

Recommended Levels of Physical Activity to Avoid an Excess of Body Fat in European Adolescents

The HELENA Study

David Martinez-Gomez, MSc, Jonatan R. Ruiz, PhD, Francisco B. Ortega, PhD, Oscar L. Veiga, PhD, Diego Moliner-Urdiales, PhD, Beatrice Mauro, BSc, Miriam Galfo, PhD, Yannis Manios, PhD, Kurt Widhalm, PhD, Laurent Béghin, PhD, Luis A. Moreno, PhD, Denes Molnar, PhD, Ascension Marcos, PhD, Michael Sjöström, PhD, on behalf of the HELENA Study Group

Background: It is unclear how much physical activity is necessary to prevent obesity during adolescence.

Purpose: The purpose of this study was to examine whether the current physical activity guidelines for youth are associated with a lower risk of excess of body fat in European adolescents.

Methods: A sample of 2094 adolescents from the HELENA cross-sectional study was selected. Levels of moderate, vigorous, and moderate to vigorous physical activity (MVPA) were assessed using accelerometers. BMI and percentage of body fat (skinfolds) were calculated and used to categorize the adolescents as normal-weight/normal-fat, overweight/overfat, and obese. Data were collected during 2006–2007. Receiver operating characteristic (ROC) analysis, performed in 2009, was used to determine thresholds that best discriminate between weight and body fat categories.

Results: ROC analysis showed that ≥ 18 minutes/day in vigorous physical activity and ≥ 55 minutes/day in MVPA significantly discriminated between normal-weight and overweight+obesity categories. Moreover, ≥ 9 minutes/day of vigorous physical activity and ≥ 49 minutes/day of MVPA discriminated between normal-fat and overfat/obese adolescents. Adolescents who did not meet the current physical activity guidelines for youth of 60 minutes/day in MVPA increased the risk of having overweight+obesity (OR=1.24, 95% CI=1.01, 1.534) and overfat+obesity (OR=1.79, 95% CI=1.33, 2.42). ORs increased when adolescents did not meet the guidelines of at least 15 minutes/day in vigorous physical activity.

Conclusions: Current physical activity guidelines seem to be appropriate to prevent excess of body fat in European adolescents. However, participation in vigorous physical activity might have additional importance in preventing obesity.

(Am J Prev Med 2010;39(3):203–211) © 2010 American Journal of Preventive Medicine

From the Unit for Preventive Nutrition (Martinez-Gomez, Ruiz, Ortega, Sjöström), Department of Biosciences and Nutrition at Novum, Karolinska Institute, Huddinge, Sweden; Immunonutrition Research Group (Martinez-Gomez, Marcos), Department of Metabolism and Nutrition, Institute of Refrigeration, Institute of Food Science, Technology and Nutrition (ICTAN), Spanish National Research Council; Department of Physical Education (Martinez-Gomez, Veiga), Sport and Human Movement, Faculty of Teacher Training and Education, The Autonomous University of Madrid, Madrid; Department of Medical Physiology (Ortega), Faculty of Medicine, Granada; Growth, Exercise, Nutrition and Development (GENUD) research group (Moliner-Urdiales, Moreno), University School of Health Sciences, University of Zaragoza, Zaragoza, Spain; INRAN—National Research Institute for Food and Nutrition (Mauro, Galfo), Rome, Italy; Department of Nutrition and

Dietetics (Manios), Harokopio University, Athens, Greece; Division of Nutrition and Metabolism (Widhalm), Department of Pediatrics, Medical University of Vienna, Vienna, Austria; Clinical Investigation Center (Béghin), National Institute for Medical Research (INSERM), Regional University Hospital Center (CHRU) of Lille, and Faculty of Medicine, Institute of Preventive Medicine and Therapeutic Research, University Lille, Lille, France; and Department of Pediatrics (Molnar), University of Pecs, Pécs-József, Hungary

Address correspondence to: Michael Sjöström, PhD, Unit for Preventive Nutrition, Department of Biosciences and Nutrition at Novum, Karolinska Institute, 14157 Huddinge, Sweden. E-mail: michael.sjostrom@prevnut.ki.se.

0749-3797/\$17.00

doi: 10.1016/j.amepre.2010.05.003

Introduction

Many years have passed since the first recommendation of physical activity for children and adolescents stated by the American College of Sports Medicine in 1988¹ up to the more recent physical activity guidelines for youth from the USDHHS in December 2008.² During these years, findings from cross-sectional, longitudinal, and experimental studies have contributed to the development of different physical activity guidelines. Several experimental studies helped to examine the dose–response effect of physical activity on pediatric obesity.³ On the other hand, cross-sectional studies have also evaluated dose–response associations^{4,5} and adherence to physical activity recommendations.^{6–8} In spite of this, the question about how much physical activity is necessary to prevent obesity in young people remains to be elucidated.⁹

Several physical activity recommendations suggest that youth should engage in at least 60 minutes/day in moderate to vigorous physical activity (MVPA).^{2,10–17} However, Health Canada promoted a recommendation among Canadian children and adolescents that reached 90 minutes/day in MVPA.¹⁷ Another concern is that these physical activity recommendations do not distinguish between children and adolescents¹⁸ despite the well-documented biological differences between the two life periods¹⁹ as well as the decrease of physical activity from childhood to adolescence.^{20,21} Therefore, specific recommendations for children and adolescents are warranted. To date, only one old physical activity recommendation has been specifically developed for adolescents,²² and it is stated that adolescents should participate in at least 20 minutes/day of MVPA.

The aim of the present study was to examine whether the current physical activity guidelines are associated with a low risk of having excess of body fat in European adolescents participating in the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross-Sectional Study (HELENA-CSS).

Methods

Design and Participants

The HELENA-CSS is a multicenter investigation carried out in 10 European cities: Athens (Greece); Dortmund (Germany); Ghent (Belgium); Heraklion (Greece); Lille (France); Pécs (Hungary); Rome (Italy); Stockholm (Sweden); Vienna (Austria); and Zaragoza (Spain). The main aim of the HELENA-CSS was to obtain reliable and comparable data on a broad battery of relevant nutrition- and health-related parameters.²³ The sampling and recruitment processes were detailed in a previous report.²³ In brief, a multiple-stage cluster random sample of adolescents, stratified for geographic location, age, and SES, was obtained, striving for repre-

sentativeness on the level of these cities. Data collection from the HELENA-CSS took place in 2006–2007.

A total of 3865 adolescents were recruited at schools and met the general HELENA-CSS inclusion criteria: aged 12.5–17.5 years, not participating simultaneously in another clinical trial, free of any acute infection 1 week before the inclusion, and having information on weight and height.²³ Adolescents and their parents or guardians were informed of the nature and characteristics of the study, and all provided a written informed consent. Ethics committees from each country approved the HELENA-CSS protocols.²⁴

Body Fat Measurements

Measurements were performed with the adolescent barefoot and in underwear. Body weight was measured to the nearest 0.1 kg with an electronic scale and height was measured with a telescopic stadiometer to the nearest 0.1 cm.²⁵ BMI was calculated as body weight divided by the square of height (kg/m²). Skinfold thickness was measured to the nearest 0.2 mm in triplicate in the left with a Holtain caliper.²⁵ Body fat percentage (%BF) was calculated from triceps and subscapular skinfolds using Slaughter's equations.^{26,27} Age- and gender-standardized BMI cutoff points were used to define overweight and obesity.²⁸ In addition, age- and gender-specific 85th and 95th percentile of %BF in the study sample were used to define overfat and obese adolescents.

Physical Activity Measurements

Levels of physical activity were objectively measured using the ActiGraph GT1M accelerometer. This accelerometer is a compact, small, lightweight, and uniaxial monitor designed to detect vertical acceleration movements. This accelerometer has been widely validated in youth.²⁹ Adolescents were instructed to place the accelerometer at the lower back using an elastic waistband. They were also instructed to wear the accelerometer at all times for 7 consecutive days and to remove it only during water-based activities and sleeping. The interval of time (epoch) was set at 15 seconds in concordance with consensus recommendations for assessing physical activity in these ages.³⁰ The data were downloaded onto a computer using the manufacturer's software and later were analyzed by a software based on Visual Basic. The analyzer excluded from the analysis bouts of 20 continuous minutes of zeros output, considering these periods as nonwearing time. Inclusion criteria of at least 3 days of valid recording and a minimum of 8 hours' registration per day were necessary to be included in the study.

The time spent (minutes/day) in moderate and vigorous physical activity was calculated based on cutoffs of 500 counts per 15 seconds and 1000 counts per 15 seconds, respectively. Further, MVPA was calculated using the cutoff point of ≥ 500 counts per 15 seconds that is equivalent to walking at 3 km/hour.³¹ These cutoff points to define the intensity categories are similar to those used in previous studies^{32,33} with European children and adolescents.

Statistical Analyses

A sample of 2199 adolescents had valid data on physical activity and BMI. Both samples were equivalent to the full HELENA-CSS sample according to age, gender distribution, and anthropometric measures. Further, because the aim of this study was to study the excess of body fat, those adolescents classified as underweight³⁴ were not included ($n=105$), even though there were no differences

in levels of physical activity between underweight and normal-weight adolescents (all $p > 0.05$). Thus, the present study sample comprised 2094 adolescents (973 boys and 1121 girls), and a total of 1994 (902 boys and 1092 girls) had valid data on skinfold thicknesses.

Study sample characteristics are presented as mean (SD), unless otherwise stated. Differences between genders were analyzed by ANOVA for continuous variables and by the chi-square test for nominal variables. Receiver operating characteristic (ROC) curves³⁵ were used to calculate the optimal physical activity cutoff points for moderate physical activity, vigorous physical activity, and MVPA that best discriminate between the normal-weight/normal-fat and overweight+obesity/overfat+obesity categories. Additional analyses were performed to discriminate between normal-weight/normal-fat and obesity using both classifications.

An ROC curve provides the whole spectrum of specificity/sensitivity values for all the possible cutoffs. Sensitivity was considered as the probability to correctly identify an overweight/overfat or obese adolescent (true-positive proportion). Specificity was considered to be the probability of correctly identifying a normal-weight/normal-fat adolescent. The false-positive proportion were those normal-weight/normal-fat adolescents who were incorrectly identified as being overweight/overfat or obese.

To identify the best cutoff, the distance between the ideal test and each sensitivity and 100-specificity pair was calculated with the MedCalc statistical software, version 10.4.5). The area under ROC curve (AUC) and 95% CIs were calculated using the same software. The AUC represents the ability of the test to correctly classify

adolescents according to their weight/body-fat category. Values of AUC range from 0.5 (noninformative test) to 1.0 (ideal test). The cutoffs, AUC, and the sensitivity/specificity pairs were also calculated for the total sample and for each gender.

Finally, the percentages of adolescents meeting different definitions of physical activity recommendations for youth (20, 60, and 90 minutes/day in MVPA, 60 minutes/day in MVPA with 30 minutes/day in vigorous physical activity, and the recommendation obtained in this study from the ROC analysis) were calculated. Further, the relationship between not meeting the physical activity recommendations and an unhealthy weight or body fat status was examined by binary logistic regression analysis. These analyses were conducted using SPSS, version 15.0, for Windows, and the level of significance was set at < 0.05 . All the analyses were performed in 2009.

Results

Characteristics of the study sample are shown in Table 1. ROC analysis using BMI categories (Table 2) showed that moderate physical activity does not discriminate among weight status categories, whereas vigorous physical activity significantly discriminated between normal-weight and overweight+obesity, and between normal-weight and obesity. The significant cutoff points of vigorous physical activity associated with normal-weight were 18 minutes/day for all, 18–19 minutes/day in boys, and 10 minutes/day in girls. The

optimal cutoffs for time spent in MVPA were also significant between normal-weight and overweight+obesity and between normal-weight and obesity. These cutoffs were with 55–71 minutes/day in MVPA for all, 56 minutes/day of MVPA for boys, and 49–51 minutes/day of MVPA for girls.

Receiver operating characteristic analysis using %BF categories (Table 3) showed that a cutoff point of 29 minutes/day in moderate physical activity discriminated between the normal-fat and excess-of-body-fat categories in girls. Vigorous physical activity and MVPA cutoffs significantly discriminated between the normal-fat and ex-

Table 1. Physical characteristics, body fat, and levels of physical activity in European adolescents

Characteristics	All	Boys	Girls	P_{gender}
<i>n</i>	2094	973	1121	
Age (years)	14.7 (1.2)	14.7 (1.2)	14.7 (1.2)	0.683
Weight (kg)	59.0 (11.7)	61.7 (13.0)	56.6 (9.9)	< 0.001
Height (cm)	165.5 (9.2)	169.6 (9.8)	162.0 (7.0)	< 0.001
BMI	21.4 (3.4)	21.3 (3.5)	21.5 (3.3)	0.257
Overweight (%) ^a	17.8	18.6	17.1	0.060
Obesity (%) ^a	5.3	6.4	4.4	0.042
Overweight+obesity (%) ^a	23.1	25.0	21.5	0.060
Body fat (%) ^b	23.8 (9.2)	20.2 (10.2)	26.7 (6.9)	< 0.001
Accelerometer wearing time (minutes/day)	772 (93)	778 (97)	766 (90)	< 0.005
Moderate physical activity (minutes/day)	39 (15)	42 (16)	37 (14)	< 0.001
Vigorous physical activity (minutes/day)	19 (14)	24 (14)	14 (11)	< 0.001
MVPA (minutes/day)	58 (25)	66 (26)	50 (25)	< 0.001

Note: Values are M (SD) unless otherwise specified.

^aOverweight and obese adolescents were classified according to age- and gender-reference values proposed by the International Obesity Task Force.

^b $n = 1994$, 902, and 1092 for all, boys, and girls, respectively. MVPA, moderate to vigorous physical activity

Table 2. Physical activity cutoff points to identify the risk of an excess of body fat according to BMI categories^a in adolescents by ROC analysis

Subjects	Normal-weight vs overweight+obesity					Normal-weight vs obesity				
	Cutoff (minutes/day)	Se (%)	Sp (%)	AUC (95% CI)	p-value	Cutoff (minutes/day)	Se (%)	Sp (%)	AUC (95% CI)	p-value
All										
Moderate physical activity	47	29.1	74.9	0.48 (0.46, 0.51)	0.287	46	35.1	73.2	0.48 (0.42, 0.53)	0.390
Vigorous physical activity	18	67.1	46.9	0.58 (0.55, 0.61)	<0.001	18	80.2	47.2	0.66 (0.61, 0.71)	<0.001
MVPA	71	79.8	26.7	0.53 (0.51, 0.56)	0.022	55	64.9	49.8	0.57 (0.51, 0.62)	0.012
Boys										
Moderate physical activity	47	36.2	69.4	0.48 (0.44, 0.52)	0.363	45	48.4	64.0	0.47 (0.39, 0.54)	0.365
Vigorous physical activity	18	53.5	66.7	0.61 (0.57, 0.65)	<0.001	19	75.8	62.9	0.70 (0.63, 0.77)	<0.001
MVPA	56	44.9	65.3	0.55 (0.51, 0.59)	0.022	56	53.2	64.4	0.58 (0.50, 0.65)	0.030
Girls										
Moderate physical activity	38	46.1	59.4	0.50 (0.46, 0.54)	0.881	28	34.7	73.1	0.51 (0.43, 0.60)	0.784
Vigorous physical activity	10	55.6	59.2	0.59 (0.55, 0.63)	<0.001	10	79.6	56.2	0.70 (0.63, 0.77)	<0.001
MVPA	51	62.2	45.1	0.54 (0.50, 0.58)	0.039	49	71.4	49.3	0.61 (0.54, 0.69)	0.003

Note: p-values indicate AUC significantly >0.50.

^aBMI categories were classified according to age- and gender-reference values proposed by the International Obesity Task Force.

AUC, area under the ROC curve; MVPA, moderate to vigorous physical activity; ROC, receiver operating characteristic; Se, sensitivity; Sp, specificity

cess-of-body-fat categories. The vigorous physical activity cutoffs were 11–12 minutes/day for all, 17–18 minutes/day for boys, and 9–10 minutes/day for girls. The MVPA cutoffs were 49–52 minutes/day for the total sample, 47–55 for boys, and 41–42 for girls. The higher AUC

values were always found when comparing the normal-weight/normal-fat and obesity categories.

From the results obtained with the ROC analyses, cutoff points for MVPA could be slightly rounded to 60 minutes/day for boys and girls. However, the large differ-

Table 3. Physical activity cutoff points to identify the risk of an excess of body fat according to body fat categories^a in adolescents by ROC analysis

Subjects	Normal-fat vs overfat+obesity					Normal-fat vs obesity				
	Cutoff (minutes/day)	Se (%)	Sp (%)	AUC (95% CI)	p-value	Cutoff (minutes/day)	Se (%)	Sp (%)	AUC (95% CI)	p-value
All										
Moderate physical activity	28	27.2	78.9	0.51 (0.46, 0.55)	0.749	34	48.5	62.5	0.56 (0.49, 0.62)	0.054
Vigorous physical activity	11	53.0	70.3	0.65 (0.61, 0.69)	<0.001	12	69.7	66.2	0.73 (0.69, 0.78)	<0.001
MVPA	49	52.3	62.4	0.59 (0.56, 0.63)	<0.001	52	70.7	57.3	0.66 (0.60, 0.72)	<0.001
Boys										
Moderate physical activity	45	42.2	63.1	0.51 (0.45, 0.57)	0.694	38	53.3	55.5	0.49 (0.40, 0.58)	0.792
Vigorous physical activity	17	60.7	68.2	0.68 (0.62, 0.74)	<0.001	18	77.8	67.3	0.77 (0.70, 0.83)	<0.001
MVPA	47	35.6	79.3	0.59 (0.53, 0.65)	<0.001	55	62.2	65.2	0.63 (0.55, 0.72)	<0.001
Girls										
Moderate physical activity	29	39.3	72.6	0.55 (0.50, 0.61)	0.024	29	50.0	72.6	0.62 (0.54, 0.70)	0.001
Vigorous physical activity	9	63.8	63.2	0.65 (0.59, 0.71)	<0.001	10	81.5	61.6	0.76 (0.69, 0.82)	<0.001
MVPA	41	47.2	68.8	0.61 (0.55, 0.67)	<0.001	42	66.7	65.9	0.71 (0.64, 0.77)	<0.001

Note: p-values indicate AUC significantly >0.50.

^aBody fat categories were classified according to age- and gender-specific 85th and 95th percentile.

AUC, area under the ROC curve; MVPA, moderate to vigorous physical activity; ROC, receiver operating characteristic; Se, sensitivity; Sp, specificity

Table 4. Percentage of adolescents meeting physical activity recommendations for youth stratified in body fat categories

Categories	<i>n</i>	20 minutes/day MVPA	60 minutes/day MVPA	90 minutes/day MVPA	90 minutes/day MPA with 30 minutes/day VPA	The present study ^a
BMI CATEGORIES^b						
All						
Normal-weight	1610	96.7	42.0	10.2	8.3	37.8
Overweight	373	96.5	38.3	9.9	7.2	33.0
Obesity	111	100	31.5	9.0	5.4	23.4
Boys						
Normal-weight	730	98.4	58.8	17.7	14.7	50.0
Overweight	181	98.9	51.4	16.0	12.7	40.3
Obesity	62	100	45.2	14.5	8.1	22.6
Girls						
Normal-weight	880	95.3	28.1	4.5	3.1	26.4
Overweight	192	94.3	26.0	4.2	2.1	24.0
Obesity	49	100	14.3	2.0	2.0	14.3
% BODY FAT CATEGORIES^c						
All						
Normal-fat	1696	98.6	42.6	10.6	8.8	38.0
Overfat	199	97.5	35.2	6.5	3.0	30.2
Obesity	99	97.0	19.2	5.1	1.0	14.1
Boys						
Normal-fat	767	99.7	58.5	17.7	15.5	49.7
Overfat	90	98.9	53.5	10.0	5.6	38.9
Obesity	45	100	33.3	11.1	2.2	15.6
Girls						
Normal-fat	929	97.7	29.5	4.7	3.2	27.8
Overfat	109	96.3	20.2	3.7	0.9	16.5
Obesity	54	94.4	7.4	0	0	7.4

^a60 minutes/day in MVPA with 15 minutes/day in VPA (all), 20 minutes/day in VPA (boys), or 10 minutes/day in VPA (girls)

^bBMI categories were classified according to age- and gender-reference values proposed by the International Obesity Task Force.

^cPercentage of body fat categories were classified according to age- and gender-specific 85th and 95th percentile.

MPA, moderate physical activity; MVPA, moderate to vigorous physical activity; VPA, vigorous physical activity

ences between boys and girls in cutoff points for vigorous physical activity deserve emphasis. Therefore, three recommendations were proposed, based on the time spent in vigorous-intensity activity: (1) a combined recommendation for boys and girls of 60 minutes in MVPA with at least 15 minutes in vigorous physical activity; (2) a recommendation for boys of 60 minutes in MVPA with at least 20 minutes/day of vigorous physical activity; (3) a recommendation for girls of 60 minutes of MVPA with at

least 10 minutes of vigorous physical activity. The percentages of adolescents meeting the physical activity recommendations by gender, weight, and body fat categories are displayed in Table 4.

Figure 1a shows the OR of having overweight+obesity and overfat+obesity if the adolescent did not meet the physical activity recommendations for the total sample and by gender. In the whole sample, only those adolescents who did not meet the 60 minutes in MVPA recom-

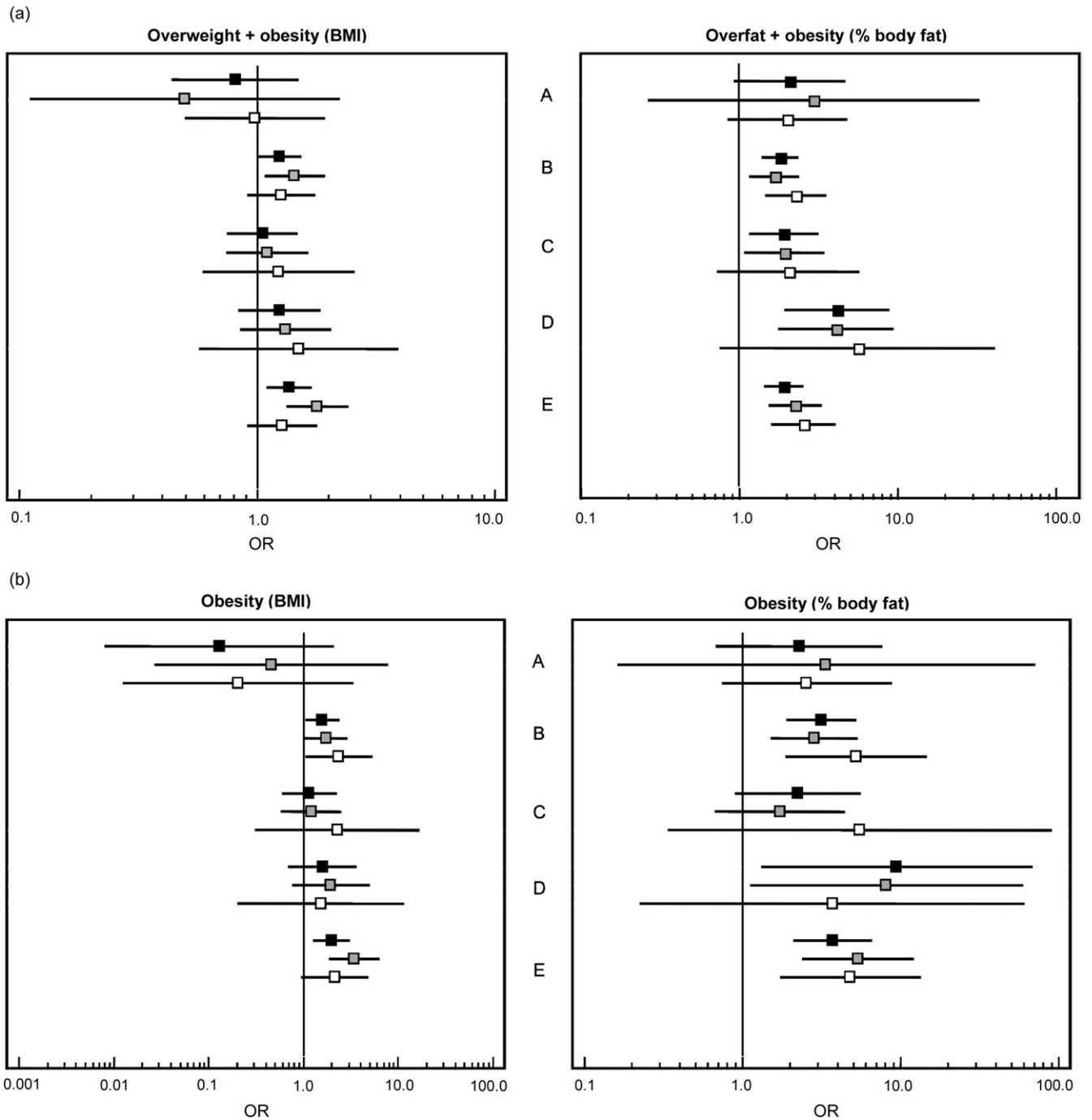


Figure 1. OR and 95% CI for having overweight+obesity and overfat+obesity (a) and obesity (b) in adolescents not meeting the physical activity recommendation, compared to those meeting the recommendations for the total sample (■); boys (▒); and girls (□)
 Note: The physical activity recommendations for youth are the following: A: 20 minutes/day in MVPA; B: 60 minutes/day in MVPA; C: 90 minutes/day in MVPA; D: 90 minutes/day in MVPA with 30 minutes/day in VPA; E: The present study: 60 minutes/day in MVPA with 15 minutes/day in VPA (all); or 20 minutes/day in VPA (boys); or 10 minutes/day in VPA (girls). MVPA, moderate to vigorous physical activity; VPA, vigorous physical activity

mentation and the recommendation of 60 minutes in MVPA with at least 15 minutes in vigorous physical activity had an increased risk of being in both the overweight+obesity (OR=1.24, 95% CI=1.01, 1.53, and

OR=1.36, 95% CI=1.10, 1.70, respectively) and the overfat+obesity (OR=1.79, 95% CIs=1.33, 2.42, and OR=1.85, 95% CI=1.40, 2.45, respectively) categories. Similarly in boys, only the 60 minutes in MVPA recommenda-

tion and the recommendation of 60 minutes in MVPA with at least 20 minutes in vigorous physical activity obtained significant ORs of having both overweight+obesity and overfat+obesity. In girls, none recommendation obtained significant ORs for overweight+obesity. Despite this, the 60 minutes in MVPA recommendation and the recommendation of 60 minutes in MVPA with at least 10 minutes in vigorous physical activity obtained significant ORs of overfat+obesity in girls. All analyses were repeated by analyzing the risk of having obesity in normal-weight/normal-fat adolescents and results were similar (Figure 1b).

Discussion

The main result of the current study suggests that physical activity recommendations for youth that advise 60 minutes/day in MVPA are associated with reduced risk of overweight and obesity in European adolescents. Adolescents who did not meet 60 minutes/day in MVPA with at least 10–20 minutes/day in vigorous physical activity might have a higher risk of having an excess of body fat than adolescents who meet the daily overall 60 minutes in MVPA.

The USDHHS together with several medical institutions recently launched the Physical Activity Guidelines for Children and Adolescents, where it is mentioned that this population group should participate in 60 minutes or more of physical activity daily.² This recommendation continues along the same lines as previous public health recommendations for this population. However, a final note in the USDHHS recommendation suggests that children and adolescents should do vigorous physical activity at least 3 days per week but none volume is stated.² The current results concur with these recommendations because it was also shown that between 10 and 20 minutes/day in vigorous physical activity might have a major benefit in reducing body fat in this life period. Only the Health Canada recommendation of 90 minutes/day in MVPA included a specific recommendation for vigorous physical activity (i.e., 30 minutes in vigorous physical activity).¹⁷ Conversely, the possibility to achieve this goal is questioned as observed in the current findings, and recently they have adhered to the standard 60 minutes in MVPA guidelines.¹¹ In contrast, the old recommendation for adolescents of 20 minutes in MVPA²² was achieved for most of adolescents independently of gender and body fat. According to the current results, the 20 and 90 minutes/day in MVPA thresholds do not seem to be adequate.

A threshold of 60 minutes/day in MVPA might discriminate between normal-weight and overweight+obesity adolescents as well as between those in the normal-fat versus overfat+obesity category. Nevertheless, approximately 20 minutes/day in vigorous physical activity in boys, 10 minutes/day in girls, and 15 minutes/day com-

binated for both genders discriminated more accurately between normal-weight/normal-fat and healthier weight and body fat categories. The key role of vigorous physical activity on overweight and obesity has been highlighted in a number of cross-sectional and experimental studies. For example, an earlier study³⁶ evaluated the effect of a vigorous physical activity training in 38 nonobese adolescents (18 control) and the results showed reductions in subcutaneous adipose tissue measured by magnetic resonance. Another study³⁷ examined the associations of objectively assessed physical activity with body fat measured by dual-energy x-ray absorptiometry (DXA), and only objectively assessed vigorous physical activity explained a significant proportion of the variance in body fat after controlling for potential confounders. Similarly, one study³⁸ found that insufficient vigorous physical activity estimated by accelerometry was the only risk factor for higher weight in 878 adolescents. Likewise, the authors have found similar results in previous reports.^{39–41} These and the current findings highlight the role of daily vigorous physical activity to prevent overweight and obesity during adolescence.

When the thresholds were examined by intensities, in general, moderate physical activity cutoff points did not significantly discriminate among weight and body fat categories, whereas vigorous physical activity always found significant cutoffs. Interestingly, MVPA cutoffs also discriminated between weight status and body fat categories. Taken together, the current results suggest that MVPA is negatively associated with an excess of body fat as a result of the vigorous physical activity included into the MVPA threshold. Likewise, in a previous study with a subsample of 365 Spanish adolescents from the HELENA-CSS, where body fat was measured by DXA, BodPod, and anthropometry, MVPA and especially vigorous physical activity were negatively associated with indicators of body fat.³⁹ Subsequently, the MVPA cutoff points found in the current study seem to represent the necessary time in MVPA to guarantee enough time in vigorous physical activity, in order to avoid excess of body fat in adolescents. Following this rationale, it is recommended that the guideline of 60 minutes in MVPA be maintained and that a specific period of vigorous physical activity be added as part of that time period instead of adding more overall time spent in physical activity (e.g., 60 minutes in MVPA plus 15 minutes in vigorous physical activity). Thus, an after-school intervention in black girls provided 80 minutes in MVPA in order to ensure enough vigorous physical activity, and the greatest decreases were found in those girls who maintained the highest heart rates during the training.⁴²

Differences observed between boys and girls in vigorous physical activity cutoff points allowed a different recom-

mentation with 20 minutes/day for boys and 10 minutes/day for girls and a combined recommendation of 15 minutes/day for both genders. The obvious biological and physical activity differences between genders across adolescence may need to be reflected in the physical activity guidelines. Several recommendations based on steps measured by pedometer have suggested different thresholds for boys and girls related to a healthy weight status.⁴³⁻⁴⁵ Nevertheless, a combined recommendation was included for both genders of 60 minutes/day in MVPA including 15 minutes/day in vigorous physical activity, similar to the recommendation made in a previous study.⁴⁶ This study⁴⁶ found that 45 minutes/day in moderate physical activity and 15 minutes/day in vigorous physical activity were independently associated with reduced body fat and BMI status in children. Unfortunately, the small sample did not allow an analysis by gender, but girls were engaged in less-vigorous physical activity than boys.

In further analyses, an examination was made of the ORs of having overweight+obesity, overfat+obesity, and obesity in adolescents not meeting several physical activity recommendations, including the current proposals obtained by the ROC analysis. These analyses showed that the whole sample that did not meet the recommendation had a significantly greater risk of having an excess of body fat than other recommendations. These results were stronger in boys than in girls, for whom the current proposal obtained similar results compared with the overall 60 minutes/day in MVPA recommendation. All the other physical activity recommendations failed to detect significant risks of having both overweight+obesity and overfat+obesity if the adolescent did not meet such recommendations.

Strengths of the current study include measurements by accelerometer and a relatively large sample of adolescents from 10 European cities. Also, two methods were used to estimate body fat (BMI and %BF by skinfolds). BMI is widely used for the screening of obesity both in children and adolescents; however, BMI seems to be associated with lean mass rather than with fat mass.⁴⁷ Likewise, physical activity might have an effect on both lean and fat masses.² Moreover, BMI seems to be a better indicator of adiposity than %BF obtained by skinfolds in obese adolescents.⁴⁸ These are the reasons why both BMI and %BF variables were included in this study.

The current study has limitations as well. The cross-sectional design limits the possibility to infer directionality. Thus, although reverse causality might be considered, there is certain evidence with regard to the plausible effect of physical activity on body fat in youth.^{36,42,49} Another limitation of the study is that both BMI and %BF by skinfolds are indirect methods to assess body fat. In addition, there are inherent limitations when the current

physical activity outcomes are compared with those of other studies because of several factors such as type of monitor, length of the epoch, and cutoff points selected.⁸

In summary, the physical activity recommendation of 60 minutes/day in MVPA may be enough to avoid excess of body fat in adolescents. However, vigorous physical activity seems to be a key factor for decreasing the possibility of being obese. Therefore, public health recommendations should include a specific amount of vigorous physical activity for adolescents. In this framework, these results need to be contrasted in experimental designs.

We acknowledge the help of all the adolescents who took part in the Helena study. The writing group takes sole responsibility for the content of this article. The content of this article reflects the views of the authors only, and the European Community is not liable for any use that may be made of the information contained therein. The HELENA study was supported by the European Community 6th RTD Framework Programme (Contract FOOD-CT-2005-007034). This study is also being supported by grants from the Spanish Ministry of Education (EX-2007-1124, EX-2008-0641, AP2006-02464), the Spanish Ministry of Health (Maternal, Child Health and Development Network, RD08/0072), the Swedish Council for Working Life and Social Research, and the Swedish Heart Lung Foundation (20090635).

No financial disclosures were reported by the authors of this paper.

References

1. American College of Sports Medicine. Opinion statement on physical fitness in children and youth. *Med Sci Sports Exerc* 1988;20:422-3.
2. USDHHS. 2008 Physical activity guidelines for Americans. Be active, healthy and happy! Washington DC: USDHHS, 2008.
3. Connelly JB, Duaso MJ, Butler G. A systematic review of controlled trials of interventions to prevent childhood obesity and overweight: a realistic synthesis of the evidence. *Public Health* 2007;121:510-7.
4. Marshall SJ, Biddle SJ, Gorely T, Cameron N, Murdey I. Relationships between media use, body fatness and physical activity in children and youth: a meta-analysis. *Int J Obes Relat Metab Disord* 2004;28:1238-46.
5. Jiménez-Pavón D, Kelly J, Reilly JJ. Associations between objectively measured physical activity and adiposity in children and adolescents: systematic review. *Int J Pediatr Obes* 2010;5:3-18.
6. Troiano RP, Berrigan D, Dodd KW, Mâsse LC, Tilert T, McDowell M. Physical activity in the U.S. measured by accelerometer. *Med Sci Sports Exerc* 2008;40:181-8.
7. Riddoch CJ, Bo Andersen L, Wedderkopp N, et al. Physical activity levels and patterns of 9- and 15-yr-old European children. *Med Sci Sports Exerc* 2004;36:86-92.
8. Martínez-Gómez D, Welk GJ, Calle ME, Marcos A, Veiga OL; and the AFINOS Study Group. Preliminary evidence of physical activity levels measured by accelerometer in Spanish adolescents. *The AFINOS Study. Nutr Hosp* 2009;24:212-8.

9. Reichert FF, Baptista Menezes AM, Wells JC, Carvalho Dumith S, Hallal PC. Physical activity as a predictor of adolescent body fatness: a systematic review. *Sports Med* 2009;39:279–94.
10. Strong WB, Malina RM, Blimkie CJ, et al. Evidence based physical activity for school-age youth. *J Pediatr* 2005;146:732–7.
11. Janssen I. Physical activity guidelines for children and youth. *Can J Public Health* 2007;98(2S):S109–21.
12. Kushi LH, Byers T, Doyle C, et al. American Cancer Society Guidelines on Nutrition and Physical Activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. *CA Cancer J Clin* 2006;56:254–81.
13. USDHHS. Physical activity. In: *Dietary guidelines for Americans 2005*. Washington DC: U.S. Government Printing Office, 2005:19–22.
14. Biddle SJ, Cavill NA, Sallis JF. Policy framework for young people and health-enhancing physical activity. In: Biddle SJ, Sallis JF, Cavill NA, eds. *Young and active? Young people and health-enhancing physical activity. Evidence and implications*. London: Health Education Authority, 1998:3–16.
15. Corbin CB, Pangrazi RP. Physical activity for children: a statement of guidelines for children aged 5–12. 2nd ed. Reston VA: National Association for Sport and Physical Education, 2004.
16. Department of Health and Ageing. National physical activity guidelines for Australians. Canberra: Commonwealth of Australia, 1999.
17. Public Health Canada. Family guide to physical activity for youth 10–14 years of age. Ottawa: Government of Canada, 2002.
18. Hallal PC, Victora CG, Azevedo MR, Wells JC. Adolescent physical activity and health: a systematic review. *Sports Med* 2006;36:1019–30.
19. Malina RM, Bouchard C, Bar-Or O. Growth, maturation, and physical activity. 2nd ed. Champaign IL: Human Kinetics, 2004.
20. Nader PR, Bradley RH, Houts RM, McRitchie SL, O'Brien M. Moderate-to-vigorous physical activity from ages 9 to 15 years. *JAMA* 2008;300:295–305.
21. Malina RM. Tracking of physical activity and physical fitness across the lifespan. *Res Q Exerc Sport* 1996;67(3S):S48–57.
22. Sallis JF, Patrick K. Physical activity guidelines for adolescents: consensus statement. *Pediatr Exerc Sci* 1994;6:302–14.
23. Moreno LA, De Henauw S, González-Gross M, et al.; HELENA Study Group. Design and implementation of the Healthy Lifestyle in Europe by Nutrition in Adolescence cross-sectional study. *Int J Obes (Lond)* 2008;32(5S):S4–11.
24. Béghin L, Castera M, Manios Y, et al.; HELENA Study Group. Quality assurance of ethical issues and regulatory aspects relating to good clinical practices in the HELENA cross-sectional study. *Int J Obes (Lond)* 2008;32(5S):S12–8.
25. Nagy E, Vicente-Rodriguez G, Manios Y, et al.; HELENA Study Group. Harmonization process and reliability assessment of anthropometric measurements in a multicenter study in adolescents. *Int J Obes (Lond)* 2008;32(5S):S58–65.
26. Slaughter MH, Lohman TG, Boileau RA, et al. Skinfold equations for estimation of body fatness in children and youth. *Hum Biol* 1988;60:709–23.
27. Rodríguez G, Moreno LA, Blay MG, et al.; AVENA-Zaragoza Study Group. Body fat measurement in adolescents: comparison of skinfold thickness equations with dual-energy X-ray absorptiometry. *Eur J Clin Nutr* 2005;59:1158–66.
28. Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;320:1240–3.
29. Freedson P, Pober D, Janz KF. Calibration of accelerometer output for children. *Med Sci Sports Exerc* 2005;37(11S):S523–30.
30. Ward DS, Evenson KR, Vaughn A, Rodgers AB, Troiano RP. Accelerometer use in physical activity: best practices and research recommendations. *Med Sci Sports Exerc* 2005;37(11S):S582–8.
31. Brage S, Wedderkopp N, Anderson LB, Froberg K. Influence of step frequency on movement intensity predictions with the CSA accelerometer: a field validation study in children. *Pediatr Exerc Sci* 2003;15:277–87.
32. Andersen LB, Harro M, Sardinha LB, et al. Physical activity and clustered cardiovascular risk in children: a cross-sectional study (The European Youth Heart Study). *Lancet* 2006;368:299–304.
33. Ekelund U, Anderssen SA, Froberg K, et al. Independent associations of physical activity and cardiorespiratory fitness with metabolic risk factors in children: the European youth heart study. *Diabetologia* 2007;50:1832–40.
34. Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cutoffs to define thinness in children and adolescents: international survey. *BMJ* 2007;335:194.
35. Zweig MH, Campbell G. Receiver-operating characteristic (ROC) plots: a fundamental evaluation tool in clinical medicine. *Clin Chem* 1993;39:561–77.
36. Eliakim A, Makowski GS, Brasel JA, Cooper DM. Adiposity, lipid levels, and brief endurance training in nonobese adolescent males. *Int J Sports Med* 2000;21:332–7.
37. Gutin B, Yin Z, Humphries MC, Barbeau P. Relations of moderate and vigorous physical activity to fitness and fatness in adolescents. *Am J Clin Nutr* 2005;81:746–50.
38. Patrick K, Norman GJ, Calfas KJ, et al. Diet, physical activity, and sedentary behaviors as risk factors for overweight in adolescence. *Arch Pediatr Adolesc Med* 2004;158:385–90.
39. Moliner-Urdiales D, Ruiz JR, Ortega FB, et al. Association of objectively assessed physical activity with total and central body fat in Spanish adolescents; The HELENA Study. *Int J Obes (Lond)* 2009;33:1126–35.
40. Ruiz JR, Rizzo NS, Hurtig-Wennlöf A, Ortega FB, Warnberg J, Sjöström M. Relations of total physical activity and intensity to fitness and fatness in children; The European Youth Heart Study. *Am J Clin Nutr* 2006;84:298–302.
41. Ortega FB, Ruiz JR, Sjöström M. Physical activity, overweight and central adiposity in Swedish children and adolescents: the European Youth Heart Study. *Int J Behav Nutr Phys Act* 2007;4:61.
42. Barbeau P, Johnson MH, Howe CA, et al. Ten months of exercise improves general and visceral adiposity, bone, and fitness in black girls. *Obesity (Silver Spring)* 2007;15:2077–85.
43. Tudor-Locke C, Pangrazi RP, Corbin CB, et al. BMI-referenced standards for recommended pedometer-determined steps/day in children. *Prev Med* 2004;38:857–64.
44. Duncan JS, Schofield G, Duncan EK. Step count recommendations for children based on body fat. *Prev Med* 2007;44:42–4.
45. Laurson KR, Eisenmann JC, Welk GJ, Wickel EE, Gentile DA, Walsh DA. Evaluation of youth pedometer-determined physical activity guidelines using receiver operator characteristic curves. *Prev Med* 2008;46:419–24.
46. Wittmeier KD, Mollard RC, Kriellaars DJ. Physical activity intensity and risk of overweight and adiposity in children. *Obesity (Silver Spring)* 2008;16:415–20.
47. Maynard LM, Wisemandle W, Roche AF, et al. Childhood body composition in relation to body mass index. *Pediatrics* 2001;107:344–50.
48. Castro-Piñero J, Artero EG, España-Romero V, et al. Criterion-related validity of field-based fitness tests in youth: a systematic review. *Br J Sports Med* 2009. [Epub ahead of print].
49. Riddoch CJ, Leary SD, Ness AR, et al. Prospective associations between objective measures of physical activity and fat mass in 12–14 year old children: the Avon Longitudinal Study of Parents and Children (ALSPAC). *BMJ* 2009;339:b4544.

Appendix

Supplementary data

Supplementary data associated with this article can be found, in the online version, at [doi:10.1016/j.amepre.2010.05.003](https://doi.org/10.1016/j.amepre.2010.05.003).