevancia a la hora de proponer programas de intervención, el potenciar este tipo de actividades a lo largo de la semana o incluso plantear un aumento en la frecuencia de las mismas.

Bibliografía

1. Aibar, A., Bois, J. E., Zaragoza Casterad, J., Generelo, E., Paillard, T., & Fairclough, S. (2013). Weekday and weekend physical activity patterns of French and Spanish adolescents. *Eur J Sport Sci, 12*(3), 500-509.
2. Andersen, L. B., Harro, M., Sardinha, L. B., Froberg, K., Ekelund, U., Brage, S., & Anderssen, S. A. (2006). Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *The Lancet, 368*(9532), 299-304.
3. Aznar, S., Naylor, P., Silva, P., Pérez, M., Angulo, T., Laguna, M., . . . López-Chicharro, J. (2011). Patterns of physical activity in Spanish children: a descriptive pilot study. *Child: care, health and development, 37*(3), 322-328.
4. Blaes, A., Ridgers, N. D., Aucouturier, J., Van Praagh, E., Berthoin, S., & Baquet, G. (2013). Effects of a playground marking intervention on school recess physical activity in French children. *Prev Med, 57*(5), 580-584. doi: 10.1016/j.ypmed.2013.07.019
5. Cole, T. J., Bellizzi, M. C., Flegal, K. M., & Dietz, W. H. (2000). Establishing a standard definition for child overweight and obesity worldwide: international survey. *Bmj, 320*(7244), 1240.
6. Evenson, K. R., Catellier, D. J., Gill, K., Ondrak, K. S., & McMurray, R. G. (2008). Calibration of two objective measures of physical activity for children. *Journal of sports sciences, 24*(14), 1557-1565.
7. Fairclough, S., Breighle, A., Erwin, H., & Ridgers, N. (2012). School day segmented physical activity patetrs of high and low active children. *BMC public health, 12*(406).
8. Fairclough, S., & Stratton, G. (2005). Physical activity levels in middle and high school physical education: a review. *Pediatric Exercise Science, 17*(3), 217-236.
9. Huberty, J. L., Siahpush, M., Beighle, A., Fuhrmeister, E., Silva, P., & Welk, G. (2011). Ready for recess: A pilot study to increase physical activity in elementary school children. *Journal of School Health, 81*(5), 251-257.
10. Janz, K. F., Dawson, J. D., & Mahoney, L. T. (2000). Tracking physical fitness and physical activity from childhood to adolescence: the muscatine study. *Med Sci Sports Exerc, 32*(7), 1250-1257.
11. Martinez-Gomez, D., Veiga, O. L., Zapatera, B., Gomez-Martinez, S., Martinez, D., & Marcos, A. (2013). Physical Activity During High School Recess in Spanish Adolescents: The AFINOS Study. *J Phys Act Health, 11*(6), 1194-1201.
12. Martínez-Martínez, J., Contreras, O. R., Lera, Á., & Aznar, S. (2012). Niveles de actividad física medido con acelerómetro en alumnos de 3º ciclo de educación primaria: actividad física diaria y sesiones de educación física. *Revista de Psicologia del Deporte, 21*(1), 117-123.
13. McGill, H. C., McMahan, C. A., Herderick, E. E., Malcom, G. T., Tracy, R. E., Strong, J. P., & Group, t. P. D. o. A. i. Y. R. (2000). Origin of atherosclerosis in childhood and adolescence. *Am J Clin Nutr, 72*(5), 1307s-1315s.
14. Meyer, U., Roth, R., Zahner, L., Gerber, M., Puder, J., Hebestreit, H., & Kriemler, S. (2011). Contribution of physical education to overall physical activity. *Scandinavian Journal of Medicine & Science in Sports, 23*(5), 600-606. doi: doi: 10.1111/j.1600-0838.2011.01425.x
15. Pate, R. R., Davis, M. G., Robinson, T. N., Stone, E. J., McKenzie, T. L., & Young, J. C. (2006). Promoting physical activity in children and youth: a

leadership role for schools: a scientific statement from the American Heart Association Council on Nutrition, Physical Activity, and Metabolism (Physical Activity Committee) in collaboration with the Councils on Cardiovascular Disease in the Young and Cardiovascular Nursing. *Circulation, 114*(11), 1214-1224. doi: 10.1161/circulationaha.106.177052

16. Ramirez-Rico, E., Hilland, T. A., Foweather, L., Fernández-Garcia, E., & Fairclough, S. J. (2013). Weekday and weekend patterns of physical activity and sedentary time among Liverpool and Madrid youth. *Eur J Sport Sci, 14*(3), 287-293.
17. Ridgers, N., Saint-Maurice, P. F., Welk, G. J., Siahpush, M., & Huberty, J. (2011). Differences in physical activity during school recess. *Journal of School Health, 81*(9), 545-551.
18. Ridgers, N. D., Salmon, J., Parrish, A. M., Stanley, R. M., & Okely, A. D. (2012). Physical activity during school recess: a systematic review. *Am J Prev Med, 43*(3), 320-328. doi: 10.1016/j.amepre.2012.05.019
19. Santos-Lozano, A., Santín-Medeiros, F., Cardon, G., Torres-Luque, G., Bailón, R., Bergmeir, C., . . . Garatachea, N. (2013). Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points. *Int J Sports Med, 34*(11), 975-982.
20. Treuth, M., Schmitz, K., Catellier, D., McMurray, R., Murray, D., Almeida, M., . . . Pate, R. (2004). Defining accelerometer thresholds for activity intensities in adolescent girls. *Med Sci Sports Exerc, 36*(7), 1259.
21. Troiano, R. P., Berrigan, D., & Dodd, K. (2008). Physical Activity in the United States Measured by Accelerometer. *Med Sci Sports Exerc, 40*(1), 181-188.
22. Trost, S. G., McIver, K. L., & Pate, R. R. (2005). Conducting accelerometer-based activity assessments in field-based research. *Med Sci Sports Exerc, 37*(11 Suppl), S531.
23. WHO. (2010). *Global Recommendations on Physical Activity for Health*. Geneva, Switzerland: WHO.
24. Wickel, E. E., & Eisenmann, J. C. (2007). Contribution of Youth Sport to Total Daily Physical Activity among 6-to 12-yr-old Boys. *Medicine & Science in Sports & exercise: Official Journal of the American College of Sports Medicine, 39*(9), 1493-1500.

V

PHYSICAL ACTIVITY BOUT PATTERNS IN PHYSICAL EDUCATION CLASSES, RECESS (SCHOOL TIME) AND NON-PHYSICAL EDUCATION OR RECESS ACTIVITIES.

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Physical activity bout patterns in physical education classes, recess and non-physical education or recess activities: The GEOS Project

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Abstract

Background: Physical activity (PA) during school-based activities has been widely analyzed. During childhood and adolescence, PA is highly transitory and PA patterns are usually engaged in a very sporadic manner rather than in consistent bouts. There is a dearth of information relating to bouts during school-based activities and out-of school activities. Additionally, no previous studies have considered net bouts of PA was found taking into consideration net bouts. The aim of this paper is to describe PA levels and bouts of moderate to vigorous PA (MVPA) during non-PE or recess activities (NPERA), Physical Education (PE) and recess.

Methods: One-hundred and thirty-six Spanish children and adolescents from 3rd to 12nd grade, aged 8 – 18 years from 8 elementary and high schools met the inclusion criteria. PA levels were measured with GT3X Actigarph accelerometers over 7 days, weekend data were excluded from the analysis. Total PA (min/day and percentage of PA) and 1, 2, 4, 5, 6, 8, 10 and 12-minute bouts (net and accumulated) were analyzed. PA and bouts were compared between NPERA, PE and recess.

Results: NPERA was the category with more min/day of PA, whereas PE and recess showed the highest percentage of PA. NPERA was the category where more net and accumulated bouts were accrued compared to PE and Recess. Regarding sex, accumulated bouts displayed more differences (especially during recess) than net bouts in primary school subjects; whereas no differences were found for secondary school participants. Overall, all variables from 1 to 10 Bouts related to net and accumulated bouts showed significant differences ($p \leq 0.001$) during NPERA, PE and recess time revealing no differences between 12 min bouts.

Conclusion: School-aged participants showed differences in PA, net and accumulated bouts during NPERA, PE and Recess. In order to compare results with previous studies,

accumulated bouts might be appropriate. Results suggest different pattern of behavior when using accumulated or net bout approaches.

Introduction

There is considerable interest about levels of physical activity (PA) in children and adolescents since they must related with the increased prevalence of childhood obesity (1) and other health outcomes (2, 3). So meeting 60-minute of moderate vigorus PA (MVPA) guidelines (4, 5) is a main concern in order to promote a healthy lifestyle among youth (6).

PA patterns of PA at early age are commonly intermittent, where the majority of children accumulate their PA in random pattern more than continuous bouts (7-11), however this profile might differ among age groups (7). Additionally, PA seems to vary according to the environment, moment of the day and curriculum activities (12-14) (15). For instance, PE and recess time may contribute 11%-16% and 16-18% for total daily MVPA respectively (15). Likewise, out-of school activities and extracurricular activities/sports, represent up to 50% of overall daily MVPA (13, 14, 16, 17). Thus, evidence suggests both physical education (PE)/recess or extracurricular activities both are equally important in promoting MVPA (12, 14). It is therefore of interest to scientists and practitioners to examine PA patterns form a bout perspective rather than simply total MVPA.

In order to analyze PA patterns in detail, authors have been mainly focused on examining bout lenght measurement and its relatinship with health outcomes (18-21). As an example, two studies reporterd that the greater number of 5 and 10 min MVPA bouts performed, the lower thecardiovascular risk at young ages (21, 22). Other research suggested that short bouts (4 sec to 5 min) were as equally effective as longer bouts (≥5min) in positively influencing health outcomes (20). rFurthermore,it has also been reported that 1-minute to >10-minute bouts were equally effective for weight control independently of total MVPA (18). Collectively, these previous data highlight the relevance of accumulating bouts of MVPA for health benefit..

Despite this, prior research assessing accelerometer derived PA is subject to a number of methodological issues which may bias the conclusions made by these authors (References needed). Among such considerations, the epoch variable (short epoch definition) may impact on bouts quantification. The use of a longer epoch might not be capable to capture shorts burst of vigorous PA or notably underestimate vigorous PA (23). There is therefore a need for researchers to better understand the most appropriate epoch length to assess how bout length impacts on MVPA estimation when using accelerometry. has been other factor not always considered or well manipulated, firstly data must be corrected for the number of days wearing the ACL (27); on the other hand a threshold of hours a day has to be adopted in order to measure a significant time, currently bout patterns using a minimum record threshold of 10 hours have been reported for 10-minute MVPA bouts in American and European scholars aged between 6 to 19 (24); the prevalence of 10-minute bouts (25); differences among longer and shorter than 5-minute bouts for week and weekend days (26); seasonal changes in bouts (27) and sedentary bouts of school time and after school time (28). Finally, comparisons of bout ranges have been performed for sporadic and short (1 to 4 min), short (5 to 9 min) and medium-to-long (≥10min) (18-20). Despite all of these approaches, less is known about differences on short/long bout patterns between school time and out-of school, which may help to design more specific and adapted strategies of PA promotion for children and adolescents (1, 29).

Additionally, no previous research has been conducted using net bouts, which may be of relevance, because accumulated bouts are obtained by default from specific software, which add the number of bouts from shorter epoch length to longer ones. On the contrary, net bouts can be calculated as the time that a bout of specific length is performed without considering the longer ones (in instance, a 10-minute bout can include five 2-minute bouts)A better understanding regarding the relationship bewteen volume (number and length of bouts) and intensity of PA and health outcomes could be elucidated with this approach..

Hence, the present research aimed to describe and compare different lengths of accumulated and net bouts (1, 2, 4, 5, 6, 8, 10 and 12 min) between three daily periods: PE, recess and non-PE or recess activities (NPERA) among children and adolescents.

Material and Methods

Subjects

In this cross-sectional study, 668 healthy 3rd – 12nd grade children and adolescents, aged 8 – 18 years were recruited from 8 elementary and high schools from Spain (Malaga, Galicia and Jaen) where 44.9% were children attending to elementary school and 55.1% adolescents of secondary school (two students were nineteen years old but still attending secondary school). Children were eligible to participate if they attended elementary or secondary school and had no physical limitations. Written informed consent to participate was obtained from parents/guardians and students after an information meeting, where the study risks and benefits were explained. All procedures were in accordance with the ethical principles for medical research involving human subjects, the Geneva convention and approved by an Ethic Committee of the University of Malaga, Spain.

A total of 668 acelerometers were distributed and worn, but only 282 participants had valid ACL data and 386 invalid ACL data (lost data (33 ACLs), lost device (3 ACLs) and not meeting a priori criteria (28) of ≥10 valid wear hours per day (350 ACLs)), which represents an attrition rate of 42.2%. After considering the classical inclusion criteria, we filtered the data for selecting only those with at least 4 valid days of NPERA and recess and at least one class of PE recorded. The so considered sample were one-hundred and thirty-six scholars, thus the final attrition rate was 20.3%

Accelerometry

Actigraph GT3X ACLs were used to measure PA (GT3X) (Actigraph, Pensacola, FL, USA), which have been previously validated (30). The ActiLife 6.0 software was used to manage the ACL data (intensity cut-offs, bout integration, malfunctions and extreme or unusual values). As recommended (31), accelerometers were worn at the right hip, on the iliac bone (32) and fastened with an elastic belt. Data was collected with 1 s epoch as suggested in previous studies with children between 5 and 16 years (30, 33). in order to obtain a reliable pattern of usual PA students were instructed to wear the ACL for 7 consecutive (34, 35) and to remove it only during water activities (swimming or showering) or while sleeping. ACL started time (9.00 am) and the time to stop collecting data (12.00 pm) were set at the day where the devices were handed and placed on participant's waist, face-to-face to children by researchers. By this manner, information during school (9.00 am and 2.00 pm) and out-of school activities (between 2.31 pm and 12.00 am) was recorded. Weekend PA data was not included in the analysis because these measurements do not involved PAs at school or after school. Regarding weekly frequency of PE and recess, that was the same for elementary and high schools: two PE lessons per week (60 min each) and 5 recesses per week (30 min each). A weekly diary was also given, in which subjects were asked to enter recess, PE, got up and went to bed times.. Written instructions for wearing the instrument were explained and given to each participant. As previously reported by Troiano, Berrigan (24), a wear-time of ≥ 10 hours/day for ≥ 5 days for weekly measurements (7 days) were adopted as quality control. No-wear time was defined as at least 60 consecutive minutes of zero counts, with allowance for up to 2 minutes between 0 and 100 counts ((36)). Mean wear time of the sample was 781 min/day (51.1%).

PA intensity was selected using the cut-points proposed by Evenson (31): Sedentary PA ≤ 100; Light PA ≥ 100; Moderate PA ≥ 2296 and Vigorous PA ≥ 4012 counts·min-¹, these limits have been recently validated for adolescents (33)). All PA values have been reported as minutes/day or steps/day and percentage in order to standardize PA values. Daily PA and bouts (2, 4, 5, 6, 8, 10 and 12 min) with 1-minute tolerance of MVPA were analyzed. One minute bouts were calculated by substracting total MVPA/day bouts from 2-minute bouts/day. Accumulated bouts were estimated using the software ActiLife 6.0. by default.

Net bouts were calculated as bout time engaged at a specific length but not adding previous shorter bouts as is the regularly used procedure for accumulated bouts. Net bouts were obtained by subtracting the next accumulated bouts from the bout-length, which was aimed to calculate of accumulated bouts. For example, 4-minute net bouts = 6-minute accumulated bouts – 4-minute accumulated bouts. By this manner, if a participant engages a bout of 6 min/day, that bout will be included only in this interval of net bouts; whereas accumulated bout procedure would automatically indicate this 6 min bout/day and also shorter ones (2, 4 and 5 min bouts/day, depending on the parameters selected in the Actilife software). Finally, all net and accumulated bouts were averaged per hour in order to standardize results and compare between NPERA (11 hours), PE (1 hour) and recess (0.5).

Statistical Analysis

All variables are shown as mean and SD or median and ranges. The sample was split into a binary variable according to two BMI categories (normal weight and overweight plus obese participants) according with international cut-offs (37). The

Kolmogorov-Smirnov test was used to confirm a non-parametric distribution of the variables. Comparisons of PA and BMI variables between sexes were conducted by Mann-Whitney-U test for non-parametric variables. The Kruskal-Wallis test (k independent samples) was carried out to examine any differences between PA, net and accumulated bouts during NPERA, PE and recess, when it was needed Mann-Whitney-U was performed to detect which groups differed significantly. Comparisons of net and accumulated bouts between daily periods were performed by Wilcoxon´s test for paired non-parametric variables. The level of significance was set at $p \leq 0.05$ for all the tests. Analyses were conducted with the statistics software SPSS (v. 20.0).

Results

Sample characteristics and Total PA Levels along different daily periods are displayed in table 1 and 2.

Elementary and secondary school participants showed overall a similar rate of normal weight (table 1) and a low meeting of PA health recommendations (33.3 and 27.0 minutes/day, girls and boys of elementary school respectively; 24.3 and 50.0 minutes/day, girls and boys of secondary school respectively, table 1), with poor levels of MVPA (table 1). These later values were lower among female participants of secondary school (48.1 and 49.8 minutes/day, girls and boys of elementary school respectively, $p>0.05$; 41.5 and 55.7 minutes/day, girls and boys of secondary school respectively, $p\leq0.01$; table 1). Statistical differences between sexes of secondary school were related to minutes/day of light ($p\leq0.05$), vigorous PA ($p \leq 0.001$), MVPA ($p \leq 0.01$), total PA and steps ($p \leq 0.05$) whereas no differences appeared according to school MVPA. Conversely, no significant differences were found among girls and boys of elementary school except for school MVPA (medians: 12.3 vs. 16.4 minutes/day, $p \leq 0.05$). Regarding the percentage of daily time, girls of secondary school expended more time in sedentary activities and less vigorous and MVPA than boys ($p \leq 0.01$ for all; table 1); children from elementary school showed similar values (table 1).

Differences of PA intensity and volume among daily periods and academic level

Total PA levels on each academic level along different daily periods analyzed are revealed in Table 2.

In regard to total PA Levels (minutes/day), participants accrued more total PA, MVPA, steps, contribution to healthy guidelines and contribution to total MVPA during NPERA than PE and recess respectively ($p \leq 0.001$) either in elementary or secondary school. All daily periods displayed numerous differences between boys and girls regarding absolute among variables analyzed (minutes/day); where NPERA and PE contrasted with recess period, such as later showed overall differences in every variable among boys and girls of elementary school and for sedentary, light and total PA of secondary school (table 2 for both). The only difference during PE period was for moderate intensity for children of elementary school (medians: 3.6 vs. 5.1 minutes/day, girls and boys respectively, $p \leq 0.05$). On the other hand, regarding % of PA, PE, recess and NPERA were significantly different each other for all variables during elementary school, but Mann-Whitney-U test detected differences between PE and recess only for light intensity (Table 2), while medians of NPERA were always significantly lower than recess and PE periods (Table 2), indicating that during these periods more PA per hour is met. Different results were found for secondary school, without significant differences among the three daily periods for sedentary time and moderate PA (Table 2). Moreover, we could not observe any differences between NPERA and PE for any variable expressed as percentage of time period. All together these results suggests a different behavior during recess period among academic levels. Finally, as expected the most important percentage of time in meeting healthy PA guidelines was covered by NPERA, followed by PE and recess periods (table 2).

Differences of Net bouts among daily periods and academic level

. Table 3 reports the number of net bouts and time bouts along different daily periods analyzed.

Several differences were found regarding periods analyzed as table 3, NPERA was the period where more net bouts were accumulated, followed by PE and recess respectively. Statistical differences were found between NPERA and PE/recess periods, especially for less than 5 minutes bouts among children in elementary school (table 3). PE and recess were significantly different for 1-minute bouts in elementary school ($p<0.001$, table 3), also in the same academic level difference between boys and girls were observed for 1-minute and 12-minute bouts during recess period and bouts of 8 and 12 minutes for PE (see table 3 for values).

Regarding secondary school NPERA had higher quantity of all kind of bouts. PE and recess were significantly for bout lengths of 1, 2, 6 and 8 minutes. Girls showed significantly less 5-minute bouts than boys during recess (table 3).

Differences of Accumulated bouts among daily periods and academic level

Number of accumulated bouts and total time bouts are presented in Table 4, where significant differences among all bout lengths were found for both academic levels. The main difference between secondary and elementary schools was that girls exhibited lower quantity of all types of accumulated bouts than boys during recess (table 4), which did not happen for net bouts (table 3). No sex effect was found on secondary school students (table 4).

NPERA was the element of the school day where adolescents accrued more accumulated bouts than PE and recess ($p<0.001$ for all, table 4). However, in children NPERA was not significantly across daily periods along all lengths of bouts, without a clear trend among the differences (table 4). PE and recess accumulated bouts were only different for bouts shorter than 10 minutes (table 4).

Differences of Total time and net and accumulated bouts among daily periods.

Overall, all variables from 1 to 10 Bouts related to net and accumulated bouts showed significant differences ($p \leq 0.001$) during NPERA, PE and recess time. There were no differences between 12 min bouts (table 5).

Discussion

The main purpose of the paper was to measure PA levels and different bout-lengths (1, 2, 4, 5, 6, 8, 10 and 12 min) during NPERA, PE and recess. To our knowledge, this is the first study, concerning school-based participants, where bouts are analyzed exhaustively (nets and accumulated using specific bouts-lengths) during three different elements of the school day of relevance for students. There were three main findings in this paper: A) NPERA showed higher levels of min/day of PA whereas PE and recess displayed in % of PA, but only for elementary school period; B) net and accumulated bouts analyzed were different during NPERA, PE and recess; C) net and accumulated bouts were statistically differentto each other, either as number of bouts or time bout.

Before starting the discussion, it is also important to highlight that the different time segments/periods of the school day comprise of different time lengths. Firstly, NPERA corresponds to longer time (11 hours) than PE (1 hour) and Recess (0.5 hours). For instance, PA regarding min/day will be higher during NPERA than PE and Recess.

However, these descriptive data are important and useful in order to provide specific information about PA during different activities and compare results with others papers.

Additionally, in order to standardize PA levels during different segments of the school day (daily periods), it is important to unify measurements according to a standard time-length. These differences in length-measurement among segments do not exist concerning % PA, which will allow us explain some differences among countries during this discussion. Regarding PA during NPERA, Spanish participants showed similar values to our sample during non-school activities, ranging from 31 to 36 min of MVPA (38, 39). This MVPA was also similar with British school-aged subjects (17). This NPERA have been issued to be the major contributor to total MVPA; which is in line with our results (64%) (11, 16). In spite of this, NPERA was not similar to values published in the literature (11), our results are higher than reported; this might by explained because in this research we recorded all activities apart from PE and Recess, and authors only recorded extracurricular activities (11, 16). Since, extracurricular activities seem to provide more MVPA because they are longer than other activities such as Recess and PE. For future research, would be valuable to create new variables with equal units of time. Conversely, during PE, Swiss and Spanish school-aged subjects reported 9 to 17% of MVPA(13, 40), which was similar to our sample (12.8%). PE has been cited as contributing around 11% of total PA (16), which is similar to the results presented in this study (16.8%). Finally, MVPA levels accrued during recess time seem to be low (3 min), but in accordance with other European data (17). However, upper MVPA time and % of MVPA has been also reported with Spanish and European. Regarding the contribution to total MVPA, previous authors reported 11% (14, 41, 42), in line with our data (7.9%). These low values of MVPA during recess may be explained by the low engagement in daily MVPA of the sample (Table 1); or even multiple aspects we did not analyze in this study which might affect PA during this context, such as social and behavioral reasons (43). Regarding MVPA time differences during school, boys accrued more MVPA than girls ($p \leq 0.05$), consistentwith that reported elsewhere (17). Additionally, elementary female students displayed higher MVPA time (47.3 minutes/day) compared to secondary school female students (39.8 minutes/day). Finally, the percentage of students who met healthy PA guidelines was similar between males and females and academic categories with the exception of male adolescents (50% vs. 24.3-33%, table 1).

In respect to differences among the various segments of the day examined in this study, , the Kruskal-Wallis tests indicated statistical differences across all variables analyzed. Large differences were displayed between segments taking into consideration the total time of recording (min/day; steps/day and contribution to MVPA and Recommendations) where NPERA accrued more PA. However, measurement-time was equalized among all segments, these differences disappeared according to % of PA, where NPERA were not significantly higher than recess or PE for sedentary time and MVPA, but only in adolescents. This fact is noticeable because, when taken in absolute terms, NPERA seems to be the segment where children and adolescents were more active, but recess and PE revealed a smaller % of sedentary time and higher MVPA than NPERA in children only. In adolescents PE and NPERA did not showed differences, nevertheless % of MVPA during recess period was significantly lower than PE and NPRA segments. According to these findings, it would be helpful for designing strategies and policies for PA promotion with this population. According to our results, unstructured (recess) and structured PA (PE) seem to provide similar % of PA in children. The only differences were found in light PA ($p \leq 0.05$, table 2). This fact suggests that PA behavior during school time follow a similar patter among children but not on adolescents (secondary school).. Differences in PA between the different segments of the day could not be compared with previous studies, because these prior studies have tended to focus on PA differences between gender groups and do not examine differences between total PA during different segments of the day (16, 17, 44).

Few data has been reported concerning accumulated bouts during NPERA, PE or recess (45), and no previous attempt has examined net bouts. This study suggests that 1min to 10 min net bouts and accumulated bouts of PA are different (Tables 3, 4 and 5). There were no differences between 12 min bouts during the different segments of the day as it was the same value in net and accumulated bouts. This current data shows that the choice of using net bouts or accumulated bouts of PA will notably affect the results obtained from analysis. For example, if a subject engages 10 min bouts, the Actilife program automatically measures 1 bout of 2, 4, 5, 6, 8 and 10 minutes; which is notably different from recording 1 bout of 10 min. This fact, which has not been taken into account previously, is important when interpreting results and for defining the more accurate effects of bouts of PA on a variety of health indices. When planning their analysis researchers therefore need to consider whether they wish to present data on accumulated bouts of PA or whether presenting data related to net bouts of PA is their primary research focus.

In regard to net bouts, NPERA revealed the same tendency as previously described, displaying higher differences than the other segments analyzed in this study. However, these differences were higher for bouts that lasted 8 minutes or less in elementary school children (table 3) compared to longer bouts than 8 min. Between PE and Recess time, fewer differences were found; bouts engaged of 1 ($p \leq 0.001$, table 3). These differences were likely due to the length of measurement, because the segments with similar duration (PE and recess) indicated smaller and fewer statistical differences. However, for secondary school differences for all lengths were found between NPERA and PE/recess periods, and among PE and recess for bouts of 1, 2, 6 and 8 minutes. .

This point suggests that for 1 to 6 min of net bouts, shorter activities such as PE and recess provide greater MVPA than longer ones, as NPERA.

Another important fact for standardizing measurement time would be discriminating the segment or period of the day that provides greater opportunities to accrue bouts of MVPA.. In the current study, the segment where subjects accrued more bouts from 1 min to 12 min was NPERA, followed by PE and recess time respectively in both, net and accumulated bouts. This was also the case with total bout length engaged from 1 to 12 min. When examining bout patterns, the majority of daily bouts engaged in, correspond to 1 and 2 min in duration. If considering longer bouts of PA, there was a lower incidence of engagement, across all segments of the day, compared to shorter bouts. Accumulated bouts from 1 and 2 min were performed around 4 to 8 times a day rather than 4 to 12 min. Our results were in accordance with MVPA bouts recently published elsewhere (Saunders et al., 2014). Authors indicate that 1 to 3 min bouts correspond up to more than 50% total bouts in PE and leisure time; additionally these differences were higher in leisure time (in our study NPERA) than in PE. This tendency also happened with net bouts, however these differences were more noticeable, 1 and 2 min were accrued from 9 to 13 more engage than 4 to 12 min. The daily period where the most differences were displayed between shorter and longer net and accumulated bouts was NPERA; this would be probably caused because was the moment that lasted more hours. These results were in accordance to previous findings which identified that PA during youth is highly transitory, accumulating PA in sporadic rather than consistent bouts (7-10). However, our results suggest an effect of maturation since, we found different patterns among academic levels (table 3 and 4).

For accumulated bouts, as previously reported in PA and net bouts, NPERA met more quantity of bouts than PE and recess, mainly for secondary school students. However, in spite of the relatively short duration of daily segments such as PE and recess, statistically significant differences were found concerning bouts across PE an recess periods. As explained above in relation in net bouts, bout variables should be standardized to provide a more reliable comparison between different segments. So, we could observed, that our resulted differed among academic levels when expressed as net or accumulated bouts (tables 3 and 4).

This paper is novel as to our knowledge, this is the first study to compare specific bout lengths and bouts and also the first which examines any differences between accumulated and net bouts. As such it provides useful information related to measurement of PA using accelerometry.

This study also has some limitations that should be taken into account in order to interpret the results. The sample might be skewed as around 60% of our sample do not meet PA criterions for accelerometer wear time (28) and were removed from all analysis. However students removed from this analysis were not significantly different on BMI or age that the final sample. Additionally, even if accelerometers have shown to be a valid and reliable measure of PA in children and adolescents they have some limitations; these devices do not recognize the type of PA behavior (e.g., sitting, standing still, strength activities), the particularities of the week that might influence the extent or increase of PA during activities analyzed were not controlled. It is also important to note that no measure of maturation could be obtained in our sample. Given the age ranges examined in the current study, it is possible that maturation may have had a greater influence on net bouts of PA compared to school year or chronological age. Future research on this topic would therefore be welcome which also controls for maturation in its analysis. Furthermore, the cross sectional study design and a relatively small sample of subjects (n=132) mean the findings of this study may not be widely extrapolated to the general European population Future studies should extend the assessment of the pattern of children´s PA bouts in these contexts to larger samples.

In summary, our results confirmed that school-aged children and adolescents accrued more minutes/day of PA during NPERA, PE and Recess respectively. Conversely, after controlling for total length of activities and considering % of PA, recess and PE showed higher PA time than NPRA in elementary school children. Related to net and accumulated bouts, NPERA displayed more 1 to 12 bouts, which was likely caused to its longer duration compared to PE and recess. Net and accumulated 1 to 10 bouts were statistically different between each other ($p \leq 0.001$). In order to compare results with previous studies, accumulated bouts might be appropriate. However, if the intention is to provide a better understanding of PA bouts and their impact on health, net bouts may be a more appropriate measure to employ, so differences among academic levels might be blunted when accumulated bouts are used. Also, differences between boys and girls during recess period could be only observed using accumulated bouts. All together, these results must suggest different pattern of behavior when using accumulated or net bout approaches.

References

1. Freedson PS, Pober D, Janz KF. Calibration of accelerometer output for children. Med Sci Sports Exerc. 2005;37(11 Suppl):S523.
2. Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, et al. Evidence based physical activity for school-age youth. J Pediatr. 2005;146(6):732-7.
3. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 2010;7(40):1-16.
4. WHO Global Recommendations on Physical Activity for Health. Geneva, Switzerland: WHO; 2010.
5. Tremblay MS, Warburton DE, Janssen I, Paterson DH, Latimer AE, Rhodes RE, et al. New Canadian physical activity guidelines. Applied physiology, nutrition, and metabolism. 2011;36(1):36-46.
6. Ortega F, Ruiz J, Castillo M, Sjöström M. Physical fitness in childhood and adolescence: a powerful marker of health. Int J Obes. 2008;32(1):1-11.
7. Baquet G, Stratton G, Van Praagh E, Berthoin S. Improving physical activity assessment in prepubertal children with high-frequency accelerometry monitoring: a methodological issue. Preventive medicine. 2007;44(2):143-7.

8. Armstrong N, Balding J, Gentle P, Kirby B. Patterns of physical activity among 11 to 16 year old British children. BMJ: British Medical Journal. 1990;301(6745):203.
9. Bailey RC, Olson J, Pepper SL, Porszasz J, Barstow TJ, Cooper DM. The level and tempo of children's physical activities: an observational study. Med Sci Sports Exerc. 1995;27(7):1033-41. Epub 1995/07/01.
10. Berman N, Bailey R, Barstow TJ, Cooper DM. Spectral and bout detection analysis of physical activity patterns in healthy, prepubertal boys and girls. American Journal of Human Biology. 1998;10(3):289-97.
11. Sanders T, Cliff DP, Lonsdale C. Measuring adolescent boys' physical activity: bout length and the influence of accelerometer epoch length. PLOS ONE. 2014;9(3):e92040. Epub 2014/03/20.
12. Trost S, Rosenkranz R, Dzewaltowski D. Physical activity levels among children attending after-school programs. Med Sci Sports Exerc. 2008;40(4):622-9.
13. Meyer U, Roth R, Zahner L, Gerber M, Puder J, Hebestreit H, et al. Contribution of physical education to overall physical activity. Scandinavian Journal of Medicine & Science in Sports. 2011;23(5):600-6.
14. Ridgers N, Saint-Maurice PF, Welk GJ, Siahpush M, Huberty J. Differences in physical activity during school recess. Journal of School Health. 2011;81(9):545-51.
15. Silva P, Sousa M, Aires L, Seabra A, Ribeiro J, Welk G, et al. Physical activity patterns in Portuguese adolescents: The contribution of extracurricular sports. European Physical Education Review. 2010;16(2):171-81.
16. Wickel EE, Eisenmann JC. Contribution of Youth Sport to Total Daily Physical Activity among 6-to 12-yr-old Boys. Medicine & Science in Sports & exercise: Official Journal of the American College of Sports Medicine. 2007;39(9):1493-500.
17. Fairclough S, Breighle A, Erwin H, Ridgers N. School day segmented physical activity patetrs of high and low active children. BMC public health. 2012a;12(406).
18. Mark AE, Janssen I. Influence of bouts of physical activity on overweight in youth. Am J Prev Med. 2009;36(5):416-21.
19. Stone MR, Rowlands AV, Eston RG. Characteristics of the activity pattern in normal weight and overweight boys. Preventive medicine. 2009;49(2):205-8.
20. Stone MR, Rowlands AV, Middlebrooke AR, Jawis MN, Eston RG. The pattern of physical activity in relation to health outcomes in boys. Int J Pediatr Obes. 2009;4(4):306-15.
21. Andersen LB, Harro M, Sardinha LB, Froberg K, Ekelund U, Brage S, et al. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). The Lancet. 2006;368(9532):299-304.
22. Holman RM, Carson V, Janssen I. Does the fractionalization of daily physical activity (sporadic vs. bouts) impact cardiometabolic risk factors in children and youth? PLoS One. 2011;6(10):e25733.
23. Nilsson A, Ekelund U, Yngve A, Sjostrom M. Assessing physical activity among children with accelerometers using different time sampling intervals and placements. Pediatric Exercise Science. 2002;14(1):87-96.
24. Troiano RP, Berrigan D, Dodd K. Physical Activity in the United States Measured by Accelerometer. Med Sci Sports Exerc. 2008;40(1):181-8.
25. Baptista F, Santos DA, Silva AM, Mota J, Santos R, Vale S, et al. Prevalence of the Portuguese population attaining sufficient physical activity. Med Sci Sports Exerc. 2012;44(3):466-73.
26. Rowlands AV, Pilgrim EL, Eston RG. Patterns of habitual activity across weekdays and weekend days in 9–11-year-old children. Preventive medicine. 2008;46(4):317-24.

27. Rowlands AV, Pilgrim EL, Eston RG. Seasonal changes in children's physical activity: an examination of group changes, intra-individual variability and consistency in activity pattern across season. Annals of human biology. 2009;36(4):363-78.
28. Saunders TJ, Tremblay MS, Mathieu ME, Henderson M, O'Loughlin J, Tremblay A, et al. Associations of sedentary behavior, sedentary bouts and breaks in sedentary time with cardiometabolic risk in children with a family history of obesity. PLoS One. 2013;8(11):e79143. Epub 2013/11/28.
29. Trost SG, Pate RR, Sallis JF, Freedson PS, Taylor WC, Dowda M, et al. Age and gender differences in objectively measured physical activity in youth. Med Sci Sports Exerc. 2002;34(2):350.
30. Santos-Lozano A, Santín-Medeiros F, Cardon G, Torres-Luque G, Bailón R, Bergmeir C, et al. Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points. Int J Sports Med. 2013;34(11):975-82.
31. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. J Sports Sci. 2008;24(14):1557-65.
32. Treuth M, Schmitz K, Catellier D, McMurray R, Murray D, Almeida M, et al. Defining accelerometer thresholds for activity intensities in adolescent girls. Med Sci Sports Exerc. 2004;36(7):1259.
33. Trost SG, Loprinzi PD, Moore R, Pfeiffer KA. Comparison of accelerometer cut points for predicting activity intensity in youth. Med Sci Sports Exerc. 2011;43(7):1360-8.
34. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. Med Sci Sports Exerc. 2005;37(11 Suppl):S531.
35. Frömel K, Stelzer J, Groffik D, Ernest J. Physical activity of children ages 6–8: The beginning of school attendance. Journal of Research in Childhood Education. 2008;23(1):29-40.
36. Colley R, Connor Gorber S, Tremblay MS. Quality control and data reduction procedures for accelerometry-derived measures of physical activity. Health Rep. 2010;21(1):63-9. Epub 2010/04/30.
37. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. Bmj. 2000;320(7244):1240.
38. Aibar A, Bois JE, Zaragoza Casterad J, Generelo E, Paillard T, Fairclough S. Weekday and weekend physical activity patterns of French and Spanish adolescents. Eur J Sport Sci. 2013b;12(3):500-9.
39. Ramirez-Rico E, Hilland TA, Foweather L, Fernández-Garcia E, Fairclough SJ. Weekday and weekend patterns of physical activity and sedentary time among Liverpool and Madrid youth. Eur J Sport Sci. 2013;14(3):287-93.
40. Martínez-Martínez J, Contreras OR, Lera Á, Aznar S. Niveles de actividad física medido con acelerómetro en alumnos de 3º ciclo de educación primaria: actividad física diaria y sesiones de educación física. Revista de Psicologia del Deporte. 2012;21(1):117-23.
41. Martinez-Gomez D, Veiga OL, Zapatera B, Gomez-Martinez S, Martinez D, Marcos A. Physical Activity During High School Recess in Spanish Adolescents: The AFINOS Study. J Phys Act Health. 2013;11(6):1194-201. Epub 2013/08/22.
42. Mota J, Silva P, Santos M, Ribeiro J, Oliveira J, Duarte J. Physical activity and school recess time: differences between the sexes and the relationship between children's playground physical activity and habitual physical activity. Journal of Sports Sciences. 2005;23(3):6.

43. Ridgers ND, Salmon J, Parrish AM, Stanley RM, Okely AD. Physical activity during school recess: a systematic review. Am J Prev Med. 2012a;43(3):320-8. Epub 2012/08/18.
44. Sarkin JA, McKenzie TL, Sallis JF. Gender differences in physical activity during fifth-grade physical education and recess periods. Journal of Teaching in Physical Education. 1997;17(1):99-106.
45. Babraj JA, Vollaard NB, Keast C, Guppy FM, Cottrell G, Timmons JA. Extremely short duration high intensity interval training substantially improves insulin action in young healthy males. BMC Endocrine Disorders. 2009;9(1):3.

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Tables

Table 1. Descriptive characteristics and weekly PA of the sample.

Elementary School		Girls (n=24) 40%					Boys (n=37) 60%					Sig.
		Median	Range	Mean		SD	Median	Range	Mean		SD	
Age	*(years)*	10.6	28.1	10.7	±	0.9	11.0	32.9	11.0	±	1.1	
BMI	*(kg/m^2)*	19.0	31.4	19.7	±	3.1	18.9	30.8	19.5	±	3.0	
NW	*(%)*			45.8					56.7			
Sedentary	*(min/day)*	1142.8	30.4	1106.8	±	231.1	1125.7	31.4	1153.1	±	152.6	
Light	*(min/day)*	92.7	31.4	92.8	±	24.7	94.3	30.7	91.4	±	24.0	
Moderate	*(min/day)*	23.0	28.1	25.2	±	9.4	27.0	32.9	27.2	±	8.4	
Vigorous	*(min/day)*	20.2	29.5	23.0	±	13.4	22.2	32.0	22.6	±	8.8	
MVPA	*(min/day)*	47.3	29.3	48.1	±	21.8	49.9	32.1	49.8	±	16.8	
Total PA	*(min/day)*	141.1	30.7	140.9	±	42.9	138.4	31.2	141.2	±	38.4	
MVPA School	***(min/day)***	**12.3**	**25.0**	**12.1**	**±**	**6.9**	**16.4**	**34.9**	**15.8**	**±**	**6.4**	*
Sedentary	*(% of day)*	88.6	30.1	88.1	±	4.9	89.0	31.6	88.9	±	3.8	
Light	*(% of day)*	7.4	32.5	7.9	±	3.3	6.8	30.0	7.2	±	2.3	
Moderate	*(% of day)*	1.9	30.0	2.1	±	1.0	2.0	31.6	2.2	±	0.9	
Vigorous	*(% of day)*	2.0	31.4	1.9	±	1.0	1.6	30.8	1.8	±	0.8	
MVPA	*(% of day)*	3.8	31.5	4.0	±	1.9	3.6	30.7	3.9	±	1.7	
Steps	*(steps/day)*	7530.1	30.0	8143.3	±	3001.0	7936.0	31.7	8218.9	±	2269.4	
Meeting Guid	*(%)*			33.3					27.0			

Secondary School		Girls (n=37) 49%					Boys (n=38) 51%					Sig.
		Median	Range	Mean		SD	Median	Range	Mean		SD	
Age	*(years)*	15.0	36.1	14.8	±	1.6	15.2	39.9	15.3	±	1.8	
BMI	*(kg/m^2)*	19.7	34.0	20.2	±	4.1	20.4	41.9	21.1	±	3.7	

NW	*(%)*			78.3					84.2			
Sedentary	*(min/day)*	619.2	40.0	624.7	±	99.7	601.1	36	600.2	±	89.1	
Light	***(min/day)***	**80.2**	**32.0**	**101.8**	**±**	**62.2**	**97.2**	**43.8**	**118.5**	**±**	**57.7**	*****
Moderate	*(min/day)*	26.8	34.3	26.6	±	8.0	29.4	41.6	31.5	±	14.5	
Vigorous	***(min/day)***	**11.9**	**29.8**	**14.9**	**±**	**9.4**	**22.4**	**46.0**	**24.3**	**±**	**14.8**	*******
MVPA	***(min/day)***	**39.8**	**30.3**	**41.5**	**±**	**15.1**	**54.4**	**45.5**	**55.7**	**±**	**23.5**	******
Total PA	***(min/day)***	**127.0**	**30.5**	**143.3**	**±**	**63.9**	**159.1**	**45.3**	**174.2**	**±**	**59.0**	******
MVPA School	*(min/day)*	5.5	36.6	6.7	±	4.9	4.8	39.3	7.9	±	6.4	
Sedentary	***(% of day)***	**82.8**	**45.1**	**81.6**	**±**	**7.0**	**79.6**	**31.1**	**77.4**	**±**	**7.5**	******
Light	*(% of day)*	11.0	33.1	13.0	±	6.9	12.8	42.8	15.3	±	7.0	
Moderate	*(% of day)*	3.5	34.9	3.5	±	1.0	3.8	41.0	4.1	±	2.1	
Vigorous	***(% of day)***	**1.7**	**30.2**	**2.0**	**±**	**1.2**	**2.9**	**45.6**	**3.2**	**±**	**1.9**	******
MVPA	***(% of day)***	**5.3**	**30.9**	**5.5**	**±**	**1.9**	**6.7**	**44.9**	**7.3**	**±**	**3.3**	******
Steps	***(steps/day)***	**7174.2**	**30.6**	**7392.5**	**±**	**2122.5**	**8518.1**	**45.2**	**9180.2**	**±**	**2960.2**	******
Meeting Guid	*(%)*			24.3					50.0			

BMI:Body Mass Index; NW: Normo weight; PA: Physical Activity; TPA: Total Physical Activity (Light+Moderate+Vigorous); MVPA: Moderate to Vigorous PA; MVPA School: MVPA engaged during school time; Meeting Guid: Meeting 60 min MVPA health guidelines;
*. p≤0.05; **: p≤0.01; ***: p≤0.001. for Mann-Whitney-U test

Table 2. Physical Activity Levels during NPERA. PE and Recess.

Elementary School		**NPERA (1)**				Sig.	**PE (2)**				Sig.	**RECESS (3)**				Sig.	Sig.	Sig.	Sig.	Sig.
		Girls (n=24)		**Boys (n=37)**		Boys vs Girls	**Girls (n=24)**		**Boys (n=37)**		Boys vs Girls	**Girls (n=24)**		**Boys (n=37)**		Boys vs Girls	K-W	1 vs 2	1 vs 3	2 vs 3
		Median	Range	Median	Range		Median	Range	Median	Range		Median	Range	Median	Range					
Sedentary	*(min/day)*	392.5	33.4	382.3	29.5		34.7	34.0	32.7	29.1		19.8	39.4	15.6	25.6	◊◊	***	***	^^^	+++
Light	*(min/day)*	46.4	27.7	48.1	33.1		11.3	27.0	13.3	33.6		7.4	24.9	8.7	35.0	◊	***	***	^^^	+++
Moderate	*(min/day)*	14.1	28.3	14.8	32.7		3.6	25.4	5.1	34.7	◊	2.2	24.5	3.3	35.2	◊	***	***	^^^	+++
Vigorous	*(min/day)*	13.9	30.4	15.3	31.4		4.9	28.9	6.0	32.3		2.0	25.0	2.7	34.9	◊	***	***	^^^	+++
MVPA	*(min/day)*	31.3	29.5	30.3	32.0		8.4	27.5	11.5	33.3		3.5	23.9	4.7	35.6	◊	***	***	^^^	+++
Total PA	*(min/day)*	68.6	27.4	75.3	33.3		21.8	26.3	24.5	34.0		11.2	23.5	16.5	35.9	◊◊	***	***	^^^	+++
Sedentary	***(%)***	**85.1**	**34.2**	**83.5**	**33.3**		**62.9**	**35.1**	**57.7**	**28.4**		**63.7**	**38.8**	**50.9**	**25.9**	◊◊	*******	*******	**^^^**	
Light	*(%)*	8.6	27.2	9.7	28.9		20.4	26.6	22.9	33.8		23.8	24.3	28.1	35.4	◊	***	***	^^^	+
Moderate	***(%)***	**2.9**	**28.4**	**3.2**	**32.7**		**6.4**	**25.5**	**8.8**	**34.5**		**7.0**	**24.1**	**10.5**	**35.5**	◊	*******	*******	**^^^**	
Vigorous	***(%)***	**3.1**	**30.7**	**3.4**	**31.2**		**8.7**	**29.3**	**10.2**	**32.1**		**6.4**	**24.8**	**8.5**	**35.0**	◊	*******	*******	**^^^**	
MVPA	***(%)***	**6.4**	**29.8**	**6.8**	**31.8**		**15.1**	**27.5**	**18.9**	**33.3**		**13.7**	**24.3**	**18.8**	**35.4**	◊	*******	*******	**^^^**	
Contr Rec	*(%)*	52.2	29.5	50.4	32.0		14.1	27.5	19.1	33.3		7.1	24.5	9.7	35.2	◊	***	***	^^^	+++
Contr MVPA	*(%)*	60.1	31.1	62.6	30.9		17.5	27.4	22.7	33.3		8.4	23.3	12.8	36.0	◊◊	***	***	^^^	+++
Steps	*(steps/day)*	4366.7	29.4	4530.4	32.0		1432.8	27.5	1829.0	33.2		764.5	23.8	1166.0	35.6	◊	***	***	^^^	+++

Secondary School		**NPERA (1)**				Sig.	**PE (2)**				Sig.	**RECESS (3)**				Sig.	Sig.	Sig.	Sig.	Sig.
		Girls (n=37)		**Boys (n=38)**		Boys vs Girls	**Girls (n=37)**		**Boys (n=38)**		Boys vs Girls	**Girls (n=37)**		**Boys (n=38)**		Boys vs Girls	K-W	1 vs 2	1 vs 3	2 vs 3
		Median	Range	Median	Range		Median	Range	Median	Range		Median	Range	Median	Range					
Sedentary	*(min/day)*	353.4	40.3	332.6	35.7		48.8	39.7	48.4	36.3		25.5	44.0	23.6	32.1	◊	***	***	^^^	+++
Light	*(min/day)*	48.9	33.3	58.1	42.5		7.5	36.3	7.5	39.7		4.0	32.1	5.9	43.8	◊	***	***	^^^	++
Moderate	*(min/day)*	19.7	38.7	18.6	37.3		2.2	37.7	1.7	38.3		1.0	36.7	1.0	39.3		***	***	^^^	++
Vigorous	*(min/day)*	9.2	32.8	16.0	43.0	◊	2.0	36.7	1.5	39.9		0.4	36.8	0.5	39.2		***	***	^^^	+++
MVPA	*(min/day)*	28.9	34.9	36.7	41.0		4.3	37.2	3.0	38.8		1.2	36.7	1.5	39.2		***	***	^^^	+++
Total PA	*(min/day)*	80.0	31.8	96.7	44.0	◊	12.3	36.7	11.7	39.3		5.3	32.3	7.4	43.5	◊	***	***	^^^	+++
Sedentary	***(%)***	**81.4**	**44.0**	**76.3**	**32.2**	◊	**79.9**	**39.2**	**80.8**	**36.8**		**82.2**	**43.8**	**75.7**	**32.3**	◊				
Light	*(%)*	11.4	32.9	14.3	43.0	◊	12.3	36.1	12.3	39.9		12.9	31.8	18.3	44.1	◊	**		^	+++

Moderate	***(%)***	**4.4**	**39.5**	**4.1**	**36.5**		**3.6**	**37.8**	**2.8**	**38.2**	**3.1**	**36.4**	**3.4**	**39.5**				
Vigorous	*(%)*	2.0	32.6	3.9	43.3	◊	3.4	36.5	2.5	39.4	1.4	36.7	1.6	39.3	**		^^^	+
MVPA	*(%)*	7.1	35.0	8.2	41.0		7.1	36.9	4.9	39.1	4.6	36.0	5.3	39.9	**		^^	+++
Contr Rec	*(%)*	48.1	34.9	61.2	41.0		7.2	37.2	4.9	38.8	2.4	36.0	2.7	39.9	***	***	^^^	+++
Contr MVPA	*(%)*	66.5	41.6	64.2	33.6		12.4	38.6	9.6	36.4	3.6	39.4	3.2	35.7	***	***	^^^	+++
Steps	*(steps/day)*	4808.5	36.4	5575.1	39.6		769.5	37.9	492.8	38.1	324.0	36.4	356.7	39.6	***	***	^^^	+++

Range: Mean Range; NPERA: Non-PE or Recess Activities; PA: Physical Activity; MVPA: Moderate to Vigorous; Total PA: Physical Activity (Light+Moderate+Vigorous); Contr Rec: Contribution to 60 min MVPA health recommendations; Contr MVPA: Daily Contribution to total MVPA.

Girls vs Boys, Mann-Whitney-U test for comparing medians among sexes, ◊: p≤0.05; ◊◊: p≤0.01; K-W: Kruskall-Wallis for comparing medians among daily periods; Mann-Whitney-U test for comparing medians among two daily periods: ***: p≤0.001; **: p≤0.01; 1 vs 2 (NPERA VS PE): **: p≤0.01; ***: p≤0.001; 1 vs 3 (NPERA VS RECESS): ^: p≤0.05; ^^: p≤0.01; ^^^: p≤0.001; 2 vs 3 (PE VS RECESS): +=≤0.05; ++=p≤0.01; +++: p≤0.001.

Table 3. Number of net bouts and total time bouts during NPERA, PE and Recess.

Elementary School		NPERA (1)				Sig.	PE (2)				Sig.	RECESS (3)				Sig.	Sig.	Sig.	Sig.	Sig.
		Girls (n=24)		Boys (n=37)		Boys vs Girls	Girls (n=24)		Boys (n=37)		Boys vs Girls	Girls (n=24)		Boys (n=37)		Boys vs Girls	K-W	1 vs 2	1 vs 3	2 vs 3
		Median	Range	Median	Range		Median	Range	Median	Range		Median	Range	Median	Range					
B ≥1 m	*(bouts/day)*	17.0	33.7	15.7	28.4		7.3	29.3	7.6	32.1		2.8	23.5	4.2	35.8	◊◊	***	***	^^^	+++
B 2 m	*(bouts/day)*	4.5	27.4	5.2	33.3		0.5	28.1	0.5	32.9		0.4	29.8	0.6	31.8		***	***	^^^	
B 4 m	*(bouts/day)*	0.3	30.0	0.4	31.6		0.0	29.4	0.0	32.0		0.0	28.1	0.2	32.9		***	**	^^^	
B 5 m	*(bouts/day)*	0.2	31.2	0.2	30.9		0.0	32.3	0.0	30.1		0.0	29.9	0.0	31.7		*	*	^	
B 6 m	***(bouts/day)***	**0.1**	**31.5**	**0.0**	**30.7**		**0.0**	**28.2**	**0.0**	**32.8**		**0.0**	**28.8**	**0.0**	**32.4**					
B 8 m	***(bouts/day)***	**0.0**	**31.0**	**0.0**	**31.0**		**0.0**	**26.5**	**0.0**	**33.9**	◊◊	**0.0**	**29.3**	**0.0**	**32.1**					
B 10 m	***(bouts/day)***	**0.0**	**31.0**	**0.0**	**31.0**		**0.0**	**29.2**	**0.0**	**32.1**		**0.0**	**29.7**	**0.0**	**31.9**					
B 12 m	***(bouts/day)***	**0.0**	**29.8**	**0.0**	**31.8**		**0.0**	**34.9**	**0.0**	**28.5**	◊	**0.0**	**25.3**	**0.0**	**34.7**	◊◊			^	
T B 2 m	*(min/day)*	9.9	27.7	12.5	33.1		1.5	28.2	1.5	32.8		0.9	28.7	1.4	32.5		***	***	^^^	
T B 4 m	*(min/day)*	0.9	29.7	1.5	31.9		0.0	29.2	0.0	32.2		0.0	28.3	0.8	32.8		***	**	^^^	
T B 5 m	*(min/day)*	0.8	30.6	0.9	31.3		0.0	32.3	0.0	30.1		1.3	24.6	2.8	35.2	◊	***	*	^^^	+++
T B 6 m	*(min/day)*	0.6	31.2	0.0	30.9		0.0	28.3	0.0	32.7		0.0	31.0	0.0	31.0		***		^^^	+++
T B 8 m	***(min/day)***	**0.0**	**31.0**	**0.0**	**31.0**		**0.0**	**26.5**	**0.0**	**33.9**	◊◊	**0.0**	**28.6**	**0.0**	**32.5**					
T B 10 m	***(min/day)***	**0.0**	**31.0**	**0.0**	**31.0**		**0.0**	**28.7**	**0.0**	**31.7**		**0.0**	**29.9**	**0.0**	**31.7**					
T B 12 m	***(min/day)***	**0.0**	**29.8**	**0.0**	**31.8**		**0.0**	**34.9**	**0.0**	**27.6**	◊	**0.0**	**25.3**	**0.0**	**34.7**	◊◊		*	^	

Secondary School		NPERA (1)				Sig.	PE (2)				Sig.	RECESS (3)				Sig.	Sig.	Sig.	Sig.	Sig.
		Girls (n=37)		Boys (n=38)		Boys vs Girls	Girls (n=37)		Boys (n=38)		Boys vs Girls	Girls (n=37)		Boys (n=38)		Boys vs Girls	K-W	1 vs 2	1 vs 3	2 vs 3
		Median	Range	Median	Range		Median	Range	Median	Range		Median	Range	Median	Range					
B ≥1 m	*(bouts/day)*	17.9	36.4	19.2	38.6		2.0	38.9	1.4	36.1		1.2	38.9	1.0	36.1		***	***	^^^	+
B 2 m	*(bouts/day)*	3.8	35.5	5.0	39.5		0.5	36.5	0.5	38.5		0.0	33.4	0.3	41.7		***	***	^^^	++
B 4 m	***(bouts/day)***	**0.3**	**34.0**	**0.5**	**41.0**		**0.0**	**36.9**	**0.0**	**38.1**		**0.0**	**36.5**	**0.0**	**38.5**		***	***	^^^	
B 5 m	***(bouts/day)***	**0.4**	**38.5**	**0.4**	**36.5**		**0.0**	**38.0**	**0.0**	**37.0**		**0.0**	**35.5**	**0.0**	**39.5**	◊	***	***	^^^	

B 6 m	*(bouts/day)*	0.5	38.6	0.4	37.4	0.0	36.8	0.0	39.2	0.0	37.0	0.0	39.0	***	***	^^^	++
B 8 m	*(bouts/day)*	0.2	39.9	0.0	36.1	0.0	38.9	0.0	37.1	0.0	38.0	0.0	38.0	***	***	^^^	+
B 10 m	***(bouts/day)***	**0.0**	**38.6**	**0.0**	**37.5**	**0.0**	**37.5**	**0.0**	**38.4**	**0.0**	**37.5**	**0.0**	**38.5**	***	***	^^^	
B 12 m	***(bouts/day)***	**0.0**	**38.3**	**0.0**	**37.7**	**0.0**	**38.0**	**0.0**	**38.0**	**0.0**	**38.0**	**0.0**	**38.0**	***	***	^^^	
T B 2 m	*(min/day)*	9.0	34.5	13.2	39.5	1.1	36.3	1.1	37.7	0.0	33.4	0.5	40.7	***	***	^^^	++
T B 4 m	*(min/day)*	1.1	32.7	2.1	41.5	0.0	36.4	0.0	37.6	0.0	35.9	0.0	38.1	***	***	^^^	+
T B 5 m	***(min/day)***	**2.1**	**37.8**	**2.0**	**36.2**	**0.0**	**37.4**	**0.0**	**36.5**	**0.0**	**35.9**	**0.0**	**38.1**	***	***	^^^	
T B 6 m	*(min/day)*	2.6	36.6	2.7	37.4	0.0	36.1	0.0	37.9	0.0	37.0	0.0	37.0	***	***	^^^	+++
T B 8 m	*(min/day)*	2.0	39.0	0.0	34.9	0.0	38.3	0.0	35.6	0.0	37.0	0.0	37.0	***	***	^^^	+
T B 10 m	***(min/day)***	**0.0**	**37.7**	**0.0**	**36.3**	**0.0**	**36.5**	**0.0**	**37.5**	**0.0**	**36.5**	**0.0**	**37.5**	***	***	^^^	
T B 12 m	***(min/day)***	**0.0**	**37.6**	**0.0**	**36.3**	**0.0**	**37.1**	**0.0**	**36.9**	**0.0**	**37.0**	**0.0**	**37.0**	***	***	^^^	

Range: Mean Range; NPERA: Non-PE or Recess Activities; B: Bouts; T: Time, m: minutes.

Girls vs Boys, Mann-Withney-U test for comparing medians among sexes: ◊: p≤0.05; ◊◊: p≤0.01; Kruskall-Wallis (K-W) for comparing medians among daily periods; Mann-Withney-U test for comparing medians among two dailt periods:*: p≤0.05; **: p≤0.01; ***: p≤0.001; 1 vs 2 (NPERA VS PE): *: p≤0.05; **: p≤0.01; ***: p≤0.001; 1 vs 3 (NPERA VS RECESS): ^: p≤0.05; ^^^: p≤0.001; 2 vs 3 (PE VS RECESS): +=≤0.05; ++=p≤0.01; +++: p≤0.001.

Table 4. Number of accumulated bouts and total time bouts during NPERA,

PE and Recess.

Elementary School		NPERA (1) Girls (n=24) Median	Range	Boys (n=37) Median	Range	Sig. Boys vs Girls	PE (2) Girls (n=24) Median	Range	Boys (n=37) Median	Range	Sig. Boys vs Girls	RECESS (3) Girls (n=24) Median	Range	Boys (n=37) Median	Range	Sig. Boys vs Girls	Sig. K-W	Sig. 1 vs 2	Sig. 1 vs 3	Sig. 2 vs 3
B ≥1 m	*(bouts/day)*	23.3	31.0	22.8	30.2		7.6	28.2	8.9	32.8		3.5	23.9	4.7	35.6		***	***	^^^	+++
B 2 m	*(bouts/day)*	4.9	27.6	6.0	33.2		1.5	26.1	2.0	34.2		0.7	26.9	1.2	33.7	◊	***	***		+++
B 4 m	*(bouts/day)*	0.6	31.0	0.6	31.0		1.0	28.1	1.0	32.9		0.3	24.5	0.6	35.2	◊	***	*	^^^	+++
B 5 m	*(bouts/day)*	0.4	32.1	0.4	30.3		0.5	29.0	0.5	32.3		0.2	25.4	0.4	34.6	◊	***	*	^^^	+++
B 6 m	*(bouts/day)*	0.2	31.6	0.2	30.6		0.0	26.3	0.5	34.0		0.0	24.8	0.3	35.0	◊	***		^^	+++
B 8 m	*(bouts/day)*	0.0	30.7	0.0	31.2		0.0	29.8	0.0	31.8		0.0	25.8	0.0	34.4	◊	**		^^	+
B 10 m	***(bouts/day)***	**0.0**	**30.6**	**0.0**	**31.2**		**0.0**	**32.8**	**0.0**	**29.8**		**0.0**	**25.1**	**0.0**	**34.8**	◊	**	*	^^	
B 12 m	***(bouts/day)***	**0.0**	**29.8**	**0.0**	**31.8**		**0.0**	**34.9**	**0.0**	**28.5**		**0.0**	**25.3**	**0.0**	**34.7**	◊◊	*	*	^	
T B 2 m	*(min/day)*	13.1	28.0	16.7	33.0		7.5	28.0	10.0	33.0		3.0	24.1	5.5	35.5	◊	***	***	^^^	+++
T B 4 m	*(min/day)*	3.5	30.9	3.8	31.1		6.0	29.2	6.5	32.1		1.6	23.4	3.8	36.0	◊◊	***		^^^	+++
T B 5 m	*(min/day)*	2.4	31.3	2.4	30.8		4.3	29.8	5.0	31.8		1.3	24.6	2.8	35.2	◊	***	*	^^^	+++
T B 6 m	*(min/day)*	1.2	31.3	1.3	30.8		0.0	27.8	4.0	33.1		0.0	25.1	0.0	34.8	◊	***	*	^^^	+++
T B 8 m	***(min/day)***	**0.0**	**30.8**	**0.0**	**31.2**		**0.0**	**30.6**	**0.0**	**31.2**		**0.0**	**25.5**	**0.0**	**34.5**	◊				
T B 10 m	***(min/day)***	**0.0**	**30.6**	**0.0**	**31.3**		**0.0**	**33.3**	**0.0**	**29.5**		**0.0**	**25.2**	**0.0**	**34.8**	◊		*		
T B 12 m	***(min/day)***	**0.0**	**29.8**	**0.0**	**31.8**		**0.0**	**34.9**	**0.0**	**27.6**	◊	**0.0**	**25.3**	**0.0**	**34.7**	◊◊			^	

Secondary School		NPERA (1) Girls (n=37) Median	Range	Boys (n=38) Median	Range	Sig. Boys vs Girls	PE (2) Girls (n=37) Median	Range	Boys (n=38) Median	Range	Sig. Boys vs Girls	RECESS (3) Girls (n=37) Median	Range	Boys (n=38) Median	Range	Sig. Boys vs Girls	Sig. K-W	Sig. 1 vs 2	Sig. 1 vs 3	Sig. 2 vs 3
B ≥1 m	*(bouts/day)*	22.4	35.4	27.6	40.5		3.0	37.9	2.5	38.1		1.2	36.7	1.5	39.2		***	***	^^^	+++
B 2 m	***(bouts/day)***	**5.5**	**34.9**	**8.1**	**41.0**		**0.5**	**36.6**	**0.8**	**39.4**		**0.0**	**33.5**	**0.3**	**42.4**		***	***	^^^	
B 4 m	*(bouts/day)*	2.0	37.4	1.9	38.6		0.0	37.5	0.0	38.4		0.0	36.5	0.0	39.5		***	***	^^^	+++

B 5 m	*(bouts/day)*	1.5	39.4	1.3	36.6	0.0	39.3	0.0	36.8	0.0	37.0	0.0	39.0	***	***	^^^	+++
B 6 m	*(bouts/day)*	1.0	39.2	0.8	36.9	0.0	38.5	0.0	37.5	0.0	37.4	0.0	38.5	***	***	^^^	+++
B 8 m	*(bouts/day)*	0.4	39.7	0.3	36.3	0.0	38.5	0.0	37.5	0.0	38.0	0.0	38.0	***	***	^^^	++
B 10 m	***(bouts/day)***	**0.2**	**39.4**	**0.0**	**36.7**	**0.0**	**37.6**	**0.0**	**38.4**	**0.0**	**37.5**	**0.0**	**38.4**	***	***	^^^	
B 12 m	***(bouts/day)***	**0.0**	**38.3**	**0.0**	**37.7**	**0.0**	**38.0**	**0.0**	**38.0**	**0.0**	**38.0**	**0.0**	**38.0**	***	***	^^^	
T B 2 m	*(min/day)*	21.4	35.1	30.8	40.9	2.7	36.5	2.2	39.5	0.0	33.7	0.6	42.2	***	***	^^^	+++
T B 4 m	*(min/day)*	11.7	37.3	13.6	38.7	0.0	37.9	0.0	38.1	0.0	36.5	0.0	39.5	***	***	^^^	+++
T B 5 m	*(min/day)*	10.1	39.0	11.7	37.1	0.0	39.1	0.0	36.9	0.0	37.0	0.0	39.0	***	***	^^^	+++
T B 6 m	*(min/day)*	7.0	38.8	8.4	37.2	0.0	38.7	0.0	37.3	0.0	37.5	0.0	38.4	***	***	^^^	+++
T B 8 m	*(min/day)*	4.3	39.5	2.7	36.6	0.0	38.5	0.0	37.6	0.0	38.0	0.0	38.0	***	***	^^^	+++
T B 10 m	*(min/day)*	2.3	39.2	0.0	36.8	0.0	37.8	0.0	38.2	0.0	37.5	0.0	38.4	***	***	^^^	+
T B 12 m	***(min/day)***	**0.0**	**37.9**	**0.0**	**38.1**	**0.0**	**38.1**	**0.0**	**37.9**	**0.0**	**38.0**	**0.0**	**38.0**	***	***	^^^	

Range: Mean Range; NPERA: Non-PE or Recess Activities; B:Bouts; T: Time. m: minutes.

Girls vs Boys, Mann-Withney-U test for comparing medians among sexes: ◊: p≤0.05; ◊◊: p≤0.01; Kruskall-Wallis (K-W) for comparing medians among daily periods; Mann-Withney-U test for comparing medians among two dailt periods:*: p≤0.05; **: p≤0.01; ***: p≤0.001; 1 vs 2 (NPERA VS PE): *: p≤0.05; ***: p≤0.001; 1 vs 3 (NPERA VS RECESS): ^^: p≤0.01; ^^^: p≤0.001; 2 vs 3 (PE VS RECESS): +=≤0.05; ++=p≤0.01; +++: p≤0.001.

Table 5. Comparison between net and accumulated bouts.

Elementary School		**NPERA (1)**				Sig.	**PE (2)**				Sig.	**RECESS (3)**				Sig.
		N	Range -	N	Range +		N	Range -	N	Range +		N	Range -	N	Range +	
Bouts 1 m	(bouts/day)	57	31.0	2	2.5	***	24	19.5	16	21.9		31	26.0	16	20.2	*
Bouts 2 m	(bouts/day)	52	26.5	0	0.0	***	45	23.0	0	0.0	***	50	25.5	0	0.0	***
Bouts 4 m	(bouts/day)	42	21.5	0	0.0	***	43	22.0	0	0.0	***	43	22.0	0	0.0	***
Bouts 5 m	(bouts/day)	36	18.5	0	0.0	***	36	18.5	0	0.0	***	35	18.0	0	0.0	***
Bouts 6 m	(bouts/day)	18	9.5	0	0.0	***	22	11.5	0	0.0	***	25	13.0	0	0.0	***
Bouts 8 m	(bouts/day)	8	4.5	0	0.0	**	16	8.5	0	0.0	***	20	10.5	0	0.0	***
Bouts 10 m	(bouts/day)	5	3.0	0	0.0	*	12	6.5	0	0.0	**	14	7.5	0	0.0	***
Bouts 12 m	**(bouts/day)**	**0**	**0.0**	**0**	**0.0**		**0**	**0.0**	**0**	**0.0**		**0**	**0.0**	**0**	**0.0**	
T Bouts 2 m	(min/day)	52	26.5	0	0.0	***	45	23.0	0	0.0	***	50	25.5	0	0.0	***
T Bouts 4 m	(min/day)	42	21.5	0	0.0	***	43	22.0	0	0.0	***	43	22.0	0	0.0	***
T Bouts 5 m	(min/day)	36	18.5	0	0.0	***	36	18.5	0	0.0	***	20	10.5	0	0.0	***
T Bouts 6 m	(min/day)	18	9.5	0	0.0	***	22	11.5	0	0.0	***	20	10.5	0	0.0	***
T Bouts 8 m	(min/day)	8	4.5	0	0.0	*	16	8.5	0	0.0	***	21	18.1	8	6.8	***
T Bouts 10 m	(min/day)	5	3.0	0	0.0	*	9	5.0	6	12.5		16	16.5	8	4.5	***
T Bouts 12 m	(min/day)	5	3.0	0	0.0	*	0	0.0	11	6.0	**	0	0.0	14	7.5	***

Secondary School		**NPERA (1)**				Sig.	**PE (2)**				Sig.	**RECESS (3)**				Sig.
		N	Range -	N	Range +		N	Range -	N	Range +		N	Range -	N	Range +	
Bouts 1 m	(bouts/day)	64	38.0	8	24.1	***	37	26.6	12	20.1	***	31	17.0	2	17.0	***
Bouts 2 m	(bouts/day)	66	33.5	0	0.0	***	27	14.0	0	0.0	***	6	3.5	0	0.0	*
Bouts 4 m	(bouts/day)	64	32.5	0	0.0	***	23	12.0	0	0.0	***	6	3.5	0	0.0	*
Bouts 5 m	(bouts/day)	63	32.0	0	0.0	***	22	11.5	0	0.0	***	5	3.0	0	0.0	*
Bouts 6 m	**(bouts/day)**	**49**	**25.0**	**0**	**0.0**	***	**17**	**9.0**	**0**	**0.0**	***	**4**	**2.5**	**0**	**0.0**	
Bouts 8 m	**(bouts/day)**	**36**	**18.5**	**0**	**0.0**	***	**9**	**5.0**	**0**	**0.0**	**	**3**	**2.0**	**0**	**0.0**	
Bouts 10 m	**(bouts/day)**	**30**	**15.5**	**0**	**0.0**	***	**6**	**3.5**	**0**	**0.0**	*	**2**	**1.5**	**0**	**0.0**	

Bouts 12 m	**(bouts/day)**	**0**	**0.0**	**0**	**0.0**		**0**	**0.0**	**0**	**0.0**		**0**	**0.0**	**0**	**0.0**	
T Bouts 2 m	(min/day)	65	33.0	0	0.0	***	27	14.0	0	0.0	***	6	3.5	0	0.0	*
T Bouts 4 m	(min/day)	63	32.0	0	0.0	***	23	12.0	0	0.0	***	6	3.5	0	0.0	*
T Bouts 5 m	(min/day)	62	31.5	0	0.0	***	22	11.5	0	0.0	***	3	2.0	0	0.0	
T Bouts 6 m	(min/day)	47	24.0	0	0.0	***	16	8.5	0	0.0	***	3	2.0	0	0.0	
T Bouts 8 m	(min/day)	34	17.5	0	0.0	***	9	5.0	0	0.0	**	16	9.5	1	1.0	***
T Bouts 10 m	(min/day)	28	14.5	0	0.0	***	6	3.5	3	8.0		9	6.0	1	1.0	**
T Bouts 12 m	(min/day)	30	15.5	0	0.0	***	0	0.0	6	3.5	*	0	0.0	2	1.5	

Range -: Negative Ranges; Range +: Positives Ranges; NPERA: Non-PE or Recess Activities; T: Time. m: minutes.
*. p≤0.05; **: p≤0.01; ***: p≤0.001. for Wilcoxon´s test comparing ranges of accumulated minus net bouts during NPERA. PE and Recess.

VI

RECESS SEDENTARY TIME AND CRF IN SCHOOL-AGED CHILDREN AND ADOLESCENTS

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Title: Recess Sedentary time and CRF in School-Aged Children and Adolescents

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Abstract:

Background: School-based activities (SBA) might be a main contributor to total daily physical activity (PA), which should be related with health outcomes. Recess time (RT) is a main component of SBA where scholars play freely and could contribute up to 40% health guidelines. The main goal of this study was to analyze the association between accelerometer-measured PA during RT and cardiorespiratory fitness (CRF) in children and adolescents.

Methods: 172 Spanish 3rd to 12th grade children and adolescents, aged 8 – 19 years were recruited from 8 schools and high schools. PA levels were measured with GT3X accelerometers over 7 days. CRF was measured using a portable breath-by-breath gas analyzer (Metamax 3B). Sample was split in different categories: gender, BMI and health status. A general lineal model (GML) was conducted to analyze the association between PA intensities and maximum oxygen uptake (VO_{2Max}) during RT. Additionally a logistic binary regression was used to evaluate the risk of unhealthy CRF among different categories of PA and sedentary time.

Results: Those participants classified as healthy showed higher PA levels during RT than unhealthy. GML analysis showed sedentary time during RT was significantly associated with VO_{2Max}. Finally, pupils who did not meet at least 15 min sedentary time during RT presented high probability of having unhealthy CRF (OR = -3.774; 95% CI - 0.002 to 0.235) .

Conclusion: Our data seem to suggest an effect of sedentary time and unhealthy CRF. Thus, school-aged children and adolescents must be empowered to perform PA during RT in order to prevent deleterious effects of sedentary time in CRF.

Key Words: adolescents, children, physical activity, physical education and training, schools.

Introduction

There is an increased health-related interest about physical activity (PA) and sedentary behavior in children and adolescents (1). It is well-known that regular moderate to vigorous PA (MVPA) influences positively cardiorespiratory fitness (CRF), which is associated to numerous health-related benefits (2). Sedentarism has been related with cardiovascular diseases (CVD) (3) and metabolic diseases (4) independently of PA. Also, sedentary time (ST) has been associated with a low CRF, which has been reported to influence negatively CVD (5) and metabolic diseases (6). However, less is known about the influence of sedentary time (ST) on CRF as assessed by maximum oxygen uptake (VO_{2Max}) in children and adolescents, particularly during school time.

ST and MVPA have been described as the most two PA dimensions associated with VO_{2Max} (7), moreover, they might have independent effect on health (4). So, sedentary behavior should be considered distinct from a lack of MVPA, such that excessive sedentary behavior has been linked with CVD and low VO_{2Max} independently of MVPA (7-9). Thus, it has been reported that engaging small PA breaks during ST, there must be benefits on health outcomes and reduced CVD risk factors can be attained in adults (10). Regarding PA in youth, studies have been mainly focused on whole-day activities (2, 11) or exercise during school-based interventions (12), so studies with school-aged subjects have shown improvements of body composition, bone-mass, academic achievements and VO_{2Max} with exercise programs of PA bursts or reduced length-bouts (13-16). These previous findings provided empirical knowledge to support school schedule can represent a valuable time in promoting actual health outcomes. Although interventions have showed proven efficacy (12, 14), usually those not include all students or they can continue expending a significant ST during school schedule, which may represent a limitation. Additionally, early research in the field of sedentary behavior was used to assess ST by self-report questionnaires, computer time or TV viewing (17), which do not asses accurately sedentary behavior and this measurements should not be interpreted as a reflection of total ST (18). On the other hand most studies that measured VO_{2Max} used indirect equations (7, 19), which are prone to errors and should not be considered as a valid individual predictor of VO_{2Max} with children (20).

Recess time (RT) is a daily opportunity where scholars can freely choose their activities and it has reported as contributing up to 40% to recommended daily PA (21, 22). In spite of this positive contribution, the influence of PA levels during RT on VO_{2Max} still remains unclear. Moreover, ST of RT has been rarely reported and much less analyzed its deleterious influence in VO_{2Max}. Classical surveys have been focused on searching the daily PA intensity levels associated with VO_{2Max} (23). Another analysis perspective has been the healthy (H) and unhealthy (UH) VO_{2Max} cutoffs for children and adolescents, which have been associated with cardiovascular or metabolic markers (5, 7, 24), but there is lack of knowledge regarding how PA dimension can influence the risk of having H or UH VO_{2max}. As consequence, studies have been largely focused on general weekly PA, not measuring specific PA contexts such as RT (1, 9, 17, 18), which can determine VO_{2Max} in general scholar population since is a daily common appointment for all children and adolescents. Identifying daily time more associated with low or high VO_{2Max} may help us to implement educative policies in order to promote or avoid healthy/unhealthy behaviors.

In our knowledge, it does not exist any study, which has analyzed the impact of recess PA or sedentary time (assessed by accelerometry) on VO_{2Max} (measured) in children and adolescents. The purpose of this study was to examine whether objectively measured recess PA and ST are associated with VO_{2Max} independently of total daily PA. Additionally, we hypothesize that there could be some recess PA or ST variables, which will partially determine unhealthy or healthy VO_{2Max} condition in children and adolescents.

Methods

Sample

In this cross-sectional study, 172 healthy 3rd – 12th Spanish grade children and adolescents, aged 8 – 19 years were recruited from 8 schools and high schools from Spain (Malaga, Orense and Jaen regions). Detailed information about procedures and risks was exposed to parents/guardians and a written informed consent was obtained prior to participation in the study. All procedures were in accordance with the ethical principles for medical research involving human subjects from Helsinki declaration (25) and, approved by the Ethical Committee of the University of Malaga, Spain.

Accelerometry

Actigraph GT3X monitors were used to measure PA (Actigraph, Pensacola, FL, USA), which collects motion data on 3 orthogonal axes, which was reported reliability to quantify PA (26). Participants wore accelerometers next to the right hip (27) and fastened with an elastic belt. Data was collected with 1 s epoch as previous studies with children between 5 and 16 years (26, 28), to accurately capture patterns of high intensity and short duration PA.

In order to show differences between weekdays and weekend PA patterns, students were instructed to wear the accelerometer for 7 consecutive days (5 week-days and the whole weekend) except during water activities (swimming, showering) or while sleeping (29). Day one and day eight were combined to form a composite seventh day of data, briefly: The first day (1^{st} at 9.00 AM) and the time to stop collecting data (12.00 PM) were set, the following days (2^{nd} to 7^{th}), ACLs were programmed to record whole-day (0.00 AM to 23.59 PM). The last day (8^{th}) ACLs were set to record from 0.00 to 8.59 AM. Researchers placed devices during the first day in an explanatory session. Additionally, information about activities during school (9.00 AM and 2.00 PM) and the rest of the day (between 2.01 PM and 12.00 PM) were recorded. A weekly diary was also given for the purpose, in which subjects were asked to write down when they got up and went to bed, such as attendance to PE classes. Written instructions for wearing the instrument was explained and given to each participant. A wear-time of ≥ 10 hours/day for ≥ 5 days was used as the criterion for a valid measurement (30). From those, subjects who had at least 4 of 5 accelerometer data from recess were included in the analysis.

Data were downloaded from GT3X to the same computer where it was initialized to prevent time disturbances. Data analysis was carried out using the software ActiLife 6.0 (ActiGraph). The cut-off points proposed by Evenson, Catellier (27) were used: Sedentary PA ≤ 100; Ligh PA ≥ 100; Moderate PA ≥ 2296 and Vigorous PA ≥ 4012 counts·min^{-1}. Daily PA including PE days, daily PA without PE days, PE classes and weekly usual day (weighted average considering two days of PE a week and two weekend days) were analyzed. All PA levels have been reported as minutes/day or minutes/class of PE, steps/day, steps/session of PE and daily percentage in order to standardize PA values.

Cardiopulmonary exercise test (CPX-T)

The Chester Step Test was selected as CPX-T, which is a validated incremental five-level step test (31). It consists of going up and down in a bench (from 32 to 52 cm) at a pace set by a signal sound, which progressively was speeded up throughout the course of five levels. All children engaged a previous test and they were reminded briefly what students were required to do. Later, they were encouraged until exhaustion and the test was terminated either by the subject (because of dyspnea and/or leg fatigue) or by the supervisor when the student was unable to maintain properly the cadence for 15 seconds (32).

VO_{2Max} was assessed using a portable breath-by-breath metabolic unit (Metamax 3B, Cortex Biophysic, Leipzig, Germany) while performing CPX-T. The gas analyzers were calibrated using as references the room air and a bottle of known O_2 and CO_2 concentrations (5.0% CO_2, 15.0% O_2). Volume calibration was conducted with a three-liter volume syringe (Calibration syringe D, Sensormedics Hans Rudolph Inc 5530) each testing day. Heart rate was also collected using a Polar Team^2 (Finland) stored every 5 seconds.

A total of 668 acelerometers were worn. Considering lost data device, lost device and not meeting Troiano, Berrigan (30) recommendations, 282 accelerometers were stored. From those, 172 had at least 4 recordings of recess accelerometers. Regarding CPX-T, 503 breath-by-breath tests were performed until volitional exhaustion. Four hundred eighteen were considered valid (85 were discarded because of telemetry errors, non-valid data or technical issues). All together aceletrometry and VO_{2Max} valid data included a total of 147 participants.

Statistical Analysis

All variables are shown as mean and SD or median and ranges. The Kolmogorov-Smirnov test was used to confirm a non-parametric distribution. Spearman´s correlation analyses were carried out in order to explore associations between VO_{2Max} and PA intensities during RT. Further, a general lineal model was used to identify which recess PA variables were significantly associated with the outcome variable (VO_{2Max} as independent variable). The model was adjusted for daily ST and MVPA time without RT.

Additionally, children and adolescents were classified as “High VO_{2Max} / Healthy” (H) or “Low VO_{2Max} / Unhealthy” (UH) according to sex-specific and age-specific cut-off criteria for participants between 10 and 18 years (24) and under 10 years (5). U of Mann-Whitney tests were conducted to compare PA variables between sexes and VO_{2Max} categories. In order to conduct binary logistic regression (adjusted for age, sex and daily PA without recess) between recess PA and VO_{2Max} categories, recess PA variables were transformed into binary variables as follow: i) scholars who met or not 15 min of ST during RT; ii) scholars who met or not 5 minutes of MVPA (5min MVPA). The level of significance was set at $p \leq 0.05$ for all the tests. Analyses were conducted with the SPSS software (v. 20.0).

Results

Participants included in this analysis were 12.9 years old on average and 69% were normal weight without difference between girls and boys (Table 1). Both girls and boys did not meet PA activity recommendations, although boys performed significantly more minutes of MVPA than girls (46.2 vs. 52.7, $p \leq 0.05$). VO_{2Max} was higher in boys than girls.

TABLE 1 HERE

Overall, H and boys were more active during RT and less sedentary than their UH and female counterparts (both min/day and %). Regarding VO_{2Max} categories, all variables revealed high statistical differences ($p \leq 0.001$). Regarding sex, main differences shown that boys had higher VO_{2Max}, (44.1 vs. 35.9; $p \leq 0.001$) total PA (11.0 vs. 8.1 min/day; $p \leq 0.001$), light PA (22.4% vs. 17.5%; $p \leq 0.001$) and less ST (20.0 vs. 23.2 min/day and 64.6% vs. 74.3%; both $p \leq 0.001$) ($p \leq 0.001$) compared to girls. H participants displayed lower BMI than UH (19.5 vs. 20.1; $p \leq 0.05$) whereas no differences were found between male and female.

Additionally, no differences were revealed regarding sexes between H students. UH differences revealed that girls accrued a higher contribution to total MVPA than UH boys (4.7% vs. 3.2%; $p \leq 0.005$).

TABLE 2 HERE

Correlations adjusted for total daily PA among VO_{2Max}, BMI and PA intensities during RT are reported in table 3. All PA intensities during RT were associated with VO_{2Max}

and BMI. Negative associations were found VO_{2Max} between BMI and ST (-0.180, $p \leq 0.05$; -0.471, $p \leq 0.001$, respectively), whereas light (0.417), moderate (0.352), vigorous (0.451), MVPA (0.422) and total daily PA (0.464) were positively associated (all $p \leq 0.001$) with VO_{2Max}.

TABLE 3 HERE

General lineal model showed that ST during RT (β = - 0.577; $p \leq 0.001$) and age (β = -1.297; $p \leq 0.001$) were inversely correlated with VO_{2Max}, whereas sex (β = 6.323; $p \leq 0.01$), was also a predictor of VO_{2Max}. The final model adjusted for daily ST and daily MVPA time without RT, explained 39.3% of variance of VO_{2Max} ($R^2 = 0.393$, $p < 0.001$).

Odds ratios adjusted from the logistic regression between VO_{2Max} categories and categorical variables of recess PA. There was a likehood of -3.774 times to be in H category among those participants who met at least 15 minutes of ST during RT ($p < 0.01$). Regarding 5 min MVPA category, this was not a significant predictor of healthy VO_{2Max}.

TABLE 4 HERE

Discussion.

In this paper, we analyzed PA levels during RT, where our primary aim was to examine associations between PA and VO_{2Max} during RT in school-aged participants. The main findings were: A) H participants have higher PA time during RT than those classified as UH; b) we confirmed the importance of sedentary behavior as main determinant of VO_{2Max} and C) moreover, we found a higher likelihood to be an UH VO_{2Max} when spending more than 15 minutes during RT.

Our PA data during RT (Table 2) were similar with MVPA reported from English children (33). However % of MVPA was lower than children and adolescents from England and Spain (22, 34), which suggests our participants were poorly active, as confirmed by the low accomplishment of MVPA guidelines of 60 minutes a day (Table 1). Those differences might be consequence of several aspects such as social characteristics, boys/girls ratio, sport playgrounds, space availability and access to sport equipment have been suggested to influence PA behavior (35). It does not seem probable social characteristics or environment affect our results since this study was conducted only in public primary and secondary schools allocated in middle class neighbors in different regions of Spain (North and South), also assessments were conducted between the late September and early October, when the weather is similar in both areas (no significant rainfalls and mild temperatures). However, we cannot confirm results from other regions of Spain or Europe were obtained in similar circumstances and settings. All schools have large sport playgrounds equipped with basketball rings and futsal goals, also wide yards surrounded the playground, moreover children and adolescents could ask for sport goods to play during recess, so sport playgrounds, space availability and access to sport equipment should had affected all participants similarly, not being a source of bias in our sample. Regarding sex, we had a well-balanced boys/girls ratio, and in accordance with previous studies, boys were more active than girls during RT (22, 34-36), despite boys and girls had similar opportunities engage freely in PA and be successful. Since some authors have reported no significant differences between boys and girls from the same regions during other school-based PA such as physical education (36), that suggests that may be some social, psychological or physiological issues restrict girls to occupy their leisure time with PA.

When using VO_{2Max} as health CDV criteria, the PA results reported in the previous paragraphs may have implications for CDV health since all PA intensities (min/day or %) were significantly higher in H than UH participants. That profile followed similar trend for BMI and ST, so UH children and adolescents had higher values than H on average. Our general lineal model analysis confirmed the importance of BMI, age and ST, which were significant predictors of VO_{2Max} independently of total daily PA.

The novel finding of this study was that ST during RT was negatively associated with VO_{2Max} independently of total daily PA, which was not confirmed for MVPA during RT. Additionally, results from the binary logistic regression confirmed that participants who kept sedentary more than 15-minute RT, were more likely to be classified as UH compared to those who were not. To our knowledge, there is no previous research reporting associations between sedentary RT and VO_{2Max}; or analyzing VO_{2Max} categories and PA patterns during RT. However, the effects of ST on impaired VO_{2Max} have been reasonably well established, in instance prolonged sitting time during childhood has been inversely related with VO_{2Max} (11). Although the inheritance of VO_{2Max} has been reported to contribute up to 50% (37, 38) it seems that ST should be taken into account for youth healthy lifestyle (10, 39). Thus it has been suggested that a 10-minute increase of MVPA lessened 14-minute ST, or 5-minutes of vigorous PA prompted less 11 minutes of ST (39). Short breaks of PA have been also useful strategies to promote health outcomes (9, 10, 40, 41). We could not confirm those strategies, however our analysis revealed that avoid expend more than 50% of the recess (15 minutes) on sedentary behavior reduced the probability of having UH VO_{2Max} on 3.774, in accordance with school-based interventions during teaching time, which reported benefits on BMI, CRF, bone mass and cognitive function (13-15). Those results confirmed that encouraging children to interrupt ST (with bursts of PA, if possible MVPA) is viable strategy in scholar settings, which can ensure a healthy VO_{2Max} on average.

We could not explore the underlying mechanisms that explain why young break sedentary mechanism during RT, which is yet poorly understood. This study has been mainly focused on the efficacy of avoiding ST on VO_{2Max} variable, nevertheless we do not know if a 15-minute bout is worse than fifteen 1-minute bouts ST. Previous studies, have described either short or long bouts provided similar benefits on VO_{2Max} (16), which may confirm our 15 minute as a valid threshold. Although RT lasts half hour per school-day in Spain, the total amount of time per week accumulate 2.5 hours, which has been suggested to compensate seven hours a week of watching TV or similar activity (42) and significant contribution for meeting healthy guidelines of PA (21).

Regarding age, papers spotlighted that reporting changes in VO_{2Max} per kilogram of body mass would be a confounder, due to the growth-associated changes in body mass (43). During growth, the rate of decline of relative VO_{2Max} was affected by inactivity; which was more acute in girls across adolescence whereas in boys was more stable (44). During growth, a decrease in VO_{2Max} has been issued, similar to our results (β = -1.297). Additionally, similar findings have been displayed during a RT-based context over 2 to

5 years period of follow-up with elementary and high school subjects, where the levels and bouts of ST increased significantly statistically during school, being more inactive at later age (1, 45). Boys might consider this unstructured environment as an opportunity to be competitive and were prone to play sport games, dominating the space, whereas girls tended to do less demanding activities such as skipping rope, walking or socialize with friends (35, 36). Sex-based expectations and norms may influence a child's choice of PA, being more likely to be active during unstructured situations such as RT (36). Subsequently, in order to avoid this behavior, particularly among girls, targeting and encouraging PA among girls might be important in order reduce their ST.

Results suggested that children and adolescents should discourage ST because those who met more than 15-minute of ST during RT had higher likelihood of being UH than those who were less sedentary during RT. Further, targeting sedentary subjects RT might have a reflection on total PA and VO_{2Max}; further, seems easy and feasible to identify rather than others PAs, which request longer exposure time to detect this behavior. Previous findings may be of vital importance for future policies and CRF status with school-aged subjects.

Strenghts and limitations.

Strengths of this research were that CRF has been assessed by a breath by breath portable unit. PA was monitored using GT3X accelerometers (at 1 s epoch) in 3 Spanish regions (including 8 schools and high schools). Hence, objective sedentary PA levels have been collected during a daily free-play activity instead of self-report questionnaires or TV viewing. Children and teachers were told about the function of the accelerometers but it was mentioned that the aim was to assess overall PA without mentioning the RT. These measurements included at least 4 of 5 recesses, which was a solid measurement of PA pattern.

There are some limitations that may make us to interpret our results cautiously. The sample was drastically reduced because around 60% do not meet PA criterions published in Troiano, Berrigan (30) and were removed from the analyses. Additionally, even if accelerometers have shown to be valid and reliable for PA measurement, they have some limitations; these devices do not recognize the type of PA behavior (sitting, standing still, strength activities…) and the particularities of the week that might influence the extent or increase of PA during RT were not controlled, on the other hand we assume it is impossible to measure the same week twice in free living conditions. Furthermore, RT cut-points related to PA intensities were not found in papers, therefore further research of more specific cutoffs and its influence on health might be of interest. And finally should be taken into account the cross sectional study design and a limited sample of subjects (n=172). Future studies should extend the assessment of patterns of children´s PA and associations with VO_{2Max} in different school-based contexts to larger samples.

Bibliography.

1. Carson V, Cliff DP, Janssen X, Okely AD. Longitudinal levels and bouts of sedentary time among adolescent girls. BMC pediatrics. 2013;13:173. Epub 2013/10/22.
2. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. Int J Behav Nutr Phys Act. 2010;7(40):1-16.
3. Carnethon MR. Physical Activity and Cardiovascular Disease: How Much is Enough? American journal of lifestyle medicine. 2009;3(1 Suppl):44S-9S. Epub 2010/04/27.
4. Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. Physiological and health implications of a sedentary lifestyle. Applied physiology, nutrition, and

metabolism = Physiologie appliquee, nutrition et metabolisme. 2010;35(6):725-40. Epub 2010/12/18.
5. Adegboye AR, Anderssen SA, Froberg K, Sardinha LB, Heitmann BL, Steene-Johannessen J, et al. Recommended aerobic fitness level for metabolic health in children and adolescents: a study of diagnostic accuracy. Br J Sports Med. 2011;45(9):722-8. Epub 2010/06/19.
6. Lakka TA, Laaksonen DE, Lakka HM, Mannikko N, Niskanen LK, Rauramaa R, et al. Sedentary lifestyle, poor cardiorespiratory fitness, and the metabolic syndrome. Med Sci Sports Exerc. 2003;35(8):1279-86. Epub 2003/08/06.
7. Santos R, Mota J, Okely AD, Pratt M, Moreira C, Coelho ESMJ, et al. The independent associations of sedentary behaviour and physical activity on cardiorespiratory fitness. Br J Sports Med. 2013;0:6. Epub 2013/02/16.
8. Carson V, Janssen I. Volume, patterns, and types of sedentary behavior and cardio-metabolic health in children and adolescents: a cross-sectional study. BMC public health. 2011;11:274. Epub 2011/05/06.
9. Saunders TJ, Tremblay MS, Mathieu ME, Henderson M, O'Loughlin J, Tremblay A, et al. Associations of sedentary behavior, sedentary bouts and breaks in sedentary time with cardiometabolic risk in children with a family history of obesity. PLOS ONE. 2013;8(11):e79143. Epub 2013/11/28.
10. Healy GN, Dunstan DW, Salmon J, Cerin E, Shaw JE, Zimmet PZ, et al. Breaks in sedentary time: beneficial associations with metabolic risk. Diabetes care. 2008;31(4):661-6. Epub 2008/02/07.
11. Chinapaw M, Proper K, Brug J, Van Mechelen W, Singh A. Relationship between young peoples' sedentary behaviour and biomedical health indicators: a systematic review of prospective studies. Obesity reviews : an official journal of the International Association for the Study of Obesity. 2011;12(7):e621-e32.
12. Blaes A, Ridgers ND, Aucouturier J, Van Praagh E, Berthoin S, Baquet G. Effects of a playground marking intervention on school recess physical activity in French children. Prev Med. 2013;57(5):580-4. Epub 2013/08/13.
13. Donnelly JE, Lambourne K. Classroom-based physical activity, cognition, and academic achievement. Prev Med. 2011;52 Suppl 1:S36-42. Epub 2011/02/02.
14. McKay HA, MacLean L, Petit M, MacKelvie-O'Brien K, Janssen P, Beck T, et al. "Bounce at the Bell": a novel program of short bouts of exercise improves proximal femur bone mass in early pubertal children. Br J Sports Med. 2005;39(8):521-6. Epub 2005/07/28.
15. Katz DL, Cushman D, Reynolds J, Njike V, Treu JA, Walker J, et al. Putting Physical Activity Where It Fits in the School Day: Preliminary Results of the ABC (Activity Bursts in the Classroom) for Fitness Program. Preventing Chronic Disease. 2010:09_0176.
16. Stone MR, Rowlands AV, Middlebrooke AR, Jawis MN, Eston RG. The pattern of physical activity in relation to health outcomes in boys. Int J Pediatr Obes. 2009;4(4):306-15.
17. Ekelund U, Brage S, Froberg K, Harro M, Anderssen SA, Sardinha LB, et al. TV viewing and physical activity are independently associated with metabolic risk in children: the European Youth Heart Study. PLoS medicine. 2006;3(12):e488.
18. Verloigne M, Van Lippevelde W, Maes L, Yildirim M, Chinapaw M, Manios Y, et al. Self-reported TV and computer time do not represent accelerometer-derived total sedentary time in 10 to 12-year-olds. European journal of public health. 2013;23(1):30-2. Epub 2012/05/01.

19. Denton SJ, Trenell MI, Plötz T, Savory LA, Bailey DP, Kerr CJ. Cardiorespiratory fitness is associated with hard and light intensity physical activity but not time spent sedentary in 10–14 year old schoolchildren: the HAPPY study. PLOS ONE. 2013;8(4):e61073.
20. Melo X, Santa-Clara H, Almeida JP, Carnero EA, Sardinha LB, Bruno PM, et al. Comparing several equations that predict peak VO2 using the 20-m multistage-shuttle run-test in 8-10-year-old children. Eur J Appl Physiol. 2011;111(5):839-49. Epub 2010/11/11.
21. Ridgers ND, Stratton G, Fairclough SJ. Physical activity levels of children during school playtime. Sports medicine (Auckland, NZ). 2006;36(4):359-71. Epub 2006/04/01.
22. Ridgers N, Saint-Maurice PF, Welk GJ, Siahpush M, Huberty J. Differences in physical activity during school recess. Journal of School Health. 2011;81(9):545-51.
23. Martinez-Gomez D, Ruiz JR, Ortega FB, Casajús JA, Veiga OL, Widhalm K, et al. Recommended levels and intensities of physical activity to avoid low-cardiorespiratory fitness in European adolescents: The HELENA study. American Journal of Human Biology. 2010;22(6):750-6.
24. Welk G, Meredith MD. FITNESSGRAM/ACTIVITYGRAM: reference guide. Dallas, Texas. : The Cooper Institute; 2008.
25. Association WM. Declaration of Helsinki, ethical principles for medical research involving human subjects. Edinburgh, Scotland2000.
26. Santos-Lozano A, Santín-Medeiros F, Cardon G, Torres-Luque G, Bailón R, Bergmeir C, et al. Actigraph GT3X: Validation and Determination of Physical Activity Intensity Cut Points. Int J Sports Med. 2013;34(11):975-82.
27. Evenson KR, Catellier DJ, Gill K, Ondrak KS, McMurray RG. Calibration of two objective measures of physical activity for children. Journal of sports sciences. 2008;24(14):1557-65.
28. Trost SG, Loprinzi PD, Moore R, Pfeiffer KA. Comparison of accelerometer cut points for predicting activity intensity in youth. Med Sci Sports Exerc. 2011;43(7):1360-8.
29. Trost SG, McIver KL, Pate RR. Conducting accelerometer-based activity assessments in field-based research. Med Sci Sports Exerc. 2005;37(11 Suppl):S531.
30. Troiano RP, Berrigan D, Dodd K. Physical Activity in the United States Measured by Accelerometer. Med Sci Sports Exerc. 2008;40(1):181-8.
31. Sykes K, Roberts A. The Chester step test—a simple yet effective tool for the prediction of aerobic capacity. Physiotherapy. 2004;90(4):183-8.
32. De Camargo AA, Justino T, De Andrade CH, Malaguti C, Dal Corso S. Chester step test in patients with COPD: reliability and correlation with pulmonary function test results. Respiratory care. 2011;56(7):995-1001. Epub 2011/07/12.
33. Fairclough S, Breighle A, Erwin H, Ridgers N. School day segmented physical activity patetrs of high and low active children. BMC public health. 2012;12(406).
34. Martinez-Gomez D, Veiga OL, Zapatera B, Gomez-Martinez S, Martinez D, Marcos A. Physical Activity During High School Recess in Spanish Adolescents: The AFINOS Study. J Phys Act Health. 2013;11(6):1194-201. Epub 2013/08/22.
35. Ridgers ND, Salmon J, Parrish AM, Stanley RM, Okely AD. Physical activity during school recess: a systematic review. Am J Prev Med. 2012;43(3):320-8. Epub 2012/08/18.
36. Sarkin JA, McKenzie TL, Sallis JF. Gender differences in physical activity during fifth-grade physical education and recess periods. Journal of Teaching in Physical Education. 1997;17(1):99-106.

37. Bouchard C, Daw EW, Rice T, Perusse L, Gagnon J, Province MA, et al. Familial resemblance for VO2max in the sedentary state: the HERITAGE family study. Med Sci Sports Exerc. 1998;30(2):252-8. Epub 1998/03/21.
38. Bouchard C, Sarzynski MA, Rice TK, Kraus WE, Church TS, Sung YJ, et al. Genomic predictors of the maximal O(2) uptake response to standardized exercise training programs. Journal of applied physiology (Bethesda, Md : 1985). 2011;110(5):1160-70. Epub 2010/12/25.
39. Herman KM, Paradis G, Mathieu ME, O'Loughlin J, Tremblay A, Lambert M. Association between accelerometer-measured physical activity intensities and sedentary time in 8- to 10-year-old children. Pediatr Exerc Sci. 2014;26(1):76-85. Epub 2013/09/11.
40. Saunders TJ, Larouche R, Colley RC, Tremblay MS. Acute sedentary behaviour and markers of cardiometabolic risk: a systematic review of intervention studies. Journal of nutrition and metabolism. 2012;2012:712435. Epub 2012/07/04.
41. Healy GN, Matthews CE, Dunstan DW, Winkler EA, Owen N. Sedentary time and cardio-metabolic biomarkers in US adults: NHANES 2003-06. European heart journal. 2011;32(5):590-7. Epub 2011/01/13.
42. Van den Bulck J, Hofman A. The television-to-exercise ratio is a predictor of overweight in adolescents: results from a prospective cohort study with a two year follow up. Prev Med. 2009;48(4):368-71. Epub 2009/05/26.
43. Teran-Garcia M, Rankinen T, Bouchard C. Genes, exercise, growth, and the sedentary, obese child. Journal of applied physiology (Bethesda, Md : 1985). 2008;105(3):988-1001. Epub 2008/06/07.
44. Bouchard C. Genetics of fitness and physical performance: Human Kinetics; 1997.
45. Ridgers ND, Timperio A, Crawford D, Salmon J. Five-year changes in school recess and lunchtime and the contribution to children's daily physical activity. Br J Sports Med. 2012b;46(10):741-6. Epub 2011/05/21.

CONCLUSIONES

a) Los diferentes criterios empleados a nivel metodológico en el empleo de acelerómetros, dificultan la comparación entre estudios a pesar de que existan ciertos puntos a nivel metodológico.

b) Los mejores predictores del VO_{2Max} son la edad, el tiempo total a intensidad sedentaria y la categoría de índice de masa corporal.

c) Los niveles de AF son bajos, así como el cumplimiento de recomendaciones en la población escolar.

d) El recreo y la educación física permiten acumular una mayor cantidad de actividad física a intensidad desde moderada a vigorosa por hora que otras actividades de mayor duración.

e) Se muestran diferencias en los niveles de actividad física, así como en los bouts netos y acumulados durante el receo, EF y resto de actividades.

f) Los resultados en el análisis de bouts, sugieren diferentes patrones de comportamiento de los bouts en función de su análisis como bouts netos o acumulados.

g) Los alumnos deben evitar permanecer a intensidad a nivel sedentaria durante el recreo, debido a que quienes acumularon más de 15 minutos tuvieron mayores posibilidades de tener un consumo máximo de oxígeno catalogado como no saludable.

Conclusión general:

Los resultados de la presente tesis revelan diferencias en los niveles de AF, bouts acumulados y netos durante las actividades analizadas dentro y fuera del horario escolar. En general se muestran unos niveles bajos de AF en escolares de primaria y secundaria. Al respecto, cobra importancia reducir los niveles semanales y durante el recreo a intensidad sedentaria para no disminuir los valores de VO_{2Max}.

CONCLUSIONS

a) The different methodological criteria used with accelerometer, makes it difficult to compare criteria among researchs in spite of some papers carried out similar methods.

b) Main predictors of maximum oxygen uptake are age, total sedentary time and body mass index category.

c) Overall, subjects displayed low physical activity levels and low meeting of health guidelines among school-aged population.

d) Recess and physical education classes allow accruing a higher moderate to vigorous physical activity per hour than other longer activities.

e) Differences in PA levels, net and accumulated bouts are displayed during recess, PE and NPERA.

f) Analysis of bouts suggest different pattern of behavior when using accumulated or net bout approaches.

g) School-aged subjects should discourage sedentary time during recess because those who met more than 15-minute had higher likelihood of being UH.

Overall conclusion:

Our results show differences regarding PA levels, net and accumulated bouts during school-based activities and out-of-school activities. Overall, low levels of PA are displayed in elementary and secondary school subjects. In regard of VO_{2Max}, discouraging weekly and recess ST is important for not lessen VO_{2Max} levels.