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Original Article

Students with excess weight obtain lower physical fitness test scores in physical education than normal weight pairs: myth or reality?

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Abstract:
The aim of this study was to investigate through a systematic review the possible influence of excess weight on physical fitness test results carried out by adolescents in physical education classes, taking into account potential confounders. Fourteen studies were identified in four databases (PubMed, SportDiscus, Web of Science, and SCOPUS) from January 2000 through to April 2018. Titles and abstracts were reviewed to determine whether the studies met the inclusion criteria. The quality of the reporting of the measures was assessed using a tailored list. Four studies were longitudinal and nine used a cross-sectional design. Overweight and obese youth were associated with lower cardiorespiratory fitness and motor fitness than their normal weight peers in 10 and 7 studies, respectively. Likewise, overweight and obesity impair performance in muscular fitness tests where body weight acted as ballast (i.e. standing long jump or abdominal tests), while the relationship with regard to other muscular fitness tests (i.e. handgrip) and flexibility (sit and reach) has been less studied and the results show no association. Conclusively, in adolescents, excess weight negatively influences cardiorespiratory fitness, motor fitness, and muscular tests that involve mobilizing body weight.
Key words: weight status, body mass index, adolescents, systematic review, confounder.

Introduction

Physical fitness (PF) refers to competence levels to perform physical activity, and it encompasses results of several components such as cardiorespiratory fitness (CRF), muscular fitness, motor fitness, or flexibility (Ruiz et al., 2011). The assessment of these PF components has traditionally been differentiated according to age and sex (Castro-Piñero et al., 2013). Nevertheless, it has been shown that an excess of weight can also influence PF test results (Antunes et al., 2015; Gulias-Gonzalez et al., 2014; Palomäki et al., 2015), and therefore, youth with higher body mass index (BMI) would be at a disadvantage compared to the rest of their peers. Despite the progressive increase in overweight and obesity in the last two decades (Ogden et al., 2016), physical fitness capacities are still compared to those of their normal weight counterparts (Morrow, Zhu, Franks, Meredith & Spain, 2009), with low equity results (Antunes et al., 2015; Gulias-Gonzalez et al., 2014; Palomäki et al., 2015) and negative consequences at a psychological level (Martínez-López, Grao-Cruces, Moral-García & de la Torre Cruz, 2013). In fact, overweight children and adolescents are sometimes underestimated by their lower physical performance and suffer from discriminatory attitudes by their peers (Puhl, Peterson & Luedicke, 2013) and their physical education (PE) teachers (Martínez-López, Zamora-Aguilera, Grao-Cruces, & de la Torre Cruz, 2017). For some authors, the school should protect overweight students from these negative attitudes, and favour their expectations of learning and overcoming (Martínez-López et al., 2013). PE should also offer to young people adapted physical activity programmes and an adequate evaluation of their PF (Grao-Cruces, Ruiz-López, Moral-García, Ruiz-Ariza, & Martínez-López, 2016; Martínez-López et al., 2013).

However, the last statement has been questioned, since excess weight does not seem to affect in the same way the results of all PF tests (Artero et al., 2010; Botelho, Aguiar, & Abrantes, 2013; Fogelholm, Stigman, Huisman, & Metsamuuronen, 2008). Currently, there is wide scientific evidence of the beneficial effect of high PF in overweight youth (Savva et al., 2014). However, very few studies have analysed the opposite effect – the effect of excess weight in PF test results. Moreover, the majority of these studies are cross-sectional (Antunes et al., 2015; Castro-Piñero et al., 2013; Raistenskis, Sidlauskiene, Strukcinskiene, Uğur Baysal, & Buckus, 2016), and they do not include confounders, which could decisively influence the associations, such as socioeconomic status (Aires et al., 2012) or the amount of daily physical activity (Antunes et al., 2015).

The question of this study was: *Can excess weight negatively influence physical fitness test results?* This could clarify whether it is necessary to adapt the PF assessment according to the BMI in PE classes. Therefore, the objective of the present systematic review was to investigate the association of an excess of

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weight in adolescents and the results in different components of PF tests used in PE class. Additionally, this paper also reviewed potential mediators and moderators (i.e. socio-economic variables or sex) that could influence the above relationship.

Material & methods

The study was designed following the structure and recommendation of other systematic reviews (Pozo, Grao-Cruces, & Pérez-Ordás, 2016; Ruiz-Ariza, Grao-Cruces, Loureiro, & Martínez-López, 2017), the treatment used by PRISMA guidance for reports and studies (Moher, Liberati, Tetzlaff, & Altman 2009), and the Newcastle–Ottawa approach for observational studies (Wells et al., 2013).

Search limits - A comprehensive search of four databases of literature (PubMed, SPORTDiscus, Web of Science, and SCOPUS) from 2000/01/01 to 2018/04/30 was undertaken. Additionally, the reference lists of the selected papers were reviewed. The principal categories of search terms were identified and used in different combinations: (1) weight status (weight status, nutritional status, body composition, normal weight, overweight, obesity, fatness, body mass index); (2) physical fitness (physical fitness, fitness, cardiorespiratory fitness, aerobic capacity, maximum oxygen consumption, muscular fitness, musculoskeletal fitness, strength, motor fitness, speed, agility, flexibility); (3) adolescent (adolescent, teenager).

Selection criteria - The relevant papers selected for inclusion in the review were checked against the following criteria: (1) the study was a full report published in a peer-reviewed journal; (2) the study population was a healthy community-based population; (3) it included papers written in English, with specific analyses in a population of secondary-education adolescents between 11 and 18 years old; (4) it determined weight status, differentiating almost normal weight and overweight/obese, and fitness with measures taken at school; (5) it established weight status according to the International Obesity Task Force (IOTF), Centers for Disease Control and Prevention (CDC) or World Health Organization (WHO) criteria; (6) it searched the influence of excess of weight on fitness, not the other way; (7) there were no exclusion criteria with regard to ethnic origin.

Quality assessment - The quality assessment of the question was carried out on the basis of other standardized assessment lists (Pozo et al., 2016; Ruiz-Ariza et al., 2017) and on our selection criteria. The list included 7 items (A–G) on peer-reviewed journal, population, measurements, design, and confounders. Each item was rated as '1' (reported) or '0' (not reported or unclear). For all studies, a total quality score was calculated by counting the number of positive items (a total score between 0 and 7). Three levels of evidence were constructed. Studies were defined as of high quality (HQ) if they had a total score of 5 or higher. A total score of 3 or 4 was defined as of medium quality (MQ), and a score of less than 3 was defined as low quality (LQ).

Results

The flow of search results through the systematic review process is shown in Figure 1. A detailed analysis of the 14 studies finally selected, showed that 3 (21.4%) were longitudinal studies (Aires et al., 2012; Baranowski et al., 2013, Palomäki et al., 2015) and 11 (78.5%) were cross-sectional studies (Aires et al., 2010; Antunes et al., 2015; Artero et al., 2010; Botelho et al., 2013; Chen, Fox, Haase, & Wang, 2006; Chwałczyńska, Jędrzejewski, Socha, Jonak, & Sobiech, 2017; Fogelholm et al., 2008; Gulias-Gonzalez et al., 2014; Monyeki, Neetens, Moss, & Twisk, 2012; Okely, Booth, & Chey, 2004; Raistenskis et al., 2016). With regard to quality assessment, 10 papers had high quality and 4 had medium quality (see Table 1).

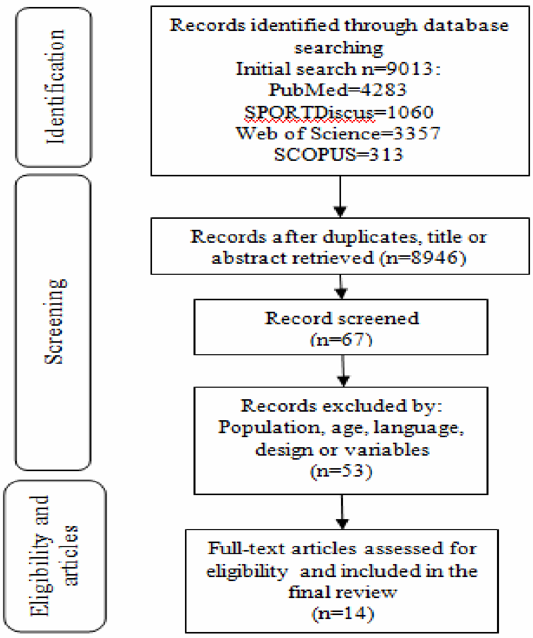


Fig. 1. Flow of articles through the search process

Table 1. List of included studies with quality scores

Authors and variables	A	B	C	D	E	F	G	Total Score	Quality level
Aires et al. (2012). Weight status and CRF	1	1	1	1	0	1	1	**6**	**HQ**
Aires et al. (2010). Weight status and CRF	1	1	1	0	0	1	0	**4**	**MQ**
Antunes et al. (2015). Weight status and motor fitness	1	1	1	1	1	1	0	**6**	**HQ**
Artero et al. (2010). Weight status, CRF, muscular fitness, motor fitness and flexibility	1	1	1	1	1	1	0	**6**	**HQ**
Baranowski et al. (2013). Weight status and CRF	1	1	1	1	1	1	1	**7**	**HQ**
Botelho et al. (2013). Weight status, CRF, muscular fitness, motor fitness and flexibility	1	1	1	0	1	0	0	**4**	**MQ**
Chen et al. (2006). Weight status, CRF, muscular fitness and flexibility	1	1	1	0	1	0	0	**4**	**MQ**
Chwalczyńska et al. (2017).Weight status, muscular fitness, motor fitness and flexibility	1	1	1	1	1	0	0	**5**	**HQ**
Fogelholm et al. (2008). Weight status, CRF, muscular fitness, motor fitness and flexibility	1	1	1	0	1	1	0	**5**	**HQ**
Gulias-González et al. (2014). Weight status, CRF, muscular fitness and motor fitness	1	1	1	1	1	0	0	**5**	**HQ**
Monyeki et al. (2012). Weight status and muscular fitness	1	1	1	0	1	1	0	**5**	**HQ**
Okely et al. (2004). Weight status and motor fitness	1	1	1	0	1	1	0	**5**	**HQ**
Palomäki et al. (2015). Weight status and CRF	1	1	0	0	1	1	1	**5**	**HQ**
Raistenskis et al. (2016). Weight status and CRF	1	1	1	0	1	0	0	**4**	**MQ**

Note. Rating for total score: MQ = medium quality, HQ = high quality. BMI = body mass index. CRF = cardiorespiratory fitness.
A: The study was a full text report published in a peer-reviewed journal.
B: The study population was healthy.
C: The selected weight status and physical fitness outcomes were objectively measured and clearly described.
D: Data analysis distinguished between overweight and obesity.
E: Random sample of secondary-education adolescents between 11 and 18 years of age.
F: Data was adjusted for confounders.
G: The study had a longitudinal design.

This review includes data from 36,660 individuals and the sample size of the studies varied from 111 (Aires et al., 2010) to 19,578 participants (Chen et al., 2006). The samples were from 9 different countries: 1 study was conducted in Australia (Okely et al., 2004), 1 in the USA (Baranowski et al., 2013), 1 in South Africa (Monyeki et al., 2012), 1 in Taiwan (Chen et al., 2006), 1 in Poland (Chwałczyńska et al., 2017), 1 in Lithuania (Raistenskis et al., 2016), 2 in Finland (Fogelholm et al., 2008; Palomäki et al., 2015), 2 in Spain (Artero et al., 2010; Gulias-Gonzalez et al., 2014), and 4 in Portugal (Aires et al., 2010, 2012; Antunes et al., 2015; Botelho et al., 2013). Detailed information about all the studies is presented in Table 2.

Table 2. Characteristics of analyzed studies (n = 14)

Authors and variables	Sample size/ Age/ Country	Study design / Confounders / Duration	Weight status measures	Physical fitness measures	Results
Aires et al. (16). Weight status and CRF	170 (73 boys) / 11-17 years / Portugal	Longitudinal / Age, maturation, and socioeconomic status / 4 years	Objectives and according to the IOTF	CRF (20m-SRT)	CRF showed a negative association with BMI categories
Aires et al. (22). Weight status and CRF	111 (49 boys) / 11-18 years / Portugal	Cross-sectional / Age and gender / ---	Objectives and according to the IOTF	CRF (20m-SRT)	Adolescents with overweight/obesity were less likely to perform more laps than normal weight counterparts
Antunes et al. (3). Weight status and motor fitness	538 (257 boys) / 12-14 years / Portugal	Cross-sectional / Age, physical activity and socioeconomic status / ---	Objectives and according to the IOTF	Gross motor coordination (balance while moving backwards, jumping laterally, hopping on one leg over an obstacle, and shifting platforms)	Normal weight scored significantly better than their obese peers in all gross motor coordination tests. Also, overweight boys and girls scored significantly better than their obese colleagues in these test, but significantly only in some of them
Artero et al. (11). Weight status, CRF, muscular fitness, motor fitness and flexibility	2474 (1196 boys) / 13-18.5 years / Spain	Cross-sectional / Age, sexual maturation, free fat mass, and fat mass / ---	Objectives and according to the IOTF	CRF (20m-SRT), muscular fitness (handgrip strength, standing long jump, bent arm hang test), motor fitness (4x10m SRT), flexibility (sit and reach test)	Overweight and obese adolescents presented a lower performance in 20-m SRT, bent arm hang, standing long jump and SRT 4x10 m tests, but a higher performance in handgrip strength compared with normal weight. In weight-bearing tests, the association became non-significant after adjusting for fat mass
Baranowski et al. (21). Weight status and CRF	3998 (1914 boys) / 11 years at	Cross-sectional and longitudinal / Parental education	Objectives and according	CRF (20-m SRT)	Subject who lowered their BMI group or remained in the healthy or overweight groups had significantly

	baseline / USA	and pubertal stage / 3 years	to the CDC		increases in CRF than those in the stayed obese or increased a BMI category group
Botelho et al. (12). Weight status, CRF, muscular fitness, motor fitness and flexibility	257 (153 boys) / 12-17 years / Portugal	Cross-sectional / --- / ---	Objectives and according to the CDC	CRF (one mile test), muscular fitness (horizontal jump, 30s abdominal, launch the medicinal ball), motor fitness (40m maximal sprint), flexibility (seat and reach test)	Obese adolescents were slower in CRF, lower body and abdominal strength and speed tests comparing to other groups, except in 15 year old group for strength and speed. No differences were found for upper body strength and flexibility
Chen et al. (23). Weight status, CRF, muscular fitness and flexibility	12,483 (3962 boys) in the 1999 survey and 7065 (6088 boys) in the 2001 survey / 15-18 years / Taiwan	Cross-sectional / --- / ---	Objectives and according to the IOTF	CRF (a 3-min step test), muscular fitness (the number of bent-leg curl-ups attained in 1 min), flexibility (sit-and-reach test)	Overweight/obese group had poorer performances in bent-leg curl-ups test and step test. In the sit-and-reach test the results were inconsistent
Chwalczyńska et al. (24).Weight status, muscular fitness, motor fitness and flexibility	200 (100 boys) / 14-16 years / Poland	Cross-sectional / --- / ---	Objectives and according to the WHO	Muscular fitness (standing long jump, hanging from a bar, straight-leg scissors), motor fitness (fast running on the spot for 10 seconds, with high knees and with clapping hands under raised leg), and flexibility (standing forward fold)	Normal weight achieved better performance for motor fitness, standing long jump and hanging from a bar than their overweight and/or obese peers in both genders. No significant differences were determined for straight-leg scissors and flexibility
Fogelholm et al. (13). Weight status, CRF, muscular fitness, motor fitness and flexibility	2266 (1120 boys) / 15-16 years / Finland	Cross-sectional / Physical activity / ---	Objectives and according to the IOTF	CRF (20-m SRT), muscular fitness (sit up beep test, five-jump), motor fitness (back-and-forth jumping, ball skills test, coordination test), and flexibility (sit-and-reach)	Overweight is related to impaired performance in tests requiring CRF, muscular fitness, speed and agility. Overweight was not associated with sit-and-reach test and only weakly with the ball skills test
Gulias-González et al. (4). Weight status, CRF, muscular fitness and motor fitness	791 (394 boys) / 12-17 years / Spain	Cross-sectional / --- / ---	Objectives and according to the IOTF	CRF (20-m SRT), muscular fitness (handgrip test, standing broad jump test), motor fitness (10x5m SRT)	Overall, 12-17 years adolescents with overweight and obesity presented similar performance in the handgrip test to those normal weight, but lower performance in the broad jump test and muscular fitness index. Also, especially obese subjects scored lower than normal weight for endurance SRT. For 10x5 test, scores were similar for all
Monyeki et al. (25). Weight status and muscular fitness	256 (100 boys) /14 years / South Africa	Cross-sectional / Race and locality / ---	Objectives and according to the IOTF	Muscular fitness (standing broad jump, bent arm hang, sit-ups)	For all three fitness tests, normal weight group performed better than overweight adolescents
Okely et al. (26). Weight status and motor fitness	1960 (1048 boys) / 8th and 10th grades / Australia	Cross-sectional / Age, socioeconomic status, cultural background, and rurality / ---	Objectives and according to the IOTF	Six fundamental movement skills (run, vertical jump, throw, catch, kick, and strike) were assessed by observation	Overweight were less likely to possess high levels of fundamental movement skills than nonoverweight
Palomäki et al. (5). Weight status and CRF	2258 (1116 boys) in 2003 and 1301 (661 boys) in 2010 / 15-16 years / Finland	Longitudinal / Physical activity / 7 years	Self-reported and according to the IOTF	CRF (20-m SRT)	Normal weight had better CRF than overweight adolescents. When participants were divided according to their LTPA, very active overweight adolescents performed as well as moderate active normal weight
Raistenskis et al. (15). Weight status and CRF	532 (244 boys) / 11-14 years / Lithuania	Cross-sectional / --- / ---	Objectives and according to the WHO	CRF (six-minute walk test)	Obese and overweight adolescents showed lower CRF than normal weight

Note. BMI = Body mass index. IOTF = International obesity task force. CDC = Centers for disease control and prevention. WHO = World Health Organization. CRF = Cardiorespiratory fitness. VO_{2max}= Maximum Oxygen consumption. LTPA=Leisure time physical activity. SRT = Shuttle run test.

Assessment of weight status

Twelve studies calculated the BMI using objective measures of weight and height, while in two studies these variables were self-reported (Fogelholm et al., 2008; Palomäki et al., 2015). To determine the weight status, 10 studies applied the IOTF standards, using some of the different versions (Cole, Bellizzi, Flegal, & Dietz, 2000; Cole & Lobstein, 2012), 2 studies (Baranowski et al., 2013; Botelho et al., 2013) used the CDC protocol (Kuczmarski et al., 2002), and 2 (Chwałczyńska et al., 2017; Raistenskis et al., 2016) used the WHO criteria (de Onis et al., 2007).

Assessment of physical fitness

The PF measures used in each study are shown in Table 2. Ten studies used objective measures to assess CRF. Among them, 7 used the 20 m shuttle-run test (20 m SRT) (Aires et al., 2010, 2012; Artero et al., 2010; Baranowski et al., 2013; Fogelholm et al., 2008; Gulias-Gonzalez et al., 2014; Palomäki et al., 2015), 1 used the one-mile test (Botelho et al., 2013), 1 carried out the 3 minutes step test (Chen et al., 2006), and 1 used the 6 minutes walking test (Raistenskis et al., 2016). To assess the muscular fitness a wide variety of tests were used. Six studies performed the upper-limb muscular strength. Of those, 2 used the handgrip-strength test (Artero et al., 2010; Gulias-Gonzalez et al., 2014), 2 used the bent-arm hang test (Artero et al., 2010; Monyeki et al., 2012), 1 used medicinal ball throws (Botelho et al., 2013), and 1 the hanging from a bar test (Chwałczyńska et al., 2017). Among the 6 studies analysing the lower limb muscular fitness, 5 used the standing long jump (Artero et al., 2010; Botelho et al., 2013; Chwałczyńska et al., 2017; Gulias-Gonzalez et al., 2014; Monyeki et al., 2012) and 1 used the five-jump test (Fogelholm et al., 2008). Finally, 5 studies assessed the core muscular fitness: 2 used the sit up in 30 seconds (Botelho et al., 2013; Monyeki et al., 2012), 1 the sit-up beep test (Fogelholm et al., 2008), 1 the bent-leg curl up (Chen et al., 2006), and 1 the straight-leg scissors (Chwałczyńska et al., 2017). Motor fitness was measured in 6 studies: 2 of them used the 4x10m (Artero et al., 2010) and 10x5m the shuttle-run tests (Gulias-Gonzalez et al., 2014), 1 carried out the 40 m sprint test (Botelho et al., 2013), 1 used the coordination test, with ball skills test, and back-and-forth jumping (Fogelholm et al., 2008), 1 performed six fundamental motor skills (Okely et al., 2004), and 1 used the Körperkoordinations Test für Kinder (KTK) (Antunes et al., 2015). Flexibility was assessed in five studies, the sit-and-reach test was used in all of them (Artero et al., 2010; Botelho et al., 2013; Chen et al., 2006; Chwałczyńska et al., 2017; Fogelholm et al., 2008).

Potential mediators and moderators that could influence the relationship of excess body weight with physical fitness

Nine (69.2%) of the 13 studies used confounders. These were age (Aires et al., 2010, 2012; Antunes et al., 2015; Artero et al., 2010; Okely et al., 2004), sexual maturation (Aires et al., 2012; Artero et al., 2010; Baranowski et al., 2013), sex (Aires et al., 2010, 2012), socio-economic status (Aires et al., 2012; Antunes et al., 2015; Baranowski et al., 2013; Okely et al., 2004), race (Monyeki et al., 2012), locality (Monyeki et al., 2012; Okely et al., 2004), body fat and free fat mass (Artero et al., 2010), and physical activity (Antunes et al., 2015; Fogelholm et al., 2008; Palomäki et al., 2015).

Relationship between excess body weight and cardiorespiratory fitness

Seventy-seven per cent of studies examining the relationship between weight status and CRF concluded that excess weight negatively influenced the CRF. Baranowski et al. (2013) found that adolescents who lowered their weight status group or remained in the normal or overweight groups, during the three years of study, had significant increases in CRF compared to those in the remained obese or the increased weight status group. In this context, Aires et al. (2012), after four years of observation, showed that obesity was negatively associated with CRF in all studied cases. Moreover, results have shown that excess weight decreases by between 10.3% (Raistenskis et al., 2016) and 16.3% (Aires et al., 2010) the maximum oxygen consumption (VO_{2max}) – ml/kg/min – and by around 30% the distance, time, stages, and number of laps in the 20 m SRT (Artero et al., 2010; Fogelholm et al., 2008; Gulias-Gonzalez et al., 2014; Palomäki et al., 2015). A more detailed study showed that obese subjects decreased their distance by 25–26 % (Artero et al., 2010) and the time by 22–30 % in this test (Gulias-Gonzalez et al., 2014) compared to their overweight peers.

Relationship between excess body weight and muscular fitness

In general, excess weight negatively influenced muscular fitness tests that require body weight to be supported or mobilized. Youths with excess weight performed between 62 and 80 % less than their normal weight peers in the bent-arm hang test (Monyeki et al., 2012). At the same time, the obese scored in this test 17–44 % less than overweight young (Artero et al., 2010). In a similar test as the hanging from a bar, similar differences were found between normal weight and obese adolescents (Chwałczyńska et al., 2017). Results of adolescents with excess weight are lower – between 8 and 14% – than normal weight peers in the standing long jump and in the five-jump test (Chwałczyńska et al., 2017; Fogelholm et al., 2008; Monyeki et al., 2012). Likewise, three of five studies that used abdominal tests (i.e. sit-ups) have shown results between 4 and 40 % lower in adolescents with excess weight (Botelho et al., 2013; Chen et al., 2006; Fogelholm et al., 2008). However, results in the medicine ball throws were similar in overweight and normal weight youth (Botelho et al., 2013). The handgrip test showed contradictory results. While some authors found no differences (Gulias-Gonzalez et al., 2014), others revealed higher results in obese compared to overweight adolescents, and in overweight compared to normal weight (Artero et al., 2010).

Relationship between excess body weight and motor fitness

No studies examined the relationship between excess weight and motor fitness in a longitudinal way. Cross-sectional studies showed that obesity is associated with a lower performance in motor fitness tests: ≤10% in 4x10 m SRT (Artero et al., 2010), 10x5 m SRT (Gulias-Gonzalez et al., 2014), 40 m sprints (Botelho et al., 2013) and 10 seconds sprint test (Chwałczyńska et al., 2017); and between 10 and 42 % in tests from the KTK (Antunes et al., 2015).

Relationship between excess body weight and flexibility

The five cross-sectional studies (Artero et al., 2010; Botelho et al., 2013; Chen et al., 2006; Chwałczyńska et al., 2017; Fogelholm et al., 2008) that studied the relationship between weight status and flexibility agree that there is no significant relationship between the two variables.

Discussion

This systematic review has analysed the association between excess weight and the results in different PF tests used in PE classes during adolescence. A total of 14 articles met the inclusion criteria. Overweight and obese were associated with lower CRF and motor fitness than their normal weight peers, in 10 and 6 studies, respectively. Likewise, overweight and obesity impair the performance in muscular fitness tests where body weight acted as ballast (bent-arm hang, standing long-jump test, abdominal tests), while the relationship with regard to other muscular fitness tests (throws, handgrip) and flexibility has been less studied and the results suggest that there is no association. Among the 14 studies, only the 64.2% used confounders.

The present study found that adolescents with overweight and obesity reached lower VO_{2max} than normal weight peers. In a similar way, Stensel, Lin, Ho and Aw (2001) found a lower VO_{2max} in obese than non-obese youth, in a sample of 40 Chinese Singaporean boys aged 13–15 years. These differences do not appear when VO_{2max} is expressed as L/min (Norman et al., 2005; Stensel et al., 2001), a direct consequence of it not being divided by the body weight. Other indicators of CRF found in our study, such as the distance travelled or the time achieved, were also adversely affected by overweight and obesity. These results are similar to those found by Castro-Piñero et al. (2011) in Spanish youth aged 6–17 years, Nunez-Gaunaurd, Moore, Roach, Miller and Kirk-Sanchez (2013) in American youth aged 10–15 years, Dumith et al. (2010) in Brazilian youth aged 7–15 years and Deforche et al. (2003) in Flemish adolescents aged 12–18 years. All of them showed that overweight and obese young produced the worst scores and a lower distance than normal weight in CRF tests.

Young people with excess weight also show lower results than normal weight in those tests that require lifting their own body weight. These results are in line with the finding in the bent-arm hang test in Spanish youth aged 6–17 years (Castro-Piñero et al., 2009), and similar to results obtained in jump tests in Brazilian youth aged 7–15 years (Dumith et al., 2010), in Taiwanese youth aged 10–18 years (Liao et al., 2013), and in German youth aged 4–17 years (Woll et al., 2013), and in abdominal tests (Castro-Piñero et al., 2009; Dumith et al., 2010; Liao et al.,2013). On the other hand, in muscular fitness tests which did not imply effort with the body weight – throws and handgrip – youth with excess weight have shown similar results than those with normal weight (Artero et al., 2010; Botelho et al., 2013; Gulias-Gonzalez et al., 2014). These results have been verified by Chivers, Larkin, Rose, Beilin and Hands (2013) in the handgrip test in Australian youth aged 10 and 14 years, and Deforche et al. (2003) in Flemish adolescents aged 12–18 years. In this context, Castro-Piñero et al. (2009) and Dumith et al. (2010) also obtained similar results in normal weight and excess weight adolescents in throwing tests. To explain the above, a recent study carried out by Martínez-López et al. (2017) quantified the effect size of overweight on muscular strength tests. This research showed, in a total of 11,044 Spanish adolescents aged 12–16 years, that 76.3% and 72.8% of overweight boys and girls, respectively, performed a standing long jump equal to or less than the normal weight average. A total of 67.4% and 67.1% of overweight boys and girls, respectively, showed manual dynamometer values equal to or greater than the normal weight average, and 68.7% and 65.9% of overweight boys and girls, respectively, obtained measures for 30 s of sit-ups equal to or lower than the normal weight pairs. Thus, this study verifies the differences between the different muscular tests according to the kind of test and whether it requires body mobilization. Finally, these authors conclude that it is important to take into account BMI in PF scales within PE classes, in addition to sex and age.

The seven studies assessing motor fitness have shown that overweight adolescents, and especially the obese young, show lower results than normal weight youths. Studies developed in Spanish, Australian and Brazilian children and adolescents found similar results (Castro-Piñero et al., 2010; Chivers et al., 2013; Dumith et al., 2010). In addition to the need to shift a greater amount of fat mass (Raj & Kumar, 2010), those with an excess of weight could suffer biomechanical alterations that affect the gait (Shultz, D'Hondt, Fink, Lenoir, & Hills, 2014).

In terms of flexibility, the excess weight showed no influence in any of five studies analysed. Current studies carried out in Spain, Germany, Taiwan and Brazil (Castro-Piñero et al., 2013; Dumith et al., 2010; Liao et al., 2013; Woll et al., 2013, respectively) found that excess weight does not affect results in the sit-and-reach test. However, there is some controversy when flexibility is assessed with other tests, such as the shoulder-stretch test. In this case, Castro-Piñero et al. (2013) and Joshi, Bryan and Howat (2012) verified in Spanish and

American youth, respectively, that children aged 5–17 years with excess body fat mass in the arm and upper back had more limited mobility in this area.

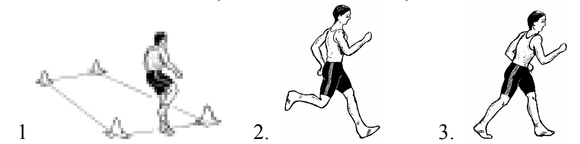
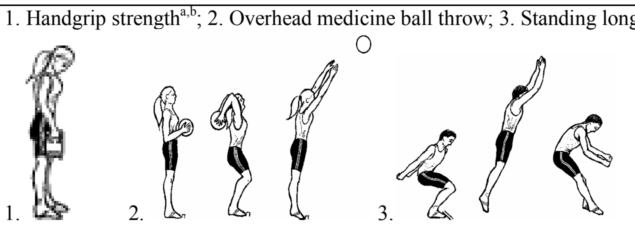
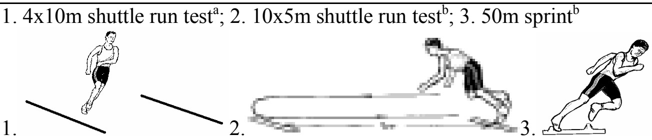
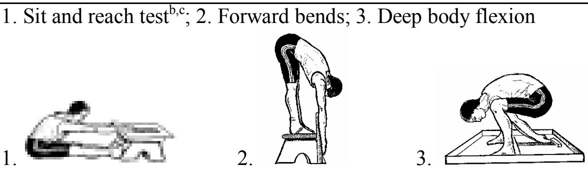
During adolescence, age, mature status, and socio-economic status are positively associated with PF results (Bohr, Brown, Laurson, Smith, & Bass., 2013; Castro-Pinero et al., 2009, 2011; Deforche et al., 2003). The association of excess weight with PF were shared by studies that adjusted by confounders – 64% – and by those that did not adjust by them. An exception to the above was shown by Artero et al. (2010), who verified that the association between excess weight and fitness was not significant when it was adjusted by body fat mass. This finding reinforces the argument that mobilizing a greater amount of body fat mass could be an important cause of a lower PF in overweight and obese adolescents (Fogelholm et al., 2008; Gulias-Gonzalez et al., 2014). Also, Antunes et al. (2015), Fogelholm et al. (2008) and Palomäki et al. (2015) reported that subjects with excess weight have lower PF than normal weight subjects, independently of the physical activity practised. Nevertheless, Palomäki et al. (2015), verified that when physical activity was used as a confounder, the more active overweight subjects had better PF than inactive normal weight. The above suggests that understanding the true relationship between an excess of weight and PF is still not resolved, and that the use of confounders is an aspect to be employed in future similar studies.

The novelty of this review is that it has analysed the influence of excess weight on the results of physical fitness in secondary schools, and not in the opposite sense. A quality standardized assessment list was used to select the studies. The review included longitudinal and cross-sectional studies, and potential confounders were taken into account. However, this review also has some limitations. For example, we gave equal importance to studies with small sample sizes and studies with larger samples. Other databases were not included in the current systematic review. Likewise, we included studies with participants from 11 to 18 years old, similarly to other studies (Aires et al., 2010, 2012), however PRISMA guidance (Moher et al., 2009) narrows the age of adolescence to 13 to 18 years old.

Conclusions

In conclusion, the present review found a negative influence of excess weight on CRF, motor skills and some muscular fitness tests in adolescents. Nevertheless, overweight and obesity do not decrease the performance in muscular fitness tests that do not mobilize own body weight nor in the flexibility tests. Table 3 shows recommended physical fitness tests for the use of physical fitness in PE classes with overweight and obese adolescents. It is suggested that PE teachers use scales adjusted by weight status to assess PF levels, beyond the traditional classifications according to age and sex.

Table 3. Recommended physical fitness tests in physical education classes with overweight and obese adolescents

Physical fitness component	Physical fitness test	Adaptations*
Cardiorespiratory fitness	1. 20m shuttle run test[a,b,c]; 2. One-mile run test[c]; 3. One-mile walking test[c] 	[1-3]Results expressed in L/min or compared with scales adjusted by weight status
Muscular fitness	1. Handgrip strength[a,b]; 2. Overhead medicine ball throw; 3. Standing long jump[a,b] 	[1,2]None [3]Results expressed in cm/kg or compared with scales adjusted by weight status
Motor fitness	1. 4x10m shuttle run test[a]; 2. 10x5m shuttle run test[b]; 3. 50m sprint[b] 	[1-3]To use scales adjusted by weight status
Flexibility	1. Sit and reach test[b,c]; 2. Forward bends; 3. Deep body flexion 	[1-3]None

Note. [a]Test include in the Alpha fitness test battery. [b]Test include in the Eurofit battery. [c]Test include in the FitnessGram battery

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