Original Research Article

Recommended Levels and Intensities of Physical Activity to Avoid Low-Cardiorespiratory Fitness in European Adolescents: The HELENA Study

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Objectives: The purpose of this study was to determine the sex-specific physical activity (PA) intensity thresholds that best discriminate between unhealthy/healthy cardiorespiratory fitness (CRF).

Methods: Participants included 1,808 adolescents (964 girls), aged 12.5–17.5 years, from the HELENA study. We measured PA by accelerometer and calculated the time spent at light, moderate, vigorous, and moderate-to-vigorous (MVPA) intensities. CRF was assessed by the 20-m shuttle-run test. Adolescents were dichotomized (unhealthy/healthy) based on sex- and age-specific FITNESSGRAM standards. Receiver operating characteristic (ROC) analysis was used to determine thresholds that best discriminate between CRF categories.

Results: ROC analyses revealed that the PA thresholds that best discriminate between unhealthy/healthy CRF were $\geq$152, $\geq$33, $\geq$13, and $\geq$52 min/day in light, moderate, vigorous, and MVPA, respectively. In boys, the PA thresholds associated with a healthy CRF were $\geq$37, $\geq$19, and $\geq$56 min/day in moderate, vigorous, and MVPA, respectively, whereas in girls were $\geq$152, $\geq$34, $\geq$12, and $\geq$51 min/day in light, moderate, vigorous, and MVPA, respectively. Spending at least 60 min/day in MVPA was also associated with a healthy CRF (odds ratios: 1.75, 1.94, and 1.57, all $P < 0.05$, for the whole sample, boys, and girls, respectively).

Conclusions: This study shows sex- and intensity-specific PA thresholds to discriminate between adolescents with a healthy CRF from those with a less favorable or unhealthy CRF level. Journal of Hospital Medicine. Society of Hospital Medicine. Am. J. Hum. Biol. 22:750–756, 2010.

Current evidence suggests that low-cardiorespiratory fitness (CRF) has harmful implications for health in both young people and adults (Kodama et al., 2009; Ortega et al., 2008b; Ruiz et al., 2009). In the 1990s, FITNESSGRAM established sex- and age-specific CRF cut-off values for adolescents known as Healthy Fitness Zones (The Cooper Institute, 2004). The Healthy Fitness Zones were designed to represent the healthy levels of CRF (expressed as maximum oxygen consumption relative to body weight, ml/kg/min) linked to adequate health-related outcomes in adolescents. The validity of these thresholds was successfully tested in American and European youth (Lobelo et al., 2009; Ortega et al., 2008c), and the findings indicated that a healthy CRF level according to the FITNESSGRAM standards is associated with a healthier cardiovascular profile in children and adolescents.

It is often assumed that physical activity (PA) and CRF are tightly associated in children and adolescents, but this assumption is not so obvious (Ortega et al., 2008b). Longitudinal studies showed that habitual PA explains around 10% of CRF variance across the lifespan (Malina, 1996, 2001). However, other nonmodifiable factors such as genetic, biologic, and growth are known to influence CRF (Teran-Garcia et al., 2008). Experimental studies have provided some insights regarding the dose-response between PA and CRF (Baquet et al., 2003), and it is generally accepted that 60 min/day of moderate-to-vigorous PA (MVPA) is associated with healthy CRF levels (Strong et al., 2005). However, the value of this PA recommendation based on objective methodology and related to CRF in current generations of European adolescents has not been tested.

To better understand the association between PA (assessed with objective methodology) and CRF is of public health relevance. Moreover, it is of importance to elucidate the role of different PA intensities. Therefore, the aim of this study was to examine the association between PA intensity levels and CRF in European adolescents and to determine the sex-specific PA intensity thresholds that best discriminate between unhealthy and healthy CRF levels based on the FITNESSGRAM standards.

MATERIALS AND METHODS

Design and participants

Adolescents were part of the Healthy Lifestyle in Europe by Nutrition in Adolescence Cross Sectional Study (HELENA-CSS), which is a multicenter study conducted in 10 cities from nine European countries: 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 nutrition and health-related parameters such as PA, fitness, body composition, food choices and preferences, cardiovascular risk factors, vitamins and mineral status, immunological biomarkers, and genetic markers (Moreno et al., 2008a,b). Data collection from the HELENA-CSS was carried out in the 2006−2007 period.

A total of 3,865 adolescents aged 12.5–17.5 years were recruited at high schools and met the inclusion criteria established in the HELENA study (Moreno et al., 2008a). This study included a total of 1,808 adolescents (844 boys and 964 girls) with valid data on weight, height, objectively measured PA by accelerometry, and CRF. All participants were recruited at schools and met the inclusion criteria established in the HELENA-CSS. Adolescents and theirs parents/guardians were informed of the characteristics of the HELENA-CSS, and all provided written informed consent. Ethics committees from each country approved the HELENA-CSS protocol (Béghin et al., 2008), and regulatory aspects relating to good clinical practices were conducted in concordance with the ethical guidelines of the Declaration of Helsinki (1961), as revised in Edinburgh (2000).

Anthropometric measurements

Body weight was measured with an electronic scale SECA 861 to the nearest 0.1 kg, and height was measured barefoot with a telescopic stadiometer SECA 225 to the nearest 0.1 cm (Nagy et al., 2008). Body mass index (BMI) was calculated as body weight divided by the square of height (kg/m^2).

PA measurements

Patterns of PA were objectively assessed using the ActiGraph GT1M (ActiGraph™, Pensacola, FL). This accelerometer is a compact, small (3.8 × 3.7 × 1.8 cm), lightweight (27 g), and uniaxial monitor designed to detect vertical accelerations ranging in magnitude from 0.05 to 2.00 *G*'s with a frequency response of 0.25–2.50 Hz. The ActiGraph has been previously validated in laboratory and free-living conditions in young people (Freedson et al., 2005).

Adolescents were instructed to wear the accelerometer for 7 consecutive days positioned at the lower back by using an elastic waistband. The accelerometer was worn during all time awake and only removed during water-based activities. In the HELENA-CSS, the interval of time (epoch) was set at 15 s according to consensus recommendations for assessing PA in youth (Ward et al., 2005). The data were downloaded onto a computer using the software provided by the manufacturer and were later analyzed by a software based on Visual Basic.

The choice of the inclusion criteria was based on thorough analyses of accelerometer data performed immediately after data collection. These analyses aimed to identify an optimal balance between the selection of appropriate criteria that lead to reliable PA data and avoid large reductions in the statistical power. Three criteria were examined: (i) number of valid days; (ii) length of a valid day, and (iii) definition of the nonwear time (i.e., 10, 20, 30, and 60 min of 0 values). The results suggested that a fair trade-off between the number of days needed to identify the usual PA level (reliability of at least 0.80), and statistical power can be achieved when using the following inclusion criteria: (i) minimum of 3 days measured, (ii) at least 8 h/day of valid records, and (iii) 20 min of consecutive epochs with 0 counts were deleted (unpublished observations).

The time spent in light PA (1.5–3 metabolic equivalents, METs), moderate PA (3–6 METs), and vigorous PA (>6 METs) were calculated based upon cut offs of 100, 2,000, and 4,000 counts per minute, respectively (Ekelund et al., 2007; Nilsson et al., 2009). Furthermore, the time spent in MVPA was calculated as the sum of moderate and vigorous periods. These cut-offs points to define the intensity categories are similar to those used in previous studies in youth (Ekelund et al., 2007; Nilsson et al., 2009).

CRF measurements

Levels of CRF were assessed by using the standardized 20-m shuttle-run test (Leger et al., 1988). Procedures, reliability, and normative levels of this test in the adolescents participating in the HELENA-CSS can be found elsewhere (Ortega et al., 2008a, in press). In brief, participants were required to run between two lines 20-m distant while keeping pace with audio signals emitted from a prerecorded CD. The initial speed is 8.5 km/h, which is increased by 0.5 km/h per minute or stage. The test was finished when the participant failed to reach the end lines concurrent with the audio signals on two consecutive occasions or stopped because of fatigue. The maximal oxygen consumption (VO_2max, ml/kg/min) was estimated by the Leger et al. (1988) equation. Adolescents were dichotomized based on meeting (healthy) or failing (unhealthy) the sex- and age-specific VO_2max FITNESSGRAM standards (The Cooper Institute, 2004).

Statistical analyses

Mean (SD) differences in descriptive statistics between boys and girls, and CRF status categories (unhealthy/healthy) were examined by two-way analysis of variance (ANOVA) for continuous variables and the χ^2 test for nominal variables.

Receiver operating characteristic (ROC) curve analysis (Zweig and Campbell, 1993) was used to calculate the optimal PA cut-off points for light PA, moderate PA, vigorous PA, and MVPA that best discriminate between unhealthy and healthy CRF. The area under the ROC curve (AUC) represents the ability of the test to correctly classify adolescents with unhealthy and healthy CRF. Values of AUC range from 0.5 (noninformative test) to 1.0 (ideal test). Sensitivity was considered as the probability to correctly identify an adolescent with healthy CRF (true-positive rate). Specificity was considered as the probability to correctly identify an adolescent with unhealthy CRF. The ROC curve provides the whole spectrum of specificity/sensitivity values for all the possible cut-off points. The optimal combination of true-positive rate and false-positive rate is the point closest to the perfect test.

Differences in stages and VO_2max, between adolescents who meet or not the cut offs obtained in the ROC curves, were analyzed by analysis of covariance (ANCOVA) adjusting for age, center, and BMI. We also performed binary logistic regression analysis to examine the relationship between meeting the PA cut-offs and having a healthy CRF adjusting for age, center, and BMI.

Additionally, ANCOVA was performed to examine whether meeting the current PA guidelines, that is, spending at least 60 min/day at MVPA, are associated with high-CRF. Moreover, we performed logistic regression analysis to study whether meeting the PA guidelines was associated with healthy CRF.

ANOVA, ANCOVA, and logistic regression analyses were conducted using SPSS version 15.0 for Windows (SPSS, Chicago, IL), and ROC analyses were performed with the MedCalc statistical software (version 10.4.5, MedCalc Software, Mariakerke, Belgium). The level of significance was set at $P < 0.05$ for all the analyses.

RESULTS

Descriptive characteristics in the whole adolescent sample are shown in Table 1. ROC analysis showed a significant discriminatory accuracy of PA at all intensities for identifying unhealthy versus healthy CRF in adolescents (Table 2). The PA thresholds associated with a healthy CRF were 152, 33, 13, and 52 min/day in light, moderate, vigorous, and MVPA, respectively. In boys, the light PA cut-off did not significantly discriminate between CRF levels, whereas, in girls, a cut-off of at least 152 min/day of light PA significantly discriminated between unhealthy and healthy CRF. The AUC for vigorous PA showed higher values than the other PA intensities in all the analyses (Table 2).

Adolescents who met the calculated cut-offs of light, moderate, vigorous, and MVPA had significantly higher levels of CRF than those not meeting the PA cut-offs (all $P < 0.05$) after adjustments for age, sex, center, and BMI (Table 3). Odds ratios (ORs) and 95% CIs adjusted for the same potential confounders showed that adolescents who

TABLE 1. Descriptive characteristics of the study sample

	All (n = 1808)		Boys (n = 844)		Girls (n = 964)			
	Unhealthy CRF (n = 676)	Healthy CRF (n = 1132)	Unhealthy CRF (n = 267)	Healthy CRF (n = 577)	Unhealthy CRF (n = 409)	Healthy CRF (n = 555)	P_{sex}	$P_{CRF\ group}$
Prevalence (%)	37.4	62.6	31.6	68.4	42.4	57.6	<0.001	<0.001
Age (year)	14.7 (1.2)	14.6 (1.2)	14.8 (1.3	14.6 (1.2)	14.6 (1.2)	14.6 (1.1)	0.100	0.072
Height (cm)	164.5 (9.3)	166.2 (9.2)	169.4 (9.9)	169.7 (9.6)	161.3 (7.2)	162.4 (7.1)	<0.001	0.087
Weight (kg)	61.2 (14.1)	56.0 (10.3)	66.0 (15.8)	58.4 (11.2)	58.0 (11.9)	53.5 (8.6)	<0.001	<0.001
Body mass index (kg/m^2)	22.5 (4.3)	20.2 (2.6)	22.9 (4.6)	20.1 (2.7)	22.2 (4.0)	20.2 (2.6)	0.102	<0.001
20mSRT (stage)	2.8 (1.3)	6.7 (2.3)	3.8 (1.4)	8.2 (1.8)	2.2 (0.7)	5.2 (1.6)	<0.001	<0.001
VO_2max (ml/kg/min)	34.9 (3.7)	45.7 (6.2)	37.4 (3.4)	49.7 (4.7)	33.2 (2.8)	41.6 (4.5)	<0.001	<0.001
Light PA (min/day)	167 (40)	171 (41)	175 (45)	174 (44)	162 (36)	167 (37)	<0.001	0.241
Moderate PA (min/day)	38 (15)	40 (14)	41 (16)	43 (15)	36 (12)	38 (13)	<0.001	0.001
Vigorous PA (min/day)	16 (13)	21 (13)	22 (15)	26 (15)	12 (11)	16 (10)	<0.001	<0.001
MVPA (min/day)	54 (23)	62 (24)	63 (26)	70 (25)	48 (20)	54 (19)	<0.001	<0.001
Meeting PA guidelines (%)	31.8	47.7	46.8	63.4	22.0	31.4	<0.001	<0.001

Values are mean (SD). PA, physical activity; MVPA, moderate-to-vigorous PA; CRF, cardiorespiratory fitness; SRT, shuttle run test; VO2max, maximum oxygen consumption, estimated using the equation suggested by Leger et al. (1988).

TABLE 2. Physical activity (PA) cut-off points to discriminate between unfit and fit adolescents by receiver operating characteristics analysis

	Unhealthy CRF *vs.* healthy CRF				
	Cut-off (min/day)	Se (%)	Sp (%)	AUC (95% CIs)	P
All (n = 1808)					
Light PA	152	40.8	65.7	0.530 (0.502, 0.557)	0.033
Moderate PA	33	47.2	66.7	0.571 (0.544, 0.599)	<0.001
Vigorous PA	13	51.8	70.9	0.642 (0.615, 0.668)	<0.001
MVPA	52	56.8	62.5	0.615 (0.588, 0.642)	<0.001
Boys (n = 844)					
Light PA	173	51.3	54.8	0.491 (0.448, 0.534)	0.679
Moderate PA	37	48.7	64.1	0.553 (0.510, 0.595)	0.012
Vigorous PA	19	53.6	67.9	0.626 (0.585, 0.667)	<0.001
MVPA	56	49.1	69.0	0.596 (0.554, 0.637)	<0.001
Girls (n = 964)					
Light PA	152	45.7	64.3	0.549 (0.512, 0.586)	0.009
Moderate PA	34	52.6	61.3	0.568 (0.531, 0.605)	<0.001
Vigorous PA	12	62.1	60.2	0.634 (0.598, 0.670)	<0.001
MVPA	51	64.5	52.4	0.605 (0.569, 0.641)	<0.001

AUC, area under the ROC curve; MVPA, moderate-to-vigorous PA; Se, sensitivity; Sp, specificity.

met the PA cut-offs were about 1.5 to two times more likely to have a healthy CRF (Table 3).

Adolescents who met at least 60 min/day in MVPA had significantly (all $P < 0.001$) higher levels of CRF that those engaged in less than 60 min/day of MVPA (see Fig. 1). The ORs for meeting the PA recommendation and having a healthy CRF were 1.75 (95% CIs: 1.41–2.17), 1.94 (95% CIs: 1.42–2.65), and 1.57 (95% CIs: 1.15–2.12) for the whole sample, boys and girls, respectively. All the analyses were repeated in younger and older groups (12.5–14.99 and 15–17.5 years, respectively), and the results did not materially change (data not shown).

DISCUSSION

The main findings of this study show that specific doses of light, moderate, vigorous, and MVPA are associated with healthy CRF levels in European adolescents. The MVPA cut-offs associated with healthy CRF were similar to the current PA recommendations: 52, 56, and 51 min/day for the whole sample, boys and girls, respectively. Likewise, the current PA recommendations (to be engaged in at least 60 min/day of MVPA) for adolescents were also significantly associated with high-CRF in European adolescents. These findings support the use of the current PA recommendations for preventive purposes related to a healthier CRF in adolescents.

The ROC analysis showed that spending more than 50 min/day at MVPA intensity was associated with high levels of CRF. Adolescents who met these thresholds had higher VO_2max and increased approximately twofold the likelihood for having a healthy CRF. The current PA guidelines suggest that adolescents should be active daily for at least 60 min in moderate and vigorous intensity (Strong et al., 2005). Several studies using accelerometers showed that moderate PA and vigorous PA are associated with high-CRF in children and adolescents, but no adjustments were performed for body fat measures (Gutin et al., 2005; Ruiz et al., 2006). Similarly to this study, Ortega et al. (2008c) showed that those adolescents meeting the PA guidelines were more likely to have a healthier CRF level independently of their adiposity status. Although the current PA guidelines suggest 60 min per day in MVPA, our findings showed that slightly lower doses of MVPA are also associated with a healthy CRF. Nevertheless, higher doses of MVPA may be necessary to prevent other health factors (Hallal et al., 2006). For example, Andersen et al. (2006) suggested that at least 90 min per day in MVPA was necessary to prevent cardiovascular and metabolic risk factors, mainly insulin resistance, in children and adolescents.

It must be noted that moderate PA showed weaker association with CRF than vigorous PA, which concur with previous studies (Gutin et al., 2005; Ruiz et al., 2006). Daily participation in more than 33 min in moderate PA was independently and positively associated with a healthy CRF in our study. Moderate PA involves participation in activities such as walking, households, and leisure sports. As mentioned earlier, objectively measured moderate PA has been also associated with CRF in previous studies in children and adolescents, but these associations were, as in our study, weaker than the observed associations for vigorous PA (Gutin et al., 2005; Ruiz et al., 2006).

TABLE 3. Associations of physical activity (PA) levels and intensities with cardiorespiratory fitness in adolescents

	Cut-off (min/day)	*n*	20mSRT, stage mean (SD)	*P*	VO_2max, ml/kg/min mean (SD)	*P*	OR (95% CI)
All[a]							
Light PA	<152	668	5.1 (2.7)	0.123	40.7 (7.5)	0.107	Ref.
	≥152	1140	5.3 (2.7)		42.2 (7.5)		1.55 (1.25–1.93)
Moderate PA	<33	653	4.6 (2.5)	0.001	39.8 (6.8)	<0.001	Ref.
	≥33	1155	5.6 (2.8)		42.7 (7.7)		1.71 (1.39–2.12)
Vigorous PA	<13	708	4.0 (2.1)	<0.001	38.5 (6.0)	<0.001	Ref.
	≥13	1100	6.0 (2.7)		43.7 (7.7)		2.17 (1.74–2.71)
MVPA	<52	807	4.3 (2.3)	<0.001	39.2 (6.4)	<0.001	Ref.
	≥52	1001	6.0 (2.8)		43.6 (7.8)		1.96 (1.58–2.43)
Boys							
Light PA	<173	448	7.1 (2.5)	0.310	46.1 (7.0)	0.762	Ref.
	≥173	396	6.5 (2.8)		45.5 (7.4)		0.96 (0.69–1.34)
Moderate PA	<37	344	6.5 (2.6)	0.003	44.6 (6.9)	<0.001	Ref.
	≥37	500	7.0 (2.7)		46.7 (7.3)		1.81 (1.31–2.49)
Vigorous PA	<19	329	5.9 (2.5)	<0.001	43.5 (6.6)	<0.001	Ref.
	≥19	515	7.4 (2.6)		47.3 (7.2)		2.27 (1.64–3.14)
MVPA	<56	308	6.1 (2.6)	<0.001	43.9 (6.8)	<0.001	Ref.
	≥56	536	7.2 (2.6)		47.0 (7.2)		2.13 (1.54–2.94)
Girls							
Light PA	<152	388	3.8 (1.9)	0.008	37.1 (5.5)	<0.001	Ref.
	≥152	576	4.0 (2.0)		38.6 (5.7)		1.86 (1.40–2.47)
Moderate PA	<34	433	3.6 (1.7)	<0.001	37.1 (5.1)	<0.001	Ref.
	≥34	531	4.2 (2.1)		38.8 (6.0)		1.68 (1.28–2.21)
Vigorous PA	<12	491	3.3 (1.6)	<0.001	36.8 (4.9)	<0.001	Ref.
	≥12	473	4.5 (2.1)		39.3 (6.1)		2.32 (1.75–3.06)
MVPA	<51	527	3.5 (1.7)	<0.001	37.0 (5.0)	<0.001	Ref.
	≥51	437	4.4 (3.9)		39.2 (6.2)		1.90 (1.45–2.51)

CI, confidence interval; MVPA, moderate to vigorous PA; OR, odds ratio; SD, standard deviation; 20mSRT, 20 meter shuttle run test; VO_2max, maximal oxygen consumption, estimated using the equation suggested by Leger et al. (1988). Data were adjusted for center, age, and body mass index.[a]Additionally adjusted for sex.

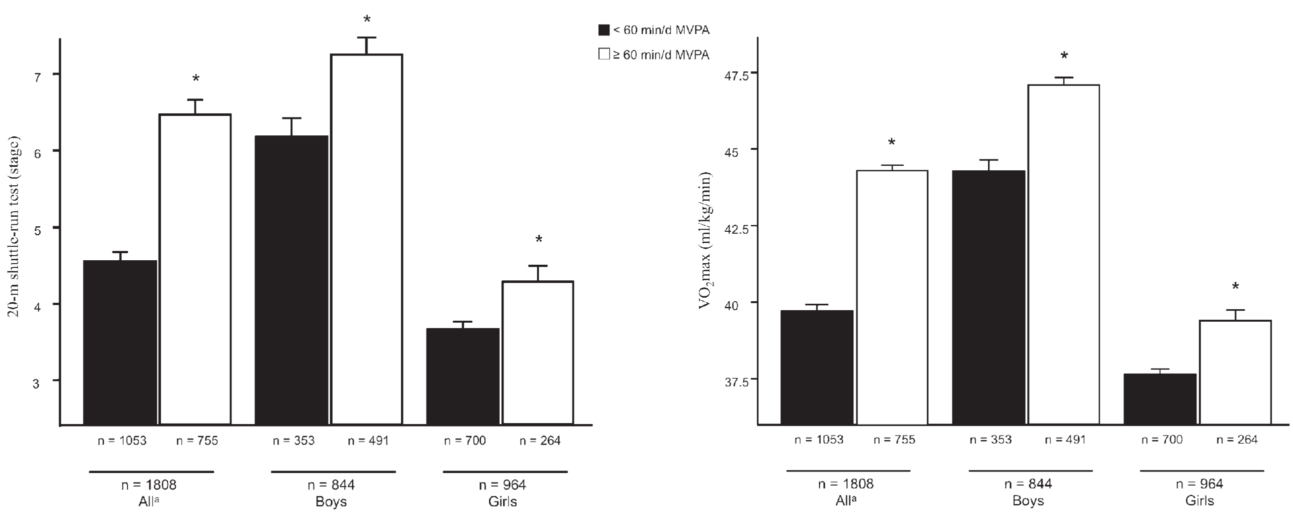

Fig. 1. Differences in cardiorespiratory fitness between physical activity levels according to current physical activity (PA) recommendations for youth. Footnotes: MVPA: moderate to vigorous PA. Data were adjusted for center, age, and body mass index. [a]Additionally adjusted for sex. $*P \leq 0.001$ between PA groups.

Intervention studies in youth showed significant improvements in CRF levels only when vigorous intensities were achieved (Baquet et al., 2003; Ortega et al., 2008b; Strong et al., 2005).

There is agreement among studies regarding the key role of vigorous PA on several health outcomes in children and adolescents. Vigorous PA measured by accelerometer is associated with body fat (Gutin et al., 2005; Ortega et al., 2007; Ruiz et al., 2006), cardiovascular disease risk factors (Ekelund et al., 2007; Rizzo et al., 2008), and other health-related physical fitness components in youth (Martínez-Gómez et al., 2009; Ortega et al., 2008b). In this study, around 15 min per day in vigorous PA was associated with higher CRF. Recent reviews stated that only interventions based on continuous vigorous PA for more than 30 min at least 3 days per week had success to improve CRF in young people (Ortega et al., 2008b).

The recently launched PA recommendations for youth from the U.S. Department of Health and Human Services suggest that children and adolescents should participate daily 60 min in MVPA, but it also states "and should include vigorous-intensity PA at least 3 days a week" (U.S. Department of Health and Human Services, 2008). Unfortunately, none specific dose of vigorous PA was added. A recommendation from Health Canada suggested a goal of 30 min per day in vigorous PA, even though the amount of daily-recommended PA reached 90 min per day in MVPA for young people (Public Health Canada, 2002). These recommendations showed to be unachievable goals for most adolescents, and, nowadays, they are promoting the every day 60 min in MVPA recommendation (Janssen, 2007).

An interesting finding from our study was the positive and significant association between light PA and CRF in girls. These results suggest a sex effect of light PA on CRF. On average, adolescent girls have lower CRF levels than boys. Moreover, CRF declines during adolescence, and this decline seems to be more attenuated in girls (Pfeiffer et al., 2007). Taken together, these findings may indicate that increasing light PA levels during adolescence in girls may be a suitable target for improving CRF, regardless of more efforts to increase MVPA. Nonetheless, the capacity to correctly identify an adolescent girl with a healthy CRF based on her light PA level was the lowest (AUC = 0.55), and, therefore, these results must be interpreted with caution.

Ekelund et al. (2007) also found positive and significant associations between objectively measured light PA and CRF in a large sample of 9- and 15-year adolescents. Conversely, other studies failed to detect significant associations between both variables (Kriemler et al., 2008). Recently, new postulates have highlighted the key role of light PA (also known as nonexercise activity thermogenesis) in obesity, cardiovascular disease, and metabolic abnormalities (Hamilton et al., 2007). With the help of new technology developments, several studies are emerging and show the importance of increase light PA and reduce sedentary behaviors—sitting time—on different health outcomes in children, adolescents, and adults.

This study shows notable strengths, such as the use of accelerometers to assess adolescents' PA, the standardized, reliable, and valid test for assessing CRF (Castro-Piñero et al., in press; Ortega et al., 2008a; Ruiz et al., 2009), as well as a relatively large sample of adolescents from nine European countries. The study has however several limitations. First, a causal inference cannot be drawn due to the study design (i.e., cross-sectional). Second, CRF was estimated using a field-based test. Third, PA intensity thresholds obtained by the ROC curves provide maximal accuracy, but there is always a degree of error that should be assumed. Finally, assessments of PA by accelerometer have inherent limitations (e.g., water-based activities are not captured, and inability to detect horizontal movements as biking), which make comparisons between studies difficult due to the dissimilarities in the inclusion criteria, cut-offs to define PA intensities, epochs, and accelerometer models (Freedson et al., 2005; Martínez-Gómez et al., in press).

In conclusion, we have shown sex- and intensity-specific PA thresholds to discriminate between adolescents with a healthy CRF from those with a less favorable or unhealthy CRF level. To note is that the MVPA thresholds are rather similar to the current PA recommendations (i.e., 60 min/day). Identification of children who fail to meet these PA recommendations can help to detect the target population for pediatric prevention strategies.

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