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Levels of Physical Activity, Physical Fitness and Overweight/Obesity in Children and Adolescents

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Keywords: HABITUAL PHYSICAL ACTIVITY, SEDENTARY TIME, ACCELEROMETRY, FITNESS, ADIPOSITY, YOUTH.

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Resumo

A proposta deste trabalho é examinar as associações entre excesso de peso/obesidade, actividade física (AF), actividades sedentárias e aptidão física (ApF), em estudos transversais, longitudinais e de intervenção. Os estudos foram realizados com uma amostra de alunos entre os 11 e os 19 anos da Escola Secundária de Valongo, localizada na periferia do grande Porto. Uma parte dos dados foi recolhida nesta escola durante 3 anos (2005-2008). Outra parte da amostra foi obtida num programa de intervenção para crianças obesas. Através de um questionário, recolheram-se informações sobre índice de AF (IAF), o tempo de actividades sedentárias e o transporte casa/escola. Para avaliar as diferentes intensidades da AF, foram usados acelerómetros. As componentes da ApF relacionadas com a saúde foram avaliadas através do *Fitnessgram*. O Índice de Massa Corporal foi categorizado de acordo com pontos de corte específicos para idade e género em Peso Normal, Excesso de peso e Obesidade. A composição corporal foi estimada a partir de três pregas de adiposidade. A maturação foi classificada de acordo com os critérios de Tanner. Os resultados principais destas amostras mostram que: I) Crianças e adolescentes com excesso de peso/obesidade têm valores menores de ApF em comparação com os seus pares de peso Normal. Muitos jovens com peso normal foram também classificados abaixo da zona saudável de ApF. II) Os resultados por acelerometria mostram que a AF e a adiposidade estão associados apenas para as actividades vigorosas. III) Quer nos estudos transversais quer nos longitudinais, os níveis de ACR foram os melhores preditores do excesso de peso/obesidade. IV) Foi encontrada uma associação positiva e independente da ΔAF com a ΔACR e negativa da ΔIMC quando ajustado à *baseline*. Com o IMC como variável dependente apenas a ACR e a força abdominal se mostraram preditores. V) Programas de exercício físico podem aumentar a AF moderada e vigorosa diária em crianças com excesso de peso/obesidade, o que realça a importância da intervenção nesta população especial. Os resultados desta tese, adicionam algumas evidencias sobre a importância de AF de intensidades elevadas para aumentar níveis de ApF na prevenção e redução do excesso de peso/obesidade em crianças e adolescentes.

Palavras Chave: ACTIVIDADE FÍSICA HABITUAL, TEMPO DE SEDENTARISMO, ACELEROMETRIA, APTIDAO, ADIPOSIDADE, JOVENS.

Abstract

The overall purpose of this study was to examine the associations of overweight/obesity with Physical activity, sedentary activities and Physical Fitness in the Portuguese youth. We used both, cross-sectional, and longitudinal studies along with an intervention study. This was a school-based study (Escola Secundária de Valongo) with an average of 1200 students evaluated each year. The data collection took place throughout three school years (2005 - 2008) in a public school. The intervention study was carried out in a 10-month interdisciplinary, outpatient obesity intervention program for children. An index of PA, sedentary time and Commuting to/from was obtained by questionnaire; PA intensity levels were measured with accelerometers. Health-related components of PF were evaluated using the *Fitness gram* battery. Body mass index was categorized in normal weight, overweight and obesity with specific cut points for age and gender and body composition was estimated from three skin fold thicknesses. Stages of sexual maturation were identified according to Tanner criteria. The main outcomes in these samples were: I) overweight/obese children and adolescents have lower PF level compared to normal weight peers. A large number of children with normal weight were also identified as under healthy zone. II) The results with accelerometers showed associations only between BMI and vigorous intensities. III) In both cross-sectional and longitudinal studies, CRF level was the best predictor for BMI. IV) Positive and independent association was found between PA and CRF when the lattes was used as a dependent variable. There was also, a negative association with BMI after adjustments to baseline. V) Structured PA program can increase the daily moderate to vigorous PA level of overweight/obese children, emphasizing the importance of organized PA for this special population. The findings reported in this thesis add some evidences to the importance of higher intensity levels of PA to enhance PF and prevent or reduce Overweight/obesity among children and adolescents.

Keywords: HABITUAL PHYSICAL ACTIVITY, SEDENTARY TIME, ACCELEROMETRY, FITNESS, ADIPOSITY, YOUTH.

Résumé

Le but de ce travail, c'est d'examiner les liens entre surpoids/obésité, Activité Physique habituelle, comportements sédentaires et fitness chez les enfants et adolescents âgés entre 11 et 19 ans au moyen des études transversales, longitudinales et d'une étude d'intervention. Cette étude a été réalisée sur des élèves de l'Ecole Secondaire de Valongo, située dans la banlieue de Porto. Prés de 1100 élèves ont été testés par an. Une partie des donnés a été collectée pendant 3 ans (2005-2008), une autre partie de l'échantillon a été lors d'un programme d'intervention pour des enfants obèses. A l'aide d'un questionnaire, nous avons pu réunir des informations sur l'indice d'Activité Physique (AP), la durée des activités sédentaires et le transport du trajet scolaire. Pour évaluer les différentes intensités de l'AP on a utilisé des accéléromètres (MTI Actigraph). Les éléments du fitness en rapport avec la santé ont été testés avec une batterie de tests du *Fitness gram*. L'indice de Masse Corporelle a été classé, suivant des points de coupe spécifiques à l'âge et au genre, en Poids Normal, Surpoids et Obésité. La composition corporelle a été estimée à partir de trois bourrelets adipeux. La maturation a été classifiée suivant les critères de Tanner. Les principaux résultats de ces échantillons montrent que : 1) Les enfants et adolescents en surpoids/obésité ont des indices de fitness inférieurs comparativement aux autres enfants et adolescents de poids Normal. De nombreux jeunes de poids normal n'ont pas atteint la zone salutaire du fitness. II) Les résultats obtenus avec l'accéléromètre montrent que l'AP et l'adiposité ne sont associés qu'en présence d'activités intensives. III) Les niveaux de la capacité cardio-respiratoire (CRC) ont été les meilleurs pronostiqueurs de surpoids/obésité. IV) Une association positive et indépendante de la AP avec CRC a été décelée quand analysée comme variable dépendante. On a aussi constaté une association négative avec l'obésité quand ajustée à la baseline. V) Des programmes d'exercices physiques peuvent contribuer à l'augmentation de l'AP modérée, intensive quotidienne chez les enfants en excès de poids/obèses ce qui prouve l'importance de l'intervention chez cette population bien spécifique. Les résultats de cette thèse réunissent quelques évidences sur l'importance d'une AP de forte intensité qui augmente les niveaux de CRC ce qui influence la prévention et la réduction du surpoids/obésité chez les enfants et les adolescents.

Mots clés : ACTIVITÉ PHYSIQUE. DURÉE D'ACTIVITÉS SÉDENTAIRES, ACCÉLÉROMÈTRE, CAPACITÉ PHYSIQUE, ADIPOSITÉ, ENFANTS, ADOLESCENTS.

List of abbreviations

ACORDA	Stands for obese children and adolescents engaged in a nutritional and physical activity program
AC	Active commuting
BMI	Body Mass Index
CRF	Cardiorespiratory Fitness
CS	Commuting to school
CU	Curl-ups
Count	accelerometer measurement without direct expression with standardized measures
Count.**min**	Counts per minute
CVD	Cardiovascular disease
ESV	Escola Secundária de Valongo
HP 2010	Healthy People 2010
Kg	kilogram
m	Metro
MET	Metabolic equivalent
MTI	Manufactoring Technology, Inc
MVPA	Moderate to vigorous physical activity
Ow/Ob	Overweight/obesity
PA	Physical activity
PF	Physical Fitness
PU	Push-ups
SD	Standard deviation
ST	Screen Time
VPA	Vigorous physical activity
VVPA	Very vigorous physical activity
20-mSR	20 meters Shuttle Run
Δ	Variation
%	Percentage

Introduction

Childhood and adolescence are complex stages with profound changes due to growth and maturation. The behaviour pattern obtained throughout this stage can be crucial to a healthier future and greater quality of life.

Obesity has characterized generations in the last decades. Studies following children into young adulthood suggest that overweight children might become overweight adults, particularly if obesity is present in adolescence (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Considering that Cardiovascular diseases (CVD) begin in childhood and tracks into adulthood (L. B. Andersen, Hasselstrom, Gronfeldt, Hansen, & Karsten, 2004), these modifiable risk factors should be addressed early (Boreham et al., 2002). Although other factors such as genetics (Bouchard, 1991) play an important role in obesity-related genesis, the increased prevalence of obesity has been associated with the reduction of physical activity (Prentice & Jebb, 1995)

Longitudinal studies show that physical activity and physical fitness tend to decrease in all ages and in both genders. However, there is still many conflicting results respecting to health-related physical activity and physical fitness in general and obesity in particular (Caspersen, Nixon, & DuRant, 1998; Eisenmann, 2004). The lack of solid evidence is mainly due to the complexity of physical activity evaluation, and the purpose of health-related cut points at these ages. The priorities of international recommendations call for the increase of moderate to vigorous activities and physical fitness for health benefits. However, evidence has suggested that the majority of children and adolescents do not achieve the 60 minutes per day of these activities (Pate et al., 2002).

Several studies have addressed relationship of physical activity and physical fitness with adiposity. Physical activity, especially vigorous physical activity, but not total physical activity is negatively related to body fatness, whereas both amount and intensity of physical activity are positively associated with CRF in children (Gutin, Yin, Humphries, & Barbeau, 2005; Ruiz et al., 2006). Physical activity may have a greater impact in preventing obesity in children than lower physical activity intensity levels, whereas both total and at least moderate to vigorous physical activity may improve children’s cardiorespiratory fitness (CRF) (Ruiz et al., 2006).

Sustaining the idea of this complex network of interrelationships between Adiposity, physical activity and physical fitness, we intend to construct general and specific aims to find results that strengthen scientific knowledge in this domain.

Aim

The aim of this thesis was to increase knowledge and strengthen evidences about the associations between physical activity, physical fitness and overweight/obesity in a cross-sectional, longitudinal and intervention perspective. Therefore, we used a cross-sectional and longitudinal design as well as an interventional study. In this context the following specific objectives were set:

Specific Aims

I. Analyse the relationship of different physical fitness components, namely, strength, flexibility and CRF with overweight/obesity.

II. Examine the relationship of physical fitness levels and objectively measured physical activity, with overweight/obesity.

III. Analyse associations of physical activity, sedentary activities and Overweight/obesity with CRF.

IV. Investigate in a longitudinal perspective how variations in body mass index, physical activity index and sedentary activities, are associated with variations in physical fitness

V. Investigate in a longitudinal perspective, how variations in physical fitness, PAI, and sedentary activities can influence the risk of weight gain over three years.

VI. Analyse is an extracurricular intervention program can contribute to the increase of moderate to vigorous activities e in children and adolescents with overweight/obesity.

List of Publications [a] and Manuscripts

The papers presented here, published or being revised in journals with peer-review, were structured from specific aims, which may provide a rationale for a line of action in the field.

I. Aires, L., Silva, P., Santos, R., Santos, P., Ribeiro, J. C., & Mota, J. (2008). Association of physical fitness and body mass index in youth. *Minerva Pediatr, 60*(4), 397-405.

II. Aires, L., Silva, P., Silva, G; Santos, P., Ribeiro, J. C., & Mota, J. Intensity of physical activity, cardiorespiratory fitness and body mass index in youth. JPAH (in Press)

III. Aires, L., Pratt, M., Lobelo, F., Santos,R., Santos, M.P., Ribeiro, J.C., Mota,J. Association of cardiorespiratory fitness, with physical activity, active commuting to school and screen time in youth (under revision)

IV. Aires, L., Andersen, L.B., Mendonça, D.; Clarice Martins, Gustavo Silva; Mota, J. A 3 year longitudinal analysis of changes in fitness, physical activity, fatness, and screen time. Acta Paediatrica (in Press)

V. Aires, L.; Mendonça, D.; Silva, G; Gaya, A.R.; Santos, M.P.; Ribeiro, J.C.; Mota, J. A 3 year longitudinal analysis of changes in body mass índex (under revision)

VI. Aires, L., Santos, R., Silva, P., Santos, P., Oliveira, J., Ribeiro, J. C., Mota, J. (2007). Daily differences in patterns of physical activity among overweight/obese children engaged in a physical activity program. *Am J Hum Biol, 19*(6), 871-877.

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[a] The papers were presented in this thesis with the permission of their publishers

[Chapter I.]

[I.]

1. Background

Evidence and considerations about physical activity physical fitness and overweight/obesity analyzed in three methodological perspectives:

- 1.1 Cross-sectional studies
- 1.2 Longitudinal studies
- 1.3 Tracking studies

1.1 Cross-sectional studies

1.1.1 Physical Activity

Physical activity includes all types of movement, from the smallest to the most complex. It may be voluntary, (including structured physical activity, planned, relatively limited in time and implemented to improve certain attributes of physical fitness or energy expenditure) or daily life activities (which includes walking, household, occupational activities or transportation). It can be typically involuntary and spontaneous, from small body movements, like a blink of an eye, to all muscle contractions associated with different postures of the body. However, it is difficult to assess and quantify separately these different physical activity domains, which leads them to being considered together (Teixeira, Silva, Vieira, Palmeira, & Sardinha, 2006).

Cross-sectional studies showed in different ways children and adolescents' physical activity. Physical activity is a topic of current discussion as an important issue for health and well being in the short and long term. Several factors must be recognized in physical activity analysis such as age, gender (Trost et al., 2002) socio economic status (SES), (Mota, Ribeiro, & Santos, 2008), environment and social support (Mota, Almeida, Santos, & Ribeiro, 2005). Furthermore, the attention has been focused also in sedentary behaviours as a general preference of the new generations (Caspersen, Pereira, & Curran, 2000) and for being positively associated with overweight/obesityin children and adolescents (Ekelund et al., 2006; Lioret, Maire, Volatier, & Charles, 2007; Must et al., 2007).

As Malina and Little (2008) said “The current scenario begs several questions which have implications for contemporary human biology related to sustaining the pace of cultural changes on a biological base that is increasingly being compromised by physical inactivity, overweight and obesity.

Although sedentary behaviours (by designation, is every physical activity with low energy expenditure) comprise the classic physical activity definition by Caspersen (1985) (“any bodily movement produced by energy expenditure.”), they correspond to a different category, and do not indicate the absent of light or moderate activities. Sedentary behaviours and physical activity are only modestly correlated; they have different types of socio-demographic determinants and are differently associated with health-related risk factors (Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Brodersen, Steptoe, Williamson, & Wardle, 2005). Many studies show that time devoted to sedentary behaviours is not associated with time spent in physical activity (Ekelund et al., 2006; Lioret et al., 2007; Vandewater et al., 2007), another author considers that these two variables are inversely related (Koezuka et al., 2006; Zabinski, Norman, Sallis, Calfas, & Patrick, 2007) or even that these types of activities, such as watching TV or using a computer, might have different value in relation to physical activity for youth (Santos, Gomes, & Mota, 2005).

Taking into account the decreasing levels of physical activity and health risk factors, scientific and governmental commissions have recommended not only the reduction of sedentary activities, but also the promotion of physical activity in children and adolescents: the American Academy of Paediatrics (AAP, 2001) published guidelines to reduce hours in activities with low energy expenditure like watching TV (with good quality programs) to at least an average of two hours per day .

Regarding physical activity guidelines, Pate et al., (2002) analyzed three recommendations and concluded that prevalent estimates for compliance were dramatically different: 1) Over 90% of the students met the Healthy People

2010, aim 22.6 for moderate to vigorous physical activities MVPA (≥30 min, ≥ 5 d/wk ≥ METs) (METs or metabolic equivalents) which appear to be a too low standard. 2) In contrast, very few students (less then 3%) met the requirements of HP 2010, aim 22.7 for vigorous physical activities (VPA) (≥ 20 continuous minutes, ≥ 3 d/wk, ≥ 6 METs) which seems to be an inappropriate standard for youth, because it may prescribe a form of physical activity that is common for adults, but uncharacteristic of children and youth. 3) Lastly, the United Kingdom Group recommendation of accumulating 60 minutes of MVPA, (≥60 minutes, ≥ 5 d/wk ≥ 3 METs) was supported as the best existing guidelines for youth and has been adopted elsewhere since then.

Nonetheless, we must recognize that the selection of these *guidelines*, are based in arbitrary classifications of 3 or 6 MET's in moderate or vigorous intensities (L. B. Andersen et al., 2006; Freedson, Pober, & Janz, 2005; J. W. Twisk, 2001).

Actually, the main difficulty is to answer multiple questions related to the methodological issues to evaluate habitual physical activity in the field. There are several methods to evaluate physical activity: questionnaires, diaries, direct observation, heart rate monitors and motion sensors (pedometers and accelerometers). However, some studies show inconsistent results between physical activity obtained by objective and subjective measurements. With subjective instruments children and adolescents tend to overestimate physical activity levels (Sallis & Saelens, 2000). Despite the fact that questionnaires might classify physical activity with larger error compared to objective assessments, they might be valid in the field and is useful in large samples. Direct observation can be an excellent tool, but still has the disadvantage in time and number of investigators required in the field, which increases the costs. Heart rate monitors and motion sensors can overcome the problems of individuals' subjectivity or memory and are less expending than direct observation. However, they can bring some technical problems, and they do not capture detailed information about patterns or contexts of physical activity. In addition, there is no international consensus about specific cut points or about regression equations to estimate energy expenditure (L. B. Andersen et al., 2006; Trost et al., 1998). Moreover, the main issue is to find the boundary for moderate to vigorous intensities. Several studies support the attribution of 3.38 e 4.15 km/h (average of all studies) to 1000 and 2000 counts/min, respectively (Brage, Wedderkopp, Andersen, & Froberg, 2003; Puyau, Adolph, Vohra, & Butte, 2002; Trost et al., 1998).

Each method has advantages and limitations; therefore, some concerns must be taken into account about which is more important in the cultural, social and physical environment context, to choose the adequate instrument (Pate, 1993). Double-labelled water is the gold standard technique to evaluate total energy expenditure and others emerge as accurate methods such as direct and indirect calorimetry. The main limitation is the absence of a *gold standard* method for validation of indirect methods as indicators of energy expenditure in children and adolescents (Pate et al., 2002).

Assessing physical activity in all its magnitude is indeed a great challenge. The inconsistency of results may be explained by several existing methods of assessment (Sirard & Pate, 2001; Welk, Blair, Wood, Jones, & Thomson, 2000; Welk, Corbin, & Dale, 2000). Future validations are needed in accelerometry to convert cut-points into physiologic intensities, for a uniformity of results (L. B. Andersen et al., 2006).

1.1.2 Physical Fitness

The analysis of physical fitness population has shown in the last decades a greater interest, because the recognition of the associations that can be established with habitual physical activity, health and well-being. Therefore, it seems essential for students to evaluate physical fitness in any physical activity program or Physical Education (PE) classes, establishing their baseline in order to achieve the healthy zone and supervise its progress.

Physical fitness is a set of attributes that people have or achieve. Being physically fit has been defined as "the ability without undue fatigue and with ample energy to enjoy leisure time pursuits and to meet unforeseen emergencies" (Caspersen et al., 1985), but it is modifiable through exercise training within individuals intra-variability. The most frequently cited components fall into two groups: one related to health and the other related to skills. The health related components are cardio-respiratory fitness (CRF), which reflects the capacity of the respiratory and cardiovascular system to bear prolonged exercise (Taylor, Buskirk, & Henschel, 1955); muscular strength, an essential component for daily life (Malina, Bouchard, & Bar-Or, 2004); flexibility as the component that relates to the range of motion available at the joint and the ability of appropriate amplitude of movement; and for lost body composition. Each of these components varies with age and gender. In all of them (except flexibility) boys show better performances than girls, which might be related to the rapid increase in muscle mass (Malina et al., 2004).

Several cross-sectional studies have shown positive associations with physical activity during childhood and adolescence (Ekelund et al., 2001; Johnson et al., 2000; Katzmarzyk, Malina, Song, & Bouchard, 1998; Norman et al., 2005), as well as negative associations with body fat (BF). Fitness components in general and CRF in particular, seem to relate strongly to CVD risk factors then objectively measured physical activity components. While BF exacerbate these risk factors, higher CRF levels may play an important role in prevention in young ages (Hurtig-Wennlof, Ruiz, Harro, & Sjostrom, 2007). School-based fitness programs can improve CRF levels quickening insulin levels and body composition in obese children in the absence of detectable changes in BMI (Carrel et al., 2005).

Better CRF performances can be a high marker of physical activity levels, not only of the total amount or volume essentially of higher intensities, with evidence highlighting vigorous activities (Ruiz et al., 2006).

Regarding physical fitness evaluation, several batteries can be used with different protocols, which makes the comparison of results difficult. There is strong evidence indicating that the 20-meter shuttle run (20-m SR) is a valid test to estimate CRF (Castro-Pinero et al., 2009). The performances of obese children can be penalized on weight bearing tests. In spite of the tests, which remove the effect of weight, it may overestimate the results by the extra muscle mass that exists in those of whom are overweight. Issues associated with determining this use a weight-bearing test versus a non–weight-bearing test, and using weight-relative values versus absolute values, are complex. On the one hand, use of a weight-bearing test and expression of fitness relative to body weight potentially penalize the heavier child and adolescent by making values seem lower compared to normal weight counterparts. On the other hand, use of a non–weight-bearing test can potentially inflate estimation of fitness because of the work that can be done by extra muscle mass, which may or may not translate into fitness condition. (Pfeiffer, Dowda, Dishman, Sirard, & Pate, 2007).

1.1.3 Obesity

The prevalence of overweight/obesityhas increased in different populations with The United States in the leadership (Flegal, Ogden, Wei, Kuczmarski, & Johnson, 2001; Troiano & Flegal, 1998) following other European countries (L. F. Andersen et al., 2005; Lobstein & Frelut, 2003; Papandreou et al., 2008), Asian countries like India (Bhardwaj et al., 2008; Chen, Fox, Haase, & Wang, 2006), Australia (Magarey, Daniels, & Boulton, 2001) and all over the world (Lissau et al., 2004; WHO, 2000). Portugal has one of the highest prevalence of Europe with 31.6% of children between 7 and 9 year-olds (Padez, Fernandes, Mourao, Moreira, & Rosado, 2004) and 18% for those between 10 and 16 year-olds (Janssen et al., 2005); Epidemiologic studies show that obesity is the result of a long term imbalance between energy intake and energy expenditure. Its aetiology is influenced, by socio-demographic factors, such as age, socio-economic status (Mota et al., 2007), behavioural and environmental factors (O'Brien et al., 2007), diet (French, Story, & Jeffery, 2001) and physical activity (Trost, Kerr, Ward, & Pate, 2001).

Several studies have shown inverse associations between BF, physical activity and CRF (Johnson et al., 2000; Mota, Flores, Flores, Ribeiro, & Santos, 2006; Norman et al., 2005). Sedentary behaviours may have a dual role in rising obesity, not only because they involve very low costs of energy, but also because they are associated with high caloric food intake and with low nutritional quality. Notwithstanding, caloric and fat intake did not increase quantitatively in children and adolescents over the centuries (Troiano, Briefel, Carroll, & Bialostosky, 2000), suggesting a sedentary lifestyle as an important factor for the dramatic increase of obesity.

There are several valid and reliable methods to assess adiposity, as Hidrodensitometria, Dual Energy X-ray absorptiometry (DEXA), computed axial tomography, magnetic resonance imaging, bioelectrical impedance, or skin folds, even though this last one can be less reliable in cases of morbid obesity (Slaughter et al., 1988). Less precise, the anthropometric methods or the assessment of circumferences are more accessible though, because it is of easy administration in the field, and at a low cost (Rolland-Cachera et al., 1997).

Even without international consensus about waist circumference (WC) cut points for children, some authors prefer the use of WC for abdominal obesity evaluation, while others argue that skin folds are a better indicator of fat mass (FM). However, many studies use BMI to define weight or adiposity status. Despite the limitations in distinguishing muscle mass from fat mass, BMI is perfectly suitable for clinical practice and for studies with large samples and appears to be an excellent indicator of health in both short and long term. BMI correlates with direct assessments of body fat (Pietrobelli et al., 1998) as well as indirect assessments such as WC ($r = 0.92$) and FM ($r = 0.92$), without significant differences between gender in adults (Bouchard, 2007).

Maturational status is another aspect that might be related with obesity. Between the sixties and nineties of the last century the population average age at menarche in US girls dropped from 12.75 years to 12.45 years. Increased BMI was associated with increased likelihood of being menarcheal, adjusted to age and race. Currently, this decrease in age of menarche (Anderson, Dallal, & Must, 2003; Freedman et al., 2002) as well as the premature development of secondary sexual characteristics (Kaplowitz, Slora, Wasserman, Pedlow, & Herman-Giddens, 2001) might be associated with the rising prevalence of obesity.

Correlation has been shown between obesity in girls and pubic hair development, (Tanner & Whitehouse, 1976) breast (Kaplowitz et al., 2001) and premature menarche (Freedman et al., 2002). A study carried out by Denzel et al., (2007) comparing the maturational development of obese boys and girls with reference data of the Zurich Longitudinal Study, showed no changing in boys and girls' pubic hair and no changes in genital development in boys. However, in girls there was an increase of breast development in stage 3 in obese girls.

1.1.4. Methodological considerations

Cross sectional studies have the advantage of gathering larger samples, even so, the causal direction between physical activity, physical fitness and obesity is not known, because variables are determined in one time point evaluation. Actually, this causality between physical activity, physical fitness and obesity can be explained in several directions: the populations can be fit because they are more active, or they can be more active because they are more fit (Kemper, de Vente, van Mechelen, & Twisk, 2001). Similarly, sedentary activities can be an indicator of several health determinants, and then again, individuals genetically predisposed to be obese or to be unfit may decide for a less active lifestyle.

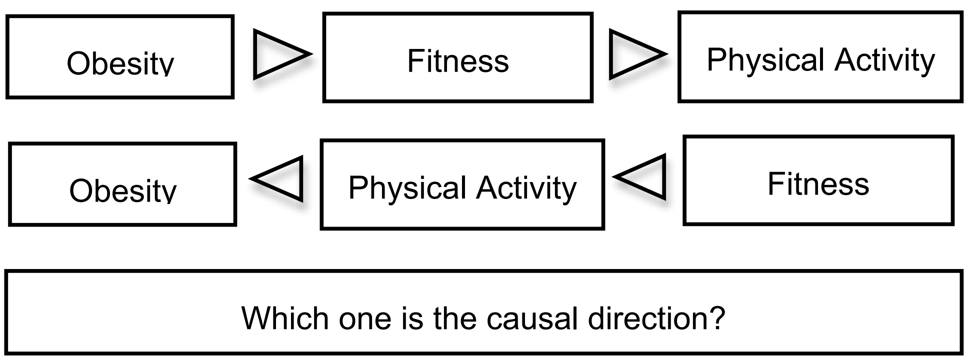

Fig. 1. Direction of causality

Eventually, the causality can be examined in longitudinal studies.

1.2 Longitudinal Studies

1.2.1 Physical Activity

Since birth, in all stages of growing and aging, there are changes in physical activity levels and patterns over time. These important changes in physical activity can be clearly observed in longitudinal studies. Literature shows that physical activity decreases during lifetime, but there is some room for discussion to know how it decreases in the most critical period of adolescence.

Several longitudinal studies, in Europe (Telama & Yang, 2000; Van Mechelen, Twisk, Post, Snel, & Kemper, 2000), or in USA (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Kimm et al., 2002), have shown a marked decline of physical activity from childhood to adolescence, more pronounced in girls than in boys, perhaps by social and cultural conditions (Kemper et al., 2001; Kimm et al., 2002; Yang et al., 2007), more pronounced between 15 and 16 year-olds in both genders (Pratt, Macera, & Blanton, 1999). Overall, physical activity can decline 1% to 20% per year (Aaron et al., 1992; Kimm et al., 2000; Yang et al., 2007).

Recently, one study demonstrated that physical activity can decline not in a linear but in a quadratic shape: in boys physical activity increased until 11 years old and after a *platô* decreased from 13 years old, whilst in girls, increased until 12-13 years old and began to decrease from that age on. In addition to the social and cultural factors, such as academic responsibilities, other biological factors can mediate this process, like changes in the dopamine system, which can regulate the motivation for action, (Kahn et al., 2008).

Habitual physical activity pattern also changes during growth: the domain of spontaneous recreational activities are replaced by structured activities in sports clubs or gyms (Malina, 1991).

The main concern for most researchers is the decline of physical activity in youth lifestyle as a result of ecological changes verified in the last decades. (Pratt et al., 1999). Not only the volume but also moderate to vigorous intensities (MVphysical activity) have been decreasing over time (Baquet, Twisk, Kemper, Van Praagh, & Berthoin, 2006; 2000; Kemper et al., 2001; Van Mechelen et al., 2000). And as important as the positive effect of vigorous activities is the adverse effect of sedentary behaviours (Dietz, 1996). In the new generations children and adolescents spend more time watching television (TV) or using computer for work or for leisure time and social activities. Adolescence seems to be a particular vulnerable period for this type of sedentary behaviours (Hardy, Bass, & Booth, 2007; Must et al., 2007; Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006). However, there are conflicting results both in cross-sectional and longitudinal studies, regarding the influence of sedentary leisure time in overweight with positive associations (Proctor et al., 2003), negative associations (Horn, Paradis, Potvin, Macaulay, & Desrosiers, 2001) or even without association (Salbe et al., 2002). In a review, (Must & Tybor, 2005), giving many of the inconsistencies to methodological and statistical issues, most longitudinal studies suggests that increased physical activity and decreased sedentary behaviour are protective against relative weight and fatness gain throughout childhood and adolescence.

There is indeed a protective effect of physical activity on BF throughout childhood. Despite the general decline in physical activity levels over age, more active children tend to have lower values of BF in early adolescence (Moore et al., 2003). Thus, providing high physical activity levels in pre-school age can delay the beginning BF rebound that usually occurs between 4 and 6 years of age.

1.2.2 Physical Fitness

The overall picture indicates a decline in physical fitness (strength and CRF) about -0.36% per year, since the decade of the 70's related to social, behavioural, physical, physiological and psychological factors (Tomkinson & Olds, 2007) in different ages, genders and geographic areas (Corbin & Pangrazi, 1992; Dollman, Olds, Norton, & Stuart, 1999). In a study carried out between 1974 and 1995 in Sweden, CRF decreased, although with an enhancement in static strength performances (Westerstahl, Barnekow-Bergkvist, Hedberg, & Jansson, 2003). These results are in part due to the increase in body weight and BMI. However, the decline of physical fitness over time has been noticed in all BMI categories, not only in those with overweight/obesity(Stratton et al., 2007; Wedderkopp, Froberg, Hansen, & Andersen, 2004). Children are loosing the metabolic effect of fitness that might protect them from excessive weight gain as well as other metabolic ill health (Stratton et al., 2007).

Physical fitness, especially CRF is considered a powerful marker of health (Krahenbuhl, Morgan, & Pangrazi, 1989; Ortega, Ruiz, Castillo, & Sjostrom, 2008). Prospective studies in adults have shown that low levels of physical fitness, especially CRF, are strongly associated to the risk of developing heart disease (Laukkanen, Kurl, Salonen, Rauramaa, & Salonen, 2004; Talbot, Morrell, Metter, & Fleg, 2002) hypertension (Blair et al., 1995) Diabetes Mellitus typo II (Sawada, Lee, Muto, Matuszaki, & Blair, 2003) CVD (Church, LaMonte, Barlow, & Blair, 2005; Katzmarzyk, Church, & Blair, 2004) cancer (Evenson, Stevens, Cai, Thomas, & Thomas, 2003; C. D. Lee & Blair, 2002) and all cause of mortality (Katzmarzyk et al., 2004). In children and adolescents, low levels of CRF are related to an adverse profile of chronic disease risk factors (Freedman, Dietz, Srinivasan, & Berenson, 1999; Williams et al., 1992). In results from the European Youth Heart Study (EYHS) the opposite trends of physical fitness and obesity in children suggests a future generation with a higher degree of CVD risk. (Wedderkopp, Froberg, Hansen, Riddoch, & Andersen, 2003).

Several studies observed secular trends of CRF in children. As in physical activity and physical fitness in general, there was a decline in CRF levels in the last decades (Moller, Wedderkopp, Kristensen, Andersen, & Froberg, 2006; Tomkinson, Olds, & Gulbin, 2003; Wedderkopp et al., 2004). Stratton et al., (2007) showed a decrease in 20-m SR scores in about 23% between 1998 and 2004 in children from 9 to 11 years old in both genders. There was an increase around 36% in girls and 80% in boys under healthy zone (UHZ). However, other authors revealed no significant change in CRF in girls over the same period (Wedderkopp et al., 2004).

Although it is generally recognized that physical fitness can be an indicator of physical activity levels, a four-year longitudinal study during adolescence (Baquet et al., 2006), showed that the increase in physical activity levels was not associated with physical fitness when comparing active with sedentary children. The absolute values of the performances in fitness tests were not different between children who increased or decreased their physical activity levels. Furthermore, if children increased their physical activity levels they never reached the fitness performances of some who were physically active at baseline. Physical fitness performances were more associated with maintaining a high level of physical activity. The regularly active group not only had higher performances in CRF, as in other fitness components, and for girls, flexibility, but also further increased these performances compared with the other groups. Therefore, for those authors, it seems important to promote physical activity early in childhood to have a high level of physical activity. However, another author stated that changes in physical activity levels from childhood to adolescence may only have a marginal influence on physical fitness, compared with the sedentary subject (Malina, 2001). Similarly, from adolescence to adulthood this longitudinal relationship appears to be significant only for CRF (Kemper et al., 2001). Regarding strength, flexibility and body composition (BC), longitudinal results show that these components of the physical fitness are not correlated with physical activity levels (Beunen et al., 1992; Malina, 2001).

1.2.3 Obesity

The increase of BMI and adiposity by skinfolds seem to be related to decreasing levels of physical activity (Kimm et al., 2005), but there is still conflicting results (Johnson et al., 2000). Within the lifestyles parameters that can influence changes in BF throughout childhood and adolescence, studies based on hierarchical models elect physical activity as the most decisive, followed by physical fitness. (Koutedakis, Bouziotas, Flouris, & Nelson, 2005). Other factors are, gender, degree of obesity at baseline and parental obesity (Goran et al., 1998). In these recent studies, caloric intake was not a factor influencing weight loss, while other studies (Goran et al., 1998; Prentice & Jebb, 1995) showed no changes in caloric intake over time.

The quality of family ties is crucial: parent control, amount of toys and games at home, or activities structured by the adults, may provide more or less opportunity to be active and expose children to reduced time watching TV (O'Brien et al., 2007). In this study, children who maintained their OW status, from primary school were more sedentary and presented lower physical activity levels. Apparently, no one single factor was consistently linked to OW, but a set of interconnected factors in a socio-cultural level (family, socio-economic status, gender), intra-and inter-personal level (parents psychological health and welfare in general) and environment (safety, physical activity levels and sedentary activities). Sedentary activities such as time spent watching TV seems to be the most recurrent behaviour throughout adolescence and is associated to OW lipid profile as cholesterol levels (Hancox, Milne, & Poulton, 2004) and hypertension (Virdis et al., 2009) in adulthood.

1.2.4 Methodological considerations

The popularity of longitudinal studies is that there is a general belief that with longitudinal studies the problem of causality can be solved. However, there are several important criteria essential to causality: strength of the relationship, consistency in different populations and under different circumstances, specificity (cause leads to a single effect), biological gradient (dose-response) relationship, biological plausibility, experimental evidence and the temporality (cause precedes effect in time) the one that is specific to longitudinal studies The cause (predictor variable) must precede the effect in time, which in the case of physical activity, physical fitness and adiposity, the main mechanisms is complex to find (J. W. Twisk, 2003).

Because obesity develops in a small negative balance over time, it is likely that researchers find small effects. On account of these modest results, relatively large samples are needed to find statistical significance. This may explain the null results, especially in small samples, which usually occur in longitudinal studies.

1.3 Tracking Studies

The word “Tracking” (that will be used along in the text) refers to stability of a characteristic or the maintenance of a relative position within a group over time (Malina, 1996).

1.3.1 Physical Activity

Analysis conducted through questionnaires showed an effect of low stability in physical activity from childhood to adolescence and from adolescence to adulthood (Barnekow-Bergkvist, Hedberg, Janlert, & Jansson, 1996; Malina, 2001; Raitakari et al., 1994). Objective measures of physical activity have a moderate tracking from childhood to adolescence, with coefficients of stability around 0.50 (Kristensen et al., 2008). Also with Pedometers moderate correlations were observed for those who were insufficiently active during adolescence, with higher tracking coefficients in boys than in girls (Raustorp, Svenson, & Perlinger, 2007). The type and intensity of activity can also be influencing factors of physical activity in adulthood (Tammelin, Nayha, Hills, & Jarvelin, 2003), with higher coefficients in organized sports (Kraut, Melamed, Gofer, & Froom, 2003) and for vigorous intensities. Briefly, with objective instruments, the tracking of physical activity from childhood to adolescence and from adolescence to adulthood, may be higher comparing with questionnaires, because of the error variation within the study (misclassification). A coefficient of tracking can never be greater than the error within the study. If an instrument has a reproducibility of r=0.50 between two assessments a week a part, it is difficult to obtain a higher coefficient between measurements taken years apart.

The transition from adolescence to adulthood is characterized by big changes in behaviours associated with marriage, new home, first job and birth of children. And the behaviours obtained in this period are more important than family history as a key in the new cycle of life (Hogan, 1978). In another study (Gordon-Larsen, Nelson, & Popkin, 2004) the majority of adolescents who did not achieve 5 or more days per week of MVPA maintained that physical activity level later on throughout adulthood.

Several studies have shown that girls had better coefficients of tracking for vigorous activities then boys. Boys, were more likely to maintain sedentary behaviors in adulthood when compared with their more active peers (Janz, Dawson, & Mahoney, 2000; Raitakari et al., 1994; J. W. Twisk, Kemper, & van Mechelen, 2000). Again, the decrease of physical activity levels is inevitably linked to the increase of sedentary behaviours. There is a clear trend to maintain or increase sedentary behaviours over time (Baquet et al., 2006; Gordon-Larsen et al., 2004).

Physical activity provides a long-term protective effect on bone health, and an indirect effect on all health benefits resulting from adult physical activity.
Although literature suggests that physical activity in adolescence is an important contributing factor to adult physical activity levels, existing results do not allow a clear recommendation on the amount of physical activity in adolescence that is required to build an active lifestyle in adulthood (Hallal, Victora, Azevedo, & Wells, 2006).

1.3.2 Physical Fitness

It is known that physical fitness tracks from childhood to adolescence (Janz, Dawson, & Mahoney, 2002) and from adolescence to adulthood (Hasselstrom, Hansen, Froberg, & Andersen, 2002; Malina, 1996; J. W. Twisk et al., 2000). The tracking of CRF, and muscular strength (adjusted to body weight) are in general moderate with coefficients around 0.5. In strength components (isometric) some studies show high coefficients of 0.7 (L. B. Andersen, 1994; J. W. Twisk et al., 2000).

CRF show better tracking than physical activity. The explanation may be, first, the genetic component of CRF compared with the behavioural component of physical activity and secondly, as was referred before, because the misclassification of physical activity assessed through questionnaire.

In a study over 23 years, (kemper & koppes, 2006) the importance of physical activity in adolescence and its influence in physical fitness in adulthood was irrelevant; no relationship was found in both genders. However, coefficients tend to be lower when longer periods of time are in analysis, for instance between childhood and adulthood (Malina, 2001). Actually, in the first 15 years of that study carried out by Kemper and Kroppes (2006), the strength of the relationship between physical activity and physical fitness was highly significant. Nevertheless, the functional implications seem to be less expressive: an increase of 30% in physical activity (approximately 1000 METs/week) results in an increase of only 2% in CRF. If the results are not significant over 23 years, then it is not possible to prove an existent relationship between physical activity and CRF over time in men and women. Thus, on the one hand, we have to consider that the effect of physical activity in CRF is so small that it is not detectable in longitudinal studies so extensive in time, and on the other hand, we have to assume the importance of genetics in this process.

The relationship of physical activity and CRF in a short and long term, arise another concern: the consequence of reducing sedentary behaviours because they are negatively associated with CRF levels in adulthood (Hancox et al., 2004).

The rational explanation for this association between sedentary behaviours in children and physical fitness in adults is related to physical activity levels. Although physical activity can be a confounder, it can also be a mediator for health in adulthood.

1.3.3 Obesity

A review study reported an increased risk of overweight and obese youth becoming overweight adults, suggesting that the likelihood of persistence of overweight into adulthood is moderate for overweight and obese youth. However, predictive values varied considerably (Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008).

Depending on the stage that a child begins to be obese, the risk of maintaining obesity into adulthood, may be higher. About 40% of 7-year-old obese children and 70% of obese adolescents can become obese adults (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). More recent studies confirm this theory (Dietz, 2004; Freedman et al., 2005; Matton et al., 2006; Whitaker et al., 1997).

In a study carried out by Togashi et al., (2002) with 10 and 11-year-old children, the results showed a tracking of overweight and obesity from childhood to adulthood in 54.7% of the cases. The risk of obesity in adulthood was twice higher in boys moderately obese comparing to girls, even when receiving treatment for obesity during this period of childhood.

However, in the previous study, among the children who received treatment for over a year, 76.5% of whom with the lower obesity and 58.8% of whom with moderate obesity, achieve a normal BMI in adulthood. Obesity tracks moderately from adolescence to adulthood along with another risk factor as CVD (Eisenmann, Wickel, Welk, & Blair, 2005; Katzmarzyk et al., 2001).

The idea of a moderate longitudinal stability in obesity tracking gives an ability to determine the risk to health. This underlines the importance of preventive interventions, such as surveillance, counselling, and monitoring overweight and obese children, so as to counteract this trend (Fuentes, Notkola, Shemeikka, Tuomilehto, & Nissinen, 2003; Stettler, Kumanyika, Katz, Zemel, & Stallings, 2003).

Several authors analysed another tracking, showing an inverse association between CRF in adolescence and obesity in adulthood (Eisenmann et al., 2005; J. W. Twisk, Kemper, & van Mechelen, 2002). Figure 1 gathers some coefficients found in two studies linking physical activity, physical fitness and BMI (Eisenmann et al., 2005; Kemper et al., 2001; Yang et al., 2007).

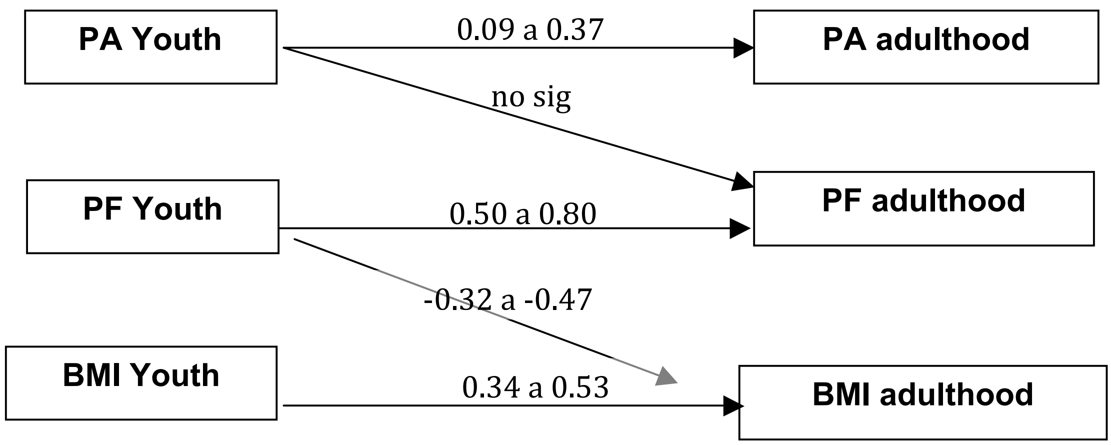

Figure 2. Coefficients of *Tracking* between physical activity, physical fitness and body mass index

1.3.4 Methodological considerations

When we analyse coefficients of tracking we must consider the extension of age, age at baseline, changes in environment and variability of assessments. When coefficients of tracking are high, this not necessarily means that absolute values of that variable remain in the same level.

Limiting aspects with respect to generalization and methodological issues, statistical procedures are constantly present, which make difficult to compare coefficients between studies in physical activity, physical fitness and BMI.

1.4 Prevention

Preventive medicine or preventive care refers to measures taken to prevent illness or injury, rather than curing them. It can be contrasted not only with curative medicine, but also with public health methods (which work at the level of population health rather than individual health). This takes place at primary, secondary and tertiary prevention levels. *Primary prevention* avoids the development of a disease. Most population-based health promotion activities are primary preventive measures. *Secondary prevention* activities are aimed at early disease detection, thereby increasing opportunities for interventions to prevent progression of the disease and emergence of symptoms. *Tertiary prevention* reduces the negative impact of an already established disease by restoring function and reducing disease-related complications.

Childhood is the perfect time to intervene with primary prevention for several reasons: (i) Obese children are more likely to be obese adults (Power, Lake, & Cole, 1997); (ii) there is a growing evidence pointing to the adverse consequences of obesity for health in both children and adults (Reilly et al., 2003); (iii) in intervention strategies children can be more receptive to changing behaviour, comparing to adults (Epstein, Valoski, Kalarchian, & McCurley, 1995); (iv) treatment of obesity is difficult and with limited efficacy (Summerbell et al., 2003). But when obesity is already a problem, remains secondary prevention that can be functional through school-based interventions.

1.5 Interventions

Currently, children and young people do not find sufficient opportunity to accomplish an appropriate level of physical activity as a routine. Children should be engaged in more MVPA at school or outside school, participating in voluntary activities, spontaneous or organized, in order to obtain benefits to health.

Intervention programs can provide the means of maximizing energy expenditure and knowledge about a healthy lifestyle.
A preventive intervention may be essential to reduce the amount of hypo kinetic diseases, improve methods to encourage children's to be physically active and evaluate the effectiveness of the program.

Based on the tracking studies there are evidence that it is difficult to establish and maintain healthy behaviours throughout life. Previous school-based intervention studies confirm that changing behaviours is a long-term and complex process to reach positive results. In Trial for Activity for Adolescent Girls (TAAG), during two years of school-based intervention, linked to PE, communities and marketing, each children increased an average of 1.6 minutes of MVPA per day (Webber et al., 2008).

Meta-analysis study showed unenthusiastic perspectives about interventions to weight loss. The effectiveness of interventions in changing behaviours is only minimal in their objectives. However there are several common points that must be recognized: a) more efficacy reducing sedentary behaviours in children than in adolescents, b) more efficacy in long-term treatments (>6 months); c) Short-term treatments more effective in reducing unhealthy diets (Kamath et al., 2008). This study found small beneficial changes on the target behaviours and no significant effect on BMI as compared to control. Strategies attempting to reduce unhealthy behaviours (i.e., decreasing sedentary behaviours and dietary fat) seem to be more effective than those promoting positive behaviours (i.e. increasing physical activity and consumption of fruits and vegetables) (Kamath et al., 2008; Sharma, 2006). Certainly, these behaviours are likely to interact when impacting obesity to the extent that we believe obesity to result from an imbalance between energy expenditure and consumption (Kamath et al., 2008). Yet, in intervention combining diet, physical activity increment and pharmacological agents, show limited effectiveness in the short and long term (McGovern et al., 2008).

Other studies with systematic reviews and meta-analysis (Harris, Kuramoto, Schulzer, & Retallack, 2009; Li, Li, Baur, & Huxley, 2008) showed no strong evidences about the efficacy in secondary preventions with overweight and obese children and adolescents. However, the latest study (Harris et al., 2009) has stressed other important effects on health. Given the inconsistency of the evidence, the impact in longer term remains unclear, in children and adolescents. However we must continue considering new strategies, new study designs to be more effective in primary and secondary prevention for this special population. Interventions to increase physical activity in children and adolescents, can be successful considering multiple levels, combining the school with family, community, education and environment (van Sluijs, McMinn, & Griffin, 2007), in a short-term (Shaya, Flores, Gbarayor, & Wang, 2008) or in a long-term (Brown & Summerbell, 2008).

Concerning to mediators authors are in agreement that self-efficacy and enjoyment in the activity as more supportive in the relationship theory/practice of physical activity (Lubans, Foster, & Biddle, 2008). Enhancing personal skills and self-efficacy, limit the control and external motivations, ensure positive and inspiring experiences during and after physical activity are crucial aspects in the long term regulation (Teixeira et al., 2006)

Based on a review study, (Doak, Visscher, Renders, & Seidell, 2006), table 1 shows the common denominator in interventions with efficacy and without efficacy regarding the desired outcomes in each of them:

Table 1. Common denominators in interventions with and without efficacy

With efficacy	Without efficacy
Large samples, but smaller number of participating schools	Include many components simultaneously
Inclusion of MVPA	Large community involvement
Those that directly change social involvement: physical activity practice and changes in the canteen With therapies promoting behavioural changes Older children (between 10 to 14 years)	Heterogeneous groups in age, gender, socio-economic status and ethnicity
In those who are obese	
In girls	

1.5.1 Methodological considerations

All review and meta-analysis studies alert to the methodology limitations heterogeneity of study designs, different types of outcomes assessed and the weakness of the evaluations, which do not contribute to an informed analysis of the success or failure of interventions.

1.6 The School

It is the privilege set for obesity intervention in children and adolescents. Schools have the advantage to monitor and influence a large number of children, at low costs and with the proximity of parents. Parents can be involved in meetings, or be informed through didactic materials. On the other hand, children have PE classes (mandatory in our country). PE in the school system can be very effective by incorporating a theoretical approach or involving the PE teachers to deliver or supplement the messages of a healthy and active lifestyle.

Nevertheless, if PE can provide an extraordinary opportunity to increase energy expenditure and to promote healthy habits and behaviours, it seems insufficient to achieve the physical activity recommendations. PE teacher can have the key role in the coordination in school-based intervention programs, involving parents, teachers, community, and institutions in an interdisciplinary network.

The school is the perfect place for extra-curriculum interventions to overcome barriers for physical activity, such as the lack of transportation, security, and others (Cohen et al., 2006; Mota et al., 2005). There are many other factors and levels of influence in physical activity particularly in MVphysical activity, like the size and quality of gyms and recreational spaces, quality of sports teachers in PE and the quality of their classes.

1.7 Family

Family is the foundation of any child. There is an inter-generational transmission of behaviour related to health, which means that, parents can influence children's behaviour as a representative model of an active and healthy-related lifestyle (Kahn et al., 2008). Therefore, parents should be supportive in daily activities, e.g. in active transportation home/school, promoting self-recreation, encouraging towards organized sports and being a model for physical activity and healthy eating (Dowda, Dishman, Pfeiffer, & Pate, 2007; Trost et al., 2003). The other way around, children should also be an influence in their families bringing home knowledge from what they learn at school about the importance of physical activity for a healthy lifestyle.

1.8 What has been done in Portugal?

The "National Charter Counteracting Obesity" included in the National Health Plan intends to contribute to the promotion of weight loss in obese people with type II diabetes and CVD, promoting a culture of healthy habits. physical activity is included in both National plans. We selected some principals of these documents: improve diet and increase physical activity levels; policy tools to reduce the extent and impact of commercial promotion of energy-dense foods and beverages, particularly to children, with the development of international approaches, such as a code on marketing for children in this area; and the adoption of regulations for safer roads to promote cycling and walking; giving special attention to children and adolescents, whose inexperience should not be exploited by commercial activities. The purpose of “National Charter Counteracting Obesity” is to reverse the increasing prevalence of overweight and obesity in Portugal with intersectional cooperation, which all sectors must play a role at an international, national and local level.

Thus, we must act in a multidisciplinary and multi-institutional plan to achieve the aims identified for an intervention program to help children at risk, to be able to have healthy choices in their social environment and family in order to obtain health benefits.

[Chapter II.]

[II.]

2. Methods

This chapter will present the general information about the samples, instruments and methods used. Specifications of each instrument and method can be found in the six papers (Chapter III).

The data for the first five studies were collected in Escola Secundária de Valongo. This school has an average population of approximately 1200 students, from 7^{th} to 12^{th} grade, from 11 to 19 years old. Data collection took place throughout the school years of 2005-06, 2006-07 and 2007-08 during the months of October and November.

For longitudinal data we gathered 345 students with the same evaluations over the 3 years: BMI, Questionnaires, Physical Fitness.

3 years after	Age in 2005-06	11	12	13	14	15	16
	Age in2007-08	14	15	16	17	18	19

For the sixth paper, data was collected in the Intervention Program "ACORDA". This program designed for overweight and obese children and adolescents has two one-hour sessions per week. The sample included 41 subjects from 6 to 16 years old. The sample was collected in May 2005, near the end of the program.

2.1. Measurements

2.1.1. Questionnaires

Several questions were gathered for different variables: 1) five questions for physical activity index (PAI), 2) questions related to time spent watching TV or using computer during the week and weekend 3) questions related to type and time used in transportation house/school. The whole questionnaire can be found in the supplement session.

2.1.2. Accelerometers

Students used accelerometers from *MTI Actigraph* throughout seven consecutive days. At least five days of recording with a minimum of 10 hours registration per day, was set as an inclusion criterion. Data was analysed with specific software (MAHUffe, www.mrc.epid.cam.ac.uk) using 1-minute epoch. Physical activity intensities were based upon specific cut points. In the second paper we used the threshold for MVPA >2000 counts/min, which corresponds to a walking of about 3-4 Km/h (Brage et al., 2003). For the sixth paper we used Puyau et al., (2002) cut points.

2.1.3. Fitness tests

Five tests from *Fitnessgram* were used: curl-ups, push-ups, trunk lift, back-save sit and reach and 20-m shuttle run. These tests are included in Portuguese Curricula for PE classes (Prudencial FITNESSGRAM, 1994).

2.1.4 Anthropometry

Height was measured using a *Holtain* stadiometer and body mass was measured with an electronic weight scale (*Tanita Inner Scan BC 532*). BMI was calculated from the ratio weight/height^2 (Kg.m^{-2}). When BMI was categorized in normal weight, overweight and obesity, specific cut points were used adjusted to age and gender (Cole, Bellizzi, Flegal, & Dietz, 2000). Triceps, sub scapular and mid calf skin fold thickness were measured according to (Heyward, 1998). A *Harpenden Skin fold Calliper* with a constant pressure of 10 g/mm^2 was used. The sum of the 3 Z-scores from skin fold thickness measurements was calculated as a final value.

2.1.5. Maturation criteria

Children and adolescents were interviewed separately during evaluation. Each subject was asked to self-assess his/her stage of secondary sex characteristics.

Stage of breast development in females and pubic hair in males was evaluated according to Tanner's criteria (Tanner & Whitehouse, 1976) used and validated in a similar sample (Mota et al., 2002).

2.2.3. Parents' education level

Socio-economic position was established from Parents' educational level. Categories were based on the Portuguese Educational system: (1) 9 years' education or less–sub-secondary level; (2) 10–12 years' education – secondary level and (3) College/ Master/Doctoral degree - higher education level). These three levels were named as Low, Middle and High level of education. Similar procedures have previously been applied in the Portuguese context (Mota & Silva, 1999).

Table 2. Evaluations and percentage of students assessed per year

	2005	**2006**	**2007**
School Population ESV (n total)	1007	1005	1146
IBMI (%)	85	85	86
Questionnaires **(%)** - PAI - TV time and computer use - Commuting house/school - Parents' educational level	60	85	80
Fitness tests **(%)**	51	82	84
Sexual maturation **(%)**	-	75	84
Waist Circumference **(%)**	-	75	84
Skin folds **(%)** Triceps, sub scapular and mid calf	-	75	84
Accelerometers **(%)** 7 days, epochs of 1 min.	-	30	-

[Chapter III.]

I Paper

Association of physical fitness and Body Mass Index in youth

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Aim. **The aim of this study was to establish physical fitness (PF) levels in a school population of 11-18-year-old students and analyse differences according to body mass index (BMI) status in overweight**

Methods. **This is a cross-sectional study. The sample comprises 636 children and adolescents (mean age of 14.5±1.5 years), 288 boys (45.3%) and girls 347 (54.7%). Six tests from Fitness-gram battery were used as an objective measure of physical fitness. Overweight/ Obesity status was determined using age and sex adjusted cut-off points.**

Results. **Both girls and boys with obesity performed a significantly reduced number of tests in healthy fitness zone suggesting a decrease of performances in strength and cardiovascular fitness, from normal weight status to overweight and from overweight to obesity. Boys and girls with obesity are likely to be Under HFZ than normal weight.**

Conclusion. **The results suggest that obese and overweight children have low PF level compared to normal weight peers. A large number of children with normal weight were identified as well as unfit. These data also showed that a low BMI level would significantly improve some PF component.**

Key words: **Child - Adolescent - Body Mass Index - Physical fitness.**

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There is a growing global childhood epidemic obesity, with a large variation in secular trends across countries[1] and Portugal is not the exception. Indeed, previous studies have shown a high prevalence of overweight and obesity in children [2] and adolescents.[3] Although other factors such as genetics [4] and diet [5] play an important role in obesity-related genesis, the increased prevalence of obesity has been associated with the reduction of physical activity (PA) [6] as well as with low levels of physical fitness (PF).[7] Longitudinal studies of children followed into young adulthood suggested that overweight children may become overweight adults, particularly if obesity is present in adolescence,[8, 9] and that the level of PF in adults is conditioned by the level of PF in childhood or adolescence![10, 11] Given this figure, which affects an increased number of children, obesity and poor PF represents a health problem ought to be screened.[12]

Health-related PF variables included cardiorespiratory fitness (CRF), abdominal muscular strength and endurance, lower back flexibility and fatness.[13] Several cross-sectional and longitudinal studies showed an association between CRF and cardiovascular risk factors in youth,[14, 15] including obesity.[16-18] Nevertheless, while several studies reported the relationship between CRF and obesity (Body Mass Index, BMI) few studies assess other fitness outcomes associated with obesity.

Obese children may reduce their fitness by abstaining from exercise,[19] conversely, higher fitness is associated with lower fat mass [20] but it is more likely that both factors are interrelated and interdependent.[21]

However, further strategies targeting youth at risk for overweight/obesity should be developed based on substantial population obesity data. Therefore the aim of this study was to establish Physical Fitness levels in a school population of 11-18-year-old students and analyse differences according to BMI.

Materials and methods

Subjects

This is a cross-sectional study carried out in a middle and high school from suburban setting comprising all the students from the 7th until 12th grade. A letter informing families that students will be measured was sent home two weeks before measurements took place. Written given consent was required. The Portuguese Ministry for Science and Technology provided permission to conduct this study.

The school population comprised 1 226 students from which 1 024 are inhabitant set in a suburban area, 280 are from periphery and 202 students live out of this periphery. Students that failed to complete fitness tests, or did not complete the anthropometric measures (N=590, 42.1%) were excluded from the analysis. Therefore the sample of this study comprised 636 students (289 boys and 347 girls) with an age comprised between 10 to 18 years.

Anthropometry

Height was measured using a Holtain stadiometer. Values of height were recorded in meters to the nearest millimetre. Body mass was measured to the nearest 0.1 kg with an electronic weight scale (Tanita Inner Scan BC 532) with subjects in t-shirts and shorts. The BMI was calculated from the ratio weight/height^2 (kg/m^2) and organized using age and sex adjusted cut-off points described by Cole *et al.*[22] Then participants were categorized as normal weight, overweight or obese group.

Physical fitness

Health-related components of PF were evaluated using the Fitnessgram battery test.[23] The Fitnessgram uses criterion-referenced standards to evaluate fitness performance. The standards were established by the Cooper Institute for Aerobics Research to represent a level of fitness that offers some degree of protection against diseases that result from sedentary living. Findings from current research based on the United States national norms have been used as the basis for establishing the Fitnessgram standards.

Performance was classified into two general areas: “in the healthy fitness zone” and “needs improvement” on a particular test item by different age and gender. The Fitnessgram is included on physical education curriculum, and the 5 tests recommended in the Portuguese National Program (curl-up; push-up; trunk-lift; the modified back saver sit and reach and the 20 m shuttle run) were used in this study.

Test results were split in two fitness categories such as under healthy fitness zone (under HFZ), equivalent to “needs improvement”, and healthy fitness zone or above (HFZ). For sit and reach students were required to reach the distance to pass. Thus, test was split into two categories: pass/fail.

The Fitnessgram was chosen because of its simplicity of administration to large samples, its reliability and validity. All tests were conducted according to the Fitnessgram measurement procedures.[23] The physical education teachers involved in this project undertook training sessions, worked together with qualified staff in order to assure the standardization, and reliability of the measurements. Students were familiarized with the

TABLE I.—*Participants' characteristics.*

	Girls N=348 (54.7%)							Boys N=288 (45.4%)						
	Normal weight N=273 (78.7%)		Overweight N=63 (18.1%)		Obesity N=11 (3.2%)		P	Normal weight N=215 (74.7%)		Overweight N=56 (19.4%)		Obesity N=17 (5.9%)		P
	X	SD	X	SD	X	SD		X	SD	X	SD	X	SD	
Age	14.49	1.42	14.30	1.19	14.18	1.54	0.510	14.68**	1.53	14.86	1.66	13.47***	1.37	0.005
Weight	51.72*	8.13	65.98**	8.54	81.63	7.13	0.000	56.10*	9.61	74.02**	10.47	71.23	14.27	0.000
Height	1.61	0.07	1.62	0.07	1.61	0.07	0.778	1.69*	0.09	1.70**	0.09	1.61	0.09	0.007
BMI	19.98*	2.27	25.11**	1.62	31.36	1.97	0.000	19.55*	1.98	25.32**	1.76	29.23	1.85	0.000

*Scheffé post hoc comparison; different from overweight and obesity. **Scheffé post hoc comparison; different from obesity. ***Scheffé post hoc comparison; different from overweight.

procedure for each test before recording data. Further, the participants received verbal encouragements from the investigators in order to achieve maximum performance.

Statistical analysis

Means and standard deviations were calculated to describe participants' characteristics by sex and BMI. Analysis of variance (ANOVA) was used to test differences between BMI groups for anthropometric measures and age, followed by a Scheffé test.

χ^2 test was used to calculate the proportions of healthy fitness levels reached in each item among BMI categories. Because gender was analyzed separately, some of the cells of overweight and obesity observations expected frequencies of less than 5. Given that, data failed to meet the underlying assumptions necessary for reliable results using the standard asymptotic method. Thus, Monte Carlo Test was used to obtain accurate results with a confidence interval (CI) set at 99%. Somers'd test was used to indicate the strength and direction of the relationship.

General linear model multivariate analysis by gender and adjusted for age was used, to analyse PF variables as dependent variable, and BMI as independent variable. In order to evaluate multiple comparisons among BMI categories Bonferroni's correction was applied.

A multivariate logistic regression model fitted to assess Odds ratio (OR) and 95% Cl for overweight and obesity. Because there was frequencies equals to zero, Shuttle Run test was analyzed as a continuous variable adjusted to age.

Statistical analysis was performed using SPSS 15 software (SPSS Inc., Chicago, IL, USA) and Microsoft Excel 2000. The level of significance was set at $P \leq 0.05$.

Results

Participants' anthropometric characteristics are shown in Table I, as mean (X) and Stand Deviation (SD).

Boys showed significant differences in age and anthropometric measures among BMI categories. Those who were obese were the youngsters (X=13.5 year-old). Statically significant differences were found in weight and BMI between normal weight overweight and obese girls.

Tables II, III show PF categories according to obesity level for girls and boys, respectively. Boys presented higher prevalence of overweight and obesity (19.4% and 5.9%) than girls (18.2% and 3.2%).

χ^2 test shows that a higher percentage of girls and boys with overweight and obesity were under HFZ compared to the normal weight counterparts. A significant negative association was found in boys, between BMI categories and curl ups ($P<0.001$), push ups ($P<0.05$) and shuttle run ($P<0.001$), whereas in girls this association was seen in curl ups ($P<0.001$) and shuttle run ($P<0.001$).

The prevalence of overweight and obesity was inversely associated with the number of tests accomplished. Both girls and boys

TABLE II.—*Physical fitness categories according to BMI for girls.*

Fitness tests	Fitness Categories	Girls				
		Normal weight %	Over-weight %	Obesity %	χ^2 value	Somers'd value
Curl-ups (cadence)	Under HFZ	22.1	41.3	72.7	21.463**	-0.224**
	HFZ	79.9	58.7	27.3		
Push-ups (cadence)	Under HFZ	47.1	49.2	90.9	8.128*	-0.146
	HFZ	52.9	50.8	9.1		
Trunk lift	Under HFZ	5.4	4.8	9.1	0.342	-0.02
	HFZ	94.6	95.2	90.9		
SIt and reach Right leg	Failed	49.6	38.1	45.5	0.110	0.128
	Passed	50.4	61.9	54.5		
SIt and reach Left leg	Failed	51.8	49.2	45.5	0.329	0.645
	Passed	48.2	50.8	54.5		
Shuttle run 20 m	Under HFZ	36.6	52.4	100		
	HFZ	63.4	47.6	0	21.324**	-0.197**
Under fit	Falling 2 tests or more	66.2	69.8	100		
Nº of tests in HFZ	6	13.6	11.1	0	35.516**	0.100*
	5	20.3	19.0	0		
	4	31.2	25.4	27.3		
	3	17.8	22.2	27.3		
	2	12.7	12.7	0		
	1	4.3	9.5	45.5		
	0	0.7	0	0		

HFZ: Healthy fitness zone; *P<0.05; **P<0.001.

with obesity performed a significantly reduced number of tests in HFZ suggesting a decrease of fitness performances when BMI increases. However two girls (0.7%) with normal weight failed all test. Students' overall fitness levels was dichotomized as "fit" if passing 4 of the 6 tests and "unfit" if falling at least 2 test. More than 50% of boys almost 70% of girls with normal weight and overweight status and 100% of boys and girls with obesity were considered unfit.

The results in Table IV showed a decrease of performances in strength and cardiovascular fitness, from normal weight status to overweight and from overweight to obesity. Differences seem to be strongest between normal weight and obesity.

The multivariate logistic regression analyses support these findings. The OR and 95% CI relating BMI categories to fitness levels can be found in Table V. In curl ups test, boys (OR=7.138) and girls (OR=5.641) with obesity are likely to be Under HFZ than normal weight. With regards to CRF, girls (OR=0.959; OR=0.821) and boys (OR=0.961; OR=0.905) with overweight and obesity, respectively, were less likely to perform more laps than normal weight counterparts.

Discussion

The aim of this study was to analyze the relationship of PF and BMI in youth population. However, a lack of consensus concerning to the use of different test procedures and the appropriate use of cut-points to establish fitness performance related to health, expresses a difficulty of comparison and interpretation of the results.

The percentage of overweight and obesity in this study, respectively 18.2% and 3.2% for girls and 19.4% and 5.9% for boys, was below the values described for Portugal[2, 3] and for some Mediterranean countries.[24]

The findings of this study are in agreement

TABLE III.—*Physical fitness categories according to BMI for boys.*

Fitness tests	Fitness Categories	Boys				
		Normal weight %	Over-weight %	Obesity %	χ^2 value	Somers'd value
Curl-ups (cadence)	Under HFZ	22.5	23.2	70.6	19.319 **	-0.142*
	HFZ	77.5	76.8	29.4		
Push-ups (cadence)	Under HFZ	45.1	60.7	76.5	9.407 *	-0.171*
	HFZ	54.9	39.3	23.5		
Trunk lift	Under HFZ	8.9	10.7	11.8	0.281	-0.028
	HFZ	91.1	89.3	88.2		
SIt and reach Right leg	Failed	20.2	14.3	29.4	0.502	0.808
	Passed	78.8	85.7	70.6		
SIt and reach Left leg	Failed	25.8	16.1	41.2	0.463	0.690
	Passed	74.2	83.9	58.8		
Shuttle run 20 m	Under HFZ	38.5	64.3	100		
	HFZ	61.5	35.7	0	32.049**	-0.306*
Under fit	Falling 2 tests or more	50.8	58.9	100		
Nº of tests in HFZ	6	26.8	21.4	0	32.719**	-0.177**
	5	22.5	19.6	0		
	4	24.9	25	11.8		
	3	16	21.4	52.9		
	2	8.5	7.1	29.4		
	1	1.4	5.4	5.9		

HFZ: Healthy fitness zone; *P<0.05; **P≤0.001.

TABLE IV.—*Mean differences in Fitnessgram variables in association with BMI and gender.*

Fitness tests	Girls			Boys		
	Normal *vs*		Overweight *vs* Obesity	Normal *vs*		Overweight *vs* Obesity
	Overweight	Obesity		Overweight	Obesity	
Curl ups	5.6 (-0.5; 11.7)	21.5** (8.1; 34.8)	15.8* (1.6; 30.1)	0.9 (-5.8; 7.6)	14.6* (3.2;26.1)	13.7* (1.1;26.2)
Push ups	1.2 (-1.0; 3.4)	6.3* (1.4; 11.1)	5.1 (-0.3; 10.2)	4.5* (1.3; 7.8)	7.5* (2; 13.2)	3 (-3.1; 9.2)
Trunk lift	-0.7 (-3.5; 2.1)	0.4 (-6.5; 5.7)	0.3 (-6.2.2; 6.8)	-1.1 (-3.9; 1.8)	-3.2 (-8.1; 1.6)	-2.2 (-7.5; 3.1)
Sit reach Right leg	0.3 (-18; 1.2)	1.4 (-1.9; 4.7)	1.7 (-1.8; 5.2)	-0.6 (-2.7; 1.4)	1.7 (-1.7; 5.2)	2.4 (-1.4; 6.2)
Sit reach Left leg	0.2 (-1.5; 1.7)	1.6 (-1.9; 5.1)	1.4 (-2.3; 5.2)	-0.8 (-2.1; 1.3)	1.9 (-1.7; 5.5)	2.7 (-1.3; 6.7)
Shutlle run	5.3* (1.3; 9.3)	16.2** (7.4; 24.9)	10.8* (1.5;20.3)	16.4** (9.0; 23.8)	28.1** (15.5; 40.6)	11.6 (-2.2; 25.5)

Data are mean differences in Fitnessgram tests (95% Confidence Interval) as estimated by General Linear Model Multivariate, adjusted for age. *The mean difference is significant at the 0.05 level. **The mean difference is significant at the 0.001 level.

with other studies showing that overweight and obese youth are generally less fit then normal weight pairs.[20, 25] The authors found an exception in flexibility tests (trunk lift and sit and reach). Moreover, excess fatness was not likely to reduce flexibility performance either in cross-sectional studies [19, 26] or longitudinal ones.[27]

Table V.—*Odds Ratios (OR) and 95% Confidence Intervals (CI) from logistic regression model predicting overweight and obesity.*

	Overweight		Obesity	
	OR	(95% CI)	OR	(95% CI)
Girls				
Curl ups				
— Under HFZ	2.454 *	(1.374-4.384)	5.641*	(2.282-13.942)
— HFZ or above	1		1	
Push Ups				
— Under HFZ	0.999	(0.5716-1.747)	7.761*	(1.969-30.591)
— HFZ or above	1		1	
Shuttle Run 20 m[a] (N of laps)	0.959**	(0.934-0.985)	0. 821**	(0.744-0.907)
Boys				
Curl ups				
— Under HFZ	0.960	(0.473-1.950)	7.138**	(2.379-21.690)
— HFZ or above	1		1	
Push ups				
— Under HFZ	1.888*	(1.032-3.455)	3.026	(0.925-9894)
— HFZ or above	1		1	
Shuttle Run 20 m[a] (N of laps)	0.961**	(0.945-0.977)	0. 905**	(0.867-0.944)

CI: confidence interval; OR: odds ratio; 1: reference category; [a]adjusted for age; *P<0.05; **P<0.001.

While some studies evaluate upper strength where work is performed against an external force (*e.g.* handgrip), showing that body weight and body size were positively correlated to performance [19, 26] these data pointed on that low levels of abdominal strength and upper body strength were associated with higher BMI, which are consistent with other studies.[19, 28, 29] In this case, obese children are in disadvantage in tests where they need to apply a greater energy to move or lift their larger mass against gravity or for the lack of experience in weight-bearing tasks, which may be an explanation for the inverse relationship between these items and body fatness.[27, 30] This is also worthy to comment because decreased muscular strength and power may affect the youth's ability to become skilled and successfully perform daily activities particularly during their development years.[31]

Differences by sex should also be acknowledged. For Instance, our data showed that in push up test, girls with overweight tend to be in HFZ but boys with overweight are more likely to be Under HFZ, which seems to escape to a plausible explanation. However, several possibilities can account for this variation. In our sample, overweight boys are taller and heavier than normal weight and obese counterparts, which might support different maturation levels.

Despite girls with overweight account better scores than boys in some tests, in the overall fitness performances, girls showed to be less fit then boys. Considering that girls are more likely to be gain weigh [32] and to be less active,[33] with age, they must have a special attention in their development years.

Regarding to CRF the negative association with BMI is clear. But the mechanism by which high CRF reduces the risk of obesity is not so clear, though relationships of aerobic fitness and fatness to some risk factors were found even in childhood.[34, 35] The total sample (100%) of obese boys and girls as well as more than 50% of overweight boys and girls (52.4% and 64.3%, respectively) were considered unfit. Despite differences in assessing CRF this result is consistent with a large number of studies that found a significant and inverse relationship between CRF and body fatness.[7, 16, 19] This highlights the importance of increasing CRF for a protective effect in early ages. In a study carried out by Klasson-Heggebo *et al.*[17] a curvilinear relation was found between cardiorespiratory fitness and health parameters, identifying the health impact of small increases in children and adolescents with lower fitness levels. Indeed, there evidences showing that low levels of CRF associated with excess body fat and sedentary daily life are significant predictors of developing heart disease.[36] On the other hand, in adults it was shown that unfit lean men were found to have doubled the risk of all-cause mortality compared to fit obese man.[37] The findings of that study suggest that obese individuals are not homogeneous with respect to PF and they also suggested that the benefits of leanness are restricted to those who are fit. Persons who are physically fit maintain a more favourable caloric balance and lower body weights, both of which protect against the development of cardiovascular disease risk factors.[38]

Although this is not a longitudinal study, our results can suggest that a decrease in BMI from obesity to overweight status would improve PF with special emphasis on strength (curl ups) and CRF (shuttle run). Therefore, the importance of health-related PF benefits underlines the need to provide an intervention strategy that promotes youth's PA and PF, particularly of strength and cardio-respiratory fitness.

In the last two decades some authors reported that physical education teachers give special attention to skills instead of focusing activities with higher intensity levels to improve cardio respiratory fitness (Malina *et al.*[39] Blair and Meredith [40]). Some countries, such as USA (Healthy People 2010), recommend to increase the proportion of adolescents who spend at least 50 percent of school physical education class time being physically active, and some authors believe that physical education class should be taught by experts, with contents directed to the promotion of a healthy lifestyle.[41, 42] In the Portuguese system, the new curricula undertake some of these fundamental conditions: physical education is mandatory for all students from 5th to 12th degree; physical education class has been enlarged from 2 or 3 hours to 4 hours per week; teachers are specialized and, optionally, students can participate in school sportive clubs during extra curriculum schedule. However, classes are still too large, playgrounds too small which hinder the task of rising motor density, frequency and mean length of classes.[43] Additionally, school sportive clubs, which are the perfect places for fit students, can be considered intimidating for those with overweight and obesity.

Conclusions

Fitness tests results are an indicator that there is plenty of work to do, to a modernized physical education engaged in the promotion of healthy life styles and enjoyment. Therefore, programs and curricula should be designed to increase student interest in health issues and their self-efficacy in controlling their own health destinies.[44]

The main strength of this study was the use of several tests for fitness assessment. Fitnessgram is widely accepted to evaluate fitness components because it is easy of administration and applicable in large-scale studies, which make it a valuable tool in school setting. In this study some children are unfit, and this group needs to be identified and programs to help them improve should be implemented. Indeed, the major problem associated with child obesity is its persistence into adult life; it is likely that obese children will become obese adults and carry all the extra risks for non-communicable diseases.[8] Therefore, the schools, which commonly administer physical fitness tests, are prime sites for identifying high-risk children, in addition to sources for instituting specialized programs for these children.[45] The data of this study call for the development of effective preventive strategies either for all unfit children or targeted towards those in high risk such as overweight/obese girls. Thus, this study presents data that support the idea suggested by youth guidelines PA, which emphasizes strength and flexibility activities in their statement.[46]

Limitations should also be recognized: First, the sample is limited to one school, which makes it difficult to generalize these findings. Additionally, the cross-sectional design limits the authors' ability to determine causality in the results. Another potential limitation was the lack of additional measurements potentially associated with obesity such as physical activity levels [47] socio-economic status [48, 49] and biological maturation.[50] Additional data is needed to replicate these findings using longitudinal designs.

In conclusion, this study adds data to the current database concerning to the relation between Fitness and BMI. The results suggest that obese and overweight children have low PF level compared to normal weight peers. A large number of children with normal weight were identified as well as unfit. These data also show that a low BMI level would significantly improve some PF component.

Riassunto

Associazione tra fitness fisica e indice di massa corporea nella giovinezza

Obiettivo. L'obiettivo di questo studio è stato quello di valutare i livelli di fitness fisica (*physical fitness*, PF) in una popolazione di studenti di età compresa tra 11 e 18 anni e di analizzare le differenze in base all'indice di massa corporea (body mass index: BMI) nei soggetti in soprappeso.

Metodi. Lo studio è di tipo trasversale. Il campione studiato era composto da 636 bambini ed adolescenti (età media: 14,5 ±1,5 anni), 288 di sesso maschile (45,3%) e 347 di sesso femminile (54,7%). Per la misurazione obiettiva della fitness fisica sono stati utilizzati 6 test della batteria Fitnessgram. La condizione di soprappeso/obesità è stata determinata utilizzando cut-off aggiustati per l'età e il sesso.

Risultati. Sia i soggetti di sesso femminile che quelli di sesso maschile obesi hanno eseguito un numero significativamente ridotto di test nella zona healthy fitness (HFZ), suggerendo una diminuzione delle performance relative alla forza e alla fitness cardiovascolare; questa riduzione aumentava tra i soggetti soprappeso rispetto a quelli normopeso e tra quelli obesi rispetto a quelli soprappeso. I soggetti obesi di sesso maschile e quelli di sesso femminile hanno mostrato una probabilità di essere sotto la HFZ rispetto a quelli normopeso.

Conclusioni. I risultati suggeriscono che i bambini obesi e quelli soprappeso hanno un livello di PF inferiore a quelli normopeso. Un grande numero di bambini normopeso sono stati identificati come di debole costituzione. Questi dati hanno anche evidenziato che un basso livello di BMI migliorerebbe significativamente alcune componenti della PF.

Parole chiave: Età pediatrica - Adolescenza - Indice di massa corporea - Attività fisica.

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II Paper

Intensity of Physical Activity, Cardiorespiratory Fitness and Body Mass Index in Youth

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In Press

Abstract

Background: The purpose of this study was to analyze the relation between BMI, Cardiorespiratory Fitness (CRF) and levels of PA (PA), from sedentary to very vigorous intensities, measured by accelerometry, in students from a Middle and High School.

Methods: This cross-sectional study included 111 children and adolescents, aged 11-18 years. PA was assessed with the accelerometer (MTI); model 7164, for 7 consecutive days (1 minute epoch), using specific cut-points. PA components were derived using special written software (MAHUffe). CRF was assessed by maximal multistage 20m-Shuttle-Run. T test was used to test differences between BMI groups, Pearson's correlation, to analyse correlations between all variables and multinomial logistic regression to predict the value of BMI categories.

Results: This paper provides evidences that BMI was inversely and significantly correlated with CRF and Vigorous PA levels. Children with Overweight/Obesity were less likely to perform more laps than normal weight counterparts. Physical Activity either total amount or intensity level did not showed any influence on BMI level.

Conclusions: Low CRF is strongly associated with obesity, which highlights the importance of increasing CRF for a protective effect even in youth. No associations were found for PA and BMI.

Introduction

The increasing prevalence of overweight and obesity has been linked to environments that encourage sedentary behaviours. Portuguese children have one of the highest prevalence's of obesity and the lowest rates of Physical Activity (PA) in European Union [1, 2].

Current guidelines encourage healthy children and adolescents to engaged in moderate to vigorous physical activities (MVPA) at least 60 minutes per day, 5 or more days per week [3]. However, it is unknown what is recommended for overweight and obese children. In fact, one hour of MVPA might not be enough for normal weight children to prevent clustering of cardiovascular risk factors [4]. Nevertheless, studies examining the relationship between intensity of PA and body composition have been equivocal [5] [6], recently it was shown that adolescents who engage in larger amount of vigorous but not moderate PA tended to have better CRF and lower body fat than those who did not [7]. Thus, it seems that vigorous PA (VPA) may have a greater effect on preventing obesity in children than does PA of lower intensity [7, 8].

Besides PA level, physical fitness (PF), especially cardiorespiratory fitness (CRF), it is also an important factor associated with body mass index (BMI) and adiposity in the youngsters [7]. Indeed, moderate to higher levels of CRF have been associated with lower abdominal adiposity suggesting a mechanism exists by which CRF attenuates the health risk of obesity independently of sedentary activities or PA [9]. Few studies have addressed the relationship between objectively assessed PA intensities, CRF and obesity level in youngsters. However it has been complex to identify in which intensity level, PA varies between students with overweight and obesity and their peers with normal weight. Therefore, the purposes of this study was (1) to compare levels of PA (sedentary, light, moderate, vigorous and very vigorous) assessed by accelerometers, between normal weight and overweight/obesity categories and (2) to analyze how these intensities are associated with CRF and BMI categories.

Methods

Subjects and Settings

This is a cross-sectional study carried out in a middle and high school from suburban setting comprising all the students from the 7th to 12th grade registered in 2007 academic year. A letter informing families that students will be in the study was sent home two weeks before measurements were taken place. Written consent was obtained from all parents. The Portuguese Ministry for Science and Technology granted permission to conduct this study.

The school population comprised 1226 students from which 1024 reside in a suburban area, 280 are from periphery and 202 students live out of these areas. For the purpose of this study only students who wore accelerometers (n=111) correctly during seven days were included. Thus, the sample of the present study was comprised of 49 boys and 62 girls aged 11–18 years.

Anthropometry

Height was measured using a Holtain stadiometer. Values of height were recorded in meters to the nearest millimeter. Body mass was measured to the nearest 0.1 kg with an electronic weight scale (Tanita Inner Scan BC 532) with subjects in t-shirts and shorts. The BMI was calculated from the ratio weight/height^2 (Kg/m^2) and categorized using age and sex adjusted cut-off points described by Cole et al, [10]. For the purpose of this study students were assigned into two groups: normal weight and overweight/obese.

Maturation Criteria

Regarding the maturational stage, the children and adolescents were inquired separately during physical examination. Each subject self-assessed his/her stages of secondary sex characteristics. Stage of breast development in females and pubic hair in males was evaluated according to the Tanner’s criteria and have been previously used and validated in a similar sample [11].

Physical Activity

PA was assessed during seven consecutive days using the accelerometer Manufacturing Technology Incorporated (MTI); model 7164, formerly known as the Computer Science Applications activity monitor, Shalimar, FL. This lightweight, electronic motion sensor measures acceleration/decelerations in the vertical plan of body movement. Validation studies examining this accelerometer suggest that is a valid and reliable measurement of PA in children being strongly correlated (r= 0.86) with energy expenditure, assessed by indirect calorimetry as well as a high degree of inter-instrument reliability [12-14].

For the present study, the accelerometer was worn on the hip secured by an elastic waist belt, the epoch period (i.e. the duration of the sampling period**)** was set at **one** minute and the output was expressed as counts per minute (counts.min^{-1}). Subjects were provided with written instructions regarding care and placement of the accelerometers. A data sheet was given to each participants' providing instructions to remove the accelerometers each time they performed any restricted activities like showering and swimming. Before each testing period and for every participant the activity monitors were tested to check abnormal functions or battery capacity. The monitors were initialized as described by the manufacturer.

Data Reduction

Activity counts were summed for each hour that the accelerometer was worn between 7:00h and 24:00h to provide a representative picture of daily activity. Criteria for a successful recording were a minimum of four days of the week and one day of the weekend, and more than 600 minutes per day. Time periods of at least 10 consecutive minutes of zero counts were considered as periods when the monitor was not worn and thus disregarded before analysis. The data was processed with a specific software (MAHUffe, www.mrc.epid.cam.ac.uk) The counts ranges for the various activity intensities were 0 to 499 for sedentary, 500 to 1999 for light (LPA), 2000 to 2999 for Moderate (MPA), 3000 to 4499 for vigorous (VPA) and >4500 for Very Vigorous (VVPA). The threshold of Moderate to Vigorous activities MVPA (>2000 counts/min) corresponds to a walking of about 3-4 Km/h [15].

Cardiorespiratory Fitness

Cardiorespiratory Fitness (CRF) was assessed by a maximal multistage 20m shuttle-run test according to procedures described from FITNESSGRAM. The FITNESSGRAM was selected because of its ease administration to large numbers of subjects, and in addition its choice of reliable and valid health-related physical fitness measures [16]. The Shuttle Run Test predicted maximal aerobic capacity and showed significant correlation with VO_2max (r=0.80) suggesting that **it** could be used as a measure of aerobic fitness in children [17]. Students were familiarized with the procedure for each test before recording data. Furthermore**,** the participants received verbal encouragement from the investigators in order to achieve maximum performance. The results were recorded as laps taken to complete the 20m shuttle-run test.

Statistics

Means and Standard Deviations (SD) were used to describe participants' characteristics according to BMI categories (normal weight and overweight/obesity). The square root of VPA and VVPA was calculated to proceed with parametric analysis. Independent sample T**-**tests were used to test differences between BMI groups for anthropometric measures, age and PA intensities. Pearson's correlation was used to analyse the correlations between all variables. Multinomial logistic regression was used to obtain adjusted odds ratio (OR) and 95% confidence intervals (CI) to predict the value of BMI categories. Statistical analysis was performed using SPSS 15 software (SPSS Inc., Chicago, IL, USA) and Microsoft Excel 2000. The level of significance was set at $p < 0.05$.

Results

The descriptive data (mean ± SD) of physical characteristics are shown in Table 1. Overweight/obese participants were heavier (p<0.05) and had higher BMI (p<0.05) than their lean peers. Further, they had lower CRF levels (p<0.05) than they normal weight counterparts. 27.4% of the girls and 38.8% of the boys were found to be overweight/obese.

Table 1 – Descriptive characteristics of subjects by BMI categories

	All Subjects	Normal Weight	Overweight/Obesit
	Mean (SD)	Mean (SD)	Mean (SD)
Age	14.54 (1.58)	14.61 (1.55)	14.42 (1.66)
Weight (kg)	61.40 (11.86)	56.00 (7.99) [3]	72.03 (11.02)
Height (m)	1.66 (0.09)	1.66 (0.09)	1.66 (0.09)
BMI (kg/m^2)	22.24 (3.53)	20.34 (1.82) [3]	26.09 (2.88)
CRF [2]	44.10 (22.06)	46.73 (21.35) [3]	39.10 (22.72)
PA from Accelerometers			
Sedentary (min/day)	626.05 (63.18)	634.39 (62.16)	608.68 (62.59)
Light (min/day)	84.33 (23.68)	81.61 (23.98)	90.01 (22.29)
MPA (min/day)	34.02 (16.49)	33.31(14.02)	35.50 (20.88)
VPA (min/day)	2.0 (1.95)	2.16 (2.06)	1.67(1.67)
VVPA [1] (min/day)	0.23 (0.24)	0.23 (0.23)	0.23 (0.26)
MVPA [1](min/day)	36.62 (17.96)	36.02 (15.42)	37.87 (22.54)
Count/min	528.97 (141.56)	521.36 (131.45)	544.82(161.45)

[1] Square-Root-transformed values were used in the analysis but non-transformed values are presented in the table

[2] Adjusted for Age and Gender for Independent T-Test

[3] Significantly different from Overweight/Obesity ($p<0.05$)

The bivariate association between all variables in analysis are shown in table 2. The data showed that BMI was inversely correlated with CRF (r=-0.200, *p*<0.05). CRF was positively correlated with VPA (r=0.393, *p*<0.001), VVPA (r=0.278, *p*<0.001), and with the amount of PA (r=0.282, *p*<0.001).

Maturation status was not correlated with BMI and CRF, therefore, logistic regression was adjusted only for age and gender.

Table 2. Bivariate correlations between BMI, CRF, intensities of PA and total amount of PA.

	BMI	CRF
Age	0,171	0.288 **
Gender	0.038	0.601 **
Tanner	0.133	0.115
Sedentary time	-0.095	0.105
LPA	0.086	0.031
MPA	0.082	0.020
VPA[1]	-0.166	0.393 **
VVPA[1]	-0.087	0.278 **
MVPA	0.054	0.314**
Counts.min1	0.147	0.282 **
BMI	1	-0.200 *
CRF	-0.200 *	1

** Correlation is significant at the 0.01 level (2-tailed)

* Correlation is significant at the 0.05 level (2-tailed).

[1] Square-Root-transformed values were used in the analysis;

Logistic Regression adjusted to age and gender found significant inverse association between overweight/obesity and CRF. Results showed that children and adolescents with higher levels of CRF presented lower relative risk of being overweight/obesity (OR=0.968; p=0.037), than normal weight counterparts (Table 3). PA either total amount or intensity level did not showed any association on BMI level.

Table 3 - Odds Ratios (OR) and 95% Confidence Intervals (CI) from Logistic Regression predicting Overweight/Obesity Adjusted for **Age** and Gender.

	OR	**95% CI**	***p***
Sedentary time	0.993	(0.984;1.002)	0.143
LPA	1.003	(0.985;1.021)	0.779
MPA	1.01	(0.976;1.046)	0.548
VPA[1]	0.634	(0.332; 1.209)	0.167
VVPA[1]	0.484	(0.124; 1.889)	0.296
MVPA	1.003	(0.984;1.023	0.727
Counts/min	1.403	(0.998; 1.004)	0.867
CRF	0.968	(0.939; 0.998)	0.037

[1] Square-Root-transformed values were used in the analysis

Discussion

This study reports information about the relationship of BMI, CRF and PA assessed by accelerometers in seven consecutive days. There are few studies evaluating accelerometer derived PA patterns in overweight/obese children. However, such data is valuable for assisting in the design of interventions to increase PA as well as for tailoring an individual exercise prescription [18].

The main finding of this study was that after adjustment for age and gender, CRF showed a significant and inverse relationship with and BMI. Despite differences in assessing CRF this result is consistent with a large number of studies [19-21]. Although the mechanism by which high CRF reduces the hazard risk of obesity is not clear the relationship between aerobic fitness and fatness with particular risk factors has been reported in children [22]. Indeed, several cross-sectional and longitudinal studies showed an association between CRF and cardiovascular risk factors in youth [23, 24], including obesity [21, 25, 26]. One study, showed a curvilinear relation between CRF and health parameters, identifying the health impact of small increases in children and adolescents with lower fitness levels [25]. Indeed, there is evidence showing that low levels of CRF associated with excess body fat and a sedentary daily lifestyle are significant predictors of heart disease [27].

Bivariate correlation showed that CRF was positively associated with VPA, VVPA and counts.min^{-1} and negatively correlated with BMI. The lake of a relationship between PA intensity and BMI is some how unexpected. However, while a few studies showed inverse associations [28] [29] others did not find evidence of this relationship [30], specially when energy expenditure is adjusted for fat free mass [31]. Nevertheless, the relationship of vigorous intensities to lower level of body fat as been described in both, American [7] and European children [32]. In adolescents, it has been reported that those engaged in higher intensity exercise improved their body fat percentage as well as their CRF, although for some obese adolescents, it is difficult to maintain the high-intensity PA levels [33].

Additionally, some methodological considerations should be considered. In fact, there is a lack of consensus with regard the cut-off points applied to define intensity levels in youth, which can give different PA levels, depending upon the criterion selected to distinguish activity from inactivity [34]. This problem raised questions about the difference in the prevalence estimates of PA. Another potential consideration is associated with differences in estimating VPA according to the epoch time (sampling interval) procedures. Some studies point-out that a shorter epoch (five seconds) would be more sensitive to assess PA activities for vigorous PA [35] than the one used in our study. Nevertheless, when longer epochs are used, as in this study, creating a new variable with the sum of moderate, vigorous and very vigorous intensities, as MVPA, can minimize the underestimation of these intensities [36].

The current study 87.4% didn't accomplish recommendations, which is lower than what was found in a European Youth Heart Study [37]. This might be one reason why no association between PA and BMI was found. As the level of PA is lower, even for normal-weight students, it might be possible that we could not find a relationship between those variables. According to guidelines of PA for health, our data do suggest that children and adolescents accumulate less MVPA than the recommended. However, we have to recognize that these recommendations are based in an arbitrary threshold to classify moderate activity of 3 METs for health, and remains a lack of empirical evidences for establish these guidelines [4, 38, 39].

Even if controversy remains about the association of PA and total or central adiposity, PA still is considered the modifiable variable of body weight genesis and the common denominator for CRF. Thus, it might be possible that PA directly influences CRF levels and may favourably impact BMI. Indeed, obese individuals may have lower levels of fitness due to sedentary lifestyles [19], conversely, higher_fitness is associated with lower fat mass [40]. However, the fundamental concern is to improve CRF levels, in particular for those with overweight/obesity. In adults, Blair et al. [41] shown that those who improved or maintain adequate PF were less likely to die from all cause of mortality than persistently unfit men.

The main strength of this study was the use of accelerometers to assess PA, which allowed to the intensities classification. The use of an objective measure with a high compliance rate (at least 10 hours/day), enhances the confidence in our findings because it was suggested that objective measures such as accelerometers provide more valid assessments for youth of all ages [42]. On the other hand, ease administration of shuttle run test and its common use in large-scale studies makes it as a valuable tool for studying CRF in youngsters. Some limitations of the study should, however, be recognized. First, the study was limited in sample size and provides only cross-sectional data focus on one school, which makes it difficult to generalize these findings, thus poor external validity. Secondly obesity was assessed indirectly. Although BMI has become a very common way of assessing overweight/obesity, it does not capture variations in fat and fat-free mass. Nevertheless, recently it was shown that, regardless the cut-off point, overweight/obesity assessed by BMI during childhood is strong predictor of obesity and coronary heart disease risk factors in young adulthood [43]. Nonetheless, our data were adjusted for age, which may overcome those concerns and can lead to the importance of our data from preventive point of view.

Conclusions

In conclusion our data showed that low level of CRF is strongly associated with obesity, which highlight the importance of increasing CRF for a protective effect even in youth. No associations were found for PA, either total amount or intensity level, with BMI level. Further longitudinal studies are needed to analyse these interaction in a long term period.

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III Paper

Associations of Cardiorespiratory Fitness in Children and Adolescents With Physical Activity, Active Commuting to School, and Screen Time

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Running Head: Cardiorespiratory Fitness, Physical Activity, Screen Time, and Commuting in Adolescents

The findings and conclusions in this report are those of the authors and do not necessarily represent the views of the Centers for Disease Control and Prevention.

Abstract

Purpose

The objective of this study was to analyze associations of cardiorespiratory fitness, by gender, with physical activity, time spent watching television and using a computer, and mode of commuting to school.

Methods

Participants were 856 children and adolescents (54.9% girls), aged 11-20 years. We evaluated cardiorespiratory fitness using a 20-meter shuttle run test, assessed Tanner maturation stage, body mass index, and skinfold thickness, and used a questionnaire to assess physical activity, television and computer time, and mode of commuting to school .We conducted a regression analysis using cardiorespiratory fitness as the dependent variable and physical activity, Tanner stage, skinfold measurements, and gender as covariates.

Results

Cardiorespiratory fitness was independently and positively associated with physical activity (ß=1.024 [95% CI = 0.747; 1.300]; $p<0.001$) and active commuting to school (ß=4.634; [95% CI = 1.820; 7.448]; $p<0.001$) and was negatively associated with television time (ß=-0.003 [95% CI = -0.025; -0.00049]; $p<0.05$), and computer time (ß=-0.017 [95% CI = -0.033; -0.001]; $p<0.05$).

Conclusions

Although our study is cross-sectional, these findings suggest that increasing overall physical activity levels through interventions in different domains such as active commuting to school and reducing sedentary activities (television or computer time) might be effective strategies for improving cardiorespiratory fitness in children and adolescents.

Introduction

Recent studies have shown that poor cardiorespiratory fitness (CRF) is independently associated with cardiovascular disease risk factors and total and abdominal adiposity (Ortega et al., 2008, Lobelo and Ruiz 2007). Given that development of cardiovascular disease begins in childhood and tracks into adulthood (Andersen et al., 2004), these modifiable risk factors should be addressed early (Boreham et al., 2002).

Several studies have assessed the association between active commuting to school (e.g., walking or bicycling), habitual physical activity, and CRF in children and adolescents. Active commuting to school has been associate to higher amounts of habitual physical activity in primary-school children (Cooper et al., 2003) and with levels of moderate to vigorous activities throughout the day (between 9 and 16 yr) (Cooper et al., 2005, Alexander et al., 2005). Recently, bicycling to school as been associated with higher levels of cardiovascular fitness in children and adolescents (Cooper et al., 2006); however, it remains to be determined whether walking to school alone is sufficient to improve CRF (Cooper et al., 2008).

Other behavioral changes, such as reducing sedentary time, may also have beneficial health effects in children and adolescents. Electronic media use is a common pastime for children today, becoming more prominent as they get older. The household media environment has been associated with many negative outcomes, including poor scholastic performance (Borzekowski and Robinson 2005), sleep deprivation (Owens et al., 1999), poor diet (Coon et al., 2001), and higher BMI (Laurson et al., 2008). The current guideline from American Academy of Pediatrics recommends limiting children's total media time to no more than two hours of quality programming per day (AAP 2001). Evidence indicates that physical activity and sedentary time are independent constructs. Sedentary behaviours and physical activity are only modestly correlated; they have different type of socio-demographic determinants and are differently associated with health-related risk factors (Marshall et al., 2004), but there is limited evidence showing inverse associations between amount of sedentary time, compliance with current physical activity standards, and CRF (Hardy et al., 2009, Lobelo, Dowda et al., 2009). However, it has been suggested that few studies to date have correctly measured sedentary behaviors (Pate et al., 2008). Activity intensities should be treated as potentially independent influences on health outcomes, and conclusions should be stated in terms that are limited to those behaviors actually measured.

Although associations of adiposity with physical activity, sedentary time, and mode of commuting to school have been commonly reported, the relationship of all these variables with CRF is less well established. Therefore, the purpose of this study was to investigate whether physical activity levels, time spent watching a television or using a computer, and mode of commuting to school were independently associated with levels of CRF in girls and boys aged 11-20 years.

Methods

Subjects and Data Collection

We conducted a cross-sectional study of middle and high school students from Valongo, Portugal. Situated in the Porto District, Valongo is a largely urban area (total area, 78km^2; 100,000 inhabitants) that also includes some rural and forested areas. The majority of the population comes from lower socio-economic backgrounds; the average educational level is 4th grade. The school population consisted of 1506 students, of whom 1024 resided in the school neighborhood, 280 lived within the nearby neighborhood, and 202 lived outside of the district.

All students were invited to perform a 20m shuttle run test (20m-SR) and to answer a questionnaire. Written consent from the family was required of all participants. A consent letter was sent home two weeks prior to the measurements. Participation was voluntary for all evaluations. The *Fitnessgram* battery is an integrated fitness and activity assessment program that can greatly enhance the effectiveness of school-based physical education programs and is included in the Portuguese national curriculum; six tests are recommended in the Physical Education program (curl-up; push-up; trunk-lift; the modified back saver sit and reach, 20m-SR and body composition). However, for this study only 20m-Shutlle Run was used. Students that did not complete the 20m-SR or the anthropometric measures (30.2%) were excluded from the analysis. The Portuguese Ministry for Science and Technology granted permission to conduct this study.

Anthropometry

Height was measured using a Holtain stadiometer. Values of height were recorded in meters to the nearest millimetre. Body mass was measured to the nearest 0.1 kg with an electronic weight scale (Tanita Inner Scan BC 532) with subjects in t-shirts and shorts. BMI was calculated from the ratio weight/height^2 (Kg.m^{-2}). Tricep, subscapular, and mid-calf skinfold thickness were measured per Heyward (1998) Each skinfold was measured twice consecutively, on the right side of the body. If measurements differed by more than 5%, a third measure was taken. A Harpenden Skinfold Caliper with a constant pressure of 10 g/mm^2 was used and the same observer completed all measurements. The sum of the three z-scores from skinfold thickness measurements was calculated as a final value.

Maturational Stage

Children and youth were grouped by Tanner maturational stage. To determine maturational stage (ranging from Stage 1 to 5), each subject was asked to self-assess his/her stage of secondary sex characteristics. Stage of breast development in females and pubic hair in males were used to assign a maturational stage according to Tanner's criteria, which were previously validated in a similar sample (Mota et al., 2002).

Cardiorespiratory Fitness

We measured CRF using the maximal multistage 20mSR test, following procedures described in the *Fitnessgram* battery. The 20m-SR estimates maximal aerobic capacity and shows significant correlation with VO_2 max (r=0.80), suggesting that this test can be used as a measure of aerobic fitness in children (Vincent et al., 1999). Students were familiarized with the procedure of the test before data was recorded and received verbal encouragement from the investigators in order to achieve maximum performance. The result was recorded as maximum number of laps completed in the 20mSR. Prior to testing, the PE teachers involved in this project received three training sessions and worked with qualified staff in order to assure the standardization and reliability of the measurements.

Physical Activity Index

Physical activity was assessed by a questionnaire that was previously determined to have good reliability with inter-correlation coefficients (ICC: 0.92–0.96) (Mota and Esculcas 2002). The questionnaire has five questions (1) Do you take part in organized sport outside school?; (2) Do you take part in non-organized sport outside school?; (3) How many times per week do you take part in sport or physical activity for at least 20 minutes outside school?; (4) How many hours per week do you usually take part in physical activity outside school, which causes you to get out of breath or sweat?; and (5) Do you take part in a competitive sport? Each question could have four or five choices (four/five-point scale): For the first and second questions: 1) Never, 2) Less then one week, 3) at least one week, 4) almost every day. For the third question, 1) Never, 2) less then once a month, 3) between once a week and once a month, 4) 2 or 3 times a week, 5) 4 times a week or more. For the forth question 1) Never, 2) 30 minutes to 1 hour, 3) 2 to 3 hours, 4) 4 to 6 hours, 5) 7 hours or more. For the fifth question: 1) Never, 2) No, but I already had, 3) Yes, at school, 4) Yes, in a club The overall maximum possible number of points possible was 22; we used each student's total score as a physical activity index (PAI).

Mode of Commuting to School

Participants were asked how they went to school (by car, bus, train, bicycle, or walking), and how much time it took. Based on their answers, the respondents were categorized as using active (walking, bicycling) or passive (bus, train, car) commuting (Tudor-Locke et al., 2001). For the purpose of this study, we considered participants to be active commuters if they reported at least one trip to school by walking or bicycling. We classified time spent commuting to and from school into five categories (Tudor-Locke et al., 2001): (1) five minutes or less; (2) between 5 and 15 minutes; (3) between 15 and 30 minutes; (4) between 30 and 60 minutes; and (5) more then 60 minutes.

Screen Time

We measured time spent watching television (TV time) and using a computer (PC time) with a questionnaire. Participants were asked how many hours and minutes they usually watched television or used a computer for work or leisure during the day preceding the examination (to measure weekday usage) as well as during the weekend, using the following questions: (1) How much time per day do you spend watching television?; (2) How much time per day do you use your computer to work or study?; and (3) How much time per day do you use your computer for leisure? Students were asked how many hours they spent in each activity; we converted this figure to minutes for the purpose of our analysis (Eisenmann et al., 2002).

Statistical Analysis

Because the data were nonparametric even after logarithm transformation, we measured gender differences for all variables and anthropometric characteristics using a Mann-Whitney U Test. We used a chi-square test to find associations between gender and amount of time spent in active commuting.

We used linear regression to estimate CRF based on PAI, TV Time, PC Time, mode of commuting to school, gender, skinfold measurements, and maturational stage. After analyzing each variable separately in linear regression, we then used models that treated all variables as covariates. We performed statistical analysis using SPSS v.15 software and Microsoft Excel 2000; the level of significance was set at $p \leq 0.05$.

Results

Participants' anthropometric characteristics, TV Time, PC Time, and PAI (as medians and interquartile ranges), as well as percentage of students who were active commuters, are shown in Table 1.

Table 1. Participant characteristics, by gender

	Girls (n=470) (54.9%)		**Boys (n= 386) (45.1%)**		
	Median	**IQR**	**Median**	**IQR**	***p*** [a]
Tanner stage (%)					
Stage 1	0.2		0.8		
Stage 2	1.7		2.1		
Stage 3	17.3		15.2		
Stage 4	63.7		62.4		
Stage 5	17.1		19.5		
Age (year)	15.00	2	15.00	2	0.413
Weight (kg)	55.55	12.25	63.35	16.25	0.000
Height (m)	1.62	0.9	1.73	0.11	0.000
BMI	21.05	3.9	21.23	4.22	0.372
Skin folds (sum Z-scores)	0.48	2.76	-2.12	2.98	0.000
Cardiorespiratory fitness	32	16	55	31	0.000
PAI [b]	10.00	6	14.00	6	0.000
Screen time					
Television time	180	105	180	120	0.003
Computer time	90.00	75	120.00	90	0.000
Total passive commuters	**N**	**81%**	**N**	**76.6%**	
Car or motorcycle	102	24.6	91	27.6	
Bus	180	43.4	131	38.4	
Train	54	13	36	10.6	
Total active commuters	**N**	**19.0 %**	**N**	**23.5%**	
Bicycle	5	1.2	0	0.0	
Walk	74	17.8	80	23.5	

[a] Mann Whitney U-test.

[b] Possible physical activity scores ranged from 5 (least active) to 22 (most active).

IQR = interquartile range.

Overall, boys were heavier and taller (p<0.001; p<0.001) and more active (p<0.001), and spent less time watching TV (p=0.003) and more time using a PC (p<0.001). In terms of mode of commuting, the percentage of boys versus girls who were active commuters did not differ significantly.

Modes of transport used to travel to school are summarized by gender in Table 2. No significant differences in frequency of modes of commuting were found between boys and girls. Buses were the most common mode of transport to school in all participants (43.4% in girls and 38.4% in boys), followed by cars (24.6% in girls and 27.6% in boys). A smaller percentage of students used active modes of transportation (19% in girls and 23.5% in boys)

Table 2. Association between active commuting and gender

	Passive			**Active**[a]		
	Girls (%)	**Boys** (%)	**Total**	**Girls** (%)	**Boys** (%)	**Total**
≤ 5 minutes	6.7	4.4	11.1	13.8	7.5	21.4
5-15 minutes	25.5	18.3	43.7	19.5	27.0	46.5
15-30 minutes	15.7	16.1	31.8	11.9	11.9	23.9
30-60 minutes	7.4	4.0	11.4	4.4	3.8	8.2
>60 minutes	1.0	1.0	2.0	-	-	-
Total	56.3	43.7	100.0	49.7	50.3	100.0

[a] There was a significant association between active commuting and gender, estimated by Pearson Chi-Square (χ^2 = 6.5; *p* = 0.013)

Active commuters generally spent between 5 and 15 minutes in transit. A higher percentage of boys spent 5 to 15 minutes walking or biking to school, compared with girls, who tended to spend less time (5 minutes or less) doing so.

Table 3. Linear regression predicting cardiorespiratory fitness

	Cardiorespiratory Fitness		
	β	**(95% CI)**	***p***
Gender[a]	13.907	(11.280; 16.533)	0.000
Skinfolds	- 2.601	(-3.041; -2.161)	0.000
Maturation	3.791	(2.154; 5.429)	0.000
Physical activity index	1.024	(0.747; 1.300)	0.000
TV time	- 0.013	(-0.025; -0.00049)	0.042
PC time	- 0.017	(-0.033; -0.001)	0.033
Commuting to school [b]	4.436	(1.820; 7.488)	0.001

β: Unstandardized coefficients.

CI: confidence interval.

Reference categories: [a]boys [b]active.

Our data showed that physical activity levels and active commuting to school were independently and positively associated with CRF (p=0.000; p=0.001), while TV time and PC time were independently and negatively associated with CRF (p=0.042; p=0.033).

Figure 1 shows the association between time spent actively commuting and CRF, by gender. Among boys, CRF levels increase as the time spent actively commuting to/from school increases.

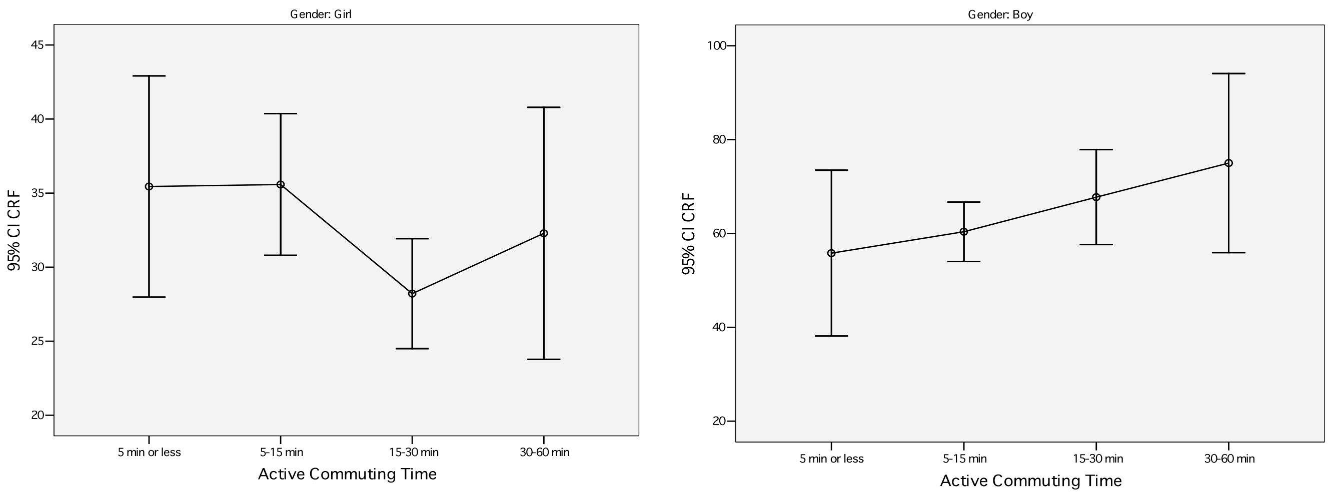

Figure 1. Associations between active commuting to school and cardiorespiratory fitness.

Discussion

It is widely accepted that youth spend too much time watching TV and using computers and do not engage in sufficient amounts of physical activity. These behaviors can contribute to lower CRF, overweight and obesity, and other unhealthy outcomes. The main results of our study demonstrate independent and positive associations of CRF with physical activity and active commuting to school. Time spent watching TV or using a PC and adiposity were inversely and independently associated with CRF. Mean time spent watching TV exceeded the current guidelines of two hours or less per day. Compared to girls, boys were consistently more active and spent more time using the computer.

The positive associations that we found between physical activity and CRF are consistent with previous research (Cooper et al., 2006, Li et al., 2007, Schneider et al., 2007), as are the associations of sedentary activities and lower total adiposity (assessed by skinfold thickness) with higher CRF levels (Ruiz et al., 2006).

Physical activity levels may be decreased by time spent watching TV or using computers and videogames (Marshall et al., 2004, Tammelin et al., 2007). However, studies examining these relationships have reported contradictory results; some have found no association between physical activity and TV viewing (Ekelund et al., 2006, Utter et al., 2003); others, positive associations between physical activity and time spent using computers (Santos et al., 2005). Hardy et al. (2009) found an inverse association between self-reported sedentary behavior and CRF. Since fit children are typically more active (Baquet et al., 2003), this inverse association might be related to the amount of time absorbed by sedentary activities (Tomkinson et al., 2003). In both cross-sectional and longitudinal analyses, Lobelo et al. (2009) found an inverse relationship in girls between exposure to electronic media and compliance with current physical activity standards. The researchers noted a possible threshold effect for compliance with standards at an exposure level of four or more 30-minute blocks per day, highlighting the potential importance of public health recommendations that address physical activity and CRF, in addition to body composition standards.

Regarding transportation to school, higher fitness levels in the active commuters may be due in part to walking, especially for those with longer commuting distances. Most of the active commuters in our study chose walking as their primary form of transportation, citing social, environmental, and personal factors as reasons for doing so. Lack of secure pathways and bicycle lanes were commonly identified as barriers to walking and bicycling to and from school. In a previous study, children who were active commuters spent 19% more time in moderate intensity physical activity compared with peers who were driven to school (Heelan et al., 2005). However, to the best of our knowledge, only one study with cross-sectional and longitudinal components (Cooper et al., 2006, Cooper et al., 2008) has analyzed the association between mode of commuting and fitness in youth. In this study, bicycling to school was associated with higher fitness levels, but walking to school was not. Trends among American school children document a sharp decrease in active commuting from 1969 to 2001 (McDonald 2007), and a similar trend has occurred in Europe (Roman-Vinas et al., 2007). This declining rate represents a worrisome loss of physical activity that may negatively influence fitness levels in children and adolescents. We do not know if the differences in fitness between active and passive commuters observed in our study is due exclusively to walking or biking behaviors. Nevertheless, these data suggest that walking to school may improve youth fitness.

Our findings in children and adolescents aged 11-20 years of strong and independent associations of CRF with adiposity, as well as with several domains of physical activity, (e.g.Commuting mode, household, recreation in organized or non-organized activities, competitive sports) suggests that all of these factors may make important contributions to health-related fitness. Different mechanisms may account for each of these relationships. Physical activity and sedentary behaviors have diverse socio-demographic determinants and are associated differentially with risk factors for health (Biddle et al., 2004, Brodersen et al., 2005). Although the process by which high CRF reduces the risk of obesity it is not clear, associations of aerobic fitness and adiposity with some risk factors have been found in children (Ekelund et al., 2007).

Some limitations of this study should be noted. The study was limited in sample size and provides only cross-sectional data from one school, which makes it difficult to generalize these findings. The self-reported nature of the data is also a limitation and may bias results. Additionally, we were not able to use more sophisticated and objective approaches to geographic information.

A strength of this study was the application of the 20m-SR to estimate CRF. This measure is easy to administer in a typical school setting and it has been previously shown to be a valid, reliable research tool (Castro-Pinero et al., 2009). *Fitnessgram* standards appear to discriminate low from high cardiovascular disease risk in youth, reinforcing their clinical and biological impact (Lobelo, Pate et al., 2009).

Based on our findings, we encourage the inclusion of CRF testing in health monitoring systems. Schools, which commonly administer physical fitness tests, are prime places for identifying high-risk children. Work has already begun in Portugal to to implement the *Fitnessgram* battery in elementary and secondary schools, during physical education classes, although it will take some time to widely institutionalize these procedures. Schools offer guaranteed access to a large majority of children, and the potential is great for health surveillance and control systems for all children, including adolescents at high risk. It is equally important to provide opportunities for being active at school, through recess and physical education classes. Bicycle lanes and pedestrian pathways also can provide a good environment for encouraging active commuting, provided they are well designed and safe. Another effective strategy might be to build schools within neighborhoods so that a majority of students live within reasonable walking distance. However, distance from school may still preclude active commuting for some students, suggesting that physical education and after-school programs will remain important components of youth physical activity promotion programs.

In conclusion, although more research is needed to further elucidate the complex interrelationships between obesity, CRF, and physical activity in youth, our results suggest that adiposity and all physical activity-related domains in this analysis independently contribute to CRF. Thus, interventions should target all of these factors through a variety of strategies including environment and policy change.

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IV Paper

A 3 year longitudinal analysis of changes in Fitness, physical activity, fatness, and screen time

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Short Title: Changes in fitness, physical activity, screening and BMI

In Press

Abstract

Aim: To analyze whether changes in physical activity index (PAI), screen time (ST: television, computer), and body mass index (BMI) made a contribution to longitudinal changes in Fitness of children and adolescents. Additionally, we analyzed interaction between baseline fitness level and changes in fitness.

Methods: This is a three years longitudinal study of 345 high school students aged 11-19 years. Students performed curl-ups, push-up, and 20m shuttle run tests from Fitnessgram. PA and ST were evaluated using a standard questionnaire. Standardized scores of fitness tests were summed. Changes over time, were calculated Δ_1 (2007 minus 2006), Δ_2 (2008 minus 2007), and Δ_3 (2008 minus 2006).

Results: Changes in PAI were positively and independently associated with changes in fitness in Δ_1, Δ_2, and Δ_3. Changes in BMI were negative associated with changes in fitness in Δ_3. Participants highly fit at baseline were those who showed positive changes in PAI over Δ_3, decreased changes ST and had the lowest increase in BMI over three years compared with who were low-fit at baseline.

Conclusions: Changes in BMI were associated with changes in fitness over three years. However, changes in PAI were the best predictor for changes in Fitness in each year and over the three years of evaluation in youth.

Key words: BMI, HABITUAL PHYSICAL ACTIVITY, PHYSICAL FITNESS, SEDENTARY TIME, YOUTH.

Introduction

Physical fitness (PF) is one of the most important targets in preventing childhood obesity by the recognition of its relationship with physical activity habits, health and welfare. There are evidences that pointed out a decline in PF [strength and cardiorespiratory fitness (CRF)] about 0.36% per year, since the decade of the 70^{th} related to social, behavioural, physical, physiological and psychological factors (1) in different ages, genders and geographic areas (2-5). On the other hand, it is generally recognized that PF can be an indicator of physical activity (PA) levels (6, 7) and longitudinal findings suggested a decline in PA especially in MVPA youth as a consequence of sedentary behaviours (8). Given these evidences it has been recommended not only to reduce of sedentary activities (to at least an average of two hours per day) (9) but also the promotion of 60 minutes or more of MVPA, at least 5 days/week for children and adolescents (10).

Fitness has been proposed as a major marker of health status at any age (11) and low fitness is associated with high fatness and low PA (12, 13). Further, some data showed that children are loosing the metabolic effect of fitness that might protect them from excessive weight gain as well as other metabolic diseases (12). On the other hand PF levels track from childhood to adolescence, and from adolescence to adulthood (13) with moderate to strong coefficients for CRF and strength (14) as well as PA (15) and obesity (16).

However, at the best of our knowledge few longitudinal studies have addressed this issue. Therefore, this study aimed to examine the association between changes in PAI, ST and BMI with changes in PF over a 3 year period, and to analyse the influence of fitness levels at baseline in those changes.

Methods

Participants and data collection

This is a school-based longitudinal study carried out in a middle and high public school from suburban setting comprising all the students from the 7^{th} until 12^{th} grade. Over a period of 3 years, from 2005 to 2008, 345 students, (147 boys, 42.6%) were followed with starting ages from 11 to 19 years. All students were invited to perform fitness tests and to answer a questionnaire. *Fitnessgram* battery is included in the national curriculum; however, participation was voluntary for all evaluations. Therefore, a letter informing families that students would be measured was sent home two weeks before measurements took place each year. Written consent was required. The Portuguese Ministry for Science and Technology provided permission to conduct this study.

Physical Fitness

Health-related components of PF were evaluated using the FITNESSGRAM battery test. Procedures described from Test User's Manual was used for all tests (17). The PE teachers involved in this project undertook training sessions, worked together each year, with qualified staff in order to assure the standardization, and reliability of the measurements. Students were familiarized with the procedure for each test before recording data. Further, the participants received verbal encouragement from the investigators in order to achieve maximum performance.

Three tests of the *Fitnessgram* battery recommended in the Portuguese National Program were used for this analysis: Curl-Up, Push-Up, and maximal multistage 20m shuttle-run (20m-SR).

Physical Activity Index

PA was assessed by a questionnaire (18). Application to a Portuguese population has previously been described elsewhere, with good reliability (ICC: 0.92–0.96) (19). A significant and negative correlation was found between the index of physical activity and heart rate at rest, serum insulin and skin fold measurements, and assumed as indication of validity of activity measure (20). The questionnaire had five questions with four or five choices (four/five-point scale): i) Do you take part in organized sport outside school? ii) Do you take part in non-organized sport outside school? iii) How many times per week do you take part in sport or physical activity for at least 20 minutes outside school? iv) How many hours per week do you usually take part in physical activity so much that you get out of breath or sweat outside school? v) Do you take part in competitive sport? The overall maximum number of points possible was 22. A PA Index (PAI) was obtained according to the total sum of the points with increasing ranks from the sedentary to vigorous activity levels.

Screen Time

Time spent watching television (TV Time) and using computer (PC Time) was measured with a questionnaire. Participants were asked how many hours and minutes they usually watched television or used a computer for work and for leisure during the day preceding the examination (weekdays) and during the weekend. Hours were converted to minutes (21) and summed to obtain a screen time (ST) score.

Statistical analysis

Mean and standard deviations described anthropometrics, PAI, ST, BMI and fitness. PF tests (curl-ups, push-up and 20mSR) were standardized (Z-scores). Then, the three Z-scores were summed to construct a composite Z score (ZPF). For participants who were evaluated at the three time points, repeated measures analysis of variance was used to compare mean values at different time points, (2006, 2007 and 2008). Pairwise comparisons were made for each variable and Bonferroni correction was used. To analyze how variables changed over time, Δ_1 (2007 minus 2006), Δ_2 (2008 minus 2007), and Δ_3 ((2008 minus 2006) were calculated. Multiple linear regressions were used to examine associations between changes (Δ) in PAI, ST, BMI (as independent variables) and Δ ZPF (as dependent variables) over time. Variables were analyzed separately in an unadjusted model, and in a model successively adjusted for age, gender, ZPF at baseline, interaction of each variable with gender, ΔBMI, and ΔST. An additional analysis was made for the mean ΔPAI, ΔST and ΔBMI over time according to baseline fitness level. Participants were categorized as "low-fit" group if PF scores were lower than the first tertile and the "fit" group otherwise. Standardized scores of Δ_3PAI, Δ_3ST and Δ_3BMI were also calculated and Independent-Sample T test was used to find differences between these variable according to fitness categories at baseline. The level of significance was set at $p \leq 0.05$. Data were analyzed using SPSS (Windows version 15.0).

Results

Participants' anthropometric characteristics and variables considered for analysis are presented in Table 1. In general, all variables showed increased values ($p>0.05$)

over time (Δ_3). Participants spent more time watching TV than using computer over a 3 year period (Δ_3), however no statistical significant differences were found with regard ST over the same period. Further, while mean scores of CU, PU and 20-m SR increased over time (Δ_3), additional differences were found for Shuttle Run in Δ_1 and Δ_2.

Table 1 – Description of participants for means and standard deviation.

		2006		2007		2008	
	N	Mean	SD	Mean	SD	Mean	SD
Weight (kg)	225	56.83[a]	11.86	59.52[b]	11.37	62.45	11.25
Height (m)	226	1.64[a]	0.09	1.66[b]	0.08	1.68	0.08
BMI (kg/m^2)	225	20.74[a]	3.6	21.67[b]	3.44	22.16	3.37
Fitness (ZFP) *	185	0.34	2.45	0.15	2.38	0.25	2.28
Curl-Ups (n rep)	217	36.03[b]	24.02	39.46	22.5	50.88	21.70
Push-ups (n rep)	217	11.53[b]	9.10	12.36	8.65	17.53	9.61
20-m SR (n laps)	233	36.53[a]	20.83	43.17[d]	20.91	49.02	22.95
PAI #	136	12.3	4.08	12.6	4.0	12.7[c]	4.9
Screen Time	164	162.1	70.1	149.9	66.6	150.8	68.4
TV time (min)	161	208.4[b]	99.1	194.5	91.1	174.5	95.7
PC time (min)	153	119.9[b]	75.7	104.8	65.0	124.4	66.9

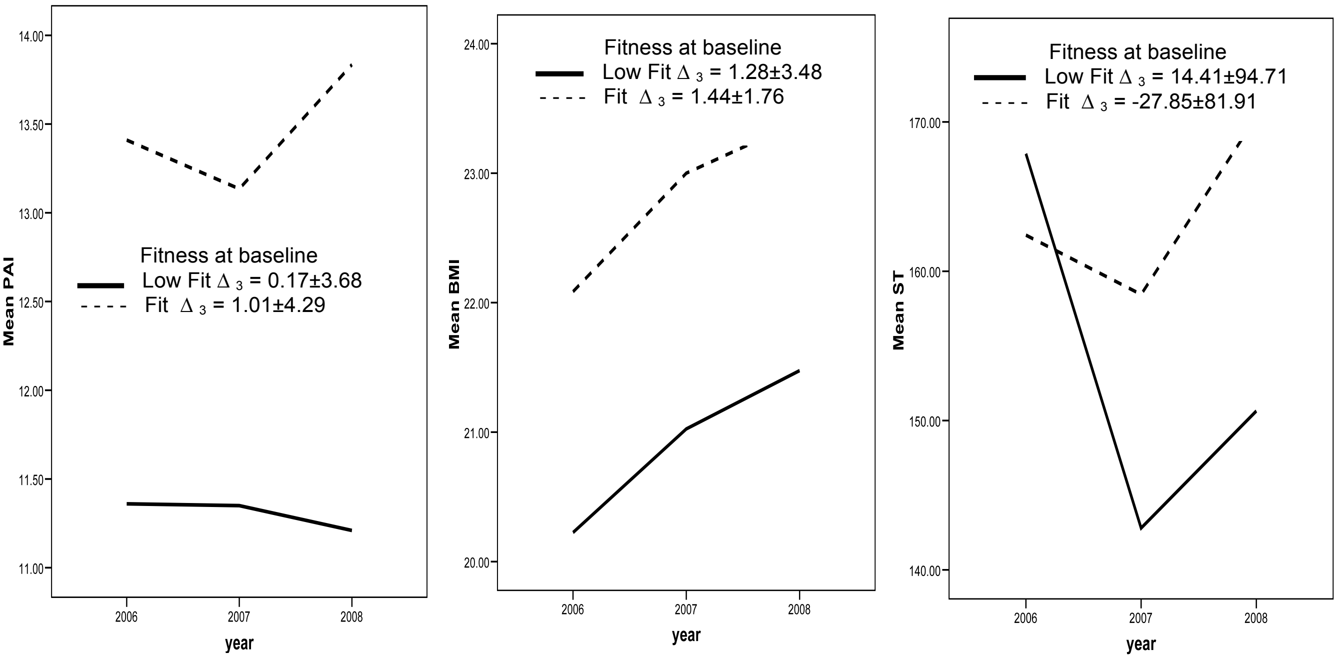
Repeated measures analysis of variance used to test for mean differences between the three time points; Adjustment for multiple comparisons with Bonferroni; the mean difference is significant at the 0.05 level;
* Sum of the standardized fitness tests (Curl-ups, Push-ups and Shuttle run-20m); # Ranges from 5 (lowest active) to 22 (most active)
[a] Significantly different from 2007 and 2008; [b] Significantly different from 2008; [c] Significantly different from 2007; [d] Significantly different from 2006

As can been seen in table 2, ΔPAI is positive and significantly associated with ΔPF, after adjustments for age, gender, and Fitness at baseline. The stronger independent association for the adjusted models was observed in Δ_3. On the other hand, both unadjusted and adjusted models showed that ΔPAI and ΔBMI were significantly associated with ΔPF in Δ_3 period.

Table 2 - Multiple linear regressions regarding the relationship between changes in PF and changes in PAI, BMI and ST across three years. Dependent Variable: Changes in Δ_1ZPF, Δ_2ZPF and Δ_3ZPF; β - Standardized coefficients. Confidence interval (CI 95%)

	Δ_1 (2006-2007)				**Δ_2 (2007-2008)**				**Δ_3 (2006-2008)**		
	β	**(CI 95%)**	***p***		**β**	**(CI 95%)**	***p***		**β**	**(CI 95%)**	***p***
Unadjusted Models											
Δ_1 PAI	0.114	(-0.013;-0.137)	NS	**Δ_2 PAI**	0.071	(0.001;0.140)	0.047	**Δ_3 PAI**	0.111	(0.026;0.196)	0.011
Δ_1BMI	-0.045	(-0.131;0.071)	NS	**Δ_2BMI**	-0.127	(-0.173;0.006)	0.066	**Δ_3 BMI**	-0.145	(-0.275;0.000)	0.050
Δ_1ST	0.005	(-0.005;0.005)	NS	**Δ_2ST**	-0.033	(-0.555;-0.332)	NS	**Δ_3 ST**	-0.071	(-0.006;-0.003)	NS
Adjusted Models											
Δ_1 PAI	0.087	(-0.026;-0.148)	0.005	**Δ_2 PAI**	0.072	(0.004;0.139)	0.037	**Δ_3 PAI**	0.138	(0.37;0.238)	0.008
Age	0.280	(-0.059;0.35)	NS	**Age**	0.108	(-0.098;0.313)	NS	**Age**	0.135	(-0.099;0.368)	NS
Gender	1.334	(0.780;1.88)	0.000	**Gender**	0.626	(0.112;0.139)	0.017	**Gender**	1.034	(0.378;1.690)	0.002
ZPF Baseline	-0.517	(-0.642;-0.39)	0.000	**ZPF Baseline**	-0.177	(-0.284;-0.071)	0.001	**ZPF Baseline**	-0.547	(-0.678;-0.415)	0.000
								Δ_{tot}PAI*gender	-0.019	(-0.154;0.117)	NS
								Δ_{tot}ST	-0.002	(-0.006;0-002)	NS
								Δ_{tot}BMI	-0.022	(-0.175;0.131)	NS
Adjusted Models											
Δ_1 BMI	-0.067	(-0.132;0.041)	NS	**Δ_2 BMI**	-0.127	(-0.173;0.006)	NS	**Δ_3 BMI**	-0.157	(-0.292;-0.023)	0.022
								age	-0.317	(-0.534;-0.100)	0.004
								gender	0.611	(0.038;1.184)	0.037
Adjusted Models											
Δ_1 ST	-0.023	(-0.005;0.003)	NS	**Δ_2 ST**	-0.042	(-0.004;0.002)	NS	**Δ_3 ST**	-0103	(-0.006;-0.001)	NS

In figure 1 it is depicted the comparisons between low fit group and fit group at baseline for PAI (2a), BMI (2b) and ST (2c), respectively. Fit participants were more active for each given point, while those who were low-fit showed higher BMI comparing with fit peers. For ST (figure 2c) there was a marked negative slope from 2006-2007 and an increased ST for 2007-2008 for both groups, although low-fit participants showed higher levels of ST.



2a 2b 2c

Figure **1** - Mean of absolute values of PAI, BMI and ST at the three time points 2006, 2007 and 2008 and mean ± SD for Δ_3 by low-fit vs. fit at baseline.

Discussion

The main purpose of this study was to examine how ΔPAI, ΔST and ΔBMI, are associated with ΔPF over time (3 year-period) and to analyze the importance of fitness level at baseline on this changes.

The main finding of this study was that our results showed that maintaining positive ΔPAI, was positive and significantly associated with ΔPF over time, independently of age, gender, fitness levels at baseline, BMI and ST. On the other hand, our data also showed that those with higher fitness level at baseline had higher PAI levels at each given period (Δ_1, Δ_2, Δ_3), showed positive ΔPAI. In contrast, those with low fitness at baseline had a slight decrease in PAI over the three years period. In addition, linear regressions pointed out an inverse association between ΔBMI and ΔPF. However, when adjusted for fitness at baseline, no statistical significant results were found, which might suggest that the relationship between ΔBMI and ΔPF can be somewhat explained by fitness levels at baseline. These outcomes are worthy to notice because it was suggested that preventive efforts focused on maintaining and increasing PF and PA through puberty will have favourable health benefits in later years (22).

Furthermore, our low-fit participants had small ΔBMI values (Δ_3) compared to their fit peer. This data agree with evidences suggesting that participants whose PF remained high over time have less adiposity and abdominal adiposity than their low-fit peers (23). Further, in accordance with our results other studies have shown that PF at baseline was inverse and significantly associated with adiposity (BMI and skinfolds), as well as other CVD risk factors (24). Besides, a study showed that low-fit children were more likely to be BMI gainers than those classified as fit at baseline (25). This slight positive ΔBMI gain in high-fit participants can also be explained by the increased muscle mass. However, this issue cannot be explored, as we did not have direct measure of lean mass.

In our study, participants with higher fitness levels at baseline had also negative ΔST. Nevertheless, linear regressions showed no associations between ΔST and ΔPF, which, however, it is difficult to compare because limited information has been published on the association between ST over time and fitness (26).

Strengths of this study are its longitudinal design with repeated measures, which allowed us to measure changes in PF, PAI, BMI and ST over time. These findings are important because they provide a database for monitoring future trends in this population. The ease of administration of FITNESSGRAM tests and its common use in large-scale studies makes a valuable tool for studying fitness condition in a school population. Recently, the Portuguese curriculum program for Physical Education included the FITNESSGRAM battery test, which is an important step for students' population scrutiny related to health conditions. Effective community-based programs are needed to include a culture of active habits and to offer further opportunities to increase PA and PF.

Nonetheless, limitations should also be recognized. First, the use of a questionnaire to estimate the time spent watching TV or using computer can be somehow difficult for children. Youngsters have difficulties to recall, quantify, and categorize this type of information about their behaviour. In addiction, there is the lack of questionnaire validation for ST and PAI against accelerometers. Another limitation was the absent of sexual maturation in a period of rapid growth. BMI is an accepted measure, however, does not capture variations in fat mass and fat free mass that can be differentially related to PF. Nevertheless, the most of the variance in obesity-related anthropometrics is capture by BMI, and it is equally well correlated with fat mass and waist circumference (27).

In conclusion, our data showed that many children and adolescents changed their levels of PA, BMI, ST and PF over time. However, ΔPAI seemed to be the best indicator for ΔPF in youth. The results might also reinforce the attempt to work out strategies to increase PA levels leading the PF levels improvements and counteract the increased obesity prevalence. However, more longitudinal studies are needed to ascertain the direction and sequence of associations of PF, PA and obesity.

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V Paper

A 3 year longitudinal analysis of changes in body mass index

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Abstract

The aim of this study was to analyze whether Physical Activity Index, Physical Fitness, Screen Time (TV watch and Computer use), Socio-Economic Status and Commuting to School made a significant contribution to longitudinal changes in Body Mass Index, in youth. This is a longitudinal study over a period of 3 years of 345 students (147 boys) with starting ages of 11 to 16 yr-old. Students were invited to perform tests from Fitnessgram battery for Curl-Ups, Push-Ups, back-saver sit and reach, and 20m shuttle-run (CRF). Fitness tests were categorized in “Healthy Zone” (HZ) and “Under Healthy Zone”(UHZ), PAI in “less active” and “active”; Socio-Economic Status, in Low, Middle and High education level, and Commuting in active and passive. BMI was corrected for age and gender meaning that we subtracted the age-and-sex-specific cut points for overweight. Corrected body mass index was used as dependent variable in a Linear Mixed Model. The main result was the strong positive and independent association of individuals with CRF performances UHZ with corrected body mass index. In conclusion, the results of this longitudinal study showed markedly an important relationship of lower fitness levels with the risk of being overweight/obese, in particular CRF and abdominal strength.

Keywords: longitudinal study, cardiorespiratory fitness, electronic media exposure, commuting, obesity, children.

Introduction

The increasing prevalence of obesity is widely expressed in literature and became one of the major health concerns in children and adolescents. Higher levels of physical fitness (PF) and physical activity (PA) are considered the main components required to protect youth from excessive weight gain as well as other metabolic diseases [1, 28]. PA has been promoted as a lifelong positive health behaviour in children and adolescents and PF that reflects many aspects of physiologic function and performances, has been proposed as a major marker of health status at any age [21]. In fact, since the eighties, associations between the level of cardiorespiratory fitness (CRF) and the risk of all-cause of mortality have been established [2].

In last decades, evidences from longitudinal studies showed a decline of PA and PF as a consequence of youth preferences for sedentary activities [19]. Several authors suggest that increasing overall PA through different behaviour such as commuting to school (CS) could contribute to prevent obesity [9]. However, this relationship between active commuting (AC) and BMI has inconsistent evidences, or is not in the expected direction [25].

Gaining weight and height is a natural condition of growth and maturation in children and adolescents, though, identify excessive BMI gain and recognize the impact of activity behaviours in these ages can indicate the pathway for intervention. However, there is a paucity of longitudinal studies analysing associations of active or sedentary behaviours, as screen time (ST), different parameter of fitness performances and risk of being overweight. Therefore, the aim of this study was to examine the longitudinal associations of changes in PF, PAI, ST and CS with changes in body mass index (BMI) over three years.

Methods

Participants and data collection

This is a school-based longitudinal study carried out in a middle and high public school from suburban setting comprising all the students from the 7th until 12th. Over a period of 3 years, from 2005 to 2008 academic years, 345 students, (147 boys, 42.6%) were followed with ages at baseline from 11 to 16 years.

All students were invited to perform a fitness battery tests and to answer a questionnaire. *Fitnessgram* battery is included in the national curriculum; however participation was voluntary for all evaluations. Therefore, a letter informing families that students would be measured was sent home two weeks before measurements took place each year. Written and verbal given consent was required.

The Portuguese Ministry for Science and Technology provided permission to conduct this study.

Physical Fitness

Health-related PF components were evaluated using the *Fitnessgram* battery test [29]. Four tests recommended in PE curriculum of Portuguese National Program, were used for this analysis: Curl-Ups (CU), Push-Ups (PU); Back-Saver Sit and Reach (B-S SR), and maximal multistage 20 meters Shuttle Run (20m-SR). Procedures described from FITNESSGRAM Test User's Manual [29] was used for all tests. The Physical Education (PE) teachers involved in this project undertook training sessions, worked together each year, with qualified staff in order to assure the standardization, and reliability of the measurements. Students were familiarized with the procedure for each test before recording data. Further, the participants received verbal encouragements from the investigators in order to achieve maximum performance. Fitness variables were categorized in "Healthy Zone" and "Under Healthy Zone" according to establish cut points [23].

Physical Activity Index

Physical activity was assessed by a questionnaire that was previously determined to have good reliability with inter-correlation coefficients (ICC: 0.92–0.96) [16]. The questionnaire had five questions with four answer choices (four-point scale): i) Do you take part in organized sport outside school? ii) Do you take part in non-organized sport outside school? iii) How many times per week do you take part in sport or physical activity for at least 20 minutes outside school? iv) How many hours per week do you usually take part in physical activity so much that you get out of breath or sweat outside school? v) Do you take part in competitive sport? The overall maximum number of points possible was 22. A PA index (PAI) was obtained according to the total sum of the points with increasing ranks from the sedentary to vigorously activity levels.

Parents' education level

Socio-economic position was established from Parents' educational level. Categories were based on the Portuguese Educational system: (1) 9 years' education or less–sub-secondary level; (2) 10–12 years' education – secondary level and (3) College/ Master/Doctoral degree - higher education level). These three levels were named as Low, Middle and High level of education. Similar procedures have previously been applied in the Portuguese context [18].

Commuting to and from school

Participants were asked if they went to school by car, bus, train, bike or walked to and from school, and how much time it took. Based on their answers, the respondents were categorized as using active (walking, bicycling) or passive (bus, train, car) commuting [27]. For the purpose of this study we considered participants to be active transporters once they reported at least one school trip by walking or bicycling. Time spent commuters to and from school was categorized as: (1) five minutes or less; (2) between 5 and 15 minutes; (3) between 15 and 30 minutes; (4) between 30 and 60 minutes; (5) more then 60 minutes, according to an established protocol [27].

Screen Time

Time spent watching Television (TV Time) and using Computer (PC Time) was measured with a questionnaire. Participants were asked how many hours and minutes they usually watched television or used a computer, for work and for leisure, in the day preceding the examination (weekdays) and during weekend: (i) How much time per day do you spend watching TV? (ii) How much time per day do you use your computer to work or study? (iii) How much time per day do you use your computer for laser? Hours were converted in minutes. The variable screen time (ST) was the result of the mean of TV and PC time.

Statistical analyzes

Descriptive analyzes for the subjects at study entry (TP_0), and at the two consecutive years (TP_1 and TP_2) were undertaken to provide a picture of the 3 points in time. Independent t-test for continuous variables (mean and standard deviations) and Chi-square test for categorical variable (percentages), were performed to compare characteristics of the normal weight and overweight/obesity participants at each of the three time points.

Linear mixed effects modelling was performed to evaluate the relation between BMI and the Fitness tests, ST, CS, PAI. In these analyzes BMI used as dependent variable was corrected for age and gender (BMIc). BMIc was calculated subtracting to the absolute BMI the value obtained from the age-and-sex-specific cut points for overweight, according to Cole et al., [6]. Thus, positive values indicate overweigh/obesity, and negative values indicate normal weight. For independent variables fitness tests were categorized in “Healthy Zone” and “Under Healthy Zone”; PAI in “less active”, “active”; SES in “low”, “medium” and “high education”, and CS in “active” and “passive”. The time baseline was coded as zero and subsequence measurement times were coded as one and two. This statistical analysis is highly suitable for longitudinal data because it takes into account that the repeated observations within one individual are not independent.

The level of significance alpha was set at 0.05 for all analyzes. Data were analyzed using SPSS (Windows version 17.0).

Results

Participants' characteristics in each time point by BMI categories are presented in Table 1. Significant differences were found for weight, BMI and BMIc in all time point periods.

The great majority of participants spent more than 2 hours per day watching TV or using computer. Overweight and obese participants were more exposed to electronic media than normal weight peer, reaching statistical significance at TP_1 (71.2% *vs* 57.5%). The majority of participants use the passive commute (car, bus or train). There were significant higher percentages of overweight and obese participants UHZ in Push-Ups at TP_0 and TP_2 and in 20-mSR at all time point periods.

Table 1 - Participants' characteristics in each time point by BMI categories

	TP_0 (2006)				TP_1 (2007)				TP_2 (2008)			
	NW		OW/OB		NW		OW/OB		NW		OW/OB	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	13.98	1.38	14.00	1.39	14.83	1.32	14.94	1.44	15.89	1.29	15.89	1.46
Weight	52.64 **	9.53	69.74	9.79	55.35**	7.86	72.64	10.53	58.41**	7.57	76.17	10.80
Height	1.64	0.09	1.65	0.08	1.65	0.08	1.67	0.09	1.68	0.08	1.68	0.09
BMI	19.55**	2.45	25.73	3.23	20.16**	2.04	25.97	2.96	20.70**	1.82	26.87	2.87
BMIc (corrected)	-3.42**	1.85	3.30	3.18	-3.35**	1.85	2.55	3.11	-3.34**	1.72	2.92	3.00
	%		%	*p*	%		%	*p*	%		%	*p*
	79.6		**20.4**		**73.7**		**26.3**		**76.7**		**23.3**	
ST > 2h/day	70.3		70.3	0.568	57.5		71.2	0.026	60.8		70.6	0.133
< 2h/day	29.7		29.7		42.5		28.8		39.3		29.4	
CS Passive	97.5		100	0.435	78.3		86.8	0.087	81.1		78.4	0.401
Active	2.5		0		21.7		13.2		18.9		21.6	
PAI Low Active	28.9		41.7	0.100	34.8		29.4	0.253	31.4		32.6	0.502
Active	71.1		58.3		65.2		70.6		68.8		67.4	
CU UHZ	20.6		25.5	0.285	18.9		21.1	0.326	8.4		6.1	0.373
HZ	79.4		74.5		81.1		77.9		91.6		93.9	
PU UHZ	42.9		64	**0.006**	46.4		55.7	0.102	21		40.9	**0.001**
HZ	57.1		36		53.6		44.3		79		59.1	
B-SSR UHZ	35.1		28.6	0.248	32.6		31.6	0.498	32.9		31.4	0.469
HZ	64.9		71.4		67.4		68.4		67.1		68.6	
20-mSR UHZ	39.1		72.5	**<0.001**	33		64.9	**<0.001**	33.9		64.2	**<0.001**
HZ	60.9		27.5		67		35.1		66.1		53.8	

Independent sample t-test; NW – normal weigh significantly different from OW/OB –overweight/obesity * p≤0.05; ** p≤0.001 Chi-Square Test for categorical variables; CU - Curl-ups; PU – Push-ups; B-S SR – Back saver sit and Reach; 20-m SR - Shuttle Run; UHZ – Under Healthy Zone; HZ – Healthy Zone.

Results of various mixed effect models including year of measurement and each one of variables separately are shown in Table 2. Those who present performances UHZ in 20m-SR and CU tests had a significant increase in corrected BMI.

Table 2 – Estimated of fixed effects for BMIc adjusted for time

	Estimate (95%CI)	p
CU (UHZ) [a]	0.601 (0.183;1.017)	0.005
PU (UHZ) [a]	0.308 (-0.013;0.629)	0.060
B-S SR (Failed) [b]	-0.340 (-0.612;0.131)	0.205
20-m SR (UHZ) [a]	0.435 (0.116; 0.754)	0.008
ST (more than 2h) [c]	0.238 (-0.122;0.598)	0.195
CS (Passive) [d]	0.228 (-0.328;0.785)	0.421
PAI (Low active) [d]	0.019 (-0.409;0.448)	0.928

Dependent variable: BMI corrected to age and gender according to Cole et al. (2000) cut points; Reference categories: [a] Healthy Zone; [b] Passed; [c] Less than 2 hours; [d] Active;

Table 3 shows results of the multivariable mixed effect model adjusted for all variables. After controlling for the remaining variables, participants UHZ in 20m-SR remained positively associated with BMIc ($p \leq 0.001$), while CU performance was no longer significantly related to BMIc.

Table 3– Estimated of fixed effects for BMIc. Model adjusted for all variables

	Estimate	95% CI	p
Intercept	-3,657	(-5,080;-2,235)	<0,001
year=1	0,564	(0,107;1,020)	0,016
year=2	0,358	(-0,133;0,849)	0,153
Mothers' education – low	0,663	(-0,565;1,891)	0,289
Mothers' education - medium	0,431	(-0,859;1,721)	0,512
CU (UHZ) [a]	0,432	(-0,195;1,059)	0,176
PU (UHZ) [a]	0,216	(-0,270;0,702)	0,383
B-S SR (Failed) [b]	-0,164	(-0,728;0,400)	0,567
20-m SR (UHZ) [a]	0,766	(0,289;1,244)	0,002
ST [b]	-0,079	(-0,551;0,394)	0,744
CS [c]	0,384	(-0,293;1,061)	0,265
PAI [c]	-0,371	(-0,906;0,163)	0,173

Dependent variable: BMI corrected to age and gender according to Cole et al. (2000) Reference categories: [a] Healthy Zone; [b] Passed; [c] Less than 2 hours; [d] Active; Estimate of Intercept Variance = 7.02 (p≤0.001); 95%CI (5.622;8.767)

Discussion

We examined the longitudinal association of some behavioural variables such as CS, ST and PAI as well as fitness components, with BMI corrected for age and gender. The main result was the strong positive and independent association of individuals with CRF performances UHZ and the risk of being overweight/obese over time, even after controlling for the remaining variables. A second association was found with CU after adjustments for time. No other significant relationship with BMI over time was revealed. Our results are in agreement with other studies. Although the majority are cross-sectional studies there are evidences of the association of CRF with lower visceral and abdominal subcutaneous adiposity tissue and waist circumference [11]. The same results were verified for CRF and BMI or skinfolds in a longitudinal analysis [15]. In another 2 years-longitudinal study [17], those who were unfit were more likely to gain weight over time, than those who were fit at baseline. A study with a similar Portuguese sample, revealed a markedly low CRF over time as well as higher risk factor clustering between 1998 and 2003 [14]. Considering the evidences on the tracking of CRF [8] and BMI from childhood to adulthood [30], these results reinforce the appeal that youth should engage in regular physical activity to improve aerobic fitness and reduce adiposity.

Regarding strength tests, a recent systematic review gave support to the assumption, already discussed, that muscular strength is highly influenced by body weight in children aged 6-17 years [4], especially when refers to weight bearing tests. The study suggest that these tests are not appropriate to measure upper body endurance strength in children and adolescents [5]. Regarding to B-S SR, the same authors showed that this test have moderate validity to measure hamstring flexibility and lumbar flexibility, although with limited evidences. Still, the selection of these fitness tests are used in to the Fitnessgram battery proposed in the Portuguese National Curriculum for Physical Education classes and therefore should be reconsidered.

PA has been inversely associated with overweigh/obesity, both in cross-sectional [26], and longitudinal studies [22]. However, these relationships have ambiguous evidence. In a review with longitudinal studies, this inverse relationship between PA and obesity was shown only in youngest children [20]. In cross-sectional study using accelerometers, the accumulated amount of time spent in moderate and vigorous activities was related to body fatness in children, but this relation was weak; the explained variance was less then 1% [7]. Besides, in our results, PAI, CS and ST showed no association with the risk of being overweight/obese over time. The question if active transportation to school is related to decreased adiposity, remains unclear. In a systematic review, only 3 of 18 studies examining weight found consistent results, suggesting that there might be no association between active commuting and reduced weight or body mass index [10].

Regarding ST, a meta-analysis found that time spent watching television was related to overweight but the association was weak and most likely, not clinically relevant [13]. In a review conduct to analyze sedentary behaviours and obesity found that although the majority of the studies have controversy results, the methodological issues can explain the lack of effects [24]. Our results can be due to sample size, but can also be related to failure of the assessment methods to accurately capture changes in PA or sedentary behaviours. The use of a questionnaire to estimate the time watching television or using computer can be somehow difficult for children. Youngsters have difficulties to recall, quantify, and categorize this type of information about their behaviour. Therefore, choosing objective measurements could overcome these limitations. Further, body fat was assessed indirectly through BMI. It is a common way of assessing overweight/obesity, however, BMI does not capture variations in fat mass and fat free mass that can be differentially related to PF. Nevertheless, the most of the variance in obesity-related anthropometrics is capture by BMI, and it is equally well correlated with fat mass and waist circumference [3]. Another limitation was the absent of information about smoking habits, once it can influence CRF performance.

The strength of this study was the longitudinal design with repeated measures analysed by a linear mixed model. FITNESSGRAM standards appear to discriminate low from high CVD risk in youth, reinforcing their clinical and biological impact [12]. Appropriate fitness tests can give important indicators of PE classes' efficacy, as they are also related to different levels of healthy life styles of children and adolescents. Therefore, schools, which consistently monitor healthy–related PF are prime sites for identifying children at risk. This data set calls for the implementation of effective preventive strategies either for all unfit children or targeted towards those with "high risk", namely overweight/obese subjects.

In conclusion, the results of this longitudinal study showed markedly an important relationship of lower fitness levels with the risk of being overweight/obesity, in particular CRF and abdominal strength.

The cumulative effect of being overweight and unfit is of great importance for the negative impact on health.

These complex network of interrelationships demand further research. Descriptive longitudinal and intervention studies covering the adolescent period will be of great help.

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VI Paper

AMERICAN JOURNAL OF HUMAN BIOLOGY 19:871–877 (2007)

Original Research Article

Daily Differences in Patterns of Physical Activity Among Overweight/Obese Children Engaged in a Physical Activity Program

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ABSTRACT The aim of this study was to compare the physical activity of overweight/obese children during days when they attended a physical activity program, and days when they did not. This is a cross-sectional intervention study of daily physical activity. The participants were referred by family, doctors, or hospital pediatricians to take part in a 10-month interdisciplinary, outpatient obesity intervention program for children. The subjects included 41 overweight and obese children aged 8–16 years, 19 boys (46%) and 22 girls (54%); BMI: 25.7 + 3.3 kg m^{-2}. The MTI Actigraph was used as an objective measure of daily physical activity over seven consecutive days. Physical activity program days presented a significantly higher percentage of time (4.68%) spent in moderate-to-vigorous activity compared with no physical activity program days (3.16%) and weekend (2.7%). The results of this study suggest that a physical activity program can help increasing daily physical activity in obese children, with a special focus on MVPA level. Our data point that obese children are less active at weekend than during weekdays. Am. J. Hum. Biol. 19:871–877, 2007.

Obesity is one of the most common health problems being now considered a disease of epidemic proportions with increasing prevalence worldwide (WHO, 2000).

Previous studies have shown a high prevalence of overweight and obesity in Portuguese children (Padez et al., 2004) and adolescents (Ribeiro et al., 2003). Overweight and obesity are associated with an increased risk of CVD risk factors early in life (Freedman et al., 1999). Additionally, longitudinal studies of children followed into young adulthood suggested that overweight children may become overweight adults, particularly if obesity is present in adolescence (Dietz, 1998; Whitaker et al., 1997).

Although other factors such as genetics (Bouchard, 1991; Mota et al., 2006) and diet (Campbell et al., 2006) play an important role in obesity-related genesis, the increased prevalence of obesity has been associated with the reduction of physical activity (PA) (Prentice and Jebb, 1995). Besides, PA patterns and the total amount of activity appear to play an important role in successful long-term weight regulation program (Cooper et al., 2000; Fulton et al., 2001). PA seems to be an ideal focus of intervention, because it has many other benefits in addition to body weight regulation, such as psychological and social well being (Gortmaker et al., 1993).

Current health-related PA guidelines encourage children to accumulate a minimum of 60 min of moderate-to-vigorous daily activity (3–6 METs) for a healthy lifestyle (Cavill et al., 2001). Thus, an important strategy would likely be to encourage participation of overweight and obese children in lifestyle PA that is accumulated throughout the day to achieve healthier body composition (Bouchard and Blair, 1999). Therefore, targeting children's

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patterns of PA is especially important, given the argument that increasing PA in childhood might be essential for the lifetime of regular PA (Twisk et al., 1997). Some studies have addressed the daily patterns of PA in youth, describing differences between defined time blocks within days (Mota et al., 2002a; Trost et al., 2001). Other studies analyzed the between-day variability, namely differences in weekdays vs. weekend days. These latter studies gave additional information in the PA-related obesity concerns, because several studies reported youth as being more active during weekdays compared with weekends (Janz et al., 2005; Trost et al., 2000), as well as weekends being described as a critical period of interventions targeting sedentary behavior (Epstein et al., 1997; Jago et al., 2005).

Many PA intervention programs are set up to provide children with moderate-to-vigorous intensity PA (MVPA). Although the outcomes suggested that obese children can be successfully treated with BMI and risk factors decreasing and physical performance improving (Korsten-Reck et al., 2005) or reaching a successful sedentary behavior decrease (Epstein et al., 1997), information whether these programs are effective or not to increase MVPA levels is scarce.

Indeed, little is known about the activity patterns of obese children and if there are substantial differences in days where obese children are involved in PA programs compared with those where they are not, whether these be weekdays or weekend days. To the best of our knowledge, very few studies have reported the influence of a PA intervention program on the daily PA level and patterns of obese children. This might be an important topic, since further strategies of PA program development targeting youth at risk for overweight/obesity should be developed based on substantial population obesity data.

Therefore, the purpose of this cross-sectional study was to compare the PA of overweight/obese children during days when they attended a PA program, and days when they did not.

METHODS AND PROCEDURES

Participants

Overweight/obese children aged 8–16 (boys: $n = 19$; 46% and girls: $n = 22$; 54%) participated in the program. All the participants were referred by either family doctors or hospital pediatricians. The inclusion criterion was a BMI above the 85th percentile based upon up-to-date BMI curves for Portuguese children (Santiago et al., 2002). The mean of BMI was 25.7 ± 3.3 kg m^{-2} (range 19.0–35.1 kg m^{-2}), with 53 and 47% being referred as overweight and obese children (according to >85th and 95th age and sex-matched percentile), respectively.

All subjects were volunteers, and informed written consent was obtained from the children's parents/guardian and children. The Portuguese Ministry for Science and Technology provided permission to conduct this study.

PA program

ACORDA program (ACORDA stands for obese children and adolescent involved in PA and diet program) is a 10-month interdisciplinary, outpatient obesity intervention program for children. Parents were also involved in a similar class at the same schedule, supporting their own children. The program consists of regular physical exercise (two times a week) plus dietary and behavioral education. Both dietary and behavioral messages to change behavior patterns were delivered through the practical exercise activities.

Each session lasted 1 h (5:30–6:30 p.m.) and the sessions provided different kind of activities such as ball games (e.g. basketball), calisthenics, gymnastics, and exercises to improve coordination, flexibility, and strength training. The exercise program was also designed to enhance the enjoyment and body awareness looking to long-term changes in behavioral patterns.

Objective measure of daily PA

The MTI ActiGraph was used as an objective measure of daily PA over seven consecutive days. For the present study, the epoch duration or sampling period was set at 1 min, and the output was expressed as counts per minute (counts min^{-1}). The accelerometer was placed in a small nylon pouch and firmly adjusted at the child's waist by an elastic belt over the hip. All children, together with their parents, were instructed about how to carry out the measurements. A data sheet was given to each child who was instructed to record the time when the monitor was attached in the morning and detached in the evening and every time he/she performs any restricted activities like showering and swimming. Before each testing period and for every child, the activity monitors were tested. The monitors

TABLE 1. Differences between gender in programmed activity weekdays (PAW), nonprogrammed activity weekdays (NPAW), and weekend

	PAW				NPAW				Weekend			
	Girls, mean	Boys, mean	t	P value	Girls, mean	Boys, mean	t	P value	Girls, mean	Boys, mean	t	P value
Counts min^{-1}	534.06	643.21	−1.300	0.203	516.88	539.32	−0.330	0.744	522.36	507.40	0.182	0.857
Total amount of minutes in sedentary activities	693.97	694.48	−0.015	0.988	606.63	612.42	−0.139	0.891	601.89	587.34	0.404	0.689
Total amount of minutes in light activities	144.91	140.24	0.164	0.777	133.37	134.12	−0.055	0.957	128.75	112.41	1.015	0.318
Total amount of minutes in moderate-to-vigorous activities	36.90	46.78	−1.163	0.253	24.80	31.73	−0.956	0.346	21.03	22.09	−0.118	0.906
Percentage of minutes spend in sedentary activity	79.73	78.91	0.438	0.664	82.10	81.08	0.507	0.617	80.49	81.41	−0.341	0.735
Percentage of minutes spend in light activity	15.99	15.94	−0.34	0.973	15.06	15.39	−0.219	0.829	16.89	15.15	0.910	0.370
Percentage of minutes spend in moderate-to-vigorous activity	4.27	5.14	−0.944	0.352	2.83	3.53	−0.855	0.401	2.62	2.80	−0.158	0.875

were initialized as described by the manufacturer. In the literature, the monitor has shown a highly significant correlation ($r = 0.86$) with energy expenditure, assessed by indirect calorimetry (Trost et al., 1998) as well as exhibited a high degree of inter-instrument reliability (Janz et al., 1995).

Data reduction

Activity counts were summed for each hour that the accelerometer was worn between 7:00 h and 24:00 h to provide a representative picture of daily activity. These data, summarized as counts per day, were considered to be complete if ~70% of the day (1,000 min) was recorded for at least four of the 5 weekdays, and 2 days in the weekend.

Minute-by-minute activity counts were summed for each epoch hour of measurement. For each measurement period, the total counts were divided by the number of registered hours to adjust for unequal monitoring times, and then converted to counts min^{-1}, for concordance with other studies. The daily time spent in sedentary, light, and moderate-to-vigorous (MVPA) activities was analyzed. The daily time spend in MVPA (>3 MET) was calculated by summing the minutes of moderate, vigorous, and very vigorous PA for each day. The counts ranges for the various activity intensities were <800 (sedentary time), <3,200 (light activity), <8,200 (moderate activity), and ≥8,200 (vigorous activity) according to Puyau et al. (2002).

Statistics

A preliminary independent t-test compared gender differences. Table 1 showed no statistical significant differences between sexes; therefore, all variables were analyzed taking into consideration the whole sample.

Means and SDs were calculated to describe the activity data and the participants' characteristics. To examine patterns of PA, data from the daily PA was collapsed into three groups: (1) weekdays with PA intervention program (PAW); (2) weekdays without PA intervention program (NPAW); and (3) weekend. Univariate analysis of variance was used to compare total activity (counts min^{-1}), mean of time and percentage of time spent in sedentary, light and MVPA. Post hoc Tukey followed all significant analysis. All statistical analyses were performed using Statistical Package for Social Science version 14.0 (SPSS) software,

TABLE 2. Participant's characteristics

	Mean ± SD
Age	10.8 ± 2.4
Weight (kg)	58.5 ± 13.2
Height (m)	1.5 ± 0.1
BMI (kg m^{-2})	25.7 ± 3.3
Monitored time (h day^{-1})	14.4 ± 1.2

and Microsoft Excel 2000. The level of significance was set at $P \leq 0.05$.

RESULTS

The descriptive data (mean ± SD) of physical characteristics are shown in Table 2. The participants' MTI records ranged between an average of 13.20 h/day and 16.4 h/day of measurement. The number of hours the MTI monitors that were worn each day are consistent with the expected sleeping habits of children and adolescents (Trost et al., 2002) and are at the same magnitude to other reported data in the similar population (Mota et al., 2002b).

The differences of the activity levels according to PAW, NPAW, and weekend are presented in Table 3. Obese children during PAW were significantly more ($P \leq 0.05$) engaged in MVPA activities compared with NPAW and weekend days. Moreover, sedentary activities were significantly higher during NPAW compared with PAW and weekend days. Nevertheless, the total amount of PA (counts min^{-1}) did not show statistical significant differences.

Figure 1 shows the percent of time spent in each PA intensity category, adjusted for the absolute measured time. Differences were reported in MVPA between PAW (4.68%), NPAW (3.16%), and weekend (2.7%), while no statistical significant differences were found for light and sedentary activities.

Figure 2 shows the percentage of minutes spent in MVPA during 17:30 and 18:30, which is the period allocated to the PA. As expected, the class time contributed to obese children having a higher percentage of MVPA (P = 0.000) in PAW (21.1%) compared with NPAW (11%) and weekend (8.2%).

DISCUSSION

This study reports information about the 7-day PA levels of overweight/obese children, ranging in age from 8 to 16 years, enrolled in a 2-day per week, PA intervention program. Few studies evaluating accelerometer-derived PA patterns in overweight/obese children have been published, which can make direct comparison of results difficult. However, such data is valuable for assisting in the design of interventions to increase PA as well as for tailoring individual exercise prescription (Cooper et al., 2000).

The data of the present study suggested that the PA program was effective at increasing levels of PA. Indeed, during PAW, overweight/obese children engaged significantly more in MVPA (41.55 min/day) than during NPAW (28.06 min/day) and weekend (21.53 min/day). This pattern was also observed for light activities, but without significant differences. Sedentary values (ranging between 79.35% and 81.62%) were higher during NPAW compared with PAW and weekend (80.94%). Our results were similar to those described in other study, where obese children spent on average 80.4% of their monitored time in sedentary behavior (Hughes et al., 2006). In that study, despite the fact that obese children were not engaged in a structure activity, they spent 2.4% (equivalent to 18 min/day of monitored time) in MVPA during the week. In our study, the percentage of time spent in MVPA was 4.68% in PAW, 3.16% in NPAW, and 2.7% in weekend, with statistical differences between PAW and the other days of the week. In the context of increasing levels of PA in overweight/obese children, these findings are worthy of comment. In obese, it was shown that when comparing minutes of MVPA, obese boys were 15% less active on schooldays and 29% less active on weekend days compared with nonobese boys, whereas this figure for girls was 20% and 36%, respectively (Page et al., 2005). Furthermore, some studies highlights weekends as critical periods in interventions targeting sedentary behavior (Epstein et al., 1997). No statistically significant differences were found between NPAW and weekend, suggesting similar pattern of daily PA in this overweight/obese sample, with a large amount of time spent in sedentary behaviors. This might be particularly important because physical inactivity is an important contributing factor to the maintenance of childhood obesity (Trost et al., 2001). This highlights the importance of PAW in increasing the time spent in MVPA of these overweight/obese children, which can counteract the traditional lower engagement in those activities during weekends (Janz et al., 2005; Trost et al., 2000). This stresses the importance of organized activities as strategy to enhance levels of PA among youth, particularly those being at risk of obesity.

TABLE 3. Physical activity levels in programmed activity weekdays (PAW), nonprogrammed activity weekdays (NPAW), and weekend

	PAW	NPAW	Weekend
	Mean ± SD	Mean ± SD	Mean ± SD
Monitored time (min day^{-1})	878.47 ± 124.85	870.41 ± 77.42	737.63 ± 119.83
Counts min^{-1}	585.4 ± 247.3	527.4 ± 195.2	515.3 ± 236.0
Total amount of minutes in sedentary activities	694.21 ± 98.32*	708.63 ± 76.91*	595.04 ± 103.47
Total amount of minutes in light activities	142.71 ± 46.97	133.72 ± 39.42	121.05 ± 46.9
Total amount of minutes in moderate-to-vigorous activities	41.55 ± 5.26*	28.06 ± 21.07**	21.53 ± 26.2

*Significantly different from weekend ($P < 0.05$).
**Significantly different from PAW ($P < 0.05$).

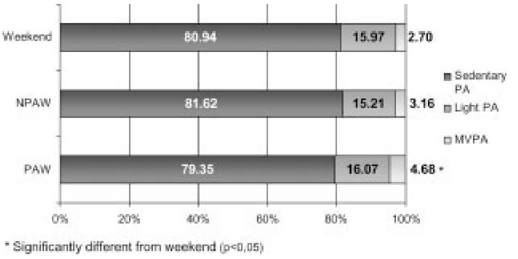

Fig. 1. Relative contribution of time spent in sedentary, light activity, and moderate-to-vigorous activity according to programmed activity days, nonprogrammed activity days, and weekend. *Significantly different from weekend ($P < 0.05$).

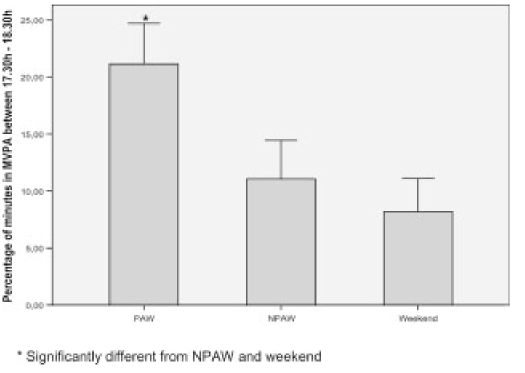

Fig. 2. Relative contribution of class to time spent in moderate-to-vigorous activities. *Significantly different from NPAW and weekend.

Current health-related PA guidelines for youth encourage accumulating a minimum of 60 min of MVPA for a healthy life style. Despite the contribution of the intervention program to increase the MVPA, on average, the mean minutes spent in MVPA failed to reach such recommendations. Our data are slightly less than another study in overweight/obese Portuguese children (Mota et al., 2002a), where the time spent in MVPA varied between 50.7 ± 22 min and 86.5 ± 40.5 min. In a study carried out by Kalakanis et al. (2001), children spent an average of 4.2 min in 12.2 bouts of MVPA per day. Another study with British obese children showed that on average girls spent 8.4 min/h and boys spent 11.1 min/h in MVPA (Page et al., 2005). These differences might be associated with the use of different cut-off points (Freedson et al., 2005; Trost et al., 2006). Estimates of adherence to published recommendations for PA depend on estimates of time spent in MVPA, and fulfils this recommendation depends upon the cut-point used (Cavill et al., 2001). Indeed, several age-specific PA cut-points thresholds have been suggested for youth (Freedson et al., 1998; Puyau et al., 2002). In this study, we used Puyau et al. (2002) cut-points because they were originated in daily routine activities with target on sedentary ones. However, previous studies showed that this cut-point values may lead to a underestimation of moderate activities (Anderson et al., 2005) and, therefore, may underestimate the actual time spent in MVPA. This problem raised questions about the difference in the prevalence estimates of PA. To what extent youth meet the recommended guidelines is a timely issue with a public health interest, because there is a risk of misinterpretation depending on cut-points used. However, this issue is behind the scope of this study. Additionally, the large SDs suggest wide individual variations addressing the importance of the participants' intra-individual variability in PA behavior. Nevertheless, our study clearly shows the influence of the program enhancing MVPA. The time period of PA program was 17:30–18:30, which is a out-side school period. Our findings showed, as expected, that the class time contributed to obese children higher percentage ($P = 0.00$) of MVPA in PAW (21.1%) compared with NPAW (11%) and weekend (8.2%). Based on these outcomes, we can suggest that structured programs of PA are important to increase level of PA and likely MVPA. Thus, organized (structured) PA might be an interesting and valuable strategy not only to increase MVPA but also to fight the low levels of MVPA seen in NPAW and weekend period. Such results will inform design of interventions from public health programs.

Some limitations of the study should be recognized. The study was limited in sample size and provides only cross-sectional data, which makes it difficult to generalize these findings. Nevertheless, this study focuses on the assessment of PA levels in an obese pediatric population using an objective measure with a high compliance rate (14–16 h per day). This enhances the confidence in our findings, because it was suggested that objective measures such as accelerometers provide more valid assessments for youth of all ages (Welk et al., 2000). However, other studies should be carried out to replicate our data.

Another potential limitation was the lack of a measure of biological maturation with such a wide age range. The earlier maturation associated to obesity in both sexes (Ribeiro et al., 2006; Wang, 2002) has been described and could affect the data. Indeed, maturity has long been associated with variations of fat patterns and weight gain (Korsten-Reck et al., 2005), which in turn, might affect levels and patterns of PA. Thus, further studies controlling the effects of maturity in levels of PA might be helpful for the study of the obesity-PA relationship.

In conclusion, the results of this study suggest that structured PA program increased the daily MVPA level of overweight/obese children, emphasizing the importance of organized PA for this special population. Thus, we recommend that these children enroll in community-based exercise programs in order to help them to increase their MVPA.

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[Chapter IV.]

[IV.]

4.1. Discussion of main results

Structuring this work we started to analyze the relationship between physical fitness and the different categories of BMI. The results were similar to other studies (Moller et al., 2006; Mota et al., 2006) showing that students with overweight/obesity were, generally less fit comparing with their peer with normal weigh, with a strong negative association between CRF and overweight/obesity (see main results in table 1of this chapter). The importance of young people to be fit can contribute to a more favourable energy balance to obtain a healthy weigh. The cumulative aspect of being overweight and be unfit may affect the ability of young people develop other skills (Haga, 2008). Beyond CRF and strength, there are other important fitness components such as coordination, balance, agility, among others, which may not directly influence health, but are important for daily tasks, especially at this age of growth and maturation (Faigenbaum et al., 2007). Then, we analyzed in cross-section studies what was he best predictor for overweight/obesity, considering physical fitness in general and CRF in particular, and different intensities of habitual physical activity measured by accelerometers and questionnaires. Although some studies show the importance of moderate, vigorous and very vigorous activities in overweight/obesity (Gutin, Yin, Humphries, & Barbeau, 2005) our results showed that these high intensities were not predictor of overweight/obesity, although they were correlated. In contrast, our study showed clearly CRF as the main predictor of overweight/obesity. In fact, CRF levels, proved to be important in those associations we found, even when controlled for other variables and possible confounders, like in a previous study (Ruiz et al., 2006). Another interesting result was the significant association found between all variables and CRF in the 3rd study, which are: PAI, TV time and computer use, time and distance using active commuting (AC). These robust results can be related to the size sample comparatively large with the samples of the other studies (856 students), on the other hand may be due to the choice of the CRF as dependent variable.

Table 1. Main results

Studies /Variables	**BMI** **Skinfolds**	**PF** CU, PU, B-S SR, TL and 20mSR	**PA Questionnaire Accelerometry**	**TV and Computer**	**Commuting House /school**
1st study cross-sectional n= 636	Decreasing from Ob to Ow is associated to the increase of CRF and abdominal strength	- Number of tests in HZ inversely associated to BMI - High % of students with Nw UHZ	Not analyzed	Not analyzed	Not analyzed
2 º estudo transversal n= 111	Negative association with CRF independently of physical activity levels	Correlations with vigorous and very vigorous physical activity Students in HZ of CRF with lower risk of being Ow/Ob	No associations found with ACR and Ow/Ob	Not analyzed	Not analyzed
3º estudo transversal n= 856	Negative association of skinfolds with CRF	Positive association of CRF with PAI	Positive and independent association with CRF	Negative and independent association and with CRF	In boys CRF increases with distance when they are AC
4º estudo longitudinal n=345 (Dependente ACR)		Positive Δ of BMI (when adjust fitness to baseline) are predictor of positive Δ in CRF	Positive Δ of PAI predictor of Positive Δ in CRF	No associations found	No associations found
5º estudo longitudinal n=345 (Dependente BMI)	CRF and abdominal strength UHZ are predictors of Ow/Ob in any of the 3 years		No associations found	No associations found	No associations found
6 estudo intervenção n=41	Not analyzed	Not analyzed	Increase of MVPA in children and adolescents with Ow/Ob	Not analyzed	Not analyzed

Δ – Variation; UHZ – under healthy zone, CRF – cardiorespiratory fitness, Ow/Ob – overweight and obesity; BMI- body mass index; MVPA – moderate to vigorous physical activity; AC – active commuters

Even so, these associations indicate that all physical activity domains may have an important contribution to increase physical fitness performance.

Indeed, when the same variables were analyzed in the longitudinal model, the results showed that if positive variations of physical activity were maintained in the long-term, this could have an important role to improve physical fitness, regardless of fitness levels at baseline. A longitudinal work produced in Portugal (Mota, Ribeiro, Carvalho, Santos, & Martins, 2009) showed that children and adolescents less fit at baseline were those who presented four times more risk of weight gain after 2 years, which emphasizes the idea of being “fit”.

Both in cross-sectional and longitudinal studies, results showed that CRF was the only predictor of Ow/Ob. Nevertheless, Ow/Ob, some physical activity domains and sedentary activities were predictors of changes in physical fitness in general and in CRF in particular. This set of results suggest that high levels of physical activity maintained over time can contribute to an increase in the physical fitness and can be the key to the decrease of total adiposity in children and adolescents.

In a review study with adults, (D. C. Lee, Sui, & Blair, 2009) the evidences indicate that both physical activity and CRF could decrease the damage of obesity to health regardless other obesity indicators, sex, or status at baseline. The greatest risk of morbidity and mortality was observed in individuals who were both obese and inactive or with low levels of physical fitness.

Based on the evidence from studies in tracking, early intervention is the key in or out of curriculum time.

It is important emphasis the role of intervention programs focused on children and adolescents with overweight/obesity in order to increase MVPA levels, improve several components of physical fitness and simultaneously re-educate and encourage young people to transfer the enjoyment for physical activity and exercise in daily life.

In the six papers worked for this thesis, we must recognize some methodological limitations. Sexual maturation can influence physical fitness and physical activity levels of children and adolescents, in spite of the fact that the lack of data in the first year of collection restricted the use of the maturational criteria in the first paper and in longitudinal studies. However, age and gender were always included in all statistical analysis to minimize this restriction. Moreover, for the same reasons given above, skin folds were included only in the third study. However, searching for the best indicators of obesity for analyzes, we confirmed that all of them (BMI, WC and skin folds) were well and equally correlated with the other variables, and consequently were not so critical for the results.

The first three studies, for having cross-sectional design, provided information about the association between predictive variables (physical activity, sedentary activities, commuting to/from school and the predicted (physical fitness and BMI)), but the direction of causality is difficult to identify. Even in the two following longitudinal studies, in spite of the temporality inherent in this type of study, the answers about the direction of causality can be compromised by the lack of other criteria as referred to in point 1.1.4. The cause of obesity is difficult to find; while it may be suggested, it is difficult to prove (J. W. Twisk et al., 2000), whether it is physical activity, physical fitness, or obesity or each of them with cumulative effects. The main strength of this study was to compare and combine variables in several methodological models - transverse, longitudinal and intervention. The evaluation of physical fitness through methods played in the field and especially in the school environment is an advantage to be taken into account. A strength of this study was the application of the FITNESSGRAM battery test because it is a valid, reliable research tool (Castro-Pinero et al., 2009) and easy to administer well in a typical school setting. FITNESSGRAM standards appear to discriminate low from high CVD risk in youth, reinforcing their clinical and biological impact (Lobelo, Pate, Dowda, Liese, & Ruiz, In Press).

Fitness tests results are important indicators of the efficacy of PE classes, as they are also related to different levels of healthy life styles and life enjoyment of children and adolescents. Therefore, schools, which consistently monitor health-related physical fitness, are prime sites for identifying children at risk.

In summary, all the results of this thesis reinforce the existing evidence about CRF as a key element in prevention of overweight and obesity in children and adolescents. Despite the lack of associations between different intensities objectively measured and BMI, CRF was strongly influenced by physical activity levels, especially for vigorous and very vigorous intensities. Nevertheless, in the intervention study, results highlighted the importance of exercise to increase MVPA as a means to increase daily physical activity in children and adolescents with overweight/obesity.
Yet, more intervention studies are needed with longitudinal design, because of the lack of evidence about the program effectiveness to prevent and reduce overweight/obesity at these ages.
The enjoyment for sport should be strongly encouraged in daily routine to maintain a healthy weight and an active lifestyle from childhood to adulthood.

4.2 Perspectivas para o futuro

The ACORDA project has expanded its operations to schools since 2007-2008 setting up the ACORDA-Escolas. The intention is to minimize barriers, such as transport or safety, avoiding in this way that children and adolescents move away from their school territory. The principles and methods are the same as the ones used in the Program that is taking place in the Faculty of Sports premises, which was mentioned in the last article of this thesis. Our objective is to expand our intervention area to the surrounding communities, so as to, not only offer support to the community, but also use this as an analysis tool over the success capability of the intervention program for overweight and obese children.

Knowing that physical activity is “behaviour” and that physical fitness and Obesity are “effect” and these effects are as well result of a genetic component, we think that in the way to follow would be important to identify and analyse the variables that could be related to predisposition of being more apt or obese, complementing in this way the investigation scenery.

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Supplement

	Hours per day during week	Hours per day during weekend
How much time per day do you spend watching TV?	☐h ☐ min	☐h ☐min
How much time per day do you use your computer to work or study?	☐h ☐ min	☐h ☐min
How much time per day do you use your computer for laser?	☐h ☐ min	☐h ☐min
For how long per day do you use to stay seat reading or studying?	☐h ☐min	☐h ☐min

Outside school, do you take part in organized sport? (In a club or other place)?

☐ Never ☐ Less than once a week ☐ At least once a week ☐ Almost every day

Outside school, do you take part in non-organized sport?

☐ Never ☐ Less than once a week ☐ At least once a week ☐ Almost every day

Outside school, how many times a week do you take part in sport or physical activity for at least 20 minutes

☐ Never ☐ Less than once a month ☐ Between once a week and once a month ☐ 2 or 3 times a week
☐ 4 times a week or more

Outside school hours, how many hours a week do you usually take part in physical activity so much that you get out of breath or sweat?

☐ Never ☐ 30 min to 1 hour ☐ 2 to 3 hours ☐ 4 to 6 hours ☐ 7 hours or more

Do you take part in competitive sport?

☐ Never ☐ No, but I already had ☐ Yes, at school ☐ Yes, in a club

How do you commute home/school?

☐ Car ☐ Bus ☐ Motorcycle ☐ Bicycle ☐ Walking Other (?) ☐ ____________

How long does it take ?

☐ 5 minutes or less ☐ Between 5 and 15 min ☐ Between 15 and 30 minutes ☐ Between 30 and 60 minutes
☐ More than 60 minutes

Código:________

Caro aluno,
Obrigado pela tua disponibilidade para participar neste projecto, que procura recolher dados que permitam uma descrição dos hábitos de actividade física dos jovens. Por esta razão agradecemos que preenchas na totalidade as questões apresentadas de seguida e garantimos-te que as informações obtidas serão utilizadas apenas com este fim

Nome: ____________________ _________________________Ano: ___ Turma: _______Nº ____

1) Sexo ☐ Masculino ☐ Feminino Data de Nascimento ____(dia)____(mês)_____(ano)

2) Com quem vives actualmente? (Coloca uma cruz nos quadrados respectivos)

☐ Ambos os pais ☐ só com a mãe ☐ só com o pai ☐ irmã(o)s ☐ outros

3) Qual a Profissão do teu pai? (Escreve o que faz o teu pai; por exemplo, mecânico, advogado, construção civil, médico, funcionário, professor, etc.) ____

4) Ano de escolaridade do pai

☐ a) Não sei ☐ b) Sem estudos ☐ c) 1º Ciclo (1º,2º,3º,4º) ☐ d) 2º Ciclo (5º, 6ª)
☐ e) 3º Ciclo (7º, 8º, 9ª) ☐ f) ensino secundário (10º,11º,12º) ☐ g) Curso superior
☐ h) mestrado/doutoramento

5) Qual a profissão da tua mãe? (Escreve o que faz a tua mãe por exemplo: doméstica, advogada, secretária, médica, funcionária, professora, etc.) ____.

6) Ano de escolaridade da mãe

☐ a) Não sei ☐ b) Sem estudos ☐ c) 1º Ciclo (1º,2º,3º,4º) ☐ d) 2º Ciclo (5º, 6ª)
☐ e) 3º Ciclo (7º, 8º, 9ª) ☐ f) ensino secundário (10º,11º,12º) ☐ g) Curso superior
☐ h) mestrado/doutoramento

	Horas por dia durante a semana	Horas por dia durante o fim-de-semana
7) Quanto tempo passas por dia a ver TV?	____h____min	____h____min
8) Durante quanto tempo utilizas o computador para trabalhos ou estudo?	____h____min	____h____min
9) Durante quanto tempo utilizas o computador para lazer?	____h____min	____h____min
10) Durante quanto tempo costumas ficar sentado a ler ou a estudar?	____h____min	____h____min

11) Qual o meio de transporte que utilizas para a escola?

☐ Automóvel ☐ autocarro ☐ motociclo ☐ bicicleta ☐ vou a pé ☐ outro

12) Quanto tempo demoras no percurso de casa para a escola? (Coloca uma cruz no quadrado respectivo)

☐ Até 5 min. ☐ entre 5 e 15 min ☐ entre 15 e 30 min. ☐ entre 30 e 60 min. ☐ mais de 60 minutos

13) Que refeições costumas fazer por dia? (Coloca uma cruz nos quadrados respectivos)

☐ Pequeno almoço ☐ lanche da manha ☐ almoço ☐ lanche da tarde ☐ jantar ☐ ceia

14) Fazes actividades desportivas fora da escola (Num clube ou noutro sitio)? (Coloca uma cruz no quadrado respectivo)

☐ Nunca ☐ menos uma vez por semana ☐ pelo menos uma vez por semana ☐ quase todos os dias

15) Participas em actividade física de lazer (sem integrar nenhum clube)? (Coloca uma cruz no quadrado respectivo)

☐ Nunca ☐ menos uma vez por semana ☐ pelo menos uma vez por semana ☐ quase todos os dias

16) Para além das actividades lectivas quantas vezes praticas actividade física ou desporto, pelo menos 20 minutos?

(Coloca uma cruz no quadrado respectivo)

☐ Nunca ☐ menos uma vez por mês ☐ entre uma vez por mês e uma por semana ☐ 2 ou 3 vezes por semana

☐ 4 vezes por semana ou mais

17) Fora do tempo escolar quanto tempo dedicas à prática de actividades físicas e desportivas ao ponto de ficares ofegante (a respirares depressa ou com dificuldade) ou transpirado? (Coloca uma cruz no quadrado respectivo)

☐ Nunca ☐ entre meia hora e 1 hora ☐ 2 a 3 horas ☐ 4 a 6 horas ☐ 7 horas ou mais

18) Participas em competições desportivas? (Coloca uma cruz no quadrado respectivo)

☐ Nunca participei ☐ não, mas já participei ☐ sim, ao nível escolar ☐ sim ao nível de um clube

19) O seguinte conjunto de questões refere às diversas estruturas existentes na tua vizinhança (área de residência). Referimo-nos a toda a área envolvente acessível a pé, no espaço de 10 a 15 minutos.

	Discordo plenamente	Discordo de certa forma	Concordo de certa forma	Concordo plenamente	Não sei, não tenho certeza
a) "Muitas lojas, mercados ou outros estabelecimentos onde faço compras estão a uma distância de rápido acesso a pé"	☐	☐	☐	☐	☐
b) "De minha casa, a pé, demoro entre 10 a 15 minutos a chegar a uma paragem de transportes públicos	☐	☐	☐	☐	☐
c) "A maior parte das ruas da minha vizinhança têm passeio"	☐	☐	☐	☐	☐
d)"Nas ruas da minha área de residência, ou muito próximo, existem faixas de circulação próprias para ciclistas"	☐	☐	☐	☐	☐
e) "No local onde moro existem várias zonas de lazer, de acesso gratuito ou a preço baixo (piscinas, parques, jardins)"	☐	☐	☐	☐	☐
f)"A criminalidade na minha vizinhança não permite passear na rua à noite, por falta de segurança"	☐	☐	☐	☐	☐
g) " Há tanto trânsito nas ruas que é desagradável ou perigoso andar a pé na vizinhança"	☐	☐	☐	☐	☐
h) "Vejo muitas pessoas a fazer actividade física na minha vizinhança (a correr, a andar de bicicleta, etc.)"	☐	☐	☐	☐	☐
i) "Na área da minha residência há muitas coisas importantes para apreciar enquanto se passeia"	☐	☐	☐	☐	☐
j) "Na área da minha residência, os passeios estão em bom estado de conservação"	☐	☐	☐	☐	☐
k) "Há muitos sítios próximos da minha casa onde posso ir facilmente a pé	☐	☐	☐	☐	☐

20) O presente questionário pretende saber em que actividades ocupas, normalmente, o teu tempo livre. (Coloca uma cruz nos quadrados respectivos)

a) ☐ Ouvir musica

b) ☐ Tocar ou cantar

c) ☐ Ver televisão

d) ☐ Trabalhar para ganhar algum dinheiro

e) ☐ Conversar com os amigos (as)

f) ☐ Namorar, estar com o namorado (a)

g) ☐ Jogar às cartas, jogos de vídeo ou computador

h) ☐ Ler (livros, revistas, banda desenhada)

i) ☐ Praticar um desporto orientado por um treinador / professor

j) ☐ Assistir a acontecimentos desportivos

k) ☐ Fazer os trabalhos de casa ou trabalhos suplementares à escola

l) ☐ Ir a festas / discoteca

m) ☐ Participar em actividades de arte e expressão

n) ☐ Estar só (a relaxar, a pensar)

o) ☐ Fazer compras ou ver montras

p) ☐ Ir ao cinema, concertos ou teatro

q) ☐ Realizar trabalhos de solidariedade social (peditórios, apoio a um hospital, etc.)

r) ☐ Ajudar nos trabalhos domésticos (em casa)

s) ☐ Participar em associações ou movimentos de juventude (escuteiros, catequese, etc.)

t) ☐ Visitar a família ou pessoas conhecidas

u) ☐ Praticar um desporto não orientado por um treinador / professor

Destas alíneas da questão 20:

21) Se respondeste à alínea i) refere qual o desporto____

22) Se respondeste à alínea u) refere qual o desporto. ______________________________________

23) Quantos veículos motorizados existem no teu agregado familiar (em tua casa) por exemplo: automóveis, motos, etc. ______________

Obrigada pela tua participação!