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Self-reported and measured cardiorespiratory fitness similarly predict cardiovascular disease risk in young adults

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We aimed to (a) examine the validity and reliability of the International FItness Scale (IFIS) in Spanish young adults and (b) compare the capacity of self-reported vs measured fitness to predict cardiovascular disease (CVD) risk. The study comprised 276 participants (18–30 years). Fitness level (overall and specific components) was both self-reported (IFIS) and measured using standard fitness tests. Total and trunk fat was assessed by dual-energy X-ray absorptiometry. We computed a previously validated metabolic syndrome score. A separate sample of 181 of same age and characteristics fulfilled IFIS twice for reliability purposes. The results of the present study support the validity and reliability of self-reported fitness, as measured by IFIS, in Spanish young adults. Our data also suggest that not only measured cardiorespiratory fitness but also self-reported cardiorespiratory fitness predicts CVD risk, as assessed by adiposity and metabolic syndrome indicators. The associations for muscular fitness (both reported and measured) differed depending on how it was expressed (i.e., absolute vs relative terms). Self-reported fitness, as assessed by IFIS, can be a good alternative when physical fitness cannot be measured in large surveys.

Cardiorespiratory fitness is a powerful marker of the cardiovascular health status in children, adolescents, and adults (Ortega et al., 2008b; Kodama et al., 2009; Ruiz et al., 2009). Likewise, muscular fitness has recently been proposed a health indicator in people from different countries and of different ages (Garcia-Artero et al., 2007; Ruiz et al., 2008; Ruiz et al., 2009; Steene-Johannessen et al., 2009; Artero et al., 2011c). As a consequence of this evidence, accurate physical fitness assessment has become a key issue in health-related epidemiology and public health research. Methodological advances able to accurately measure physical fitness level at a population level are timing. In this context, the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study, conducted on adolescents from 10 different European cities, designed a self-report fitness tool, namely the International FItness Scale (IFIS), in order to assess physical fitness levels in large-scale surveys in which physical fitness cannot be measured because of time or budget limitations (Ortega et al., 2011b). This scale is available in nine different languages, including Spanish, and has been shown to be reliable and valid in ranking adolescents according to their measured overall physical fitness, cardiorespiratory fitness, muscular fitness, speed-agility, and flexibility levels (Ortega et al., 2011b). Before the IFIS can be accepted for global use, it should be validated in different populations and age groups. In addition, to better understand the potential of this new tool, it is interesting to test the extent to which self-report fitness can "challenge" measured fitness in terms of predicting cardiovascular disease (CVD) risk.

In the present study, we aimed to (a) examine the validity and test–retest reliability of the Spanish version of the IFIS in young adults and (b) compare the capacity of self-reported (IFIS) vs measured (cardiorespiratory and muscular) fitness to predict CVD risk in young adults.

Method

Study design and sample

This is a cross-sectional study involving first-year university students aged 18–30 years of the University of Castilla-La Mancha, Cuenca Campus, Spain. More information about the characteristics of the study sample, methods, and procedures is available elsewhere (Solera-Martinez et al., 2011). Participants with valid data on self-reported fitness and at least one of the fitness tests were included in this study (*n* = 276, 77 men and 199 women; 72%

women). The participants belonged to the following university degrees: education, psychology, law, nursing, fine arts, and social work. The percentage of women in these degrees in Cuenca Campus is higher than the percentage of men and is equivalent to the gender distribution participating in this study (i.e., ~70% women). Data collection was performed during the academic year 2009–2010.

The enrolled university students were not included for test–retest reliability purposes because the physical fitness testing took place immediately after the IFIS was administered and this could influence the perception on their fitness levels at the retest. We recruited a separate sample of first-year university students from the Ciudad Real Campus (University of Castilla-La Mancha, Spain) to complete the IFIS twice, 2 weeks apart. A total of 181 participants (73.48% women) aged 18–43 years successfully completed the IFIS on the two occasions and were included in the current study. None of these students were participating in another study.

Ethics

The study was approved by the Cuenca Clinical Research Ethics Committee, and all participants gave their written consent to participate in the study after they were duly informed about the purposes and procedures of the study.

Self-reported fitness

Self-reported fitness was assessed by the IFIS, previously validated in European adolescents (Ortega et al., 2011b). The IFIS consists of a Likert-type scale (range 1–5) with five response options (very poor, poor, average, good, and very good) about perceived overall fitness, and its main components are cardiorespiratory fitness, muscular strength, speed-agility, and flexibility. The IFIS in the nine different languages are available at the HELENA study Web site (http://www.helenastudy.com/IFIS). The English and Spanish versions of the IFIS, minimally modified to be adapted to adults, are available as Supporting Information Appendices S1 and S2, respectively.

Physical fitness

The field-based fitness tests used in this study have been shown to be valid and reliable in young people (Ortega et al., 2008a; Castro-Pinero et al., 2010; Artero et al., 2011a; Ruiz et al., 2011).

Cardiorespiratory fitness was assessed by the 20-m shuttle run test (Leger et al., 1988). Participants are required to run between two lines 20 m apart 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/min (1 min equals one stage). The participants were encouraged to keep running as long as possible throughout the course of the test. The last completed stage or half-stage at which the participant drops out was scored. More detailed information about the protocol has been published elsewhere (Ortega et al., 2011a).

Muscular fitness was assessed using two tests: (a) handgrip test (maximum handgrip strength assessment) using a hand dynamometer with adjustable grip was used (TKK 5401 Grip D; Takey, Tokyo, Japan). The participant squeezes gradually and continuously for at least 2 s, performing the test with the right and left hands in turn, using the optimal grip span. The handgrip span was adjusted according to hand size using the equation that we have developed specifically for adults (Ruiz-Ruiz et al., 2002). The maximum score in kilograms for each hand was recorded. The average (in kilograms) of both hands was used in the analysis. (b) The standing long jump test (lower limb explosive strength assessment): from a starting position immediately behind a line, standing with feet approximately shoulder's width apart, the student jumps as far as possible with feet together. The result was recorded in centimeters. A nonslip hard surface, chalk, and a tape measure were used to perform the test.

Muscular fitness or strength can be expressed in absolute or relative terms. Examples of absolute strength include weight lifting, carrying a suitcase or moving a heavy object, and the handgrip strength test. Relative strength includes any activity in which the person has to lift, hold, or carry his or her own body weight, e.g., hanging from a bar or tree branch and jumping. In our analyses, we divided the score in handgrip by weight, which implies a transformation from absolute strength to relative strength, and we multiplied the score in the standing long jump test by weight, so that it was transformed from relative strength to absolute strength. The analysis of these four variables (two original + two transformed) in relation to the IFIS informs about what the participants report (absolute vs relative strength) when they are asked about their muscular fitness levels. We determined an index of *muscular fitness* (in absolute strength terms), which is a sex- and age-specific average z-score computed from the handgrip z-score and the standing long jump × weight z-score.

Flexibility was assessed using the sit and reach test (Chillon et al., 2010). This test uses a standard box with a small bar that has to be pushed by the participant. The student bends his or her trunk and reaches forward as far as possible from a seated position, with legs straight without bending his or her knees. The farthest position of the bar reached was scored in centimeters.

For logistic reasons, no fitness test for assessing speed-agility was performed.

Adiposity and anthropometric variables

Height and weight were measured using standard procedures. Waist circumference was measured after inspiration at the midway between the lowest rib and the iliac crest. Total body fat (kg) and trunk fat (kg) were measured by a whole-body dual energy X-ray absorptiometry (DXA) scanning using a total body scan mode: Lunar iDXA (GE Medical Systems Lunar, Madison, Wisconsin, USA). The analyses were performed using enCoreTM 2008 software version 12.30.008 (General Electric Company, Madison, Wisconsin, USA). By using specific anatomic landmarks (Gallagher et al., 2000), fat mass in the region of the trunk was measured.

Other CVD risk factors

Blood sampling and blood pressure procedures have been previously described (Solera-Martinez et al., 2011). Briefly, the following biochemical parameters were measured after at least 12 h of fasting: glucose, triglycerides, high-density lipoprotein cholesterol (HDLc), and insulin. The insulin resistance was determined by homeostasis model assessment ($HOMA_{IR}$): fasting glucose (mmol/L) x fasting insulin (μU/mL)/22.516. Blood pressure was obtained by automated procedure by OMRON M5-I monitor (Omron Healthcare Europe BV, Hoofddorp, Netherlands). We calculated mean arterial pressure: diastolic blood pressure + [0.333 × (systolic blood pressure – diastolic blood pressure)]. We calculated a *metabolic syndrome index* composed of the sum of standardized z-scores in waist circumference, triglycerides/HDLc ratio, mean arterial pressure, and $HOMA_{IR}$, in which construct validity has been previously demonstrated using confirmatory factor analysis (Solera-Martinez et al., 2011).

Statistical analysis

For all the analyses, we used IBM SPSS 19. Cohen's weighted Kappa is not available in the standard SPSS package, but command syntax is available from the "Knowledgebase" at SPSS.com (SPSS, 2010). Data for imputation into the syntax were generated from cross-tabulation.

Validity of the IFIS in young adults (Aim 1)

The capacity of the IFIS to correctly rank university students into appropriate physical fitness levels was determined by means of analysis of variance without any adjustment and after adjustment [analysis of covariance (ANCOVA)] for sex and age. Measured fitness variables were entered as dependent variables and self-reported fitness variables as fixed factors.

Reliability of the IFIS in young adults (Aim 1)

The test–retest reliability of the IFIS was examined by weighted Kappa coefficient, which is more appropriate when dealing with ordered categorical data (Cohen, 1968). Cohen's weighted Kappa accounts for strict agreement (as does the "unweighted" Kappa) but also provides weighting to adjacent categories.

The IFIS and CVD risk (Aim 2)

We studied the association of self-reported and measured fitness with adiposity indicators (total body fat and trunk fat) and a metabolic syndrome index by means of ANCOVA after adjustment for sex and age. Adiposity indices were expressed in absolute terms (i.e., in kilograms instead of percentage or ratios) and adjusted by height (Cole et al., 2008). Sex- and age-specific percentiles 25th and 75th for physical fitness variables were calculated and used to class the participants into measured fitness groups: low (< P25th), medium (P25th–P75th), and high (> P75th). The distribution of participants falling into the measured fitness groups was equivalent to that from the self-reported fitness groups, i.e., very poor/poor, average, and good/very good.

Results

The distribution of the answers of the IFIS (Fig. 1) was rather symmetric, with a low percentage of participants reporting to have a very low or very high fitness level. Because of the small number of participants in the extreme categories, the categories were merged as very poor/poor and good/very good for the rest of the analyses, except for reliability analyses where the original variable was used.

Validity of the IFIS in young adults

Participants reporting good/very good cardiorespiratory fitness, muscular fitness, and flexibility had a better measured cardiorespiratory fitness, muscular fitness, and flexibility, respectively, compared with participants reporting very poor/poor fitness levels (Table 1). Fig. 2 panel a shows a dose-response association between self-reported and measured cardiorespiratory fitness and flexibility. Fig. 2 panel b shows a dose-response association between self-reported muscular fitness and muscular fitness tests expressed as absolute muscular strength, i.e., handgrip, standing long jump × weight, and an averaged z-score computed from both tests (namely muscular fitness index). The association was not anymore lineal when muscular fitness was expressed in relative terms, i.e., handgrip/weight and standing long jump (the test itself is relative to the participant's body weight; thus, it does not need to be corrected by weight). Overall, the associations were slightly stronger (i.e., larger differences among groups) for cardiorespiratory fitness and flexibility than for muscular fitness.

Reliability of the IFIS in young adults

Table 2 shows the test–retest reliability statistics for the five items that compose the IFIS, i.e., overall fitness and four main fitness components: cardiorespiratory fitness, muscular strength, speed-agility, and flexibility. Weighted Kappa ranged from 0.54 (muscular fitness) to 0.65 (overall fitness), and the averaged weighted Kappa was 0.59.

The IFIS and CVD risk

Figure 3 shows the association of self-reported fitness (panel a) and measured fitness (panel b) with total and central adiposity measured by DXA. The associations were consistent for self-reported and measured fitness, showing an inverse association between cardiorespiratory fitness (both self-reported and measured) and total body fat or trunk fat. Self-reported overall fitness was also inversely associated with adiposity indicators. The associations between muscular fitness (both self-reported and measured) and adiposity indicators were inverse for muscular fitness in relative terms (adjusted by weight) and were positive for muscular fitness in absolute terms (nonadjusted by weight).

Figure 4 shows that a high level of cardiorespiratory fitness (both self-reported and measured) is related to a lower CVD risk, as measured by a metabolic syndrome index (Solera-Martinez et al., 2011). The same pattern was observed for self-reported overall fitness. No association between muscular fitness (both self-reported and measured) and metabolic syndrome was observed for muscular fitness in relative terms (model adjusted by weight), while a positive association (both self-reported and measured) was observed for muscular fitness in absolute terms (model nonadjusted by weight).

Discussion

The results from the present study suggest that (a) young adult people are able to accurately report their physical fitness level, both overall fitness and specific fitness components, as shown by the high agreement observed between self-reported (IFIS) and measured fitness; (b) self-reported fitness (IFIS) is acceptably reliable in young adults; (c) both self-reported and measured cardiorespiratory fitness similarly predict adiposity and metabolic syndrome indicators in young adults, while such

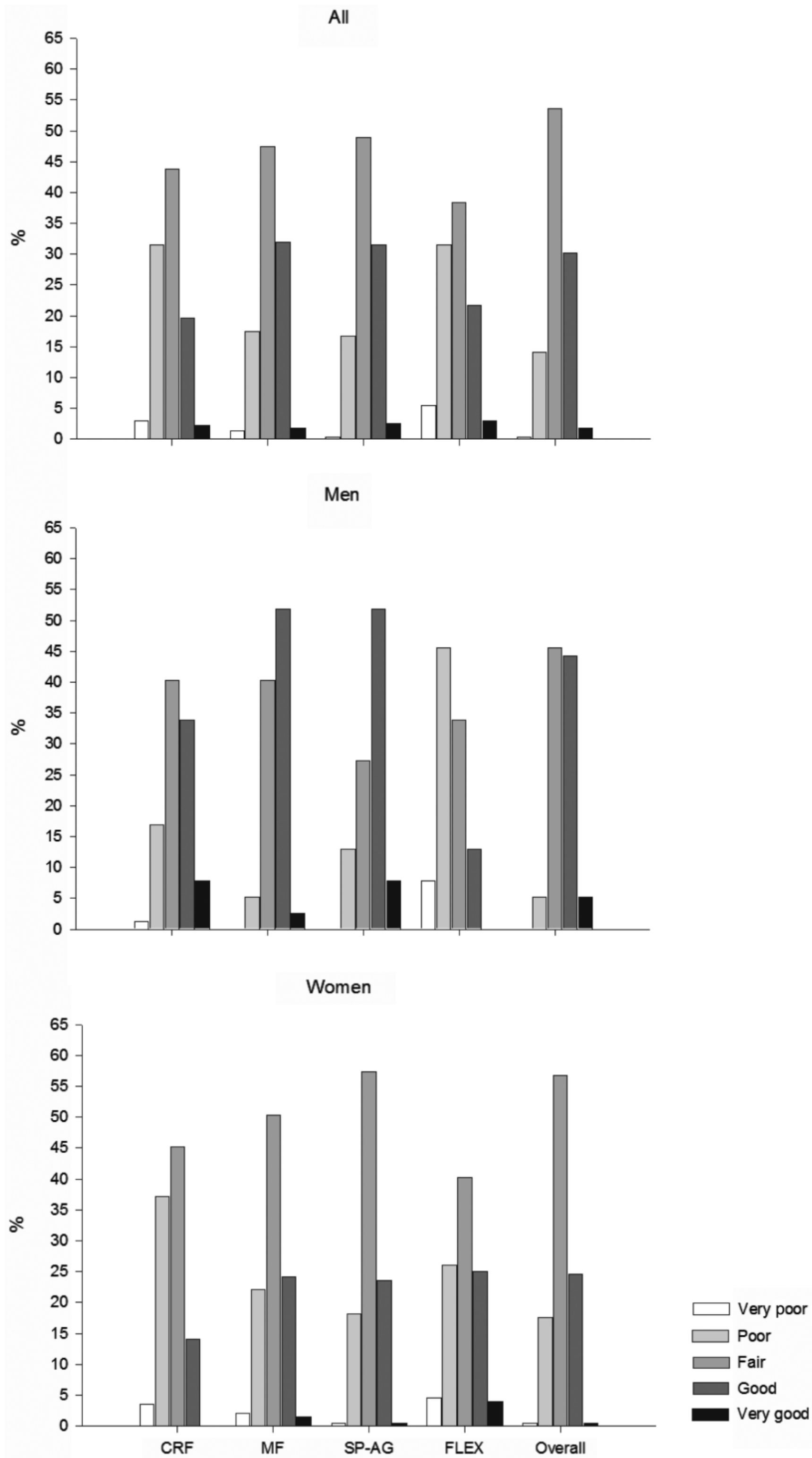

Fig. 1. Distribution of the answers for the five questions of the International Fitness Scale in male and female young adults (n = 276, 77 men and 199 women). CRF, cardiorespiratory fitness; MF, muscular fitness; FLEX, flexibility; overall, overall physical fitness.

associations for muscular fitness differ depending on the way it is expressed, i.e., absolute strength vs relative strength (relative to body weight).

The levels of agreement between self-reported and measured fitness observed in this sample of young adults are in line with those previously observed in the adolescent population (Ortega et al., 2011b). Of note is that the distribution of responses to IFIS questions was more symmetrical (closer to the Normal distribution) in adults than in adolescents (Ortega et al., 2011b), who tended to

Table 1. Means and standard error (SE) of measured physical fitness according to self-reported physical fitness categories in young adults

	n	Very poor/poor		Average		Good/very good		P	Pairwise comparisons†		
		Mean	SE	Mean	SE	Mean	SE		1–2	2–3	1–3
Unadjusted models											
Cardiorespiratory fitness											
20-m shuttle run (stage)	156	4.1	0.4	5.5	0.2	7.6	0.3	<0.001	<	<	<
Muscular fitness											
Handgrip (kg)	276	24.2	1.1	28.3	0.7	35.0	0.8	<0.001	<	<	<
Standing long jump (m)	271	1.3	0.2	1.4	0.3	1.6	0.4	<0.001	ns	<	<
Flexibility											
Sit and reach (cm)	275	19.0	0.6	25.4	0.6	31.7	0.8	<0.001	<	<	<
Adjusted models*											
Cardiorespiratory fitness											
20-m shuttle run (stage)	156	4.6	0.2	5.7	0.2	6.9	0.2	<0.001	<	<	<
Muscular fitness											
Handgrip (kg)	276	27.4	0.6	29.0	0.4	32.2	0.4	<0.001	ns	<	<
Standing long jump (m)	271	1.4	0.2	1.4	0.3	1.5	0.4	<0.001	ns	ns	<
Flexibility											
Sit and reach (cm)	275	19.5	0.7	25.3	0.6	31.3	0.8	<0.001	<	<	<

*Analysis of covariance adjusted for sex and age.

†Bonferroni-adjusted pairwise comparisons: the symbol < in the column 1–2, for instance, indicates a significant difference ($P < 0.05$) in the direction 1 < 2; ns, nonsignificant.

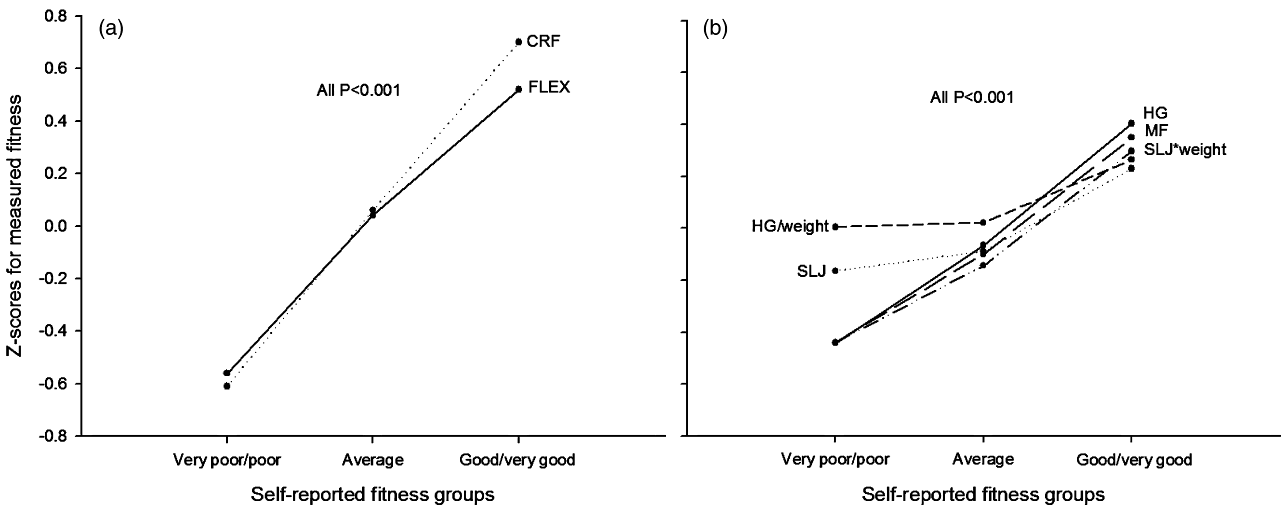

Fig. 2. Comparison between self-reported and measured physical fitness in young adults. (a) CRF and FLEX. (b) MF. CRF, cardiorespiratory fitness; FLEX, flexibility; HG, handgrip strength; SLJ, standing long jump; MF, muscular fitness, which is an average z-score computed from the HG z-score and the SLJ × weight z-score. All z-scores were sex and age specifically computed.

overreport the upper category (very good fitness) and underreport the lower one (very poor fitness). Other self-reported fitness scales [e.g., the modified version of the Physical Self-Concepts (PSK)] are available to be used in elderly people (Amesberger et al., 2011).

The present study in young adults provides an important insight on how the IFIS should be used and interpreted concerning muscular fitness. The results suggest that when participants are asked about their muscular fitness levels, they answer thinking in absolute strength terms rather than in relative strength terms, as shown

Table 2. Test–retest (2 weeks apart) reliability of self-reported fitness in young adults ($n = 181$)

IFIS items	Weighted Kappa coefficients
Overall fitness	0.65
Cardiorespiratory fitness	0.58
Muscular fitness	0.54
Speed-agility	0.60
Flexibility	0.59
Average Kappa	0.59

IFIS, International Fitness Scale.

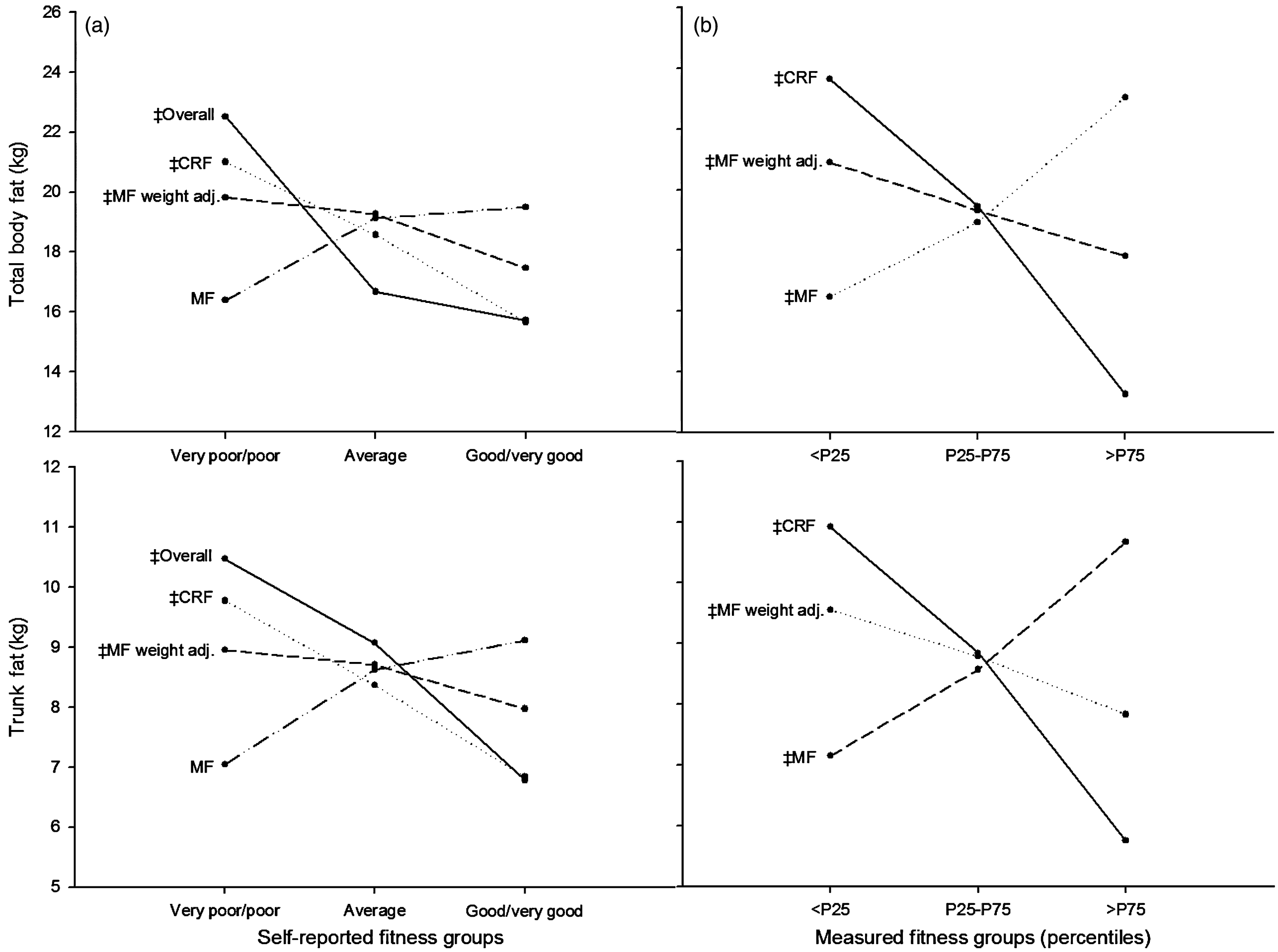

Fig. 3. Differences in adiposity indicators according to categories of self-reported and measured physical fitness in young adults ($n = 276$ for total body fat measured by dual energy X-ray absorptiometry and trunk fat, respectively). (a) Self-reported fitness. (b) Measured fitness. CRF, cardiorespiratory fitness; MF, muscular fitness, which, for measured fitness, is an average z-score computed from the HG z-score and the SLJ × weight z-score; overall, overall physical fitness. † $P < 0.05$, ‡ $P < 0.01$, between "very good/good" and "very poor/poor." Analysis of covariance adjusting for sex, age, and height. Data for MF are presented both with and without additional adjustment for weight.

by the optimal self-reported vs measured agreement observed for handgrip and standing long jump × weight. This is an important finding that needs to be considered when interpreting the results derived from the IFIS and its associations with different health outcomes.

The test–retest reliability of the IFIS observed in the present study (young adults) is nearly the same as that previously reported in adolescents (Ortega et al., 2011b). Although there is no full consensus about what is acceptably reliable and what is not, some cut points for weighted Kappa statistics are commonly used (Landis & Koch, 1977) and inform that the observed Kappa statistics (ranging from 0.54 to 0.65) can be considered "moderate" to "good" agreement.

A key finding in this study is the consistency between self-reported and measured fitness in relation to adiposity and metabolic syndrome. This suggests that studies in which fitness cannot be measured can use a short and simple self-reported fitness scale, the IFIS, as a good alternative. Self-reported cardiorespiratory fitness predicts adiposity (assessed by sophisticated methods, i.e., DXA) and CVD risk (a continuous score of metabolic syndrome) nearly as well as measured cardiorespiratory fitness. This is of most relevance from a public health point of view, further supporting the inclusion of self-reported fitness into health monitory systems.

The associations observed between muscular fitness (both self-reported and measured) and adiposity are in line with the literature. Absolute strength is positively associated with adiposity because overweight and obese people have higher absolute strength as a consequence of their higher lean mass (Artero et al., 2010; Silverman, 2011); on the other hand, relative strength is inversely related to adiposity (Jackson et al., 2010).

Higher levels of cardiorespiratory fitness have been consistently associated with lower CVD risk (Ortega

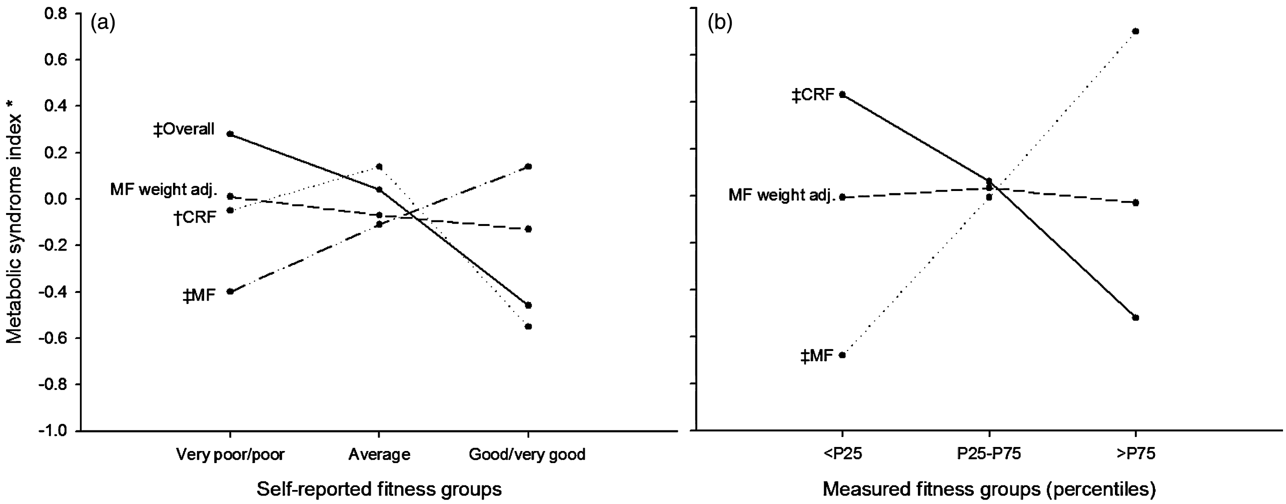

Fig. 4. Differences in the metabolic syndrome index ($n = 260$) according to categories of self-reported and measured physical fitness in young adults. (a) Self-reported fitness. (b) Measured fitness. † $P < 0.01$ between "average" and "very good/good," ‡ $P < 0.001$ between "very good/good" and "very poor/poor." CRF, cardiorespiratory fitness; MF, muscular fitness, which, for measured fitness, is an average z-score computed from the HG z-score and the SLJ × weight z-score; overall, overall physical fitness. Analysis of covariance adjusting for sex and age. Data for MF are presented both with and without additional adjustment for weight. * The metabolic syndrome index was computed as the sum of standardized z-scores in waist circumference, triglycerides/high-density lipoprotein cholesterol ratio, mean arterial pressure, and $HOMA_{IR}$, in which construct validity has been previously demonstrated using confirmatory factor analysis (Solera-Martinez et al., 2011).

et al., 2008b; Kodama et al., 2009; Ruiz et al., 2009; Sato et al., 2009). The contribution of this study to the previous literature is that self-reported cardiorespiratory fitness, as measured by the IFIS, has a similar capacity than measured cardiorespiratory fitness for classifying individuals according to different CVD risk groups. Although high muscular fitness (relative strength) has also been associated with a lower CVD risk (Metter et al., 2002; Ortega et al., 2008b; Ruiz et al., 2008; Ruiz et al., 2009; Artero et al., 2011b), our results, both using self-reported and measured muscular fitness, did not support this notion. This discrepancy could be due to the fact that recent studies conducted on young individuals used relative strength indexes (e.g., handgrip divided by weight) in their analyses (Steene-Johannessen et al., 2009; Artero et al., 2011c) instead of absolute strength indexes (i.e., handgrip without correction by body weight and standing long jump × body weight) as used in the present study. Whether relative strength vs absolute strength should be used as a health indicator is a controversial issue.

In accordance with our results, some studies have reported a beneficial association between overall self-reported fitness and several outcomes, such as the risk of burnout in physical education teachers (Carraro et al., 2010), anxiety (Delignieres et al., 1994), musculoskeletal injuries (Nabeel et al., 2007), systemic inflammation (C-reactive protein) (Borodulin et al., 2006), and all-cause mortality (Phillips et al., 2010). Although most of previous studies used a single question about overall fitness, others explored some dimensions of physical fitness. Monroe et al. (2010) observed significant correlations between self-reported and measured cardiorespiratory fitness, muscular fitness, and flexibility using the Physical Self-Description Questionnaire (Marsh, 1996). These findings, together with those from the present study, support the usefulness and potential of self-reported fitness tools in a public health context.

Limitations

No speed-agility fitness test was carried out in this study because of logistic problems that preclude comparisons between self-reported and measured speed agility. A limitation of the IFIS is that the output can be affected by the average fitness level of region/country differences. For this reason, the IFIS should be mainly used for categorizing a study population into different fitness levels and to relate this with different health outcomes.

It is important to highlight the need for additional cross-validation testing in different samples and ethnics before the IFIS can be considered acceptable for global use.

Strengths and epidemiological implications

This study suggests that the self-report tool used in this study, the IFIS, is a useful method to be used in large-scale surveys and epidemiological studies in which, because of time, equipment, or qualified personnel limitations, fitness cannot be directly measured. A major advantage of the IFIS is that its structure and content is simple and it can be completed within 1–5 min. A major strength is that the IFIS was originally tested in a European study and is available in nine different languages (English, German, Austrian German, Greek, Flemish, French, Hungarian, Italian, Spanish, and Swedish).

Perspective

It is known that fitness in adulthood is a powerful predictor of health status and survival. Fitness assessment is of clinical and public health relevance. However, fitness testing is not always possible in large surveys because of budget or logistic limitations. In this context, a short and simple scale to assess different dimensions of physical fitness, namely the IFIS, has recently been launched and validated in the adolescent population. The present study indicates that the IFIS is valid and reliable in adult people, and that self-reported cardiorespiratory fitness (assessed by the IFIS) predicts adiposity (assessed by sophisticated methods, i.e., DXA) and CVD risk (a continuous score of metabolic syndrome) nearly as well as measured cardiorespiratory fitness. The IFIS can be a good alternative tool for assessing fitness levels in large surveys.

Key words: adiposity, adult, cardiovascular diseases, physical fitness, risk factors, self report.

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Supporting information

Additional Supporting Information may be found in the online version of this article:

Appendix S1. English version of the International FItness Scale (IFIS).
Appendix S2. Spanish version of the International FItness Scale (IFIS).

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