

***Níveis de Actividade Física, Aptidão Física e Excesso de  
Peso/Obesidade em Crianças e Adolescentes***

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Palavras-chave: ACTIVIDADE FÍSICA HABITUAL, TEMPO DE SEDENTARISMO, ACELEROMETRIA, APTIDÃO, ADIPOSIDADE, JOVENS.

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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 estudo de intervenção. Este estudo foi realizado com 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 obtidos 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 variação da AF com a variação da ACR e negativa da variação do IMC com a variação da ACR 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 obtidos, adicionam algumas evidências 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, APTIDÃO, ADIPOSIDADE, JOVENS.



## Abstract

The overall purpose of this study was to examine the associations of overweight/obesity with physical activity (PA), sedentary activities and physical fitness (PF) in 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), in a public school set in suburban area of Porto. The data collection took place during three school years (2005 - 2008). 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 *Fitnessgram* 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 skinfold 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 identified as well 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 latter was used as 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 for 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, 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 d'études transversales, longitudinales et 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 données a été collectée pendant 3 ans (2005-2008), une autre partie de l'échantillon a été lors d'un programme d'intervention pour 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 de le fitness en rapport avec la santé ont été testés avec une batterie de tests du *FitnessGram*. 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 salubre de le 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 cardio-respiratoire capacité (CRC) ont été les meilleurs pronostiqueurs de surpoids/obésité. IV) Il a été décelé une association positive et indépendante de AP avec CRC quand analysée comme variable dépendante. Il a aussi été 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 des 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.



## Lista de abreviaturas

|                           |                                                                                                         |
|---------------------------|---------------------------------------------------------------------------------------------------------|
| <b>ACORDA</b>             | Adolescentes e Crianças Obesas em Regime de Dieta e Actividade Física                                   |
| <b>AF</b>                 | Actividade Física                                                                                       |
| <b>ApF</b>                | Aptidão Física                                                                                          |
| <b>ACR</b>                | Aptidão cardiorespiratoria                                                                              |
| <b>Count</b>              | Unidade de medida do acelerómetro <i>MTI Actigraph</i> , sem expressão directa com medidas padronizadas |
| <b>Count.min</b>          | Counts por minuto                                                                                       |
| <b>DCV</b>                | Doenças cardiovasculares                                                                                |
| <b>EP/Ob</b>              | Excesso de Peso e Obesidade                                                                             |
| <b>Epoch</b>              | Somatório de valores registados num determinado período de tempo                                        |
| <b>ESV</b>                | Escola Secundária de Valongo                                                                            |
| <b>EYHS</b>               | European Youth heart Study                                                                              |
| <b>IMC</b>                | Índice de massa corporal                                                                                |
| <b>Kg</b>                 | quilograma                                                                                              |
| <b>m</b>                  | Metro                                                                                                   |
| <b>Máx.</b>               | Valor máximo                                                                                            |
| <b>MET</b>                | Metabolic Energy Turnover (Equivalente metabólico)                                                      |
| <b>MG</b>                 | Massa gorda                                                                                             |
| <b>MVPA</b>               | Actividades físicas de intensidades moderadas a vigorosas                                               |
| <b>SPSS</b>               | Statistical Package for the Social Sciences                                                             |
| <b>VO<sub>2</sub> máx</b> | Consumo máximo de oxigénio.                                                                             |
| <b>%</b>                  | Percentagem                                                                                             |
| <b>WHO</b>                | World Health Organization                                                                               |
| <b>ZS</b>                 | Zona saudável de aptidão física                                                                         |



## Introdução

A infância e adolescência são fases complexas pelas profundas transformações inerentes ao crescimento e maturação. Ao longo destas transformações, os padrões de comportamentos que os jovens adquirem podem ser decisivos para um futuro mais saudável e com maior qualidade de vida.

A obesidade tem caracterizado as gerações nas ultimas décadas. Estudos de *tracking* que acompanham as crianças até à idade adulta, sugerem que o excesso de peso e obesidade na infância é um factor de risco com grande probabilidade de persistir até à idade adulta (Whitaker, Wright, Pepe, Seidel, & Dietz, 1997). Considerando que as doenças cardiovasculares (DCV) não se manifestam por completo antes da fase adulta mas têm o seu início na infância, elas devem ser identificadas o mais cedo possível (L. B. Andersen, Hasselstrom, Gronfeldt, Hansen, & Karsten, 2004; Boreham et al., 2002). Embora a genética cumpra o seu papel na génese da obesidade (Bouchard, 1991), o aumento da prevalência da obesidade tem sido há muito tempo associada à redução da actividade física (Prentice & Jebb, 1995).

Estudos longitudinais têm mostrado uma tendência de diminuição de actividade física e aptidão física em todas as idades e ambos os sexos. No entanto apesar de já se terem construído muitas evidências, existem ainda dúvidas por esclarecer no que respeita às questões relacionadas com a actividade física, aptidão física, saúde em geral e obesidade em particular durante a infância e adolescência (Caspersen, Nixon, & DuRant, 1998; Eisenmann, 2004). A falta de convergências sólidas de resultados está relacionada, por um lado, com a complexidade da avaliação da actividade física e, por outro lado, com dificuldade de estabelecer pontos de corte para a saúde nestas idades. A prioridade das recomendações internacionais apontam para a necessidade de aumentar níveis de actividade física em especial de intensidades moderadas e vigorosas, assim como os níveis de aptidão física para obter benefícios para a saúde. Contudo, evidências têm sugerido também que a maioria das crianças e adolescentes não atingem estas recomendações e que os valores têm diminuído nas ultimas décadas (Pate et al., 2006). Embora, se tenha atribuído

importância à quantidade de actividade física habitual, os estudos mais recentes apontam para a importância de intensidades elevadas para o aumento da aptidão física, que parece ser a chave na prevenção da obesidade. Tendo em conta as evidências mais recentes sobre as questões relacionadas com a “triangulação” adiposidade, actividade física e aptidão física, construímos um conjunto de objectivos com o propósito de tentar encontrar resultados que ajudem a fortalecer o conhecimento científico construído neste domínio.

## **Objectivo geral**

Os estudos realizados para esta tese tiveram como objectivo geral aumentar conhecimentos e fortalecer evidências sobre as associações entre actividade física, aptidão física e excesso de peso/obesidade. Usamos por isso um desenho transversal e longitudinal bem como um estudo de intervenção. Neste contexto definimos os seguintes objectivos específicos:

## **Objectivos específicos**

- I. Analisar a relação das varias componentes da aptidão física, nomeadamente, força, flexibilidade e aptidão cardiorespiratoria (ACR) com os níveis de excesso de peso/obesidade.
- II. Examinar a relação dos níveis de aptidão física e das diferentes intensidades da actividade física estimadas através de avaliação objectiva, com os níveis de excesso de peso/obesidade.
- III. Analisar a influencia da actividade física, das actividades sedentárias e do excesso de peso/obesidade no desempenho de uma das componentes da aptidão física, a ACR.
- IV. Investigar, numa perspectiva longitudinal, de que forma as variações da adiposidade, do índice de actividade física (IAF) e dos comportamentos sedentários podem estar associados às variações da aptidão física.
- V. Investigar, numa perspectiva longitudinal, de que forma a aptidão física, a actividade física e os comportamentos sedentários podem influenciar o risco de aumento de peso ao longo de três anos.

VI. Analisar se um programa de intervenção extracurricular pode implicar num aumento dos níveis de intensidades moderadas e vigorosas em crianças com excesso de peso e obesidade.

### **Lista de Publicações e Manuscritos <sup>a</sup>**

O produto de análise resultou na submissão de artigos em revistas com revisão entre pares. Os artigos aqui apresentados, publicados, ou em fase de revisão, foram estruturados a partir de objectivos específicos, que poderão vir a servir de fundamentação para uma linha de actuação no terreno.

- 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)
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- 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 index (under revision)
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<sup>a</sup> Os artigos publicados, estão reproduzidos nesta tese com a permissão das respectivas editoras.



**[capitulo I.]**



# [1.]

## 1. Revisão da Literatura

Evidências e considerações sobre actividade física, aptidão física e obesidade em crianças com excesso de peso e obesidade vistas sob três tipos de análises metodológicas:

- 1.1 Estudos Transversais
- 1.2 Estudos Longitudinais
- 1.3 Estudos de *Tracking*

### 1.1 Estudos Transversais

#### 1.1.1 Actividade Física

A actividade física é um termo abrangente que inclui todo o tipo de movimento, desde o mais pequeno ao mais complexo. A actividade física pode ser voluntária (inclui actividade física estruturada, planeada, relativamente bem limitada no tempo e executada com o objectivo de despende energia ou de melhorar alguns atributos da aptidão física) ou enquadrada no quotidiano (inclui a marcha diária e todos os movimentos realizados no seio das actividades domésticas, ocupacionais ou como forma de transporte). Pode ainda ser espontânea, tipicamente involuntária, constituída pelos pequenos movimentos do corpo, desde o piscar de olhos a todas as contracções musculares associadas às diferentes posturas do corpo. No entanto, existe uma grande dificuldade em avaliar e quantificar separadamente a actividade física associada ao estilo de vida e a actividade física espontânea o que leva a que muitas vezes sejam consideradas em conjunto (Teixeira, Silva, Vieira, Palmeira, & Sardinha, 2006)

Inúmeros estudos transversais identificam a actividade física em crianças e adolescentes de diversas formas, mas todos são consensuais em referir que a actividade física é um factor essencial para a saúde e bem-estar quer a curto quer a longo prazo. No entanto, a actividade física é influenciada por inúmeros factores, como a idade, o género (Troiano et al., 2008; Trost et al., 2002), o

estatuto sócio económico (Mota, Ribeiro, & Santos, 2008), o envolvimento e o suporte social (Mota, Almeida, Santos, & Ribeiro, 2005).

O actual cenário levanta algumas questões relacionadas com a sustentação da velocidade das alterações culturais numa base biológica que tem sido progressivamente comprometida pelo sedentarismo, excesso de peso e obesidade (Malina & Little, 2008). Na realidade, os comportamentos sedentários têm vindo a tornar-se mais comuns nas novas gerações (S. J. Biddle, 2007) e podem estar positivamente associados ao excesso de peso e obesidade em crianças e adolescentes (Ekelund et al., 2006; Lioret, Maire, Volatier, & Charles, 2007; Must et al., 2007).

Os comportamentos sedentários (por definição, actividades físicas com baixo dispêndio energético) apesar de se enquadrarem na definição clássica de actividade física de Caspersen (1985) (“qualquer movimento corporal produzido pela contracção do músculo-esquelético resultando num dispêndio energético”) representam uma natureza de comportamento diferente, não significando simplesmente ausência de actividades de intensidades ligeiras ou moderadas. Os comportamentos sedentários e a actividade física são correlacionados apenas modestamente, têm outro tipo de determinantes sócio-demográficos e estão associados de forma diferente aos factores de risco para a saúde (S. J. Biddle, Gorely, Marshall, Murdey, & Cameron, 2004; Brodersen, Steptoe, Williamson, & Wardle, 2005). Muitos estudos mostram que o tempo dispendido em actividades sedentárias não está associado ao tempo dispendido em actividades físicas (Ekelund et al., 2006; Lioret et al., 2007; Vandewater et al., 2007), outros dizem que estas duas variáveis estão inversamente relacionadas (Koezuka et al., 2006; Zabinski, Norman, Sallis, Calfas, & Patrick, 2007) ou ainda que o tipo de actividades como ver televisão ou usar computador, podem ter valores diferentes na relação com a actividade física (Santos, Gomes, & Mota, 2005).

Em função da diminuição dos níveis de actividade física e do risco que constitui para a saúde, comissões científicas e governamentais têm emitido recomendações não só para reduzir o tempo de actividades sedentárias mas

também para promover a actividade física em crianças e jovens. A American Academy of Pediatrics publicou recomendações no sentido de serem reduzidas as horas de actividades de baixo dispêndio energético como ver televisão (com programas de qualidade) para um máximo de 2 horas em média por dia (AAP, 2001).

Quanto às recomendações para aumentar os níveis de actividade física, Pate et al., (2002) analisaram três propostas: 1) O Healthy People 2010, objectivo 22.6 para MVPA (>30 min, > 5 dias da semana > 3 METs) (METs ou equivalentes metabólicos) mostrou ser um valor *standard* demasiado baixo porque a maioria dos jovens atingiam estas recomendações. 2) O Healthy People 2010, objectivo 22.7 para actividades vigorosas ( $\geq 20$  minutos contínuos  $\geq 3$  dias/semana,  $\geq 6$  METs ) pareceu ser inapropriado por ser um padrão de actividade física característico dos adultos, mas incharacterístico das crianças e adolescentes. Por ultimo, 3) o Grupo do Reino Unido (S. Biddle, Sallis, & Cavill, 1998) que aconselhou que as crianças acumulassem 60 minutos por dia de MVPA, ( $\geq 60$  minutos,  $\geq 5$  dias da semana  $\geq 3$  METs) mostrou ser a melhor e mais adaptada recomendação para esta faixa etária .

Apesar das razões que levaram à eleição destas recomendações, elas não deixam de ser de ser baseadas em considerações arbitrárias, na atribuição de 3 ou 6 MET's para classificar as actividades de intensidades moderadas ou vigorosas (L. B. Andersen et al., 2006; Freedson, Pober, & Janz, 2005; J. W. Twisk, 2001).

Na realidade, o grande obstáculo para encontrar resposta para as múltiplas questões relacionados com a actividade física diária, está relacionado com os métodos de avaliação da própria actividade em condições de terreno. Existem inúmeros métodos de avaliação da actividade física como: inquéritos, registos diários, observação directa, monitores da frequência cardíaca e sensores do movimento (pedómetros e acelerómetros). Contudo, alguns estudos mostram grandes discrepâncias nos valores de prevalência da actividade física entre os resultados estimados objectivamente e através de questionários, indicando por exemplo que nas medidas subjectivas as crianças e adolescentes tendem a

sobrestimar muito os valores da actividade física (Sallis & Saelens, 2000). Mas apesar dos questionários poderem classificar a actividade física com um erro maior, comparativamente às avaliações objectivas, podem ser estimadores válidos no terreno. Um estudo de Troiano et al., (2008) que comparou a actividade física avaliada de forma objectiva ou avaliada subjectivamente, mostrou resultados qualitativos semelhantes no que respeita à idade e ao género. No entanto, no que respeitava ao cumprimento das recomendações da actividade física, a avaliação realizada por acelerometria apresentou valores substancialmente mais baixos que a avaliação através de questionários.

A observação directa pode ser um excelente instrumento de avaliação, no entanto também pode ter desvantagens no tempo e na necessidade de dispor de observadores no terreno, o que eleva os custos. Os sensores do movimento e monitores da frequência cardíaca ultrapassam os problemas de subjectividade e memória do entrevistado num questionário e são mais baratos que a observação directa. No entanto, podem trazer alguns problemas técnicos e não captam certas informações sobre actividades específicas ou sobre o contexto das actividades. Além disso, ainda não se conseguiu chegar a um acordo quanto aos pontos de corte a usar ou quanto às equações para determinar o dispêndio energético (L. B. Andersen et al., 2006; Trost et al., 1998). E apesar da grande questão ser encontrar a fronteira para as actividades moderadas e vigorosas, parece haver recentemente uma convergência de opiniões na atribuição média entre estudos de 3.38 e 4.15 km/h para 1000 e 2000 counts.min, respectivamente (Brage, Wedderkopp, Andersen, & Froberg, 2003; Puyau, Adolph, Vohra, & Butte, 2002; Trost et al., 1998).

Cada um dos métodos tem vantagens e limitações, devendo por isso ter-se em linha de conta o que é mais importante na contextualização do envolvimento físico e social, para escolher o instrumento mais adequado (Pate, 1993). As técnicas de referencia mais usadas são a observação directa, a avaliação do dispêndio energético total através da água duplamente marcada e a calorimetria indirecta. A maior limitação continua a ser a ausência de uma avaliação *gold standard* que permita uma validação destes métodos como

indicadores da energia despendida em crianças e adolescentes (Pate et al., 2002).

A tarefa de avaliar a actividade física em toda a sua magnitude é, de facto, um grande desafio. A inconsistência de resultados pode ser explicada pelos inúmeros métodos de avaliação existentes (Sirard & Pate, 2001; Welk, Blair, Wood, Jones, & Thomson, 2000; Welk, Corbin, & Dale, 2000). Na avaliação com acelerómetros, serão necessárias futuras validações para a conversão dos pontos de corte em intensidades fisiológicas (L. B. Andersen et al., 2006) para uma uniformidade de critérios.

### **1.1.2 Aptidão Física**

O estudo da aptidão física das populações tem, nas últimas décadas, conhecido um interesse crescente, pelo reconhecimento da associação que se pode estabelecer entre ela, os hábitos de actividade física, e o estado de saúde e bem-estar. Por isso, a avaliação da aptidão física parece ser fundamental a qualquer programa de actividade física que tenha como objectivo melhorar a saúde e estabelecer um ponto de partida para que os indivíduos possam definir metas e monitorizar o seu progresso.

A aptidão física é uma característica do indivíduo que se traduz na sua capacidade de realizar uma tarefa física. Tem uma forte componente genética, mas é modificável através do treino dentro da variabilidade individual (Caspersen et al., 1985). É constituída por várias componentes, entre elas: a ACR, que reflecte a capacidade do sistema respiratório e cardiovascular de suportar exercícios prolongados (Taylor, Buskirk, & Henschel, 1955); a força muscular, uma componente essencial pela importância de alcançar certos níveis para a aplicação nas tarefas do dia-a-dia (Malina, Bouchard, & Bar-Or, 2004); a flexibilidade, isto é, a capacidade de realizar movimentos em certas articulações com apropriada amplitude de movimento, e ainda a composição corporal. Cada uma destas componentes, varia de forma diferente nas diversas idades e géneros. Em todas elas (com a excepção da flexibilidade) os rapazes apresentam melhores performances que podem ser influenciadas pelo súbito aumento da massa muscular (Malina et al., 2004). Vários estudos transversais

têm mostrado associações positivas com a actividade física durante a infância e adolescência (Ekelund et al., 2001; Johnson et al., 2000; Katzmarzyk, Malina, Song, & Bouchard, 1998; Norman et al., 2005), assim como associações negativas com a gordura corporal (McGavock, Torrance, McGuire, Wozny, & Lewanczuk, 2009). Das componentes da aptidão física em geral, a ACR em particular parece estar mais fortemente relacionada com os factores de risco das DCV que os componentes da actividade física avaliada objectivamente com acelerómetros. Mas enquanto a gordura corporal em excesso pode agravar estes factores de risco, o aumento dos níveis da ACR, podem ser fundamentais na prevenção tal como deve acontecer nestas idades (Hurtig-Wennlof, Ruiz, Harro, & Sjostrom, 2007; McGavock et al., 2009). Crianças obesas envolvidas em programas de exercício físico orientado com base na escola, mostram aumento significativo da ACR, melhores níveis de insulina em jejum e podem melhorar a composição corporal mesmo que não se verifiquem alterações do índice de massa corporal (IMC) (Carrel et al., 2005).

Uma melhor ACR pode ser indicadora de níveis mais elevados de actividade física, não apenas em função da quantidade total ou volume, mas acima de tudo em função da intensidade, com as evidências a darem cada vez mais destaque às actividades de intensidade vigorosas (Ruiz et al., 2006).

Quanto à avaliação da aptidão física, existem várias baterias de testes com diferentes protocolos de avaliação, que também dificultam a comparação de resultados. Mas no que diz respeito à ACR um estudo de revisão mostrou que o Vaivém (20m) é um teste valido para ser usado em condições de terreno (Castro-Pinero et al., 2009).

Alguns testes de aptidão física implicam a sustentação do peso corporal, podendo penalizar os indivíduos com obesidade. Mas por outro lado, os testes que permitem não sustentar o peso corporal, podem sobrestimar os valores do teste pela massa muscular extra que existe na composição corporal de um indivíduo com excesso de peso (Pfeiffer, Dowda, Dishman, Sirard, & Pate, 2007).

### 1.1.3 Obesidade

A prevalência da obesidade tem vindo a aumentar em diferentes populações, com a liderança dos Estados Unidos (Flegal, Ogden, Wei, Kuczmarski, & Johnson, 2001; Troiano & Flegal, 1998) seguindo-se outros países da Europa (L. F. Andersen et al., 2005; Lobstein & Frelut, 2003; Papandreou et al., 2008), países Asiáticos como a Índia (Bhardwaj et al., 2008; Chen, Fox, Haase, & Wang, 2006), e Austrália (Magarey, Daniels, & Boulton, 2001) entre muitos outros países (Lissau et al., 2004; WHO, 2000). Em Portugal atinge-se um das prevalências mais elevadas da Europa com valores de IMC na ordem de 31.6% entre os 7 e 9 anos (Padez, Fernandes, Mourao, Moreira, & Rosado, 2004) e de 18% entre os 10 e 16 anos (Janssen et al., 2005); Investigações epidemiológicas mostram que a obesidade resulta do desequilíbrio, no tempo, entre a energia gasta e a energia ingerida. A sua etiologia é influenciada, de uma forma complexa, por factores sócio-demográficos, tal como a idade, estatuto sócio económico (Mota et al., 2007), factores comportamentais e ambientais (O'Brien et al., 2007), hábitos alimentares (French, Story, & Jeffery, 2001) e actividade física (Ness et al., 2007; Trost, Kerr, Ward, & Pate, 2001).

Muitos estudos têm demonstrado uma associação inversa entre a gordura corporal, a actividade física e a ACR (Johnson et al., 2000; Mota, Flores, Flores, Ribeiro, & Santos, 2006; Norman et al., 2005). Pensa-se que os comportamentos sedentários podem ter um duplo papel no aumento da obesidade, não só porque envolvem gastos muito baixos de energia, mas também porque estão associados à ingestão de alimentos com muitas calorias e de baixa qualidade nutricional. No entanto, as evidências mostram que ao longo dos séculos não tem havido um aumento quantitativo da ingestão calórica e de gorduras em crianças e adolescentes (Troiano, Briefel, Carroll, & Bialostosky, 2000) sugerindo que os comportamentos sedentários podem ser moderadores entre a actividade física e o excesso de peso/obesidade (DeMattia, Lemont, & Meurer, 2007; Wong & Leatherdale, 2009).

Existem vários métodos válidos e fiáveis para avaliar a adiposidade, como a Hidrodensitometria, *Dual Energy x-Ray Absorptiometry* (DEXA), Tomografia

Axial Computorizada (TAC), Ressonância Magnética, Bioimpedância, ou ainda Pregas de Adiposidade, apesar de poder ser menos fiável em casos de obesidade mórbida (Slaughter et al., 1988). Mas os métodos antropométricos ou a avaliação de perímetros são mais acessíveis, não só pelos baixos custos mas também pela facilidade de utilização no terreno, apesar de menos precisos (Rolland-Cachera et al., 1997).

Mesmo não havendo ainda consenso internacional em relação aos valores de referência para crianças, alguns autores elegem o perímetro de cintura para a avaliação da obesidade abdominal, enquanto outros defendem que as pregas de adiposidade podem ser melhores indicadores da massa gorda. Mas muitos estudos baseiam-se no IMC para retratarem o estatuto do peso ou da adiposidade. Apesar das limitações para distinguir a massa muscular da massa gorda, o IMC é perfeitamente adequado para avaliações na prática clínica e em estudos com grandes amostras e parece ser um excelente indicador da saúde quer a curto quer a longo prazo. O IMC correlaciona-se com avaliações directas da gordura corporal (Pietrobelli et al., 1998) assim como com avaliações indirectas como o perímetro de cintura ( $r=0.92$ ) e a massa gorda ( $r=0.92$ ), sem diferenças significativas entre género em adultos (Bouchard, 2007).

Outro aspecto que parece estar relacionado com a obesidade, é o estado maturacional. No último século, o tempo de desenvolvimento da puberdade tem sido sujeito a alterações nos rapazes e raparigas. A diminuição da idade da menarca tem sido uma realidade desde a nova era industrial e que se tem vindo a confirmar em estudos realizados entre os anos 60 e 90 (Anderson, Dallal, & Must, 2003; Freedman et al., 2002) assim como uma pré-maturidade do desenvolvimento das características sexuais secundárias (Kaplowitz, Slora, Wasserman, Pedlow, & Herman-Giddens, 2001). Pensa-se que este desenvolvimento precoce da puberdade, pode ser atribuído ao aumento da prevalência da obesidade. De facto, tem-se verificado correlações entre a obesidade nas raparigas e o desenvolvimento dos pêlos púbicos, com níveis mais elevados no estágio de maturação sexual (Tanner & Whitehouse, 1976) relativamente ao tamanho do peito (Kaplowitz et al., 2001) e da menarca

antecipada (Freedman et al., 2002). Um estudo de Denzel et al., (2007) que comparou a evolução maturacional dos rapazes e raparigas obesas com dados de referência do Zurich Longitudinal Study, mostrou não haver evoluções do aumento dos pelos púbicos nos rapazes e raparigas do tamanho dos testículos nos rapazes. No entanto, nas raparigas houve um aumento do tamanho do peito no estágio 3 nas raparigas obesas.

#### 1.1.4. Considerações metodológicas

Os estudos transversais podem ser uma vantagem quando se pretende obter grandes amostras, contudo, não se podem estabelecer direcções de causalidade, porque analisam casos num determinado momento no tempo. Por exemplo, um problema que se coloca é o de saber qual a direcção da associação entre actividade física e aptidão física. Esta pode ser explicada nos dois sentidos: as populações em estudo podem ser mais aptas fisicamente porque são mais activas e do mesmo modo, podem ser mais activas porque são mais aptas fisicamente (Kemper, de Vente, van Mechelen, & Twisk, 2001). Do mesmo modo, as actividades sedentárias podem ser um indicador para alguns determinantes da saúde, mas por outro lado, indivíduos com uma predisposição genética para serem obesos ou para serem menos aptos fisicamente podem preferir um estilo de vida menos activo.

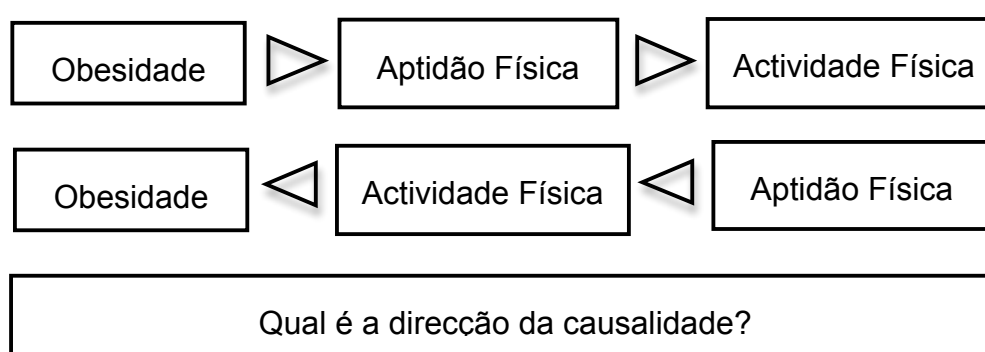


Figura 1. Direcção da causalidade

O sentido da causalidade pode eventualmente ser observada em estudos longitudinais.

## 1.2 Estudos Longitudinais

### 1.2.1 Actividade Física

Desde o nascimento, em todas as fases de desenvolvimento e envelhecimento, os níveis e padrões de actividade física modificam-se naturalmente. Nas crianças e adolescentes existem alterações importantes na actividade física que devem ser consideradas e que podem ser observadas com mais clareza em estudos longitudinais. A literatura mostra que a actividade física decresce ao longo da vida, mas ainda há algum espaço para debate para saber como decresce, em especial na fase mais crítica da adolescência.

Vários estudos longitudinais, na Europa (Telama & Yang, 2000; Van Mechelen, Twisk, Post, Snel, & Kemper, 2000), ou nos EUA (Aaron, Storti, Robertson, Kriska, & LaPorte, 2002; Kimm et al., 2002), têm mostrado uma diminuição acentuada da actividade física à medida que se avança na adolescência, sendo esse decréscimo mais acentuado nas raparigas que nos rapazes, talvez motivada por condicionantes sociais e culturais (Kemper et al., 2001; Kimm et al., 2002; Yang et al., 2007). A descida pode ser mais acentuada entre os 15 e os 16 anos em ambos os sexos (Pratt, Macera, & Blanton, 1999). A actividade física em geral pode declinar entre 1% a 20% por ano (Aaron et al., 1992; Kimm et al., 2000; Yang et al., 2007).

Recentemente, um estudo demonstrou que a actividade física pode decrescer, não de forma linear, mas de forma quadrática: os seus resultados mostraram que nos rapazes aumentou até aos 11 anos e depois de um *platô* decresceu a partir dos 13 anos, enquanto nas raparigas aumentou até aos 12-13 anos e começou a decrescer a partir dessa idade. Para além dos factores sociais e culturais como as responsabilidades académicas, outros factores biológicos podem intervir neste processo como alterações do sistema da dopamina (precursor natural da adrenalina e norodrenalina) que regula a motivação para o movimento, (Kahn et al., 2008).

Também o padrão da actividade física habitual passa a ter outros contornos ao longo do crescimento: o domínio das actividades espontâneas de recreio dá

lugar às actividades estruturadas como os desportos de clube ou de ginásio (Malina, 1991).

Mas o problema que tem vindo a preocupar a generalidade dos investigadores, está relacionado com declínio da actividade física no estilo de vida dos jovens, como resultado das alterações ecológicas verificadas nas últimas décadas (Pratt et al., 1999). Não só o volume, mas também as intensidades moderadas a vigorosas (MVPA) tem vindo a decrescer ao longo dos tempos (Baquet, Twisk, Kemper, Van Praagh, & Berthoin, 2006; 2000; Kemper et al., 2001; Van Mechelen et al., 2000).

Mas tão importante como a análise do efeito positivo das actividades vigorosas, é também a análise do efeito adverso dos comportamentos sedentários (Dietz, 1996). Os comportamentos sedentários passaram a ocupar grande parte do tempo dos jovens, com mais horas dedicadas a ver televisão e ao uso do computador, quer em actividades laborais quer em actividades de lazer ou de socialização. E a adolescência parece ser um período particularmente vulnerável para a escolha deste tipo de actividades (Hardy, Bass, & Booth, 2007; Must et al., 2007; Nelson, Neumark-Stzainer, Hannan, Sirard, & Story, 2006). No entanto, tal como nos estudos transversais, os longitudinais mostram também alguns resultados controversos no que respeita à influencia do tempo de lazer sedentário no excesso de peso, com associações positivas (Proctor et al., 2003), com associações negativas (Horn, Paradis, Potvin, Macaulay, & Desrosiers, 2001) ou mesmo sem qualquer associação (Salbe et al., 2002). Ainda assim, numa revisão de estudos longitudinais (Must & Tybor, 2005), que atribuiu muitas das inconsistências a questões metodológicas e estatísticas, os resultados mostraram uma associação inversa do peso e adiposidade com a actividade física e uma relação directa com os comportamentos sedentários. Existe de facto um efeito protector da actividade física nos valores de gordura corporal ao longo da infância. Apesar de um declínio generalizado dos níveis de actividade física ao longo da idade, as crianças mais activas tendem a apresentar valores menores de gordura corporal no início da adolescência (Moore et al., 2003). Estas evidências sugerem que proporcionar níveis elevados de actividade física na idade pré-escolar pode adiar o início do

período de rápido aumento da gordura corporal que ocorre geralmente entre os 4 e os 6 anos de idade, assim como pode adiar ou atrasar o início da síndrome metabólica mais tarde nos jovens adultos.(Yang et al., 2008)

### **1.2.2 Aptidão Física**

O cenário global indica um decréscimo da aptidão física (da força e da ACR) de cerca de -0.36% por ano, desde a década de 70, resultantes de uma rede de factores sociais, comportamentais, físicos, fisiológicos e psicológicos (Tomkinson & Olds, 2007) e este decréscimo acontece em todas as idades sexos e áreas geográficas (Corbin & Pangrazi, 1992; Dollman, Olds, Norton, & Stuart, 1999). Num estudo realizado entre 1974 e 1995, na Suécia, os resultados também mostraram decréscimo na ACR, mas com um aumento da performance em testes de força estática (Westerstahl, Barnekow-Bergkvist, Hedberg, & Jansson, 2003). Estes resultados devem-se, pelo menos em parte, ao aumento do peso corporal e do IMC. No entanto, todas as reduções da aptidão física ao longo do tempo têm-se verificado em todas as categorias de IMC, não se restringindo apenas aos que apresentam excesso de peso e obesidade (Stratton et al., 2007; Wedderkopp, Froberg, Hansen, & Andersen, 2004).

As crianças e jovens estão a perder o efeito metabólico da aptidão física que os pode proteger do aumento de peso e de outros problemas metabólicos (Stratton et al., 2007). Tal como já foi dito anteriormente, a aptidão física em geral e a ACR em particular é considerada como um dos melhores indicadores da saúde (Krahenbuhl, Morgan, & Pangrazi, 1989; Ortega, Ruiz, Castillo, & Sjostrom, 2008). Estudos longitudinais têm demonstrado que níveis reduzidos de aptidão física, em especial de ACR, estão fortemente associados ao risco de desenvolverem DCV (Church, LaMonte, Barlow, & Blair, 2005; Kvaavik, Klepp, Tell, Meyer, & Batty, 2009), Diabetes Mellitus tipo II (Sawada, Lee, Muto, Matuszaki, & Blair, 2003) cancro (Evenson, Stevens, Cai, Thomas, & Thomas, 2003; C. D. Lee & Blair, 2002) síndrome metabólica (Ekelund et al., 2009) e todas as causas de mortalidade (Katzmarzyk, Church, & Blair, 2004). Em crianças e adolescentes, os níveis baixos de ACR estão associados a um perfil

desfavorável de risco de doenças crónicas (Freedman, Dietz, Srinivasan, & Berenson, 1999; Williams et al., 1992). Resultados do *European Youth Heart Study* (EYHS) mostram que a tendência oposta do aumento da obesidade e da diminuição da aptidão física sugere uma geração futura com um elevado grau de risco das DCV (Wedderkopp, Froberg, Hansen, Riddoch, & Andersen, 2003).

Alguns estudos examinaram as tendências seculares da ACR nas crianças. Tal como a actividade física, também se tem verificado uma diminuição dos níveis de ACR na população juvenil nas últimas décadas (Moller, Wedderkopp, Kristensen, Andersen, & Froberg, 2006; Tomkinson, Olds, & Gulbin, 2003; Wedderkopp et al., 2004). Um estudo de Stratton et al., (2007) indicou um decréscimo no teste de Vaivém (20m) de cerca de 23% entre 1998 e 2004, em crianças dos 9 aos 11 anos em ambos os sexos. Neste estudo, as crianças consideradas abaixo da zona saudável de aptidão física aumentaram cerca de 36% nas raparigas e 80% nos rapazes. No entanto, outros autores mostram não haver alterações significativas da ACR nas raparigas, ao longo do período analisado (Wedderkopp et al., 2004).

É geralmente aceite que os níveis de aptidão física podem ser indicadores dos níveis de actividade física. Num estudo longitudinal de 4 anos realizado durante a adolescência (Baquet et al., 2006), mostrou que quando se compararam crianças activas com sedentárias, os grupos regularmente activos não só tiveram melhores desempenhos na ACR como nas restantes componentes (e para as raparigas a flexibilidade) como também aumentaram posteriormente essas performances comparativamente com os outros grupos. O desempenho da aptidão física estava mais associado com a manutenção de níveis elevados de actividade física, e com os níveis de actividade encontrados na *baseline*, então parece importante promover níveis elevados de actividade física desde cedo na infância para que se mantenham elevados ao longo da vida. No entanto, alguns autores dizem que a alteração dos níveis de actividade física da infância para a adolescência pode ter apenas uma influência marginal na aptidão física, comparando com sujeitos sedentários (Malina, 2001). Do mesmo modo, da adolescência para a idade adulta esta relação longitudinal parece ser

significativa apenas para ACR (Kemper et al., 2001). No que diz respeito à força, à flexibilidade e à composição corporal, evidências mostram que estas componentes da aptidão física, não estão correlacionados com os níveis de actividade física (Beunen et al., 1992; Malina, 2001).

### **1.2.3 Obesidade**

O aumento do IMC e da pregas de adiposidade parece estar relacionado com o decréscimo dos níveis de actividade física (Kimm et al., 2005), mas tal como nas alíneas anteriores, a controvérsia mantém-se (Johnson et al., 2000). Metcalf et al., (2008) mostrou que em crianças, níveis de actividade física abaixo das recomendações de intensidade de 3 METs estava associada com um aumento progressivo de saúde metabólica mas não nas alterações do IMC ou da gordura corporal. No entanto, dentro dos parâmetros dos estilos de vida que podem influenciar as alterações da gordura corporal durante a infância e adolescência, estudos baseados em modelos hierárquicos elegem a actividade física como o factor mais determinante, ficando a aptidão física em segundo lugar (Koutedakis, Bouziotas, Flouris, & Nelson, 2005). Outros factores indicados são, o género, o grau de obesidade no início do tratamento e a obesidade parental (Goran et al., 1998). Nos estudos anteriormente referidos, a ingestão calórica não foi um factor influenciador na perda de peso enquanto que noutros não houve sequer alterações da ingestão calórica ao longo do tempo (Goran et al., 1998; Prentice & Jebb, 1995). A qualidade de envolvimento familiar também é determinante através do controlo dos pais, da quantidade de brinquedos no lar ou das actividades estruturadas pelos adultos, que podem proporcionar menos oportunidade de serem activos e expor as crianças demasiado tempo à televisão (O'Brien et al., 2007). Neste estudo, as crianças que mantiveram o seu estatuto de excesso de peso desde a escola primária diferiram dos restantes pelo tempo passado em actividades sedentárias e pelos seus índices de actividade física. Parece pois não haver um único factor isolado que esteja consistentemente ligado ao excesso de peso, mas sim um conjunto de factores interligados entre si ao nível

sociocultural (família, estatuto sócio-económico, género), intra e inter-pessoal (saúde psicológica dos pais, e bem estar em geral) e do envolvimento (segurança, níveis de actividade física e actividades sedentárias). Das actividades sedentárias, o tempo dispendido a ver televisão parece ser o mais recorrente durante a adolescência e pode estar fortemente associado ao aumento de peso, ao aumento do colesterol (Hancox, Milne, & Poulton, 2004) e à hipertensão na idade adulta (Virdis et al., 2009).

#### **1.2.4 Considerações metodológicas**

A popularidade dos estudos longitudinais deve-se ao facto de se acreditar que eles podem resolver a questão da causalidade. Dos vários critérios necessários para a determinar, podemos referir: a força das relações, a consistência em diferentes populações e sob diferentes circunstâncias, a especificidade (a causa leva a um único efeito), o gradiente biológico (relação dose-resposta), a plausibilidade biológica, a evidência experimental e a temporalidade (a causa antecede o efeito no tempo – critério específico dos estudos longitudinais). A causa (variável preditora) tem de preceder o efeito no tempo, o que no caso da actividade física, aptidão física e adiposidade esta precedência é difícil de encontrar (J. W. Twisk, 2003) .

No que respeita à obesidade em particular, como esta é consequência de pequenos balanços negativos ao longo do tempo, é provável que os investigadores procurem pequenos efeitos. Devido a estes efeitos modestos nos resultados, são necessárias amostras relativamente grandes para encontrar significados estatísticos. Isto pode explicar os resultados nulos, principalmente em amostras pequenas, que geralmente acontecem em estudos longitudinais.

### **1.3 Estudos de *Tracking***

A palavra Inglesa “*Tracking*” (que irá ser usada ao longo do texto) refere-se à estabilidade de uma característica ou a manutenção duma posição relativa dentro de um grupo, ao longo do tempo (Malina, 1996).

### 1.3.1 Actividade Física

Análises de *tracking* efectuadas através de questionários mostram um efeito de estabilidade dos níveis de actividade física da infância para adolescência e desta para a idade adulta (Azevedo, Araujo, Cozzensa da Silva, & Hallal, 2007; Barnekow-Bergkvist, Hedberg, Janlert, & Jansson, 1996; Malina, 2001).

Num estudo recente realizado com acelerómetros, os resultados exibem um *tracking* moderado da actividade física desde a infância para a adolescência, independentemente do género, com coeficientes de estabilidade de aproximadamente 0.50 (Kristensen et al., 2008). Também com pedómetros observaram-se correlações moderadas, mas desta vez para os insuficientemente activos durante a adolescência, com os rapazes a expressarem um *tracking* mais elevado que as raparigas (Raustorp, Svenson, & Perlinger, 2007). O tipo e a intensidade da actividade também podem ser factores de influência na actividade física do adulto (Tammelin, Nayha, Hills, & Jarvelin, 2003), com melhores coeficientes para desportos organizado (Kraut, Melamed, Gofer, & Froom, 2003) e para intensidades vigorosas (Barnekow-Bergkvist et al., 1996; Janz, Burns, & Levy, 2005). Em resumo, quer com instrumentos subjectivos, quer com objectivos, a maioria dos estudos parecem indicar um *tracking* moderado da actividade física da infância para a adolescência e da adolescência para idade adulta.

O período de vida de maior transição corresponde à passagem da adolescência para a idade adulta devido a uma vasta alteração de comportamentos associados à saída de casa, formação da família, participação no trabalho e nascimento de filhos. Hogan et al., (1978) mostram que os padrões adquiridos neste período de transição são mais importantes que o historial familiar, como chave para a entrada no novo ciclo de vida. Num estudo de Gordon-Larsen, et al., (2004) a maioria dos adolescentes que não atingiam 5 ou mais momentos de actividades moderadas a vigorosas por semana continuaram a não atingir esse nível na idade adulta.

Vários estudos mostraram que as raparigas apresentam melhores coeficientes de *tracking* nas actividades vigorosas, enquanto os rapazes têm mais

probabilidades de manterem os comportamentos sedentários na idade adulta quando comparados com os seus pares mais activos (Janz, Dawson, & Mahoney, 2000; Raitakari et al., 1994; J. W. Twisk, Kemper, & van Mechelen, 2000). Mais uma vez, a questão do decréscimo da actividade física está inevitavelmente ligada ao aumento dos comportamentos sedentários. Há uma tendência evidente de manter ou até acentuar os comportamentos sedentários ao longo dos anos (Baquet et al., 2006; Gordon-Larsen et al., 2004).

A longo prazo, a actividade física tem um efeito protector da saúde óssea e um efeito benéfico indirecto na saúde em geral como resultado dos níveis de actividade física no adulto. A literatura sugere que a actividade física na adolescência é um factor importante para a manutenção de níveis elevados de actividade física na fase adulta, mas os resultados existentes não permitem estabelecer recomendações precisas sobre a quantidade de actividade física necessária na adolescência para a construção de um estilo de vida activo a longo prazo (Hallal, Victora, Azevedo, & Wells, 2006).

### **1.3.2 Aptidão Física**

Os níveis de aptidão física tendem a prosseguir da infância para a adolescência (Janz, Dawson, & Mahoney, 2002) e da adolescência para a idade adulta (Hasselstrom, Hansen, Froberg, & Andersen, 2002; Malina, 1996; J. W. Twisk et al., 2000). O *tracking* da ACR, e da força muscular (ajustadas ao peso corporal) são em geral moderados com coeficientes de cerca de 0.5. Note-se, no entanto, que esses coeficientes passam a ser mais baixos, quando são analisados períodos de tempo mais longos entre a infância e a idade adulta (Malina, 2001). Para a força (isométrica) alguns estudos mostram coeficientes mais elevados de 0.7 (L. B. Andersen, 1994; J. W. Twisk et al., 2000). Pelos valores referidos nos vários estudos citados anteriormente, as melhores correlações de *tracking* verificam-se na ACR e não na actividade física. A explicação pode estar, por um lado, na componente genética da ACR em comparação com a larga componente comportamental da actividade física e, por outro lado, porque a actividade física, regra geral, é avaliada através de questionário o que aumenta a variabilidade entre estudos.

No entanto, num estudo realizado ao longo de 23 anos, (Kemper & Koppes, 2006) quando se analisou a importância da actividade física na adolescência e a sua influência na aptidão física na idade adulta, parece não ter existido uma relação entre estas duas variáveis em ambos os sexos. Embora neste estudo, nos primeiros 15 anos, a força da relação entre a actividade física e aptidão física tenha sido significativa, as implicações funcionais parecem ter sido menos expressivas: um aumento de 30% na actividade física (aproximadamente igual a 1000 METs/semana) resultou num aumento de apenas 2% na ACR. Em 23 anos se o resultado não foi significativo, não foi então possível provar que existe uma relação entre a actividade física e ACR quer em homens quer em mulheres ao longo do tempo. Por isso, os resultados levam-nos a reconhecer por um lado a importância do factor genético e que o efeito da actividade física na ACR é tão curto que não é detectável em estudos longitudinais demasiado extensos no tempo.

A par da preocupação sobre os níveis da actividade física e a sua relação com a ACR quer a curto quer a longo prazo, surge um outro foco de interesse: a importância de reduzir o tempo de actividades sedentárias como ver televisão, por estarem também associadas negativamente com o nível de ACR na idade adulta (Hancox et al., 2004). A explicação mais óbvia para esta associação entre comportamentos sedentários nas crianças e a aptidão física nos adultos relaciona-se com os níveis de actividade física. Apesar da actividade física poder ser possível confundidora, ela pode ser também a mediadora para a saúde na idade adulta.

### **1.3.3 Obesidade**

É conhecido da literatura que a obesidade segue um *tracking* da infância para a adolescência e da adolescência para a idade adulta (Singh, Mulder, Twisk, van Mechelen, & Chinapaw, 2008). Dependendo da fase em que a criança começa a ser obesa, o risco de se manter obesa até à idade adulta, pode ser maior. Cerca de 40% das crianças com 7 anos e 70% dos adolescentes obesos podem tornar-se adultos obesos (Whitaker et al., 1997). Estudos mais recentes confirmam estes resultados mostrando que a probabilidade de se ter

excesso de peso na idade adulta quando se tem excesso de peso na adolescência é substancialmente maior (Dietz, 2004; Freedman et al., 2005; Matton et al., 2006).

Num estudo realizado por Togashi et al., (2002) com crianças de 10 e 11 anos os resultados mostraram um *tracking* de excesso de peso e obesidade da infância para a idade adulta de 54.7% dos casos. O risco de obesidade na idade adulta foi duas vezes maior nos rapazes moderadamente obesos que nas raparigas. Quanto maior fosse o nível de obesidade maior seria o risco de se tornarem adultos obesos, mesmo quando recebiam tratamentos para a obesidade nesse período da infância. No entanto, das crianças participantes neste estudo, que receberam tratamento durante 1 ano, 76.5% das que tinham obesidade ligeira e 58.8% das moderadamente obesas conseguiram atingir um IMC normal na idade adulta. A obesidade também segue um *tracking* moderado desde a adolescência até à idade adulta, a par de outros factores de risco das doenças cardiovasculares (DCV) (Eisenmann, Wickel, Welk, & Blair, 2005; Katzmarzyk et al., 2001).

A ideia de uma estabilidade longitudinal moderada na observação do *tracking* da obesidade estabelece uma capacidade de determinação do risco para a saúde. Este facto sublinha a importância de colocar as crianças com excesso de peso e obesidade sob observação, aconselhamento e orientação e todas as outras em estado preventivo para contrariar esta tendência (Fuentes, Notkola, Shemeikka, Tuomilehto, & Nissinen, 2003; Stettler, Kumanyika, Katz, Zemel, & Stallings, 2003).

Vários autores analisam ainda outra possibilidade de *tracking*, mostrando uma associação inversa da ACR na adolescência com a obesidade na idade adulta (Eisenmann et al., 2005; J. W. Twisk, Kemper, & van Mechelen, 2002). A figura 2 mostra os coeficientes entre a actividade física, aptidão física e IMC apresentados em vários estudos (Eisenmann et al., 2005; Kemper et al., 2001) (kemper & koppel, 2006).

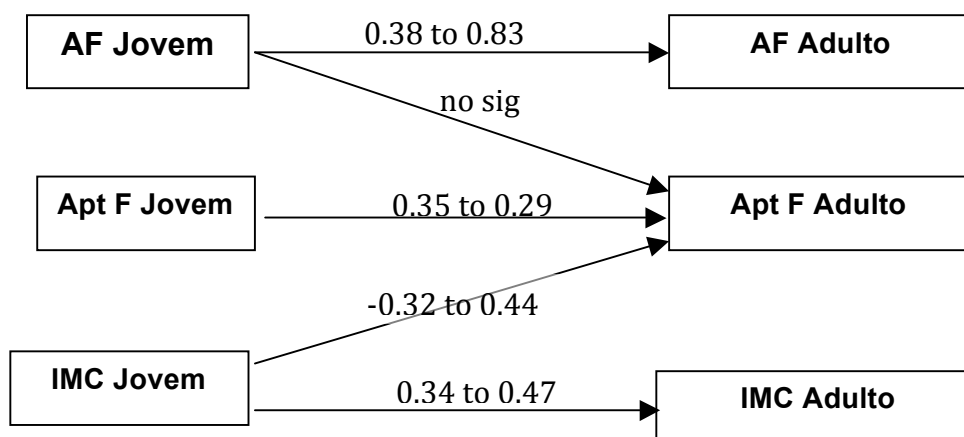


Figura 2 - Coeficientes de estabilidade entre actividade física, aptidão física e índice de massa corporal

### 1.3.4 Considerações metodológicas

Para analisar os coeficientes de *tracking* deve-se ter em linha de conta a extensão da idade, a idade da 1ª observação, as alterações do envolvimento e a variabilidade das avaliações. Quando um coeficiente de *tracking* é elevado não quer dizer necessariamente que os valores absolutos dessa variável se mantenham no mesmo nível.

As diferenças que se verificam nos coeficientes encontrados tanto na actividade física, na aptidão física como na obesidade, podem dever-se às diferenças metodológicas e estatísticas utilizadas.

## 1.4 Prevenção

Dos vários níveis de prevenção, destacam-se: a prevenção primária - conjunto de acções que visam evitar a doença na população, removendo os factores causais, ou seja, intentam na diminuição da incidência da doença. Tem por objectivo a promoção de saúde e protecção específica; e a prevenção secundária - conjunto de acções que procuram identificar e corrigir o mais precocemente possível qualquer desvio da normalidade, de forma a colocar o indivíduo de imediato na situação saudável, ou seja, tem como objectivo a diminuição da prevenção da doença. Passa do diagnóstico, ao tratamento e à limitação do dano.

A infância é o período ideal para a prevenção primária, por várias razões: (i) crianças obesas têm mais probabilidade de serem adultos obesos (Power, Lake, & Cole, 1997); (ii) há um crescendo de evidências que apontam para as consequências adversas da obesidade para a saúde tanto em crianças como em adultos, (Reilly et al., 2003); (iii) as crianças podem ser mais capazes de alterar comportamentos em estratégias de intervenção comparativamente aos adultos (Epstein, Valoski, Kalarchian, & McCurley, 1995); (iv) o tratamento da obesidade é difícil e de eficácia limitada (Summerbell et al., 2003). Mas quando a obesidade é já um problema, resta a prevenção secundária que pode ser praticável através de intervenções com base na escola.

## **1.5 Intervenção**

Vários alertas têm referido o problema das crianças e jovens de hoje não encontrarem oportunidades suficientes para atingirem um nível apropriado de actividade física no dia-a-dia, quer em actividades escolares, quer em actividades de participação voluntária, espontâneas ou organizadas, de forma a obter benefícios para a saúde. Tal como foi demonstrado ao longo deste primeiro capítulo, actualmente os níveis quer de actividades moderadas e vigorosas das crianças, quer de aptidão física, não são suficientes para obter benefícios para a saúde.

Os programas de intervenção de actividades organizadas podem ser o meio de proporcionar uma maximização da aprendizagem motora e do dispêndio energético.

Um programa de intervenção preventivo pode ser fundamental para reduzir a quantidade das doenças hipocinéticas, aperfeiçoar métodos de promoção da actividade física e avaliar se esses planos estratégicos são eficazes ou não.

Com base nas evidências de *tracking*, sabe-se que é difícil estabelecer e manter comportamentos saudáveis ao longo da vida. Experiências passadas mostram que, desenvolver uma intervenção com intenções de alteração de comportamentos é um processo complexo e demorado para se alcançarem resultados positivos. Por exemplo, no *Trial for Activity for Adolescent Girls*

(TAAG), em 2 anos de intervenção, associando as escolas com agências comunitárias, Educação Física e Marketing, cada criança alcançou apenas, em média, menos de dois minutos por dia de aumento de actividades moderadas e vigorosas (Webber et al., 2008).

Os estudos de revisão têm apresentado perspectivas pouco animadoras nas intervenções que têm como objectivo a perda de peso. A eficácia das intervenções na alteração de comportamentos é apenas mínima (nos respectivos objectivos) observando-se: a) maior eficácia na redução dos comportamentos sedentários nas crianças que nos adolescentes; b) maior eficácia nos tratamentos prolongados (>6 meses); c) tratamentos de curta duração mais eficazes na redução de dietas não saudáveis (Kamath et al., 2008). Esta revisão conclui ainda que o impacto é mínimo na alteração de comportamentos e sem efeito significativo na alteração do IMC. As estratégias que visaram focar a redução de comportamentos negativos, como o tempo de actividades sedentárias (ver televisão) (Kamath et al., 2008; Sharma, 2006) e o uso de dietas não saudáveis, parecem ter sido mais eficazes que aquelas que promoveram os comportamentos positivos. Mas será certamente mais provável que estas dimensões de comportamentos, negativa e positiva, interajam entre si ou tenham um efeito complementar, que pelo contrario, sejam entre elas substituíveis. Mesmo nas intervenções que usam agentes farmacológicos combinados com o aumento da actividade física com dieta, mostram eficácias limitadas a curto e a longo prazo (McGovern et al., 2008).

Em outros estudos de revisão (Harris, Kuramoto, Schulzer, & Retallack, 2009; Li, Li, Baur, & Huxley, 2008) sobre trabalho de intervenção, nenhum dos estudos apresentou evidências convincentes sobre a eficácia na prevenção secundária do excesso de peso e obesidade em crianças e adolescentes, embora o estudo mais recente tenha realçado existirem outros efeitos importantes para a saúde.

Tendo em conta a inconsistência das evidências, o impacto a longo prazo nas crianças e adolescentes, continua a ser pouco claro. No entanto, devemos continuar a ponderar sobre as estratégias a utilizar de forma a que as

intervenções sejam, de facto, bem delineadas e mais efectivas na prevenção primária e secundária da obesidade nestas idades.

Intervenções para aumentar os níveis de actividade física em crianças e adolescentes, parecem apresentar resultados mais promissores considerando uma abordagem em múltiplos níveis, combinando a escola, com a família ou comunidade envolvente, educação e envolvimento (van Sluijs, McMinn, & Griffin, 2007), a curto prazo (Shaya, Flores, Gbarayor, & Wang, 2008) ou a longo prazo (Brown & Summerbell, 2008). No que respeita aos mediadores, existe uma unanimidade de resultados que apontam para auto-eficácia e prazer na actividade como os que mais apoiam na relação teoria/prática da actividade física (Lubans, Foster, & Biddle, 2008). Valorizar a competência pessoal e a auto-eficácia, limitar o controlo e fontes de motivação externas e garantir experiências positivas e enriquecedoras durante e após a prática da actividade física assumem-se como aspectos decisivos a longo prazo (Teixeira et al., 2006)

Com base num estudo de Doak, et al., (2006), podemos observar (quadro 1) um tipo de padrão de actuação comum nas intervenções que apresentam resultados com ou sem eficácia relativamente aos resultados pretendidos em cada uma delas:

Quadro 1. Padrão de actuação entre intervenções com e sem eficácia

| <b>Com eficácia</b>                                                                                                                                                                                                                                                                                                                                                                                      | <b>Sem eficácia</b>                                                                                                                                                             |
|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <p>Maiores amostras, mas menor número de escolas participantes</p> <p>Inclusão de actividades com intensidades moderadas a vigorosas</p> <p>Com terapias que promovam alteração de comportamentos</p> <p>As que alteram directamente o envolvimento social: prática da AF e alterações na cantina</p> <p>Crianças mais velhas (entre 10 e 14 anos)</p> <p>Nos que têm obesidade</p> <p>Nas raparigas</p> | <p>Incluem muitas componentes em simultâneo</p> <p>Envolvimento comunitário muito abrangente</p> <p>Grupos heterogéneos em idade, género, estatuto sócio-económico e etnias</p> |

### **1.5.1 Considerações metodológicas**

Todos os estudos de revisão advertem para as limitações das metodologias da heterogeneidade de *designs* de estudo, dos diferentes tipos de *outcomes* avaliados e da fraqueza das avaliações, que em nada contribuem para uma análise esclarecida do sucesso ou insucesso das intervenções.

## **1.6 A Escola**

É um local privilegiado para a intervenção da obesidade infanto-juvenil. As escolas têm a vantagem de acompanhar e influenciar um número alargado de crianças, a custos mínimos e com a proximidade dos pais. Os pais podem ser envolvidos através de reuniões, ou de material educativo. Mas se, por um lado, a disciplina de Educação Física proporciona uma extraordinária oportunidade de contribuir para o aumento do dispêndio energético e para a educação de hábitos e comportamentos saudáveis, por outro lado, parece não ser suficiente para alcançar os níveis de actividade física recomendados. Os professores de Educação Física podem ter um papel fundamental na coordenação de programas de intervenção nas escolas, envolvendo outras instituições e implicando toda a população, pais, crianças, professores e auxiliares da acção educativa, num trabalho de interdisciplinaridade. A escola como local de intervenção em horário pós-curricular pode ser o meio ideal para ultrapassar factores condicionantes da actividade física como a inadequação ou a falta de transportes para as actividades assim como problemas de segurança (Cohen et al., 2006; Mota et al., 2005). É possível que haja muitos outros domínios e níveis de influência da actividade física, em especial das de intensidades moderadas e vigorosas, como o tamanho e qualidade dos espaços desportivos e a qualidade dos professores de Educação Física e consequentemente das suas aulas.

## **1.7 A Família**

A família é o alicerce de qualquer criança. Existe uma transmissão intergeracional de comportamentos relacionados com a saúde, por isso os pais

podem influenciar o comportamento dos filhos sendo um modelo representante de um estilo de vida relacionado com a saúde (Kahn et al., 2008). Os pais devem, por isso, ser um modelo e um apoio nas actividades do dia a dia, por exemplo, no transporte activo casa/escola, na promoção da auto-recreação, no encorajamento do desporto, no apoio psicológico e na prática de uma alimentação saudável (Dowda, Dishman, Pfeiffer, & Pate, 2007; Trost et al., 2003). De forma dialéctica, as crianças também devem ser uma influência na família levando da escola para casa saberes, transmitindo e impulsionando o prazer pela actividade física para um estilo de vida saudável.

## **1.8 O que tem sido feito em Portugal**

A “Carta Nacional do Combate contra a Obesidade”, (Maio de 2007) integrada no Plano Nacional de Saúde propõe-se, contribuir para a promoção da perda de peso na população obesa, com diabetes tipo II e doenças cardiovasculares, desenvolvendo uma cultura de hábitos saudáveis. A actividade física está incluída tanto no Plano Nacional de Saúde como na “Carta Nacional de Combate contra a Obesidade”. Dos nove princípios destacamos: melhorar dietas e aumentar níveis de actividade física; medidas políticas para reduzir a pressão dos *Mass Media* na publicidade de comidas e bebidas de grande densidade calórica. A atenção especial é focada nos grupos mais vulneráveis como as crianças e adolescentes, cuja inexperiência não deve ser explorada pelas actividades comerciais. O objectivo da Carta Portuguesa no combate contra a obesidade é o de reverter o aumento da prevalência da pré-obesidade e obesidade em Portugal numa cooperação intersectorial não apenas num nível internacional mas também nacional e local. Impõe-se, portanto, uma actuação multi-disciplinar e multi-institucional em sincronia para alcançar os objectivos apontados de um programa de intervenção que ajude as crianças em risco a saberem fazer, de forma autónoma, opções saudáveis no seu ambiente social e familiar, de forma a obterem benefícios para a saúde.



**[capitulo II.]**



# [II.]

## 2. Material e Métodos

Neste capítulo apresentaremos apenas as linhas gerais das amostras, dos instrumentos e métodos de análise utilizados, uma vez que as descrições mais detalhadas estão especificadas em cada artigo.

Os dados para os cinco primeiros estudos foram recolhidos na Escola Secundária de Valongo. Esta escola tem uma população média de cerca de 1200 alunos, do 7º ao 12º ano de escolaridade, entre os 11 e os 19 anos. As recolhas começaram a ser efectuadas no ano lectivo de 2005-06, no primeiro período entre Outubro e Novembro e repetiram-se até 2007-08.

As recolhas longitudinais, reuniram 345 sujeitos com avaliações comuns aos 3 anos de recolha: IMC, questionário, aptidão física.

|                  |                                                                                     |                  |    |    |    |    |    |    |
|------------------|-------------------------------------------------------------------------------------|------------------|----|----|----|----|----|----|
| 3 anos<br>depois |  | Idade em 2005-06 | 11 | 12 | 13 | 14 | 15 | 16 |
|                  |                                                                                     | Idade em 2007-08 | 14 | 15 | 16 | 17 | 18 | 19 |

Os dados para o sexto estudo foram recolhidos no programa de intervenção “ACORDA” que se realiza duas vezes por semana nas instalações da Faculdade de Desporto. A amostra é constituída por 41 sujeitos entre os 6 e 16 anos com excesso de peso e obesidade. Para este estudo houve uma única recolha realizada perto do final do programa, em Maio de 2005.

### 2.1. Instrumentos de avaliação

#### 2.1.1. Questionários

Foram consideradas questões para calcular o IAF, questões relacionadas com o tempo destinado a ver televisão e a usar computador durante a semana e fim de semana, para determinar o tempo de actividades sedentárias, e questões sobre o tipo e tempo de transporte entre casa e escola. O questionário é apresentado em anexo.

### **2.1.2. Acelerómetros**

Foram utilizados acelerómetros marca *MTI Actigraph* durante sete dias, no mínimo com 10 horas de monitorização por dia. Os dados foram tratados com um software específico (MAHUffe, [www.mrc.epid.cam.ac.uk](http://www.mrc.epid.cam.ac.uk)) com epochs de 1 minuto e com pontos de corte estabelecidos para determinar as diferentes intensidades. No estudo transversal - de 0 a 499 para intensidades sedentárias, 500 a 1999 para ligeiras, 2000 a 2999 para moderadas, 3000 a 4499 para vigorosas (VPA) e maiores que 4500 para muito vigorosas. No estudo de intervenção - entre 0 a 799 para intensidades sedentárias 800 a 3199 para ligeiras, 3200 a 8199 para moderadas, e maiores que 8200 para vigorosas.

### **2.1.3. Aptidão Física**

Os testes aplicados pertencem à bateria de testes *Fitnessgram*. Foram escolhidos cinco testes, abdominais, extensão de braços, extensão de tronco, senta e alcança e vaivém (20m), por fazerem parte do Programa Curricular das aulas de Educação Física e serem especificamente utilizados na Escola onde a amostra foi recolhida.

### **2.1.4 Antropometria**

A altura foi medida com um estadiómetro Holtain. Os valores foram registados em metros até ao milímetro mais próximo. O peso corporal foi medido com a aproximação a 0.1 kg com uma balança electrónica (Tanita Inner Scan BC 532) com os sujeitos em camisola e calções. O IMC foi calculado pela divisão peso/altura<sup>2</sup> (kg/m<sup>2</sup>) e nos estudos em que os sujeitos foram categorizados em peso normal, excesso de peso e obesidade, foram utilizados pontos de corte específicos para o sexo e idade (Cole, Bellizzi, Flegal, & Dietz, 2000).

### **2.1.5. Maturação sexual**

Os sujeitos foram questionados separadamente por um professor ou professora no caso de ser rapaz ou rapariga, respectivamente. Cada

sujeito registou o seu estágio sexual secundário: o estágio do desenvolvimento da mama para as raparigas e o pêlo púbico para os rapazes de acordo com os critérios estabelecidos (Tanner & Whitehouse, 1976) previamente usados e validados numa amostra semelhante (Mota et al., 2002).

### 2.1.6. Nível de educação dos pais

A posição sócio económica foi estabelecida através do nível de educação dos pais. As categorias foram baseadas no sistema educacional Português: (1) 9º ano nível de escolaridade baixo; (2) 10º–12º anos – nível médio (3) Universidade/ Mestrado/Doutoramento – nível de educação elevado. Procedimentos semelhantes foram aplicados previamente no contexto português (Mota & Silva, 1999).

Apresentamos resumidamente os testes realizados e a percentagem de indivíduos avaliados em relação ao total da população escolar por ano lectivo de recolha

Tabela 1. Avaliações e percentagem de indivíduos avaliados

|                                   | 2005 | 2006 | 2007 |
|-----------------------------------|------|------|------|
| População ESV (inscritos em EF)   | 1007 | 1005 | 1146 |
| IMC (%)                           | 85   | 85   | 86   |
| Questionário (%)                  |      |      |      |
| - IAF                             |      |      |      |
| - tempo de televisão e computador | 60   | 85   | 80   |
| - transporte casa/escola,         |      |      |      |
| - nível de educação dos pais      |      |      |      |
| Testes de aptidão física (%)      | 51   | 82   | 84   |
| Maturação Sexual (%)              | -    | 75   | 84   |
| Perímetro de Cintura (%)          | -    | 75   | 84   |
| Pregas de Adiposidade (%)         | -    | 75   | 84   |
| Tricipital, Subscapular, Geminal  |      |      |      |
| Acelerometria (%) 7 dias          | -    | 30   | -    |



**[capitulo III.]**



**I artigo**



# 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  $14.5 \pm 1.5$  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<sup>1</sup> and Portugal is not the exception. Indeed, previous studies have shown a high prevalence of overweight and obesity in children<sup>2</sup> and adolescents.<sup>3</sup> Although other factors such as genetics<sup>4</sup> and diet<sup>5</sup> play an important role in obesity-related genesis, the increased prevalence of obesity has been associated with the reduction of physical activity (PA)<sup>6</sup> as well as with low levels of physical fitness (PF).<sup>7</sup> Longitudinal studies of children followed into young adulthood suggested that overweight children may become overweight adults, particularly if obesity is present in adolescence,<sup>8,9</sup> and that the level of PF in adults is conditioned by the level of PF in childhood or adolescence.<sup>10,11</sup> Given this figure, which affects an increased number of children, obesity and poor PF represents a health problem ought to be screened.<sup>12</sup>

Health-related PF variables included cardio-respiratory fitness (CRF), abdominal muscular strength and endurance, lower back flexibility and fatness.<sup>13</sup> Several cross-sectional and longitudinal studies showed an associa-

tion between CRF and cardiovascular risk factors in youth,<sup>14, 15</sup> including obesity.<sup>16-18</sup> 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,<sup>19</sup> conversely, higher fitness is associated with lower fat mass<sup>20</sup> but it is more likely that both factors are interrelated and interdependent.<sup>21</sup>

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 7<sup>th</sup> until 12<sup>th</sup> 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<sup>2</sup> (kg/m<sup>2</sup>) and organized using age and sex adjusted cut-off points described by Cole *et al.*<sup>22</sup> 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. 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.<sup>23</sup> 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<br>N=273 (78.7%) |      | Overweight<br>N=63 (18.1%) |      | Obesity<br>N=11 (3.2%) |      | p     | Normal weight<br>N=215 (74.7%) |      | Overweight<br>N=56 (19.4%) |       | Obesity<br>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.

$\chi^2$  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% CI 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). Statistically 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%).

$\chi^2$  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           |               |           | $\chi^2$ value | Somers'd value |
|-------------------------|-------------------------|-----------------|---------------|-----------|----------------|----------------|
|                         |                         | Normal weight % | Over-weight % | Obesity % |                |                |
| 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       | 21.324**       | -0.197**       |
|                         | HFZ                     | 63.4            | 47.6          | 0         |                |                |
| 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&lt;0.05; \*\*P&lt;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 nor-

mal 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 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<sup>2,3</sup> and for some Mediterranean countries.<sup>24</sup>

The findings of this study are in agreement

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

| Fitness tests           | Fitness Categories      | Boys            |               |           | $\chi^2$ value | Somers'd value |
|-------------------------|-------------------------|-----------------|---------------|-----------|----------------|----------------|
|                         |                         | Normal weight % | Over-weight % | Obesity % |                |                |
| 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       | 32.049**       | -0.306*        |
|                         | HFZ                     | 61.5            | 35.7          | 0         |                |                |
| 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&lt;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<br>(-0.5; 11.7) | 21.5**<br>(8.1; 34.8) | 15.8*<br>(1.6; 30.1)  | 0.9<br>(-5.8; 7.6)    | 14.6*<br>(3.2; 26.1)   | 13.7*<br>(1.1; 26.2)  |
| Push ups            | 1.2<br>(-1.0; 3.4)  | 6.3*<br>(1.4; 11.1)   | 5.1<br>(-0.3; 10.2)   | 4.5*<br>(1.3; 7.8)    | 7.5*<br>(2; 13.2)      | 3<br>(-3.1; 9.2)      |
| Trunk lift          | -0.7<br>(-3.5; 2.1) | 0.4<br>(-6.5; 5.7)    | 0.3<br>(-6.2; 6.8)    | -1.1<br>(-3.9; 1.8)   | -3.2<br>(-8.1; 1.6)    | -2.2<br>(-7.5; 3.1)   |
| Sit reach Right leg | 0.3<br>(-18; 1.2)   | 1.4<br>(-1.9; 4.7)    | 1.7<br>(-1.8; 5.2)    | -0.6<br>(-2.7; 1.4)   | 1.7<br>(-1.7; 5.2)     | 2.4<br>(-1.4; 6.2)    |
| Sit reach Left leg  | 0.2<br>(-1.5; 1.7)  | 1.6<br>(-1.9; 5.1)    | 1.4<br>(-2.3; 5.2)    | -0.8<br>(-2.1; 1.3)   | 1.9<br>(-1.7; 5.5)     | 2.7<br>(-1.3; 6.7)    |
| Shuttle run         | 5.3*<br>(1.3; 9.3)  | 16.2**<br>(7.4; 24.9) | 10.8*<br>(1.5; 20.3)  | 16.4**<br>(9.0; 23.8) | 28.1**<br>(15.5; 40.6) | 11.6<br>(-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 than normal weight pairs.<sup>20, 25</sup> 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<sup>19, 26</sup> or longitudinal ones.<sup>27</sup>

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)       |
| <i>Girls</i>                              |            |                |         |                |
| 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 <sup>a</sup> (N of laps) | 0.959**    | (0.934-0.985)  | 0.821** | (0.744-0.907)  |
| <i>Boys</i>                               |            |                |         |                |
| 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 <sup>a</sup> (N of laps) | 0.961**    | (0.945-0.977)  | 0.905** | (0.867-0.944)  |

CI: confidence interval; OR: odds ratio; 1: reference category; <sup>a</sup>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<sup>19, 26</sup> 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.<sup>19, 28, 29</sup> 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.<sup>27, 30</sup> 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.<sup>31</sup>

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 than boys. Considering that girls are more likely to be gain weight<sup>32</sup> and to be less active,<sup>33</sup> 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.<sup>34, 35</sup> 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.<sup>7, 16, 19</sup> This highlights the importance of increasing CRF for a protective effect in early ages. In a study carried out by Klasson-Heggebo *et al.*<sup>17</sup> a curvilinear relation was found between cardiorespiratory fitness and health parameters, identifying the health im-

pact 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.<sup>36</sup> 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.<sup>37</sup> 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.<sup>38</sup>

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.*<sup>39</sup> Blair and Meredith<sup>40</sup>). 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.<sup>41, 42</sup> In the Portuguese system, the new curricula undertake some of these fundamental conditions: physical education is mandatory for all students from 5<sup>th</sup> to 12<sup>th</sup> 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.<sup>43</sup> 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.<sup>44</sup>

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.<sup>8</sup> 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.<sup>45</sup> 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.<sup>46</sup>

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<sup>47</sup> socio-economic status<sup>48, 49</sup> and biological maturation.<sup>50</sup> 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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**Il artigo**



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

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**Running Title: Physical Activity, Fitness and BMI in adolescents**

**Keywords: accelerometry, cardiovascular health, body composition, adolescent**

**In Press**

## **Abstract**

**Background:** The purpose of this study was to analyze the relation between body mass index (BMI), cardiorespiratory fitness (CRF) and levels of physical activity (physical activity), 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. physical activity was assessed with the accelerometer (MTI); model 7164, for 7 consecutive days (1 minute epoch), using specific cut-points. physical activity 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 physical activity 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 physical activity 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 in European Union <sup>1,2</sup>.

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 <sup>3</sup>. 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 <sup>4</sup>. Nevertheless, studies examining the relationship between intensity of physical activity and body composition have been equivocal <sup>5 6</sup>, recently it was shown that adolescents who engage in larger amount of vigorous but not moderate physical activity tended to have better CRF and lower body fat than those who did not <sup>7</sup>. Thus, it seems that vigorous physical activity (VPA) may have a greater effect on preventing obesity in children than does physical activity of lower intensity <sup>7,8</sup>.

Besides physical activity level, physical fitness, especially CRF, it is also an important factor associated with body mass index (BMI) and adiposity in the youngsters <sup>7</sup>. 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 physical activity <sup>9</sup>. Few studies have addressed the relationship between objectively assessed physical activity intensities, CRF and obesity level in youngsters. However it has been complex to identify in which intensity level, physical activity 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 physical activity (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 7<sup>th</sup> to 12<sup>th</sup> 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<sup>2</sup> (Kg/m<sup>2</sup>) and categorized using age and sex adjusted cut-off points described by Cole et al,<sup>10</sup>. 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<sup>11</sup>.

## **Physical Activity**

Physical activity 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 physical activity 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<sup>12-14</sup>.

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 ( $\text{counts} \cdot \text{min}^{-1}$ ). 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](http://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 <sup>15</sup>.

### **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 <sup>16</sup>. The Shuttle Run Test predicted maximal aerobic capacity and showed significant correlation with  $\text{VO}_2\text{max}$  ( $r=0.80$ ) suggesting that it could be used as a measure of aerobic fitness in children <sup>17</sup>. 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 physical activity 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  $\pm$  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/obesity |
|-----------------------------|-----------------|----------------------------|--------------------|
|                             | 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) <sup>3</sup>  | 72.03 (11.02)      |
| Height (m)                  | 1.66 (0.09)     | 1.66 (0.09)                | 1.66 (0.09)        |
| BMI (kg/m <sup>2</sup> )    | 22.24 (3.53)    | 20.34 (1.82) <sup>3</sup>  | 26.09 (2.88)       |
| CRF <sup>2</sup>            | 44.10 (22.06)   | 46.73 (21.35) <sup>3</sup> | 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 <sup>1</sup> (min/day) | 0.23 (0.24)     | 0.23 (0.23)                | 0.23 (0.26)        |
| MVPA <sup>1</sup> (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)     |

<sup>1</sup> Square-Root-transformed values were used in the analysis but non-transformed values are presented in the table

<sup>2</sup> Adjusted for age and gender for Independent T-Test

<sup>3</sup> 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 physical activity ( $r = 0.282$ ,  $p < 0.001$ ). 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 physical activity and total amount of physical activity.

|                   | 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 <sup>1</sup>  | -0.166   | 0.393 ** |
| VVPA <sup>1</sup> | -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).

<sup>1</sup> 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). physical activity 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 <sup>1</sup>  | 0.634 | (0.332; 1.209) | 0.167 |
| VVPA <sup>1</sup> | 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 |

<sup>1</sup> Square-Root-transformed values were used in the analysis

## Discussion

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

The main finding of this study was that after adjustment for age and gender, CRF showed a significant and inverse relationship with BMI. Despite differences in assessing CRF this result is consistent with a large number of studies <sup>19-21</sup>. 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 <sup>22</sup>. Indeed, several cross-sectional and longitudinal studies showed an association between CRF and cardiovascular risk factors in youth <sup>23, 24</sup>, including obesity <sup>21, 25, 26</sup>. 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<sup>25</sup>. 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<sup>27</sup>.

Bivariate correlation showed that CRF was positively associated with VPA, VVPA and counts.min<sup>-1</sup> and negatively correlated with BMI. The lack of a relationship between physical activity intensity and BMI is somehow unexpected. However, while a few studies showed inverse associations<sup>28 29</sup> others did not find evidence of this relationship<sup>30</sup>, specially when energy expenditure is adjusted for fat free mass<sup>31</sup>. Nevertheless, the relationship of vigorous intensities to lower level of body fat as been described in both, American<sup>7</sup> and European children<sup>32</sup>. 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 physical activity levels<sup>33</sup>.

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 physical activity levels, depending upon the criterion selected to distinguish activity from inactivity<sup>34</sup>. This problem raised questions about the difference in the prevalence estimates of physical activity. 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 physical activity activities for vigorous physical activity<sup>35</sup> 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<sup>36</sup>.

The current study 87.4% didn't accomplish recommendations, which is lower than what was found in a European Youth Heart Study<sup>37</sup>. This might be one reason why no association between physical activity and BMI was found. As the level of physical activity 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 physical activity 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 <sup>4, 38, 39</sup>.

Even if controversy remains about the association of physical activity and total or central adiposity, physical activity still is considered the modifiable variable of body weight genesis and the common denominator for CRF. Thus, it might be possible that physical activity directly influences CRF levels and may favourably impact BMI. Indeed, obese individuals may have lower levels of fitness due to sedentary lifestyles <sup>19</sup>, conversely, higher\_fitness is associated with lower fat mass <sup>40</sup>. However, the fundamental concern is to improve CRF levels, in particular for those with overweight/obesity. In adults, Blair et al. <sup>41</sup> shown that those who improved or maintain adequate physical fitness 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 physical activity, 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 <sup>42</sup>. 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 <sup>43</sup>. 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 physical activity, 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 artigo**



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

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**Key words:** CARDIORESPIRATORY FITNESS, PHYSICAL ACTIVITY, SCREEN TIME, COMMUTING, CHILDREN, ADOLESCENTS

**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 ( $\beta=1.024$  [95% CI = 0.747; 1.300];  $p<0.001$ ) and active commuting to school ( $\beta=4.634$ ; [95% CI = 1.820; 7.448];  $p<0.001$ ) and was negatively associated with television time ( $\beta=-0.003$  [95% CI = -0.025; -0.00049];  $p<0.05$ ), and computer time ( $\beta=-0.017$  [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 associated 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 has 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<sup>2</sup>; 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 4<sup>th</sup> 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-Shuttle 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  $\text{weight/height}^2$  ( $\text{Kg.m}^{-2}$ ). 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  $10 \text{ g/mm}^2$  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  $\text{VO}_2 \text{ max}$

( $r=0.80$ ), 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 than one week, 3) at least one week, 4) almost every day. For the third question, 1) Never, 2) less than 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 fourth 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 than 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)<br>(54.9%) |               | Boys (n= 386)<br>(45.1%) |              |                       |
|--------------------------------|--------------------------|---------------|--------------------------|--------------|-----------------------|
|                                | Median                   | IQR           | Median                   | IQR          | <i>p</i> <sup>a</sup> |
| 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 <sup>b</sup>               | 10.00                    | 6             | 14.00                    | 6            | 0.000                 |
| <b>Screen time</b>             |                          |               |                          |              |                       |
| Television time                | 180                      | 105           | 180                      | 120          | 0.003                 |
| Computer time                  | 90.00                    | 75            | 120.00                   | 90           | 0.000                 |
| <b>Total passive commuters</b> | <b>N</b>                 | <b>81%</b>    | <b>N</b>                 | <b>76.6%</b> |                       |
| Car or motorcycle              | 102                      | 24.6          | 91                       | 27.6         |                       |
| Bus                            | 180                      | 43.4          | 131                      | 38.4         |                       |
| Train                          | 54                       | 13            | 36                       | 10.6         |                       |
| <b>Total active commuters</b>  | <b>N</b>                 | <b>19.0 %</b> | <b>N</b>                 | <b>23.5%</b> |                       |
| Bicycle                        | 5                        | 1.2           | 0                        | 0.0          |                       |
| Walk                           | 74                       | 17.8          | 80                       | 23.5         |                       |

<sup>a</sup> Mann Whitney U-test.

<sup>b</sup> 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 <sup>a</sup> |          |       |
|---------------|-----------|----------|-------|---------------------|----------|-------|
|               | 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 |

<sup>a</sup> There was a significant association between active commuting and gender, estimated by Pearson Chi-Square ( $\chi^2 = 6.5$ ;  $p = 0.013$ )

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 |                    |          |
|-----------------------------------------|---------------------------|--------------------|----------|
|                                         | $\beta$                   | (95% CI)           | <i>p</i> |
| <b>Gender<sup>a</sup></b>               | 13.907                    | (11.280; 16.533)   | 0.000    |
| <b>Skinfolds</b>                        | - 2.601                   | (-3.041; -2.161)   | 0.000    |
| <b>Maturation</b>                       | 3.791                     | (2.154; 5.429)     | 0.000    |
| <b>Physical activity index</b>          | 1.024                     | (0.747; 1.300)     | 0.000    |
| <b>TV time</b>                          | - 0.013                   | (-0.025; -0.00049) | 0.042    |
| <b>PC time</b>                          | - 0.017                   | (-0.033; -0.001)   | 0.033    |
| <b>Commuting to school <sup>b</sup></b> | 4.436                     | (1.820; 7.488)     | 0.001    |

$\beta$ : Unstandardized coefficients.

CI: confidence interval.

Reference categories: <sup>a</sup>boys <sup>b</sup>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.

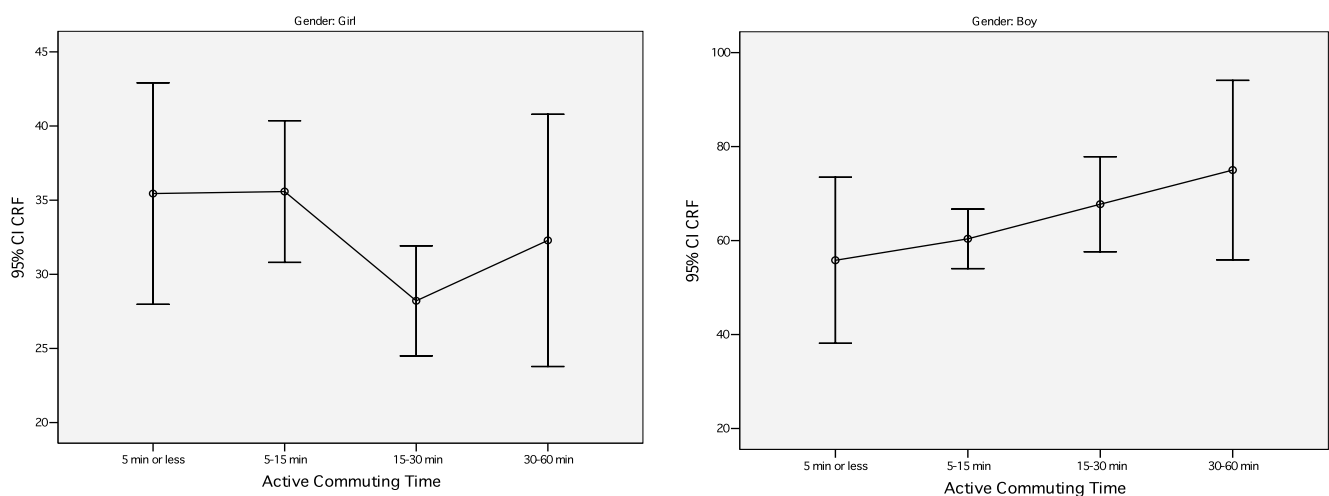


Figure 1. Associations between active commuting to school and cardiorespiratory fitness.

## 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 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 artigo**



## **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. physical activity and ST were evaluated using a standard questionnaire. Standardized scores of fitness tests were summed. Changes over time, were calculated  $\Delta_1$  (2007 minus 2006),  $\Delta_2$  (2008 minus 2007), and  $\Delta_3$  (2008 minus 2006).

**Results:** Changes in PAI were positively and independently associated with changes in fitness in  $\Delta_1$ ,  $\Delta_2$ , and  $\Delta_3$ . Changes in BMI were negative associated with changes in fitness in  $\Delta_3$ . Participants highly fit at baseline were those who showed positive changes in PAI over  $\Delta_3$ , decreased changes in 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 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 physical fitness [strength and cardiorespiratory fitness (CRF)] about 0.36% per year, since the decade of the 70<sup>th</sup> 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 physical fitness can be an indicator of physical activity levels (6, 7) and longitudinal findings suggested a decline in physical activity 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 physical activity (12, 13). Further, some data showed that children are losing the metabolic effect of fitness that might protect them from excessive weight gain as well as other metabolic diseases (12). On the other hand physical fitness 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 physical activity (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, screen time and BMI with changes in physical fitness 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<sup>th</sup> until 12<sup>th</sup> 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 physical fitness 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**

Physical activity 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 physical activity 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. physical fitness 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,  $\Delta_1$  (2007 minus 2006),  $\Delta_2$  (2008 minus 2007), and  $\Delta_3$  (2008 minus 2006) were calculated. Multiple linear regressions were used to examine associations between changes ( $\Delta$ ) in PAI, ST, BMI (as independent variables) and  $\Delta$  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,  $\Delta$ BMI, and  $\Delta$ ST. An additional analysis was made for the mean  $\Delta$ PAI,  $\Delta$ ST and  $\Delta$ BMI over time according to baseline fitness level. Participants were categorized as “low-fit” group if physical fitness scores were lower than the first tertile and the “fit” group otherwise. Standardized scores of  $\Delta_3$ PAI,  $\Delta_3$ ST and  $\Delta_3$ BMI 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 ( $\Delta_3$ ). Participants spent more time watching TV than using computer over a 3 year period ( $\Delta_3$ ), 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 ( $\Delta_3$ ), additional differences were found for Shuttle Run in  $\Delta_1$  and  $\Delta_2$ .

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 <sup>a</sup> | 11.86 | 59.52 <sup>b</sup> | 11.37 | 62.45             | 11.25 |
| Height (m)               | 226  | 1.64 <sup>a</sup>  | 0.09  | 1.66 <sup>b</sup>  | 0.08  | 1.68              | 0.08  |
| BMI (kg/m <sup>2</sup> ) | 225  | 20.74 <sup>a</sup> | 3.6   | 21.67 <sup>b</sup> | 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 <sup>b</sup> | 24.02 | 39.46              | 22.5  | 50.88             | 21.70 |
| Push-ups (n rep)         | 217  | 11.53 <sup>b</sup> | 9.10  | 12.36              | 8.65  | 17.53             | 9.61  |
| 20-m SR (n laps)         | 233  | 36.53 <sup>a</sup> | 20.83 | 43.17 <sup>d</sup> | 20.91 | 49.02             | 22.95 |
| PAI <sup>#</sup>         | 136  | 12.3               | 4.08  | 12.6               | 4.0   | 12.7 <sup>c</sup> | 4.9   |
| Screen Time              | 164  | 162.1              | 70.1  | 149.9              | 66.6  | 150.8             | 68.4  |
| TV time (min)            | 161  | 208.4 <sup>b</sup> | 99.1  | 194.5              | 91.1  | 174.5             | 95.7  |
| PC time (min)            | 153  | 119.9 <sup>b</sup> | 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); <sup>#</sup> Ranges from 5 (lowest active) to 22 (most active)

<sup>a</sup> Significantly different from 2007 and 2008; <sup>b</sup> Significantly different from 2008; <sup>c</sup> Significantly different from 2007; <sup>d</sup> Significantly different from 2006

As can be seen in table 2,  $\Delta$ PAI is positive and significantly associated with  $\Delta$ PF, after adjustments for age, gender, and Fitness at baseline. The stronger independent association for the adjusted models was observed in  $\Delta_3$ . On the other hand, both unadjusted and adjusted models showed that  $\Delta$ PAI and  $\Delta$ BMI were significantly associated with  $\Delta$ PF in  $\Delta_3$  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  $\Delta_1$ ZPF,  $\Delta_2$ ZPF and  $\Delta_3$ ZPF;  $\beta$  - Standardized coefficients. Confidence interval (CI 95%)

|                   | $\Delta_1$ (2006-2007) |                 |       |                | $\Delta_2$ (2007-2008) |                 |       |                           | $\Delta_3$ (2006-2008) |                 |       |
|-------------------|------------------------|-----------------|-------|----------------|------------------------|-----------------|-------|---------------------------|------------------------|-----------------|-------|
|                   | $\beta$                | (CI 95%)        | $p$   |                | $\beta$                | (CI 95%)        | $p$   |                           | $\beta$                | (CI 95%)        | $p$   |
| Unadjusted Models |                        |                 |       |                |                        |                 |       |                           |                        |                 |       |
| $\Delta_1$ PAI    | 0.114                  | (-0.013;-0.137) | NS    | $\Delta_2$ PAI | 0.071                  | (0.001;0.140)   | 0.047 | $\Delta_3$ PAI            | 0.111                  | (0.026;0.196)   | 0.011 |
| $\Delta_1$ BMI    | -0.045                 | (-0.131;0.071)  | NS    | $\Delta_2$ BMI | -0.127                 | (-0.173;0.006)  | 0.066 | $\Delta_3$ BMI            | -0.145                 | (-0.275;0.000)  | 0.050 |
| $\Delta_1$ ST     | 0.005                  | (-0.005;0.005)  | NS    | $\Delta_2$ ST  | -0.033                 | (-0.555;-0.332) | NS    | $\Delta_3$ ST             | -0.071                 | (-0.006;-0.003) | NS    |
| Adjusted Models   |                        |                 |       |                |                        |                 |       |                           |                        |                 |       |
| $\Delta_1$ PAI    | 0.087                  | (-0.026;-0.148) | 0.005 | $\Delta_2$ PAI | 0.072                  | (0.004;0.139)   | 0.037 | $\Delta_3$ 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 |
|                   |                        |                 |       |                |                        |                 |       | $\Delta_{tot}$ PAI*gender | -0.019                 | (-0.154;0.117)  | NS    |
|                   |                        |                 |       |                |                        |                 |       | $\Delta_{tot}$ ST         | -0.002                 | (-0.006;0.002)  | NS    |
|                   |                        |                 |       |                |                        |                 |       | $\Delta_{tot}$ BMI        | -0.022                 | (-0.175;0.131)  | NS    |
| Adjusted Models   |                        |                 |       |                |                        |                 |       |                           |                        |                 |       |
| $\Delta_1$ BMI    | -0.067                 | (-0.132;0.041)  | NS    | $\Delta_2$ BMI | -0.127                 | (-0.173;0.006)  | NS    | $\Delta_3$ 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   |                        |                 |       |                |                        |                 |       |                           |                        |                 |       |
| $\Delta_1$ ST     | -0.023                 | (-0.005;0.003)  | NS    | $\Delta_2$ ST  | -0.042                 | (-0.004;0.002)  | NS    | $\Delta_3$ 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.

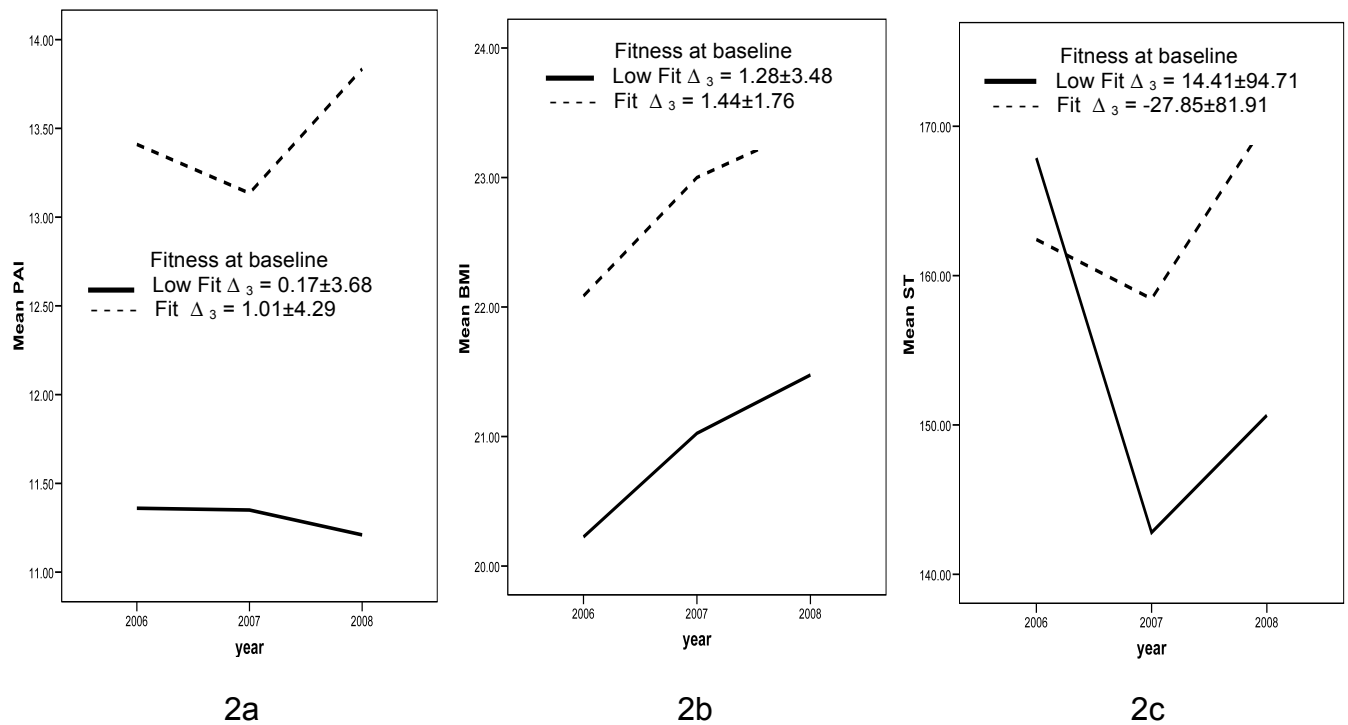


Figure 1 - Mean of absolute values of PAI, BMI and ST at the three time points 2006, 2007 and 2008 and mean  $\pm$  SD for  $\Delta_3$  by low-fit vs. fit at baseline.

## Discussion

The main purpose of this study was to examine how  $\Delta$ PAI,  $\Delta$ ST and  $\Delta$ BMI, are associated with  $\Delta$ PF 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  $\Delta$ PAI, was positive and significantly associated with  $\Delta$ PF 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 ( $\Delta_1$ ,  $\Delta_2$ ,  $\Delta_3$ ), showed positive  $\Delta$ PAI. 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  $\Delta$ BMI and  $\Delta$ PF. However, when adjusted for fitness at baseline, no statistical significant results were found, which might suggest that the relationship between  $\Delta$ BMI and  $\Delta$ PF 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 physical fitness and physical activity through puberty will have favourable health benefits in later years (22).

Furthermore, our low-fit participants had small  $\Delta$ BMI values ( $\Delta_3$ ) compared to their fit peer. This data agree with evidences suggesting that participants whose physical fitness 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 physical fitness 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  $\Delta$ BMI 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  $\Delta$ ST. Nevertheless, linear regressions showed no associations between  $\Delta$ ST and  $\Delta$ PF, 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 physical fitness, 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 physical activity and physical fitness.

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 addition, 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 physical fitness. 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 physical activity, BMI, ST and physical fitness over time. However,  $\Delta$ PAI seemed to be the best indicator for  $\Delta$ PF in youth. The results might also reinforce the attempt to work out strategies to increase physical activity levels leading the physical fitness levels improvements and counteract the increased obesity prevalence. However, more longitudinal studies are needed to ascertain the direction and sequence of associations of physical fitness, physical activity and obesity.

### **Acknowledgements**

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**V artigo**



## **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 (PAI), physical fitness, screen time (television watch and computer use), socio-economic status and commuting to school made a significant contribution to longitudinal changes in body mass index (BMI), 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 BMI. 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 and physical activity are considered the main components required to protect youth from excessive weight gain as well as other metabolic diseases [1, 28]. Physical activity has been promoted as a lifelong positive health behaviour in children and adolescents and physical fitness 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 physical activity and physical fitness as a consequence of youth preferences for sedentary activities [19]. Several authors suggest that increasing overall physical activity 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 physical fitness, 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 7<sup>th</sup> until 12<sup>th</sup>. 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 physical fitness 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 physical activity 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 than 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 leisure? 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<sub>0</sub>), and at the two consecutive years (TP<sub>1</sub> and TP<sub>2</sub>) 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 overweight/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<sub>1</sub> (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<sub>0</sub> and TP<sub>2</sub> and in 20-mSR at all time point periods.

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

|                  |            | TP <sub>0</sub> (2006) |      |             |                  | TP <sub>1</sub> (2007) |      |             |                  | TP <sub>2</sub> (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             |
|                  |            | %                      |      | %           | <i>p</i>         | %                      |      | %           | <i>p</i>         | %                      |      | %           | <i>p</i>         |
|                  |            | <b>79.6</b>            |      | <b>20.4</b> |                  | <b>73.7</b>            |      | <b>26.3</b> |                  | <b>76.7</b>            |      | <b>23.3</b> |                  |
| 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          | <b>0.006</b>     | 46.4                   |      | 55.7        | 0.102            | 21                     |      | 40.9        | <b>0.001</b>     |
|                  | 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        | <b>&lt;0.001</b> | 33                     |      | 64.9        | <b>&lt;0.001</b> | 33.9                   |      | 64.2        | <b>&lt;0.001</b> |
|                  | 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 \*  $p \leq 0.05$ ; \*\*  $p \leq 0.001$

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) <sup>a</sup>          | 0.601 (0.183;1.017)   | 0.005 |
| PU (UHZ) <sup>a</sup>          | 0.308 (-0.013;0.629)  | 0.060 |
| B-S SR (Failed) <sup>b</sup>   | -0.340 (-0.612;0.131) | 0.205 |
| 20-m SR (UHZ) <sup>a</sup>     | 0.435 (0.116; 0.754)  | 0.008 |
| ST (more than 2h) <sup>c</sup> | 0.238 (-0.122;0.598)  | 0.195 |
| CS (Passive) <sup>d</sup>      | 0.228 (-0.328;0.785)  | 0.421 |
| PAI (Low active) <sup>d</sup>  | 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: <sup>a</sup> Healthy Zone; <sup>b</sup> Passed; <sup>c</sup> Less than 2 hours; <sup>d</sup> 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 BMlc. 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) <sup>a</sup>        | 0,432    | (-0,195;1,059)  | 0,176  |
| PU (UHZ) <sup>a</sup>        | 0,216    | (-0,270;0,702)  | 0,383  |
| B-S SR (Failed) <sup>b</sup> | -0,164   | (-0,728;0,400)  | 0,567  |
| 20-m SR (UHZ) <sup>a</sup>   | 0,766    | (0,289;1,244)   | 0,002  |
| ST <sup>b</sup>              | -0,079   | (-0,551;0,394)  | 0,744  |
| CS <sup>c</sup>              | 0,384    | (-0,293;1,061)  | 0,265  |
| PAI <sup>c</sup>             | -0,371   | (-0,906;0,163)  | 0,173  |

Dependent variable: BMI corrected to age and gender according to Cole et al. (2000) Reference categories: <sup>a</sup> Healthy Zone; <sup>b</sup> Passed; <sup>c</sup> Less than 2 hours; <sup>d</sup> Active; Estimate of Intercept Variance = 7.02 ( $p \leq 0.001$ ); 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.

Physical activity has been inversely associated with overweight/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 physical activity 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 than 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 conducted to analyze sedentary behaviours and obesity found that although the majority of the studies have controversial 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 physical activity or sedentary behaviours. The use of a questionnaire to estimate the time watching television or using a 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 physical fitness. Nevertheless, the most of the variance in obesity-related anthropometrics is captured by BMI, and it is equally well correlated with fat mass and waist circumference [3]. Another limitation was the absence 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 physical fitness 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 artigo**



*Original Research Article***Daily Differences in Patterns of Physical Activity Among Overweight/Obese Children Engaged in a Physical Activity Program**LÚISA AIRES,<sup>1\*</sup> RUTE SANTOS,<sup>1</sup> PEDRO SILVA,<sup>1</sup> PAULA SANTOS,<sup>1</sup> JOSÉ OLIVEIRA,<sup>1</sup> JOSÉ C. RIBEIRO,<sup>1</sup> CARLA REGO,<sup>2</sup> AND JORGE MOTA<sup>1</sup><sup>1</sup>Research Centre in Physical Activity, Health and Leisure, Faculty of Sports, University of Porto, Porto, Portugal<sup>2</sup>Nutrition Unit, Department of Paediatrics, Faculty of Medicine, University of Porto and S. João Hospital, Porto, Portugal

**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:  $25.7 \pm 3.3 \text{ kg m}^{-2}$ . 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. © 2007 Wiley-Liss, Inc.

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; Ful-

ton 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  $25.7 \pm 3.3 \text{ kg m}^{-2}$  (range 19.0–35.1  $\text{kg m}^{-2}$ ), 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 ( $\text{counts min}^{-1}$ ). 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 | <i>t</i> | <i>P</i> value | Girls, mean | Boys, mean | <i>t</i> | <i>P</i> value | Girls, mean | Boys, mean | <i>t</i> | <i>P</i> value |
| Counts min <sup>-1</sup>                                     | 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<sup>-1</sup>, 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 moder-

ate, 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<sup>-1</sup>), 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 $\pm$ SD   |
|---------------------------------------|-----------------|
| Age                                   | 10.8 $\pm$ 2.4  |
| Weight (kg)                           | 58.5 $\pm$ 13.2 |
| Height (m)                            | 1.5 $\pm$ 0.1   |
| BMI (kg m <sup>-2</sup> )             | 25.7 $\pm$ 3.3  |
| Monitored time (h day <sup>-1</sup> ) | 14.4 $\pm$ 1.2  |

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

## RESULTS

The descriptive data (mean  $\pm$  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<sup>-1</sup>) 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

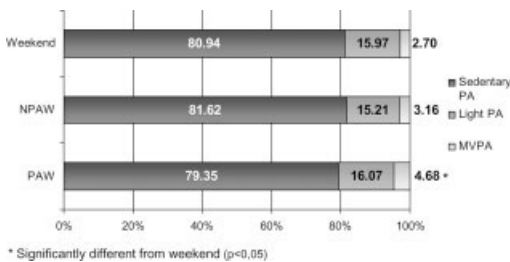
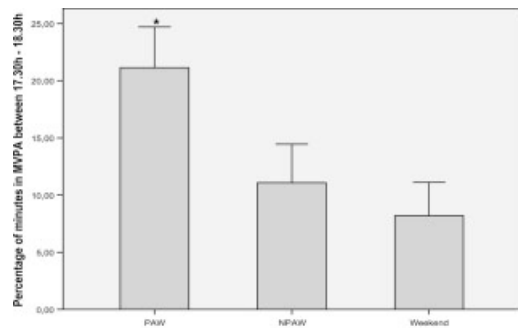
This study reports information about the 7-day PA levels of overweight/obese children, ranging in age from 8 to 16 years, enrolled in a 2-day per week, PA intervention program. Few studies evaluating accelerometer-derived PA patterns in overweight/obese children have been published, which can make direct

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 $\pm$ SD       | Mean $\pm$ SD       | Mean $\pm$ SD       |
| Monitored time (min day <sup>-1</sup> )                    | 878.47 $\pm$ 124.85 | 870.41 $\pm$ 77.42  | 737.63 $\pm$ 119.83 |
| Counts min <sup>-1</sup>                                   | 585.4 $\pm$ 247.3   | 527.4 $\pm$ 195.2   | 515.3 $\pm$ 236.0   |
| Total amount of minutes in sedentary activities            | 694.21 $\pm$ 98.32* | 708.63 $\pm$ 76.91* | 595.04 $\pm$ 103.47 |
| Total amount of minutes in light activities                | 142.71 $\pm$ 46.97  | 133.72 $\pm$ 39.42  | 121.05 $\pm$ 46.9   |
| Total amount of minutes in moderate-to-vigorous activities | 41.55 $\pm$ 5.26*   | 28.06 $\pm$ 21.07** | 21.53 $\pm$ 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 ( $P < 0.05$ ).

\* Significantly different from NPAW and weekend

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  $50.7 \pm 22$  min and  $86.5 \pm 40.5$  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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**[capitulo IV.]**



## [IV.]

### 4.1. Discussão dos resultados principais

Na estruturação deste trabalho começamos por analisar a relação da aptidão física com o excesso de peso e obesidade. Os resultados foram previsíveis tendo em conta estudos anteriores (Moller et al., 2006; Mota et al., 2006) mostrando que indivíduos com excesso de peso/obesidade eram na generalidade menos aptos que os seus pares não obesos, com um destaque para a associação negativa entre a ACR e o excesso de peso/obesidade (ver quadro 1 dos resultados principais). A importância de os jovens se manterem aptos fisicamente pode contribuir para um balanço energético mais favorável e consequentemente à obtenção de um peso saudável. O aspecto acumulativo do excesso de peso e de baixos níveis de aptidão física pode afectar a capacidade dos jovens desenvolverem outras capacidades (Haga, 2008). De facto para além da ACR e da força, existem várias componentes importantes como a coordenação, o equilíbrio, a agilidade, entre outras, que podendo não influenciar directamente a saúde, são importantes na realização das tarefas diárias, em particular nestas idades de crescimento e maturação (Faigenbaum et al., 2007).

Nos estudos transversais aqui apresentados, procuramos saber qual o melhor preditor para o excesso de peso/obesidade, tendo por um lado a aptidão física (em especial a ACR), e por outro lado as diferentes intensidades e domínios de actividade física avaliadas com acelerómetros e com questionários. Apesar de alguns estudos mostrarem claramente a importância das actividades moderadas, vigorosas e muito vigorosas no excesso de peso/obesidade, (Gutin, Yin, Humphries, & Barbeau, 2005) os resultados obtidos mostraram que as intensidades mais elevadas não foram preditoras do excesso de peso/obesidade, embora estivessem correlacionadas. Em contrapartida, os nossos resultados continuaram a indicar a ACR como preditora principal do excesso de peso/obesidade. A ACR, mostrou-se sempre determinante nas associações encontradas, mesmo quando controladas para outras variáveis e

possíveis confundidores, à semelhança de estudos anteriores (Ruiz et al., 2006).

Quadro 1. Resumo dos resultados principais

| Estudos /Variáveis                                           | BMI<br>Pregas de adiposidade                                                                | Aptidão física<br>ACR; Força;<br>Flexibilidade                                                             | AF<br>Questionários<br>Acelerómetros                               | Tempo de<br>televisão e<br>computador        | Transporte<br>casa/escola                           |
|--------------------------------------------------------------|---------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------|----------------------------------------------|-----------------------------------------------------|
| <b>1º estudo transversal<br/>n= 636</b>                      | Diminuição de Ob para EP associado ao aumento da ACR e força abdominal.                     | - Nº de testes na ZS inversamente associado ao IMC<br>- % elevada de alunos com PN abaixo da ZS            | Não analisadas                                                     | Não analisadas                               | Não analisadas                                      |
| <b>2º estudo transversal<br/>n= 111</b>                      | Associação negativa com a ACR independentemente dos níveis de AF                            | Correlações com AF Vigorosa e muito Vigorosa<br><br>Indivíduos na ZS da ACR com menor risco de terem EP/Ob | Sem associações com ACR e excesso de EP/Ob                         | Não analisadas                               | Não analisadas                                      |
| <b>3º estudo transversal<br/>n= 856</b>                      | Associação negativa das pregas de adiposidade com a ACR                                     | Associação positiva da ACR com IAF                                                                         | Associação positiva e independente com a ACR                       | Associação negativa e independente com a ACR | Nos rapazes a ACR aumenta com a distância caminhada |
| <b>4º estudo longitudinal<br/>n=345<br/>(Dependente ACR)</b> |                                                                                             | $\Delta$ positiva do IMC quando ajustado à <i>baseline</i> é preditor da $\Delta$ positiva da ACR          | $\Delta$ positivas do IAF preditoras das $\Delta$ positivas da ACR | Sem associações                              | Sem associações                                     |
| <b>5º estudo longitudinal<br/>n=345<br/>(Dependente BMI)</b> | ACR e força abdominal abaixo da ZS são preditoras do EP/Ob em qualquer dos 3 anos avaliados |                                                                                                            | Sem associações                                                    | Sem associações                              | Sem associações                                     |
| <b>6º estudo intervenção<br/>n=41</b>                        | Não analisadas                                                                              | Não analisadas                                                                                             | Aumento da AF moderada e vigorosa em crianças com EP/Ob            | Não analisadas                               | Não analisadas                                      |

$\Delta$  – variação; ZS – zona saudável, ACR - aptidão cardiorespiratória, EP/Ob - Excesso peso/obesidade; IMC – índice de massa corporal; MVPA –actividade física moderada a vigorosa; IAF – índice de actividade física

Outro aspecto interessante a salientar é a associação significativa verificada entre todas as variáveis e a ACR no 3º estudo, sendo elas o IAF, o tempo de ver televisão e de usar computador, e o tempo de transporte activo casa/escola. Este resultado tão marcadamente significativo pode dever-se ao facto de a amostra ser maior comparativamente a todas as outras amostras (856 alunos avaliados), mas por outro lado pode dever-se à escolha da ACR como variável dependente. Mesmo assim estas associações indicam que todos os domínios da actividade física podem ter um contributo importante para o aumento dos níveis de aptidão física.

Quando as mesmas variáveis foram analisadas no modelo longitudinal os resultados do quarto estudo indicaram que um aumento continuado dos níveis de actividade física, poderia contribuir a longo prazo para o aumento da aptidão física, independentemente dos níveis de aptidão com que se concorreu à partida. Por outro lado, o estudo seguinte, mostrou claramente uma associação dos baixos níveis de aptidão física com o risco de ter excesso de peso ou obesidade. Um trabalho semelhante realizado em Portugal (Mota, Ribeiro, Carvalho, Santos, & Martins, 2009) mostrou que as crianças e adolescentes menos aptos fisicamente no início do estudo foram os que apresentaram quatro vezes mais risco de aumento de peso ao fim de 2 anos, realçando mais uma vez a importância de se ser “fit”.

Tanto nos estudos transversais como nos longitudinais, os resultados mostraram que os níveis de ACR foram os únicos preditores do excesso de peso/obesidade. Por outro lado, o excesso de peso/obesidade e os vários domínios da actividade física e actividades sedentárias foram preditores das alterações da aptidão física em geral e da ACR em particular. Este conjunto de resultados sugere que elevados níveis de actividade física mantidos no tempo podem contribuir para um aumento da aptidão física e ser a ponte de ligação para a diminuição da adiposidade total em crianças e adolescentes.

Num estudo de revisão com adultos, (D. C. Lee, Sui, & Blair, 2009) as evidências indicam que tanto a actividade física como a ACR diminuem os danos da obesidade para a saúde independentemente dos indicadores de

obesidade, do sexo, ou do estatuto na avaliação inicial. O maior risco de morbilidades e mortalidade foi observado nos indivíduos que eram simultaneamente obesos e inactivos ou com baixos níveis de aptidão física.

Tendo como base as evidências apresentadas pelos estudos de *tracking* referenciados na revisão da literatura é fundamental intervir desde cedo dentro e fora do tempo curricular. É importante destacar o papel dos programas de intervenção direccionados para as crianças com excesso de peso/obesidade com o objectivo de aumentar os níveis de actividade física em especial de intensidades moderadas e vigorosas e melhorar as diversas componentes da aptidão física, mas simultaneamente reeducar e estimular os jovens de forma a transferir para as rotinas pessoais a pratica de exercício físico diário.

Nos seis artigos que fundamentam esta tese, existem algumas limitações metodológicas que devem ser apontadas. Sabemos que o estatuto da maturação sexual pode ter uma influência nos níveis de aptidão física e da actividade física das crianças e jovens, mas a impossibilidade de usar a maturação sexual no 1º artigo e nos estudos longitudinais, foi um obstáculo por insuficiência de dados no primeiro ano de recolha. No entanto a idade e o género foram incluídas em todas as análises estatísticas, de forma a minimizar esta restrição. Devemos ainda referir que, pelas mesmas razões apontadas anteriormente, apenas no terceiro estudo foram usadas as pregas de adiposidade. No entanto, na procura dos melhores indicadores de obesidade para as análises efectuadas em cada estudo, verificamos que todos eles (IMC, perímetro de cintura e pregas de adiposidade) se correlacionavam de igual forma com as variáveis em análise, não tendo sido por isso determinantes nos resultados encontrados.

Os três primeiros estudos, por serem de design transversal, forneceram informações sobre associação entre as variáveis preditivas (actividade física, tempo de actividades sedentárias, transporte casa/escola) e as preditas (aptidão física e adiposidade) mas a direcção da causalidade é difícil de identificar. Mesmo nos dois estudos longitudinais que se seguiram, apesar da temporalidade inerente ao tipo de estudo, as respostas sobre a direcção desta

causalidade podem ter sido comprometidas pela falta de outros critérios necessários, como a comparação com diferentes populações e em diferentes circunstâncias. A causa do problema para o aumento da prevalência da obesidade é difícil de encontrar, podendo ser sugerida, mas dificilmente comprovada (J. W. Twisk et al., 2000), seja ela actividade física, a aptidão física, a adiposidade ou cada uma delas com contribuições cumulativas.

A maior vantagem deste trabalho foi poder conciliar e comparar variáveis sob vários modelos metodológicos – transversais, longitudinais e de intervenção. Também a avaliação da aptidão física através de métodos reproduzíveis no terreno e especialmente no ambiente escolar é também uma vantagem a ter em conta. Os teste de aptidão física são excelentes indicadores da eficácia das aulas de Educação Física e dos diferentes estilos de vida fora da escola. Daí a importância de monitorizar de forma consistente, os componentes da aptidão relacionados com a saúde e identificar as crianças e jovens em risco.

Em síntese, o conjunto de resultados desta tese reforçam as actuais evidências sobre a importância da ACR como elemento chave na prevenção do excesso de peso/obesidade das crianças e adolescentes. Apesar da ausência de associação das diferentes intensidades da actividade física avaliada objectivamente com o excesso de peso/obesidade, a ACR mostrou-se fortemente influenciada pelos níveis de actividade física, em especial das intensidades mais elevadas. No entanto, no estudo de intervenção ficou subjacente a importância de exercício físico direccionado para as actividades moderadas e vigorosas como meio de aumentar a actividade física diária em crianças e adolescentes com excesso de peso/obesidade.

Dada a complexidade das inter-relações entre a actividade física, aptidão física e obesidade e dada a falta de evidências sobre o sucesso dos programas na diminuição do excesso de peso/obesidade nestas idades, são necessários mais estudos de intervenção numa perspectiva de análise longitudinal.

O prazer de um individuo pela prática desportiva na rotina diária, pode ajudar à conservação de um estilo de vida activo e à manutenção de um peso saudável, pelo que deve ser fortemente estimulado.

#### **4.2 Perspectivas para o futuro**

Desde 2007-2008 o Projecto ACORDA, mencionado mais detalhadamente no ultimo artigo desta tese, foi alargado à escola com o nome ACORDA-Escolas. Esta implementação do programa fora das instalações da Faculdade de Desporto teve como objectivo minimizar as barreiras para a participação, como são a acessibilidade e a segurança, evitando o afastamento dos jovens do território escolar. Temos ainda projectado ampliar a área de intervenção às escolas primárias do Concelho para apoiar toda a comunidade.

As crianças e adolescentes participantes com excesso de peso e obesidade são avaliados no inicio e final do ano de forma a monitorizar o progresso destes jovens mas também a avaliar a eficácia do programa de intervenção.

Sabendo que a actividade física é “comportamento”, e que a aptidão física e a obesidade são “efeito”, e estes dois efeitos também são resultado de uma componente genética, pensamos que no caminho a seguir seria importante identificar e analisar as variáveis que podem estar relacionadas com a predisposição de ser mais apto ou de ser mais obeso complementando assim o quadro desta investigação.

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**Anexo**

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, 6º)  
☐ e) 3º Ciclo (7º, 8º, 9º) ☐ 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, 6º)  
☐ e) 3º Ciclo (7º, 8º, 9º) ☐ f) ensino secundário (10º, 11º, 12º) ☐ g) Curso superior  
☐ h) mestrado/doutoramento

|                                      |
|--------------------------------------|
| Horas por dia<br>durante a<br>semana |
|--------------------------------------|

|                                             |
|---------------------------------------------|
| Horas por dia<br>durante o<br>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 costumavas 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 costumás fazer por dia? (Coloca uma cruz nos quadrados respectivos)**

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

**14) Fazes actividades desportivas fora da escola (Num clube ou noutro sítio)? (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    Discordo de    Concordo de    Concordo    Não sei, não  
plenamente    certa forma    certa forma    plenamente    tenho certeza

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

**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!