COMPETÊNCIA MOTORA ASSOCIADA À ATIVIDADE FÍSICA E OBESIDADE EM CRIANÇAS PRÉ-ESCOLARES

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"*Ser feliz é encontrar força no perdão, esperança nas batalhas,*
segurança no palco do medo, amor nos desencontros.
É agradecer a Deus a cada minuto pelo milagre da vida"
Fernando pessoa

Eu dedico esta dissertação*:*
Aos Meus Pais, pelo apoio incansável e amor incondicional!
"Sois o meu melhor alimento"

Ao Paulo!
"Quando fala o amor, a voz de todos os deuses
deixa o céu embriagado de harmonia"
William Shakespeare

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Introdução: Níveis elevados de coordenação motora estão positivamente associados à atividade física e negativamente associados à obesidade na infância, no entanto, pouca atenção tem sido dada às crianças em idade pré-escolar. **Objetivos:** 1) Examinar a associação entre atividade física moderada-vigorosa (AFMV) e a coordenação motora grossa (CMG); 2) Averiguar a associação entre a CMG e o rácio cintura-estatura (RCE); 3) Examinar a associação entre aptidão motora (ApM) e a obesidade. 4) Averiguar a associação entre AFMV e coordenação motora (CM), índice de massa corporal (IMC) durante 1 ano de *follow-up* em pré-escolares. **Métodos:** As amostras em cada objetivo consistiram em 1) e 2) 209 pré-escolares (52,1% meninas), 3) 467 pré-escolares (52,8% meninas) entre os 3 e os 6 anos de idade e 4) 54 pré-escolares (42,2% meninas) entre os 4 e os 5 anos. As crianças estavam inscritas num infantário no Porto, Portugal. A Atividade física (AF) e o comportamento sedentário (CS) foram mensurados pelo acelerómetro. A CM e a CMG foram avaliadas pelo *Movement Assessment Battery for Children second edition* (MABC-2) e a ApM foi medida pelos testes de *shuttle run* e o salto a 2 pés juntos numa distância de 7 metros. O RCE foi calculado através da divisão do perímetro da cintura (cm) pela estatura (cm). A estatura e a massa corporal das crianças foram medidas e o IMC foi calculado. As variações (Δ) entre 2013 e 2014 foram calculadas por *follow-up – baseline*. Todos os dados foram verificados quanto à normalidade pelo teste *Kolmogorov-Smirnov*. As comparações entre grupos foi avaliada pelo *teste-t Student* ou pelo teste de *Qui-quadrado*. As análises de regressão linear múltipla ou regressão logística binária foram usadas para verificar as associações. O nível de significância foi $p<0,05$. **Resultados:** A AFMV foi positivamente associada à CMG, ajustada ao género e ao CS. Os pré-escolares categorizados com risco no RCE tiveram três vezes mais chance de possuírem baixa coordenação na componente Lançar& Agarrar e cinco vezes mais chance na componente equilíbrio, respetivamente, do que os seus pares sem risco, ajustado ao género e ao CS. Os pré-escolares obesos tiverem seis vezes mais chance de possuírem nível baixo de ApM do que os seus pares com peso normal. Longitudinalmente, a CM foi positivamente associada com a AFMV, no entanto, não foi encontrada diferença estatisticamente significativa para o IMC ao longo de um ano, ajustado pelo género e pela idade. **Conclusões:** O investimento na melhoria da CM em crianças tem implicações potencialmente relevantes relacionadas com a AF e com a saúde pública.

Palavras-chave: Coordenação motora; Aptidão motora; Atividade física; Índice de massa corporal; Pré-escolares

ABSTRACT

Introduction: Higher levels of motor coordination are positively associated with physical activity and negatively associated with obesity in childhood, however little attention has been given to preschool children. **Objective:** 1) To examine the association between moderate vigorous physical activity (MVPA) and gross motor coordination (GMC); 2) To examine the association between GMC and waist-to-height-ratio (WHtR); 3) To examine the association between motor fitness (MF) and obesity status; 4) To examine the association between MVPA and motor coordination (MC), body mass index (BMI) and to track these behaviours over a 1-year follow-up in preschoolers. **Methods:** Regarding each objective, the samples consisted of 1) and 2) 209 preschoolers (52. 1% girls), 3) 467 preschoolers (52.8% girls) aged 3-to-6 years-old and 4) 54 preschoolers (24 girls; 42.2%) aged 4-to-5 years-old. The children were enrolled in kindergarten in Porto, Portugal. Physical activity (PA) and sedentary behaviour (SB) were measured by accelerometer. MC and GMC were measured by Movement Assessment Battery for Children second edition (MABC-2) and Motor fitness (MF) was measured by shuttle run test (SRT) and 7 m jumping distance on 2 feet test (J2F). WHtR was calculated as the ratio of waist (cm) and height (cm). Height and body mass of children were measured and BMI calculated. Changes (Δ) between 2013 and 2014 were calculated as follow-up – baseline values. All data were checked for normality by Kolmogorov-smirnov test. The comparisons between groups were assessed by Student t test or Chi-square test. Multiple linear or binary logistic regression analysis were used to verify associations. The level of significance was $p<0.05$. **Results:** MVPA was positively association with GMC, adjusted for gender and SB. Preschoolers categorized as being at WHtR risk were three times more likely to have low coordination in aiming & catching component and five times more likely to have low coordination in balance component than their no risk counterparts, adjusted for gender and SB. Obese preschoolers were more likely six times classified as having low MF level than their non-overweight counterparts. Longitudinally, MC was positively associated with MVPA, whereas no statistically significant difference was found for BMI over a 1-year follow-up, adjusted by gender and age. **Conclusions:** Investing in the improvement of motor coordination in children has potentially relevant policy implications related to PA and public health.

Keywords: Motor coordination; Motor fitness; Physical activity; Body mass index; Preschoolers

LISTA DE ABREVIATURAS

AF	Atividade física
AFMV	Atividade física moderada a vigorosa
AFT	Atividade física total
ApF	Aptidão física
ApM	Aptidão motora
BMI	Body mass index
CM	Coordenação motora
CMF	Coordenação motora fina
CMG	Coordenação motora grossa
CS	Comportamento sedentário
DCD	Desordens coordenativas no desenvolvimento
DM	Desenvolvimento motor
GMC	Gross motor coordination
IMC	Índice de massa corporal
J2F	7 m jumping distance on 2 feet test
MABC-1	Movement Assessment Battery for Children first edition
MABC-2	Movement Assessment Battery for Children second edition
MC	Motor coordination
MF	Motor fitness
MVPA	Moderate to vigorous physical activity intensity
NW	Normal weight
OB	Overweight/obesity
OR	Odds ratio
PA	Physical activity
RCE	Rácio cintura estatura
SB	Sedentary behavior
SD	Standard deviation
SR	10 × 5m shuttle run test
TPA	Total physical activity
WC	Waist circumference
WHtR	Waist-to-height-ratio

Δ	Variação - Change
$\Delta\%$	Variação relativa - Relative change

[Capítulo I.]

Introdução e Revisão da Literatura

INTRODUÇÃO E OBJETIVOS

O dinamismo do crescimento e do desenvolvimento humano reflete, em grande parte, o longo processo de evolução biocultural das espécies, uma vez que estes fenómenos são dinamicamente modelados por um vasto conjunto de fatores biológicos e ambientais (Malina et al., 2009; Ulijaszek, 2006). Esta complexa interação entre os genes e o meio ambiente atua de modos diversos, condicionando a plasticidade do fenótipo numa ampla gama de variabilidade intra e interindividual durante o crescimento e desenvolvimento da criança (Hochberg, 2011). Neste sentido, a infância e a adolescência são consideradas fases complexas devido às profundas transformações inerentes ao crescimento e à maturação. Desta forma, o processo de crescimento, maturação e desenvolvimento interfere diretamente nas relações afetivas, sociais e motoras das crianças e adolescentes (Gallahue & Ozmun, 2011). Ao longo dessas transformações, os padrões de comportamento que as crianças e os jovens adquirem podem ser decisivos para um futuro mais saudável e com maior qualidade de vida, refletindo o nível de desenvolvimento motor (DM) da criança.

O DM é caracterizado por um processo sequencial e contínuo que está relacionado com a idade cronológica e com as habilidades motoras, sendo através dele que o ser humano adquire habilidades motoras fundamentais (Gallahue & Ozmun, 2005). Estas habilidades são caracterizadas por movimentos voluntários do corpo, que resultam de um processo sequencial, pois progridem de movimentos simples e desorganizados para a execução de habilidades motoras altamente organizadas e complexas, sejam elas desportivas ou não, tendo um objetivo definido e atingível (Getchell & Haywood, 2004).

O DM tem sido objeto de inúmeros estudos nos últimos anos (Grace et al., 2016; Pollit & Granoff, 2017; Salaj et al., 2016). Inicialmente, acreditava-se que as mudanças no comportamento motor refletiam diretamente as transformações maturacionais do sistema nervoso central. Atualmente, sabe-se que o processo de DM da criança ocorre dinamicamente e é suscetível de ser moldado por inúmeros estímulos externos (Willrich et al., 2009). Porém, existe a possibilidade de nem sempre o estado de maturação da criança (idade biológica) corresponder

à sua idade cronológica (data de nascimento) (Ré, 2011). Ademais, a idade cronológica não pode ser interpretada como um fator decisivo para entender o DM da criança, uma vez que cada indivíduo tem um tempo específico para a aquisição e para o desenvolvimento de habilidades motoras. Por isso, a maioria dos investigadores organiza os estágios e as fases do desenvolvimento associados à idade cronológica da criança, que representa uma escala de tempo aproximada na qual determinado comportamento tende a surgir (Gabbard, 2008; Gallahue & Ozmun, 2005). Desta maneira, é possível detetar crianças que, embora tenham a mesma idade cronológica, se encontrem em fases de DM distintas, manifestando diferentes níveis de coordenação motora (CM).

A identificação precoce de possíveis fatores de risco que possam prejudicar o DM da criança é reconhecida como crucial, uma vez que um fraco desempenho motor pode ter consequências negativas a longo prazo para o desenvolvimento global da criança (Giagazoglou et al., 2011). Assim sendo, a infância manifesta--se como uma etapa crítica para o desenvolvimento da CM, que provém da interação efetiva e harmoniosa entre o sistema músculo-esquelético, o sistema nervoso e o sistema sensorial, com o objetivo de propiciar ações motoras precisas e equilibradas (Gallahue & Ozmun, 2005). Estas ações tornam-se essenciais para o ser humano, porquanto permitem a satisfação e a prossecução das suas necessidades básicas, quer como comunicar e aprender (Lopes et al., 2003), quer como participar com sucesso em vários tipos de atividade física (AF) (Robinson et al.,2015). No entanto, quando existe uma falha e a interação entre os três sistemas não se desenvolve harmoniosa e economicamente, estamos perante uma desordem coordenativa no desenvolvimento (DCD) (Engel-Yeger et al., 2010).

No âmbito da literatura, é verificado que o melhor desempenho motor está associado a uma maior participação na AF (Wrotniak et al., 2006), enquanto o menor desempenho motor está associado a níveis mais baixos de AF (Williams et al., 2008), de aptidão física (ApF) (Rivilis et al., 2011), de motivação reduzida para atividades desafiadoras (Rose et al., 1998), do aumento IMC.(D'Hondt et al., 2011; Lopes et al., 2014) e do aumento do CS (Lopes et al., 2012a). Lopes e colaboradores (2011) averiguaram que a ausência de desenvolvimento da CM

conduzia a um efeito negativo na participação em AF, pois as crianças relevaram falta de competência e de confiança para participarem e desfrutarem das atividades nas quais entendiam que não seriam bem-sucedidas.

A CM, que se manifesta em vários gestos realizados pelo pré-escolar no dia-a-dia, permite a interação com o meio envolvente e é desenvolvida ao longo do processo de maturação da criança, desde o brincar até atividades físicas mais complexas (Murata & Tan, 2009). A CM pode subdividir-se em duas categorias: a coordenação motora fina (CMF) e a coordenação motora grossa (CMG) (Desrosiers et al., 1997; Rivard et al., 2011). A CMF visa utilizar os pequenos músculos de forma mais eficaz, tornando o ambiente controlável pelo corpo. Esses movimentos são delicados e específicos, tais como desenhar, abotoar e desabotoar, encaixar, recortar. Por outro lado, a CMG utiliza os grandes grupos musculares de forma mais eficaz, nomeadamente nas ações motoras e no respetivo controlo corporal, sendo, por isso, associada a tarefas tais como saltar, correr, arremessar, manter o equilíbrio, ter orientações espaciais e temporais, estando esta categoria mais relacionada com a prática da AF (Gallahue, 2008).

A participação na AF durante a infância e a adolescência é influenciada desde cedo pela competência motora (habilidades motoras de locomoção e habilidades motoras grossa) (Loprinzi et al., 2015). Deste modo, a infância revela ser não só um momento-chave para a atuação e prevenção do défice motor, mas também na implementação de hábitos de vida ativos e saudáveis. Como a maioria das crianças e adolescentes não são, desde cedo, suficientemente ativas (Reilly, 2010), tal influencia a prevalência de algumas patologias metabólicas, especialmente o excesso de peso e a obesidade que têm aumentado em todo o mundo, patologias essas associadas a resultados negativos para a saúde física e psicossocial, concomitantemente com maior risco de persistência na vida adulta (World Health Organization, 2016). Visto que, as crianças obesas revelam maior propensão para se tornarem adultos obesos (Cattuzzo et al., 2016; Veltsista et al., 2010).

A aquisição do repertório motor na infância tende a ser igualmente um pré-requisito fundamental para o envolvimento na AF na infância, e manutenção na vida adulta. Este envolvimento é considerado um comportamento modificável

para prevenir e tratar a obesidade em todas as faixas etárias (Loprinzi et al., 2012). A AF tem sido positivamente associada à ApF, que é considerada um importante marcador de saúde na infância (Janssen & Leblanc, 2010; Ortega et al., 2015) e que engloba a aptidão motora (ApM), que está relacionada com o desempenho aprimorado em habilidades desportivas, motoras e associada à diminuição da obesidade na infância e adolescência (Ortega et al., 2015).

Neste sentido, parece-nos extremamente importante identificar as crianças com dificuldades de CM, dando especial atenção à CMG e à ApM, que estão associadas com a participação em AF e diminuição da obesidade desde a infância, possibilitando, assim, uma intervenção oportuna e um acompanhamento adequado, minimizando possíveis interferências na qualidade de vida.

Com este desígnio, o objetivo principal do presente trabalho foi analisar os níveis de competência motora associados à AF e à obesidade em crianças pré-escolares. Este objetivo geral sustentou os seguintes objetivos específicos:

1. Averiguar qual a associação entre a atividade física moderada-vigorosa e coordenação motora grossa em pré-escolares;
2. Verificar a relação que existe entre a coordenação motora grossa e o rácio cintura-estatura em pré-escolares;
3. Verificar a relação que existe entre a aptidão motora e obesidade em pré-escolares;
4. Averiguar as associações entre atividade física moderada-vigorosa, coordenação motora e índice de massa corporal ao longo de um ano de *follow-up* em pré-escolares.

REVISÂO DA LITERATURA

Competência motora

A competência motora é caracterizada como um termo global e, segundo a literatura, inclui uma ampla variedade de termos (ou seja, habilidades ou movimentos motores fundamentais, desempenho ou proficiência motora, capacidade motora e CM, podendo ser descrita como a capacidade de uma pessoa ser proficiente numa variedade de atos ou habilidades motoras (Fransen et al., 2014) que dependem de um desenvolvimento ótimo das habilidade motoras fundamentais (HMF), as quais envolvem habilidade de estabilidade, locomoção e manipulação (Luz et al., 2016; Rudd et al., 2015).

As habilidades de estabilidade são caracterizadas por movimentos naturais que permitem à criança sentir um desequilíbrio corporal e reajustar-se rapidamente, por exemplo, equilíbrio dinâmico e estático. Em todos os movimentos locomotores e de manipulação, existe estabilidade.

As habilidades locomotoras são ações que envolvem o impulso vertical ou horizontal do corpo de um ponto para outro (por exemplo, salto horizontal, salto vertical), sendo a base para as atividades desportivas e recreativas.

As habilidades de manipulação são definidas como a capacidade de controlar diferentes tipos de objetos (por exemplo, lançar, agarrar, jogar e chutar) e que, na forma mais especializada, são essenciais para jogar determinados desportos.

As HMF são frequentemente descritas como habilidades que requerem maior precisão, quer na estabilidade básica, como na manipulação de objetos ou movimentos locomotores (Gallahue & Donnelly, 2007), que se desenvolvem nas fases iniciais do desenvolvimento motor (2 aos 7 anos de idade). O desenvolvimento das HMF juntamente com a CM relevam ser fulcrais para um desenvolvimento ótimo da competência motora na infância (Clark, 2007).

Segundo o modelo teórico realizado por Stodden e colaboradores (2008), a competência motora desempenha um papel primordial no desenvolvimento de

um estilo de vida ativo e saudável (Figura 1). Este facto é sustentado por Cattuzzo et al. (2016) e Robinson et al. (2015), que reforçam o modelo de Stodden et al. (2008), salientando a forte relação (positiva) entre a competência motora e ApF relacionada com a saúde, e a relação (negativa) entre a competência motora e o estado do peso, os quais aumentam com o passar do tempo e são determinantes atuais e futuros no desenvolvimento positivo das trajetórias de saúde da criança.

Figura 1 - Mecanismos de desenvolvimento que influenciam as trajetórias de atividade física das crianças, adaptado de Stodden et al. (2008).

A competência motora influencia e é influenciada por diversos mecanismos, sendo que a baixa competência motora dificulta o envolvimento da criança nas atividades da vida diária, bem como em atividades desportivas (Cairney et al., 2005)

A competência motora atribui à CM a responsabilidade de produzir uma ação ou movimento eficaz, no entanto, quando ocorre uma falha no mecanismo de coordenação motora, a competência motora fica comprometida (Magill, 2011).

Coordenação motora

Confrontados com a literatura, verificamos a variedade que envolve a expressão CM, a dificuldade da unidade na abordagem do seu conceito, a operacionalização e, ainda, a multiplicidade de instrumentos para a sua avaliação. A CM é um dos aspetos do comportamento motor que mais dificuldades tem levantado na avaliação do individuo, para além do que o termo de CM é muitas vezes confundido ou utilizado como sinónimo de conceitos como, agilidade, destreza, controle motor e mesmo de habilidade (Newell, 1985). Este equívoco poderá advir da diversidade dos âmbitos de investigações (clínicos, psicotécnicos, pedagógicos), do posicionamento epistemológico dos autores e ainda dos modelos de suporte à investigação, desde biomecânicos, psicofisiológico entre outros (Gomes, 1996).

Esta multiplicidade de aspetos aludidos anteriormente vem salientar a magnitude da complexidade da CM e a necessidade de se estabelecer um conceito consensual de forma a simplificar a sua operacionalização e a avaliação da criança. Desta forma, o interesse pelo estudo da CM tem vindo a ganhar algum destaque, sobretudo em termos pedagógicos e clínicos (Haywood & Getchell, 2014; Maia & Lopes, 2002; Piek, 2006).

Segundo Gallahue & Ozmun (2005), a CM traduz-se na capacidade de coordenação, que permite integrar padrões de movimento eficientes, sistemas motores separados com variadas modalidades sensoriais.

As múltiplas capacidades de coordenação, como a capacidade de reação, o ritmo, o equilíbrio, a orientação espacial, a destreza manual e a destreza pedal são fundamentais para um bom desenvolvimento de padrões motores básicos essenciais para a aprendizagem de habilidades motoras específicas nas várias modalidades desportivas (Gallahue & Ozmun, 2005) nas quais se integra a CMF e CMG, necessárias também para a realização das tarefas diárias (Henderson et al., 1992).

A CMG desempenha um papel crucial no crescimento e no desenvolvimento, bem como na oportunidade de adotar um estilo de vida ativo (Lubans et al., 2010).

A CMG é muitas vezes definida como a proficiência numa variedade de HMF, tais como jogar, lançar e agarrar, correr, que são idealmente aprendidas durante a pré-escola e nos primeiros anos escolares (Barnett et al., 2016) e que estão associadas com a prática da AF (Loprinzi et al., 2015). Deste modo, é fulcral a relevância que a CMG apresenta nos primeiros anos de vida, já que fornece a base para que as crianças desenvolvam sequências de movimentos mais específicos em diferentes desportos (Clark & Metcalfe, 2002), tais como: o lançamento no basebol ou habilidades motoras de AF ao longo da vida (por exemplo, ciclismo e natação) (Hulteen et al., 2015).

As dificuldades em aprender e realizar as habilidades motoras necessárias para o funcionamento diário é frequentemente identificado em crianças com baixa CM (American Psychiatric Association, 2013), sendo a CM associada positivamente à participação e manutenção da AF ao longo da vida (Laukkanen et al., 2014).

A CM está diretamente relacionada não só com as mudanças verificadas ao longo do tempo nas mais variadas facetas e expressões de comportamento motor das crianças mas também com a interação contínua de fatores mutáveis e ambientais (Gallahue et al., 2012), tais como as brincadeiras ao ar livre (*play outdoor*), que se correlacionam positivamente com a AF na infância (Pawlowski et al., 2016). Estes episódios são essenciais para promover experiências motoras que podem estimular a criança a participar em AF, incentivando, desta maneira, o desenvolvimento de habilidades e CM (Pawlowski et al., 2016).

O espaço verde de casa (jardim/terraço) e o ambiente familiar parecem também influenciar positivamente o desenvolvimento motor da criança em idade pré-escolar (Hua et al., 2016). Também a participação ativa da criança no recreio da escola influi a CM, uma vez que, durante o recreio, a criança pode participar em atividades lúdicas e brincar, já que é enquanto brinca que a criança explora o meio e desenvolve as suas habilidades motoras, o que lhe permite improvisar e experimentar, potenciando uma diversidade de movimentos no seu reportório motor

O ambiente construído que promova a mobilidade independente da criança, sendo este também influenciado pela perceção parental relativo à segurança do

meio envolvente (Santos et al., 2013), também parece favorecer os níveis de AF (Marques et al., 2014), e, consequentemente estimular o desenvolvimento da CM

O envolvimento parental poderá também influenciar e promover a participação em atividades lúdicas e, dessa forma, estimular o incremento do nível de AF, incentivando, assim, o desenvolvimento do reportório motor da criança (Tompsett et al., 2017). Neste sentido, o envolvimento dos pais e da escola poderá ser uma estratégia eficaz na promoção e no desenvolvimento da CM, incentivando maior participação em AF desde a infância. Contudo, atualmente, as crianças adotam cada vez mais um CS, tendo este comportamento sido caracterizado recentemente como atividades realizadas pelo indivíduo quando está acordado e não ultrapassa o dispêndio energético igual ou inferior à 1,5 METs, em posição sentada, reclinada ou deitada (Tremblay et al., 2017). A adoção de estilos de vida dependentes das novas tecnologias e de meios de transporte motorizados potencia o desenvolvimento de várias doenças, nomeadamente a diabetes, a osteoporose, as doenças cardiovasculares e a obesidade.

A interligação entre a obesidade e a insuficiência de AF aumenta desde cedo o CS, e também problemas motores que irão refletir-se negativamente no processo de aprendizagem motora, assim como no desenvolvimento dos mais variados padrões motores e nas capacidades cognitivas (Perera, 2005; Wilson & McKenzie, 1998).

Desordens coordenativas no desenvolvimento motor

Existem diversas situações percetíveis de desordens da CM que podem ser observadas concomitantemente com distúrbios psicológicos e neurológicos. No entanto, existem casos em que estas dificuldades aparecem isoladamente. Pulzi & Rodrigues (2015) enunciaram algumas das terminologias utilizadas para descrever esta condição como dispraxia, dificuldade motora, disfunção motora precetiva, *deficit* de atenção, controle motor e perceção.

A representação das desordens coordenativas no desenvolvimento (DCD) é um dos distúrbios mais comuns que afetam as crianças em idade escolar (Wann, 2007), sendo essencial a identificação das crianças com dificuldades de CM tão cedo quanto possível para que lhes seja dado o apoio necessário, mesmo antes de iniciar a carreira escolar (Jongmans, 2005). Para estas crianças, com dificuldades coordenativas, o desempenho de habilidades básicas como correr e andar, e até mesmo habilidades funcionais, como vestir, são muito complicadas, sendo historicamente referidas como “crianças desajeitadas” (Silva et al., 2011). Assim sendo, a avaliação da CM, juntamente com os fatores de ApF (força, resistência, resistência aeróbia, flexibilidade e composição corporal), bem como os de ApM (velocidade, agilidade, equilíbrio, coordenação) constituem a base das aprendizagens motoras (Gallahue & Ozmun, 2011), um campo relativamente recente e no qual alguns testes preenchem os critérios mínimos de estandardização de validade e fiabilidade, particularmente nas crianças em idade pré-escolar (Van Waelvelde et al., 2007).

Avaliação da coordenação motora em crianças: A bateria – MABC-2

O desenvolvimento motor da criança tem sido avaliado por diversas baterias de teste. Gallahue & Ozmun (2005) referem a importância que a avaliação tem na área do desenvolvimento motor, afirmando que, por meio da mesma, é possível observar alterações no desenvolvimento, identificar atrasos ou défices e fornecer indicações aos profissionais sobre o modo como devem orientar as suas intervenções.

Conforme mencionam Gallahue & Ozmun (2005), os instrumentos de avaliação podem ser categorizados por meio de dois testes de referência, de acordo com a ‘norma’, que se baseiam em amostras de indivíduos na ordem das centenas, ou mesmo milhares, e permitem comparar dados de um indivíduo com uma amostra estatística com características representativas da população em geral, e de acordo com o ‘critério’, que consiste em interpretar e comparar um padrão definido anteriormente por um comportamento. Nesta situação, não são feitas comparações com outros indivíduos. Os autores referem que a escolha

dependerá sempre da razão pela qual a avaliação está a ser realizada, das características dos instrumentos, da relevância das características do indivíduo e das capacidades do próprio avaliador (Gallahue & Ozmun, 2005). Além disso, os instrumentos de avaliação devem apresentar características essenciais para a sua utilização, tais como a confiabilidade; a precisão; a objetividade; a validade; referências para que se possa refletir ou comparar os resultados obtidos e que sejam de aplicabilidade fácil e com custos reduzidos (Monge Alvarado & Meneses Montero, 2002).

São vários os testes que permitem avaliar desordens ao nível coordenativo, mas o objetivo deste trabalho não é estudar cada um deles, por isso, daremos apenas o exemplo dos que têm sido mais utilizados neste âmbito e, posteriormente, publicados, como se passa a elencar:

O teste *Körperkoordination Test Für Kinder* – KTK (Kiphard & Schilling, 1974), que foi atualizado em 2007 (KTK-2) (Kiphard & Schilling, 2007), destinado a crianças entre os cinco e os catorze anos, é uma bateria orientada para o produto que se refere a uma norma e tem por objetivo a avaliação da coordenação motora grossa através das componentes de equilíbrio, ritmo, lateralidade, velocidade e agilidade. A avaliação destas componentes está dividida por quatro tarefas: trave de equilíbrio, saltos unipedais, saltos laterais e transferências sobre plataformas. Esta bateria não avalia a coordenação motora fina.

O Teste *Gross Motor Development* – TGMD (Ulrich, 1985), que foi atualizado em 2000, o TGMD-2 (Ulrich, 2000), destinado a crianças entre os três e os dez anos de idade, possui uma avaliação orientada para o processo, confiável, criteriosa e norma-referenciada, tendo como objetivo avaliar qualitativamente o desempenho de habilidades motoras grossas que inclui doze itens de habilidades motoras fundamentais, divididas em duas subescalas de movimento: locomoção e manipulação. A locomoção é avaliada por seis habilidades motoras - corrida, galope, pé-coxinho, salto, salto horizontal parado, deslocamento lateral - e a manipulação avaliada por seis habilidades de controlo de objetos - batimento numa bola estática, drible sem deslocamento, agarrar, pontapear, lançamento por cima do ombro/ lançamento por baixo.

O teste de *Bruininks-Oseretsky Test of Motor Proficiency* - BOTMP (Bruininks, 1978), que foi atualizado em 2005 (BOT-2) (Bruininks, 2005) destinado a crianças entre os quatro e os vinte e um anos, trata-se de um teste que estuda três componentes da proficiência que são a coordenação manual, coordenação corporal e coordenação motora fina, que integram catorze itens formando oito subtestes estruturados para avaliar aspetos do desenvolvimento motor. Segundo Cairney et al. (2009), consiste num instrumento altamente estruturado e não é tão fácil de aplicar como o MABC-2.

Assim sendo, no mesmo sentido de avaliação e após as baterias anteriormente citadas, foi proposto o *Movement Assessment Battery for Children* (MABC-2), uma bateria válida, norma-referenciada, em que a avaliação é qualitativa e quantitativamente orientada para o processo e para o produto (Henderson et al., 2007). Esta bateria encontra-se na segunda edição (MABC-2), e pode ser aplicada em crianças dos três aos dezasseis anos de idade, apresentando três bandas: 3-6 anos de idade, que é o foco do nosso estudo, 7-10 anos de idade e 11-16 anos de idade. Trata-se de uma bateria que avalia a destreza manual, habilidades de lançar e agarrar (controlo de objetos) e equilíbrio. O MABC-2 (Henderson et al., 2007), é atualmente reconhecido a nível mundial pelo potencial de identificar crianças com dificuldades de CM (Chow et al., 2006), e provou ser válida e confiável para crianças em idade escolar (Croce et al., 2001) e pré-escolar (Smits-Engelsman et al., 2011).

Sabemos que para a avaliação adequada das desordens coordenativas é necessário o uso de testes motores válidos e padronizados (Blank et al., 2012), visto que são vários os testes que avaliam as funções motoras, porém, apenas alguns deles foram desenvolvidos e identificados como apropriados para diagnosticar desordens coordenativas. Segundo uma revisão sistemática no âmbito de instrumentos utilizados para avaliar as habilidades motoras, o M-ABC e MABC-2 obtiveram os melhores resultados para diagnosticar desordens coordenativas em crianças, demonstrando boa a excelente confiabilidade (Chow et al., 2006; Slater et al., 2010). Estes testes foram recomendados em primeira instância para os médicos que desejavam avaliar o desempenho motor das crianças e detetar possíveis desordens coordenativas (Slater et al., 2010).

Perante a panóplia de baterias de teste explanadas, verificamos que apenas o MABC-2 se enquadra no nosso foco da análise para idade pré-escolar (3-6 anos) e uma avaliação quantitativa orientada para o produto. Porém, até ao momento, poucos estudos foram realizados associando o MABC-2 com AF (Cairney et al., 2015; Lin et al., 2016; Lopes et al., 2016) e obesidade (Zhu et al., 2011) em idade pré-escolar.

Face ao exposto, e tendo por base as diversas baterias de coordenação motora supracitadas, parece-nos importante salientar que MABC-2 se correlaciona positivamente com o TGMD-2 em crianças de 4 anos (Logan et al., 2011) e dos 3 aos 7 anos de idade (de Medeiros et al., 2016; Netelenbos, 2005; Valentini et al., 2015), como também com a bateria KTK em crianças dos 5 aos 13 anos (Smits-Engelsman et al., 1998) e BOT-2 em adolescentes dos 11 aos 16 anos de idade. Não obstante, não encontramos correlação positiva entre esta bateria e o MABC-2 dos 7 aos 10 anos de idade (Lane & Brown, 2015).

Coordenação motora, Atividade física e Obesidade

As dificuldades coordenativas em crianças influenciam a realização de habilidades motoras fundamentais, necessárias para o bom funcionamento diário (American Psychiatric Association, 2013), o que leva a uma menor participação de AF.

Segundo as recomendações de AF emitidas pelo Reino Unido, Austrália e Canadá, os pré-escolares devem acumular diariamente pelo menos 3 horas de AFT, independentemente da intensidade (Australian Governmental Departament of Health, 2010; Department of Health Physical Activity Health Improvement and Protection, 2011; Tremblay et al., 2012) Além disso, as recomendações Canadianas aconselham os pré-escolares a realizarem pelo menos 1h de AFMV diária (Tremblay et al., 2012). Ultimamente, o mesmo grupo emitiu recomendações de AF, em que é descrita a importância de 24h de monitorização da criança, a qual deve acumular pelo menos 1h de AFMV diária bem como três vezes por semana de atividade física vigorosa (AFV) atividades associadas ao reforço muscular e ósseo (Tremblay et al., 2016). Esta recente recomendação

considera que o CS deverá ser até duas horas por dia de tempo de ecrã, várias horas de atividade física ligeira (AFL), atividades estruturadas e não estruturadas e a duração do sono de 9-10 horas por noite (Tremblay et al., 2016).

A precisão da avaliação da AF surge desta maneira como extremamente relevante quando examinamos a sua relação com a saúde. Tem sido notório que as crianças, desde a pré-escola, se têm revelado fisicamente pouco ativas (Gordon et al., 2013) e, recentemente, outro estudo também demonstrou que aproximadamente 90% de 326 crianças de 9 anos de idade com baixa competência motora não cumpriram as recomendações de AFMV comparativamente com os seus pares com bons níveis de competência motora (De Meester et al., 2017).

A AFMV, tem sido positivamente associada com a CM em pré-escolares (Olesen et al., 2013). Todavia, poucos estudos na Europa têm revelado a prevalência de dificuldades de coordenação motora grossa (habilidades de controlo de objetos, como lançar e agarrar) relativos a dados norma-referenciados em crianças em idade pré-escolar e aparentemente saudáveis (Giagazoglou et al., 2011), sendo que o mesmo se detetou na componente de CM (D'Hondt et al., 2011; Graf et al., 2004; Lopes et al., 2012b; Toftegaard-stoeckel et al., 2010; Vandorpe et al., 2011).

Roth e colaboradores (2010) também averiguaram nas últimas duas décadas um declínio nas habilidades de equilíbrio e de controlo de objetos (lançar/agarrar), referindo que as habilidades adequadas de CM são necessárias para o sucesso das tarefas diárias. A baixa competência motora tem sido associada a baixos níveis de AF em pré-escolares (Williams et al., 2008). Em função disso, crianças com dificuldades de CM correm o risco de apresentar baixos níveis de participação na AF, visto que a participação bem-sucedida nas atividades quotidianas exige o domínio de diversas habilidades motoras, abrangendo um conjunto de coordenação motora grossa e fina (Hamilton & Liu, 2017).

Portanto, a competência das habilidades motoras é considerada um fator chave na participação da AF (Holfelder & Schott, 2014). Por conseguinte, crianças com elevado nível de competência motora podem achar mais fácil

participar na AF, enquanto crianças com nível de competência motora baixo podem preferir passar o seu tempo de forma mais sedentária para evitar dificuldades de movimento. Essa falta de atividade pode levar a experiências de movimento limitadas, o que impede a prática necessária para o desenvolvimento das habilidades motoras, bem como benefícios relacionados com a saúde (Robinson et al., 2015). Sendo assim, a competência motora adequada pode ajudar na manutenção de um estilo de vida fisicamente ativo, enquanto a falta dela coloca as crianças em risco de desenvolver excesso de peso e obesidade (Strong et al., 2005). À medida que as crianças com baixa proficiência motora envelhecem, existe maior probabilidade de os níveis de AF diminuírem acentuadamente (Lopes et al., 2011), acompanhados de rápidos aumentos do IMC (Lopes et al., 2014) e CS (Lopes et al., 2012a).

Para muitas crianças com dificuldades de CM, como as que estão em risco de desenvolver desordens coordenativas, experiências negativas de AF repetidas contribuem para um ciclo de privação e de recusa na participação de AF, limitando, desta forma, as oportunidades subsequentes para o desenvolvimento de habilidades motoras adequadas (Cairney et al., 2017). Contudo, a direção da causalidade nas relações entre proficiência de habilidade motora, níveis de AF e ApF são, contudo, pouco claras. (Lopes et al., 2011; Lubans et al., 2010).

Outra componente que está associada positivamente com a competência motora e relacionada com a saúde da criança é a ApF, nomeadamente a aptidão cardiorrespiratória, aptidão muscular e ApM (velocidade e agilidade)(Ortega et al., 2008)

De acordo com Cairney & Veldhuizen (2013), é referida uma associação causal entre o desenvolvimento de desordens coordenativas e a inatividade física, excesso de peso / obesidade e menor ApF. Assim sendo, é possível verificar que as crianças com dificuldades coordenativas diminuem a participação na AF, nomeadamente na AFMV e AFV (Laukkanen et al., 2014; Lin et al., 2016; Loprinzi et al., 2015; Williams et al., 2008).

Portanto, a competência motora, juntamente com a ApF, pode coadjuvar na obtenção de resultados positivos para a saúde em crianças e adolescentes

(Cattuzzo et al., 2016). Esta linha de pensamento foi sustentada recentemente por um estudo longitudinal, com crianças dos 6 -13 anos, o qual demonstrou uma associação positiva recíproca entre a AF e a competência motora durante a infância e o início da adolescência, tendo o VO_2pico mediado esta associação em ambas as direções (Lima et al., 2017a). Deste modo, parece-nos de extrema relevância a potencialidade do estímulo da competência e coordenação motora durante a infância, adolescência e, mais tarde, na idade adulta, que foi reforçado por um estudo longitudinal que avaliou os participantes aos 10, 16 e 46 anos que mostrou que o nível de CMG durante a infância foi associada à participação em AF e CS na idade adulta (Smith et al., 2015).

Parece notória, então, a necessidade de promover, desde a infância, a participação em AF, propiciando um meio adequado para a formação de habilidades motoras fundamentais, uma vez que este estádio de desenvolvimento é crucial para a fomentação de CM e ApM devido à conjetura de "barreira de proficiência", que, provavelmente, inibe aqueles que possuem baixos níveis de competência motora de participar na AF ao longo da vida (Stodden et al., 2013).

Uma outra componente que influencia a CM é a composição corporal. A literatura é profícua na sugestão que o excesso de peso está associado à baixa CM na infância (D'Hondt et al., 2011; Lopes et al., 2014). Efetivamente, crianças com sobrepeso e obesidade relevam desempenhos de habilidades motoras mais baixas e menor precisão na componente da destreza manual do que os seus pares normo-ponderais. (Gentier et al., 2013; Marmeleira et al., 2017) Até à data, a precedência temporal, ou a direção causal, desta associação não é clara. Ou seja, não é possível concluir claramente se a massa corporal elevada contribui para uma proficiência motora mais baixa, ou se, pelo contrário, esta contribui para uma maior massa corporal (Cheng et al., 2016).

Vários estudos longitudinais foram conduzidos em que apenas o peso ou as habilidades motoras foram usadas para prever mudanças subsequentes no peso ou nas habilidades motoras. Por exemplo, D´Hondt e colaboradores (2013) verificaram que o IMC elevado, entre os 6-10 anos, foi associado a declínios no desempenho da CMG nos 2 anos subsequentes (D'Hondt et al., 2013; Gentier et

al., 2013). Todavia, Rodrigues e colaboradores (2016) verificaram, através de análise de trajetórias de desenvolvimento, que as crianças que aos 6 anos tinham baixa a média competência motora e ApF apresentaram maior probabilidade de possuir sobrepeso e obesidade aos 10 anos de idade, independentemente do sexo e IMC no *baseline*. Segundo estes autores, o desenvolvimento da competência motora bem como da ApF durante a infância poderão ser protetores na obtenção de sobrepeso e obesidade (Rodrigues et al., 2016). Contudo, também recentemente, foi verificado que a obesidade aos 5 anos estava associada a declínios significativos de proficiência motora dos 5 para os 10 anos de idade, no entanto, o inverso não se verificou, isto é, ter proficiência motora aos 5anos de idade não influenciou o peso dos 5 para 10 anos de idade (Cheng et al., 2016).

Portanto, parece evidente que a promoção da competência motora, CM, ApM, da AF e do peso saudável em crianças com vista à melhoria do estado de saúde é um objetivo ambicioso. Todavia, a prevalência da obesidade infantil tem aumentado drasticamente nas últimas décadas em todo o mundo (World Health Organization, 2016) e, segundo a Organização Mundial da Saúde (OMS), 41 milhões de crianças com idade inferior a 5 anos apresentaram sobrepeso ou obesidade em 2014 (World Health Organization, 2016).

Face ao exposto, prevenir a obesidade durante a primeira infância é de particular importância, uma vez que as crianças obesas têm um risco adicional de se tornarem adolescentes e adultos obesos, associado a um risco acrescido de desenvolverem várias alterações cardio-metabólicas, incluindo hiperlipidemia, hipertensão, resistência à insulina, problemas respiratórios, complicações ortopédicas e cancro (Kim et al., 2017).

Um dos comportamentos modificáveis para prevenir e tratar a obesidade em todas as faixas etárias é a participação regular de AF (Loprinzi et al., 2012). A AF é um comportamento complexo que é influenciado por uma variedade de fatores (Schmutz et al., 2017). Neste sentido, as relações sinérgicas entre AF, competência motora, ApF e o estado do peso são fatores preponderantes no desenvolvimento saudável da criança (Stodden et al., 2008). Esta linha de investigação tem sido potenciada por vários estudos, tais como Ružbarská

(2016), que demonstrou que as crianças dos 7-10 anos com baixo nível de CM apresentaram baixo nível de ApF e aumento do peso corporal. No mesmo sentido, Fransen e colaboradores (2012) mostraram que as crianças com elevado nível de CMG obtiveram melhores resultados nos testes de ApF e participaram com maior frequência em práticas desportivas. Em contrapartida, os seus pares, com baixo nível de CMG, revelaram uma diminuta participação desportiva e, consequentemente, menor frequência na participação de AF.

Deste modo, parece ser consistente a associação entre a competência motora e AF (Cairney & Veldhuizen, 2013; Robinson et al., 2015) a ApF (Cairney & Veldhuizen, 2013; Cattuzzo et al., 2016) e o peso corporal (Cairney & Veldhuizen, 2013; Cattuzzo et al., 2016; Robinson et al., 2015) na infância e adolescência.

Portanto, reconhece-se a necessidade de mais investigação nesta área, nomeadamente em idade pré-escolar. Apesar de já se verificarem esforços ao nível da promoção da saúde em crianças em idade escolar e em adolescentes, pouca atenção tem sido dada às crianças pré-escolares. Face ao exposto, a adequada promoção de AF deverá propiciar o desenvolvimento da CM e competência motora desde a infância, favorecendo uma maior participação em práticas desportivas adequadas à idade, as quais parecem ser estratégias eficazes para o desenvolvimento saudável da criança em idade pré-escolar.

[Capítulo II.]

Métodos

MÉTODOS

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

Desenho do estudo e amostra

Os participantes dos estudos foram crianças em idade pré-escolar, matriculadas nos Jardins de infância situados na área metropolitana do Porto e que fizeram parte do projeto intitulado *"Preschool Physical Activity, Body Composition and Lifestyle Study (PRESTYLE)".*

Nos dois primeiros estudos, a amostra foi constituída por 209 pré-escolares portugueses (n = 109; 52,1% do sexo feminino), com idade média de 4,7 ± 0,7 anos. No terceiro estudo a amostra compreendeu 467 pré-escolares portugueses (n=244; 52,8% do sexo feminino), com a idade média de 4,8 ± 0,6 anos. O quarto estudo teve um *design* longitudinal e a amostra foi constituída por 54 pré-escolares portugueses (n = 24, 44,4% do sexo feminino), com idade média de 4,2 ± 0,4 no *baseline* (2013) e 5,3 ± 0,4 anos no *follow-up* (2014), sendo que todos os participantes apresentaram dados válidos de acelerómetro e da bateria do MABC-2 em ambos os momentos.

Os procedimentos do estudo foram aprovados pela Fundação para a Ciência e Tecnologia e pelo Conselho Científico do Programa de Doutoramento em Atividade Física e Saúde. O termo de consentimento foi assinado pelos pais ou tutores dos filhos, bem como pelos diretores da escola.

Os participantes foram avaliados durante o dia escolar por professores especializados.

Procedimentos e instrumentos

Avaliação antropométrica

A massa corporal foi avaliada por uma balança eletrónica digital (Tanita Inner Scan BC 532 Tokyo, Japão), com a capacidade de 150 kg e precisão de 100 g. Os participantes permaneceram imóveis em cima da balança, descalços e com roupa leve. A estatura foi obtida por um estadiómetro portátil (Holtain), comprimento de 2 metros e escala de 0,1 cm. Foi utilizada a média de duas avaliações consecutivas. O Índice de massa corporal (IMC) foi calculado segundo a divisão da massa corporal (kg) pela estatura (m) ao quadrado (kg/m^2) e classificado de acordo com *International Obesity Task Force* em três categorias, tais como peso normal, sobrepeso e obesidade (Cole et al., 2000), e também segundo o ponto de corte da Organização Mundial de Saúde (OMS)

A medição do perímetro da cintura (PC) foi avaliada na posição de pé, com uma fita métrica, com precisão de 0,1 cm, e foi considerado o ponto médio entre o bordo inferior da costela e a crista ilíaca ântero-superior no final de uma expiração normal (Lohman et al., 1988) O rácio cintura-estatura (RCE) proveio da divisão do PC (cm) pela estatura (cm). O RCE foi baseado na gordura central dos pré-escolares e foram definidos dois grupos: sem risco (RCE <0,5) e com risco (RCE ≥ 0,5) (McCarthy & Ashwell, 2006; Mendes et al., 2017)

Atividade Física e Comportamento Sedentário

A AF diária e CS foram estimados por acelerómetros GTM1 (Pensacola, FL 32502. USA), um dispositivo pequeno, leve e uniaxial. Este acelerómetro produz saída "raw" na contagem de atividades por minuto, a qual foi considerada como índice válido de "volume" total de AF (Janz, 1994). A AF foi monitorizada durante sete dias consecutivos (segunda a domingo). Foram considerados dados válidos para análise pelo menos 4 dias de utilização do acelerómetro, três dias de semana e um dia de fim de semana, e o mínimo de 10 horas por dia. Os

períodos de 60 min ou mais de zeros contínuos foram considerados tempos de não uso e excluídos das análises. A utilização do acelerómetro foi instruída ao longo do dia, exceto em atividades aquáticas. O acelerómetro foi usado confortavelmente sob a roupa, do lado direito da cintura, com o auxílio de cinto elástico ajustável.

As análises e o tratamento dos dados dos acelerómetros foram realizados no *software Actilife*, versão 6.11.4. Os dados foram classificados segundo pontos de corte pediátricos, em diferentes intensidades de AF, tais como: AFT ≥ 150 *counts* por minuto (cpm); AFMV ≥ 1680 cpm, e para o CS <150 cpm usado em vários estudos (Byun et al., 2015; Byun et al., 2011; O'Connor et al., 2014; Pate et al., 2015). Foi considerada a duração de *epoch* de 5 segundos, visto ser mais precisa para atividades espontâneas e intermitentes, caraterísticas em idade pré-escolar (Vale et al., 2009).

Coordenação Motora

A CM foi avaliada pelo Movement Assessment Battery for Children - Second Edition (MABC-2) (Henderson et al., 2007), a qual foi desenvolvida para identificar crianças em risco de disfunção motora e tem sido bastante utilizada para este fim (Smits-Engelsman et al., 2011).

O MABC-2 é subdividido na banda 1 (3-6 anos); banda 2 (7-10 anos) e banda 3 (11-16 anos) (Henderson et al., 2007). Foi utilizada a banda 1 (3 a 6 anos), a qual é composta por duas partes: o teste de desempenho e a lista de verificação, contudo apenas o teste de desempenho foi utilizado. As crianças realizaram uma série de oito tarefas motoras (finas e grossas), agrupadas em três componentes: Destreza Manual, Lançar & Agarrar e Equilíbrio. A bateria MABC-2 produz pontuação bruta como resultado de cada teste individual realizado. A partir dessa pontuação, os valores podem ser transformados em equivalentes de pontuação, ou *score*, padronizados para cada teste, de acordo com a idade em meses das crianças, e, posteriormente, em percentis. Os testes relativos a cada componente (Destreza manual, Lançar & Agarra e Equilíbrio) tiveram o seu *score* padrão somado. A CM resultou da soma dessas três

componentes, enquanto a CMG resultou da soma da componente Lançar & Agarrar e da componente de equilíbrio.

De acordo com as normas da bateria, as disfunções motoras podem ser interpretadas para percentis ≤5 e ≤15 (Henderson et al., 2007). Ou seja, se a criança tiver pontuação abaixo do percentil 5, ela é classificada com problemas motores, caso a pontuação se encontre entre o percentil 6 e 15, a criança encontra-se em risco de desenvolver um problema motor e os valores acima do percentil 15 significam que a criança apresenta habilidades motoras no *score* padrão, ou normais, para a idade.

APTIDÃO MOTORA

Para avaliar a ApM, utilizamos o *shuttle run test* (SRT de 10 × 5 m) e o salto a 2pés juntos, numa distância de 7 m (S2P). Durante a recolha dos dados, as crianças foram avaliadas individualmente num espaço tranquilo e sem foco de distração. Ambos os testes foram explicados e demonstrados antes de serem realizados pela criança. Os testes foram considerados não aplicáveis quando a criança não o realizou em duas tentativas.

Os resultados dos testes aplicados foram padronizados em Z*score* e categorizados de acordo com o desvio padrão (dp), sendo ≤1 considerado como ApM elevada e >1 como ApM baixa. Em seguida, de acordo com essa categorização, uma única variável foi formada a partir da soma de ambos os testes e subdividida em três categorias: ApM baixa (dp >1 para SRT e S2P), ApM média (dp > 1 para SRT ou S2P) e ApM elevada (dp <1 para SRT e S2P).

ANÁLISE ESTATÍSTICA

A análise estatística foi efetuada através do *software* SPSS, versão 22.0. Todos os dados foram verificados quanto à normalidade pelo teste Kolmogorov-smirnov. Utilizamos a estatística descritiva para caracterizar e descrever a amostra. O nível de significância para todas as análises foi estabelecido em 0,05.

As características básicas dos participantes, bem como as variáveis examinadas e os respetivos testes estatísticos são apresentados na Tabela 1.

Tabela 1: Resumo das características dos artigos.

Artigos	Amostra e Idades	Variáveis de interesse	Variáveis de ajuste	Procedimentos estatísticos
Association between moderate and vigorous physical activity and gross motor coordination in preschool children	n=209 3-6 anos de idade	AFMV CMG	CS Género	Teste t-student Regressão linear múltipla
GMC and WHtR in Preschoolers	n=209 3-6anos de idade	CMG RCE	CS Género	Teste t-student Regressão logística binária
Motor fitness and preschooler children obesity status.	n=467 3-6anos de idade	ApM IMC	AFT Género Idade	Teste t-student Qui-quadrado Regressão logística binária Regressão logística multinomial.
Changes in MVPA, motor coordination and BMI followed for one-year of longitudinal study in preschoolers.	n=54 4-5 anos de idade	AFMV CM	Género IMC	Teste t-emparelhado Wilcoxon signed rank test Regressão linear múltipla Δ= *Follow-up-baseline* (Δ%)= ((*follow-up-baseline*) × 100)

Nota: AFMV, atividade física moderada a vigorosa; AFT, atividade física total; ApM, aptidão motora; CM, coordenação motora; CMG, coordenação motora grossa; CS, comportamento sedentário; IMC, índice de massa corporal; RCE, rácio cintura-estatura.

[Capítulo III.]

Artigos Originais

ARTIGOS ORIGINAIS

I. Association between moderate and vigorous physical activity and gross motor coordination in preschool children

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Abstract

Introduction: Adequate gross motor coordination (GMC) is essential for children participating in age-related physical activities and seen to have an important role in maintaining sufficient level of physical activity (PA) during life course **Aim:** To examine the association between moderate vigorous physical activity (MVPA) and GMC in early infancy (ages 3–6). **Methods** The sample comprised 209 children aged 3–6 years. GMC was assessed according to the Movement Assessment Battery for Children (MABC-2). The battery to assess GMC comprised the aiming & catching and balance components. The MVPA and sedentary behaviour (SB) were measured by the accelerometer during 7 consecutive days (Monday to Sunday). **Results:** Our data showed that 31.3% had low GMC, 32.3% medium GMC and 36.0% high GMC. Multiple linear regression analysis showed that MVPA was positively association with GMC, adjusted for gender and SB. **Conclusions:** Preschoolers with high GMC spend more time in MVPA. GMC development should, therefore, be a key strategy in childhood interventions aiming to promote long-term PA.

Keywords: Preschoolers, gross motor coordination, moderate vigorous physical activity, and accelerometer.

Introduction

The acquisition of adequate gross motor coordination (GMC) is an essential developmental task in childhood. Adequate GMC is essential for children participating in age-related physical activities and seen to have an important role in maintaining sufficient level of physical activity (PA) during life course (Laukkanen et al., 2014).

GMC is considered an important element of a child's motor skills, and their cognitive and psychological behaviours (Gallahue & Ozmun, 2011). Motor coordination has been reported to be positively associated with preschool children's PA behaviour (Olesen et al., 2013).

PA has important psychological and physical implications in all age groups (Biddle & Asare, 2011; Timmons et al., 2012), including preschoolers (Tucker, 2008) and being physically active is an important healthy lifestyle habit that tracks into adulthood (Brown et al., 2009). Consequently, PA guidelines have been established for preschool children. According to the guidelines, preschoolers should accumulate 180 min of total PA throughout the day. In addition, the Canadian guidelines recommended that preschool children accumulate at least 1 h of moderate to vigorous PA (MVPA) daily (Tremblay et al., 2012). These recommendations state that children can accumulate PA intermittently throughout the day, and can include light-intensity activities such as standing, moving around and active play as well as moderate-to-vigorous intensity activities such as brisk walking, running and climbing (Australian Governmental, 2010; Tremblay et al., 2012).

The majority of evidence indicates that a substantial proportion of preschool aged children do not meet the recommendation of at least 60 min of MVPA per day (Hnatiuk et al., 2014), but rather spend most of their waking hours engaged in sedentary behaviour (SB) (Kelly et al., 2007; Reilly et al., 2004). Insufficient MVPA levels and high amounts of sedentary time are associated with poor motor skills (Iivonen et al., 2013). The reciprocal relationship between motor coordination and PA is very important, especially in preschoolers, PA seems to be positively correlated with object control, locomotor skill competence and motor

coordination in children, and negatively correlated with SB (Iivonen et al., 2013; Laukkanen et al., 2014), however, few studies have examined the association between MVPA and motor coordination in preschool children (Iivonen et al., 2013) Taking into consideration that GMC is essential for children to maintain a sufficient level of physical activity (PA) during the life and being this information crucial for public health and education professionals in understanding how best to enhance pre-schoolers' motor competence to be more active. Therefore, this study aimed to analyse the association between MVPA and GMC, as promotion of adequate fundamental GMC is an essential developmental task in childhood and as a criterion of maintaining optimal healthy lifestyle among preschoolers.

Material and Methods

Participants and data collection

Participants in this study were preschool-aged children enrolled in the Preschool Physical Activity, Body Composition and Lifestyle Project (PRESTYLE). A sample of children, aged 2–6 years, was recruited from kindergartens located in the metropolitan area of Porto, Portugal. For this analysis, we included only children aged three to six years with seven days of accelerometer data, had information about GMC, MVPA height, and body mass available were included in the sample.

The final sample this cross-sectional study included two hundred and nine preschoolers met these inclusion criteria (n=109; 52.1% girls). Data collection took place between April 2013 and November 2014. Written informed consent was obtained from parents and school supervisors. Study procedures were approved by the Portuguese Foundation for Science and Technology and by the Scientific Board of Physical Activity and Health PhD program.

Anthropometric measures

Body mass and height were measured by standard anthropometric methods. Body mass was measured to the nearest 0.10kg, with participants lightly dressed (underwear and t-shirt only) using a portable digital scale (Tanita Inner Scan BC 532, Tokyo, Japan). Height was measured to the nearest millimetre in bare or stocking feet with children standing upright against a Holtain portable stadiometer (Tanita).

Gross motor coordination

GMC was assessed using the Movement Assessment Battery for Children (MABC-2) (Henderson et al., 2007). This test battery was developed as a means of identifying those at risk of motor impairment and has been widely adopted for this purpose (Smits-Engelsman et al., 2011). The MABC-2 is designed for children from 3 to 16 years which assesses manual dexterity, aiming & catching and balance components. The MABC are composed for: age band 1 (3-6years); age band 2 (7-10years) and age band 3 (11-16 years) (Henderson et al., 2007). Manual dexterity data were not assessed in this study as the focus of the current work was on gross motor coordination (aiming & catching and balance components).

The child's performance on each of these tasks (a score for either accuracy or completion time) was summed, producing area scores, and converted to normative scores (taking age in months into considerations, age adjusted) according the MABC–2 test manual (Henderson et al., 2007). The sum of both components of GMC was subsequently converted to Z-scores.

Moderate vigorous physical activity and sedentary behaviour

MVPA and SB were measured during 7 consecutive days (Monday to Sunday using the ActiGraph GT1M accelerometer (Pensacola, FL, USA). This accelerometer provides output in activity counts, which gives information about

the intensity of PA (Janz, 1994). Alternatively, accelerometer output can be interpreted using specific cut-points, which identify time in different intensities of PA. Data reduction, cleaning and analyses of accelerometer data were performed using a specially written program described and used previously (Purslow et al., 2008; Sardinha et al., 2008). Data were analysed using specific paediatric cut-points, which have been validated for young children: ≥1680 cpm for MVPA and < 150cpm for SB, as already been used in several studies (Byun et al., 2015; Byun et al., 2011; O'Connor et al., 2014; Pate et al., 2015).

For the purpose of this study, the epoch duration was set to 5 seconds, which has been shown to be more accurate for the assessment of the preschoolers' spontaneous and intermittent activities (Vale et al., 2009). To process the data we used *Actilife*® software (Pensacola, Florida), which automatically scaled the 15-second cut-point to the 5-second epoch interval. A minimum-wear time of 10 hours per day was considered valid for inclusion in data analysis (Rich et al., 2013). Non-wear time was defined as a period of at least 60 consecutive minutes of zero counts. Parents were instructed to attach the accelerometer when the child awoke and to remove it when they went to bed. The accelerometer was firmly adjusted at the child's hip by an elastic waist belt under their clothing. All children participated in their normal activities with their classmates during the monitoring period.

Statistical analyses

Means and standard deviation (SD) were calculated to describe children's main characteristics by gender. Multiple linear regression was employed as it provides an indication of the amount of variance in MVPA explained by GMC after adjusting for gender and SB. Statistical analysis was performed using the SPSS 24.0 software (SPSS Inc., Armonk, NY). The level of significance was set at $p < 0.05$.

Results

Table 1 shows descriptive characteristics of the sample according to gender. Boys had lower body mass (p=0.04) and were more active than girls (p=0.01), boys also had less SB than girls (p=0.01). The girls had better performance on total scores for GMC compared to boys (p=0.01). No other statistical significant differences were found.

Table I. Preschool children`s characteristics.

Gender Variable	Total (n=209)	Girls (n=109)	Boys (n=100)	p-value
Age (years)	4.73±0.74	4.72±0.72	4.74±0.74	0.69
Weight (Kg)	20.73±3.91	21.22±4.21	20.12±3.42	0.04*
Height (cm)	109.01 ± 6.12	110.51±6.32	109.12±5.81	0.09
BMI (kg/m^2)	17.03±1.96	17.17±2.14	16.87±1.73	0.15
SB (min/day)	67.07±6.19	68.40±5.98	65.61±6.10	0.01*
MVPA (min/day)	92.29 ±25.72	85.44±24.99	99.86±24.43	0.01*
GMC	42.91 ±10.73	44.06 ±9.71	41.71 ±11.62	0.01*

Abbreviations: BMI, body mass index; SB, Sedentary behaviour; MVPA, Moderate vigorous physical activity; GMC, Gross Motor Coordination, *p<0.05.

Multiple linear regression analysis (Table 2) showed that MVPA was positively associated with GMC adjusted for gender and SB.

Table II. Association between moderate vigorous physical activity and gross motor coordination in preschoolers

Variables	MVPA			
	Beta	95%CI	p	R^2
ZGMC	0.12	0.63; 3.10	0.01	
SB	-0.81	-3.73; -3.03	0.01	0.69

Multiple linear regression model: MVPA; moderate vigorous physical activity, ZGMC; z-score gross motor coordination, SB; sedentary behaviour. The association was adjusted for age and gender,*p<0.05.

Discussion

This study aimed to examine the association between MVPA and GMC in preschool children. The most important finding indicated that MVPA was positively associated with GMC and negatively associated with SB, irrespective of gender. This outcome is worth highlighting because preschoolers with low GMC tend to be less physically active than their counterparts with high GMC.

Our data also shows that 31.7% of the children had low levels of GMC, 32.3% medium and 36.0% a high level of GMC. The children with high GMC undertook greater MVPA than their counterparts with low levels of GMC, and the preschoolers with high SB had low MVPA. This finding agrees with previous studies indicated that the total amount of PA, and MVPA positively, and sedentariness negatively, with the level of gross motor skills in children.(Burgi et al., 2011; Fisher et al., 2005; Laukkanen et al., 2014; Williams et al., 2008; Wrotniak et al., 2006). In longitudinal designs, the level of gross motor skills was only weakly or moderately associated with level of PA (Barnett et al., 2009; Lopes et al., 2011).

The present results also are in line with some studies that mentioned that overall PA seems to be positively correlated with object control, locomotor skill competence and motor coordination in children. (Barnett et al., 2016b; Barnett et al., 2016c) Available evidence suggests that preschoolers' motor skill performance seems to be positively associated with the time spent in health-related PA (Fisher et al., 2005). For instance, fundamental movement skills (FMS) proficiency was associated with overall PA during childhood (Iivonen et al., 2013). Therefore, our data reinforce these aforementioned studies, suggesting that the implementation of PA into children's everyday life (e.g. in the kindergarten/school settings) are of particular importance since higher levels of PA during childhood are associated with fundamental movement skills (FMS) proficiency and vice versa (Iivonen et al., 2013). Children without or with low opportunities to gain appropriate FMS levels are in danger to develop motor developmental retardations with a lower chance to successfully participate in an active and healthy sports culture (Stodden *et al*. 2008). As a consequence, children with less

developed FMS proficiency are reported to be at a higher risk to develop habitual physical inactivity, high level of SB and subsequently poorer adolescent health (Lubans *et al*. 2010). According to Lopes et al. (2011) it is possible that limited motor competence may lead to unpleasant experiences in movement activities whereas better motor competence is associated with more favourable experiences, which encourage involvement in PA.

Our findings show that preschoolers who had high levels of GMC were more active in MVPA than those that had low level of GMC. This is congruent with evidence in the literature that having high fundamental movement skill level may increase options for participation in PA, as well as increased participation leading to further development of motor skills. However, some studies suggest a reciprocal relationship between PA and FMS (Barnett et al., 2011; Kambas et al., 2012). Children tend to be physically active during play and it is possible that those who have greater motor competence may be more likely to engage and persist in challenging physically active tasks. If this is so, investing in the improvement of motor proficiency in young children has potentially relevant policy implications related to PA and health.

Despite this relevance, few studies in Europe have reported the prevalence of movement difficulties relative to norm referenced data in a high number of apparently healthy preschool children with respect to motor coordination (D'Hondt et al., 2011; Lopes et al., 2012; Toftegaard-stoeckel et al., 2010). As such, the current study extends research knowledge on this topic.

There is considerable evidence to indicate that reduced PA or increased sedentary behaviour are implicated in motor development, or the process by which a child acquires movement patterns and skills, has also been shown to be positively associated with PA (Cliff et al., 2009; Fisher et al., 2005). Early motor development is important as motor skills are a key factor in the likelihood of participation in various forms of PA during later childhood and adolescence (Barnett et al., 2009; Fisher et al., 2005). Knowing that, in early childhood, PA opportunities are essential to develop good GMC levels; and that GMC level differences become more evident between children and may in turn affect their PA participation (Barnett et al., 2009). Some of studies have given attention to

the association between MVPA and gross motor skills (Burgi et al., 2011; Olesen et al., 2013),

The present study makes an important contribution to this area by establishing the association between MVPA and GMC in pre-schoolers, a population which has received less attention in the literature than primary and secondary school aged children. As the early years of life are an important period of growth it is important to emphasize early identification and intervention of young children suspected as, or at risk of, having poor GMC.

Although our study identified that MVPA was associated positively with GMC and negatively with SB. in pre-schoolers, some limitations should be recognized. The study included preschool children from only one metropolitan area, which makes it difficult to generalize the findings to other samples. Further, because the study was cross-sectional, it is not possible to infer causal relationships. Future longitudinal research would be welcome to understand this latter point.

The strengths of this study included the assessment of GMC, which has not been measured very much in preschoolers. Therefore, although our findings demonstrate some interesting associations, these support the few data available on the topic to date. Further studies are needed to understand which strategies better suit the improvement of GMC and PA in early stages.

Conclusion

The current study demonstrates that MVPA was associated positively with GMC and negatively with SB, among Portuguese preschoolers. MVPA and GMC proficiency training seems to be associated and should be launched as early as possible. This fact is particularly important since a more active lifestyle during childhood can lead to a more developed motor competence during adulthood. Therefore, GMC development should be a key strategy in childhood interventions aiming to promote long-term PA.

Disclosure statement

No potential conflict of interest was reported by the authors.

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II. Gross motor coordination and Waist-to-height-ratio in preschoolers

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Abstract

Background: Motor coordination is inversely related with body weight. **Objective:** To examine the association between gross motor coordination (GMC) and waist-to-height-ratio (WHtR) among preschoolers. **Methods:** The sample comprised 209 children aged 3–6 years, GMC was assessed according to the Movement Assessment Battery for Children (MABC-2).The battery to assess GMC comprised the aiming & catching and balance components. Each component of GMC was categorized in tertiles in low, medium and high GMC, but in this study the focus was to analyse the extremes, low and high GMC. The WHtR was categorized as no risk (<0.05) and at risk (≥0.05). Sedentary behavior (SB) was measured by the accelerometer during 7 consecutive days (Monday to Sunday). **Results:** The prevalence of WHtR at risk was 45.2%. In our sample, the prevalence of low, medium and high level for the aiming & catching components was 40.0%, 27.0% and 33.0% and for balance component 33%, 34% and 33%. Binary logistic regression analysis, adjusted for gender and SB, showed that preschoolers categorized as being at WHtR risk were 3.5 times more likely (OR: 3.5; IC: 1.7-7.2) to have low coordination in aiming & catching component than their no risk counterparts, while in the balance component, those classified at WHtR risk were 5.0 times (OR: 5.0; IC: 2.1-12.0) more likely to have low coordination than their no risk peers. **Conclusion:** This study illustrates that low GMC is associated with a higher WHtR in preschoolers. Early interventions might be necessary to increase GMC and reduce WHtR.

Keywords: Waist-to-Height-Ratio, Gross motor coordination, Preschool children, Accelerometer, Obesity.

Introduction

Childhood obesity is a widespread and growing problem in the world even at preschool ages (World Health Organization, 2016). Abdominal or central obesity is particularly important as a marker for health status as it has emerged as a significant predictor for metabolic abnormality and adverse health status in youth (Ali et al., 2014).

Due to the expense and expertise required to measure visceral adipose tissue by imaging techniques, there is interest in identifying associated robust anthropometric markers that can be used clinically (Barreira et al., 2014). A variety of anthropometric indices have been used as proxies for total and abdominal fat to assess risk for diseases, particularly cardiovascular diseases (CVDs) and diabetes (Hara et al., 2002). The waist-to-height ratio (WHtR) has also been shown to be a good predictor of central obesity in children and adolescents (Brambilla et al., 2013; McCarthy & Ashwell, 2006) as well as in preschoolers (Mota et al., 2016). Therefore, central fat distribution is associated with greater health risks than total body fat. As a proxy measure WHtR provides information about body fat distribution as well as it was strongly correlated with abdominal fat (Despres, 2006; Soto Gonzalez et al., 2007).

In the past decade, research on the relationship between excessive body weight or fatness and the level of motor competence in children has become increasingly important (Tsiros et al., 2011). Motor competence refers to the degree of skilled performance in a wide range of motor tasks as well as the movement coordination and control underlying a particular motor outcome (Hondt et al., 2009). An adequate level of motor skills is not only considered a key factor in children's general development but also the foundation for an active lifestyle (Lubans et al., 2010). In addition, higher levels of motor coordination (MC) are inversely associated with sedentary behaviour in childhood (Lopes et al., 2012a) but little is known as GMC relates to WHtR in pre-schoolers.

In preschool children, to the best of our knowledge, there is no available information about the association between GMC and WHtR as a proxy measure of central obesity. Given the need for early intervention to reduce unhealthy

weight status in children and improve the GMC, as well as, understanding if WHtR is an effective proxy for central obesity, this study aimed to analyze the association between GMC and WHtR in preschool children.

Material and Methods

Participants and data collection

This was a cross-sectional study completed in kindergartens enrolled in the Preschool PA, Body Composition and Lifestyle Study (PRESTYLE), a longitudinal study that began in the autumn of 2012. All kindergartens located in the metropolitan area of Porto were invited to participate and 20 classes were random selected. All children belonging to the selected classes were invited to participate. A random sample of 1160 children, aged 3–6 years, was recruited from kindergartens located in the metropolitan area of Porto, Portugal. In this study, we have included results in GMC, sedentary behavior (SB), height, waist circumference (WC) and body mass information as inclusion criteria, only 209 preschoolers met the inclusion criteria (n=109; 52.1% girls). Data collection took place between April 2013 and November 2014. A written consent was obtained from parents and school supervisors. Study procedures were approved by the Portuguese Foundation for Science and Technology and by the Scientific Board of Physical Activity and Health PhD program.

Anthropometric measures

Body mass and height were measured by standard anthropometric methods. Body mass was measured to the nearest 0.10kg, with participants lightly dressed (underwear and t-shirt only) using a portable digital scale (Tanita Inner Scan BC 532, Tokyo, Japan). Height was measured to the nearest millimetre in bare or stocking feet with children standing upright against a Holtain portable stadiometer (Tanita). The measurements were repeated twice and the average was recorded. WC measurement was taken in a standing position, to the

nearest 0.1 cm, with a tape measure midway between the lower rib margin and the anterior superior iliac spine at the end of normal expiration (Lohman et al., 1988). WHtR was calculated as the ratio of waist (cm) and height (cm). A WHtR cutoff of ≥0.5 was used to define abdominal obesity in youngsters (McCarthy & Ashwell, 2006). Thus, for analyses purposes we defined two categories: the non-risk group (WHtR<0.5) and at risk group based on central fat (WHtR≥0.5) (Mc CarthyHD & M, 2006)

Gross motor coordination

GMC was assessed using the Movement Assessment Battery for Children (MABC-2) (Henderson et al., 2007). This test battery was developed as a means of identifying those at risk of motor impairment and has been widely adopted for this purpose (Smits-Engelsman et al., 2011). The MABC-2 is designed for children from 3 to 16 years which assesses manual dexterity, aiming & catching and balance components. The MABC are composed for: age band 1 (3-6years); age band 2 (7-10years) and age band 3 (11-16 years) (Henderson et al., 2007). Manual dexterity data were not assessed in this study as the focus of the current work was on gross motor coordination (aiming & catching and balance components). The child's performance on each of these tasks (a score for either accuracy or completion time) was summed, producing area scores, and converted to normative scores (taking age in months into considerations, age adjusted) according the MABC–2 test manual (Henderson et al., 2007). Each component was categorized in tertiles such as: low, medium and high level. However, in this study the focus was to analyse the extremes, low and high GMC.

Sedentary behaviour

SB was measured during 7 consecutive days (Monday to Sunday) using the GT1M ActiGraph accelerometer (Pensacola, FL USA). A minimum-wear time of 10 hours per day was considered valid data for the analysis (Rich et al., 2013). Non-wear time was defined as a period of at least 60 consecutive minutes of zero

counts. The epoch duration was set to 5 seconds, which has been shown to be more accurate for the assessment of the preschoolers' spontaneous and intermittent activities (Vale et al., 2009). SB was calculated using a cut-point of < 150 counts per minute (Pate et al., 2015; O`Connor et al., 2014). To process the data we used *Actilife*® software (Pensacola, Florida), which automatically scaled the 15-second cut-point to the 5-second epoch interval. Parents were instructed to attach the accelerometer when the child awoke and to remove it when they went to bed. The accelerometer was firmly adjusted at the child's hip by an elastic waist belt under their clothing. All children participated in normal activities with their classmates during the monitoring period.

Statistical analyses

Means and stand deviation (SD) were calculated to describe children's characteristics by sex.

The association between GMC and WHtR was examined using binary logistic regression. The model was adjusted for gender and SB. Statistical analysis was performed using the SPSS 24.0 software (SPSS Inc., Armonk, NY). The level of significance was set at $p < 0.05$.

Results

Table 1 shows descriptive characteristics of the sample according to gender. Boys had lower mass (p=0.04), smaller WC (p=0.01), WHtR (p=0.04) and smaller SB (p=0.01) than girls. Girls had significantly better performance in balance component (p=0.01); than boys. However, boys had significantly better performance in aiming & catching (p=0.01) than girls. No other statistical significant differences were found.

Table 1. Preschool children`s anthropometric and gross motor coordination characteristics

Gender Variable	Total (n=209)	Girls (n=109)	Boys (n=100)	p-value
Age (years)	4.73±0.74	4.72±0.72	4.74±0.74	0.69
Weight (Kg)	20.73±3.91	21.22±4.21	20.12±3.42	0.04*
Height (cm)	109.01 ± 6.12	110.51±6.32	109.12±5.81	0.09
BMI (kg/m^2)	17.03±1.96	17.17±2.14	16.87±1.73	0.15
SB (min/day)	67.07±6.19	68.40±5.98	65.61±6.10	0.01*
WC (cm))	55.12±5.82	56.11±6.52	54.0±4.62	0.01*
WHtR (cm)	0.50±0.04	0.50±0.05	0.46±0.03	0.04*
Aiming&catching	14.72 ±5.01	13.86 ±4.56	15.60 ±5.31	0.01*
Balance	28.10 ±7.86	29.99 ±6.92	26.11 ±8.31	0.01*

Abbreviations: BMI, body mass index; SB, Sedentary behaviour; WC, waist circumference; WHtR, waist-to-height-ratio,*p<0.05.

Binary logistic regression analysis (Table 2) showed that preschoolers classified at WHtR risk were 3.5 times more likely (OR: 3.5; IC: 1.7-7.2) to have low coordination in aiming & catching components than their counterparts at no risk. The same figure was found for balance component, in which the preschoolers at WHtR risk were 5.0 times more likely (OR: 5.0; IC: 2.1-12.0) to have low coordination in balance component compared to their counterparts classified at no risk. All associations were adjusted for gender and SB.

Table 2. Association between gross motor coordination and WHtR in preschoolers

GMC / WHtR	Aiming & Catching		Balance	
	OR (95% CI)	p-value	OR (95% CI)	p-value
<0.05	1	1	1	1
≥0.05	3.5 (1.7-7.2)	0.001*	5.0 (2.1-12.0)	0.001*

Abbreviations: GMC; Gross motor coordination; WHtR, waist-to-height ratio; All analyses were adjusted for gender and SB, sedentary behaviour, *p<0.05.

Discussion

This study aimed to examine the association between GMC and WHtR as a measure of central obesity in Portuguese preschool children. Our data identifies a strong association between WHtR and GMC. We found that 45.2% of the children were placed in WHtR risk group. Our data are slightly lower that those described previously (47.5%) in older children (Albuquerque et al., 2012). Further, altogether, 40% of the children were classified in the low coordination for the aiming & catching component and 33% for the balance component. Importantly, our data highlight that those classified as being at WHtR risk were 3.5 times more likely to have low coordination in aiming & catching components and 5.0 times more likely to have low coordination in balance component compared to their counterparts at no WHtR risk, adjusted to gender and SB. This relationship suggests that as WHtR increases, GMC declines. This is consistent with other studies that used different proxy measures of weight status, such as BMI/ WC in which, it was found an inverse relationship between GMC and weight status (Lopes et al., 2012b; Morano et al., 2011).

Children with lower GMC may lack confidence or motivation that could further hinder their participation, causing them to refrain from physical activity (Nervik et al., 2011). This may lead to a more sedentary lifestyle and further weight gain. Having all 3 factors—high BMI, low GMC, and low physical activity levels could make weight reduction difficult. The GMC for this age group are particularly important, as they focus on refining and improving basic motor

milestones developed at earlier ages and are foundational for higher-level skills (Nervik et al., 2011). The present study makes an important and novel contribution to this area be establishing the association between GMC and weight status in pre-schoolers, a population which has received less attention than primary and secondary school aged children.

Similar to the findings of D'Hondt et al. (2014) we have found that children's weight status negatively influences performance of GMC. Regardless of the motor assessment tool and BMI based classification method being used, lower fundamental motor skill mastery, as well as poorer performances on gross motor skill and coordination tests, have been reported in overweight and obese children as compared to healthy-weight peers and/or age-related standards (Castetbon & Andreyeva, 2012; D'Hondt et al., 2011).This weight status related to the impairment in motor development starts to manifest itself in preschool population (Nervik et al., 2011). In addition, it has been suggested that if no action is taken a widening gap in gross motor performance will occur over time with a more pronounced detrimental effect of excess body weight and fatness as age increases (D'Hondt et al., 2011). A first step to better target effective interventions is therefore to identify the nature of the association between GMC and weight status in pre-schoolers. The present study has addressed this issue.

Our data show a strong association between high WHtR and low GMC in pre-schoolers. These results are however difficult to compare with other studies because, to the best of our knowledge, no previous study chas assessed the association between WHtR and GMC in these ages. This outcome is also worth highlighting because children with poor motor coordination have been found to be less likely to participate in physical activities and it has been hypothesized that this condition may be a risk factor for obesity (Cairney et al., 2005).

In our study the high percentage (40%) of children that did not achieve a high coordination in aiming & catching component may lie on the lack of suitable activity options in children, such as playing outside impairing activities leading poor hand control/coordination. This explanation agrees with prior studies that found poor GMC for aiming & catching was also associated with SB in 7, 11, 16 years-old children compared to their active peers (Osika & Montgomery, 2008).

While in 6-10 year-old obese children have a lower performance compared their normal weight peers (Hondt et al., 2009).

With regards to the percentage of 33% of participants classified in low level of coordination in balance component, this may also be related with children's lower levels of overall movement and time spent playing. Our data also identified a significant correlation between balance and WHtR. This consistent with other studies that found similar results in 6-10 year-old children (Deforche et al., 2009; Hondt et al., 2009).

Although our study identified novel associations between GMC and WHtR in pre-schoolers, some limitations should be recognized. The study included preschool children from only one metropolitan area, which makes it difficult to generalize the findings to other samples. Further, because the study was cross-sectional, it is not possible to infer causal relationships using such a cross-sectional design. Identifying whether poor GMC leads to increased weight status or whether increased weight status results in children moving less and then poorer GMC is an important next step for research. The strengths of this study included the assessment of GMC, once that it has been little employed in previous research with preschoolers. Therefore, although our findings are novel, further studies are needed to understand which strategies are better suited to combat obesity early in life and also whether WHtR is a better proxy for fatness than the more widely used BMI and WC. Interventions to promote healthier weight status via the improvement of motor skills in overweight children should be specifically directed towards the aiming & catching and balance components of GMC.

Conclusion

Our results suggest that there is considerable prevalence of obesity risk, assessed using WHtR, among Portuguese preschoolers. Further, the obesity indicator was associated with poor gross motor coordination. Intervention efforts to increase levels of motor coordination through physical activity participation may be best placed to reduce unhealthy weight status over the life course. In

particular, targeting preschool children with low levels of gross motor coordination may be important in maximising health benefits from such interventions at a population level.

Key Messages:

- Waist-to-height-ratio is inversely related with gross motor coordination in pre-schoolers;
- An important number of preschoolers did not reach acceptable score in GMC once, 40% of the preschoolers were classified as low coordination in the aiming & catching component and 33% were classified as low coordination in the balance component.
- Poor GMC results at 3-6 years-old may impair further activities leading towards poor hand control/coordination and balance.
- Negative relationship between excessive body weight and the level of motor competence in preschoolers;
- Levels of motor coordination (MC) are inversely associated with sedentary behaviour in preschoolers.

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Motor fitness and preschooler children obesity status

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ABSTRACT

The aim of this study was to examine the association between motor fitness (MF) and obesity status in preschool children.

The sample comprised 467 children aged 3–6 years. Preschool children body mass index was classified according to International Obesity Task Force and categorised into three levels, normal, overweight and obesity. Total physical activity was assessed by accelerometer and MF test was assessed through two MF tests 10 × 5m shuttle run test (SRT) and a 7 m jumping distance on 2 feet test (J2F). Low MF was considered for MF if SD above 1. A single variable with three categories was created: low MF medium MF and high MF.

The prevalence of normal weight, overweight and obesity was 67.6%, 22.7% and 9.7%, respectively. The prevalence of SD > 1 for SRT was 13.7% and 14.4% for J2F, for single variable was 19.2%. Multinomial logistic regression analysis showed that obese preschoolers were more likely six times classified as having low MF level than their non-overweight counterparts (OR: 6.4; IC: 1.3–36.6).

This study showed a considerable prevalence of overweight and obesity among preschoolers. Obesity has already been associated with lower MF. Further longitudinal studies are needed to confirm this data.

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KEYWORDS
Physical fitness; motor fitness; preschool children; body mass index

Introduction

The high prevalence of childhood overweight and obesity have been cause for great concern since detrimental biological and psychological consequences of childhood overweight have been described. In addition, it was recognised that fitness and physical activity (PA) are associated with obesity. For instance, children and adolescents with overweight are less fit than their leaner peers (Kriemler et al., 2008; Ortega, Ruiz, & Castillo, 2013), while there is growing evidence that fitness during childhood and adolescence is negatively associated with total and central body fat in cross-sectional studies as well as later in life (Cadenas-Sanchez, Artero, Concha, Leyton, & Kain, 2015; Ortega et al., 2007).

Whereas physical fitness is considered a powerful health marker in children and adolescents (Ortega, Ruiz, Castillo, & Sjöström, 2008; Smith et al., 2014), motor fitness (MF) is a component of physical fitness that is related with the improvement of performance in sports and motor skills (Ortega et al., 2015). The main components of MF are speed, agility and balance (Caspersen, Powell, & Christenson, 1985; Ortega et al., 2015). Secular trends have shown a decrease for most of the basic motor abilities (Klein, Manz, Ferrari, Struder, & Graf, 2015). Although the preschool years are a critical period in terms of developing these components, available data are scarce (Klein et al., 2015). Therefore, in this age, it is very important to direct special attention in satisfying and developing fundamental motor skills, which enable children to overcome space, obstacles and resistance and to manipulate objects. Additionally, improvements in MF have shown to reduce the risk of becoming overweight/obese in adolescence (Haga, 2009; Moliner-Urdiales et al., 2011). However, the data addressing the relationship of MF with obesity status in preschool children is scarce (Bayer, Bolte, Morlock, Rückinger, & von Kries, 2009). Thus, the aim of this study was to examine the association between the MF and the obesity status in preschool children.

Methods

Participants and data collection

This was a cross-sectional study completed in kindergartens enrolled in the Preschool PA, Body Composition and Lifestyle Study (PRESTYLE), a longitudinal study that began in the autumn of 2012. All kindergartens located in the metropolitan area of Porto were invited to participate and 20 classrooms were selected. All children belonging to the selected classrooms were invited to participate. A random sample of 1160 children, aged 3–6 years, was recruited from kindergartens located in the metropolitan area of Porto, Portugal. Only 467 preschoolers met the inclusion criteria (52.8% girls). In this study, we have included results in the shuttle run test (SRT), 7 m jumping distance on 2 feet test (J2F) and total physical activity time (TPA). Height and weight information has also been included. Data collection took place between April 2013 and November 2014. A written consent was obtained from parents and school supervisors. Study procedures were approved by the Portuguese Foundation for Science and Technology and by the Scientific Board of Physical Activity and Health PhD programme.

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Anthropometric measures

Body mass and height were measured by standard anthropometric methods. Body mass was measured to the nearest 0.10 kg, with participants lightly dressed (underwear and t-shirt only) using a portable digital scale (Tanita Inner Scan BC 532, Tokyo, Japan). Height was measured to the nearest millimetre in bare or stocking feet with children standing upright against a Holtain portable stadiometer (Tanita). The measurements were repeated twice and the average was recorded. Body mass index was calculated and classified according to International Obesity Task Force into three groups, normal weight, overweight and obesity (Cole, Bellizzi, Flegal, & Dietz, 2000).

MF

For assessing MF we used the two MF tests, 10 × 5 m SRT and jumping a distance of 7 m on 2 feet (J2F). Some studies suggested that SRT and J2F are reliable tests to be used for assessing MF (speed/agility) in preschool children (Fjortoft, Pedersen, Sigmundsson, & Vereijken, 2011; Haga, 2008). Each MF test was standardised and standard deviation above one (SD > 1) was considered low motor abilities. Afterwards, MF was categorised as low MF and high MF. Afterwards, both MF tests were associated and a single variable was created with three categories: low MF (SD > 1 for SRT and J2F); medium MF (SD > 1 for SRT or J2F) and high MF (SD < 1 for SRT and J2F). Although several studies have examined the construct validation of MF tests, the majority assessed the overall scores of the subset rather than the single test measurements (Fjortoft et al., 2011; Fjørtoft, Pedersen, Sigmundsson, & Vereijken, 2003). Therefore, little information is available about which test is the most valid in this age group. In addition, no criterion-related validity or health-related studies (either longitudinal or cross-sectional) were identified (Fjortoft et al., 2011).

Children were tested individually. The SRT and JSF were explained and demonstrated before the child started. If a child made an error, instructions and demonstrations were repeated, and the child was allowed a new attempt. If a second error occurred or if a child could not perform the test, then the MF test was scored as missing.

PA

Daily PA was measured using the ActiGraph GT1M accelerometer (Pensacola, FL, USA). This accelerometer provides output in activity counts, which gives information about the intensity of PA (Janz, 1994). Alternatively, accelerometer output can be interpreted using specific cut-points, which identify time in different intensities of PA. Data reduction, cleaning and analyses of accelerometer data were performed using a specially written program described and used previously (Purslow, Hill, Saxton, Corder, & Wardle, 2008; Sardinha, Baptista, & Ekelund, 2008). Data were analysed using specific paediatric cut-points, which have been validated for young children: ≥150 cpm for active time (total PA time (TPA) as already been used in several studies (Byun, Beets, & Pate, 2015; Byun, Dowda, & Pate, 2011; O'Connor et al., 2014; Pate et al., 2015). For the purpose of this study, the epoch duration or sampling period was set to 5 s, which is more accurate for the spontaneous and intermittent activities of children as used previously with a similar sample (Vale, Santos, Silva, Soares-Miranda, & Mota, 2009). PA was monitored for seven consecutive days (Monday to Sunday). A minimum of 10 h of data per day was required for analysis. Periods of 60 min or more of continuous zeroes were considered non-wear times and were excluded from the analyses. Parents were instructed to attach the accelerometer when the child awoke and to remove it when they went to bed. The accelerometer was worn snuggly under clothing on the child's hip using a fully adjustable elastic waist belt.

Statistical analyses

Means and SD were calculated to describe children's characteristics by sex. It was analysed one association between each MF test and weight status by binary logistic regression.

The association between weight status and single variable (SRT+J2F) was examined using multinomial logistic regression. The model was adjusted by age and TPA. Statistical analysis was performed using the SPSS 21.0 software (SPSS Inc., Chicago, IL, USA). The level of significance was set at alpha level of 0.05.

Results

Table 1 shows descriptive characteristics of the sample according to gender, boys were significantly more active than girls (*P = 0.000*). Among girls, the prevalence of overweight and obesity was 23.8% and 12.6%, respectively. In comparison, the prevalence of overweight and obesity among boys was lower at 21.6% and 6.3%, respectively; this difference was statistical significance (*P = 0.014*). No other statistical significant differences were found.

Our sample has shown that 84.0% normal weight children had high MF, 14.9% medium and 1.1% low. Children with overweight, 81.3% had high MF, 17.7% medium and 1.0% low. Finally, 71.1% obese children had high MF, 23.7% medium and 5.3% high.

Binary logistic regression analysis (Table 2) showed that obese preschoolers were 4 times more likely to be classified as having low MF level in SRT than their non-overweight

Table 1. Preschool children's anthropometric and demographic characteristics.

Variables	Total (*n* = 467)	Girls (*n* = 244)	Boys (*n* = 223)	*P*-value
Weight (kg)	20.4 ± 3.8	20.6 ± 4.1	20.1 ± 3.5	0.202
Height (cm)	109.0 ± 6.4	109.1 ± 6.6	109.0 ± 6.2	0.854
BMI (kg/m^2)	17.0 ± 1.9	17.1 ± 2.1	16.8 ± 1.7	0.098
TPA (min per week)	20.3 ± 5.5	265.3 ± 49.7	289.0 ± 51.5	**0.000**
J2F (s)	5.7 ± 1.5	5.7 ± 1.4	5.8 ± 1.7	0.526
SRT (s)	27.0 ± 2.9	27.1 ± 2.7	26.9 ± 3.1	0.577
	%	%	%	
BMI group				
Normal weight (kg/m^2)	67.6	63.5	72.1	**0.014**
Overweight (kg/m^2)	22.7	23.8	21.6	
Obese (kg/m$^{2)}$	9.7	12.7	6.3	

BMI, body mass index; ≥3 h TPA, at least 3 h total physical activity per day each day a week; J2F, jumping a distance of 7 m on 2 feet; SRT, 10 × 5 m shuttle run test; bold figures indicate significant *P*-values.

Table 2. Association between performance in shuttle run test (SRT) and jumping 2 feet test (JSF) and obesity status in preschoolers.

	SRT			J2F		
BMI tests	OR (95% CI)	R^2_N	*P*-value	OR (95% CI)	R^2_N	*P*-value
Normal weight	1	0.27	1	1	0.28	1
Overweight	0.4 (0.1–1.5)		0.224	1.3 (0.5–3.2)		0.445
Obese	**4.5 (1.3–15.2)**		**0.015**	1.2 (0.3–5.0)		0.758

BMI, body mass index; TPA, total physical activity; J2F, jumping a distance of 7 m on 2 feet; SRT, 10 × 5 m shuttle run test; all analyses were adjusted for age, gender and TPA. Bold figures indicate significant *P*-values.

Table 3. Association between performance in SRT + J2F and obesity status in preschoolers.

SRT + J2F / BMI	OR (95% CI)	R^2_N	*P*-value
Normal weight	1	0.27	1
Overweight	0.3 (0,6–2.1)		0.277
Obese	**6.4 (1.3–36.6)**		**0.035**

BMI, body mass index; SRT, shuttle run test; J2F, jumping a distance of 7 m on 2 feet; TPA, total physical activity; all analyses were adjusted for age, gender and TPA. Bold figures indicate significant *P*-values.

counterparts. No statistical significant association was found for J2F (Table 2). In addition, multinomial logistic regression analysis (Table 3) showed that obese preschoolers were 6 times more likely to be classified as having low MF level than their non-overweight counterparts even after adjustment for age, gender and TPA.

Discussion

This study aimed to examine the association between MF and obesity status among Portuguese preschool children. The most important finding was that obese preschoolers were 6 times more likely to be associated with poor MF compared to their normal weight peers even after a set of adjustments such as gender and TPA. This outcome is worth highlighting because secular trends for most of the basic motor abilities showed a decline over time (Klein et al., 2015). Therefore, poor MF coupled with excess body fat along with sedentary lifestyle are significant predictors of developing coronary heart disease (Katzmarzyk et al., 2001; Ortega et al., 2008). There is also evidence that low MF results in a higher risk of later obesity in growing pre-pubertal children (Johnson et al., 2000; Moliner-Urdiales et al., 2011). In addition, our study showed that the association individually analysed was stronger in SRT and not statistically significant in J2F test. Our data has shown that the current prevalence of overweight and obesity was 22.7% and 9.7%, respectively.

Instead of evaluating only MF, the majority of the studies analysed physical fitness (either cardiorespiratory fitness (CRF) or muscular fitness (MusF)) through a set of tests using different methodologies. It has been well described that both CRF and MuscF are important markers of health in children and adolescents. A recent study showed that low aerobic fitness in late adolescence is associated with an increased risk of early death. Furthermore, the risk of early death was higher in fit obese individuals than in unfit normal-weight individuals (Högström, Nordström, & Nordström, 2015). To date only a few studies have assessed those associations in preschool children. However, those studies that examined either the association between CRF and/or MuscF with body composition have shown that obese children had lower physical fitness (Agha-Alinejad et al., 2015; Krombholz, 2013; Niederer et al., 2012; Ortega et al., 2015; Reeves, Broeder, Kennedy-Honeycutt, East, & Matney, 1999).

In our study, however, it is difficult to find data providing information on the association of MF and obesity among preschoolers having used on a single MF test. Rather, it focuses on compound activities that recruit various combinations of multiple factors, such as strength, endurance, motor coordination, balance and agility (Fjortoft et al., 2011). Hence, we used two MF tests: jumping distance, which is an important skill to assess a child's ability to co-ordinate the leg–arm movement aiming the assessment of their sense of rhythm and timing as well; the 10 × 5 m SRT which is usually used as a measure of speed and agility (Fjortoft et al., 2011). Our data has showed a significant association between lower performance in SRT (OR = 4.5) while we have not found significant association between obesity and J2F (OR: 1.2). However, when the two tests are taken together, data has shown that obese children were 6 times more likely to be associated with low MF (Table 3). Our findings are in line with previous studies in preschoolers (Agha-Alinejad et al., 2015; Halme, Parkkisenniemi, Kujala, & Nupponen, 2009). However, to the best of our knowledge, there is only one study analysing the individual items of MF in overweight and obese preschoolers (Bayer et al., 2009) A recent study in Spanish kindergarten children showed an association of health-related physical fitness components, mainly muscular strength, the 4 × 10 m SRT and CRF (i.e. speed–agility) with total and central body fat (Martinez-Tellez et al., 2015). The observed association between speed–agility and (i.e. 4 × 10 m SRT) total obesity status also agrees with data found in Thai preschoolers (Yamborisut, Sakamoto, Wimonpeerapattana, & Tontisirin, 2010) and might express, as suggested elsewhere, that obese preschool children have a lower performance on the test requiring propulsive movement of body mass in adolescents (Moliner-Urdiales et al., 2011). In our study, we could verify that there were statistically significant differences between MF categories. Children with high MF spent more time in PA than children who presented low MF. This data is in line with some studies that have shown children with low MF who had had also low levels of PA (Williams et al., 2008) and consequently spent less time outdoors as has been shown in preschoolers (Cleland et al., 2008). Moreover, the acquisition of basic skills will promote a worse motor performance.

We can assume that the importance of MF should be recognised as a target for intervention focusing in preventing the development of obesity in children. Furthermore, motor skill acquisition and PA play key roles in child development and promotion of health (Roth et al., 2015).

In addition, MF components are associated with different health findings. PA programs should be designed to improve not only the levels of cardiorespiratory and MusF but also be focused on MF, at least on these age groups (Ortega et al., 2008). Hence, the researchers in these age groups have focused on the compliance of PA guidelines and have not given so much attention to basic daily motor capacities. This panorama should be changed, once these capacities are also associated with diverse health indicators (Klein et al., 2015). Children with low MF have a tendency to be less physically active, to have increased obesity status

and reduced aerobic fitness, which are all associated with cardiovascular risk factors. These factors are critical for leading to a vicious circuit that must be targeted in an earlier intervention (Pietilainen et al., 2008). If MF is seen as a PA compliance guideline, the preschoolers will be more likely to be physically active and healthy. The foundation for the basic movement skills is created during this period and should be specialised in later motor development. It is of high importance that children possess the best possible motor abilities and skills by the time they reach school age, since during the school period this development slows down, and further progress is greatly dependent on motor-ability-skill-base previously formed in preschool (Hinkley, Crawford, Salmon, Okely, & Hesketh, 2008). In the same way, a recent study has shown that obesity preceded the decline in motor skills rather than the reverse and suggested that early childhood obesity intervention efforts might help prevent decay in motor proficiency that, in turn, may positively impact children's PA and overall fitness levels (Cheng et al., 2016). Thus, these data lead to the implementation of the motor repertoire as timely as possible in these ages, once it has an enormous potential and should be recognised as a fundamental target on PA programs within school. This component connected with intervention in this area should entail crucial advantages to both a healthy development and health across childhood and to a participant's health and quality of life (Robinson et al., 2015).

The strengths of this study focus on the assessment of MF in preschool children. Nevertheless, some limitations should be recognised. The study includes preschool children from only one metropolitan area, which makes it difficult to generalise the findings to other samples. The use of only two MF tests might be a limitation and other MF tests might be more sensitive than the two used in this study. Furthermore, the study was cross-sectional and it was not possible to infer causal relationships using such a model design.

Conclusions

Our results suggest that obesity among preschoolers was associated with lower MF. Obese children were 6 times more likely to be classified as having lower performance in the combined MF variable, since MF consists of physical fitness components that have a relationship with motor skill improvement. Therefore, our findings provide evidence to support the establishment of a tailored MF test in epidemiological and intervention studies in preschool children, as it seems that they are associated to obesity status since early ages. Nonetheless, longitudinal studies are needed to confirm these findings.

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Disclosure statement

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IV. Changes in moderate vigorous physical activity, motor coordination and body mass index followed for one-year of longitudinal study in preschoolers

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Abstract

Purpose: To examine the association between moderate vigorous physical activity (MVPA) and motor coordination (MC), body mass index (BMI) and to track these behaviours over a 1-year follow-up in preschoolers. **Methods:** The sample were 54 preschoolers (24 girls; 44.4%) aged 4 to 5 years-old, Height and body mass were measured by standard methods and BMI was then calculated. MC was assessed according to the Movement Assessment Battery for Children second edition (MABC-2).MVPA was measured by accelerometer. For each participant, change between 2013 and 2014 of MVPA, MC and BMI were computed. **Results:** Our results show that the MVPA increased over time in all levels of MC in follow-up. The BMI decreased over time for all levels in follow-up (p=0.001). The preschoolers classified as high level of MC were more likely to spend more time in MVPA (minutes) than their counterparts placed in low MC in follow-up. Multiple linear regression analysis were fit to predict Δ% MVPA by Δ% MC and Δ% BMI. The Δ% MC was positively associated with Δ% MVPA, whereas no statistically significant difference was found for Δ% BMI over time, adjusted by gender and age. **Conclusions:** Increases in MC were positively associated with MVPA. Time spent in MVPA increases due to higher performance in MC. However we did not find significant association with BMI. Investing in the improvement of motor coordination in young children has potentially relevant policy implications related to MVPA and public health.

Keywords: Motor coordination; preschool; physical activity; longitudinal survey

Introduction

Taking into consideration the negative consequences that poor motor performance might bring to a child's overall development, it is essential to identify as early as possible potential risk factors that may hinder motor development (Giagazoglou et al., 2011). The participation of children in age-related physical activities is strongly linked to the adequate development of fundamental movement skills, principally motor coordination (MC) dimensions. Moreover, the maintenance of a sufficient level of moderate vigorous physical activity (MVPA) throughout their life course can also be greatly influenced by gross motor skills (Laukkanen et al., 2014).

Childhood is an important stage when it comes to the development of MC, and that allows the successful participation of children and adolescents in various types of PA (Robinson et al., 2015). Consequently, if the development of MC is not effectively accomplished, children may move away from PA as they will not feel competent or confident enough to move and their participation will not be an enjoyable experience once they realize they will not be successful at it.

The engagement in PA is commonly linked to greater proficiency in MC (Wrotniak et al., 2006), whereas less motor proficiency is linked to lower levels of PA (Williams et al., 2008) and a higher resistance towards challenging activities (Rose et al., 1998). If it is true that children and youngsters with poor MC are more likely to present poor health signs, it must also be pointed out that this can be aggravated by an inactive lifestyle throughout youth. This connection between a higher risk of decreased PA in preschool children and poor motor skills has been evidenced by recent studies from the UK (Fisher et al., 2005), US (Williams et al., 2009; Williams et al., 2008) and Australia (Cliff et al., 2009). Even though there were some limitations to these studies (they were cross sectional in design and did not account for confounding factors), the suggestion of a link between fundamental motor skills and PA in childhood is worth to be further explored. However, the currently existing literature that establishes a relationship between MC and MVPA does show several limitations, namely the fact that it relies on self-reported PA measures and cross-sectional designs (Kwan et al., 2016). It is also

illustrated by limited longitudinal data that proficiency in movement skills at age 4-6 years did not predict PA at 12 years of age (McKenzie et al., 2002). As far as we know, the effects of MC on physical activity has not been examined by any longitudinal study through objective measurements of physical activity in these early ages. Even though the importance of motor skill proficiency to PA participation has been shown by cross-sectional evidence, there is no proved link between skill proficiency and the prediction of subsequent physical activity.

Hence, taking into consideration not only this lack of longitudinal study in pre-schoolers but also the importance of this relationship in early ages, the present study aims to examine the association between MVPA, MC and BMI and to track these behaviours throughout a 1-year follow-up in pre-schoolers.

Material and Methods

Participants and data collection

This is a preschool-based longitudinal study and the sample was part of the Preschool Physical Activity, Body Composition and Lifestyle Study (PRESTYLE).

For the present study, baseline measures were collected in 2013 when the children were 4 years old and follow-up data were collected in 2014 when the children were 5 years. A priori power calculations indicated that to detect a large effect size with alpha level at 0.05 and power at 80%, a sample size of 20 was needed. The initial sample size was 200 children at baseline and 54 children provided data at the follow up (n=24; 44.4% female), composed by children who remained in the same school, agreed to participate in the study again and had valid accelerometer data of assessment and all data that composed the Movement assessment battery for children (MABC-2) at both moments. The children mean age was 4.27±0.46 to 5.30±0.45 years old, enrolled in schools located in the metropolitan area of Porto, Portugal.

Informed written consent was obtained from the children's parents or guardians and the schools. The Portuguese Foundation for Science and Technology and the Ethics committee of the PhD programme in Physical Activity

and Health hosted by the Faculty of Sports at Porto University approved the procedures.

Anthropometric measures

Body mass and height were measured by standard anthropometric methods. Body mass was measured to the nearest 0.10kg, with participants lightly dressed (underwear and t-shirt only) using a portable digital scale (Tanita Inner Scan BC 532, Tokyo, Japan). Height was measured to the nearest millimeter in bare or stocking feet with children standing upright against a mobile stadiometer (Seca 217, Hamburg, Germany). BMI was calculated as body mass (kg) divided by height $(m)^2$.

Motor coordination

The MC was assessed using the Movement Assessment Battery for Children (MABC-2) (Henderson et al., 2007). This test battery was developed as a means of identifying those at risk of motor impairment and has been widely adopted for this purpose (Smits-Engelsman et al., 2011). The MABC-2 is designed for children from 3 to 16 years which assesses manual dexterity, aiming & catching and balance components. The MABC-2 are composed for: age band 1 (3-6years); age band 2 (7-10years) and age band 3 (11-16 years) (Henderson et al., 2007).

For the assessment of MC we used eight tests: age band 1, posting coins, threading beads and drawing trail I for Manual dexterity; throwing beanbag on mat and catching beanbag for aiming & catching component; walking heels raised, jumping on mat, one-leg-balance dominant leg and one-leg-balance non-dominant leg were evaluated for the balance component. Raw data were transformed using standard score equivalents, taking age in months into considerations. The item standard scores for each component were then summed (i.e manual dexterity, aiming & catching and balance), and the MC resulted in sum of these three components.

Children were tested individually. Each test was explained and demonstrated before the child started. If a child made an error, instructions and demonstrations were repeated, and the child was allowed to a new attempt. If a second error occurred or if a child could not perform the test, then, the motor fitness test was scored as missing.

Moderate vigorous physical activity

Daily PA was measured by an Actigraph accelerometer, model GTM1 (Pensacola, FL 32502 USA). The analyses and reduction of accelerometer data were performed using the ActiLife software, version 6.11.4. The device was used during all waking hours, except in water activities for seven consecutive days. The data was considered valid for analysis if children wore an accelerometer for at least 4 days, three weekdays and one weekend day, and the minimum of 10 hours per day.

The epoch duration or sampling period was set to 5 seconds, which is better and more accurate for the spontaneous and intermittent activities in younger children (Vale et al., 2009). Data was analysed using specific pediatric cut-points to describe different PA intensities and validated for young children, such as ≥1680 counts per minute for moderate to vigorous PA suggested by (Pate et al., 2015).

Statistical analyses

All data were checked for normality by the Kolmogorov-Smirnov test. For each participant, change between 2013 and 2014 of MVPA, MC and BMI were computed as the follow-up value minus baseline values (Δ). Relative change (Δ%) was calculated in each outcome as (((follow-up − baseline)/baseline) × 100). Descriptive data were shown in mean and standard deviation. Differences between MVPA, MC and BMI from baseline to follow-up were examined by paired-sample t-tests or Wilcoxon signed-rank test. Multiple linear regression analyses were fit to predict Δ% MVPA (outcome variable), by Δ% in MC and BMI

(exposure variables), adjusted by age and height baseline and gender. All statistics analyses were performed using SPSS software, version 24.0, and the significance level was set at $p<0.05$.

Results

Descriptive statistics for the Age, Weight, Height, BMI items and MVPA at each observation are summarized in Table 1. MVPA, weight, age, height and MC increased significantly for the whole sample ($p \leq 0.05$). No statistically significant difference was found for BMI over time. The percentages the children placed in low MC decrease over time and increase in level of high MC in follow-up ($p=0.004$).

Table 1. Means and standard deviations for descriptive characteristics of the preschoolers.

Variables	Baseline (n=54)	Follow-up (n=54)	p-value
Age (years)	4.27±0.46	5.30±0.45	0.001*
Weight (Kg)	19.17±2.99	21.91±4.12	0.001*
Height (cm)	106.36±6.09	113.29±6.03	0.001#
BMI (kg/m^2)	16.86±1.56	16.95±1.96	0.719
MVPA (min/day)	14.55±4.96	15.92±5.08	0.050#
MC	113.69±19.52	134.90±23.07	0.001*
	%	%	%
MC			
Low	45.3	18.9	
Medium	34.0	30.2	**0.004**
High	20.8	50.9	

Abbreviations: BMI, Body mass index; MVPA, Moderate Vigorous Physical Activity; MC, Motor Coordination. #indicate significant p values to paired sample t-test. *related sample Wilcoxon signed rank test significant p values. p ≤ 0.05 significant difference between follow-up and baseline for all children. Bold figures indicate significant p values to chi-squared test.

One-way Anova analysis (Table 2) shows significant association between all levels of MC and MVPA [$F_{2, 49}$= 6.749]; p=0.003 in follow-up. Our results shows that the MVPA increase over time for all levels MC in follow-up. The BMI decrease over time at different levels in follow-up (p=0.001). No statistically significant difference was found for baseline.

The preschoolers classified as high level of MC were more likely to spent time in MVPA (minutes) than their counterparts which placed in low MC in follow-up. Bonferroni post hoc pairwise comparisons identified significant differences between the group with low MC and high MC (p=0.006); medium and high MC (p=0.040); low MC and medium (p=0.025) in follow-up observation. We found also significant differences between MC and BMI in follow-up. The preschoolers classified as high level of MC were more likely to have less body mass than their counterparts which placed in low MC. Bonferroni post hoc pairwise comparisons

identified significant differences between the group with low MC and medium MC (p=0.003); low and high MC (p=0.023) in follow-up observation.

Table 2. Descriptive characteristics (means and standard deviations) and association between different levels of motor coordination and moderate vigorous physical activity and body mass index in preschoolers.

	Baseline			**F**	**p**
Variables	Low MC	Medium MC	High MC		
MVPA	15.20±5.35	13.68±4.85	14.92±4.92	0.399	0.659
BMI	16.48±2.22	17.49±1.74	16.66±1.10	1.749	0.185
	Follow-up			**F**	**p**
MVPA	13.45±4.64*	17.47±4.22**	18.90±5.08*/**	6.749	**0.003**
BMI	17.97±2.26*/**	16.01±1.14*	16.18±1.19*/**	7.458	**0.001**

Abbreviations: MVPA, Moderate vigorous physical activity; BMI, Body mass index. Bold figures indicate significant p values**. */****Difference between groups.

Table 3 shows the Δ% MVPA associations with Δ% in MC and BMI over time. Multiple linear regression analyses were fit to predict Δ% MVPA by Δ% in MC and BMI, adjusted by age, height and gender at baseline. The Δ% MC was positively associated with Δ% MVPA, whereas no statistically significant difference was found for Δ% BMI over time.

Table 3. Relative change in MVPA and its association with change in MC and BMI in a 1-year follow up

Exposure Variables	**B coefficient (95%CI)**	**p**	**Adjusted R^2**
Δ% **Change in MC**	0.081 (0.05-0.15)	0.036*	0.244
Δ% **Change in BMI**	-0.085 (-0.82-0.65)	0.818	

Abbreviations: Dependent Variable: MVPA, Moderate vigorous physical activity; Predictors variables: MC, Motor coordination; BMI, Body mass index. All analyses were adjusted for gender, age and height. ,*p<0.05

Using G*Power software, version 3.1.9.2 (Faul et al., 2007), with alpha level set at 0.05, a posteriori computed power achieved a moderate effect size for all sample (f^2 = 0.47).

Discussion

This study aimed to examine the association between MVPA and MC, BMI and to track these behaviours over a 1-year follow-up in preschoolers. The most important finding was that the MVPA increased over time all levels of MC in follow-up. The BMI decreased over time for all levels in follow-up (p=0.001). No statistically significant difference was found in baseline.

This outcome is worth highlighting because preschoolers classified as high level of MC were more likely to spend more time in MVPA (minutes) than their counterparts which placed in low MC in follow-up. Multiple linear regression analysis showed that the Δ% MC was positively associated with Δ% MVPA, whereas no statistically significant difference was found for Δ% BMI over time, adjusted by gender and age.

In what concerns literature, we have found only one longitudinal study that assessed association between PA and MC, but with another battery of test (KTK) in which it showed that initial level of MC was associated with subsequent changes in level of PA during childhood. They showed that children with low initial levels of MC decrease the most in PA over the age interval considered, followed by those with mid-level initial MC. On the other hand, children with high initial levels of MC show steady levels of PA over time that are higher than children with lower initial levels of MC over 3 years of follow-up (Lopes et al., 2011), which reinforce our results that showed that preschoolers with higher MC spend more time in MVPA than their counterparts placed in lower MC over 1 year of follow-up. It seems that the influence of MC on level of MVPA is amplified over time. If, on one hand, there is a possible connection between limited motor competence and less pleasant experiences in movement activities, on the other hand, better motor competence might be linked to more pleasant activities and, consequently, a higher motivation for engaging in MVPA.

However, our findings support the few longitudinal data that are available, such as that in adolescents from ages 12 to 13 years, with the equal battery of test used in our study demonstrated that children with poor MC engaged in less MVPA compared with their counterparts with high MC, they suggested that the

divergence in MVPA occurs earlier in childhood (Kwan et al., 2016). In the same line, previous research with 3- to 5-year-old (Cliff et al., 2009) and 7- to 11-year-old children (Barnett et al., 2009) showed that object control skill proficiency, but not locomotor skill proficiency is associated with higher levels of MVPA (Barnett et al., 2009; Cliff et al., 2009). Although there is no definitive evidence why object control skills but not locomotor skills are related to MVPA, it has been suggested that object control skills are more nearly related to activities that are moderate and/or vigorous in nature.

The present study is also supportive by another research (Henrique et al., 2017) which also demonstrated a similar finding about gross motor coordination (GMC), once that when comparing children who consistently had low GMC levels to children who showed high GMC levels during the 4 years of follow-up, the outcome was that the latter were lighter, presented lower BMI and higher scores in physical tests at 6 years of age. As a conclusion, when reaching 6 years old, the healthier profiles were present in children who had demonstrated high GMC levels over time. Beyond this, in our study the BMI was not significant predictor of change in MVPA in this longitudinal sample of Portuguese preschoolers, which agrees with results found by Lopes et al. (2011), once that BMI, skinfolds were not significant predictors of change in PA.

However, scarce studies have considered the relationship between MC and PA and BMI and they are cross-sectional (Williams et al., 2008; Wrotniak et al., 2006). Therefore, this present study makes an important contribution to this area by establishing the association between MVPA and MC, BMI and to track these behaviours over a 1-year follow-up in preschoolers. Since those early years of life are an important period of growth it is important to emphasize early identification and intervention of young children suspected as, or at risk of, having poor MC. Children who present poor motor skill development are more likely to withdraw from physical activity and, as a consequence, become less fit, conditions which are passive of change.

Therefore, in order to promote MVPA participation and improve long-term health outcomes for these children, programs are needed that consider the unique characteristics of children with motor coordination limitations. Some

potentially beneficial strategies include acknowledging the impact of poor MC, helping children find activities that are suited to their abilities and interests, breakdown and adaptation of activities to promote success, alteration of expectations, and maintenance of PA levels.

Although our study identified that MC was positively associated with MVPA in pre-schoolers, some limitations should be recognized. The study included preschool children from only one metropolitan area, which makes it difficult to generalize the findings to other samples and we also were not able to adjust for confounding variables such as physical fitness. Despite this, the longitudinal design of this study and the objective measurement of MVPA should be considered strengths. Given the small number of studies that have examined associations between changes in, MVPA, MC and BMI over time in preschoolers, especially using objective measurement, the results of the present study extend knowledge in the field of pediatric PA. Although our findings demonstrate some interesting associations, these support the few data available on the topic to date. Further studies are needed to understand which strategies better suit the improvement of MC and PA in early stages.

Conclusion

The current study demonstrates that increase in MC performance was positively associated with time spent in MVPA. This reinforces that MC may be more likely to engage in physically active tasks. Therefore, the investment in improving motor coordination in young children might have relevant policy implications in what concerns MVPA and public health.

What Does This Article Add?

- The present study has demonstrated that time spent in MVPA increased due to higher performance in MC.

- The high MC attenuates the decline in PA levels throughout childhood, particularly the MVPA on which it is connected with health benefits.
- Therefore, investing in the improvement of motor coordination in young children has potentially relevant policy implications related to MVPA and public health.
- This paper also helped to identify potential mechanisms of change by identifying the factors that are likely to make a difference in this specific group for future intervention.

Disclosure statement

No potential conflict of interest was reported by the authors.

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[Capítulo IV.]

Discussão Geral

Considerações Finais

DISCUSSÃO GERAL

Tendo em conta a escassez de informação que relaciona a CM, ApM, AF e obesidade em crianças em idade pré-escolar, os objetivos da presente tese foram averiguar a associação entre a AFMV e a CMG, verificar a relação entre a CMG e o RCE, a ApM e a obesidade na primeira infância (3-6 anos). Analisámos ainda a associação entre AFMV, CM e IMC ao longo de um ano de *follow-up* na pré-escola.

Os resultados do presente estudo sugerem que a AFMV foi positivamente associada à CMG, independentemente do CS e género. Os pré-escolares que apresentaram risco no RCE (Estudo 2) tiveram 3,5 e 5,0 vezes mais probabilidade de possuírem baixa CMG na componente "lançar & agarrar" e em equilíbrio, respetivamente, do que os seus pares sem risco, independentemente do género e CS. Da mesma forma, os pré-escolares obesos apresentaram 6,4 vezes mais probabilidade de apresentar baixo nível de ApM do que os seus pares com peso normal, independentemente do género, idade e AFT (Estudo 3). Longitudinalmente, os pré-escolares com elevado nível CM despenderam mais tempo em AFMV do que os seus pares com baixo nível CM no *follow-up*. Além disso, a Δ% CM foi positivamente associada à Δ% AFMV, apesar de não ter sido encontrada diferença estatística significativa para Δ% IMC ao longo do tempo, independentemente do género e da idade.

Em termos holísticos, os resultados do nosso estudo apontam no sentido de que os pré-escolares que apresentaram elevada CMG parecem ter maior envolvimento em AFMV corroborando estudos anteriores, (Barnett et al., 2016; Iivonen et al., 2013; Lin et al., 2016; Williams et al., 2008). Apesar de a literatura revelar evidências entre a CMG e AFT em crianças (Barnett et al., 2016; Lin et al., 2016), os nossos resultados apresentaram informação adicional no âmbito da AFMV, estimada objetivamente através de acelerómetros em idade pré-escolar. Efetivamente, esta faixa etária tem sido preterida em relação a outros grupos etários no campo da investigação, no qual se denota bastante diversidade de instrumentos de avaliação da componente motora.

Sendo a infância entendida como o período crítico no desenvolvimento e aquisição de habilidades motoras fundamentais, a falta de AF adequada pode resultar, na maioria dos casos, em carências irremediáveis (Neto, 2004). Nesta perspetiva, a aquisição adequada de CMG é essencial nas tarefas motoras na infância, permitindo uma maior participação em atividades físicas adequadas à idade e facilitando. assim, a promoção e manutenção de um estilo de vida ativo (Laukkanen et al., 2014).

A promoção de hábitos de vida saudáveis desde a infância constitui um dos interesses no âmbito da saúde pública. Desta maneira, a CMG poderá ser vista como uma estratégia relevante para a valorização da sua promoção, proporcionando uma maior participação em tarefas motoras e, consequentemente, promovendo indiretamente um estilo de vida fisicamente mais ativo. As recomendações específicas de intensidade da AF mostram que a AFMV está associada positivamente a vários indicadores de saúde, nomeadamente de densidade óssea (Harvey et al., 2012), níveis mais baixos de massa gorda (Collings et al., 2013), entre outros resultados positivos referentes à saúde. Por esse motivo, é pertinente uma investigação mais aprofundada mas também mais concisa, de modo a reduzir a variedade de ferramentas de avaliação da competência motora, nomeadamente da CM, o que tem tornado a análise bastante desafiadora em diversos países (Cools et al., 2009), prejudicando, desta forma, a compreensão global do desenvolvimento da competência motora, visto que os instrumentos de avaliação utilizados podem ser orientados para o processo ou para o produto (Logan et al., 2017). Por conseguinte, torna-se imperativo que haja a padronização e a redução de instrumentos para proporcionar orientações mais eficazes para a saúde pública de crianças e adolescentes (Holfelder & Schott, 2014).

O desempenho motor é considerado essencial para o desenvolvimento físico, psicológico e social nas crianças e adolescentes (Biddle & Mutrie, 2007; Lubans et al., 2010), aliás, o desenvolvimento da CM pode ser considerado um fator relevante nas trajetórias de peso durante a infância e adolescência (Lopes et al., 2014; Robinson et al., 2015). Em concordância com esta linha de pensamento, e apesar de se ter utilizado outro indicador de obesidade,

verificamos no nosso estudo que os pré-escolares que apresentaram risco no RCE apresentaram diminuída coordenação na componente de lançar e agarrar (controlo de objetos) e na componente equilíbrio em relação aos seus pares sem risco, independentemente do género e CS. Este resultado parece estar em concordância com estudos que referiram que as crianças com sobrepeso e obesidade foram identificadas com CMG baixa comparativamente com os seus pares normo-ponderais (D'Hondt et al., 2011; Zhu et al., 2011). No mesmo sentido, Lopes e colaboradores (2012b) averiguaram uma relação inversa entre a CM e o IMC em meninos e meninas durante a infância (6-14 anos). Recentemente, Rodrigues e colaboradores (2016) verificaram que o desenvolvimento da ApF e da competência motora durante a infância diminuem as probabilidades de desenvolvimento de excesso de peso e de obesidade. Por seu turno, D`Hondt e colaboradores (2014) averiguaram que, em crianças dos 5-13 anos, o estado do peso das crianças influencia negativamente o nível futuro de CMG e vice-versa. De acordo com estes autores, as iniciativas de prevenção e intervenção devem considerar a relação de causalidade recíproca durante o tempo de desenvolvimento motor.

Estas evidências reforçam os nossos resultados, sendo de destacar que a obesidade parece prejudicar a CMG logo em idade pré-escolar, um estádio crítico no desenvolvimento motor da criança.

A prevalência da obesidade permanece historicamente alta em todas as faixas etárias, sendo o principal catalisador para o aparecimento de doenças crónicas, bem como da redução da qualidade de vida, com influência negativa desde a idade pré-escolar (Ogden et al., 2014). Esta doença crónica afeta desde cedo a CM e a ApM, que se associa com a qualidade do desempenho da tarefa motora (Gallahue & Ozmun, 2011). Assim, os nossos resultados evidenciaram que os pré-escolares obesos apresentaram 6,4 vezes mais probabilidade de possuir níveis baixos de ApM do que os seus pares normo-ponderais. Estes resultados suportam não só as tendências seculares de obesidade (Costa et al., 2017) como o decréscimo de desenvolvimento da maioria das habilidades motoras básicas ao longo do tempo (Klein et al., 2015), uma vez que o nível baixo de ApM associado ao excesso de gordura corporal e a um estilo de vida

sedentário são preditores significativos do desenvolvimento de doença cardio-metabólica (Ortega et al., 2008). Efetivamente, o nível baixo de ApM resulta num maior risco de obesidade em crianças pré-púberes (Moliner-Urdiales et al., 2011) e pré-escolares (Martinez-Tellez et al., 2015).

Numa perspetiva mais global da CM, analisamos longitudinalmente durante 1 ano a associação entre AFMV, CM, IMC, tendo verificado uma associação positiva entre a AFMV e a CM. Não obstante, não encontramos associações significativas na variável IMC. Estes resultados comprovam o estudo de Lopes e colaboradores (2011), no qual verificaram que o nível de AF entre os 6 e os 10 anos de idade depende do nível inicial da CM, ou seja, a CM foi considerada preditora da AF, embora o IMC não se tenha revelado preditor da AF. De igual modo, Spessato e colaboradores (2013) também verificaram a mesma associação entre CM, AF e IMC em crianças dos 5-10 anos. Esta linha de investigação foi suportada recentemente por Hardman e colaboradores (2017), que verificaram uma associação positiva entre o quociente motor e AF. No entanto, apresentaram uma relação inversa com IMC em crianças dos 5-7anos de idade, tendo esta relação sido moderada pelo rendimento familiar. De igual modo, Henrique e colaboradores (2017) concluíram que as crianças com níveis elevados de CMG durante o *follow-up* de quatro anos apresentaram níveis mais baixos de IMC e gordura subcutânea, bem como melhor performance nos testes de ApF aos 6 anos de idade do que os seus pares com níveis baixos de CMG.

De acordo com Lima e colaboradores (2017b), a competência motora e VO_2 pico influenciou diretamente o desenvolvimento da gordura corporal, em crianças dos 6 aos 13 anos. O VO_2pico mediou as associações entre AFMV, AFV, competência motora e gordura corporal. A competência motora também mediou as associações entre AFMV, AFV e gordura corporal. Além disso, o VO_2pico apresentou uma maior associação negativa com gordura corporal, seguido da competência motora e AFV. Assim sendo, como AF, competência motora e VO_2pico exibiram associações longitudinais com gordura corporal, é pertinente reforçar a necessidade das intervenções promoverem o desenvolvimento da aptidão e da competência motora através de atividades físicas apropriadas ao desenvolvimento motor, já que as interações sinérgicas destas variáveis

parecem afetar significativamente a gordura corporal. Também longitudinalmente, um estudo realizado por Smith e colaboradores (2015) verificaram que o nível de CMG aos 10 e 16 anos foi associado com a participação em AF e CS na idade adulta (46anos). Deste modo, podemos referir que a relação entre CMG, CM e a AF enfatiza os sistemas metabólicos e neuromusculares em crianças, sendo que a AFMV interage com a proficiência motora grossa (Laukkanen et al., 2014). Em vista disso, a CM baixa desencoraja as crianças de participarem em AF, proporcionando um risco maior no incremento do CS e do peso corporal. A obesidade conduz a uma baixa ApM e ApF, o que acarreta fatores de risco para a saúde, quer na infância, quer mais tarde, na vida adulta (Barnett et al., 2016; Cattuzzo et al., 2016). Mais estudos longitudinais em idade pré-escolar com avaliações repetidas de AF, ApF, ApM e CM são necessários, uma vez que os estudos são limitados nesta faixa etária, e, quando existem, apresentam amostras pequenas ou períodos de seguimento relativamente curtos (Cairney et al., 2011) .

Limitações

Os quatro artigos que fundamentam a presente tese apresentam pontos fortes embora também limitações que devem ser reconhecidas.

Os estudos transversais não permitem inferir relações causais, pois apresentam um momento de avaliação. Devemos referir também que os estudos incluíram uma amostra de conveniência, crianças pré-escolares de apenas uma área metropolitana, o que dificulta a generalização dos resultados para outras amostras em diferentes áreas geográficas. Tendo em consideração que o desenvolvimento motor ocorre num contexto social específico e que cada contexto coloca solicitações particulares sobre as habilidades motoras e a coordenação motora das crianças, deveríamos ter ajustado aos nossos artigos dados referentes às condições da escola, condições de vida, composição do agregado habitacional, bem como ao estatuto socioeconómico do agregado, já que são fatores que devem ser levados em consideração ao avaliar esta temática (Venetsanou & Kambas, 2010).

No que diz respeito ao estudo longitudinal, reconhecemos que a amostra que integra o estudo é pequena e acreditamos que um grupo maior de participantes seria necessário para esclarecer até que ponto as diferenças são importantes numa possível estratégia de saúde pública. Contudo, o estudo longitudinal deve ser valorizado, uma vez que nos permite ter uma análise da forma como a CM se manifestou ao longo do tempo em idade pré-escolar. Apesar destas limitações, os estudos aqui apresentados alargam as evidências na investigação sobre a coordenação motora em idade pré-escolar.

Estudos futuros

Numa perspetiva de saúde pública, e tendo como base que habilidades motoras fundamentais são assumidas como pré-requisitos básicos de movimentos motores que sustentam a coordenação de capacidades de movimento mais integradas e avançadas, o envolvimento dos pais poderá ser uma ferramenta bem mais eficaz no aprimorar da proficiência da CM do que a Educação Física escolar isoladamente (Tompsett et al., 2017). Fomentar ambientes de intervenção que incentivem a autonomia psicológica provavelmente aumentará a competência da CM, CMG, juntamente com a AF (Tompsett et al., 2017).

A promoção e o desenvolvimento de um estilo de vida ativo e saudável é reconhecido como um dos principais objetivos da Educação Física (EF), que representa uma oportunidade crucial na acumulação e na participação adequada de AF diária. No entanto, não só tem sido dada pouca atenção às crianças pré-escolares na aula de EF como também tem sido descurada a contribuição da escola, jardim de infância, na AFT e AFMV, já que a aula de EF deverá ser reconhecida como uma peça-chave na promoção de hábitos de vida saudáveis, visto que as crianças e adolescentes passam até 12 anos da sua vida na escola (Leatherdale et al., 2010). Além disso, as aulas de EF parecem ser eficazes na contribuição para a prática de AFMV e menor CS durante o dia escolar (Gao et al., 2017).

Estudos futuros devem considerar as escolas e, particularmente, as aulas de EF, as quais podem, efetivamente, contribuir para a promoção de um estilo de vida ativo e saudável. Além disso, devemos também destacar a importância da monitorização das crianças em desenvolvimento, particularmente no ambiente pré-escolar, na aplicação de atividades destinadas a melhorar a coordenação e competência motora visto serem os anos pré-escolares um momento altamente crítico para o desenvolvimento motor bem como na implementação de hábitos de vida saudáveis (Goldfield et al., 2012). Desta forma, torna-se imperativo examinar quais as características ambientais no meio pré-escolar que poderão promover especificamente a coordenação e competência motora nesta faixa etária (True et al., 2017). A brincadeira ao ar livre tambem poderá resultar numa estratégia eficaz para aumentar a AF, CM, competência motora e ApM, e limitar o tempo sedentário bem como a diminuição da obesidade em crianças pré-escolares (Barber et al., 2013; Berglind et al., 2017; Ngo et al., 2014).

CONSIDERAÇÕES FINAIS

A presente tese pretendeu demonstrar que a AFMV foi positivamente associada à CMG. No entanto, os pré-escolares que apresentaram risco no RCE tiveram três vezes mais probabilidade de possuir baixa CMG na componente “lançar e agarrar” e equilíbrio do que os seus pares sem risco. Da mesma maneira, os pré-escolares obesos apresentaram seis vezes mais probabilidade de apresentar nível baixo de ApM comparativamente com os seus pares normo-ponderais. Durante o período de um ano, os pré-escolares com elevado nível CM despenderam mais tempo em AFMV do que os seus pares com baixo nível CM. Longitudinalmente, a CM foi positivamente associada à AFMV em idade pré-escolar.

Em suma, devido ao facto de a infância ser considerada como um período sensível para aprender e desenvolver habilidades motoras e adquirir um certo nível de competência motora durante os anos pré-escolares, tendo repercussões na vida adulta, os nossos resultados reforçam a necessidade de promover o

desenvolvimento da CM através de atividades físicas adequadas ao desenvolvimento da criança. Defendemos que crianças alfabetizadas em termos motores (literacia motora) irão manifestar um desempenho apropriado, tornando-se consequentemente crianças mais ativas e com peso saudável. Neste sentido, esforços de intervenção no âmbito da obesidade em idade pré-escolar podem ajudar a minimizar declínios subsequentes nas habilidades motoras das crianças, servindo para aumentar a AF e a aptidão em geral.

Assim sendo, espera-se que os dados da nossa investigação contribuam positivamente para a implementação de estratégias de intervenção no desenvolvimento motor, e que as políticas educativas e de saúde considerem o desenvolvimento da coordenação e competência motora como estratégias fundamentais para promover um desenvolvimento saudável ao longo da vida.

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