QUALIDADE DE VIDA RELACIONADA COM A SAÚDE, APTIDÃO FÍSICA, ÍNDICE DE MASSA CORPORAL E DIETA MEDITERRÂNICA EM ADOLESCENTES

Olga Sofia Ferreira Evaristo

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Orientadores:

Professor Doutor Jorge Augusto Pinto Silva Mota

Professora Doutora Carla Marisa Moreira

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PALAVRAS-CHAVE: ADOLESCENTES, QUALIDADE DE VIDA, APTIDÃO FÍSICA, ÍNDICE DE MASSA CORPORAL, DIETA MEDITERRÂNICA

“Para ser grande, sê inteiro: nada
Teu exagera ou exclui.
Sê todo em cada coisa. Põe quanto és
No mínimo que fazes.
Assim em cada lago a lua toda
Brilha, porque alta vive.”

Ricardo Reis (Heterónimo de Fernando Pessoa), in “Odes”.

Para a minha mãe de coração, Adelaide de Almeida

Para as minhas filhas, Ana Rita e Ana Sofia

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ABSTRACT

Adolescence represents an important stage of life for the development of healthy behaviors.

The aims of this thesis were: i) to analyze the associations between body mass index (BMI) and health-related quality of life (HRQoL) and exploring the potential mediation effect of cardiorespiratory fitness (CRF) on the relationship between BMI and HRQoL, in adolescents (study I); ii) to analyze the combined associations of CRF and muscular fitness with HRQoL and to assess the differences between HRQoL score across groups of cardiorespiratory fitness and muscular fitness (study II); iii) to explore the independent and combined associations between physical fitness and adherence to the mediterranean diet with HRQoL (study III); and iv) to explore the longitudinal association between CRF and HRQoL over time and to determine whether changes in CRF were associated with HRQoL over a two-year follow-up period (study IV).

Research was conducted using three cross-sectional studies and one longitudinal study involving 957 (study 1), 567 (study 1), 956 (study 3) and 571 (study 4) Portuguese adolescents ages 12–18 years.

Body weight and height were measured according to standard protocols. BMI was classified according to the cut-off points defined by the International Obesity Task Force. HRQoL was measured using the Kidscreen-10 questionnaire. Physical fitness was assessed with the ALPHA health-related fitness battery. Socioeconomic status was assessed using the Family Affluence Scale. Accelerometers were used to obtain objective data about time spent in physical activity. Pubertal stage was assessed using the Tanner Scale. Adherence to Mediterranean diet was assessed using the KIDMED Index.

In Study I, girls had a higher prevalence of overweight and obesity. HRQoL scores were slightly lower in girls. HRQoL was inversely and significantly associated with BMI in both sexes. CRF was qualified as a full mediator on the association between BMI and HRQoL in both sexes.

In Study II, both CRF and muscular fitness were positively associated with HRQoL. Adolescents with high CRF and high muscular fitness showed better HRQoL.

Study III, shows that high adherence to mediterranean diet and high physical fitness level were significantly and positively associated with higher HRQoL scores.

In Study IV, CRF was positively associated with HRQoL at baseline and at the follow-up. Participants with persistent high CRF over a two-year period showed the highest scores for HRQoL at follow-up. HRQoL and CRF declined significantly from baseline to follow-up. These findings re-emphasize the importance of targeting public health programmes aimed to tackle high rates of overweight and obesity as well to increase PF levels, and adherence to Mediterranean diet, as an integral part of a health-enhancing lifestyle and adolescents quality of life.

Key-words: OBESITY, HEALTH-RELATED QUALITY OF LIFE, PHYSICAL FITNESS, MEDITERRANEAN DIET, ADOLESCENTS

RESUMO

A adolescência representa um estádio de vida importante para o desenvolvimento de comportamentos saudáveis.

Os objetivos desta tese foram os seguintes: i) analisar as associações entre o índice de massa corporal (IMC) e a qualidade de vida relacionada com a saúde (QVRS) e explorar o potencial efeito de mediação da aptidão cardiorrespiratória (ACR) na relação entre o IMC e a QVRS, em adolescentes (Estudo I); ii) analisar as associações combinadas da ACR e aptidão muscular com a QVRS e avaliar as diferenças entre a pontuação da QVRS e os grupos de aptidão cardiorrespiratória e aptidão muscular (Estudo II); iii) explorar as associações independentes e combinadas entre a aptidão física e a adesão à dieta mediterrânica com a QVRS (Estudo III) e iv) explorar a associação longitudinal entre a ACR e QVRS e determinar se as mudanças na ACR foram associadas à QVRS, nos 2 anos de follow-up (Estudo IV).

Foram realizados três estudos transversais e um longitudinal, envolvendo 957 (estudo I), 567 (estudo II) , 956 (estudo III) e 571 (estudo IV) adolescentes portugueses dos 12 aos 18 anos. O peso e a altura foram medidos de acordo com os protocolos padrão. O IMC foi classificado de acordo com os pontos de corte definidos pelo *International Obesity Task Force*. A QVRS foi medida, usando o questionário *Kidscreen-10*. A aptidão física foi avaliada segundo os protocolos da bateria de testes *ALPHA*. O estatuto socioeconómico foi avaliado, usando o questionário *Family Affluence Scale.* Os acelerómetros foram utilizados para medir objetivamente o tempo de atividade física. A maturação sexual foi avaliada, utilizando os *estágios de Tanner*. A adesão à dieta mediterrânica foi avaliada, utilizando o índice *KIDMED.*

No estudo I, as raparigas apresentaram maior prevalência de sobrepeso e obesidade. Os valores de QVRS foram ligeiramente mais baixos nas raparigas. A QVRS foi inversamente e de modo significativo associada ao IMC em ambos os sexos. A ACR classificou-se como mediadora na associação entre o IMC e a QVRS, em ambos os sexos.

No estudo II, tanto a ACR como a aptidão muscular foram positivamente associadas com a QVRS. Os adolescentes com alta ACR e alta aptidão muscular apresentaram maior QVRS.

O estudo III, mostra que uma elevada adesão à dieta mediterrânica e níveis elevados de aptidão física estão significativa e positivamente associados com maiores valores de QVRS.

No estudo IV, a ACR foi positivamente associada à QVRS, no baseline e no follow-up. Os participantes com ACR elevada e persistente tiveram, em média, maiores valores de QVRS, no follow-up. A QVRS e a ACR diminuíram significativamente desde o baseline até ao follow-up.

Estes resultados reafirmam a importância de direcionar programas de saúde pública, visando abordar as altas taxas de sobrepeso e obesidade, bem como aumentar os níveis de aptidão física e adesão à dieta Mediterrânica, como parte integrante de um estilo e qualidade de vida que melhora a saúde dos adolescentes.

Palavras-chave: OBESIDADE, QUALIDADE DE VIDA RELACIONADA A SAÚDE, APTIDÃO FÍSICA, DIETA MEDITERRÂNICA, ADOLESCENTES

LISTA DE ABREVIATURAS

ACR: Aptidão cardiorrespiratória

ANCOVA: análise de covariância

ANOVA: análise de variação

IMC: Índice de Massa corporal

IOTF: *International Obesity Task Force*

OMS: Organização Mundial Da Saúde

QVRS: Qualidade de vida relacionada com a saúde

INTRODUÇÃO E OBJETIVOS

A investigação da Qualidade de Vida Relacionada com a Saúde (QVRS) tem-se intensificado nas últimas décadas. A Organização Mundial da Saúde (OMS) descreve a qualidade de vida como a perceção que o indivíduo tem sobre a sua posição na vida, no contexto da cultura e no sistema de valores no qual vive, e em relação às suas expetativas, objetivos, preocupações e padrões (WHOQOL Group, 1996). A QVRS é um indicador útil de resultados de saúde em crianças e adolescentes (Kamp-Becker et al., 2010; Majnemer et al., 2008; Varni et al., 2007), uma vez que serve para avaliar o impacto das intervenções na saúde pública numa determinada população (Matos et al., 2012), no sentido de obter informações necessárias para a promoção da qualidade de vida, nessas faixas etárias.

O estudo da QVRS nos adolescentes é uma área de investigação recente. A adolescência é caracterizada por um incremento no ritmo de crescimento e desenvolvimento, bem como por inúmeras mudanças a nível anatómico, social, psicológico, emocional e fisiológico (WHO, 2015), incluindo alterações na composição corporal, nos níveis e padrões de atividade física e aptidão física e, ainda, na alimentação (Alberga et al., 2012).

A literatura sugere que um estilo de vida "ocidentalizado" caracterizado pela ingestão excessiva de energia e comportamentos sedentários explica, em boa parte, o incremento da obesidade entre os jovens (Haug et al., 2009; Carlson et al., 2012; WHO, 2003). Entretanto, devido ao aumento rápido da prevalência e também às consequências associadas, a obesidade revela-se um dos maiores desafios à saúde do início do século XXI (Sacks et al., 2012; WHO, 2010). De acordo com a OMS, em 2016, cerca de 340 milhões de crianças e adolescentes, dos 5 aos 19 anos, apresentavam excesso de peso ou obesidade (WHO, 2017a).

O aumento da obesidade pediátrica, que muitas vezes acompanha a idade adulta, agrava o risco de desenvolver doenças cardiovasculares, colesterol, hipertensão, diabetes tipo 2 e outras doenças crónicas (Niinikoski et al., 2009; Royo-Bordonada et al., 2006; Santos et al., 2011).

Complementarmente, a obesidade afigura-se como um distúrbio nutricional que se relaciona com problemas psicossociais, dificuldades

comportamentais e relacionamentos sociais, familiares e escolares, conduzindo, por vezes, a um quadro de depressão e ansiedade (Taras & Potts-Datema, 2005).

Acresce que a circunstância de a dieta mediterrânica se caracterizar pelo elevado consumo de azeite, cereais integrais, ingestão moderada a elevada de peixe, frutas, vegetais, ingestão comedida de leite e produtos láteos e o baixo consumo de carne, é algo que tem sido relacionado com a perda de peso, redução da obesidade abdominal, resistência à insulina, menor risco de diabetes mellitus e doenças cardiovasculares (Muros et al., 2017). Daí que a adoção de um padrão alimentar saudável constitua um obstáculo determinante no aparecimento de doenças crónicas não transmissíveis (WHO, 2003).

Nesta sequência, revela-se importante o estabelecimento de hábitos e comportamentos alimentares saudáveis durante a infância e adolescência, uma vez que as práticas de nutrição saudáveis, estabelecidas nestes períodos, frequentemente persistem na idade adulta (Lake et al., 2006).

A literatura sugere também que o desenvolvimento das componentes de aptidão física relacionadas com a saúde, em idades precoces, são de importância decisiva para resultados sustentáveis de saúde e aptidão física ao longo da vida (Brooke et al., 2014; Ried-Larsen et al., 2015).

Com efeito, a aptidão física tem sido considerada um poderoso marcador de saúde, tanto na infância como na idade adulta (Ortega, Ruiz, et al., 2008), independentemente da atividade física (Blaes et al., 2011; Ekelund et al., 2007) e tem sido identificada como preditora de morbidade e mortalidade (Metter et al., 2002; Mora et al., 2004). Assim, um baixo nível de aptidão física, durante a infância e adolescência, está associado a importantes resultados relacionados com a saúde, tais como: o aumento de risco futuro de obesidade e doenças cardiovasculares, a diminuição da saúde esquelética e a redução da qualidade de vida e da saúde mental (De Miguel-Etayo et al., 2014). Não obstante a evidência dos benefícios de um empenhamento elevado na aptidão física, naquela faixa etária, tal desempenho tem vindo a decrescer, nas últimas três décadas (Catley & Tomkinson, 2011; Ortega et al., 2005; Tomkinson & Olds, 2007).

Nesta ordem de ideias, a aquisição de hábitos e comportamentos saudáveis em idade precoce, entre os quais se deve enfatizar a aptidão física e a dieta mediterrânica, terá implicações importantes para a saúde física e mental dos adolescentes.

Assim, de um modo geral, a adoção de medidas preventivas e de promoção da saúde estão entre os maiores desafios das políticas de saúde pública, nestas faixas etárias (Fuh et al., 2005), como práticas indutoras de desenvolvimento positivo em todas as esferas da vida de crianças e adolescentes, particularmente em contextos de socialização, tal como a família, os pares, a escola e a comunidade (Ferraz et al., 2007; Kahneman et al., 2006).

Entretanto, em Portugal, o número de estudos que analisam as associações entre aptidão física, índice de massa corporal (IMC), dieta mediterrânica e QVRS na adolescência revela-se bastante escasso.

Neste enquadramento, importa aclarar que o objetivo geral desta tese consistiu em analisar as associações entre a QVRS, a aptidão física, o IMC e, a adesão à dieta mediterrânica em adolescentes.

Adicionalmente, definiram-se os seguintes objetivos específicos:

i). Analisar as associações entre o IMC e a QVRS e explorar o potencial efeito de mediação da ACR na relação entre o IMC e a QVRS, em adolescentes;

ii). Analisar as associações combinadas da ACR e aptidão muscular com a QVRS e avaliar as diferenças entre a pontuação da QVRS e os grupos de aptidão cardiorrespiratória e aptidão muscular;

iii). Explorar as associações independentes e combinadas entre a aptidão física e adesão à dieta mediterrânica com a QVRS;

iv). Explorar a associação longitudinal entre a ACR e a QVRS e determinar se as mudanças na ACR foram associadas à QVRS, nos 2 anos de follow-up.

Finalmente, esclareça-se que, nesta dissertação, o primeiro capítulo apresenta uma revisão da literatura, o segundo capítulo os procedimentos metodológicos e o terceiro capítulo apresenta os quatro estudos diferentes, em que cada um deles dá resposta aos seus objetivos específicos, conforme se segue:

Artigo I - Associations between health-related quality of life and body mass index in Portuguese adolescents: LabMed Physical Activity Study;

Artigo II - *Muscular fitness and cardiorespiratory fitness are associated with health-related quality of life: results from Labmed Physical Activity Study;*

Artigo III - *Associations between physical fitness and adherence to the Mediterranean diet with health-related quality of life in adolescents: results from the LabMed Physical Activity Study;*

Artigo IV - *Cardiorespiratory fitness and health-related quality of life in adolescents: a longitudinal analysis from the LabMed Physical Activity Study.*

As principais conclusões, discussões e considerações gerais são apresentadas no capítulo IV.

Por fim, as referências da tese estão descritas no capítulo V.

CAPÍTULO I - REVISÃO DA LITERATURA

A problemática da Qualidade de Vida Relacionada com a Saúde (QVRS) tem suscitado, nos últimos tempos, um crescente interesse por parte da comunidade de saúde pública (Michel et al., 2009). Neste enquadramento, a QVRS pode ser definida: como a construção subjetiva e multidimensional que relata a saúde auto percebida de uma pessoa e que descreve os aspetos físicos, mentais, sociais, psicológicos e funcionais do bem-estar e das relações familiares (Ravens-Sieberer et al., 2005; Ravens-Sieberer et al., 2008); e, por outro lado, como sendo os níveis ótimos de funcionamento mental, físico e social, incluindo relacionamentos e perceções de saúde, aptidão física, satisfação e bem-estar com a vida (Theofilou, 2013).

A avaliação da QVRS pode ajudar a identificar os subgrupos da população com maior risco de problemas de saúde e na deteção de insuficiências no bem-estar e funcionamento precoces (Ravens-Sieberer et al., 2008), servindo para identificar e desenvolver estratégias tendentes à promoção da qualidade de vida (Drotar, 2014) e, ainda, para avaliar o impacto das intervenções na saúde pública numa determinada população (Matos et al., 2012). Contudo, o bem-estar e a QVRS em crianças e adolescentes são conceitos bastante recentes e são objeto de relevante preocupação entre os profissionais de saúde (Wallander & Koot, 2016).

As perceções das crianças e adolescentes sobre a sua QVRS são influenciadas por vários fatores: idade, género, características pessoais e familiares, bem como o estatuto socioeconómico (Caldera & Hart, 2004).

Relativamente à idade, Ravens-Sieberer et al. (2007) constataram que as crianças, com idades entre os 8 e os 11 anos, apresentaram níveis mais elevados de QVRS, nomeadamente no bem-estar físico e psicológico, do que os adolescentes dos 12 aos 18 anos. Por outro lado, num estudo português com 3195 crianças e adolescentes do 5º e do 7º ano de escolaridade, do projeto *Health Behaviour in School-Aged Children*, concluiu-se que os adolescentes que frequentavam o 7º ano de escolaridade apresentaram pior QVRS que os colegas mais velhos em todos os domínios - bem-estar físico e psicológico, humor e emoções, autoperceção, autonomia, relação dos pais e vida familiar, apoio social

e colegas, e ambiente escolar - com exceção dos domínios dos recursos financeiros e da aceitação social (Gaspar et al., 2010).

Concomitantemente, alguns estudos relataram que a QVRS diminui ao longo do tempo, e que esse padrão é mais evidente para as raparigas do que para os rapazes (Bisegger et al., 2005; Michel et al., 2009; Torsheim et al., 2006). De acordo com Meade & Dowswell (2016), o bem-estar físico e mental parece deteriorar-se com a idade, e tanto mais para as raparigas do que para os rapazes. Essas mudanças podem ser devidas ao desenvolvimento do adolescente que se caracteriza por mudanças físicas, psicológicas, vocacionais e sociais, enquanto as diferenças de género podem ser devidas a demandas sociais contraditórias sobre as raparigas (Bisegger et al., 2005) e à vulnerabilidade subsequente aos desafios de saúde física e psicológica (Patton & Viner, 2007).

Entretanto, vários estudos mencionaram diferenças de género na saúde subjetiva e na QVRS, na infância e na adolescência (Bolton et al., 2014; Kirchengast & Haslinger, 2008; Meade & Dowswell, 2015, 2016). Em alguns estudos os rapazes apresentaram níveis mais elevados de QVRS do que as raparigas, nomeadamente no bem-estar físico e psicológico e na relação e autonomia em relação aos pais (Meade & Dowswell, 2016; Ravens-Sieberer et al., 2007). Num outro estudo, as raparigas entre os 10 e os 16 anos relataram pior qualidade de vida em todos os domínios da QVRS - bem-estar físico e psicológico, estado de espírito e emoções, autoperceção, autonomia, relação dos pais e vida familiar, e aceitação social - com a exceção do domínio do ambiente escolar, quando comparado com os rapazes (Gaspar et al., 2010). Por outro lado, ainda num outro estudo em crianças e adolescentes espanhóis, Palacio-Vieira et al. (2008) examinaram as mudanças na QVRS e concluíram que esta diminuiu em oito das dez dimensões avaliadas pelo questionário *Kidscreen-52* (incluindo o bem-estar físico e psicológico, autonomia e relações parentais, apoio social e colegas e ambiente escolar) e que essas mudanças foram mais notáveis nas raparigas do que nos rapazes e nos participantes mais velhos (13-17 anos).

Por sua vez, o estatuto socioeconómico também é reconhecido por influenciar a QVRS das crianças e adolescentes (Cassedy et al., 2013). A relação entre os níveis mais elevados de estatuto socioeconómico e valores mais altos da QVRS em crianças é bem estabelecida em alguns estudos (Mansour et al., 2003; Varni et al., 2006). Assim, um estatuto socioeconómico menor está associado a sintomas mais depressivos em adolescentes e essa relação pode ser explicada por fatores de risco contextuais como: características de trabalho inferiores, desvantagens materiais, suporte social reduzido e comportamento de saúde arriscado (Stansfeld et al., 2003). De facto, tal como referido anteriormente, as condições de vida da infância são consideradas como preditoras relevantes para o estado de saúde do adulto (Rahkonen et al., 1997).

Quanto à relação dos indicadores de sono e a QVRS, tal também tem sido reportada em crianças e adolescentes. O sono insuficiente não só interfere com a qualidade de vida e o bem-estar geral, como também pode ser nefasto para a saúde (Sarchiapone et al., 2014). Alguns estudos em adolescentes relataram, de forma consistente, que as horas insuficientes de sono estão associadas a problemas emocionais, tais como sintomas de depressão e ansiedade (Reigstad et al., 2010; Suzuki et al., 2011), além de automutilação e ideias suicidas (Lee et al., 2012). O sono insuficiente também foi correlacionado com o aumento da agressividade, irritabilidade, bullying e hostilidade em adolescentes (Holley et al., 2011; Kamphuis et al., 2012) e tentativa de suicídio (Liu, 2004; Liu & Buysse, 2006). A título de exemplo, Gustafsson et al. (2016) verificaram que as crianças e adolescentes que dormem mais têm melhor QVRS. Esta associação entre o sono e a QVRS foi significativamente diferente entre os vários grupos etários. Assim, não foi encontrada uma associação significativa aos 10 anos de idade e, por outro lado, encontrou-se associação fraca aos 12 anos de idade, bem como uma associação mais forte nos adolescentes de 15 anos (Gustafsson et al., 2016). Do mesmo modo, num estudo recente, com crianças e adolescentes chineses, a duração do sono foi positiva e significativamente associada à QVRS (Xu et al., 2014). Segundo Delgado Prieto et al. (2012), os adolescentes com padrões de sono menos saudáveis têm pontuações mais baixas no

funcionamento emocional, social, escolar, psicossocial e qualidade de vida global.

Nesta linha de pensamento, estudos epidemiológicos evidenciaram a existência de uma relação positiva entre a prática da atividade física e a adoção de outras condutas relacionadas com a saúde, com consequentes impactos na melhoria da qualidade de vida e na perceção da saúde (Aarnio et al., 2002; Iannotti et al., 2009). Matsudo (2012) afirma que a atividade física atua na melhoria da autoestima, do autoconceito, da imagem corporal, das funções cognitivas e da socialização. Finne et al. (2013) destacam a atividade física como um importante fator para a sensação de bem-estar, sendo capaz de reduzir estados de ansiedade e de depressão.

Na mesma senda, a relação entre a aptidão física e a QVRS também tem sido reportada em crianças e adolescentes. A aptidão física é, assim, um conceito multidimensional que se refere ao conjunto de atributos que se relacionam com a capacidade para realizar atividade física, nomeadamente capacidade cardiorrespiratória, força, resistência muscular, flexibilidade e composição corporal (Caspersen et al., 1985).

Desta forma, a aptidão física pode ser subdividida em aptidão relacionada à saúde e aptidão relacionada à *performance*. A ACR, a composição corporal, a força muscular, a resistência e a flexibilidade são, muitas vezes, referidas como aptidão física relacionada com a saúde (Castillo Garzón et al., 2006; Zhu et al., 2011) e, geralmente, são associadas à prevenção de doenças e à promoção da saúde (Powell et al., 1989). Por conseguinte, o equilíbrio, a coordenação, a velocidade, a agilidade e a força são, recorrentemente, descritas como aptidão física relacionada com a *performance* desportiva (Howley, 2001).

Está documentado que os níveis de aptidão física tendem a progredir da infância para a adolescência e da adolescência para a idade adulta (Hasselstrøm et al., 2002; Janz et al., 2002; Malina, 1996; Twisk & Kemper, 2000). Esta é a razão pela qual a aptidão física é considerada um dos marcadores de saúde mais importantes, bem como um preditor de morbidade e mortalidade por doenças cardiovasculares (Ortega, Ruiz, et al., 2008).

Na Europa são observados baixos níveis de aptidão física em adolescentes de ambos os sexos (Artero et al., 2010; Martinez-Gomez et al., 2011). Vários estudos demonstraram que baixos níveis de aptidão na adolescência estão associados a sérios resultados relacionados com a saúde, tais como, o risco aumentado de obesidade (Ortega, Labayen, et al., 2011), fatores de risco cardiometabólicos (Andersen et al., 2015; Ruiz et al., 2016), deterioração da saúde esquelética (Vicente-Rodríguez et al., 2008), menor desempenho académico (Sardinha et al., 2016) e qualidade de vida reduzida (Morales et al., 2012), o que releva a necessidade de incluir testes de aptidão física nas escolas e nos centros de saúde (Ortega, Artero, et al., 2011).

A ACR é uma variável muito importante a considerar, uma vez que foi provado que níveis mais elevados de ACR, na infância e na adolescência, estão associados a um perfil cardiovascular mais saudável e reduzem o risco de desenvolver a síndrome metabólica e rigidez arterial no futuro (Ruiz et al., 2009). Níveis mais elevados de ACR fornecem informações prognósticas fortes e independentes sobre o risco geral de doença e morte, especialmente relacionadas a causas cardiovasculares (LaMonte & Blair, 2006).

Para além dos ganhos físicos, a ACR melhora a atenção, permite que as crianças e os adolescentes regulem melhor o seu comportamento e emoções e melhorem também o desempenho académico (Chaddock et al., 2012; Diamond, 2013; Haapala, 2013; Voss et al., 2011), assim como a saúde mental (Kabiri et al., 2017).

No entanto, apesar dos benefícios de uma ACR elevada, a *performance* de crianças e adolescentes em testes de aptidão diminuiu nas últimas décadas (Catley & Tomkinson, 2011; Dyrstad et al., 2012; Ferrari et al., 2015; Tomkinson & Olds, 2007). Num estudo recente, Tomkinson et al. (2017) estimaram as tendências temporais em 965 264 crianças e adolescentes de 19 países entre 1981 e 2014, utilizando dados de 137 estudos. Nesse estudo, verificaram que houve um declínio moderado na ACR, ao longo de um período de 33 anos. O declínio foi mais significativo nos rapazes do que nas raparigas e foi semelhante para crianças e adolescentes (Tomkinson et al., 2017). As tendências também diferiram em magnitude e direção entre países, com a maioria mostrando

declínios. Uma meta-análise concluiu que os adolescentes italianos e gregos, juntamente com adolescentes portugueses, americanos e brasileiros, têm o pior nível de ACR, a partir de uma perspetiva mundial (Olds et al., 2006).

Outra componente importante da aptidão física relacionada com a saúde é a aptidão muscular, que mostrou estar positivamente relacionada com a ACR (Ortega et al., 2005). A aptidão muscular é um construto multidimensional que compreende uma função integrada da força muscular e que permite o desempenho do trabalho contra o próprio peso corporal ou uma resistência externa (Artero et al.; 2012; Pillsbury et al.; 2013).

Altos níveis de aptidão muscular têm sido associados ao menor risco de doença cardiovascular em crianças, que podem ocorrer independentemente da massa corporal e da ACR (Artero et al., 2012; Steene-Johannessen et al., 2013).

A melhoria da aptidão muscular também foi correlacionada com a melhoria da saúde óssea, aumento da autoestima e diminuição da adiposidade em crianças (Artero et al., 2012; Pitukcheewanont et al., 2010; Smith et al., 2014). Acresce que existem algumas evidências em que altos níveis de aptidão muscular podem contrariar parcialmente outros fatores de risco cardiovascular adversos, em crianças e adolescentes com sobrepeso e obesidade (Artero et al., 2012).

De acordo com Ortega et al. (2012), a força muscular na adolescência é tão importante como o IMC ou a pressão arterial em termos de mortalidade, enquanto o IMC tem um papel maior do que a força muscular ou a pressão arterial em termos de mortalidade por doença cardiovascular. A redução da força muscular, no final da adolescência, está associada a um risco aumentado de mortalidade por suicídio, apoiando a noção de que pessoas fisicamente mais fracas também podem ser mentalmente mais vulneráveis (Ortega et al., 2012). No estudo de Ortega et al. (2012), envolvendo 1 142 599 adolescentes suecos do sexo masculino, com idades compreendidas entre 16-19 anos, sugere-se que a elevada aptidão muscular apresenta um risco 20-30% menor de morte precoce por suicídio e, por outro lado, 15 a 65% dos adolescentes são menos propensos a ter algum diagnóstico psiquiátrico, tal como: distúrbios de humor,

esquizofrenia, mostrando que a força muscular é independente e, de forma inversa, associada à morte por suicídio.

A evidência sobre a associação entre aptidão física e saúde mental em adolescentes ainda é escassa. Não obstante, um estudo português com 3554 adolescentes de 13-18 anos, do projeto *Health Behaviour in School-Aged Children*, reportou que os níveis de aptidão física autorrelatados foram associados positivamente com valores de QVRS superiores (Marques et al., 2017). A título de exemplo, Gu et al. (2016) verificaram que a ACR e a aptidão muscular contribuíram para o bem-estar físico e mental da QVRS de 201 crianças de 9-11 anos de uma escola pública do sul dos Estados Unidos da América. Outros estudos sugerem que as melhorias na ACR têm um efeito positivo no bem-estar psicológico (Bonhauser et al., 2005; Crews et al., 2004; Padilla-Moledo et al., 2012).

Concluindo, do ponto de vista preventivo da saúde pública, as escolas devem desempenhar um papel central na promoção e melhoria dos níveis de atividade física e da aptidão física nos jovens, juntamente com outros hábitos e comportamentos de saúde, na medida em que crianças e adolescentes passam uma grande parte do tempo em ambiente escolar (Pate et al., 2006).

Outro fator que expõe um impacto negativo na QVRS, é a obesidade.

Em Portugal, num estudo representativo englobando 22 048 crianças e adolescentes com idades compreendidas entre os 10-18 anos, o excesso de peso e a obesidade atingiram proporções epidémicas: um terço das crianças e adolescentes têm sobrepeso ou obesidade (Sardinha et al., 2011). A prevalência de sobrepeso e obesidade foi de 17,0 e 4,6% nas raparigas, e 17,7 e 5,8% nos rapazes, respetivamente, utilizando os pontos de corte de *International Obesity Task Force* (IOTF). No entanto, de acordo com os pontos de cortes da OMS, as raparigas apresentaram uma prevalência de sobrepeso e obesidade de 23,1 e 9,6% e de 20,4 e 10,3% nos rapazes, respetivamente (Sardinha et al., 2011).

O estudo *Health Behaviour in School-Aged Children,* em colaboração com a OMS (WHO, 2017b), monitoriza os comportamentos de saúde, resultados de saúde e ambientes sociais de rapazes e raparigas com idades entre os 11, 13 e 15 anos. Este estudo apresenta dados sobre a prevalência de obesidade em 27

países e regiões da Europa entre 2002 e 2014. Os resultados do estudo *Adolescent obesity and related behaviours: trends and inequalities in the WHO European Region, 2002-2014*, mostram que o número de adolescentes obesos continua a aumentar em muitos países e regiões, particularmente na Europa Oriental onde, até tempos recentes, a prevalência era menor do que em outras partes da Europa. Nesse estudo, a prevalência da obesidade em Portugal, nas crianças e adolescentes aos 11, aos 13 e aos 15 anos, foi de 5%. Este número representa uma subida de 0,3 pontos percentuais desde 2002, quando o objetivo era travar esta doença. Os rapazes, apresentaram uma prevalência de obesidade de 6,9% e as raparigas 3% (WHO, 2017b).

É consensual que as causas do excesso de peso e da obesidade são multifatoriais, incluindo determinantes genéticas, biológicas, sociais e ambientais, que afetam, de forma coletiva ou independente, o aumento de peso, atuando através dos mediadores do metabolismo energético e da atividade física (Ebbeling et al., 2002; Daniels, 2006).

Os fatores de risco para a obesidade infantil incluem o peso ao nascer, padrões de atividade física, dieta e obesidade parental (Agras et al., 2004). Este último fator é um forte determinante da obesidade infantil, devido a uma combinação de genes e ambiente familiar compartilhado (Parsons et al., 1999). O estatuto socioeconómico também é um fator de risco importante na obesidade infantil. Existem algumas evidências que, em países desenvolvidos, as crianças com estatuto socioeconómico mais baixo, aumentaram as taxas de obesidade (De Moira et al., 2010).

Outro fator preponderante é a circunstância de, ao longo dos anos, as crianças tornarem-se cada vez mais sedentárias, passando grande parte do tempo a ver televisão e a brincar com jogos de computador, e estando menos tempo a participar em atividades físicas, como seja caminhadas ou a praticar desportos (Cowie, 2014). Tal atitude, aliada ao aumento do consumo de alimentos de alta densidade e energia (Dhir & Ryan, 2010), significa que a ingestão excede o gasto energético, daí resultando crianças com sobrepeso e obesidade (Cowie, 2014).

Os efeitos da obesidade incluem o aumento do risco de múltiplas comorbidades (Freedman et al., 2001; Thompson & Wolf, 2001), custos mais elevados de cuidados de saúde e implicações metabólicas, anatómicas, psicológicas e comportamentais (Luiz et al., 2005), incluindo fatores de risco de doenças cardiovasculares, tais como: tolerância à glicose diminuída, hipertensão, fatores de risco ateroscleróticos e diabetes tipo II (l'Allemand et al., 2008; Kumanyika et al., 2008; Mohan et al., 2007), uma variedade de mediadores pró-inflamatórios (Kim et al., 2010), problemas ortopédicos (Ebbeling et al., 2002) e consequências psicossociais relevantes.

As questões comportamentais, especialmente entre os adolescentes, tais como a aceitação social, a dificuldade em estabelecer relacionamentos românticos e a insatisfação com a imagem corporal, podem ter repercussões graves e o impacto na qualidade de vida e a adaptação ao tratamento podem levar a depressão e a ansiedade severas (Luiz et al., 2005). Outras crianças com sobrepeso / obesidade são, frequentemente, propensas a condições insalubres, desempenho académico pobre, incapacidade social e preguiça (Chatterjee, 2002).

Neste contexto, jovens obesos relatam taxas mais elevadas de estigmatização e vitimização (Latner & Stunkard, 2003), e enfrentam reiteradamente episódios de exclusão social (Jelalian et al., 2009; Wardle & Cooke, 2005), sendo que o ajuste psicossocial destes jovens é frequentemente comprometido, em particular no que concerne à sua qualidade de vida (Jelalian et al., 2009; Jensen & Steele, 2012; Riazi et al., 2010) e funcionamento psicológico (Puder & Munsch, 2010; Storch et al., 2007; Vivier & Tompkins, 2008; Zeller & Modi, 2008). Com efeito, vários estudos mostraram uma associação negativa entre a QVRS e o IMC (Haraldstad et al., 2011; Khairy et al., 2016; Ottova et al., 2012; Edwards et al., 2012; Kunkel et al., 2009; Williams et al., 2011; Wu et al., 2012). Outros estudos referem que crianças e adolescentes com excesso de peso possuem uma perceção da QVRS inferior à dos seus pares normoponderais (Buttitta et al., 2014; Chen et al., 2014; Jansen et al., 2013; Ottova et al., 2012). Além disso, a literatura indica-nos que a menor QVRS em crianças com excesso de peso pode ser atribuída de forma semelhante ao

menor funcionamento físico, psicossocial e bem-estar (Ul-Haq et al., 2013), e tem fortes relações inversas para ambos os aspetos da QVRS (Tsiros et al., 2009).

Segundo a OMS (WHO, 2005), para controlar efetivamente o peso de indivíduos, ou de grupos com risco de obesidade, é necessário estabelecer estratégias a longo prazo. Essas estratégias incluem prevenção, controlo da morbidez e programas de perda e manutenção de peso, por meio de uma abordagem integrada, multiprofissional e adequada à população. Neste contexto, as políticas públicas, a escola e os pais, têm um papel fundamental na prevenção da obesidade, promovendo e estimulando a prática regular de atividade física e de hábitos alimentares saudáveis.

Em suma, a adolescência é um período de vida durante o qual afigura-se fundamental intervir para melhorar a saúde presente e futura, e que, concomitantemente, possui várias características psicossociais que permitem essa intervenção com resultados positivos. Por conseguinte, sempre que possível, os adolescentes devem ser apoiados na adoção de comportamentos promotores de saúde, através de apoio pessoal, comunitário e de políticas públicas em geral (Raphael, 2013).

Passando para outro parâmetro, desta feita para o domínio alimentar e a sua relação com saúde, a designação dieta mediterrânica, enquanto regime especial de alimentação, tem sido usada para descrever os hábitos alimentares tradicionais das pessoas que vivem junto ao Mar Mediterrâneo, em especial nas áreas de oliveira (Idelson et al., 2017).

Este tipo de dieta é caracterizado pelo consumo abundante de frutas, vegetais, cereais integrais, nozes e sementes, quantidades moderadas de produtos láteos, quantidades baixas a moderadas de peixe e aves, carne vermelha em baixas quantidades e azeite como a principal fonte de gordura (Costarelli et al., 2013). É, por conseguinte, um padrão de alimentação saudável associado a um risco reduzido de doenças cardiovasculares e neurodegenerativas, bem como de alguns tipos de cancro (Bonaccio et al., 2012; Sofi et al., 2010; Trichopoulou et al., 2009).

De entre outros benefícios da adesão à dieta mediterrânica tradicional,

destaca-se os que foram observados na rigidez arterial (Lydakis et al., 2012), em sintomas de asma e rinite (Chatzi et al., 2007; Garcia-Marcos et al., 2007), sobre a QVRS (Costarelli et al., 2013), no desempenho académico (Vassiloudis et al., 2011), no comportamento de atividade física intensa (Farajian et al., 2011; Tsiachris et al., 2010), e nos níveis de albuminúria (Mazaraki et al., 2011). Outras evidências apoiaram a relação entre dieta mediterrânica e depressão, mostrando um potencial papel protetor contra o aparecimento de sintomas depressivos (Rienks et al., 2013; Sánchez-Villegas et al., 2009).

Por outro lado, a dieta mediterrânica também mostrou estar positivamente associada com a QVRS. Na área do Mediterrâneo, dois estudos em adultos espanhóis mostraram que a adesão a esta dieta parece ser um fator importante associado a uma melhor QVRS (Munoz et al., 2008; Sánchez et al., 2012). Um estudo recente analisou a associação entre a adesão à dieta mediterrânica, o IMC e a atividade física com a QVRS, durante a primeira fase da adolescência, e concluiu que esses comportamentos saudáveis são bons preditores da QVRS nesta faixa etária (Muros et al., 2017). Outro estudo, desta vez realizado na Grécia, em 354 adolescentes dos 13 aos 16 anos, revelou uma significativa associação positiva entre a adesão à dieta mediterrânica e a QVRS (Costarelli et al., 2013).

Por conseguinte, a promoção da dieta mediterrânica pode contribuir para um resssurgimento ou renovação no consumo de alimentos saudáveis (Lazarou, Panagiotakos, & Matalas, 2009), tornando-se uma ferramenta poderosa para combater os atuais hábitos alimentares dos jovens, claramente prejudiciais para a saúde, caracterizados por uma alta ingestão de açúcares e gorduras saturadas e consumo insuficiente de frutas e vegetais (Arriscado et al., 2014). Paralelamente, as políticas de saúde devem ser alargadas, de forma a incluir a educação alimentar, bem como a criação de infraestruturas adequadas para o desenvolvimento de práticas recreativas e atividades físicas, produção de legislação específica para padronizar os rótulos de alimentos e regular a publicidade e comercialização de alimentos (Neves et al., 2010).

CAPÍTULO II - METODOLOGIA

2.1- AMOSTRA E DESENHO DO ESTUDO

Os dados desta tese de doutoramento são derivados de um projeto de investigação intitulado "*Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity* (*LabMed Physical Activity Study*)", conduzido pelo Centro de Investigação em Atividade Física, Saúde e Lazer (CIAFEL) da Faculdade de Desporto, da Universidade do Porto.

Neste estudo, foi considerada uma amostra de adolescentes, matriculados no ensino básico (7º ano de escolaridade) e no secundário (10º ano escolaridade), de cinco escolas do Norte de Portugal, com idades compreendidas entre os 12 e os 18 anos.

Ao longo do estudo, não foram aplicados quaisquer critérios de exclusão para evitar discriminações. No entanto, para a presente análise apenas os adolescentes aparentemente saudáveis foram considerados, ou seja, os participantes sem qualquer diagnóstico médico de doença física ou mental. Considerando potenciais recusas de participação no estudo, devido à análise de sangue ou o uso dos acelerómetros, foi permitido um "consentimento em partes". Isto permitiu aos participantes consentirem com apenas algumas partes do protocolo de estudo e outras não. Por exemplo, um adolescente poderia realizar avaliações de aptidão física e não usar os acelerómetros ou recusar submeter-se à colheita de sangue.

Todos os alunos matriculados no 7º e 10º anos das escolas participantes foram convidados a fazer parte do estudo (n = 1678). A primeira recolha de dados decorreu ao longo do ano letivo 2011/2012, e contou com a participação de 1229 sujeitos sendo que 1011 e 789 adolescentes foram reavaliados, um e dois anos depois, respetivamente.

Os participantes foram avaliados, durante as aulas de Educação Física, por avaliadores especialmente treinados para esta recolha de dados (medidas antropométricas, bateria de testes de aptidão física e aplicação de questionários).

Todos os participantes foram informados sobre os objetivos do estudo. Os próprios, bem como os seus pais/encarregados de educação formalizaram o consentimento por escrito. O estudo foi aprovado pela Faculdade de Desporto

da Universidade do Porto. Foram ainda recolhidas as autorizações da Comissão Nacional de Proteção de Dados (número: #1112434/2011), do Ministério da Educação (número: 0246200001/2011) e da Direção das escolas. O mesmo foi conduzido de acordo com a Declaração da Associação Médica Mundial de Helsínquia para estudos humanos (World Medical Association, 1989).

2.2. - INSTRUMENTOS E VARIÁVEIS

A descrição completa dos métodos, procedimentos e medidas que foram utilizados nesta tese pode ser observada em cada um dos artigos apresentados.

2.2.9 ANÁLISE ESTATÍSTICA

Todas as análises estatísticas foram desenvolvidas através do programa estatístico *Statistical Package for Social Science* (SPSS), versão 24.0 para Mac. O nível de significância foi estabelecido em $p \leq 0,05$.

A tabela 1 descreve as variáveis incluídas e o número de participantes de cada estudo, bem como os diferentes métodos estatísticos usados.

Tabela 1 - Variáveis incluídas e o número de participantes de cada estudo, bem como os diferentes métodos estatísticos usados

Artigos	Tamanho da Amostra	Idade	Variáveis principais	Covariáveis	Procedimentos estatísticos
Artigo I	957 (511 ♀)	12-18 anos	Qualidade de vida relacionada com a saúde, índice de massa corporal, aptidão cardiorrespiratória	idade, maturação sexual, estatuto socioeconómico e aptidão cardiorrespiratória	test *t,* qui-quadrado, ANCOVA, modelos de regressão linear, procedimentos de mediação bootstrapped
Artigo II	567 (280 ♀)	12-18 anos	Qualidade de vida relacionada com a saúde, aptidão muscular, aptidão cardiorrespiratória	idade, sexo, maturação sexual, estatuto socioeconómico, IMC, adesão à dieta mediterrânica, média diária de atividade física moderada a vigorosa e tempo de uso do acelerómetro	test *t,* qui-quadrado, ANCOVA, modelos de regressão linear
Artigo III	956 (510 ♀)	12-18 anos	Qualidade de vida relacionada com a saúde, aptidão física, adesão à dieta mediterrânica	idade, sexo, maturação sexual, estatuto socioeconómico, IMC e duração do sono	test *t,* qui-quadrado, ANCOVA, modelos de regressão linear
Artigo IV	571 (274 ♀)	12-18 anos	Qualidade de vida relacionada com a saúde e aptidão cardiorrespiratória	idade, sexo, maturação sexual, estatuto socioeconómico	ANOVA de medidas repetidas,qui-quadrado, ANCOVA, modelos de regressão linear

CAPÍTULO III– ARTIGOS ORIGINAIS

ARTIGO I

O.S. Evaristo, C. Moreira, R. Santos, L. Lopes, S. Abreu, C. Agostinis-Sobrinho, J. Oliveira-Santos, J. Mota (2018). Associations between health-related quality of life and body mass index in Portuguese adolescents: LabMed physical activity study. Journal of Adolescent Medicine and Health (Published).

Sofia Evaristo[1] / Carla Moreira[2] / Rute Santos[1,3] / Luís Lopes[1] / Sandra Abreu[1] / César Agostinis-Sobrinho[1] / José Oliveira-Santos[1] / Jorge Mota[1]

Associations between health-related quality of life and body mass index in Portuguese adolescents: LabMed physical activity study

[1] Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, Porto, Portugal
[2] Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, R. Plácido Costa, 91, 4200 450 Porto, Portugal, Phone: +351-22-5074786, Fax: +351-22-5500689, E-mail: carla_m_moreira@sapo.pt
[3] Early Start Research Institute, Faculty of Social Sciences, University of Wollongong, Wollongong, NSW, Australia

Abstract:
Background: In adolescence there are several biological and physiological changes associated with overweight and obesity.
Objective: The purpose of this study was to analyze the associations between health-related quality of life (HRQoL) and body mass index (BMI) in adolescents.
Methods: This is a cross-sectional analysis of 957 Portuguese adolescents (446 girls and 511 boys) aged 12–18 years. A series of variables were collected: (a) HRQoL was assessed using the KIDSCREEN-10 questionnaire; (b) socioeconomic status (SES) was measured using the Family Affluence Scale; (c) body composition (weigh, height) were measured and BMI was calculated and, (d) pubertal stage was assessed with Tanner stages; (e) the 20-m shuttle-run was used to estimate cardiorespiratory fitness. Regression models and mediation analysis were performed to assess the association between HRQoL and BMI.
Results: HRQoL was significantly higher in boys than girls ($p < 0.05$). The prevalence of overweight and obesity was 23.5% and 6.7% in girls, and 21.3% and 5% in boys, respectively. HRQoL was inversely and significantly associated with BMI in boys ($B = -0.130$; $p < 0.05$) and girls ($B = -0.148$; $p < 0.05$) after controlling for age, pubertal stage and SES. Cardiorespiratory fitness act as a full mediator variable on the relationship between BMI and HRQoL in adolescents ($p < 0.05$).
Conclusion: Our results suggest that cardiorespiratory fitness acted as a full mediator in the relationship between BMI and HRQoL, in adolescents. Public health policies targeting a wealthy weight and an improved physical fitness level could be a strategy of particular interest for improving the HRQoL of adolescents.

Keywords: BMI, LabMed study, quality of life, self-report
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Introduction

Overweight and obesity in children and adolescents is a global preoccupation, with differences in prevalence between boys and girls [1], [2]. Due the associated health consequences, obesity is considered one of the most serious health challenges of the early 21st century [3], [4]. According to Ebbeling et al. [5], the causes of overweight and obesity are multifactor including genetic, social, biological and environmental determinants.

In adolescence the effects of obesity include the increasing risk of multiple co-morbidities [6], [7], higher health care costs, and metabolic, anatomic, psychological and behavioral implications [8], including serious health consequences such as a impaired glucose tolerance, type II diabetes, atherosclerotic risk factors and hypertension [9], [10], [11], as well as a diversity of proinflammatory mediators (Kim et al. [12]) and orthopedic problems [5].

However, the relationship between different aspects of psychosocial functioning and obesity on well-being on children and adolescents is not very clear [13], [14], but, the assessment of quality of life seems pertinent to understanding the effect of overweight and obesity [15].

Carla Moreira is the corresponding author.

Health-related quality of life (HRQoL) is defined as a multidimensional construct that reports to a person's self-perceived health and consists of ratings of well-being, including emotional well-being, physical well-being/functioning, self-esteem, family relations and social functioning [16]. Several studies have shown that children and adolescents with excess of weight have lower HRQoL than their normal-weight peers [17], [18]. In addition, Tsiros et al. [19] suggests that increasing weight status has a moderate to strong negative influence on overall HRQoL and that exist an inverse linear relationship between HRQoL and body mass index (BMI) in pediatric populations.

Despite some studies have addressed this issue, at the best of our knowledge, no studies have explored the relationship between HRQoL with BMI, controlling for a series of potential confounders such as age, maturation, socioeconomic status (SES) and cardiorespiratory fitness, nor explored the potential mediation effect of cardiorespiratory fitness on the relationship between BMI and HRQoL, in a sample of Portuguese adolescents. Thus, the aim of this study was to analyze the associations between HRQoL with BMI, exploring the potential mediation effect of cardiorespiratory fitness in adolescents.

Materials and methods

Study design and participants

We used baseline data from the Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study), a school-based prospective cohort study carried out in five schools in the North Region of Portugal, that aimed to evaluate the independent and combined associations of fitness levels and dietary intake on the blood pressure levels of adolescents over a period of 3 years. A full description of the study protocol can be seen elsewhere [20].

Baseline data was collected in the fall of 2011, for all adolescents that agreed to participate in the study (n = 1229). From this initial total sample, 957 adolescents (446 girls and 511 boys) had complete variables of interest to participate in the present study. Drop off analysis of 22% showed that mean BMI, age and cardiorespiratory fitness were not different between the included and excluded participants (BMI excluded adolescents 20.5±3.1 kg/m^2; BMI included adolescents 21.4 ± 3.7 kg/m^2, p = 0.363; age excluded adolescents 14.4 ± 1.9 years; age included adolescents 14.5 ± 1.8 years, p = 0.811; cardiorespiratory fitness excluded adolescents 49.5 ± 30.3 laps, cardiorespiratory fitness included adolescents 45.8 ± 25.9 laps p = 0.580).

The study was conducted in accordance with the World Medical Association's Helsinki Declaration for Human Studies [21], the Portuguese Data Protection Authority (#1112434/2011), the Portuguese Ministry of Science and Education [246200001/2011] and all procedures were approved by the Ethical Commission of University of Porto. All participants in this study were informed of the study's goals, and written informed consent was obtained from participating adolescents and their parents or guardians. All adolescents, from who parental and individual consents were received, were enrolled in the study.

Measurements

Body weight and height

Anthropometric measurements were performed according to standard procedures. Body weight was measured to the nearest 0.10 kg, using a portable electronic weight scale (Tanita Inner Scan BC 532, Tokyo, Japan). The weight was recorded with the participant barefoot, wearing light clothing, body height was measured to the nearest 0.1 cm in bare or stocking feet with the adolescent standing upright against a portable stadiometer (Seca 213, Hamburg, Germany).

BMI was calculated as weight divided to height squared (kg/m^2), and the participants were classified as underweight, normal weight, overweight and obese using the age- and sex-specific cutoff values proposed by the International Obesity Task Force [22].

Health-related quality of life

HRQoL was evaluated by the KIDSCREEN-10, which consists of a 10-item scale. HRQoL was assessed using the Portuguese self-report version of the KIDSCREEN-10 questionnaire [23] that has been transculturally developed in 13 European countries for the population of children and adolescents aged 8–18 years. This instrument

assesses 10 dimensions and is used to validate evidence to support inferences about general measures of quality of life. The KIDSCREEN-10 is a reduced version of KIDSCREEN-52 questionnaire, of which contains 10 items answered on a five-point Likert response scale ranging from 1 (never; not at all) to 5 (always; extremely).

The KIDSCREEN-10 results in an overall value of quality of life. A low value in this tool suggests a feeling of dissatisfaction and inadequacy in many areas of the lives of children and adolescents, in particular, family, peer group and school. A high value, in turn, suggests a perception of adequacy and satisfaction with their contexts [23].

Socioeconomic status

Adolescents' SES was assessed with the Family Affluence Scale (FAS) [24] developed specifically to measure children and adolescents SES in the context of the health behavior in school-aged children study. The FAS is a four-item questionnaire that helps students report their family income objectively: it evaluates the sum of scores regarding whether the family owns a car, whether the student has his or her own bedroom, the number of family vacations during the past 12 months and the number of computers the family owns. The final score ranges from 0 to 9 points, with higher scores indicating higher SES.

Three groups were categorized in terms of the composite FAS score, in which FAS low (score = 0-1-2) indicated low affluence, FAS medium (score = 3-4-5) indicated middle affluence, and FAS high (score = 6-7-8-9) indicated high affluence.

Pubertal stage

Adolescents self-reported [25], [26], [27] their pubertal stage (from 1 to 5) relatively the secondary sex characteristics, according to the criteria of Tanner and Whitehouse [28]. Briefly, girls were assessed by the stage of breast development (Tanner A) and public hair distribution (Tanner B); boys were assessed by stage of genitalia development (penis size and testicular volume – Tanner A) and pubic hair distribution (Tanner B). In this data none of the participants self-assessed as belonging to in the first stage of pubertal maturation. For statistical analysis both Tanner A and B were used.

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed using the 20-m shuttle-run test as previously described by Leger et al. [29]. The adolescents were required to run between two lines 20-m apart, while keeping pace with a pre-recorded audio CD. The initial speed was 8.5 km/h, which was increased by 0.5 km/h each minute (1 min = one stage). Participants were instructed to run in a straight line, to turn round on completing a shuttle (20-m), and to pace themselves in accordance with the audio signals. The test was finished when the adolescent failed to reach the end lines before the audio signal on two consecutive occasions. Otherwise, the test ended when the subject stopped because of fatigue. Participants were encouraged to keep running as long as possible throughout the course of the test. Number of shuttles performed by each participant was recorded.

Statistical analysis

Descriptive data are presented as means and standard deviation for continuous variables and, in the case of categorical variables through frequencies and percentages. Independent two-tailed t-tests for continuous variables and χ^2 for categorical variables, respectively, were used to examine sex differences. Lastly, the associations of BMI with HRQoL were determined by linear regression analyses, adjusted for age, pubertal stage, SES and cardiorespiratory fitness (fully adjusted models). All regression analysis assumption were verified and all variables entered the models simultaneously. Unstandardized regression coefficients were used to express the beta in the linear regression analyses.

To examine whether the association between BMI and HRQoL was mediated by cardiorespiratory fitness, linear regression models were fitted using bootstrapped mediation procedures included in the PROCESS SPSS macro [30]. The first equation regressed the mediator (cardiorespiratory fitness) on the independent variable (BMI). The second equation regressed the dependent variable (HRQoL) on the independent variable (BMI). The third equation regressed the dependent variable (HRQoL) on both the independent (BMI) and the mediator variable (cardiorespiratory fitness). The following criteria were used to establish mediation: (1) the independent

variable (BMI) is significantly related to the mediator (cardiorespiratory fitness); (2) the independent variable (BMI) is significantly related to the dependent variable (HRQoL); (3) the mediator (cardiorespiratory fitness) is significantly related to the dependent variable (HRQoL); and (4) the association between the independent and dependent variable is attenuated when the mediator is included in the regression model. The Sobel test was used to test the hypothesis that the indirect effect was equal to zero. This analysis was adjusted by age, pubertal stage and SES. The level of significance was set at $p \leq 0.05$. Data were analyzed using SPSS (Windows version 20.0; SPSS Inc., Chicago, IL, USA).

Results

Table 1 shows the descriptive characteristics of the participants, by sex. Data showed that boys were taller and heavier ($p < 0.05$) than girls and also showed significantly higher scores in HRQoL, pubertal stage and cardiorespiratory fitness level ($p < 0.05$ for all). Further, our data also showed that the prevalence of overweight and obesity was 23.5% and 6.7% in girls and 21.3% and 5% in boys, respectively ($p < 0.05$).

Table 1: Descriptive characteristics of the participants, by sex.

	All (n = 957)	Girls (n = 446)	Boys (n = 511)	p-Value
Age	14.5 (1.8)	14.3 (1.7)	14.6 (1.9)	**0.003**
Weight, kg	55.9 (12.8)	53.6 (10.9)	57.9 (13.9)	**<0.001**
Height, m	1.61 (0.10)	1.58 (0.07)	1.64 (0.1)	**<0.001**
BMI, kg/m^2				
Normal weight, %	71.9	69.8	73.8	0.328
Overweight, %	22.3	23.5	21.3	
Obesity, %	5.8	6.7	5	
Pubertal stage A (I/II, III, IV, V), %	7.4/30.5/48.1/14	4/30.2/51.5/14.3	10.4/30.7/45.2/13.7	**0.004**
Pubertal stage B (I/II, III, IV, V), %	5.9/21.3/52.2/20.5	2.7/23.3/51/23	8.7/19.7/53.3/18.3	**0.001**
Cardiorespiratory fitness, (no. of laps)	45.9 (25.9)	30.7 (14.9)	58.9 (26.2)	**<0.001**
Socioeconomic status, %				
Low affluence	1	0.4	1.5	0.139
Middle affluence	24.2	22.8	25.5	
High affluence	74.7	76.7	73	
KIDSCREEN 10	39.1 (5.6)	38.6 (5.7)	39.5 (5.4)	**0.009**

FAS, Family Affluence Scale; BMI, body mass index. Data are presented as mean (standard deviation), except for BMI, pubertal stage, FAS and pubertal stage. Bold type: sex differences ($p < 0.05$).

Table 2 shows the linear association between HRQoL with BMI, by sex, (model 1) as well as controlling for age (model 2), pubertal stage (model 3), SES (model 4), cardiorespiratory fitness (model 5), age, pubertal stage and SES (model 6) and adjusted by all confounders (model 7). The findings highlighted that HRQoL was inversely associated with BMI in both sexes, after adjustments for age, pubertal stage and SES. However, when cardiorespiratory fitness was added to the models (model 7), the association between BMI and HRQoL disappeared.

Table 2: Associations between health-related quality of life and BMI, by sex.

BMI	Girls			Boys		
	B (95% CI)	p-Value	R^2	B (95% CI)	p-Value	R^2
Model 1 (crude)	−0.256 (−0.396; −0.115)	**<0.001**	0.028	−0.179 (−0.350; −0.052)	**0.006**	0.015
Model 2 (age)	−0.206 (−0.345; −0.066)	**0.004**	0.066	−0.135 (−0.262; −0.008)	**0.037**	0.039
Model 3 (PS)	−0.171 (−0.319; −0.023)	**0.024**	0.053	−0.162 (−0.289; −0.034)	**0.013**	0.017
Model 4 (SES)	−0.227 (−0.367; −0.086)	**0.002**	0.055	−0.171 (−0.296; −0.046)	**0.007**	0.015

Model 5 (CRF)	−0.227 (−0.374; −0.080)	**0.030**	0.003	−0.172 (−0.302; −0.042)	**0.010**	0.015
Model 6	−0.148 (−0.294; −0.003)	**0.046**	0.090	−0.130 (−0.257; −0.003)	**0.044**	0.047
Model 7	−0.094 (−0.294; 0.061)	0.233	0.099	−0.069 (−0.207; −0.069)	0.325	0.056

BMI, body mass index; PS, pubertal stage; SES, socioeconomic status; CRF, cardiorespiratory fitness; CI, confidence interval. Model 1 – crude, Model 2 – adjusted for age, Model 3 – adjusted for pubertal stage (Tanner A and B), Model 4 – adjusted for socioeconomic status, Model 5 – adjusted for cardiorespiratory fitness, Model 6 – adjusted for age, pubertal stage (Tanner A and B) and socioeconomic status, Model 7 – adjusted for age, pubertal stage (Tanner A and B) and socioeconomic status and cardiorespiratory fitness. B, unstandardized coefficients. Bold type: $p < 0.05$.

Next, we evaluated the mediating role of cardiorespiratory fitness on the association between BMI and HRQoL in both sexes (Figure 1). In the first regression equation, BMI was negatively associated with cardiorespiratory fitness ($p < 0.001$). In the second equation, BMI was also negatively associated with HRQoL ($p < 0.05$). Finally, in the third equation, when BMI and cardiorespiratory fitness were simultaneously included in the model, BMI no longer significantly predicted HRQoL. These results suggest that the effect of BMI on HRQoL was fully mediated by cardiorespiratory fitness. The Sobel test (girls: $z = -1.95$; $p \leq 0.05$; boys: $z = -2.09$; $p \leq 0.05$) indicated a percentage of effect mediated by cardiorespiratory fitness of 36, for girls and 46, for boys.

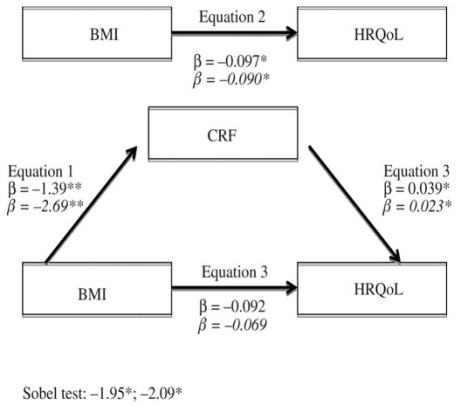

Figure 1: Cardiorespiratory fitness (CRF) mediation models of the relationship between body mass index (BMI) and health-related quality of life (HRQoL), after adjusting for age, pubertal stage and socioeconomic status.
Data in Roman type refer to boys. Data in *italics* refer to girls. **$p < 0.001$; *$p < 0.05$.

Discussion

This study aimed to analyze the associations between BMI with HRQoL in a sample of Portuguese adolescents. Data showed that girls had higher prevalence of overweight and obesity than boys (23.5%; 6.7% vs. 21.3%; 5%), although no statistical significant differences were found. Globally these findings are consistent with other international [15], [31], [32] and national studies [33], [34].

In the present study HRQoL scores were slightly lower in girls when compared to boys. These results are also consistent with previous findings, showing the same trend between sexes [15], [35], [36]. A possible explanation for these findings is that physical changes and development during puberty can strongly affect either positively or negatively, the adolescent's psychological status [37]. Studies have found that adolescents girls are less satisfied with their body than male adolescents peers while adolescent boys have higher self-esteem than their female counterparts [38], [39]. Thus, boys tend to be more comfortable with the physical changes occurring in puberty than girls [37]. Some authors reported that a more advanced pubertal development in adolescent girls predicts lower psychological well-being, depression, negative body image [40]. Similarly, the current study also showed a significantly negative association between HRQoL and BMI, adjusted for age, pubertal stage and SES. This finding are largely consistent with the HRQoL literature [17], [35], [41], [42], [43].

Some authors have identified increased BMI is associated with poor HRQoL in children and adolescents [44], [45]. Several studies with school-aged children have shown associations between both overweight and obesity [46], [47], [48], [49] and a relatively low HRQoL. Another study also found lower HRQoL in adolescents

with excess weight than in those with a BMI in the normal weight range [50]. Wardle and Cooke [51] reported that obesity has some physical well-psychosocial consequences such as body image concerns, weight-related teasing [52], low self-esteem, depression and interpersonal difficulties [53]. Furthermore, the lower HRQoL in children with excess weight is also attributed to lower physical and psychosocial functioning and well-being [54] and have strong inverse relationships to both of these HRQoL aspects [19]. Conversely, a study comprising 8947 Fiji children (age 12–18 years) concluded that there is no association between excess weight and HRQoL [55]. Moreover, excess weight might have a effect on physical functioning and well-being, although one could speculate whether other factors might influence the relationship, such as cultural expectations and culturally determined levels of daily physical activity [55].

It is important to note that, in the regression analysis (model 7), the BMI no longer significantly predicted HRQoL after cardiorespiratory fitness was added to the model. Using a mediation analysis our study showed that cardiorespiratory fitness qualified as a full mediator on the association between BMI and HRQoL, in both sexes. This result is in line with recent findings from Morales et al. [56] that provided evidence of the relationship between fitness and HRQoL in children, and found the association between excessive body composition and HRQoL almost disappears when controlling for cardiorespiratory and musculoskeletal fitness.

The present study revealed that cardiorespiratory fitness contributed significantly more to the variance to HRQoL than BMI. This suggests that maintaining and enhancing cardiorespiratory fitness levels in adolescents points toward potential physical and mental health benefits. Accordingly, health practitioners and physical education teachers should be aware that adolescents who have poorer physical fitness levels may be more likely to perceive themselves in a negative manner suggesting that we should target health-related outcomes such as HRQoL by enhancing motivation for physical activity and consequently physical fitness levels. In this line, some studies showed positive associations between HRQoL and cardiorespiratory fitness [14], [57], [58]. However, scarce information has been released addressing the association between physical fitness and mental health in adolescents [59] thus longitudinal studies are needed.

Several limitations of our study should be recognized. First, this is a cross-sectional study which does not allow us to establish causality; second, we used a sum score from the KIDSCREEN-10 questionnaire, which does not permit for analyses of dimensions of HRQoL which is verified in extended versions of this scale (27- and 53-items). In our study, the assessment of body image were not included and controlled, despite the influences on obesity. The strengths of this study include the use of KIDSCREEN 10; that proves to be a very short and psychometric measure used in national and international epidemiological studies in children and adolescents [60], and serves to recognizing strategies to promote quality of life [61]. Moreover, our models also considered important potential confounders such as age, SES and pubertal stage.

Conclusions

In summary, this study suggests that HRQoL was inversely associated with BMI in both sexes, even after controlling for age, pubertal stage, and SES; and that cardiorespiratory fitness acted as a full mediator in the relationship between BMI and HRQoL, in adolescents. The findings also contribute to identify important predictors of children's HRQoL.

This study provided an opportunity to extend research investigating the importance of BMI and cardiorespiratory fitness in adolescents' health. Public health promotion should be supported, focusing more on the positive aspects of life and health of children and adolescents. More studies are needed to replicate these findings using longitudinal designs.

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ARTIGO II

O.S. Evaristo, C. Moreira, R. Santos, L. Lopes, S. Abreu, C. Agostinis-Sobrinho, J. Oliveira-Santos, S. Póvoas, A. Oliveira, J. Mota (2018). Muscular fitness and cardiorespiratory fitness are associated with health-related quality of life: results from Labmed Physical Activity Study (Submitted).

Muscular fitness and cardiorespiratory fitness are associated with health-related quality of life: results from Labmed Physical Activity Study

Olga Sofia Evaristo[1] MSc, Carla Moreira[1] PhD, Luís Lopes[1] PhD, André Oliveira[1] PhD, Sandra Abreu[1] PhD, César Agostinis-Sobrinho[1] PhD, José Oliveira-Santos[1] PhD, Susana Póvoas[3] PhD, Rute Santos[1,2] PhD, & Jorge Mota[1] PhD

[1] Research Centre in Physical Activity, Health and Leisure, Faculty of Sport – University of Porto – Portugal.
[2] Early Start Research Institute, Faculty of Social Sciences. University of Wollongong, Australia.
[3] Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University Institute of Maia, ISMAI, Maia, Portugal

Abstract

Background: Children's physical fitness levels are an important indicator of their lifestyle and seems to have positive consequences in health-related quality of life (HRQoL).

Objective: The purpose of this study is to analyse the combined associations of cardiorespiratory fitness and muscular fitness with HRQoL and to assess the differences between HRQoL score across groups of cardiorespiratory fitness and muscular fitness in a sample of Portuguese adolescents.

Design: This is a cross-sectional analysis with 567 Portuguese adolescents aged 12-18 years-old.

Methods: HRQoL was measured using the Kidscreen-10 questionnaire. Cardiorespiratory fitness was estimated with a 20-m shuttle-run. Muscular fitness was evaluated using handgrip and standing long jump tests and a muscular fitness index was computed by means of standardized measures of both tests. Socioeconomic status was assessed using the Family Affluence Scale. Body composition (body mass and height) was measured according to standard protocols. Accelerometers were used to obtain objective physical activity time. Pubertal stage was assessed using Tanner stages. Adherence to the Mediterranean diet was assessed using the KIDMED index. Participants were divided into four groups based on low or high values of both cardiorespiratory and muscular fitness. Regression analysis and ANCOVA were performed.

Results: HRQoL was positively associated with cardiorespiratory fitness ($B=0.112$; $p<0.05$) and muscular fitness score ($B=0.328$; $p<0.05$), after controlling

for potential confounders. Analysis of covariance after adjusting for potential confounders showed that adolescents with high cardiorespiratory fitness/high muscular fitness exhibit better HRQoL when compared to those with low muscular fitness/low cardiorespiratory fitness and with those with low muscular fitness/high cardiorespiratory.

Conclusions: In adolescents, the combination of high cardiorespiratory fitness and high muscular fitness is positively associated with a better HRQoL.

Keywords: *physical fitness; cardiorespiratory fitness; muscular fitness; health-related quality of life; youth; LabMed Study*

Introduction

Research on health-related quality of life (HRQoL) has increased in the last years. HRQoL can be defined as a multidimensional construct that relates to a person's self-perceived health and consists of ratings of well-being and functionality in important life areas, including physical well-being/functioning, emotional well-being, self-esteem, social functioning, and family relations (Ravens-Sieberer et al., 2008). Assessing a youth's HRQoL can help detect early impairments in well-being and functioning, as well as identify the subgroups of the population at higher risk for health problems (Ravens-Sieberer et al., 2008).

Physical fitness is widely recognized as a powerful marker of health-related outcomes, both in childhood and adulthood and an important determinant of current and future health status (Ortega, Ruiz, et al., 2008; Ruiz et al., 2009). Indeed, low levels of physical fitness during childhood and adolescence are associated with important health-related outcomes, such as increased risk of obesity and cardiovascular risk (De Miguel-Etayo et al., 2014; Ortega, Ruiz, et al., 2008; Ruiz et al., 2009), , novel cardiovascular disease risk factors (Ruiz et al., 2007) and with arterial compliance (Reed et al., 2005) , impaired skeletal health (Moliner-Urdiales et al., 2010; Vicente-Rodríguez et al., 2008), reduced quality of life (Gu et al., 2016; Morales et al., 2012), and mental health (Castelli

et al., 2007; Ruiz et al., 2009). Although most research has focused on the relationship between cardiorespiratory fitness and health outcomes, there is a growing interest in the relationship between muscular fitness and its health-related benefits. Indeed, high levels of muscular fitness and have been associated with decreased cardiovascular risk in youth independently of body mass and cardiorespiratory fitness (Artero et al., 2012; Steene-Johannessen et al., 2013) and it has also been favorably correlated with improved bone health, enhanced self-esteem, and decreased adiposity in children (Artero et al., 2012; Smith et al., 2014).

Recently, some studies have investigated the associations between cardiorespiratory fitness and muscular fitness with HRQoL, in children (Andersen et al., 2017; Gu et al., 2016; Morales et al., 2012) and in adolescents, using self-reported measures of fitness (Marques et al., 2017). However, at best of our knowledge, no studies have explored the combined associations between cardiorespiratory fitness and muscular fitness (assessed by field measures) with HRQoL in adolescents, controlling the analyses for a series of potential confounders such for age, sex, pubertal stage, socioeconomic status, adherence to a Mediterranean dietary pattern or physical activity.

Therefore, the purpose of this study is to examine the combined associations between cardiorespiratory fitness and muscular fitness with HRQoL and to assess the differences between HRQoL score across groups of cardiorespiratory fitness and muscular fitness in adolescents.

Methods

Study design and sample

The current report is part of the “Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study)", a school-based prospective cohort study carried out in five schools from the Northern Region of Portugal.

A full description of the study protocol can be seen elsewhere (Agostinis-Sobrinho et al., 2016; Oliveira-Santos et al., 2016).

Baseline data was collected in the fall of 2011, for all students that agreed to participate in the study (n=1229; aged 12 -18 years). From this initial total sample, 567 adolescents (287 girls and 280 boys) provided full data for the variables of interest for the current report and the present study was restricted to them.

The study was conducted in accordance with the World Medical Association’s Helsinki Declaration for Human Studies (World Medical Association, 1989). The Portuguese Data Protection Authority (#1112434/2011), the Portuguese Ministry of Science and Education (0246200001/2011) and the Faculty of Sports of University of Porto approved the study. All participants were informed of the study’s goals, and written informed consent was obtained from participating adolescents and their parents or guardians.

Measures

Health-Related Quality of Life

Health-related quality of life was assessed using the Portuguese self-report version of the Kidscreen-10 questionnaire (Gaspar et al., 2008) that has been transculturally developed in 13 European countries for the population of children and adolescents aged 8 to 18 years. Kidscreen-10 is a reduced version of the Kidscreen-52 questionnaire, which contains ten items assessed on a five-point Likert response scale ranging from 1 (never; not at all) to 5 (always; extremely). Kidscreen-10 results in an overall value for quality of life. This one-dimensional measure represents a global score adequate for use in large epidemiological surveys (Matos et al., 2012; Ravens-Sieberer et al., 2010). A low

value in this tool suggests a feeling of dissatisfaction and inadequacy in many areas of the lives of children and adolescents, in particular, family, peer group and school. A high value, conversely, suggests a perception of adequacy and satisfaction with their contexts (Gaspar et al., 2008).

Physical Fitness

Physical fitness was assessed following the protocols of the ALPHA health-related fitness battery (Ruiz et al., 2011). Cardiorespiratory fitness was assessed with the 20-m shuttle run test. Adolescents were required to run, in a straight line, between two lines distanced 20-m apart, while keeping pace with a pre-recorded audio CD. The initial speed was 8.5 km h^{-1}, which was increased by 0.5 km h^{-1} each minute (1 min = one stage). The test was finished when the adolescent failed to reach the end lines before the audio signal on two occasions. The maximum oxygen consumption (VO2max, mL/kg/min) was estimated using the equation of Leger et al. (1988). Adolescents were then classified into two groups (low or high cardiorespiratory fitness) according to proposed cut-offs by Ruiz et al. (2016) (low cardiorespiratory fitness level: below 42 and 35 mL/kg/min, for boys and girls, respectively).

Muscular fitness was assessed with the handgrip strength and the long jump tests. The handgrip strength (upper body isometric strength) was assessed using a handgrip dynamometer, (T.K.K. 5001, Grip-A produced by Takei, Japan). The participants were instructed to stand with their arms by their side, fully extended, squeezing the handgrip continuously for at least two seconds, performing the test with the right and left hands in turn. A rest period of 90-sec was given between trials. The grip-span of the dynamometer was adjusted according to the hand size and sex to determine the maximum handgrip strength using the equations specifically developed for children (España-Romero et al., 2008) and adolescents (Ruiz et al., 2006). The test was performed twice and the highest score for each hand was used for the analysis. The handgrip score (kg) was calculated as the average of the best left and right scores and then was expressed as kilogram of body mass (Agostinis-Sobrinho et al., 2016; Artero et al., 2014; Steene-Johannessen et al., 2013).

In the standing long jump test (lower body explosive strength) the adolescents were instructed to jump, from the starting line and to push off vigorously and jump as far forward as possible landing on both feet and staying upright. The test was performed twice and the best distance was recorded in centimeters. The distance between the first heel-mark and the take-off line determined the standing jump score (Ruiz et al., 2011).

The results of the handgrip strength and long jump tests were transformed into standardized values (Z-scores) according to age and sex. Then the sum of the Z-Scores of the two tests was used to create the muscular fitness score. Since there is no universally agreed cut-off for muscular fitness, scores below the 20th percentile were classified as low and those above as high score (Ortega et al., 2011; Steene-Johannessen et al., 2013).

Physical Activity

Physical activity was assessed with accelerometry (GT1M Actigraph, Pensacola, Florida, USA). The accelerometer was tightly attached to the waist (on the right hip), and used over five consecutive days (three weekdays and two weekend days), during waking hours and removed during sleep and water-based activities (Rothney et al., 2008; Silva et al., 2010). To be included, adolescents had to worn the monitor for at least three valid day (two weekdays and one weekend valid day) (Matthews et al., 2008) . The epoch length was set to 2 seconds. We work with an automated data reduction program (ActivLive 6.12, ActiGraph, Pensacola, Florida, USA) to treat accelerometer data. Each period of 60 minutes of consecutive zeros was detected as non-wear time (Colley et al., 2010; Troiano et al., 2008): a minimum of 10h/day of accelerometer wear time was considered as a valid day (Colley et al., 2010; Troiano et al., 2008). The screening procedures were consistent with current accelerometry studies and also similar to the screening used in National Health and Nutrition Examination Survey (NHANES) (Colley et al., 2010; Troiano et al., 2008).

The time spent in the different physical activity intensities was determined by the raw activity “counts”, considering Evenson’s cut-points (Trost et al., 2011).

Moderate-to-vigorous physical activity (MVPA) was expressed as average minutes per day.

Adherence to Mediterranean Diet

Dietary patterns were assessed with the KIDMED index (Mediterranean Diet Quality Index for children and adolescents) (Serra-Majem et al., 2004). The index is a self-administered 16-items questionnaire, which reflects the principles of the Mediterranean dietary patterns, as well as, those that undermine it. The final results of the index varied between 0 and 12 points, with higher scores indicating higher adherence to the Mediterranean diet. Responses to questions that had a negative connotation in relation to Mediterranean diet were given a score equal to (-1) and the questions that constituted positive aspects were scored (+1).

Body Mass and Height

Anthropometric measurements were performed according to standard procedures (Lohman et al., 1988). Body mass and height were measured using a portable electronic weight scale (Tanita Inner Scan BC 532, Tokyo, Japan), and a portable stadiometer (Seca 213, Hamburg, Germany), respectively, with the participant barefoot, wearing light clothing. Body mass index (BMI) was calculated as body mass divided by height squared (kg/m^2).

Pubertal Stage

Adolescents self-reported their pubertal stage (from 1 to 5) relatively the secondary sex characteristics, according to the criteria of Tanner and Whitehouse (Tanner & Whitehouse, 1976). Briefly, girls were assessed by the stage of breast development (Tanner A) and public hair distribution (Tanner B); boys were assessed by stage of genitalia development (penis size and testicular volume - Tanner A) and pubic hair distribution (Tanner B).

Socioeconomic Status

Adolescents' socioeconomic status was assessed using the Family Affluence Scale (Currie et al., 2008) developed specifically to measure children and adolescents socioeconomic status in the context of the Health Behavior in School-Aged Children Study. The Family Affluence Scale is a four-item questionnaire that helps students report their family income objectively. The final score ranges from 0 to 9 points, with higher scores indicating higher socioeconomic status.

Statistical Analysis

Descriptive data are presented as mean and standard deviation for continuous variables and percentages for categorical variables. To assess differences between the sexes, the independent two-tailed Student's *t*-test was used for the continuous variables and the chi-square test for the categorical variables.

Linear regression models were used to determine the associations between HRQoL (as the dependent variable) and cardiorespiratory fitness and muscular fitness score (as predictor variables), adjusted for age, sex, pubertal stage, socioeconomic status, adherence to a Mediterranean dietary pattern, accelerometer wear time and daily average of MVPA. Unstandardized regression coefficients were used to express the B in the linear regression analyses.

According to the cardiorespiratory fitness levels (low and high) and muscular fitness score (low and high), four exclusive groups were created (low cardiorespiratory fitness/low muscular fitness, low cardiorespiratory fitness/high muscular fitness, high cardiorespiratory fitness/low muscular fitness and high cardiorespiratory fitness/high muscular fitness).

Analysis of covariance (ANCOVA) with Bonferroni post-hoc multiple comparison tests were used to assess the differences between mean values of HRQoL score across the four groups of cardiorespiratory fitness and muscular fitness. Covariates included were age, sex, pubertal stage, socioeconomic status, BMI, adherence to a Mediterranean dietary pattern, daily average of MVPA and accelerometer wear time.

Data analysis was performed using the statistical software Statistical Package for Social Sciences (SPSS, Version 24.0). A *p*-value ≤0.05 denoted statistical significance.

Results

Table 1 shows the descriptive characteristics of the participants. Boys performed significantly better in the long jump and handgrip tests, and had higher VO_2max and muscular fitness score than girls; boys were also more active and reported better quality of life than girls (p<0.05 for all).

Table 1 - Descriptive characteristics of the participants by sex.

	Total (n=567) [a]	Girls (n=287) [a]	Boys (n=280) [a]	*p*[b]
Age (year)	14.0 (1.7)	14.1 (1.6)	13.9 (1.7)	0.581
Body mass (Kg)	54.0 (12.4)	52.8 (11.1)	55.2 (13.6)	**0.021**
Height (cm)	159 (0.09)	158 (0.06)	161 (0.11)	**<0.001**
BMI (kg/m^2)	21.1 (3.8)	21.1 (3.7)	21.1 (3.9)	0.882
Pubertal stage A (I/II, III, IV, V) (%)	8.3/34.7/45/12	4.5/31/51.9/12.5	12.1/38.6/37.9/11.4	**<0.001**
Pubertal stage B (I/II, III, IV, V) (%)	7.1/22.9/51.5/18.5	2.8/22.6/50.2/24.4	11.4/23.2/52.9/12.5	**<0.001**
Long jump (cm)	158.2 (30.1)	145.4 (23.8)	171.3 (30.2)	**<0.001**
Handgrip (kg)	26.1 (7.2)	23.2 (4.8)	29.1 (8.0)	**<0.001**
Handgrip/body mass (kg)	0.49 (0.11)	0.44 (0.09)	0.53 (0.12)	**<0.001**
Cardiorespiratory fitness – VO_2max (mL/kg/min)	42.3 (6.8)	38.8 (4.8)	45.9 (6.7)	**<0.001**
Daily average MVPA (minutes/day)	56.9 (20.7)	51.1 (19)	62.9 (20.6)	**<0.001**
Muscular fitness score	-0.30 (1.6)	-0.29 (1.5)	0.24 (1.7)	**<0.001**
KIMED index	7.1 (2.1)	7.3 (1.8)	7.0 (2.3)	0.086
Socioeconomic status	6.4 (1.7)	6.6 (1.7)	6.2 (1.7)	**0.011**
Health-related quality of life (Kidscreeen-10)	39.6 (5.4)	39.1 (5.5)	40.2 (5.3)	**0.018**

Abbreviations: BMI, body mass index; MVPA, moderate-to-vigorous physical activity.

[a] The data shown in percentage for categorical variables and mean (SD) for continuous variables.

[b] *p* value was calculated based on Qui-squared test for categorical variables and t-test for continuous variables.

Linear regression analysis (table 2), showed that cardiorespiratory fitness (B=0,112; *p*=0.007) and a muscular fitness score (B=0.328; *p*=0.043), were positively associated with HRQoL, after adjustments for age, sex, pubertal stage, socioeconomic status, adherence to a Mediterranean dietary pattern, daily average of MVPA and accelerometer wear time (models 2 and 4).

Cardiorespiratory fitness (B=0,144; *p*<0.001) and a muscular fitness score (B=0.412; *p*<0.001), were positively associated with HRQoL in unadjusted models (models 1 and 3). However, when both cardiorespiratory fitness and

muscular fitness score were included in the same model (model 5), after adjustments for aforementioned covariates, only cardiorespiratory fitness retains significance.

Table 2- Regression analysis predicting Health-Related Quality of Life.

	B (95% CI)	β	*p-value*
Model 1 - Cardiorespiratory Fitness	0.144 (0.094; 0.194)	0.206	**<0.001**
Model 2 - Cardiorespiratory Fitness	0.112 (0.030; 0.194)	0.141	**0.007**
Model 3 - Muscular Fitness score	0.412 (0.202; 0.622)	0.135	**<0.001**
Model 4 - Muscular Fitness score	0.328 (0.011; 0.646)	0.098	**0.043**
Model 5 - Cardiorespiratory Fitness	0.093 (0.004; 0.183)	0.117	**0.041**
Muscular Fitness score	0.183 (-0.164; 0.529)	0.055	0.301

B*:* Unstandardized coefficients; **β**: Standardized coefficients; **CI**- confidence interval.
Model 1 and model 3 – unadjusted models;
Model 2, model 4 and model 5 - adjusted for age, sex, pubertal stage, socioeconomic status, BMI, adherence to a mediterranean dietary pattern, accelerometer wear time and daily average of MVPA.

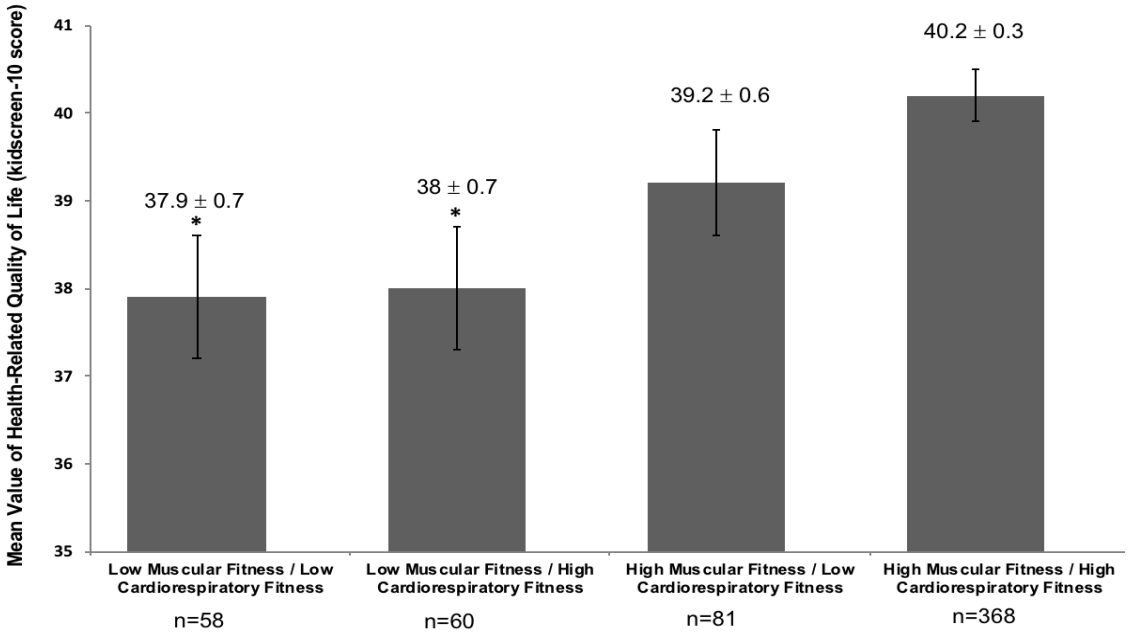

Figure 1: Mean value of health-related quality of life (Kidscreen-10) stratified in groups of cardiorespiratory fitness (low or high) and muscular fitness score (low or high).

* Significantly different from group High Muscular Fitness/High Cardiorespiratory Fitness, $p<0.05$.

As depicted in Figure 1 adolescent's group with high cardiorespiratory fitness and high muscular fitness showed significant higher HRQoL score when compared to those with low muscular fitness/low cardiorespiratory fitness and with those with low muscular fitness/high cardiorespiratory ($p<0.05$), after adjustments for age, sex, pubertal stage, socioeconomic status, adherence to a mediterranean dietary pattern, MVPA and accelerometer wear time.

Discussion

The main findings of this study suggest that both cardiorespiratory fitness and muscular fitness are positively associated with HRQoL. Moreover, when both cardiorespiratory fitness and muscular fitness score are included in the same model only cardiorespiratory fitness retains significance. Nevertheless, the interpretation should take into account the fact that the cut points of cardiorespiratory fitness were determined based on the cardiovascular disease risk, whereas the cut points for muscular fitness were based on percentile values.

Similar to our study, some studies have shown that cardiorespiratory fitness and muscular fitness are significantly related to physical and mental functioning of HRQoL. For example, Gu et al. (2016), examined the association between physical activity, physical fitness and HRQoL in 201 schoolchildren aged 9–11 years and found that all components of physical fitness including cardiorespiratory fitness, muscular fitness, and BMI were significantly related to physical and mental functioning of HRQoL, except flexibility. Andersen et al. (2017), in a cross-sectional analysis that included 1129 school children, aged 10 years, from 57 schools in Norway found that cardiorespiratory fitness is positively associated with higher scores on all five KIDSCREEN-27 domains and that explosive strength in the lower body was positively associated with higher autonomy and parent scores. Conversely, the Health Behaviour in School-Aged Children study of Portuguese adolescents showed that self-reported cardiorespiratory fitness levels, but not muscular fitness, were positively and significantly associated with HRQoL (Marques et al., 2017). Morales et al. (2012) provided the primary evidence of the relationship between fitness and HRQoL in 1,158 Spanish schoolchildren aged 8–11 years and found that the association

between being overweight and HRQoL almost disappeared when the analysis was controlled for cardiorespiratory fitness and muscular fitness. In that study, cardiorespiratory fitness and muscular fitness were associated with better scores in the dimensions of physical well-being. In boys, higher levels of cardiorespiratory fitness were associated with better scores in the dimensions of physical well-being and social support of peers; in girls, cardiorespiratory fitness was associated with physical well-being, self-perception, social acceptance, and overall KIDSCREEN-10 index (Morales et al., 2012). Furthermore, in boys, muscular fitness was also associated with social acceptance and social support of peers. In girls, muscular fitness was also associated with KIDSCREEN-10 index (Morales et al., 2012). According to Riiser et al. (2014), KIDSCREEN-10 does not allow for analyses of dimensions of HRQoL. Even so, the contribution of cardiorespiratory fitness on overall HRQoL may emphasize the importance of physical performance for well-being. Evidence suggests that improvements in cardiorespiratory fitness have a positive effect on the psychological well-being of children and adolescents (Crews et al., 2004; Ortega, Artero, et al., 2008).

As cardiorespiratory fitness is strongly and positively associated with physical activity, intervention programs aimed at enhancing physical activity and fitness levels of the youth population may benefit their cardiorespiratory fitness and consequently, improve their health perception and well-being (Fuller et al., 2017; Ørntoft et al., 2016). Thus, this is of great value to public health and an important subject of research.

One factor known to influence perceived health and well-being among adolescents is body image (Haraldstad et al., 2011). There is some research showing associations between lower levels of cardiorespiratory fitness and body dissatisfaction (Olive et al., 2012). According to Neumark-Sztainer et al. (2006), body dissatisfaction is shown to be positively related to lower exercise rates in both boys and girls.

Another variable that may explain the potential relationship between cardiorespiratory fitness and HRQoL is exercise motivation. Self-determined motivation for physical activity and exercise has been positively associated with both HRQoL and exercise behavior in adolescents (Carver & Scheier, 2001;

Gillison et al., 2006; Riiser et al., 2014). According to self-determination theory, people can be intrinsically and extrinsically motivated, as well as motivated in their regulations towards physical activity and exercise (Riiser et al., 2014).

Our results suggest that both cardiorespiratory fitness and muscular fitness may play a role on the HRQoL of adolescents after adjustment for several confounders. Indeed, adolescents with high cardiorespiratory fitness and high muscular fitness showed better HRQoL with significant differences between groups. Therefore, muscular fitness seems to have more of an impact than cardiorespiratory fitness on the quality of life of the adolescents in this sample. Previous research investigating the relationship between physical fitness and health outcomes has mainly focused on cardiorespiratory fitness; however, recent studies have shown that muscular fitness is also favorably associated with health benefits in adolescents (Agostinis-Sobrinho et al., 2016; Artero et al., 2014). Furthermore, children with high levels of cardiorespiratory fitness usually show higher physical activity levels later in life (Huotari et al., 2011; Jose et al., 2011), improved academic performance, as well as improved inhibitory control (which allows children to better regulate their behavior), attention, emotions and academic performance (Chaddock et al., 2012; Diamond, 2013; Haapala, 2013; Hillman et al., 2009; Pontifex et al., 2011; Voss et al., 2011), and leads to favorable structural and functional neuronal adaptations (Chaddock-Heyman et al., 2014).

Recently, the findings of Ortega et al. (2012) in a study involving 1,142,599 Swedish male adolescents, aged 16–19 years, suggested that high muscular fitness had a 20–30% lower risk of early death from suicide and was 15–65% less likely to have any psychiatric diagnosis, such as schizophrenia or mood disorders, showing that muscular strength is inversely and independently associated with death from suicide.

Some limitations of the present study should be recognized. First, this is a cross-sectional study, which does not allow us to establish causality. Second, we used a sum score from the Kidscreen-10 questionnaire, which does not permit for analyses of the dimensions of HRQoL, which is verified in extended versions of this scale (27- and 52-items). Strengths of this study include the novelty of the

analyses of combined associations of cardiorespiratory fitness and muscular fitness with HRQoL in adolescents. Furthermore, is the use of a valid health-related fitness battery (Ruiz et al., 2011) for physical fitness assessment, which can be administered in school settings where a large number of participants can be tested simultaneously, thus enhancing participant motivation and making it a valuable tool for routinely measuring physical fitness in youth.

Conclusions

The present study suggests that the combination of both high cardiorespiratory fitness and muscular fitness is synergistically associated with a better HRQoL in a sample of Portuguese adolescents.

From a public health perspective, our results underline the importance of promoting cardiorespiratory fitness and muscular fitness in programs aiming at improving adolescent's health and well-being. Further data are needed to replicate these findings using longitudinal designs.

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ARTIGO III

O.S. Evaristo, C. Moreira, R. Santos, L. Lopes, S. Abreu, C. Agostinis-Sobrinho, J. Oliveira-Santos, S. Póvoas, A. Oliveira, J. Mota (2018). Associations between physical fitness and adherence to the Mediterranean diet with health-related quality of life in adolescents: results from the LabMed Physical Activity Study. Journal of Public Health (Published).

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Associations between physical fitness and adherence to the Mediterranean diet with health-related quality of life in adolescents: results from the LabMed Physical Activity Study

Olga Sofia Evaristo[1], Carla Moreira[1], Luís Lopes[1], Sandra Abreu[1], César Agostinis-Sobrinho[1,2,3], José Oliveira-Santos[1], Susana Póvoas[4], André Oliveira[1], Rute Santos[1,5], Jorge Mota[1]

1 Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, Porto, Portugal
2 Faculty of Health Sciences, Klaipeda University, Klaipėda, Lithuania
3 Physical Education, Physiotherapy and Dance, Federal University of the South of Brazil, Porto Alegre, Rio Grande do Sul, Brazil
4 Research Center in Sports Sciences, Health Sciences and Human Development, CIDESD, University Institute of Maia, ISMAI, Maia, Portugal
5 Early Start Research Institute, Faculty of Social Sciences, University of Wollongong, Wollongong, NSW, Australia

Correspondence: Carla Moreira, Research Centre in Physical Activity, Health and Leisure, Faculty of Sport, University of Porto, R. Plácido Costa, 91, 4200 450 Porto, Portugal, Tel: +351 (0) 22 5074786, Fax: +351 (0) 22 5500689, e-mail: carla_m_moreira@sapo.pt

Background: Physical fitness (PF) and adherence to the Mediterranean diet are important indicators of healthy lifestyles. The purpose of this study is to analyze the independent and combined associations between PF and adherence to Mediterranean diet with health-related quality of life (HRQoL) in adolescents. **Methods:** This is a cross-sectional analysis with 956 Portuguese adolescents aged 12–18 years. HRQoL was measured with the Kidscreen-10 questionnaire. PF was assessed with the ALPHA health-related fitness battery. The 20-m shuttle run test was used for the estimation of cardiorespiratory fitness; handgrip strength and standing long jump tests were applied for the assessment of muscular fitness and the 4 × 10 m shuttle run test for the assessment of motor fitness (speed and agility). The results of the PF tests (cardiorespiratory fitness, muscular fitness and motor fitness) were transformed into standardized values (*Z*-scores) by age and sex. Adherence to the Mediterranean diet was assessed with the KIDMED index. Regression analysis and analysis of covariance were performed. **Results:** PF ($B = 0.228$; $P < 0.05$) and adherence to the Mediterranean diet ($B = 0.259$; $P < 0.05$) were positively associated with HRQoL, after controlling for several variables. Participants classified as high PF and high adherence to Mediterranean diet had on average the highest HRQoL score compared with those with low PF and low adherence to Mediterranean diet ($F_{(3,\ 939)} = 4.270$; $P = 0.005$), after adjustments for potential confounders. **Conclusions:** The combination of high PF levels and optimal adherence to Mediterranean diet is positively associated with HRQoL.

Introduction

Health-related quality of life (HRQoL) is a multidimensional construct that relates to a person's self-perceived health and consists of ratings of well-being and functionality, including physical well-being/functioning, emotional well-being, self-esteem, social functioning and family relations.[1]

During adolescence, several biological, physical, cognitive, psychological, social and emotional factors can affect one's HRQoL and well-being.[2] Physical fitness (PF) has been associated with health benefits in young people[3] and is considered a marker of a healthy lifestyle, as well as a predictor of morbidity and mortality from cardiovascular disease and other causes.[4] Previous data from Portuguese adolescents from the Health Behaviour in School-Aged Children (HBSC) study showed that self-reported fitness levels were positively associated with HRQoL.[5] Likewise, three other studies indicated that both cardiorespiratory fitness and muscular fitness were positively associated with HRQoL in schoolchildren aged 8–11 years.[6–8]

The Mediterranean diet is considered one of the healthiest dietary patterns.[9] Indeed, several studies have shown that greater adherence to a Mediterranean-like dietary pattern is associated with an improved health status[10] with beneficial effects on arterial stiffness[11]; academic performance[12] and the intensity of physical activity behaviour.[13] However, recent data indicates that adherence to this dietary pattern is decreasing in Mediterranean regions, particularly among children and adolescents.[14]

Some recent studies have investigated the associations between Mediterranean diet and HRQoL in adolescents[15,16] and reported positive associations between HRQoL and adherence to Mediterranean diet in youth. However, few studies have addressed the relationship between overall PF and Mediterranean diet with HRQoL in adolescents. Therefore, the aim of this study was to examine the independent combined associations between PF and adherence to the Mediterranean diet with HRQoL in adolescents.

Methods

Study design and sample

The current report is part of the 'Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study)', a school-based prospective cohort study carried out in five Portuguese cities from the Northern Region. The full description of the study protocol and measures can be seen in detail elsewhere.[17] Briefly, baseline data was collected in the fall of 2011, for all students that agreed to participate in the study ($n = 1229$; aged 12–18 years). From this initial total sample, 956 adolescents (446 girls and 510 boys) had provided

complete data on the variables of interest of the present report and therefore were included in this study.

The study was conducted in accordance with the Portuguese Data Protection Authority (#1112434/2011), and the Portuguese Ministry of Science and Education (0246200001/2011) and the Faculty of Sports of University of Porto approved the study. All participants were informed of the study's goals, and written informed consent was obtained from participating adolescents as well as from their parents or tutors.

Measurements

Health-related quality of life

HRQoL was assessed by Kidscreen-10 questionnaire. It contains 10 items regarding family life, peers and school life. Kidscreen-10 is a one-dimensional measure that represents a global score adequate for use in large epidemiological surveys.[18]

Physical fitness

PF was assessed following the protocols of the ALPHA health-related fitness battery.[3] Participants performed the following tests: 20-m shuttle run test to estimate cardiorespiratory fitness; handgrip strength and standing long jump tests for the assessment of muscular fitness and, the 4 × 10 m shuttle run test to assess motor fitness (speed and agility).

For the 20-m shuttle run test the participants were required to run in a straight line, between two lines distanced 20-m apart, while keeping pace with a pre-recorded audio CD. The initial speed was 8.5 km.h^{-1}, which was increased by 0.5 km.h^{-1} each minute (1 min = one stage). The test was finished when the adolescent failed to reach the end lines before the audio signal on two occasions. The number of shuttles was recorded.

Upper body isometric strength was assessed using a handgrip dynamometer, (T.K.K. 5001, Grip-A produced by Takei, Japan), adjusted by sex and hand size of each adolescent using the equations specifically developed for adolescents.[19] Participants were instructed to stand with their arms by their side, fully extended, squeezing the handgrip continuously for at least 2 s, performing the test with the right and left hands in turn. A rest period of 90-s was given between trials. The test was performed twice and the best score recorded for each hand was used for analysis. The handgrip score (in kg) was calculated as the average of the left and right best scores and then was expressed in kilograms of body mass.[20]

In the standing long jump test (lower body explosive strength), the adolescents were instructed to jump, from the starting line and to push off vigorously and jump as far forward as possible landing on both feet and staying upright. The test was performed twice and the best distance was recorded in centimeters for analysis. The distance between the first heel-mark and the take-off line determined the standing jump score.[3]

For motor fitness, the participants were asked to run 4 × 10 m (back and forth), as fast as possible. Two parallel lines were drawn on the floor 10-m apart. In the start line, there was one sponge (B) and in the opposite line there were two sponges (A, C). When the start was given, the participant (without sponge) ran as fast as possible to the other line and returned to the starting line with the sponge (A), crossing both lines with both feet, then sponge (A) was changed by the sponge B in the starting line. Afterwards, the participant went back running as fast as possible to the opposite line and changed the sponge B by the C, and then ran back to the starting line. The test was performed twice and the best score was recorded in seconds for analysis. Lower scores indicate better performance.

The results of the PF tests (cardiorespiratory fitness, muscular fitness and motor fitness) were transformed into standardized values (*Z*-scores) by age and sex. The *Z*-score of motor fitness was multiplied by −1, because a lower score indicates better performance. Then, the sum of the *Z*-Scores of tests was used to create the PF score. High PF score was considered when the participant had ≥1 SD of this *Z*-score.

Adherence to Mediterranean diet

Participants self-reported their dietary intake with the KIDMED index (Mediterranean Diet Quality Index for children and adolescents) developed by Serra-Majem et al.[21] The final scores of the KIDMED index vary between 0 and 12 points, with higher scores indicating higher adherence to the Mediterranean diet. Participants were classified into three categories: (i) ≥8, optimal Mediterranean diet; (ii) 4–7, improvement is needed to adjust intake to Mediterranean patterns and (iii) ≤3, very low diet quality as proposed by Kontogianni.[22]

Body mass and height

Anthropometric measurements were performed according to standard procedures. Body mass and height were measured using a portable electronic weight scale (Tanita Inner Scan BC 532, Tokyo, Japan) and a portable stadiometer (Seca 213, Hamburg, Germany), respectively, with the participant barefoot, wearing light clothing. Body mass index (BMI) was calculated as body mass divided by stature squared (kg/m^2).

Pubertal stage

Adolescents self-reported their pubertal stage (from 1 to 5) relatively the secondary sex characteristics, according to the criteria of Tanner and Whitehouse.[23] Girls were assessed by the stage of breast development (Tanner A) and public hair distribution (Tanner B), and boys by the stage of genitalia development (penis size and testicular volume—Tanner A) and pubic hair distribution (Tanner B).

Socioeconomic status

Adolescents' socioeconomic status was assessed using the Family Affluence Scale,[24] a four-item questionnaire where the participants report whether their family owns a car, whether they have his/her own bedroom, the number of family vacations during the last 12 months and the number of computers that the family owns. The items are summed to give a final socioeconomic index ranging from 0 to 9 points, with higher scores indicating higher socioeconomic status.

Sleep duration

Habitual sleep duration was self-reported, using the HBSC questionnaire. Adolescents were asked what time they usually woke up in the morning and what time they usually went to bed at night on a typical school day and on a typical weekend day. Average sleep duration per night was calculated as follows: 5 × sleep duration on weekdays plus 2 × sleep duration on weekend days.

Statistical analysis

Descriptive data are presented as means and standard deviations for continuous variables and in the case of the categorical variables as frequencies and percentages. To assess differences between sexes, the independent student's *t*-test was used for the continuous variables and chi-square test for the categorical variables.

Linear regression models were performed to determine the associations between PF and Mediterranean diet score (as predictors—independent and combined) and HRQoL (as dependent variable), adjusted for age, sex, pubertal stage, socioeconomic status, sleep duration and BMI. Unstandardized regression coefficients were used to express the *B* coefficients of the regression analyses.

Analysis of covariance (ANCOVA) with Bonferroni *post hoc* multiple comparison tests were used to assess the differences

Table 1 Descriptive characteristics of the participants by sex

	Total ($n=956$)[a]	Girls ($n=446$)[a]	Boys ($n=510$)[a]	P*
Age (year)	14.5 (1.8)	14.3 (1.7)	14.6 (1.9)	**0.003**
Body mass (kg)	55.9 (12.8)	53.6 (10.9)	57.9 (13.9)	**<0.001**
Height (cm)	1.61 (0.10)	1.58 (0.07)	1.64 (0.1)	**<0.001**
BMI (kg/m^2)	21.1 (3.8)	21.1 (3.7)	21.1 (3.9)	0.882
Pubertal stage A (I/II–V) (%)	7.4/30.5/48.1/14	4/30.2/51.5/14.3	10.4/30.7/45.2/13.7	**0.004**
Pubertal stage B (I/II–V) (%)	5.9/21.3/52.2/20.5	2.7/23.3/51/23	8.7/19.7/53.3/18.3	**0.001**
Long jump (cm)	161 (33)	141.4 (24.1)	177.6 (30.3)	**<0.001**
Handgrip (kg)	27.8 (8.6)	23.3 (4.8)	31.7 (9.2)	**<0.001**
Handgrip/body mass (kg)	0.50 (0.1)	0.44 (0.09)	0.55 (0.12)	**<0.001**
Cardiorespiratory fitness (number of shuttles)	45.9 (25.9)	30.7 (14.9)	58.9 (26.2)	**<0.001**
Motor fitness (s)	11.7 (1.3)	12.4 (1.2)	11.1 (1.1)	**<0.001**
PF score	−0.0088 (2.9)	−0.52 (2.9)	0.44 (1.8)	**<0.001**
Mediterranean diet (KIDMED index)	7.1 (2.1)	7.3 (1.8)	7.0 (3.1)	0.086
Very low diet quality (≤3) (%)	6.4	4	8.4	
Improvement is needed (4–7) (%)	52.8	53.2	52.4	**0.020**
Optimal Mediterranean diet (≥8) (%)	40.8	42.8	39.2	
Socioeconomic status	6.4 (1.6)	6.4 (1.6)	6.3 (1.6)	**0.011**
Sleep duration average (h)	8.6 (0.9)	8.5 (0.9)	8.6 (0.9)	0.071
Sleep duration on weekends (h)	9.6 (1.6)	10.0 (1.4)	9.3 (1.6)	**<0.001**
HRQoL (Kidscreeen-10)	39.1 (5.6)	38.6 (5.7)	39.5 (5.4)	**0.009**

Pubertal stage-A, breast development in girls; genital development in boys. Pubertal stage-B, pubic hair development.
a: The data shown in percentage for categorical variables and mean for continuous variables.
*: *P* value was calculated based on Qui-squared test for categorical variables and *t*-test for continuous variables.

between mean values of HRQoL across groups of PF (low and high) and adherence to Mediterranean diet: low (the first two categories collapsed 'improvement is needed' and 'very low quality diet') and high ('optimal Mediterranean diet'). Covariates included were age, sex, pubertal stage, socioeconomic status, sleep duration and BMI.

Data analyses were performed with the statistical software Statistical Package for Social Sciences (Windows version 24.0; SPSS Inc., Chicago, IL, USA). A P values < 0.05 was considered to indicate statistical significance.

Results

Table 1 shows the descriptive characteristics of the participants. Boys outperformed girls in all PF tests ($P<0.001$ for all), while girls reported a significantly higher optimal adherence to the Mediterranean diet ($P=0.020$) than boys.

As shown in table 2, a significant association between PF score ($B=0.228$; $P<0.05$) and adherence to Mediterranean diet ($B=0.259$; $P<0.05$) and HRQoL was found, after adjustments for age, sex, pubertal stage, socioeconomic status, sleep duration and BMI (model 6).

ANCOVA (figure 1) showed that adolescents with high PF and high adherence to Mediterranean diet had on average the highest HRQoL score ($F_{(3,\ 939)} = 4.270$ $P=0.005$). Significant differences were found for HRQoL score between low PF and low adherence to Mediterranean diet after adjustments for potential confounders.

Table 2 Unstandardized regression coefficients examining the associations between PF and adherence to Mediterranean Diet and HRQoL

	HRQoL	
	B (95% CI)	*P*-value
Model 1 (Crude)		
Mediterranean diet	0.325 (0.159–0.490)	<0.001
Model 2 (Crude)		
PF score	0.278 (0.161–0.394)	<0.001
Model 3 (Crude)		
Mediterranean diet	0.314 (0.150–0.478)	<0.001
PF score	0.274 (0.158–0.390)	<0.001
Model 4 (adjusted for all confounders)		
Mediterranean diet	0.275 (0.112–0.438)	0.001
Model 5 (adjusted for all confounders)		
PF score	0.241 (0.107–0.374)	<0.001
Model 6 (adjusted for all confounders)		
Mediterranean diet	0.259 (0.096–0.421)	0.002
PF score	0.228 (0.095–0.361)	0.001

B, Unstandardized coefficients; CI, confidence interval. Models 1–3: unadjusted model. Models 4–6: adjusted for age, sex, pubertal stage (Tanners A and B), socioeconomic status, sleep duration and BMI.

Discussion

To the best of our knowledge this is one of the first studies to analyze the associations between all components of PF (cardiorespiratory, muscular and motor fitness) and adherence to Mediterranean diet with HRQoL among adolescents. Our data showed that adolescents with high overall PF and high adherence to Mediterranean diet had the highest HRQoL score. These results suggest that the combination of these two components of healthy lifestyle seem to be beneficial to adolescents' HRQoL. In other words, the cross-sectional design of this study, PF and Mediterranean diet, seem to have a powerful combined and cumulative association on HRQoL in adolescents.

This study also showed that adherence to the Mediterranean diet was significantly and positively associated with higher HRQoL scores, which is in line with a recent study with Spanish adolescents, suggesting that higher adherence to the Mediterranean diet predicted higher HRQoL scores.[15] Likewise, another study with Greek adolescents revealed a significant positive association between adherence to the Mediterranean diet and HRQoL.[16] Several biological and physiological mechanisms could explain the beneficial effect of the Mediterranean diet on physical health.[25] Estruch et al.[26] reported that greater adherence to the Mediterranean diet is associated with a significant improvement in general physical and psychological health, in longevity and lower levels of obesity, as well as lower incidence of atherosclerosis, metabolic syndrome and inflammation, and reduced risk of major chronic diseases. Some studies attribute the Mediterranean diet with some degree of protection with respect to cognitive impairment, dementia or depression incidence.[27] Indeed, the Mediterranean

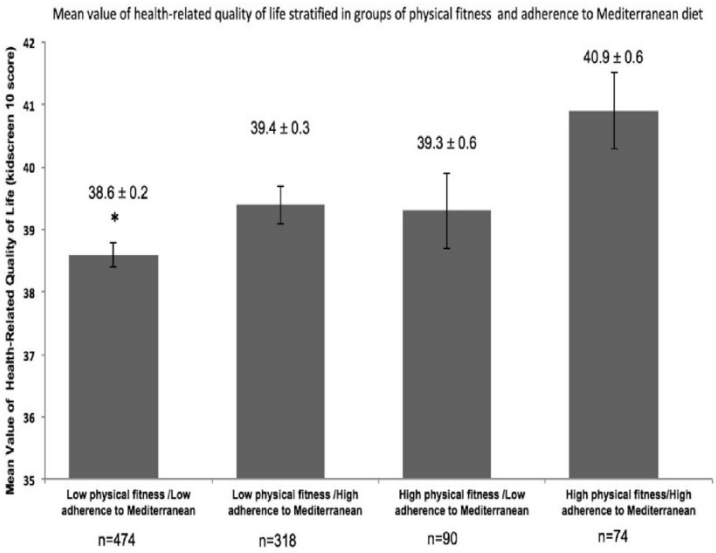

Figure 1 Mean value of HRQoL stratified in groups of PF (low or high) and adherence to Mediterranean diet (low or high). ∗Significantly different from the high PF/high adherence to Mediterranean diet ($P < 0.05$)

diet is rich in nutrients such as antioxidants, fibre, minerals, vitamins, omega-3 fatty acids (from fish) and monounsaturated fatty acids (from olive oil), whose beneficial effects on health have been recurrently established[28] Recently, some studies suggested the protective role of olive oil in mental disorders[29] and physical benefits.[30] The consumption of fish has also been related to better HRQoL because of its content in beneficial nutrients for health such as omega-3 fatty acids, vitamins and antioxidants.[25] Moreover, the consumption of fruits and vegetables has a positive association with physical and mental health status.[31]

We found a significant association between PF score and HRQoL, after adjustments for all confounders, which is consistent with other studies.[5,6] For example, Gu et al.[6] examined the association between PF and HRQoL and found that all components of PF were significantly related to physical and mental functioning of HRQoL, except flexibility. Another study, with Portuguese adolescents from the HBSC study, showed that self-reported fitness levels (overall fitness) were positively and significantly associated with HRQoL.[5]

PF is considered one of the most important health status markers that predicts cardiovascular disease and mortality.[32] Evidence suggests that the development of all components of PF early in life is of serious importance to maintaining PF and health outcomes later on in life.[33] However, a major determinant of PF is the level of physical activity.[34] The pathways by which physical activity and fitness are associated with physical and psychological well-being are still not fully perceived in adolescents; however, some mechanisms have been postulated for children.[35] For example, regular physical activity increases fitness and thus improves vascular and metabolic function[36] and leads to favourable structural and functional neuronal adaptations,[37] and improves attention, emotions, inhibitory control and academic performance.[38]

Our results suggest that maintaining and enhancing PF in adolescents has the potential of yielding physical and mental health benefits. Our data also pointed-out that girls had significantly lower HRQoL scores than boys, which is in line with previous findings.[39,40] These, sex differences in HRQoL could be explained by advanced pubertal development and social factors that may predict lower psychological well-being and negative body image in girls.

Some limitations of this study should be recognized. First, this is a cross-sectional study that does not allow us to establish causality. Second, we used a sum score from the Kidscreen-10 questionnaire, which does not allow analyses for each of the dimensions of HRQoL and is verified in extended versions of this scale (27- and 53-items). Third, we cannot rule out some reporting bias because we used self-reported dietary intake data.

Important strengths of this study include the evaluation of both independent and combined associations of lifestyle variables (PF and Mediterranean diet) that have been shown to be associated with HRQoL; the study was conducted on a relative large sample of adolescents. We controlled for a wide range of covariates, including socioeconomic status and sleep duration that are related with HRQoL.

In conclusion, we have shown that the combination of high PF levels and optimal adherence to Mediterranean diet is positively associated with better HRQoL scores in Portuguese adolescents.

The self-perceived health of adolescents is increasingly recognized as a relevant outcome in public health research. As a result, more studies investigating the effect of Mediterranean diet and PF on HRQoL in youth are needed.

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Conflicts of interest: None declared.

Key points

- Aside from the effects on biological parameters, the consideration of associations between physical fitness with psychosocial aspects of health should be taken into account.
- Both physical fitness and adherence to a healthy dietary pattern should be considered in intervention programmes to improve psychosocial aspects of health and well-being.
- Measuring health-related quality of life is important as a way of monitoring the health of the population.

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ARTIGO IV

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Cardiorespiratory fitness and health-related quality of life in adolescents: a longitudinal analysis from the LabMed Physical Activity Study

Olga Sofia Evaristo[1] MSc, Carla Moreira[1] PhD, Luís Lopes[1] PhD, César Agostinis-Sobrinho[1] PhD, Sandra Abreu[1, 2] PhD, José Oliveira-Santos[1] PhD, André Oliveira[1] PhD, Jorge Mota[1] PhD, Rute Santos[1,3] PhD

[1] Research Centre in Physical Activity, Health and Leisure, Faculty of Sport – University of Porto – Portugal.
[2] Lusófona University of Porto, Faculty of Psychology, Education and Sport, Porto, Portugal
[3] Early Start, Faculty of Social Sciences. University of Wollongong, Australia.

Abstract

Background: There is an insufficient number of longitudinal studies that examine the association between cardiorespiratory fitness and health-related quality of life (HRQoL) in adolescents.

Purpose: The purpose of this study was to examine the longitudinal associations between cardiorespiratory fitness and HRQoL in a sample of adolescents, and to determine whether changes in cardiorespiratory fitness were associated with HRQoL over a 2-year follow-up.

Design: This is a longitudinal analysis with 571 Portuguese adolescents (274 boys and 297 girls) aged 12-18 years.

Methods: HRQoL was measured with the Kidscreen-10 questionnaire; the 20 m shuttle-run was used to estimate cardiorespiratory fitness; socioeconomic status was assessed with the Family Affluence Scale; and pubertal stage was assessed with Tanner stages. One-way repeated measures analysis of variances (ANOVAs), regression analysis, and ANCOVA were performed.

Results: HRQoL decreased more over the time for girls reporting poorer HRQoL than for boys. After adjustments for potential confounders, regression analyses showed significant cross-sectional associations between cardiorespiratory fitness and HRQoL both at baseline (B=0.095; *p*=0.023) and at follow-up **(**B**=**0.090; *p*=0.012). ANCOVA showed that adolescents whose cardiorespiratory fitness decreased over time exhibited lower scores of HRQoL at follow up, compared to those with persistent high cardiorespiratory fitness; this held after adjustments for age, sex, socioeconomic status, and pubertal stage.

Conclusions: Changes in cardiorespiratory fitness during adolescence were associated with HRQoL over a two-year period. This study suggests that improving cardiorespiratory fitness could be a particularly important strategy in improving the HRQoL of adolescents.

Keywords: *Aerobic fitness; quality of life; youth; follow-up*

Introduction

Adolescence is a crucial stage of life, with many major physiological and psychological changes. During this period, lifestyle and health behaviors and habits are established, which may subsequently influence behavior and health status in adulthood (Taylor et al., 2015).

Cardiorespiratory fitness is an important marker of health (Ortega et al., 2008; Ross et al., 2016), and improvements in cardiorespiratory fitness are associated with reduced mortality risk (Lee et al., 2010) and improved mental health (Castelli et al., 2007; Ruiz, Castro-Piñero, et al., 2009). It has been shown that higher levels of cardiorespiratory fitness in childhood and adolescence are associated with a healthier cardiovascular profile and with reduced risk of developing metabolic syndrome and arterial stiffness later in life (Ruiz, Castro-Piñero, et al., 2009).

Health-Related Quality of Life (HRQoL) is commonly described as a multidimensional construct that reports a person's subjective perspective on physical, social, psychological, and functional aspects of health (Ravens-Sieberer et al., 2006). Several cross-sectional studies of youth have shown a positive association between cardiorespiratory fitness and HRQoL (Guedes et al., 2014; Marques et al., 2017; Padilla-Moledo et al., 2012; Riiser et al., 2014). However, despite of these findings, data is insufficient from prospective studies on the impact of changes in cardiorespiratory fitness on adolescents' HRQoL. Indeed, most studies that investigate the association of cardiorespiratory fitness and HRQoL are cross-sectional. Thus, until now, investigation has been unable to establish conclusions regarding the prospective association over time between cardiorespiratory fitness and HRQoL in adolescents.

Some longitudinal studies found a positive relationship between cardiorespiratory fitness and HRQoL (Sloan et al., 2009), both in apparently-healthy adults as well as in adults at risk for developing cardiovascular disease (Clennin et al., 2015). Consequently, identifying the impact of the cardiorespiratory fitness trajectory on HRQoL during adolescence is important for public health purposes, because it is known that HRQoL and cardiorespiratory fitness decrease in adolescence (Meade & Dowswell, 2016; Tomkinson et al., 2017). Therefore, the aim of this study was to examine the longitudinal association between cardiorespiratory fitness and HRQoL in adolescents, and to determine whether changes in cardiorespiratory fitness were associated with HRQoL at a 2-year follow-up.

Methods

Study design and participants

The current report is part of the “Longitudinal Analysis of Biomarkers and Environmental Determinants of Physical Activity (LabMed Physical Activity Study)", a school-based prospective cohort study carried out in five Portuguese schools from the Northern Region. A full description of the study protocol and procedures can be found elsewhere (Agostinis-Sobrinho et al., 2016; Oliveira-Santos et al., 2016). Briefly, baseline data was collected in the fall of 2011 for all students that agreed to participate in the study (n=1229; aged 12 -18 years). 1,011 and 789 subjects were reevaluated 1 and 2 years later, respectively. Of those, 571 adolescents (274 boys and 297 girls) had complete data on the variables of interest for the present study in year 1 and 3.

The study was conducted in accordance with the World Medical Association’s Helsinki Declaration for Human Studies (World Medical Association, 1989); the Portuguese Data Protection Authority (#1112434/2011); and the Portuguese Ministry of Science and Education (0246200001/2011). All participants were informed of the study’s goals, and written informed consent was obtained from participating adolescents as well as from their parents or tutors.

Measurements

Health-Related quality of life

Health-related quality of life was assessed using the Portuguese self-report version of the Kidscreen-10 questionnaire (Gaspar et al., 2008), that has been transculturally developed in 13 European countries for the population of children and adolescents aged 8 to 18 years. This instrument assesses 10 dimensions and is used to validate evidence to support inferences about general measures of quality of life. The Kidscreen-10 is a reduced version of Kidscreen-52 questionnaire, of which contains ten items answered on a five-point Likert response scale ranging from 1 (never; not at all) to 5 (always; extremely). The items resulted in one global score, with higher scores representing better HRQoL, that represents a global score adequate for use in large epidemiological surveys, as described elsewhere (Matos et al., 2012; Ravens-Sieberer et al., 2010).

Cardiorespiratory fitness

Cardiorespiratory fitness was assessed by the 20-m shuttle-run test. The adolescents were required to run in a straight line between two lines 20 m apart, while keeping pace with a pre-recorded audio CD. The test was finished when the adolescent failed to reach the end line before the audio signal on two consecutive occasions. The initial speed was 8.5 km/h^{-1}, which was increased by 0.5 km/h^{-1} each minute (1 min = one stage).

We estimated the maximum oxygen consumption (VO2max, mL/kg/min) according to the number of laps performed Leger et al. (1988). Adolescents were then classified into two groups (low or high) according to a cut-off for adolescents proposed by Ruiz et al. (2016) (low cardiorespiratory fitness level: below 42 or 35 mL/kg/min for boys or girls, respectively).

Adolescents were further divided into four groups, according to their cardiorespiratory fitness at baseline and follow-up: persistent low fitness (adolescents who were in the low-fitness category both at baseline and at follow-up); decreasing fitness (adolescents who declined from the high-fitness category at baseline to the low-fitness category at follow-up); persistent high fitness (adolescents in the high-fitness category both at baseline and at follow-up); and

increasing fitness (adolescents who increased from the low-fitness category at baseline to the high-fitness category at follow-up)

Anthropometrics

Anthropometric measurements were performed according to standard procedures. Body weight was measured to the nearest 0.10 kg using a portable electronic weight scale (Tanita Inner Scan BC 532, Tokyo, Japan), with the participant barefoot, wearing light clothing, and in the anthropometric position (standing erect, heels together, upper limbs by the side of the body, head and eyes directed forward) at the center of the weighing platform.

Socioeconomic status

Adolescents' socioeconomic status was assessed with the Family Affluence Scale (Currie et al., 2008), developed specifically to measure children and adolescents' socio-economic status in the context of the Health Behaviour in School-Aged Children Study.

The Family Affluence Scale Family Affluence Scale is a four-item questionnaire that helps students report their family income objectively: it evaluates the sum of scores regarding whether the family owns a car, whether the student has his or her own bedroom, the number of family vacations during the past 12 months, and the number of computers the family owns. The final score ranges from 0 to 9 points, with higher scores indicating higher socioeconomic status.

Pubertal stage

Adolescents self-reported their pubertal stage (from 1 to 5) relative to the secondary sex characteristics, according to the criteria of Tanner and Whitehouse (Tanner & Whitehouse, 1976).

Briefly, girls were assessed by the stage of breast development (Tanner A) and public hair distribution (Tanner B); boys were assessed by stage of

genitalia development (penis size and testicular volume - Tanner A) and pubic hair distribution (Tanner B).

Statistical analysis

Descriptive data are presented as means and standard deviations for continuous variables and as frequencies and percentages for categorical variables. To assess differences between sexes, we performed one-way repeated measures analysis of variances (ANOVAs) for continuous variables and Chi-square for categorical variables.

Linear regression models were performed to determine the associations between cardiorespiratory fitness at baseline and HRQoL, either at baseline (cross-sectional analysis) or at 2-yr follow up (longitudinal analysis); these were adjusted for age, sex, pubertal stage (Tanner A and B), socioeconomic status, and HRQoL at baseline (in the longitudinal analysis). Unstandardized regression coefficients were used to express the B coefficients of the regression analyses.

Analysis of covariance (ANCOVA) with Bonferroni post-hoc multiple comparison tests were used to determine whether changes in cardiorespiratory fitness over a two-year period were associated with HRQoL at follow-up. HRQoL at follow-up was entered as dependent variable, and cardiorespiratory fitness change categories were entered as an independent variable; also included were age, sex, pubertal stage, socioeconomic status, and HRQoL at baseline.

Data analysis was performed with the Statistical Package for Social Sciences (Version 24.0; SPSS Inc., Chicago, Illinois, USA). A *p*-value of less than 0.05 was considered to indicate statistical significance.

Results

Table 1 shows the descriptive characteristics of the participants. Boys and girls showed lower scores in HRQoL at follow-up ($p<0.05$ for both). Girls showed a significantly greater decrease in cardiorespiratory fitness levels over a two-year period ($p<0.05$).

Table 1. Differences between boys and girls from baseline to follow up

	Total sample (n=571)		Boys (n=274)		Girls (n=297)	
	Baseline Mean (sd)	Follow-up Mean (sd)	Baseline Mean (sd)	Follow-up Mean (sd)	Baseline Mean (sd)	Follow-up Mean (sd)
Age (years)	14.3 (1.8)	16.3 (1.8)[a]	14.4(1.9)	16.4 (1.9)[b]	14.2 (1.7)	16.2 (1.7)[c]
Weight (kg)	54.8 (12.3)	61.3 (11.9)[a]	56.6 (13.7)	64.7 (12.6)[b]	53.2 (10.6)	58.2 (10.3)[c,d]
Pubertal stage A (%) (I/II, III, IV, V)	8.9/34/44.8/12.3	0.2/7.1/50.7/42[a]	13.5/33.2/40.9/12.4	0.4/6.6/48.5/44.5[b]	4.7/34.8/48.3/12.2	0/7.6/52.7/39.7[c,d]
Pubertal stage B (%) (I/II, III, IV, V)	7.4/22.6/48.6/21.4	0.2/2.8/39.4/57.6[a]	11.7/20.1/48.9/19.3	0.4/1.8/38.2/59.6[b]	3.4/25/48.3/23.3	0/3.8/40.4/55.8[c,d]
Socioeconomic status	6.3 (1.6)	5.4 (1.7)[a]	6.2 (1.8)	5.2 (1.8)[b]	6.6 (1.6)	5.5 (1.6)[c, d]
Cardiorespiratory fitness (mL/kg/min)	41.9 (6.5)	41.3 (7.9)[a]	44.5 (6.2)	46.1 (7.4)[b]	38.6 (4.8)	36.9 (5.3)[c, d]
Health-related quality of life (Kidscreeen-10)	39.6 (5.6)	37.8 (5.9)[a]	40.4 (5.3)	39.3 (6.1)[b]	38.9 (5.7)	36.4 (5.4)[c, d]

a – significantly different from whole sample at baseline; b - significantly different between boys at baseline; c – significantly different from girls at baseline; d – significantly different from boys at follow-up.; sd- standard deviation

After adjustments for potential confounders, regression analyses showed significant cross-sectional associations between cardiorespiratory fitness and HRQoL at baseline model 2 (B =0.095; *p*=0.023) and at follow-up model 4 **(**B=0.090; *p*=0.012), respectively.

Table 2 - Unstandardized regression coefficients examining cross-sectional and longitudinal associations between cardiorespiratory fitness and Health-Related Quality of life.

		Cardiorespiratory fitness		
		B	*p* value	(95% CI)
Health-related quality of life (Baseline)	Model 1	0.158	**<0.001**	0.089; 0.227
	Model 2	0.095	**0.023**	0.013; 0.177
Health-related quality of life (Follow Up)	Model 3	0.147	**<0.001**	0.132; 0.278
	Model 4	0.090	**0.012**	0.020; 0.160

B- unstandardized coefficients;
Models 1 and 3- unadjusted model
Models 2 and 4- Adjusted for age, sex, pubertal stage (Tanner A and B) and socioeconomic status at baseline

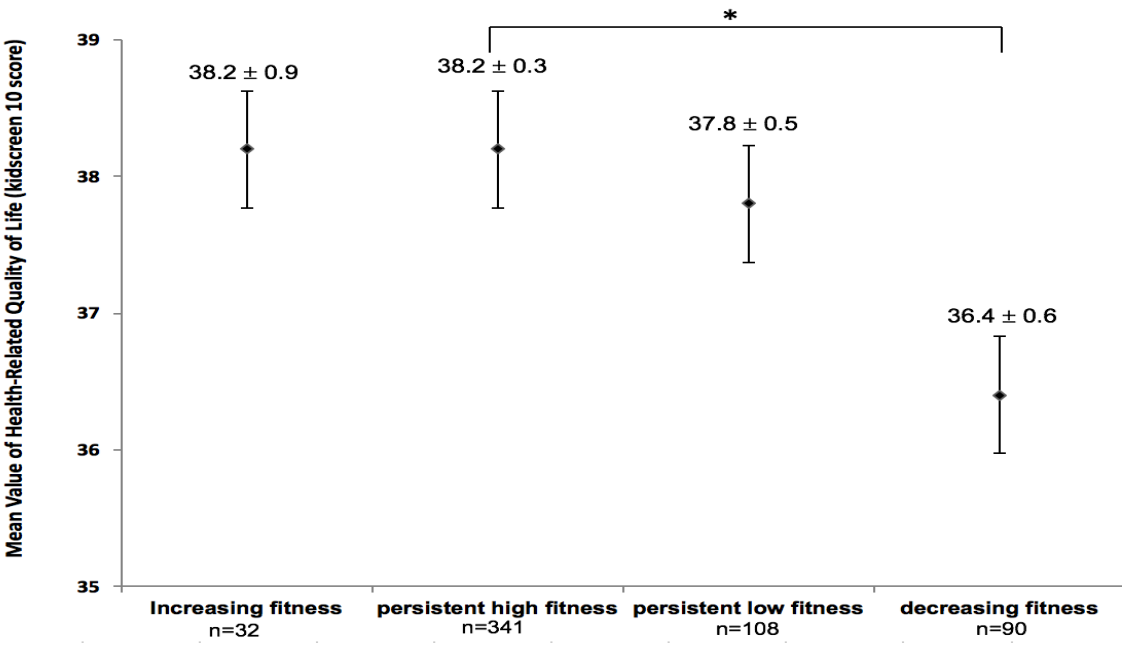

Figure 1. Mean values in health-related quality of life at follow-up stratified in groups of cardiorespiratory fitness

* Significantly different in mean HRQoL score between persistent high cardiorespiratory fitness and decreasing cardiorespiratory fitness groups (p<0.05) adjusted for age, sex, pubertal stage, socioeconomic status and HRQoL at baseline

As depicted in Figure 1, we found significant differences in mean HRQoL scores at follow-up between the persistent-high cardiorespiratory fitness group and the decreasing cardiorespiratory fitness group (p<0.05), after adjustments for age, sex, pubertal stage, socioeconomic status, and HRQoL at baseline. 32 adolescents were in the increasing-fitness category and 341 were in the persistent-high fitness category, which means that the majority of adolescents maintain their cardiorespiratory fitness.

Discussion

In our study, cardiorespiratory fitness was positively associated with HRQoL at baseline and follow-up. Participants with persistent-high cardiorespiratory fitness over a two-year period showed the highest scores of HRQoL, as well as a significant statistical difference from those that decreased their cardiorespiratory fitness over time (after adjustments for potential confounders). Our results highlight the importance of developing

cardiorespiratory fitness in youth and corroborate the need to comply with international physical activity guidelines for youth. These guidelines recommend that most daily physical activity should be aerobic, to develop a healthy cardiovascular system and experience its health-related benefits, including preventing metabolic disease and cardiovascular disease risk factors (World Health Organization, 2010).

Our results confirm and extend previous cross-sectional evidence on the positive association between cardiorespiratory fitness and HRQoL (Guedes et al., 2014; Marques et al., 2017; Padilla-Moledo et al., 2012; Riiser et al., 2014). These results underscore the potential modifying effect of cardiorespiratory fitness on HRQoL during adolescence, and may be clinically relevant to adolescents' psychological well-being. These results are important because they suggest that preventive efforts that focus on maintaining and increasing cardiorespiratory fitness through adolescence can have favorable health benefits. High cardiorespiratory fitness during childhood and adolescence is inversely associated with low-grade inflammation and blood pressure (Agostinis-Sobrinho et al., 2018; Agostinis-Sobrinho et al., 2017), as well as with features of metabolic syndrome (Andersen et al., 2008), novel CVD risk factors (Ruiz et al., 2007), and arterial compliance (Reed et al., 2005).

To the best of our knowledge, this is the first longitudinal study to evaluate the associations between cardiorespiratory fitness and HRQoL in adolescents. Some studies in adults show that relatively higher levels of cardiorespiratory fitness are associated with higher levels of HRQoL (Sloan et al., 2009), although these relationships differ by sex in other studies (Clennin et al., 2015).

Our results also show that HRQoL significantly declined from baseline to follow-up, with boys reporting better HRQoL scores than girls. These findings are in line with other studies, which show that HRQoL tends to decline during adolescence and that this is particularly frequent in girls (Bisegger et al., 2005; Meade & Dowswell, 2016; Michel et al., 2009; Torsheim et al., 2006). Indeed, girls seem to experience a gender-specific vulnerability during adolescence (Meade & Dowswell, 2016); this is most likely due to the developmental challenges that adolescents experience that are characterized by physical,

psychological, vocational, and social changes. Gender differences may be due to contradictory social demands placed on girls (Bisegger et al., 2005), who subsequently experience increased vulnerability towards physical and psychological health challenges (Patton & Viner, 2007).

In our study, cardiorespiratory fitness significantly decreased over 2 years in girls and increased slightly in boys, although only the changes in girls showed significant statistical difference. Our results are similar to other studies (Catley & Tomkinson, 2011; Ferrari et al., 2013; Flanagan et al., 2014; Marta et al., 2012; Santos et al., 2014), particularly an eight-year follow-up study of 86 Portuguese children (44 girls) from the European Youth Heart Study, which showed that cardiorespiratory fitness significantly increased in boys and decreased in girls (Ornelas et al., 2011).

A possible explanation may be that decreases in physical activity are more often found in girls than in boys (Craggs et al., 2011). Another possibility can be attributed to the inter-individual differences during the maturation process, which may moderately explain the differences in the performance of physical fitness tests; early-maturing adolescents of both sexes are absolutely stronger and have greater absolute VO2max compared with late-maturing ones, and boys show more pronounced differences than girls, which may implicate the misclassification of some adolescents as fit or unfit for age and sex (Malina & Katzmarzyk, 2006).

Our results highlight the importance of developing cardiorespiratory fitness in youth, as well as the need for future prospective studies to evaluate the cause-and-effect relationship between cardiorespiratory fitness and HRQoL among adolescents. Additionally, it is necessary to examine the relationship between exercise, cardiorespiratory fitness, and HRQoL measures, as well as the underlying physiological and psychological mechanisms that influence this relationship.

In the context of public health, our results underline the importance of promoting cardiorespiratory fitness in programs that aim improve adolescent's overall health. The results also increase the evidence for including a cardiorespiratory fitness assessment (specifically the 20-m shuttle-run test) within clinical evaluations or monitoring of health status in the school context.

Appropriately-conducted, field-based, cardiorespiratory-fitness testing offers a simple, feasible, practical, reliable, and valid alternative to gas analysis, and it has been widely used on adolescents (Ruiz, Silva, et al., 2009).

The strengths of this study include the longitudinal design and its conduction on a relative large sample of adolescents, who were followed over a two-year time period; the use of a well-validated HRQoL instrument (Matos et al., 2012; Ravens-Sieberer et al., 2010); the standardized test used for cardiorespiratory fitness measurement (Ruiz et al., 2011; Tomkinson et al., 2016); and the adjustments for a wide range of covariates. Limitations of the current study include the use of a sum score from the Kidscreen-10 questionnaire, which does not allow analyses for each dimension of HRQoL, an analysis which is verified in extended versions of this scale (27- and 52-items). The results may not be generalizable, as our sample is not representative of the Portuguese population and our sample was predominately comprised of healthy adolescents. These points must be taken into consideration when interpreting our results.

Conclusion

This longitudinal study found that HRQoL decreased over time, with girls reporting poorer HRQoL than boys. Our results also showed a positive association between cardiorespiratory fitness and HRQoL. Adolescents whose cardiorespiratory fitness decreased exhibited the lowest HRQoL scores. Our findings suggest that improving cardiorespiratory fitness could be a strategy for improving the HRQoL of adolescents. However, more longitudinal studies are needed to ascertain the direction and sequence of associations between cardiorespiratory and HRQoL.

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CAPÍTULO IV – DISCUSSÃO GERAL

Esta tese foi fundamentada em lacunas de conhecimento identificadas pela literatura em adolescentes, e teve como principais objetivos a verificação das associações entre a QVRS e a aptidão física, o IMC e a dieta mediterrânica. Os estudos I, II e III são transversais. O estudo IV é longitudinal.

No estudo I verificamos que os valores de QVRS foram ligeiramente mais baixos nas raparigas quando comparados com os dos rapazes, corroborando os resultados de outros estudos (Bolton et al., 2014; Haraldstad et al., 2011; Helseth et al., 2015). Uma possível explicação para estes resultados são as mudanças físicas e o desenvolvimento durante a puberdade que podem afetar, de forma positiva ou negativa, o estado psicológico do adolescente (Hourani et al., 2016). Nesta sequência, as raparigas adolescentes revelam-se menos satisfeitas com o seu corpo do que os adolescentes do sexo masculino, que apresentam maior autoestima do que os seus homólogos femininos (Kling et al., 1999; Mäkinen et al., 2012).

Tal como alguns estudos internacionais (Helseth et al., 2015; Juliusson et al., 2010; Sjöberg et al., 2011) e nacionais (Santos et al., 2012; Sardinha et al., 2011), neste estudo, as raparigas apresentaram uma maior prevalência de sobrepeso e obesidade do que os rapazes, porém, sem diferenças estatísticas significativas. Segundo Dunger et al. (2005), a relação entre a puberdade e o peso corporal é referida como interrelacionada, pelo que as mudanças pubertárias podem contribuir para o aumento do peso corporal e este pode contribuir para o início da puberdade. Além disso, o estágio de maturação sexual também mostrou ter um impacto no funcionamento psicossocial, especialmente, em raparigas (Conley & Rudolph, 2009), identificando a puberdade como um fator influente que afeta tanto o peso corporal como a QVRS.

Verificamos que a QVRS foi inversa e significativamente associada ao IMC tanto nos rapazes como nas raparigas, após o ajuste para idade, estágios de maturação sexual e estatuto socioeconómico, o que vai ao encontro de vários estudos (Haraldstad et al., 2011; Khairy et al., 2016; Ottova et al., 2012; Palmeira et al., 2010; Quaresma et al., 2009). Alguns autores verificaram que o IMC aumentado está associado a uma QVRS mais baixa em crianças e adolescentes (Chen et al., 2014; Jansen et al., 2013). Por sua vez, Wardle & Cooke (2005)

relataram que a obesidade possui algumas consequências físicas e psicossociais, tais como: preocupações com a imagem corporal (Puhl & Heuer, 2009), baixa autoestima, depressão e dificuldades interpessoais (Latner & Stunkard, 2003). Além disso, a menor QVRS em crianças com excesso de peso tem sido também atribuída ao menor funcionamento físico, psicossocial e bem-estar (Ul-Haq et al., 2013; Tsiros et al., 2009).

Do mesmo modo, verificamos que a ACR atua como variável mediadora na relação entre o IMC e a QVRS, em ambos os sexos. Este resultado está em linha com o estudo de Morales et al. (2012) que encontraram também, uma relação entre a aptidão física e QVRS em crianças e concluíram que a associação entre a composição corporal excessiva e a QVRS quase desaparece quando controlada pela ACR e a aptidão muscular.

Os resultados do estudo II sugerem que a ACR e a aptidão muscular estão positivamente associadas à QVRS. Similarmente, alguns estudos mostraram que a ACR e a aptidão muscular estão significativamente relacionadas com o funcionamento físico e mental da QVRS. A título de exemplo, Gu et al. (2016) examinaram a associação entre atividade física, aptidão física e QVRS, em crianças dos 9 aos 11 anos, e descobriram que todas as componentes da aptidão física (com exceção da flexibilidade) e IMC estavam significativamente relacionadas com o funcionamento físico e mental da QVRS. Andersen et al. (2017), numa análise transversal que incluiu 1129 estudantes de 10 anos, verificaram que a ACR está associada positivamente com maiores pontuações nos cinco domínios do *kidscreen-27* e que a força explosiva dos membros inferiores estava positivamente associada a uma maior autonomia. Por outro lado, o estudo *Health Behaviour in School-Aged Children*, com adolescentes portugueses, mostrou que os níveis autorreportados de ACR, mas não a aptidão muscular, estavam positivamente associados à QVRS (Marques et al., 2017).

Apesar de o *Kidscreen-10* não permitir análises de cada uma das dimensões da QVRS, a contribuição da ACR na QVRS global pode enfatizar a importância do desempenho físico para o bem-estar (Riiser et al., 2014).

Estes resultados também estão de acordo com alguns estudos que sugerem que as melhorias na ACR têm um efeito positivo no bem-estar

psicológico de crianças e adolescentes (Crews et al., 2004; Ortega, Artero, et al., 2008). Como a ACR está forte e positivamente associada à atividade física (Marques et al., 2015) em crianças e adolescentes, os programas de intervenção destinados a aumentar a atividade física e os níveis de aptidão física da população jovem podem beneficiar a ACR e, consequentemente, melhorar a sua perceção e bem-estar da saúde (Fuller et al., 2017; Ørntoft et al., 2016).

Um outro fator que é conhecido por influenciar a saúde e o bem-estar percebidos entre os adolescentes é a imagem corporal (Haraldstad et al., 2011). De facto, alguns estudos reportam associações entre os níveis mais baixos de ACR e insatisfação corporal (Olive et al., 2012). Por outro lado, uma outra variável que pode contribuir para explicar uma potencial relação entre a ACR e a QVRS é a motivação ao exercício. Assim, os nossos resultados sugerem que manter e melhorar a aptidão física em adolescentes tem o potencial de produzir benefícios para a saúde física e mental.

Acresce que esses nossos resultados sugerem também que a ACR e a aptidão muscular podem desempenhar um papel positivo na QVRS em adolescentes, após ajustes para os vários fatores de confusão. De facto, os adolescentes com alta ACR e alta aptidão muscular apresentaram maiores níveis de QVRS. A aptidão muscular parece ter mais impacto do que a ACR na qualidade de vida dos adolescentes. De um modo geral, os estudos que investigam a relação entre a condição física e os resultados de saúde concentram-se, principalmente, na ACR. No entanto, estudos recentes reportam que a aptidão muscular também está favoravelmente associada aos benefícios para a saúde em adolescentes (Agostinis-Sobrinho et al., 2016; Artero et al., 2014).

O estudo II sugere ainda que a combinação de níveis elevados de ACR e aptidão muscular se associam de forma sinérgica a uma maior QVRS em adolescentes.

No estudo III, os adolescentes com aptidão física global elevada e alta adesão à dieta mediterrânica apresentam o maior valor de QVRS. Esses resultados sugerem que a combinação dessas duas componentes de estilo de vida saudável parece ser benéfica para o bem-estar dos adolescentes. Apesar

do desenho transversal deste estudo, a aptidão física e a dieta mediterrânica parecem ter um poderoso efeito combinado e cumulativo sobre a QVRS em adolescentes. Neste mesmo estudo, também se verifica que a adesão à dieta mediterrânica foi significativa e positivamente associada a maiores pontuações de QVRS, o que está em conformidade com um estudo recente em adolescentes espanhóis, que relataram que uma maior adesão à dieta mediterrânica apresentou maiores pontuações de QVRS (Muros et al., 2017). Outro estudo, com adolescentes gregos, também revelou uma associação positiva entre a adesão à dieta mediterrânica e a QVRS (Costarelli et al., 2013). Vários mecanismos biológicos e fisiológicos podem explicar o efeito benéfico da dieta mediterrânica na saúde física (Sánchez et al., 2012). Alguns estudos relatam que uma maior adesão à dieta mediterrânica está associada a uma melhoria significativa na saúde física e psicológica em geral, na longevidade e níveis mais baixos de obesidade, bem como menor incidência de aterosclerose, síndrome metabólica, inflamação e risco reduzido de grandes doenças crónicas e mortalidade (Estruch et al., 2013; Panagiotakos et al., 2007; Sofi et al., 2008). Outros estudos ainda, atribuídos à dieta mediterrânica, revelam um certo grau de proteção em relação à deficiência cognitiva e demência (Scarmeas et al., 2009), ou incidência de depressão (Sánchez-Villegas et al., 2009).

Por outro lado, encontramos, também, uma associação significativa entre o nível da aptidão física e a QVRS, após ajustes para todos os fatores de confusão (estudo III), o que corrobora os estudos de Gu et al. (2016) e Marques et al. (2017).

Neste contexto, a aptidão física é considerada um dos marcadores de estado de saúde mais importantes que previnem doenças cardiovasculares e mortalidade (Ortega, Ruiz, et al., 2008). Há evidências que sugerem que o desenvolvimento de todas as componentes da aptidão física, no início da vida, revela-se de grande importância para manter a aptidão física e resultados de saúde, no futuro (Brooke et al., 2014; Ried-Larsen et al., 2015). No entanto, uma determinante essencial da aptidão física é o nível de atividade física (Bürgi et al., 2011; Dencker et al., 2008). Os caminhos pelos quais a atividade física e a aptidão física estão associados ao bem-estar físico e psicológico ainda não são

totalmente compreendidos em adolescentes. Contudo, alguns mecanismos foram postulados para crianças (Gerber et al., 2017). Por exemplo, a atividade física regular aumenta a aptidão física e, deste modo, melhora a função vascular e metabólica (Hanssen et al., 2012), conduz a adaptações neuronais estruturais e funcionais favoráveis (Chaddock-Heyman et al., 2014), melhora a atenção, as emoções, o controle inibitório, além de melhorar o desempenho académico (Chaddock et al., 2012; Diamond, 2013; Haapala, 2013; Hillman et al., 2009; Pontifex et al., 2011; Voss et al., 2011).

No estudo IV, os resultados mostraram que a ACR se associa positivamente à QVRS, no *baseline* e no *follow-up*. Os participantes com ACR persistente elevada, durante um período de 2 anos, mostraram maiores valores de QVRS, com uma diferença significativa para aqueles que diminuíram a ACR, durante esse período, após ajustes para potenciais fatores de confusão. Os nossos resultados confirmam as evidências transversais sobre a associação positiva entre a ACR e a QVRS (Andersen et al., 2017; Guedes et al., 2014; Marques et al., 2017; Padilla-Moledo et al., 2012; Riiser et al., 2014), a que acresce que também destacam a importância do desenvolvimento da ACR nos adolescentes e, por outro lado, corroboram a necessidade de cumprir as diretrizes internacionais de atividade física que recomendam atividades físicas aeróbicas diárias (Organização Mundial da Saúde, 2010).

Tanto quanto sabemos, o estudo IV é o primeiro estudo longitudinal, em adolescentes portugueses, a avaliar as associações entre ACR e a QVRS. Todavia, existem alguns estudos em adultos que corroboram que níveis mais elevados de ACR estão associados a níveis mais elevados de QVRS (Sloan et al., 2009). No entanto, num outro estudo, estas relações são diferenciadas por sexo (Clennin et al., 2015). Estes resultados sublinham o potencial efeito modificador da ACR na QVRS, durante a adolescência, e podem ter relevância clínica no bem-estar psicológico dos adolescentes. Estes resultados são importantes, porque sugerem que os esforços preventivos focados na manutenção e no aumento da ACR, na adolescência, podem ter benefícios favoráveis na saúde.

Verificamos, por outro lado, que a QVRS diminuiu significativamente, desde o *baseline* até ao *follow-up*, com os rapazes a demonstrar melhores resultados da QVRS do que as raparigas (estudo IV), o que está em linha com outros estudos (Meade & Dowswell, 2016; Michel et al., 2009; Torsheim et al., 2006). Na verdade, parece haver uma vulnerabilidade específica de género, nas raparigas (Meade & Dowswell, 2016), provavelmente devido aos desafios da adolescência que se caracteriza por mudanças físicas, psicológicas, vocacionais e sociais, enquanto as diferenças de género podem ser devidas a demandas sociais contraditórias sobre as mesmas (Bisegger et al., 2005).

Ainda no estudo IV, verificamos que a ACR diminuiu significativamente ao longo de dois anos nas raparigas e aumentou, ligeiramente, nos rapazes, com diferenças estatísticas significativas apenas naquelas. Os nossos resultados são semelhantes a um estudo de *follow-up* de 8 anos com 86 crianças portuguesas (44 meninas) da *European Youth Heart Study* (Ornelas et al., 2011), bem como com outros estudos (Catley & Tomkinson, 2011; Ferrari et al., 2013; Flanagan et al., 2014; Marta et al., 2012; Santos et al., 2014). Uma possível explicação para estes resultados talvez se deva à diminuição da atividade física mais frequentemente encontradas nas raparigas do que nos rapazes (Craggs et al., 2011). Outra possibilidade pode ser atribuída às diferenças interindividuais, durante o processo de maturação, que podem explicar, de alguma forma, as diferenças na realização de testes de aptidão física (Malina & Katzmarzyk, 2006).

Os resultados do estudo IV, no contexto de saúde pública, sublinham a importância de promover a ACR em programas que visam melhorar a saúde geral do adolescente e, em simultâneo, aumentar a inclusão da avaliação da ACR com o teste de vaivém (de 20 m) nas avaliações clínicas ou monitorização do estado de saúde, no contexto escolar.

Pontos fortes e limitações

Os quatro artigos que fundamentam esta dissertação, em nosso entendimento e salvo melhor opinião, apresentam alguns pontos fortes e algumas limitações metodológicas que devem ser consideradas.

Os pontos fortes deste estudo incluem um desenho longitudinal e a sua condução numa amostra relativamente grande de adolescentes, que foram seguidos durante um período de dois anos, bem como o uso de um instrumento de avaliação da QVRS validado cuja utilização é recomendada em estudos epidemiológicos que impliquem grandes amostras (Matos et al., 2012; Ravens-Sieberer et al., 2010) e, ainda, os ajustes para uma ampla gama de covariáveis (maturação sexual, estatuto socioeconómico, idade, sexo, duração do sono, dieta mediterrânica, média diária de atividade física moderada a vigorosa e média diária do uso do acelerómetro). Também, para a avaliação da ACR foi utilizado o teste vaivém de 20 metros, que tem demonstrado ser uma excelente ferramenta para a monitorização em crianças e adolescentes, pois demonstra uma forte validade e fiabilidade (Ortega et al., 2008; Ruiz et al.; 2011). Por outro lado, este teste fornece ainda uma alternativa prática, uma vez que é eficiente no tempo, com baixo custo e requisitos de equipamentos, que podem ser facilmente administrados a um grande número de pessoas, de forma simultânea (Castro-Piñero et al., 2010; Welk & Meredith, 2008; Tomkinson et al., 2016). Adicionalmente, para avaliar a condição músculo-esquelética, utilizou-se o teste de preensão manual (*handgrip test*) e o salto de impulsão horizontal (*standing long jump test*), pois, parecem ser os testes que melhor representam, de uma forma global, a aptidão muscular na adolescência, demonstrando, também, uma forte validade e fiabilidade (Pillsbury et al.; 2013; Ruiz et al.; 2011).

As limitações incluem a realização de três estudos transversais que não nos permitem estabelecer uma relação de causalidade e direccionalidade. Da mesma forma, o questionário *Kidscreen-10*, não permite análises para cada uma das dimensões da QVRS, que é verificada em versões estendidas (*Kidscreen*-27 e Kidscreen-52). Também, a avaliação da imagem corporal não foi incluída e controlada, apesar das influências sobre obesidade e QVRS. Finalmente, devemos referir que os estudos incluíram uma amostra de conveniência, com

adolescentes saudáveis, de cinco escolas do norte de Portugal, não sendo a nossa amostra representativa da população portuguesa.

Considerações Finais

Os nossos resultados sugerem que a ACR e a aptidão muscular parecem estar positivamente associadas a uma melhor QVRS nos adolescentes. Neste sentido, informações simples e acessíveis, no quotidiano escolar, como a avaliação do nível de aptidão muscular (através do teste de preensão manual) e da ACR (pelo teste do vaivém), podem fazer parte de uma estratégia de controle e de intervenção para a melhoria da QVRS.

Além disso, os resultados também reforçam as atuais evidências sobre a importância da ACR como elemento chave na prevenção do excesso de peso / obesidade dos adolescentes e potenciais benefícios para a saúde física e mental. Dada a complexidade das interrelações entre a aptidão física e obesidade e atenta a falta de evidências sobre o sucesso dos programas na diminuição do excesso de peso / obesidade, nestas idades, serão necessários mais estudos de intervenção, numa perspectiva de análise longitudinal.

Os resultados do nosso estudo corroboram as atuais diretrizes de atividade física da OMS para crianças e adolescentes, que recomendam que a maioria das atividades físicas diárias seja aeróbia, com a combinação regular de atividades de fortalecimento muscular, devido aos benefícios relacionados à saúde, incluindo a prevenção de doenças metabólicas e fatores de risco para doenças cardiovasculares.

Por outro lado, a combinação de altos níveis de aptidão física e uma inequívoca adesão à dieta mediterrânea sugere estar positivamente associada à QVRS, reforçando e sublinhando a adoção de comportamentos de promoção da saúde, bem como a importância da aptidão física e dessa dieta na QVRS dos adolescentes.

À guisa de nótula final, apraz-nos reconhecer que a adolescência é uma etapa durante a qual se impõe intervir, de forma assertiva e consequente, para melhorar a saúde presente e futura, pelo que, sempre que possível, os

adolescentes devem ser apoiados na adoção de comportamentos saudáveis, designadamente através de apoios de natureza pessoal, comunitária, bem como da adoção de políticas públicas direcionadas.

CAPÍTULO V - REFERÊNCIAS

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