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Faculdade de Educação Física e Desporto
Mestrado em Exercício e Bem-Estar

Examining Social Support and Parental Modelling Effects on Children's Moderate and Vigorous Physical Activity in Middle Childhood

Dissertação apresentada a provas públicas para a obtenção do Grau de Mestre em Exercício e Bem-Estar, orientado por Prof. Doutor António João Labisa da Silva Palmeira

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"VERSÃO FINAL"

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Índice

Índice de Tabelas

Índice de Figuras

Lista de Abreviaturas e Siglas

Português

Acrónimo	Significado
AFM	Atividade Física Moderada
AFMV	Atividade Física Moderada a Vigorosa
AFV	Atividade Física Vigorosa

Inglês

Acrónimo	Significado
ICC	Intraclass Correlation Coefficient
MOOSE	Meta-analysis Of Observational Studies in Epidemiology
MPA	Moderate Physical Activity
MVPA	Moderate-to-Vigorous Physical Activity
NHLBI	National Heart, Lung, and Blood Institute
PA	Physical Activity
PRISMA	Preferred Reporting Items for Systematic Reviews and Meta-Analyses
SOP	Standard Operating Procedures
STROBE	Strengthening the Reporting of Observational Studies in Epidemiology
SURE	Supporting the Use of Research Evidence
VPA	Vigorous Physical Activity

Resumo

Esta dissertação investiga duas questões centrais para a atividade física pediátrica. Em primeiro lugar, até que ponto a atividade física moderada a vigorosa (AFMV) parental está associada à AFMV das crianças. Em segundo lugar, se a atividade física moderada (AFM) e a atividade física vigorosa (AFV) apresentam padrões correlacionais semelhantes ou distintos durante a infância intermédia, o que permitirá determinar se as intervenções que têm como alvo a AFMV enquanto constructo único são suficientemente precisas. O projeto integra uma revisão sistemática com meta-análise de estudos observacionais sobre as correlações de AFMV entre pais e filhos, seguida de um estudo transversal realizado em crianças em idade escolar de países europeus, que desagrega AFM e AFV e considera suporte social.

A meta-análise sintetizou 27 estudos identificados através de pesquisas no PubMed e Web of Science, conduzida em conformidade com as orientações PRISMA e MOOSE. Os tamanhos do efeito foram harmonizados para o coeficiente r de Pearson através da transformação z de Fisher e agrupados com modelos de efeitos aleatórios. A correlação agrupada entre a AFMV parental e a infantil foi fraca, mas estatisticamente significativa (r = .144, IC 95% .137 a .153), com heterogeneidade moderada a elevada. As análises de subgrupos sugeriram um padrão de desenvolvimento, com a associação mais fraca na infância precoce, um pico na infância intermédia e uma associação positiva que se manteve na adolescência. Estudos de maior qualidade apresentaram efeitos agrupados superiores aos de qualidade apenas moderada. Tal como esperado, as estimativas brutas foram superiores às ajustadas, indicando que a ausência de controlo de confundidores inflaciona as associações não ajustadas entre pais e filhos. No seu conjunto, estes resultados apoiam a existência de uma associação consistente e sensível ao desenvolvimento entre a modelagem parental e a AFMV infantil, em linha com sínteses anteriores que salientaram associações positivas, ainda que pequenas, entre a atividade de pais e filhos. Evidência proveniente de estudos individuais de elevada qualidade dentro do corpus analisado indica igualmente uma concordância modesta em medidas objetivas de AFMV em díades pais–filhos.

O estudo transversal incluiu 172 díades pais–filhos da Bélgica, Chéquia e Irlanda. Foram utilizados acelerómetros de uso na cintura para captar a atividade ao longo de oito dias, aplicando pontos de corte previamente estabelecidos para classificar AFM e AFV. O suporte social foi medido com um instrumento adaptado que distingue os suportes parentais, dos pares e dos professores. As análises centraram-se nas associações específicas por intensidade. O comportamento parental apresentou correlações positivas pequenas a moderadas com a AFM das crianças, tanto em minutos como em percentagem do tempo. As associações entre o comportamento parental e a AFV das crianças foram mais fracas e inconsistentes. Após ajuste para o sexo da criança, os minutos de AFV parental apresentaram

uma associação pequena, mas significativa com os minutos de AFM infantil, enquanto um item de coparticipação ("fazer exercício ou praticar desporto contigo") se relacionou positivamente com os indicadores de AFM e AFV das crianças. O suporte dos pares revelou pouca ou nenhuma associação, apenas emergindo uma associação fraca com a AFV após a exclusão de valores extremos, e o suporte dos professores mostrou associações negligenciáveis. Estes padrões específicos de intensidade indicam que a AFM e a AFV não se comportam de forma semelhante em relação às influências sociais e à modelagem parental.

Integrando ambos os estudos, a dissertação apresenta duas conclusões principais. Em primeiro lugar, a AFMV parental está de forma consistente e positiva associada à AFMV infantil, embora a magnitude seja modesta e varie de acordo com o estádio de desenvolvimento. Em segundo lugar, quando a AFMV é desagregada, a AFM e a AFV revelam assinaturas correlacionais distintas. Esta divergência sugere que as intervenções concebidas em torno da AFMV enquanto alvo único podem ser demasiado abrangentes para otimizar ganhos em AFV. Estratégias mais precisas devem preservar os elementos que promovem a AFM através da modelagem parental e da coparticipação, ao mesmo tempo que acrescentam componentes especificamente direcionados à AFV, como oportunidades mediadas por pares, jogos vigorosos estruturados e contextos escolares ou comunitários que ofereçam um enquadramento seguro para o envolvimento em atividades de maior intensidade. As implicações metodológicas incluem a relevância de utilizar medidas objetivas e específicas por intensidade, o controlo rigoroso de confundidores e a atenção ao estádio de desenvolvimento no desenho de intervenções familiares.

Introdução

A atividade física é amplamente reconhecida como um pilar fundamental para o desenvolvimento físico, mental e social das crianças. De acordo com a Organização Mundial da Saúde (2020), as crianças devem realizar pelo menos 60 minutos diários de atividade física de intensidade moderada a vigorosa (AFMV), complementados por atividades de fortalecimento muscular e ósseo em, pelo menos, três dias por semana. Contudo, mais de 80% das crianças e adolescentes em todo o mundo não cumprem estas recomendações, o que aumenta o risco de obesidade, doenças cardiometabólicas e défices no desenvolvimento ósseo (Guthold et al., 2018). A infância intermédia, entre os nove e os doze anos de idade, constitui um período de particular relevância, uma vez que as crianças começam a exercer maior autonomia nas suas atividades quotidianas, mantendo-se, contudo, fortemente influenciadas pelos contextos familiar, escolar e de pares (Trost et al., 2003).

Os determinantes da atividade física na infância podem ser compreendidos através de modelos teóricos que se complementam A teoria social cognitiva explica que os comportamentos são adquiridos por meio da observação, modelagem e reforço de figuras significativas, processos que moldam a autoeficácia das crianças e as suas expectativas em relação aos resultados (Bandura, 1986). Os modelos ecológicos expandem esta perspetiva ao salientar que influências interpessoais, como pais, pares e professores, interagem com fatores intrapessoais, organizacionais e político-estruturais para moldar os comportamentos das crianças (Sallis et al., 2002). Entre estas influências, o suporte parental sob a forma de encorajamento, co-participação e assistência logística tem demonstrado associações positivas consistentes com os níveis de atividade física das crianças, sobretudo em estudos baseados em metodologias de autorrelato (Beets et al., 2010). Investigações que recorrem a medidas objetivas, como a acelerometria, tendem a revelar correlações mais modestas, mas ainda assim significativas, entre a AFMV de pais e filhos (Yao & Rhodes, 2015). Evidências provenientes de revisões sistemáticas indicam ainda que diferentes formas de suporte social podem predizer de forma distinta as intensidades de atividade. Por exemplo, a modelagem parental está mais fortemente associada à atividade de intensidade moderada, enquanto os pares e professores parecem facilitar a participação em atividades vigorosas (Duncan et al., 2005).

Apesar de a utilização da AFMV como medida agregada ser conveniente para efeitos de monitorização e formulação de diretrizes, esta abordagem tende a ocultar diferenças importantes entre a atividade física moderada (AFM) e a atividade física vigorosa (AFV). A evidência existente sugere que os determinantes da AFM e da AFV podem não coincidir, sobretudo no que respeita ao suporte social e à modelagem parental (Biddle et al., 2011). Embora a AFM contribua para múltiplos benefícios (Jansen & LeBlanc, 2010), existem várias evidências que demonstram que a prática de AFV possui efeitos adicionais únicos na saúde das crianças. Intervenções com treinos intervalados de alta intensidade demonstraram melhorias significativamente superiores na aptidão cardiorrespiratória e reduções mais acentuadas da pressão arterial sistólica quando comparadas com programas de intensidade moderada, mesmo quando realizadas em volumes menores ou com menor tempo por sessão (Cao et al., 2021). A capacidade cardiorrespiratória é considerada um dos mais fortes preditores de saúde cardiovascular e longevidade, enquanto a pressão arterial elevada é um fator de risco precoce para doença cardiovascular na idade adulta (Mintjens et al., 2018; Yang et al., 2020). Assim, investir em AFV, ainda que baixo volume, pode representar uma estratégia eficaz para maximizar os benefícios da atividade física na infância, sobretudo em contextos onde a adesão ao volume recomendado de AFMV é limitada. Contudo, são escassos os estudos que tenham analisado separadamente atividades específicas por

intensidade através de acelerometria, considerando simultaneamente as múltiplas fontes de suporte interpessoal relevantes para crianças em idade escolar intermédia.

A presente dissertação tem como objetivo colmatar estas lacunas através de dois propósitos complementares. O primeiro consiste na realização de uma meta-análise que sintetize a evidência existente sobre a associação entre a AFMV de pais e filhos, fornecendo uma estimativa abrangente da sua interdependência em diferentes contextos. O segundo consiste na realização de um estudo transversal numa coorte europeia de crianças dos nove aos doze anos, que explore de que forma as atividades de intensidade moderada e vigorosa diferem nos seus correlatos, particularmente no que diz respeito às influências parentais e dos pares. A combinação destas duas abordagens permitirá esclarecer se as intervenções destinadas a aumentar a AFMV podem ser demasiado abrangentes para promover eficazmente a atividade vigorosa. Em última análise, os resultados deverão contribuir para a promoção de uma visão diferente sobre estratégias direcionadas ao contexto familiar e escolar, que sejam capazes de fomentar uma participação sustentada tanto em atividades moderadas como vigorosas.

Método

Esta dissertação utiliza uma abordagem composta por uma revisão sistemática com meta-análise e um estudo observacional transversal.

Fase Um: Revisão Sistemática e Meta-Análise

Foi realizada uma revisão sistemática e meta-análise com o objetivo de quantificar as correlações de MVPA (atividade física moderada a vigorosa) entre pais e filhos ao longo dos diferentes estádios de desenvolvimento. As bases de dados PubMed e Web of Science foram pesquisadas até 31 de dezembro de 2024, de acordo com as diretrizes PRISMA 2020 e MOOSE (Page et al., 2021; Stroup et al., 2000). Foram elegíveis estudos observacionais que reportassem correlações quantitativas entre MVPA parental e infantil, medidas através de acelerometria ou questionários validados. Dois revisores efetuaram, de forma independente, o rastreio de títulos e resumos, extraíram os dados para uma folha de cálculo previamente testada e avaliaram a qualidade metodológica utilizando a ferramenta NHLBI. Os valores de r de Pearson e outros tamanhos de efeito foram harmonizados através da transformação z de Fisher (Fisher, 1921) e agregados com modelos de efeitos aleatórios com ponderação por variância inversa (Borenstein et al., 2009). A heterogeneidade foi avaliada através do

estatístico I^2 e do teste Q de Cochran, com análises de subgrupos por estádio de desenvolvimento infantil e composição da díade.

Fase Dois: Estudo Transversal

Foi realizado um estudo transversal em escolas da Irlanda, Bélgica e Chéquia entre setembro de 2023 e outubro de 2024. Participaram crianças com idades entre 9,0 e 12,9 anos e os seus cuidadores primários, recrutados através de apresentações informativas dirigidas às comunidades parentais; as díades forneceram consentimento informado por escrito antes da participação. A aprovação ética foi obtida junto das comissões de ética institucionais competentes. A MVPA de crianças e pais foi medida objetivamente utilizando acelerómetros ActiGraph wGT3X BT, posicionados na cintura, durante oito dias consecutivos, sendo o tempo não-uso definido pelo algoritmo de Troiano (≥ 60 minutos consecutivos com zero contagens) e considerados dias válidos quando incluíam pelo menos três dias de semana e um dia de fim de semana (Troiano et al., 2007; Evenson et al., 2008). As contagens de atividade foram agregadas em épocas de 60 segundos e classificadas como intensidade moderada (≥ 2296 contagens·min^{-1}) ou vigorosa (≥ 4012 contagens·min^{-1}). O suporte interpessoal foi avaliado com uma versão adaptada da escala Parental Encouragement and Support for Children's Physical Activity, originando subescalas de suporte parental, de pares e de professores (Ommundsen et al., 2008). Os questionários foram administrados em formato digital (tablet) ou em papel, e os testes preliminares indicaram boa consistência interna (α de Cronbach = .72–.89) e fiabilidade teste-reteste aceitável (ICC = .65–.80). O processamento de dados seguiu os Procedimentos Operacionais Padrão DE-PASS. As análises estatísticas incluíram estatísticas descritivas e correlações de Spearman com e sem ajustamento para determinantes socioeconómicos.

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Resultados

Manuscrito Um (Meta-analysis)

Systematic Review and Meta-Analysis of Parent–Child MVPA Correlations Across Childhood Developmental Stages and Sex-Specific Dyads

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Abstract

In a meta-analysis adhering to PRISMA and MOOSE guidelines, PubMed and Web of Science were searched through December 31, 2024, for observational studies reporting parent–child correlations in moderate-to-vigorous physical activity (MVPA). Twenty-seven studies (dyad sample sizes 22–1 328; child ages 1–18 years) met inclusion criteria. Pearson's r values were extracted or harmonized from β coefficients, odds ratios, relative risks and intraclass correlations, then pooled using random-effects meta-analysis of Fisher's z and back-transformed to r. Subgroup analyses addressed child developmental stage (early childhood, middle childhood, adolescence), dyad type, measurement method (accelerometery vs questionnaire), study quality (NHLBI "Good" vs "Fair"), and analysis type (crude vs adjusted). Heterogeneity was quantified by I^2, and χ^2 tests for subgroup differences were conducted; publication bias was assessed via funnel plots and Egger's test; study-level bias was appraised

with the NHLBI tool and overall evidence confidence with the SURE framework. The overall pooled correlation was r = 0.15 (95 % CI 0.14–0.16; I^2 = 74.8 %; p < 0.001). All correlations were significant but were weakest in early childhood (r = 0.10), peaked in middle childhood (r = 0.18), and remained positive in adolescence (r = 0.16). Good-quality studies (r = 0.148 vs 0.108; χ^2 = 8.3, p = 0.0038) and crude estimates (r = 0.162 vs 0.139; χ^2 = 5.88, p = 0.015) produced stronger correlations. No substantial publication bias was detected (p = 0.18), and overall evidence confidence was moderate. These findings underscore a modest but consistent parent-child MVPA correlation across development and support family-based strategies to bolster child MVPA.

Keywords: Physical activity; Health Behaviour; Accelerometery; Parent-Child dyads; Family Health

Introduction

Physical activity (PA) is widely recognized as a fundamental determinant of physical, mental, and social well-being among children and adolescents (Tambalis, 2022). Regular engagement in moderate-to-vigorous physical activity (MVPA) has been associated with numerous health benefits, including reduced risks of obesity, cardiovascular disease, and mental health disorders (Janssen & LeBlanc, 2010; Biddle et al., 2019). However, global trends indicate alarmingly low levels of PA among children and adolescents, with approximately 80% of youth failing to meet recommended guidelines (Guthold et al., 2016). Given the critical role of PA in health promotion and disease prevention, identifying factors that facilitate or hinder PA engagement in youth remains a major public health priority (World Health Organization, 2018).

Among the various influences on children's PA behaviour, parental engagement has emerged as a significant determinant (Edwardson & Gorely, 2010). Parents serve as role models, facilitators, and gatekeepers of children's PA by providing encouragement, logistical support, and co-participation opportunities (Rhodes et al., 2020). Parental PA levels, particularly engagement in MVPA, have been positively correlated with children's PA, suggesting that children of physically active parents are more likely to engage in higher levels of MVPA themselves (Su et al., 2022). This relationship is thought to be driven by direct mechanisms, such as joint parent-child activities, and indirect mechanisms, such as parental modelling and reinforcement (Beets et al., 2010).

The extent to which mothers versus fathers associate with children's PA participation remains debated, with some evidence suggesting that fathers may have a stronger role in encouraging sport-related activities, while mothers may be more involved in daily active behaviours (Laird et al., 2016). Conversely, some studies indicate no significant differences

between maternal and paternal correlations on child PA (Neshteruk et al., 2017). Similarly, child sex may also moderate this relationship, as boys and girls may respond differently to parental PA behaviours due to differences in socialization, interests, and opportunities for engagement in structured and unstructured PA (Yao & Rhodes, 2015).

Another potential key moderating factor in the parental MVPA-child MVPA relationship is the child's age. Research indicates that the correlation of parental MVPA is not uniform across childhood and adolescence. Studies suggest that parental correlation with child MVPA may be weakest during early childhood (ages 1–7), peaks during middle childhood (ages 7–12) and declines again in adolescence (ages 12+) (Bradley et al., 2011; Zahl-Thanem et al., 2018; Bringolf-Isler et al., 2018). This pattern likely reflects the shifting nature of PA determinants as children develop increasing independence and become more influenced by peers and external environments. In early childhood, parental involvement in PA is often constrained by children's developing motor skills and autonomy, leading to a weaker correlation (Fuemmeler et al., 2011). During middle childhood, parents play a critical role in structuring PA opportunities, providing encouragement, and modeling active behaviors, which strongly influence child MVPA levels (Zahl-Thanem et al., 2018). However, as children transition into adolescence, parental influence diminishes as peers, school-based activities, and personal motivation become more dominant factors in determining PA engagement (Ornelas et al., 2007). Existing findings, however, remain inconclusive, warranting further examination through meta-analytic synthesis. For instance, a meta-analysis by Yao and Rhodes (2015) found that parental modelling had a weak correlation with child PA, with no significant moderating effect of the child's developmental age, suggesting that the strength of this correlation does not consistently vary by age.

The current study aims to systematically examine the relationship between parental MVPA and children's MVPA, with a specific focus on how child age group and both parent and child sex moderate this correlation. Based on developmental theory and prior syntheses, parent–child MVPA correlations are hypothesized to be lowest in early childhood (2–7 years), peak in middle childhood (7–12 years), and attenuate yet remain positive during adolescence (12–18 years). Analyses adjusted for covariates are anticipated to yield smaller correlations than those based on crude estimates. A further hypothesis was that effect sizes from analyses adjusted for covariates would be smaller than those from crude correlations (Hnatiuk et al., (2016), Bringolf-Isler et al., (2018), Yang et al., (2022)).

Synthesizing evidence from existing studies will clarify the extent to which parental PA is linked with child PA, how this relationship varies developmentally and by sex, and the impact of statistical adjustment, thereby informing the design of family-based interventions to promote PA across generations.

Methods

A systematic review and meta-analysis were conducted to examine the correlation between parental and child MVPA, following the PRISMA 2020 (Page et al., 2021) and MOOSE guidelines and MOOSE (Stroup et al., 2000). This meta-analysis was pre-registered on Open Science Framework (OSF) and can be viewed at https://osf.io/e47ak/?view_only=6d847563c829452da61a3380eb398dd2. MOOSE check list can be found in supplementary data 1.

Search Strategy

A systematic literature search was conducted in PubMed and Web of Science on December 31, 2024, to identify observational studies examining correlations between parent and child moderate-to-vigorous physical activity (MVPA). Using the PICO framework, were the population was defined as parents or primary caregivers and their children aged 2 to 18 years, the exposure as parental MVPA captured via MeSH headings such as "parental physical activity" and "adult exercise" together with free text synonyms, the outcome as child MVPA identified through keywords including "children's physical activity," "youth exercise" and "accelerometry," and the study designs of interest as observational studies in cross-sectional or longitudinal formats while excluding clinical trials and disability-focused samples. Each database search combined these components with Boolean operators and was filtered to English-language human studies with full-text availability, spanning 2004 to 2024 in PubMed and, for general physical activity queries in Web of Science, 2004 to 2024 with no date restriction for accelerometry-specific terms. To capture any additional eligible studies, hand searching of the reference lists of all included articles was used, yielding four further records. No other databases or citation-tracking tools were used. Full search strings for each database are provided in supplementary data 2; aside from the date and language filters detailed above, no additional search limits were applied.

Study selection and Eligibility Criteria

All records retrieved from PubMed and Web of Science were imported into Zotero 7.0.15 and duplicate entries were removed. Titles and abstracts were screened independently by two reviewers against predefined inclusion and exclusion criteria (Table 1). Full-text articles were then obtained for assessment of eligibility, and any disagreements were resolved through discussion. Reasons for exclusion at the full-text stage were documented and are reflected in the PRISMA flow diagram (Figure 1).

Table 0.1. Pico and Eligibility Criteria

Domain	PICO
Population	Children aged 2–18 years and their parents or primary caregivers
Exposure	Parental MVPA, measured by accelerometry or validated questionnaire
Outcome	Child MVPA, measured by accelerometry or validated questionnaire
Study Designs	Observational studies—including cross-sectional, longitudinal, expectancy-value model, and ecological assessment designs
Eligibility Criteria	
Time Frame	Publications from 2004 to 2024 for Query 1 (MVPA focused) and no time frame restriction for Query 2 (accelerometry focused) from PubMed and Web of Science
Language	English only
Setting	Community or population samples; studies of clinical populations or disability excluded
Analysis	Reported or calculable Pearson's r, β coefficients, odds ratios, relative risks, or intraclass correlation coefficients

Inclusion required observational studies that examined the correlation between parental and child MVPA and reported an effect size (or sufficient data to calculate one). Excluded were interventional or experimental studies (unless baseline observational data were reported), non-English publications, studies of clinical populations (such as children with chronic illnesses), and all reviews, commentaries, case reports, and preprints. Excluded articles and reasons in supplementary data 3.

Data Extraction Process

Data were extracted into a pre-piloted Microsoft Excel spreadsheet to ensure consistency and reproducibility. For each included study it was recorded author and year; study design; country or setting; sample size; age range of the children; MVPA unit (e.g., minutes per day, percent time in MVPA); parent–child dyad type (mother–daughter, mother–son, etc.); additional covariates; the method used to measure child and parent MVPA (accelerometry or validated questionnaire); the reported effect size (Pearson's r, β coefficient, intraclass

correlation coefficient [ICC], odds ratio [OR], or relative risk [RR]) and whether a 95% confidence interval was provided.

When studies reported an effect measure other than Pearson's r, these were converted to r using established transformation methods. All conversions and derivations of confidence intervals are documented in supplementary data 4. Any discrepancies in extraction or conversion were resolved through discussion until consensus was reached.

Study Risk of Bias Assessment

The methodological quality and risk of bias of each included study were evaluated using the National Heart, Lung, and Blood Institute (NHLBI) quality assessment tool for observational cohort and cross-sectional studies. Two reviewers independently rated each domain, covering aspects such as clarity of the research question, selection of the study population, measurement of exposure and outcome, and control for confounding, and assigned an overall judgment of "Good", "Fair", or "Poor". Discrepancies in quality ratings were resolved through discussion. A detailed breakdown of NHLBI item scores and overall ratings is provided in Supplementary data 5.

Data analysis

The primary outcome measure in this meta-analysis was weighted Pearson's correlation coefficient (r), representing the correlation between parental and child MVPA, as recommended by Borenstein et al., 2009. When included studies reported alternative effect size measures, such as standardized beta coefficients (β), intra-class correlation coefficients (ICC), or Z-scores, these values were converted to weighted Pearson's r using established statistical transformations (Peterson & Brown, 2005; Rosenthal, 1994). Confidence intervals around each Pearson's r when not provided were computed via Fisher's z-transformation (Fisher, 1921) using sample size. The mathematical details for these transformations are provided in supplementary data 4.

Subgroup analyses were conducted to examine variations based on child age (Pre-K [2–7 years], Childhood [7–12 years], Adolescence [12+ years]), parental sex (Father vs. Mother), and child sex (Boy vs. Girl). When data spanned multiple age groups, it was allocated to the group with the greatest overlap to maintain consistency in our analysis.

Pearson's correlation coefficients were interpreted based on Cohen's (1988) guidelines, where r = 0.10 to 0.29 is considered a weak effect, r = 0.30 to 0.49 is a medium effect, and r ≥ 0.50 represents a strong effect.

Extracted effect sizes (all expressed as Pearson's r) were transformed via Fisher's z to stabilize variances and pooled using inverse-variance weighting under a random-effects

model to allow for between-study heterogeneity. Heterogeneity was quantified using the I^2 statistic and Cochran's Q test, thus allowing to pool accelerometer and questionnaire data to increase sample size. To explore potential sources of heterogeneity, subgroup analyses was conducted by developmental stage (early childhood, 2–7 years; middle childhood, 7–12 years; adolescence, 12–18 years), by parent–child dyad type (mother–daughter, mother–son, father–daughter, father–son), and by measurement method (objective accelerometry versus subjective questionnaire). Sensitivity analyses compared pooled estimates from studies that reported adjusted effect sizes versus those reporting only crude correlations. Publication bias was assessed visually via funnel plots and statistically with Egger's regression test (Egger et al., 1997). All analyses were conducted in R version 4.3.1 using the 'meta' and 'metafor' packages. The detailed statistical approach is provided in supplementary data 4.

Sensitivity Analyses

Each extracted effect size was first classified as "crude" if it represented a simple parent–child Pearson's r (or equivalent) with no statistical control, or "adjusted" if it originated from a multivariable model controlling for one covariate in this case either child or parent sex. Separate random-effects meta-analyses (Fisher-z approach) were then conducted for the crude-only and adjusted-only studies, with pooled z's back-transformed to r.

After applying the Risk of Bias assessment, separate random-effects meta-analyses (Fisher-z approach) were conducted for the different categories, with pooled z's back-transformed to r.

Between-group differences for both the study-quality subgroups (Good vs Fair) and the analysis-type subgroups (Crude vs Adjusted) were evaluated via a χ^2 test for subgroup differences, computed in Excel.

Applicability and Quality of the Evidence Assessment

To assess the applicability and quality of the evidence, The SURE checklist (Supporting the Use of Research Evidence, 2018) was used. This checklist includes five criteria to evaluate the identification, selection, and appraisal of studies; another five criteria to evaluate how findings were analyzed in the review; and one criterion for other considerations. detailed SURE assessment results are provided in supplementary data 6.

Results

The combined search in PubMed and Web of Science returned 1,531 records. After removing 73 duplicates, 1,458 unique titles and abstracts were screened, yielding 126 full-text articles for eligibility review plus four identified via reference lists. Eighty studies were excluded for the following reasons: 34 did not measure parental or child MVPA; 22 employed

interventional designs without baseline observational correlations; 13 provided descriptive or qualitative analyses without a reported parent–child MVPA effect size; 5 were instrument development or review articles; and 6 were excluded for other reasons (e.g., guidelines summaries, clinical–population focus, device-type mismatch). This resulted in 27 studies included in the quantitative synthesis (Figure 1). Details of each article and NHBLI rating can be seen at table 2.

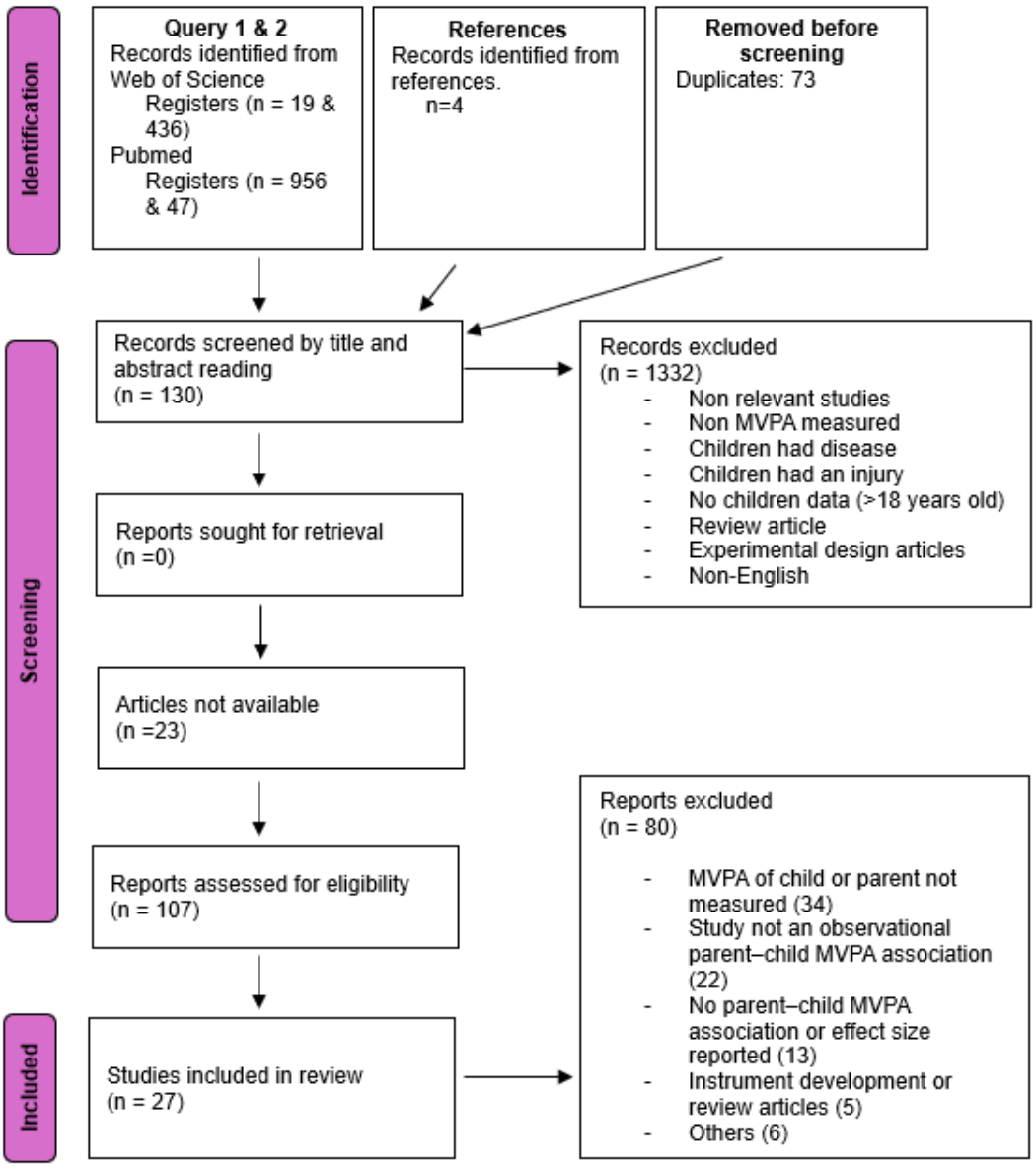

Figure 1. Prisma 2020 Flow diagram of study selection for the meta-analysis

Table 0.2. Articles description and NHLBI rating.

Article (Author et al., Year)	*Country/Setting*	*Design*	*N dyads*	*Child age (yr)*	*Child MVPA method*	*Parent MVPA method*	*Dyad type*	*NHLBI rating*
Aljuhani et al., 2022	Saudi Arabia	Cross-sectional	30	7–12	Accelerometer	Accelerometer	Parent–child	Good
Tanaka et al., 2018	Japan	Cross-sectional	489	7–12	Accelerometer	Accelerometer	Mother–child & father–child	Fair
Tate et al., 2015	USA	Cross-sectional	423	10-12	Accelerometer	Accelerometer	Parent–child	Good
Wang et al., 2017	China	Cross-sectional	323	9-10	Accelerometer	Questionnaire	Parent–child	Fair
Oliver et al., 2011	New Zealand	Cross-sectional	135	5-7	Accelerometer	Accelerometer	Mother–child	Good
Barnes et al., 2015	Australia	Cross-sectional	40	7-10	Accelerometer	Accelerometer	Mother–daughter	Good
Fuemmeler et al., 2011	USA	Cross-sectional	45	9-11	Accelerometer	Accelerometer	Mother–child & father–child	Good
Strutz et al., 2018	USA	Cross-sectional	168	8-9	Accelerometer	Accelerometer	Parent–child	Fair
Xu et al., 2018	China	Cross-sectional	247	4-5	Accelerometer	Accelerometer	Mother–child & father–child	Fair
Yang et al., 2022	USA	Longitudinal	193	9-11†	Accelerometer	Accelerometer	Mother–child	Good

Kuzik et al., 2021	Canada	Cross-sectional	89	4-5	Accelerometer	Accelerometer	Parent–child	Fair
McMurray et al., 2016	USA	Cross-sectional	199	7-10	Accelerometer	Accelerometer	Parent–child	Good
Bringolf-Isler et al., 2018	Switzerland	Cross-sectional	889 children / 1 059 parents	6–16	Accelerometer	Accelerometer	Parent–child	Good
Petersen et al., 2020	Denmark	Cross-sectional	602*	0–22***	Accelerometer	Accelerometer	Parent-child	Good
Fraysse et al., 2019	Australia	Cross-sectional	1 077	11–12	Accelerometer	Accelerometer	Mother–child	Good
Tu et al., 2015	Canada	Cross-sectional	98*	11-15****	Accelerometer	Accelerometer	Parent–adolescent	Good
Zovko et al., 2021	Slovenia	Cross-sectional	169 children / 225 parents	11–13	Accelerometer	Accelerometer	Parent–child	Good
Carson et al., 2020	Canada	Cross-sectional	1 116	4	Accelerometer	Accelerometer	Mother/father–child	Good
Jago et al., 2010	UK	Cross-sectional	340*	10–11	Accelerometer	Accelerometer	Parent–child	Fair
Hnatiuk et al., 2016	Australia	Cross-sectional	136	1–3	Accelerometer	Accelerometer	Mother–child	Good
Jago et al., 2014	UK	Cross-sectional	1 267	5–6	Accelerometer	Accelerometer	Parent–child	Good

Dempsey et al., 1993	USA	Cross-sectional	69	9–12	Questionnaire	Questionnaire	Parent–child	Fair
Garriguet et al., 2017	Canada	Longitudinal	1 328	~8†	Accelerometer + questionnaire	Accelerometer + questionnaire	Parent–child	Good
Haegele et al., 2020	USA	Cross-sectional	22	9-15****	Accelerometer	Accelerometer	Parent–child	Fair
Wirthlin et al., 2020	USA	Cross-sectional	134	5–7	Accelerometer + EMA**	Accelerometer + EMA**	Parent–child	Good
French et al., 2021	USA	Longitudinal	534	2–4†	Accelerometer	Accelerometer	Parent–child	Good
Sijtsma et al., 2015	Netherlands	Cross-sectional	299*	3–4	Accelerometer	Questionnaire	Parent–child	Good

* Sample sizes limited to dyads meeting valid accelerometry criteria.
† Approximate age when study started
**Ecological Momentary Assessment
*** Data extracted into three groups (0-6;7-11:12-22)
**** Data extracted was included into adolescence

Study characteristics

The 27 analyses spanned 11 countries across North America, Europe, Asia, and Oceania, including the United States (n = 11), Canada (n = 5), Australia (n = 3), China (n = 2), United Kingdom (n = 2), and one each from Saudi Arabia, Japan, Switzerland, Denmark, Slovenia, and the Netherlands. Sample sizes ranged from 22 to 1 328 parent–child dyads or triads, and child ages covered infancy through late adolescence (1–22 years). Eighteen studies assessed MVPA objectively via accelerometry (including hip-, wrist-, or multi-sensor devices), eight used validated questionnaires, and two combined objective and subjective measures. Designs were predominantly cross-sectional (n = 25), with two prospective cohorts.

Quality assessment

Of the 27 studies with available NHLBI ratings, 20 were judged "good" quality and seven "fair". Common sources of bias included lack of statistical adjustment for confounders and reliance on self-report measures.

Evidence Quality (SURE Assessment)

Using the SURE framework, it was judged that the evidence to have high confidence for clarity of the research question and consistency of effect measures, moderate confidence for applicability across diverse settings and precision of estimates (noting that 17 of 27 studies required CI imputation), and low confidence for implementation considerations such as contextual or policy factors. Overall confidence in the synthesized estimates was rated as moderate.

Overall Correlation of Parental MVPA with Child MVPA

The pooled meta-analysis revealed a small but statistically significant positive correlation between parental and child moderate-to-vigorous physical activity (MVPA) across all age groups with total for all data being r= 0.144 (95 % CI 0.137–0.153; I^2 = 74.8 %). This correlation was also observed consistently across subgroups defined by parent and child sex, with effect sizes ranging from r = 0.08 to 0.31. Subgroup analyses by NHLBI rating showed that the 20 studies judged good quality yielded a pooled Pearson's r of 0.148 (95 % CI 0.141–0.157; I^2 = 76.8 %), whereas the seven fair-quality studies produced a pooled r of 0.108 (95 % CI 0.083–0.135; I^2 = 54.8 %). The between-group χ^2 test confirmed a significant difference in effect size, indicating higher parent–child MVPA correlations in higher-quality studies. Ten studies (37 %) directly reported 95 % confidence intervals; the remaining 17 (63 %) required imputation.

Sensitivity Analyses: Crude versus Adjusted Effect Sizes

Comparison of studies reporting crude versus adjusted effect sizes revealed that crude correlations yielded a pooled r of 0.162 (95 % CI 0.147–0.181; I^2 = 61.7 %; Q = 93.97, df = 36, p < 0.001), whereas adjusted correlations produced a pooled r of 0.139 (95 % CI 0.130–0.149; I^2 = 77.8 %; Q=392.30, df = 87, p < 0.001). The between-group χ^2 test confirmed a significant difference between crude and adjusted effects (χ^2=5.88, p=0.015), indicating that controlling for confounders attenuates the parent–child MVPA correlation by approximately 0.023.

Parental and Child MVPA Correlations Across Age Groups

Table 0.3. Summary of effect sizes, heterogeneity, and model selection for each subgroup.

Age Group	Group data	N articles	Weighted Pearson	P-value	I^2 Statistic	p-value for Q-test	Used Model
Pre-K	Mean	10	.10	< .001	14.32	.31	FEM
	Dad	4	.11	< .001	29.78	.23	FEM
	Mother	4	.08	.005	0.00	.55	FEM
	Son	2	.09	.009	0.00	.90	FEM
	Daughter	2	.11	< .001	0.00	.95	FEM
Child	Mean	14	.18	< .001	67.56	.00	FEM
	Dad	4	.11	< .001	32.68	.22	FEM
	Mother	5	.12	< .001	35.92	.18	FEM
	Son	6	.16	< .001	41.10	.13	FEM
	Daughter	6	.18	< .001	85.75	.00	REM
Adolescent	Mean	6	.16	< .001	54.73	.05	FEM
	Dad	4	.16	< .001	37.39	.19	FEM
	Mother	3	.16	< .001	0.00	.49	FEM
	Son	2	.31	< .001	0.00	.49	FEM
	Daughter	2	.29	< .001	21.70	.26	FEM

Pre-K (0–7 years)

Among Pre-K children, the correlation between parental MVPA and child MVPA was weak but significant (r = 0.10, p < .001). When analyzed separately, fathers exhibited comparable levels of correlation (r = 0.11, p = < .001) to mothers (r = 0.08, p = .005), though both effect sizes remained small. Again, minor differences were observed between male and female children, with correlations of 0.09 (p = .009) and 0.11 (p = < .001), respectively. Heterogeneity in the sub-group was low to none, suggesting that the observed results were consistent across studies. These results are summarized in Table 3 and pooled results are visually represented in Figure 2.

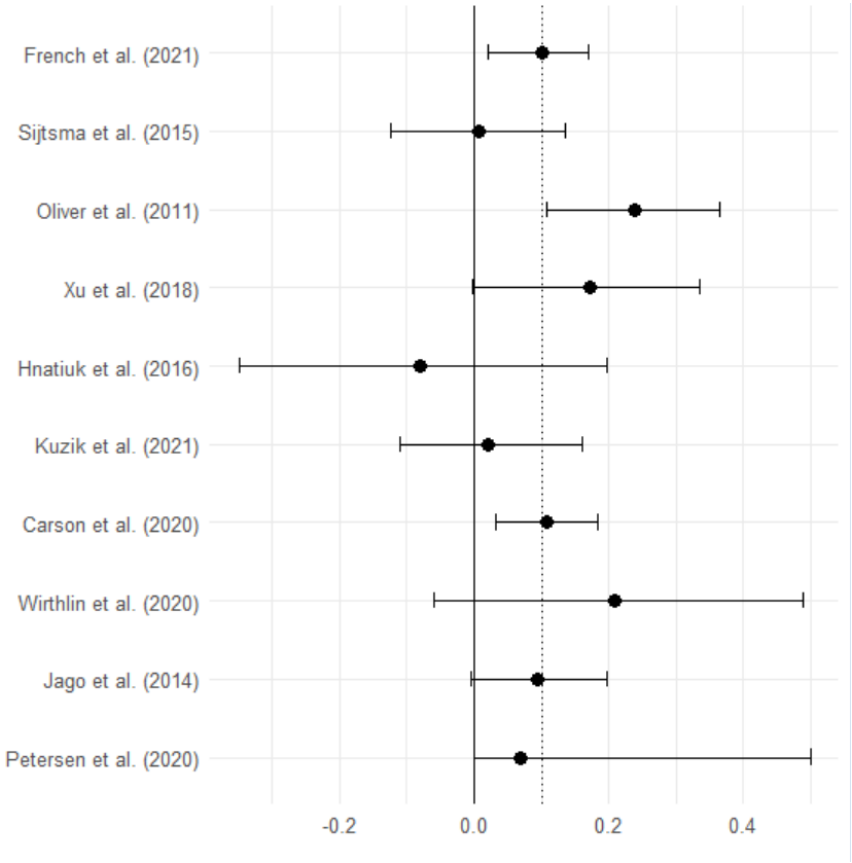

Figure 2. Forest plot for the pooled Pearson correlations of Parental MVPA correlation to child's MVPA for Pre-K group.

Middle Childhood (7–12 years)

The correlation between parental and child MVPA was highest in middle childhood, with an overall effect size of r = 0.18 (p < .001). Parental correlation appeared similar between daughters (r = 0.18, p < .001), with heterogeneity reaching a substantial level (I^2 = 82.4%) and sons, the correlation was r = 0.16 (p < .001, I^2 = 28.2%). Both fathers (r = 0.11, p = < .001) and mothers (r = 0.12, p < .001) demonstrated comparable levels of correlation on their children's MVPA. Overall heterogeneity was moderate (I^2 = 67.56%), indicating some variability in effect sizes. These findings are detailed in Table 2 and pooled results are visually illustrated in Figure 3.

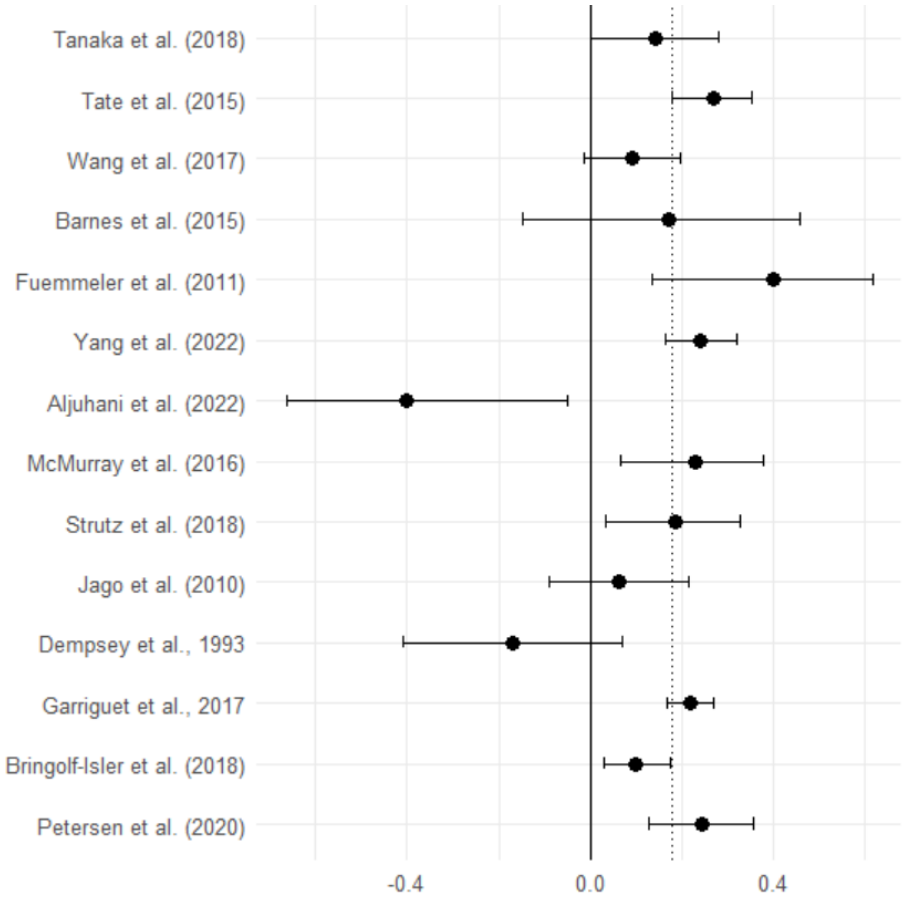

Figure 3. Forest plot for the pooled Pearson correlations of Parental MVPA correlation to child's MVPA for child group.

Adolescence (12–18 years)

Among adolescents, the correlation between parental and child MVPA remained similar to middle childhood (r = 0.16, p < .001). For female adolescents there was high heterogeneity a correlation of r = 0.29 (p = < .001) while for male adolescents, there was an observed correlation of r = 0.31 (p = < .001), though these subgroups included a limited number of studies. Maternal and paternal MVPA showed similar correlations with adolescent MVPA (r = 0.15 and r = 0.13, respectively; both p < .001), with no statistically significant difference between them. Heterogeneity across adolescent studies remained moderate (I^2 = 60.9%), suggesting variability in study methodologies and participant characteristics. These results are reported in Table 2 and pooled results are visualized in Figure 4.

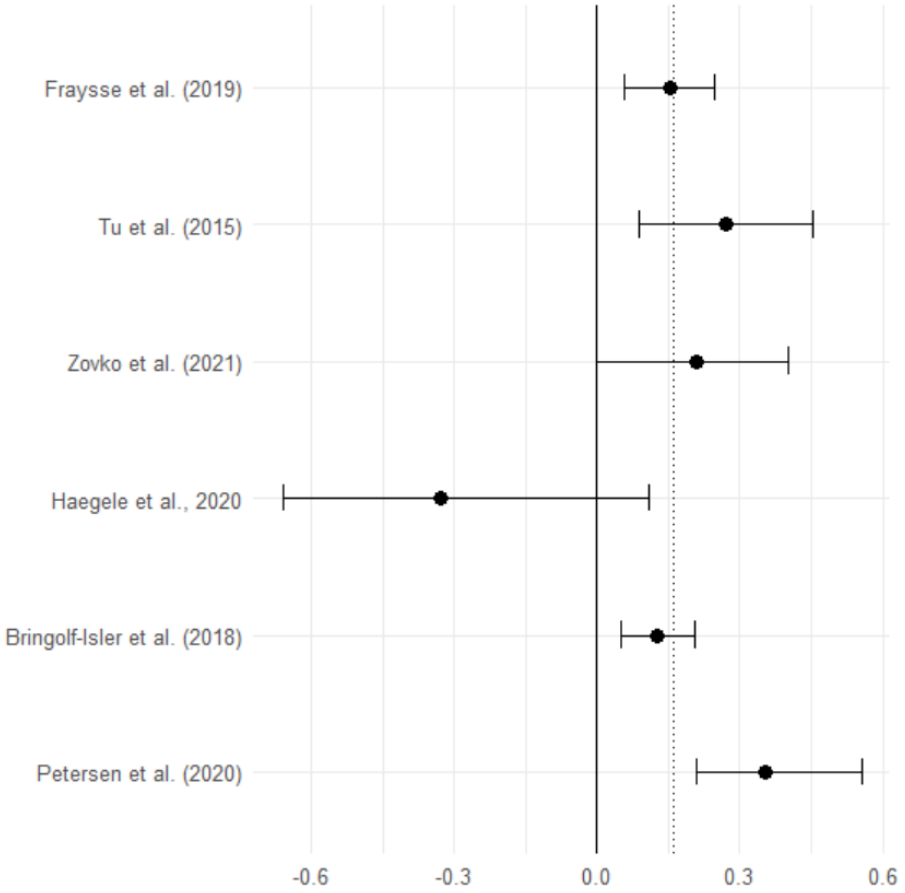

Figure 4. Forest plot for the pooled Pearson correlations of Parental MVPA correlation to child's MVPA for adolescent group.

Egger's test

Egger's regression test was conducted to assess the presence of publication bias across three age groups: Pre-K children, Children, and Adolescents (Figure 5).

In the Pre-K Children group, the intercept was −0.13 (95% CI: −2.12 to 1.86) with a p-value of 0.88, indicating no significant funnel plot asymmetry. Among Children, the intercept was −1.23 (95% CI: −3.27 to 0.80), with a p-value of 0.21, likewise suggesting no evidence of publication bias. For Adolescents, the intercept was 0.27 (95% CI: −3.63 to 4.17), and the corresponding p-value was 0.86.

Across all age groups, the p-values exceeded the conventional threshold of 0.05 and the confidence intervals encompassed zero. These findings indicate that Egger's test did not detect significant asymmetry, supporting the robustness of the meta-analytic estimates and suggesting that results are unlikely to be influenced by small-study effects or selective reporting.

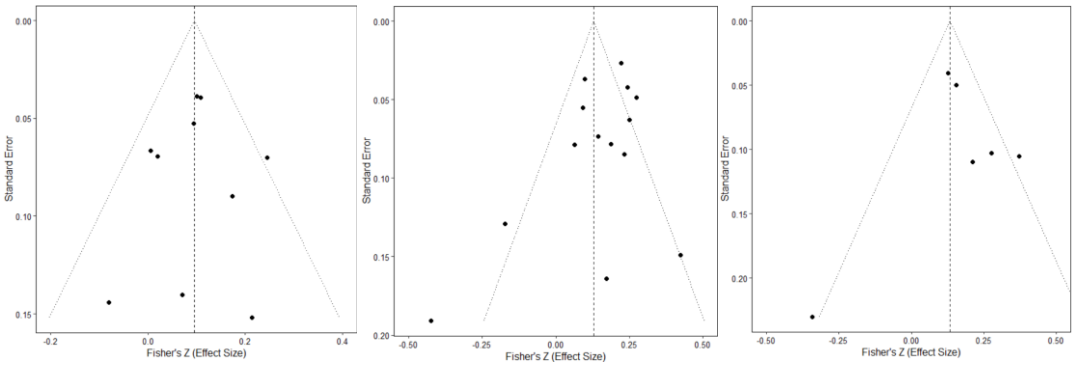

Figure 5. Funnel plot for studies (Left Pre-K child; Center Child; Right Adolescent), showing Fisher's Z-transformed effect sizes (x-axis) and standard errors (y-axis). The dashed lines indicate the expected distribution under no publication bias.

Discussion

In early childhood, modest correlations likely reflect the dominant influence of unstructured play, motor-skill emergence, and early education programming (Hnatiuk et al., 2016). For example, a large accelerometry study of 1,116 dyads found small but significant parent–child r's (r = .08–.20) with no sex differences (Carson et al., 2020). Although shared routines are less established at this age, limited co-MVPA suggests that parental modelling has only a modest direct effect. In middle childhood where a bigger data pool gave it a better robustness, shared family routines appear to strengthen MVPA alignment. Bringolf-Isler et al., (2018) reported peak correlations in 10–12-year-olds and identified indirect effects of parental activity in families with frequent co-participation. French et al. (2021) further demonstrated that each 10-minute increase in parental encouragement and logistical support corresponded to a 5-minute increase in child MVPA over three years, underlining the importance of active facilitation. Similarly, longitudinal analysis of low-income dyads showed that increased parental encouragement and logistical support predicted higher child MVPA and reduced sedentary time over three years (French et al., 2021). In adolescence, despite growing peer and school influences (Ridgers et al., 2012), the parent–child MVPA link persisted (r = 0.16), highlighting that established family activity norms continue to support adolescent MVPA even as autonomy increases (Yang et al., 2022).

Considerable heterogeneity (I^2 = 14–68 percent) reflects variation in measurement tools (hip vs. wrist accelerometers vs. questionnaires), study contexts, and analytic adjustments (Higgins et al., 2003). Subgroup analyses confirmed that studies rated "Good" quality yielded higher r's than "Fair" studies (0.148 vs. 0.108; χ^2=8.3, p=0.0038). Sensitivity analyses further revealed that crude correlations (r = 0.162) exceeded adjusted correlations (r = 0.139; χ^2=5.88, p=0.015), indicating that uncontrolled confounders potentially inflate parent–child MVPA correlations.

Mechanisms underlying these correlations likely include behavioural modelling and shared routines (Beets et al., 2010) as well as parental support behaviours such as

transportation and encouragement (Ornelas et al., 2007). Mixed-methods studies combining accelerometery with ecological momentary assessment provide valuable context for these patterns (Wirthlin et al., 2020). Peer processes also interact with parental influence; Lawler et al., (2021) found distinct patterns of adolescent MVPA shaped by both peer and parental support, highlighting the need to consider multi-level social factors.

This meta-analysis is the first to focus exclusively on parent–child moderate-to-vigorous physical activity (MVPA), yielding a pooled Pearson's *r* of 0.144 ($p < .001$). Prior reviews that combined all intensities of physical activity reported slightly lower correlations: Petersen et al. (2020) found an average *r* of approximately 0.13 across 39 studies using albatross plots, and Matos et al. (2021) observed consistent positive correlations in children aged 6–12 years. Isolating MVPA is critical because it comprises a relatively small share of daily movement yet delivers the greatest health benefits; 30–40 minutes per day of MVPA reduces all-cause mortality risk by over 20 percent (Ekelund et al., 2019), whereas light-intensity activity requires several hours daily to achieve comparable effects (Amagasa et al., 2019).

This review extends previous works by including an exclusive focus on Pearson's r effect sizes, rigorous adherence to MOOSE and PRISMA guidelines, comprehensive dual screening in Zotero, and systematic quality appraisal using the NHLBI tool. The inclusion of SURE evidence appraisal and multiple subgroup and sensitivity analyses enhances confidence in the robustness and applicability of findings. Thus, providing a more actionable insight into the dyadic transmission of health-relevant activity behaviours.

Limitations warrant caution. Language restriction to English and search in only PubMed and Web of Science may have omitted relevant studies in other databases or languages. All included studies didn't include African or South American countries and were also conducted in high-income countries, limiting generalizability to low- and middle-income contexts where environmental, cultural, and policy factors differ. The predominance of cross-sectional designs (25/27 studies) limits causal inference, and imputation of 95 percent CIs for 63 percent of studies may reduce precision. Combining objective and subjective MVPA measures introduces potential bias, and small-sample studies ($n < 50$) yield imprecise estimates, to mitigate this Inverse-variance weighting was applied partially offsetting their higher standard errors. Even though age groups were formed, sometimes, especially in the two longitudinal studies it overlapped with parts of other groups potentially reducing the adjusted effect. Correlations only capture linear and potentially crude relationships that aren't true measurements of correlation.

Future research should employ longitudinal and intervention designs to test causal pathways, integrate synchronized objective subjective MVPA assessments, and systematically

measure parental beliefs and logistical supports. Family-based interventions, such as those reviewed by van Sluijs et al., (2007) deserve rigorous randomized evaluation with mediation analyses to determine whether enhancing parental modelling translates into sustained improvements in child MVPA. Addressing these gaps will inform policies and programs that effectively engage families in promoting lifelong physical activity.

Conclusion

This meta-analysis of 27 observational studies demonstrates a modest but robust positive correlation between parent and child MVPA (overall r = 0.144), with developmental variation, weakest in early childhood (r = 0.10), highest in middle childhood (r = 0.18), and still positive in adolescence (r = 0.16). These estimates are in line with prior syntheses (Yao & Rhodes, 2015; Su et al., 2022) and underscore that parental modelling and support remain relevant across childhood and adolescence. Higher-quality studies yielded higher correlations (r = 0.148 vs. 0.108; χ^2=8.3, p=0.0038), and moderate-to-high heterogeneity (I^2 ≈15–68 %) points to differences in measurement, context, and analytic approaches. Overall evidence confidence was judged moderate. Future work should prioritize longitudinal and intervention designs, integrate objective and subjective MVPA measures, and systematically assess parental beliefs and logistical support to inform family-based strategies for promoting lifelong physical activity.

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The authors report there are no competing interests to declare.

Data Availability Statement

The data supporting the findings of this study, including calculations and original datasets, are available in annex or on the Open Science Framework (OSF).

Author Contributions

Flávio Ferreira – Conceptualization; Methodology; Investigation; Data curation; Formal analysis; Writing – original draft

Eliana V. Carraça – Validation; Writing – review & editing

Madalena Mascarenhas – Investigation; Data curation; Validation

António L. Palmeira – Conceptualization; Validation; Writing – review & editing

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Artigo Dois (Cross-sectional)

Parental Modelling and Interpersonal Support in Relation to Moderate Physical Activity and Vigorous Physical Activity in 9–12-Year-Olds: A Cross-Sectional DEPASS study

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Keywords: Accelerometry; Physical activity intensity; Interpersonal Support; Parental modelling

Abstract

Background: Moderate and vigorous physical activity (MPA and VPA) are both essential for child development and are influenced by both parental modelling and interpersonal support, yet most studies aggregate them into overall MVPA, potentially obscuring intensity-specific associations.

Objective: This cross-sectional study examined intensity-specific associations between parental modelling, parental support, peer support, and teacher support and objectively measured child MPA and VPA.

Methods: A total of 181 child–parent dyads from Belgium, Czechia, and Ireland were recruited between September 2023 and October 2024. Both children and their primary caregivers wore a hip-mounted ActiGraph wGT3X-BT accelerometer for eight consecutive days. Children and parents also completed validated Likert-scale questionnaires assessing interpersonal support and socioeconomic indicators. Associations between support variables and child PA outcomes were assessed using bivariate and partial correlations, controlling for confounders such as sex, country and socioeconomic status. Post-hoc analyses explored potential effects of extreme outliers (±2 SD from the mean).

Results: Parental MPA was moderately correlated with child MPA ($r \approx 0.30$), whereas correlations for VPA were weaker ($r \approx 0.20$). Peer and teacher support showed no significant associations with MPA and VPA in primary analyses, although peer support showed a very weak correlation with child VPA after removing outliers.

Conclusions: Parental modelling and co-participation were most strongly linked to children's MPA, suggesting that family-based strategies may be more effective when targeting

MPA. Peer support may have no role or a very limited one in VPA at this developmental stage, while teacher support showed no observable influence. These findings support the development of intensity-specific, multilevel interventions, but also highlight the need for longitudinal designs to clarify mechanisms and causality.

Introduction

Physical activity (PA) is essential for healthy growth and development in childhood. The World Health Organization 2020 guidelines recommend that children and adolescents aged five to 17 years accumulate at least 60 minutes per day of moderate to vigorous physical activity (MVPA), with muscle and bone strengthening at least three times per week (Bull et al., 2020). Despite this, over 80% of children and adolescents worldwide fall short of these targets, leaving many at increased risk for obesity, cardiometabolic disorders and suboptimal skeletal accrual during the critical years for lifelong bone health (Guthold et al., 2020). For this reason, identifying determinants of physical activity is crucial for informing both targeted interventions and broader policy strategies. Determinants may differ not only across demographic groups but also depending on the context in which adolescents live and grow. For instance, individual level factors such as self-efficacy, enjoyment of physical activity, and perceived competence often play a strong role in shaping behavior. Interpersonal influences including parental support, peer modeling, and encouragement can also significantly enhance or hinder participation. At the same time, institutional and environmental factors such as school curricula, the availability of safe recreational spaces, and access to sports facilities are important enablers or barriers. On a wider scale, community norms and policy level actions such as national guidelines, urban planning, and public health campaigns further influence the opportunities children have to engage in physical activity (Kolovelonis et al., 2024).

Among these interpersonal determinants, parental modelling has received particular attention as a powerful influence on children's engagement in physical activity. Parental modelling refers to the extent to which parents demonstrate active lifestyles through their own behaviours, thereby serving as observable examples for their children (Bringolf-Isler et al., 2018). When children witness their parents engaging in regular PA, they may be more likely to view such behaviour as normative and attainable, which in turn can positively influence their own involvement in PA. This modelling effect operates through both direct imitation and the creation of an environment that supports active choices. Additionally, parental beliefs about children's competence can interact with modelling behaviours to shape children's motivation and perceived capability for PA (Bois et al., 2005).

Parental modelling, however, represents only one part of a broader social ecological framework. Within social ecological frameworks, interpersonal support from parents, peers and teachers is a principal influence on children's activity alongside intrapersonal, environmental

and policy factors (Sallis et al., 2000). Parental support has shown robust links with child MVPA, yet most evidence has been derived from questionnaire-based PA measures that may overestimate associations (Yao & Rhodes, 2015). When both parent and child activity are assessed by accelerometry, correlations fall to approximately 0.2 for overall parental support (Trost & Loprinzi, 2011; Sarker et al., 2015). Peer support has also demonstrated associations with PA levels in both pre-adolescents (commonly defined as ages 9–12) and adolescents (ages 10–19) (Khan et al., 2020), while teacher support has been shown to boost schooltime PA through quality physical education and classroom activity breaks, yet its unique contribution to total daily activity as captured by accelerometry is small and sometimes non-significant (Sheridan et al., 2014; Sallis et al., 2002).

The intensity of PA shapes distinct health outcomes. Moderate-intensity PA (MPA, 3.0–5.9 metabolic equivalents [METs]) underpins weight management, glycemic control, and lipid metabolism, whereas vigorous-intensity PA (VPA, ≥ 6.0 METs) confers additional benefits for aerobic capacity and musculoskeletal health (Herrmann et al., 2024; WHO, 2020). Regular MPA is consistently linked to reductions in adiposity, improved glycemic regulation, and favorable changes in lipid profiles, while VPA and interval-based modalities elicit superior gains in cardiorespiratory fitness and glucose control (Gallardo-Gómez et al., 2024; Syeda et al., 2023; Wang et al., 2024). High-impact activities such as running and jumping stimulate osteogenesis, supporting accrual of peak bone mass, the strongest predictor of fracture risk in later life (Ng et al., 2023; Miao et al., 2025; Chevalley & Ferrari, 2022). Accurate assessment of intensity and duration is therefore vital. Waist-worn accelerometry provides objective, epoch-by-epoch measurement that can be classified into light, moderate and vigorous intensity bands using validated count thresholds (Evenson et al., 2008). By contrast, self-report questionnaires, though useful for capturing context and perceptions, are prone to recall error and social desirability bias and yield only modest correspondence with accelerometer-derived activity. (Duncan et al., 2005; Edwardson et al., 2014). Moreover, questionnaire-based studies often report stronger associations between interpersonal support and activity than those observed when both support and PA are measured using devices.

Most research to date aggregates MVPA into a single composite as seen in the meta-analysis by Petersen et al. (2020), masking potential differences in how support relates to each intensity. A handful of studies hint that parental modelling may be more closely tied to MPA behaviors such as walking and non-competitive play (e.g., playground games, casual bike rides, or shooting hoops, while peer invitations and structured opportunities may be more critical for VPA participation (Mattocks et al., 2007). However, intensity-specific pathways remain underexplored, especially in studies combining objective measures of activity with questionnaire-based assessments of support.

Children aged 9-12 occupy a developmental niche in which autonomy is increasing yet caregiver influence remains strong (Yao & Rhodes, 2015). In this age group, parental modelling of active behavior is likely the dominant support factor, whereas teacher encouragement is confined to the school day and may play a supplementary role. Peer support begins to emerge as a motivator for VPA such as team sports but exerts less influence over overall MVPA than parental modelling (Li-juan et al., 2017).

The present study draws on a subset of data from the European COST Action DE-PASS (Determinants of Physical Activities in Settings), which aims to identify, understand, and measure the factors that promote, sustain, or inhibit PA behaviors across the lifespan and in various settings. One of its dedicated working groups (Palmeira et al., 2024) focused specifically on children aged 9–12 and developed a harmonized set of procedures and protocols to standardize collection of PA determinant data across participating countries, ensuring methodological consistency and cross-national comparability. Currently, DE-PASS data are being processed from ten countries, forming a comprehensive pan-European database of PA determinants and behaviors. Within this framework, determinants are examined at multiple levels, including individual – psychological, individual – behavioral, interpersonal, institutional, institutional, and policy/societal thereby capturing a broad spectrum of influences on physical activity participation. This study focuses on a research question not addressed in the main DE-PASS analyses, thereby offering novel insights within the project's broader framework.

This dataset was collected by deploying accelerometers to quantify children's and parental daily MPA and VPA to measure parental modelling, and validated questionnaires to assess parent support, peer support and teacher support (Palmeira et al., 2024). Correlations among objectively measured MPA and VPA, parental modelling and each support type, were examined both separately and in aggregate. The aim of this study is (i) to verify if parental support will show the strongest associations with children's MPA (Gustafson & Rhodes, 2006), (ii) peer support is positively correlated with MPA and VPA (Khan et al., 2020), (iii) teacher support will have little association with MPA and VPA (Chen et al., 2020) and (iv) parental modelling is positively correlated with child MPA and VPA, with a stronger relationship for MPA than for VPA (Yao & Rhodes, 2015).

Methods

Study Design and Setting

This cross-sectional study was conducted in primary schools across three European countries (Belgium, Czechia, and Ireland) between September 2023 and October 2024. Ethical approval

was granted by the CEFADE 34 2023 Ethics Committee entitled DE-PASS Proof of Concept: A multi-national pilot cross-sectional study on Physical Activity Behaviours and their determinants in youth. All procedures followed the DE-PASS Proof-of-Concept Standard Operating Procedures (SOP) and the reporting adhered to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guidelines (von Elm et al., 2007) (In Annex).

Participants

Children aged 9–12 years without diagnosed mental or physical conditions likely to alter habitual PA were eligible, provided their primary caregiver (the parent or guardian most familiar with their daily routines) also consented to participate. Recruitment was school-based (both public and private) in collaboration with school principals, initiated by a researcher-led presentation to the parent community; interested families returned signed consent forms prior to data collection.

Data Collection Procedures

From each family, one study child, one primary caregiver, and one sibling (aged 8–17 years) were invited to participate, provided written informed consent (caregiver and siblings aged ≥18 years) and assent (children and younger siblings) were obtained. Families were allocated anonymized ID codes to ensure confidentiality and facilitate data linkage across measures. All procedures were approved by local ethics committees prior to implementation.

At the scheduled data collection session, families attended a face-to-face meeting with trained researchers, usually hosted in the school environment. During this visit, general family information was collected, and children's height and weight were measured following standardized anthropometric protocols. Both the study child and primary caregiver completed validated determinant questionnaires, with assistance provided if required. To capture device-based physical activity behaviors, accelerometers were distributed to the study child, one sibling, and the primary caregiver, along with an accelerometer diary to record wear times, removals, and structured physical activity. Participants were instructed to wear the devices for eight consecutive days. Families received a study care pack containing all instructions, consent forms, and return materials. Reminder text messages were sent to caregivers on days three, four, and eight to support compliance and timely return of devices and documentation. Returned data was checked for completeness before entry into the centralized DE-PASS database.

Accelerometer Protocol

Participants wore an ActiGraph wGT3X-BT monitor (ActiGraph Corp., Pensacola, FL) affixed to a latex-free elastic belt at the right hip for eight days, removed it only for water-based

activities or sleep. Initialization in ActiLife 6.13.4 30 Hz sample rate, Families received an illustrated diary and optional SMS reminders on days three and four to reinforce wear compliance. Each device was prepared and cleaned using 70% isopropyl alcohol wipes and fully charged before initialization. Devices were initialized with a delayed start (03:00 on the second day) and programmed for automatic stop after eight days, with sleep mode enabled and LED display suppressed to minimize distraction. Unique DE-PASS ID codes were entered during initialization to ensure correct data linkage.

Upon return, raw .agd and .gt3x files were downloaded following the DE-PASS folder structure and naming convention. Data were processed with a 10-s epoch, three-axis acceleration, step count, light sensor and inclinometer channels. For children, non-wear was defined by the Troiano algorithm (Troiano et al., 2008) as ≥ 60 minutes consecutive zero counts with allowance for up to 2 minutes nonzero interruptions; valid days required ≥ 480 minutes wear time, with inclusion criteria of ≥ 3 valid weekdays and ≥ 1 valid weekend day. For parents, non-wear was defined as ≥ 600 minutes consecutive zero counts. Files were processed in ActiLife using the Evenson et al. (2008) cut-points for children and the Troiano adult cut-points (Troiano et al., 2008) for parents. Average daily MPA and VPA were calculated across valid days. While many studies process data in 60-s epochs, this approach can under-detect brief and intermittent bouts of activity, particularly vigorous bursts. By processing at a 10-s epoch, our protocol aimed to better preserve these patterns, although this may limit direct comparability with studies using longer epochs. This protocol was adapted from Decelis et al. (2014). All downloaded data were securely stored in GDPR-compliant institutional servers following DE-PASS protocols, with dual verification and password-protected master ID linkage files.

Support assessment protocol

Both parents and children completed questionnaires. The child survey was an adapted version of the Parental Encouragement and Support for Children's PA scale (PEACH; Ommundsen et al., 2008). The parent survey comprised socio-demographic items from the Health Behaviour in School-aged Children questionnaire (HBSC; Roberts et al., 2009) filled by the parent. Both questionnaires followed the adaptation procedure described by Palmeira et al. (2024) and were delivered either on tablet or paper. Children PEACH questionnaire yielded three subscales: parental support, peer support and teacher support. Responses were recorded on a four-point Likert scale (1 = Hardly ever or never to 4 = Every day). The original version of the instrument demonstrated good internal consistency (Cronbach's α = .72–.89) and acceptable test–retest reliability (ICC = .65–.80) as reported in (Palmeira et al., 2024).

Missing or incomplete questionnaires were first addressed on site by the researcher's assistance; any forms still unfinished or unreturned prompted a follow-up phone call.

Instruments that remained incomplete after these recovery steps were excluded from analysis in accordance with the standard operating procedures.

Statistical methods

Participants with no valid child and parent accelerometry data or child questionnaire for the same entry, were removed from further analysis. Questionnaire responses for parental, peer, and teacher support were coded on an ordinal scale (1 = "Hardly ever or never" to 4 = "Every day"), and subscale scores were computed as the mean of their respective items (five for parental support, three each for peer and teacher support). MPA and VPA data were transformed (square root) to normalize data and Shapiro–Wilk tests were used to assess the normality of each variable's distribution, and Levene's test was used to assess equality of variances, as recommended by Field (2013). The distribution of VPA remained non-normal even after a square root transformation. Average daily MPA and VPA (minutes per day) were calculated by dividing the total accumulated minutes by the number of valid observation days.

To identify potential socioeconomic confounders, bidirectional associations between each support variable, PA outcome (MPA and VPA minutes/day, % of total) and a set of candidate covariates were examined. Candidates were screened via point-biserial correlation using Tabachnick & Fidell, 2007 recommendations (full results in Annex, socioeconomic questions in Table 1); only variables showing $p < .05$ associations with both an independent (support or Parent MPA and VPA) and a dependent (child MPA and VPA) variable were retained for adjustment. Child sex, country and age were directly included as covariates, given their established role as potential confounders (Rodríguez-Rodríguez et al., 2020; Carson et al., 2020). Regression models were then estimated with and without these covariates to assess their impact on effect estimates.

Descriptive statistics (means, standard deviations, and ranges for continuous variables; frequencies and percentages for categorical variables) characterized the sample and key measures. Correlations involving Support as the independent variable were calculated using Spearman's rank-order coefficient, and those with Parent MPA and VPA as the independent variable used Pearson's product-moment coefficient; for any variables that violated normality or homoscedasticity assumptions required by Pearson's method, Spearman's coefficient was applied instead.

Internal consistency of each support subscale in this study was assessed using McDonald's omega (ω) (McDonald, 1999), which revealed variable internal consistency. McDonald's omega was acceptable for peer support ($\omega = .70$) but lower for parental support ($\omega = .51$) and teacher support ($\omega = .38$). Since teacher and Parental support dimensions cannot be used as a single determinant, individual questions were used for the correlation analysis.

Post-hoc analyses were conducted by removing outliers from the parent–child MPA and VPA dataset, defined as values falling outside the mean ± 2 standard deviations. This approach aimed to normalize the distribution and explore whether excluding extreme cases (e.g. parents with exceptionally high VPA) would change the association patterns. All relevant variables were reanalyzed using the square root transformation procedures previously described.

Data on MVPA was not included in the present analyses, as this study was designed to focus specifically on distinguishing between MPA and VPA. Analyses of MVPA will be conducted in future work.

All analyses were conducted using JASP version 0.19.2 with a two-tailed α = .05.

Results

Descriptive statistics

There were originally 181 dyads, resulting in a final sample size of 172 after removing dyads that did not meet the eligibility criteria (Figure 1). Sample characteristics and accelerometry outcomes for the 172 child–parent dyads included in the final analysis are presented in Table 1. A post-hoc analysis was conducted using G*Power version 3.1.9.7 for a Two-Tailed Point biserial model reaching 80% for |ρ|=0.19. Children and parents were of very similar age groups, sample country distribution was balanced, child sex was balanced, while parental sex was much more female dominant. The overall group is highly educated and of a high socioeconomic status. In terms of normality, Parent VPA in minutes and % stood out as having a non-normal distribution even after transformation which remained right skewed. In terms of sex differences, they were only found in accelerometry in both child and parents and only in MPA.

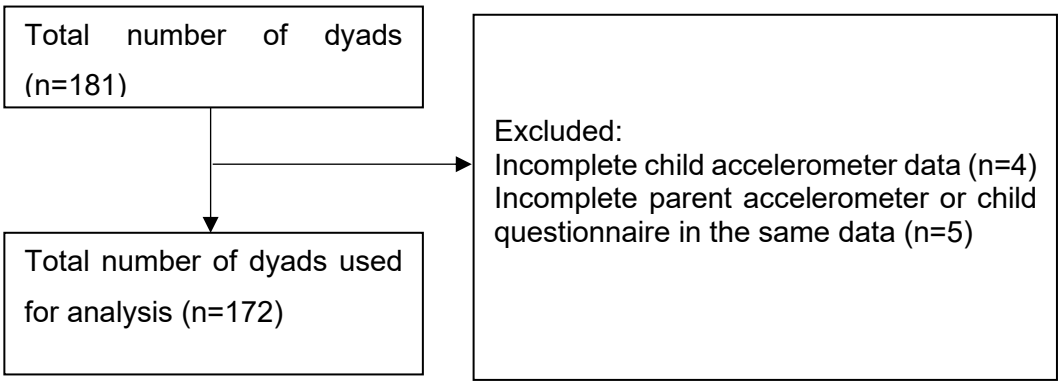

Figure 6. Dyads flow chart

Table 0.4. Demographic, Socioeconomic, and Accelerometry-Derived Physical Activity Characteristics of child–parent Dyads

Characteristic	Child (N = 172)	Parent (N = 172)
Demographics		

Age, mean (SD), years	10.9 (1.6)		42.3 (5.8)
Country of origin, n (%)			
Belgium		59 (34.3)	
Czechia		67 (39.0)	
Ireland		46 (26.5)	
Sex, n (%)[#]			
Male	86 (50.0)		40 (23.3)
Female	83 (48.3)		129 (75.0)
Education ≥ Bachelor's, n (%)	—		123 (71.5)
Socioeconomic			
Cars owned, n (%)			
0	—		3 (1.7)
1	—		44 (25.6)
2	—		110 (64.0)
≥ 3	—		8 (4.7)
Own room, n (%)			
Yes	133 (77.3)		—
No	34 (19.8)		—
Travels abroad, n (%)			—
None		18 (10.5)	
Once		75 (43.6)	
Twice		46 (26.7)	
> Twice		28 (16.3)	
Computers, n (%)			
0	—		4 (2.3)
1	—		32 (18.6)
2	—		41 (23.8)
> 2	—		90 (52.3)
Dishwasher, n (%)	—		No 14 (8.1) Yes 153 (89.0)
Bathrooms, n (%)			
1		80 (46.5)	
2		55 (32.0)	
> 2		32 (18.6)	
Physical Activity, mean (SD)			
MPA, minutes/day	33.3 (10.5)*		42.87 (16.4)*
MPA (% total PA)	4.0 (1.3)		4.9 (1.9)*
VPA, minutes/day	18.8 (10.8)		4.5 (8.3)
VPA (% total PA)	2.2 (1.2)		0.5 (0.9)
Social Support			
Peer support, mean (SD)	2.8 (0.8)		—
Parental support items, mean (SD)			—
Take you to exercise	2.8 (1.0)		—

Watch you take part in exercise	3.0 (1.0)	—
Exercise or play sports with you	3.1 (0.9)	—
Tell you to exercise	2.8 (1.0)	—
Tell you that exercise is good for your health	2.8 (1.1)	—
Teacher support items, mean (SD)		—
Talk about exercise in lessons	3.0 (1.0)	—
Organize or play games apart from PE	3.2 (0.9)	—
Tell you to exercise or play sports	2.5 (0.9)	—

*Statistically significant difference between Male and Female. **Note:** Totals aren't 100% since some entries were blank. # Three participants did not answer.

Correlation Analysis

Pearson correlation analyses between parent and child PA (Table 2) demonstrated small to moderate positive associations across corresponding intensity levels (e.g., Parent MPA minutes was associated with children MPA, but Parent VPA was not associated with children MPA). When controlling for child sex, the correlation between child MPA minutes and parental VPA minutes became significant (ρ = .156, 95% CI [0.004, 0.295], p = .043).

Adjustment for the tested confounders did not alter the statistical significance of the associations. The full correlation matrix with partial correlations can be found in Annex.

Associations between child-reported social support and PA (Table 3) were generally nonexistent to weak. After adjusting for child sex, some additional significant associations emerged. The correlation between the item 'Exercise or play sports with you' and child MPA % increased (ρ = 0.188, 95% CI [0.041, 0.337], p = 0.014). Furthermore, new significant associations with 'Exercise or play sports with you' were observed for child MPA minutes (ρ = 0.167, 95% CI [0.022, 0.301], p = 0.030), and child VPA % (ρ = 0.157, 95% CI [0.004, 0.299], p = 0.041).

When controlling for socioeconomic determinants, specifically questions "Cars owned" and "Bathrooms", the results were similar, with some already marginally significant values losing significance. The complete correlation matrix with partial correlations is available in Annex.

Removing outlier cases did not materially change the parent–child PA correlations. However, after outlier removal, peer support showed a new, weak significant correlation with child VPA minutes (ρ = .171, 95% CI [0.006, 0.327], p = .049).

Table 0.5. Pearson correlation matrix depicting associations between parent and child MPA and VPA metrics.

	Parent MPA (minutes)	**Parent MPA (%)**	**Parent VPA (minutes)[a]**	**Parent VPA (%)[a]**
Child MPA (minutes)	**.298**	**.253**	.146	.141
	[.154, .429]	[.107, .389]	[–.005, .290]	[–.010, .285]
	< .001	< .001	.058	.068
Child MPA (%)	**.291**	**.342**	.032	.045
	[.147, .423]	[.202, .468]	[–.119, .181]	[–.106, .194]
	< .001	< .001	.682	.559
Child VPA (minutes)	.092	.030	**.240**	**.230**
	[–.059, .239]	[–.121, .180]	[.093, .377]	[.082, .367]
	.233	.698	.002	.003
Child VPA (%)	.091	.081	**.198**	**.197**
	[–.060, .238]	[–.071, .228]	[.049, .338]	[.048, .338]
	.239	.295	.010	.010

[a]- Spearman correlation. **Note:** Results are presented as correlation coefficients with corresponding 95% confidence intervals and p-values.

Table 0.6. Spearman correlations between child-reported social support (parental, peer, teacher) and children's MPA and VPA outcomes.

	Peer Support	**(Parent) Take you to exercise**	**(Parent) Watch you take part in exercise**	**(Parent) Exercise or play sports with you**	**(Parent) Tell you to exercise**	**(Parent) Tell you that exercise is good for your health**	**(Teacher) Talk about exercise in lessons**	**(Teacher) Organize or play games apart from PE**	**(Teacher) Tell you to exercise or play sports**
Child MPA (minutes)	.035 [–.127, .194] .649	.104 [–.059, .255] .173	.007 [–.166, .145] .929	.122 [–.014, .267] .110	.012 [–.135, .162] .872	.061 [–.077, .207] .424	–.068 [–.221, .088] .375	–.137 [–.273, .004] .074	–.025 [–.178, .124] .745
Child MPA (%)	.039 [–.117, .184] .614	.017 [–.145, .168] .824	–.109 [–.266, .050] .154	**.159 [.022, .309], .037**	–.031 [–.176, .121] .686	–.013 [–.151, .131] .867	–.098 [–.246, .057] .201	–.037 [–.182, .113] .632	–.025 [–.166, .112] .748
Child VPA (minutes)	.011 [–.147, .163] .889	.024 [–.134, .180] .757	–.009 [–.160, .148] .907	.117 [–.033, .263] .125	–.022 [–.176, .118] .775	.011 [–.131, .167] .883	.020 [–.141, .168] .799	–.096 [–.240, .052] .210	.014 [–.148, .168] .857
Child VPA (%)	-.003 [–.162, .141] .969	-.035 [–.187, .124] .651	–.058 [–.207, .100] .448	.140 [–.014, .288] .067	–.034 [–.184, .112] .662	–.035 [–.170, .114] .650	.011 [–.151, .163] .886	–.044 [–.192, .111] .568	.018 [–.135, .171] .816

Note: Results are presented as correlation coefficients with corresponding 95% confidence intervals and p-values.

Discussion

This study revealed intensity-specific associations between interpersonal influences and children's PA, with particularly strong links between parental behaviour and MPA in children. Consistent with the fourth hypothesis and previous research, parental MPA was most strongly correlated with child MPA ($r = .342$, $p < .001$), while parental VPA showed only a weak correlation with child VPA ($\rho = .197$, $p = .010$), reinforcing the role of parental modelling primarily in moderate activity. These findings are in line with Sigmundová et al. (2024), who also reported stronger parent–child associations for MPA ($\rho = .35$) compared to VPA. MPA, such as walking or casual play, are more accessible for co-participation or observation (Gustafson and Rhodes, 2006), and adults are more likely to engage in them themselves (Yao and Rhodes, 2015; Trost et al., 2003). These patterns may help explain why parental modelling exerts a stronger influence at the moderate intensity level. Showing that MPA behaves differently from VPA which has a considerably greater variability, suggesting that distinct strategies may be required to effectively enhance VPA or MPA.

In support of hypothesis one which predicted that parental support would show the strongest associations with children's MPA, perceived parental support through the item "Exercise or play sports with child", was positively associated with child MPA % ($r = .159$, $p = .037$). This item reflects co-participation, which has been identified by Pyper et al. (2016) as a key predictor of child physical activity. Fitness levels typically decline with age, and this reduction in capacity can make participation in vigorous activities more difficult to sustain (Sun et al., 2013). Safety considerations, such as increased risk of injury or discomfort associated with high exertion, may also discourage parents from engaging in VPA with their children or alone. In contrast, MPA such as walking, cycling at a casual pace, or active play are easier to integrate into daily routines, better align with the fitness levels of most parents, and pose fewer barriers. MPA is therefore more practical for parents to adopt and to model within family contexts, making it a more promising focus for family-based interventions. However, Trost et al. (2003) suggested caution, since parental support alone may not be sufficient to overcome environmental or motivational barriers, and broader multilevel strategies may be required. These findings on parent support and modelling highlight the importance of distinguishing between types and intensities of activity.

Our second hypothesis, that peer support would be associated with child VPA, was not supported by the primary analysis, which revealed no significant correlation. This result may reflect the developmental stage of the children in this sample, aged 9 to 12 years, who are still primarily influenced by parental guidance and support, as described by Beets et al. (2010). While peer support is theorized to become more influential with age, it may not yet play a prominent role in vigorous activity at this stage of development. A post hoc exploratory

analysis, conducted after the removal of outliers, which consisted mainly of dyads with exceptionally high VPA, did reveal a weak but statistically significant correlation between peer support and child VPA minutes ($\rho = .171$, $p = .049$). Although this suggests a possible emerging influence of peers under certain conditions, it should be interpreted cautiously. Peer influence on VPA may operate indirectly through mechanisms such as shared enjoyment or self-efficacy rather than direct encouragement (Chen et al., 2017), and as mentioned before it may only gain relevance closer to adolescence (Davison et al., 2009; Zhou et al., 2023). The post hoc findings may reflect distinct behavioural patterns among children with lower parental VPA exposure, but they do not alter that, in this age group, peer support by itself was not a significant predictor of VPA. This indicates that the timing and tailoring of interventions should be based on developmental stage, and that for this age group peer focused interventions may not be the best suited.

Lastly the third hypothesis on teacher support was confirmed since no significant association with physical activity was found across any intensity level. This contrasts with some intervention studies, such as Eather et al. (2013), which demonstrated increased physical activity following teacher-supported interventions. However, those studies differ in both context and methodology. The study by Eather and colleagues focused on a structured intervention in an Australian setting, whereas this study evaluated naturally occurring behaviours in a European sample. Teacher support may vary depending on national education systems, and as suggested by Lin et al. (2024), because of this, it may be inconsistently linked to physical activity outcomes across studies. In contexts where teachers are not expected or resourced to promote activity outside of physical education, their influence may be negligible.

Overall, these findings suggest that interpersonal influences on child physical activity vary by intensity and, in the case of teacher support, by context. Parental modelling is especially relevant for MPA, while peer support probably has no major influence on this age group. The role of teachers appears non-relevant in this sample, potentially due to systemic or cultural limitations within the education system.

Limitations

This study has several limitations. The cross-sectional design prevents any inference of causality, making it impossible to determine the directionality of observed associations. The sample was primarily composed of families from higher socioeconomic backgrounds, European countries and mostly mothers (75%), which may limit the generalizability of the findings to other sex, cultural or socioeconomic groups. Other environmental factors such as physical environment or school policies which may potentially influence PA were also not accounted for in this study. Sample was also collected in a time span of around 13 months, which doesn't account for different times of the year or seasons, which may influence PA

levels, as samples within same country or different ones were collected in different times of the year. The sample could potentially be from a small set of schools or even same classes, therefore having a potential cluster (especially for teacher support) effect violating the assumption of them being independent observations, but since that data is not shared within data collection agents for confidentiality reasons and the sample has only three countries, that analysis was not possible.

Although the original parental, peer, and teacher support instruments had acceptable reliability in other research, the internal consistency of the parental and teacher support subscales was suboptimal in this study. As a result, only individual items could be used, which may have limited the ability to capture the full scope of interpersonal support constructs. It is possible that the age group studied, the method of questionnaire deployment or translation method was not optimal for capturing these two support constructs, and children's tendency to provide socially desirable responses may have introduced bias. Future research should refine and validate more comprehensive measurement tools for interpersonal influences on child activity.

The sample size, while adequate for detecting moderate associations, lacked power to identify very weak correlations. Additionally, the exploratory nature of some secondary analyses, such as stratifying by activity level or socioeconomic markers, means those findings should be interpreted with caution. The study's age range also limits its applicability to other developmental stages, particularly adolescents, where different social dynamics may be more relevant.

Conclusions

This study highlights the importance of considering the type of physical activity intensity when examining interpersonal influences on child activity. Parental modelling appears to have the most substantial influence on MPA, supporting the value of interventions that promote habitual family-based movement. Peer support did not seem to contribute to vigorous activity or at best play a limited role for this age group. Teacher support was not significantly associated with physical activity in this sample, possibly due to contextual factors within European education systems.

Future research should use longitudinal designs and refined, validated instruments to better understand the direction and mechanisms of these relationships, with particular attention to clearly distinguishing between VPA and MPA in order to determine which strategies are most effective for each intensity. Interventions should consider tailoring strategies to the specific intensity of physical activity and the developmental stage of the child, recognizing that different social influences may be relevant at different times and for different types of activity.

Other information

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Author Contributions

Flávio Ferreira – Conceptualization; Methodology; Data curation; Formal analysis; Writing – original draft

Kieran Dowd; Alan Coffey; Greet Cardon; Jan Dygrýn; Jana Pelclová; Evelien Iliano – Data collection; Writing- review

António L. Palmeira – Conceptualization; Validation; Writing – review & editing

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Discussão

Esta dissertação procurou clarificar se a AFMV parental está associada à AFMV das crianças, se a AFM e a AFV apresentam padrões correlacionais semelhantes ou distintos e se o suporte social tem um impacto na AFM e AFV durante a infância intermédia. Os dois estudos que a compõem convergem em duas mensagens centrais. Primeiro, existe uma associação fiável, positiva e sensível ao desenvolvimento entre a AFMV parental (modelagem parental) e a AFMV infantil. Segundo, quando a AFMV é desagregada, a AFM e a AFV não se comportam de forma semelhante em relação à modelagem parental e ao suporte interpessoal.

Em conjunto, estes resultados reforçam a noção de que os pais desempenham um papel significativo na formação dos comportamentos de atividade física das crianças, mas que essa influência não é uniforme em todos os níveis da atividade física. O padrão de desenvolvimento identificado na meta-análise sugere que a infância intermédia é um período particularmente sensível à modelagem parental, em consonância com a investigação que demonstra que crianças entre os nove e os doze anos permanecem recetivas à orientação parental, ao mesmo tempo que começam a desenvolver maior autonomia nas suas escolhas comportamentais (Trost et al., 2002; Edwardson & Gorely, 2010). Em simultâneo, a evidência transversal indica que a modelagem parental apoia sobretudo a AFM, enquanto a AFV parece depender mais de fatores contextuais e, eventualmente, do papel dos pares, ainda que estes se revelem mais relevantes na adolescência do que na infância intermédia. Este padrão duplo sublinha a importância de enquadrar a influência parental numa perspetiva ecológica mais ampla, onde múltiplos agentes interagem para moldar o espectro da atividade física das crianças (Sallis et al., 2008; Bronfenbrenner & Morris, 2006).

Uma observação crítica que emerge deste conjunto de dados é que a AFM se comporta estatisticamente de forma muito semelhante à AFMV, enquanto a AFV apresenta um perfil de distribuição bastante distinto. Nas crianças, a média de AFM foi de 33.3 minutos por dia (σ = 10.5), correspondendo a cerca de 4% da atividade física total, enquanto a média de AFV foi inferior, 18.8 minutos por dia (σ = 10.8), representando apenas 2.2% da atividade total. Nos pais, o contraste foi ainda mais acentuado: a média de AFM foi de 42.9 minutos por dia (σ = 16.4), equivalente a 4.9% da atividade total, enquanto a média de AFV foi apenas de 4.5 minutos por dia (σ = 8.3), correspondendo a menos de 1% da atividade total. Estes valores indicam que a AFM constitui a maioria do tempo despendido em atividades de maior intensidade em ambas as gerações, dominando efetivamente o volume de AFMV. A AFV, pelo contrário, caracteriza-se por distribuições altamente enviesadas, em particular nos adultos, nos quais a maioria acumula minutos próximos de zero e apenas um pequeno subgrupo acumula quantidades desproporcionadamente elevadas. Esta concentração em torno do zero, associada a uma cauda longa à direita, gera uma distribuição que se afasta claramente da normalidade e que apresenta pouca representação na faixa intermédia. Estas propriedades estatísticas têm consequências metodológicas: quando a AFM e a AFV são combinadas em AFMV, a predominância esmagadora da AFM em termos absolutos e proporcionais parece mascarar o comportamento específico da AFV. Neste conjunto de dados, a AFV das crianças representou menos de um terço da sua AFMV, enquanto a AFV parental representou menos de um décimo. Estas proporções ilustram porque é que análises baseadas na AFMV tendem a subestimar a contribuição da AFV para os resultados de saúde, apesar da evidência crescente de que pequenas quantidades de AFV conferem benefícios desproporcionados para a saúde cardiometabólica e a aptidão física em jovens (Ekelund et al., 2019; Poitras et al., 2016). Uma meta-análise realizada por Cao et al. (2021), que comparou os benefícios da AFM com os da AFV em indicadores de composição corporal, aptidão cardiorrespiratória, pressão arterial e metabolismo glícido e lípido, demonstrou que a AFV, mesmo em pequenas quantidades, apresentou efeitos mais significativos do que a AFM em indicadores de risco cardiovascular, nomeadamente o VO_2 máximo e a pressão arterial sistólica, reforçando assim os benefícios exclusivos da AFV. Este argumento reforça a necessidade de análises específicas por intensidade, de forma a evitar interpretações enviesadas sobre a influência parental e social na atividade física das crianças.

A divergência entre AFM e AFV levanta questões sobre os mecanismos envolvidos. A atividade moderada está frequentemente integrada em rotinas diárias, como deslocações ativas, caminhadas recreativas ou brincadeiras não estruturadas, comportamentos que os pais podem modelar, encorajar e facilitar (Gustafson & Rhodes, 2006). A atividade vigorosa, por seu lado, exige geralmente oportunidades estruturadas, competências específicas e

contextos de suporte social, como o desporto organizado ou jogos de alta intensidade em ambientes escolares e comunitários (Bauman et al., 2012). Os resultados sugerem que, embora a modelagem parental possa estabelecer uma base para o movimento diário, a promoção da AFV requer um enquadramento social e ambiental específico para além do núcleo familiar.

Estas conclusões têm implicações para o desenho de intervenções. Programas familiares que visam aumentar a AFMV infantil podem ter sucesso em elevar os níveis de AFM, mas correm o risco de ter um impacto limitado na AFV se não incorporarem outros componentes. Intervenções eficazes podem necessitar de combinar o envolvimento parental, que sustenta o envolvimento regular em AFM, com elementos estruturais que criem contextos acessíveis e motivadores para a AFV, como desporto extracurricular, oportunidades de brincadeira vigorosa durante os intervalos escolares ou iniciativas comunitárias que promovam atividades de grupo de alta intensidade (Howie et al., 2014; Khan et al., 2020). Intervenções que abordem ambas as camadas poderão estar melhor posicionadas para alcançar limiares de atividade com impacto positivo na saúde.

Do ponto de vista metodológico, emergem também considerações relevantes. A meta-análise demonstrou que associações não ajustadas tendem a sobrestimar a relação entre pais e filhos, sublinhando a importância de controlar fatores de confundimento como o estatuto socioeconómico, a escolaridade parental e os apoios contextuais. O estudo transversal destacou o valor acrescentado de medidas de acelerometria específicas por intensidade, que forneceram uma visão mais detalhada das influências parentais e sociais. As propriedades estatísticas distintas da AFM e da AFV ilustram ainda porque é que os resultados agregados de AFMV podem induzir em erro. Futuras investigações deverão combinar estas forças metodológicas através de desenhos longitudinais com medidas objetivas que captem a atividade por intensidade e que considerem também os contextos familiares, sociais e ambientais. Tal permitiria inferências causais mais robustas e clarificaria se alterações no comportamento parental podem traduzir-se em aumentos sustentados tanto de AFM como de AFV.

Outra implicação deste corpo integrado de evidência prende-se com a equidade. O acesso a oportunidades estruturadas de atividade vigorosa varia frequentemente em função da posição socioeconómica e do ambiente residencial (Salmon et al., 2011). Se a modelagem parental impulsiona sobretudo a AFM, e a AFV depende mais de oportunidades estruturadas, então as desigualdades no acesso ao desporto e a espaços seguros de prática podem constranger de forma desproporcionada as crianças de contextos mais desfavorecidos. A resposta a estas disparidades exige não apenas estratégias centradas na família, mas

também intervenções ao nível das políticas públicas que garantam uma oferta equitativa de instalações e programas em todas as comunidades (Ding et al., 2016).

Em síntese, os resultados integrados desta dissertação refinam a compreensão sobre a forma como as influências parentais e interpessoais moldam a atividade física das crianças. A modelagem parental apoia consistentemente a AFMV, sobretudo durante a infância intermédia, mas a sua influência é mais forte para a AFM do que para a AFV. Esta divergência, reforçada pelo comportamento estatístico distinto das duas intensidades, sugere que, embora os pais se mantenham centrais na promoção do movimento diário, outros fatores, como os sociais e ambientais mais alargados, podem ser determinantes para facilitar o envolvimento em atividades vigorosas. Intervenções e políticas que reconheçam estas distinções terão maior probabilidade de produzir melhorias abrangentes nos perfis de atividade física das crianças.

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Conclusão

By weaving together meta-analytic and cross-sectional intensity-specific evidence, this dissertation makes an integrated contribution to understanding how parental MVPA relates

to child MVPA and why intensity matters. It shows that parental influence is developmentally timed and intensity-sensitive; thus, interventions and policies must be calibrated accordingly. Future work should build on this integration via longitudinal, experimental, and contextually diverse designs to translate these insights into effective, equitable increases across the full spectrum of children's physical activity.

Anexos

Artigo Um

Specialist Unit for Review Evidence (SURE)

Questions to assist with the critical appraisal of a systematic review[1]

Citation: **Ferreira, F., Carraça, E. V., Mascarenhas, M., & Palmeira, A. L. (2025).** Systematic Review and Meta-Analysis of Parent–Child MVPA Correlations Across Childhood Developmental Stages and Sex-Specific Dyads

Questions ** relate to whether the methodology used is described – eg independently in duplicate

1. Does the review address a clearly focused question/hypothesis	Yes/ Can't tell/ No	Justification
Population/Problem?	Yes	The study clearly defines the research question: the association between parental MVPA and child MVPA, including age and gender as moderators.
Intervention?	No	
Comparator/control?	Yes	
Outcomes? Can you identify the primary outcome?	Yes	
2. Did the authors look for the appropriate types of paper? Did the studies address the review's question and have an appropriate design?	Yes	The inclusion criteria require studies that directly measure parental and child MVPA using validated methods (accelerometry or questionnaires).
3. Is the search likely to have identified all the relevant evidence?	Yes	A comprehensive search strategy was applied across multiple databases (Web of Science and PubMed), supplemented by reference list screening. Search terms and filters are well-documented in the Methods section.
Sufficient range of databases searched? Date range appropriate?	Yes	
Good range of search terms (indexed terms and keywords)	Yes	
Reference list/bibliography checking?	Yes	
Hand search (journals)	No	
Grey literature searched (unpublished work) Websites?	No	
Contacting experts/manufacturers?	No	
Search terms/ strategy provided? Were they comprehensive?	Yes	

Search results provided (no of hits and final studies)? Flow diagram?	Yes	
All languages included?	No	
4. Are all relevant studies likely to have been included?	Yes	Inclusion and exclusion criteria are clearly stated. Study selection was conducted by two independent reviewers with disagreements resolved through consensus.
Are the inclusion and exclusion criteria stated?	Yes	
Is the study selection process described? **	Yes	
Multiple papers relating to same study identified?	Yes	
Is the data extraction process described? **	Yes	
5. Did the authors assess the quality (rigour) of the included studies?	Yes	The study used the **NHLBI tool** to assess study quality, with studies rated as "Poor" being excluded. Multiple reviewers cross-verified ratings.
Is the assessment process described? **	Yes	
6. Information about included studies Is key information provided (eg study design, population, interventions, comparators, outcomes, areas of potential bias)?	Yes	The extracted variables include study design, sample size, parental and child demographics, MVPA measurement methods, and effect sizes (documented in tables and figures).
7. If the results of the review have been combined (meta-analysis), was this appropriate?	Yes	Effect sizes were pooled using **inverse-variance weighting (IVW).** Heterogeneity was assessed using **I² and Cochran's Q-test**, with FEM or REM applied based on heterogeneity levels.
Were the studies sufficiently similar in design and results?	Yes	
Are the reasons for any variations discussed?	Yes	
8. Are results provided for all included studies?	Yes	The study presents **effect sizes for all included studies**, with subgroup analyses (child age, parent gender, child gender). Forest plots and statistical tables are included.
Do the conclusions reflect all results?	Yes	
Is the quality assessment of individual studies reflected in the results?	Yes	
9. Were all the important outcomes considered?	Yes	The study examines overall correlation, subgroup differences by age and gender, and heterogeneity. A funnel plot and Egger's test were used to assess publication bias.
10. Is any sponsorship/conflict of interest reported?	Yes	The Funding Statement and Disclosure Statement confirm no conflicts of interest or external funding biases.
11. Finally…consider: Did the authors identify any limitations? Date of review – is it likely to be out of date?	Yes	The study discusses limitations, including **measurement variability (self-report vs. accelerometry), heterogeneity**
	No	

Are the conclusions the same in the abstract and the full text?	Yes	**across studies, and lack of causal inference due to cross-sectional designs.**
Summary The meta-analysis on the association between parental and child MVPA demonstrates strong methodological rigor, adhering to systematic review best practices with a well-defined research question, comprehensive search strategy, and robust quality assessment using the NHLBI tool. The study effectively applies meta-analytic techniques, including inverse-variance weighting and heterogeneity assessment, ensuring reliable and generalizable findings. Potential limitations include measurement variability (self-reported vs. accelerometry data), moderate heterogeneity in some subgroups, and the inability to infer causality due to the predominance of cross-sectional studies. Despite these limitations, the results provide valuable insights into how parental MVPA influences child MVPA across age and gender subgroups, supporting the study's relevance for informing family-based physical activity interventions.		

This checklist should be cited as:

Specialist Unit for Review Evidence (SURE) 2018. *Questions to assist with the critical appraisal of systematic reviews* available at: http://www.cardiff.ac.uk/specialist-unit-for-review-evidence/resources/critical-appraisal- checklists

[1] Adapted and updated from the former Health Evidence Bulletins Wales (HEBW) checklist with reference to the NICE Public Health Methods Manual (2012) and previous versions of the Critical Appraisal Skills Programme (CASP) checklists.

Table 0.1. NHLBI tool

Author	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.	11.	12.?	13.	14.	Score
Sijtsma et al. (2015)	Yes	Yes	Yes	Yes	No	Yes	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Tanaka et al. (2018)	Yes	Yes	No	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Fair
Tate et al. (2015)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Wang et al. (2017)	Yes	Yes	No	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Fair
Oliver et al. (2011)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Barnes et al. (2015)	Yes	Yes	Yes	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Fuemmeler et al. (2011)	Yes	Yes	Yes	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Strutz et al. (2018)	Yes	Yes	CD	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Fair
Xu et al. (2018)	Yes	Yes	Yes	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Aljuhani et al. (2022)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Bringolf-Isler et al. (2018)	Yes	Yes	Yes	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Petersen et al. (2020)	Yes	Yes	Yes	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Fraysse et al. (2019)	Yes	Yes	Yes	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Tu et al. (2015)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Zovko et al. (2021)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Carson et al. (2020)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Jago et al. (2010)	Yes	Yes	No	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Fair
Hnatiuk et al. (2016)	Yes	Yes	Yes	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Kuzik et al. (2021)	Yes	Yes	No	Yes	Yes	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Fair
Jago et al. (2014)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good

Garriguet et al., 2017	Yes	Yes	Yes	Yes	No	Yes	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Dempsey et al. (1993)	Yes	Yes	Yes	No	No	No	CD	No	Yes	No	Yes	No	NA	Yes	Fair
McMurray et al. (2016)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Yang et al. (2022)	Yes	Yes	Yes	Yes	No	No	CD	Yes	Yes	Yes	Yes	No	NA	Yes	Good
Haegele et al. (2020)	Yes	Yes	Yes	No	No	No	CD	Yes	Yes	Yes	Yes	No	NA	Yes	Fair
French et al. (2021)	Yes	Yes	Yes	Yes	No	Yes	CD	Yes	Yes	No	Yes	No	NA	Yes	Good
Wirthlin et al. (2020)	Yes	Yes	Yes	Yes	No	No	CD	No	Yes	Yes	Yes	No	NA	Yes	Good

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Table 0.2. Child sex Partial out Pearson correlation matrix depicting associations between parent and child MPA and VPA metrics.

	Parent MPA (minutes)	Parent MPA (%)	Parent VPA (minutes)[a]	Parent VPA (%)[a]
Child MPA (minutes)	**.302** [.166, .429] < .001	**.262** [.133, .392] < .001	**.156** [.012, .296] .043	.151 [.011, .288] .051
Child MPA (%)	**.282** [.152, .408] < .001	**.345** [.218, .459] < .001	.033 [–.112, .181] .67	.047 [–.095, .194] .546
Child VPA (minutes)	.107 [–.049, .248] .169	.033 [–.124, .176] .673	**.244** [.099, .381] .001	**.233** [.09, .373] .002
Child VPA (%)	.101 [–.051, .235] .194	.081 [–.064, .221] .294	**.198** [.056, .336] .001	**.197** [.056, .334] .01

Table 0.3. Parent question 5 partial out Child sex Partial out Pearson correlation matrix depicting associations between parent and child MPA and VPA metrics.

	Parent MPA (minutes)	Parent MPA (%)	Parent VPA (minutes)[a]	Parent VPA (%)[a]
Child MPA (minutes)	**.303** [.163, .428] < .001	**.260** [.128, .393] < .001	**.154** [.004, .303] .049	.149 [–.002, .297] .057
Child MPA (%)	**.284** [.165, .412] < .001	**.335** [.215, .462] < .001	.064 [–.094, .210] .415	.077 [–.079, .223] .328
Child VPA (minutes)	.134 [–.008, .253] .088	.069 [–.074, .197] .379	**.228** [.085, .358] .003	**.220** [.078, .350] .005
Child VPA (%)	.129 [–.006, .245] .099	.117 [–.017, .238] .137	**.194** [.049, .328] .013	**.195** [.051, .330] .012

Table 0.4. Parent question 9 partial out Child sex Partial out Pearson correlation matrix depicting associations between parent and child MPA and VPA metrics.

	Parent MPA (minutes)	Parent MPA (%)	Parent VPA (minutes)[a]	Parent VPA (%)[a]
Child MPA (minutes)	**.305** [.173, .434] < .001	**.264** [.134, .394] < .001	.140 [–.013, .292] .073	.136 [–.018, .290] .082
Child MPA (%)	**.290** [.169, .411] < .001	**.345** [.226, .462] < .001	.035 [–.109, .192] .655	.047 [–.100, .200] .546
Child VPA (minutes)	.134 [–.019, .263] .097	.056 [–.094, .188] .477	**.248** [.100, .378] .001	**.239** [.094, .372] .002
Child VPA (%)	.130 [–.008, .257] .097	.109 [–.034, .238] .167	**.210** [.065, .344] .007	**.209** [.063, .341] .007

Table 0.5. Child Sex Partial out Spearman correlations between child-reported social support (parental, peer, teacher) and children's MPA and VPA outcomes.

	Peer Support	(Parent) Take you to exercise	(Parent) Watch you take part in exercise	(Parent) Exercise or play sports with you	(Parent) Tell you to exercise	(Parent) Tell you that exercise is good for your health	(Teacher) Talk about exercise in lessons	(Teacher) Organize or play games apart from PE	(Teacher) Tell you to exercise or play sports
Child MPA (minutes)	.033 [–.132, .185] .672	.073 [–.091, .222] .342	.005 [–.145, .149] .953	**.167** [.024, .311] .030	.028 [–.113, .163] .717	.112 [–.038, .249] .144	–.026 [–.168, .117] .736	–.112 [–.251, .045] .148	–.028 [–.167, .125] .720
Child MPA (%)	.039 [–.119, .179] .614	–.012 [–.173, .149] .881	–.101 [–.252, .048] .188	**.188** [.042, .331] .014	–.019 [–.160, .129] .809	.022 [–.120, .156] .779	–.068 [–.215, .067] .382	–.010 [–.159, .148] .897	–.025 [–.170, .124] .745
Child VPA (minutes)	.014 [–.137, .161] .857	–.008 [–.166, .156] .922	.007 [–.156, .166] .925	.140 [–.007, .295] .068	–.004 [–.149, .138] .956	.051 [–.093, .196] .509	.056 [–.089, .211] .465	–.068 [–.223, .093] .379	.016 [–.135, .182] .835
Child VPA (%)	.001 [–.147, .146] .993	–.064 [–.223, .098] .406	–.044 [–.196, .113] .569	**.157** [.016, .298] .041	–.017 [–.162, .129] .824	–.002 [–.150, .144] .981	.042 [–.107, .197] .583	–.016 [–.170, .138] .834	.020 [–.127, .186] .792

Table 0.6. Parent question 4 Partial out Spearman correlations between child-reported social support (parental, peer, teacher) and children's MPA and VPA outcomes.

	Peer Support	(Parent) Take you to exercise	(Parent) Watch you take part in exercise	(Parent) Exercise or play sports with you	(Parent) Tell you to exercise	(Parent) Tell you that exercise is good for your health	(Teacher) Talk about exercise in lessons	(Teacher) Organize or play games apart from PE	(Teacher) Tell you to exercise or play sports
Child MPA (minutes)	.036 [–.120, .190] .647	.079 [–.073, .233] .310	–.012 [–.152, .139] .876	.126 [–.019, .268] .107	.022 [–.128, .163] .775	.065 [–.077, .211] .409	–.052 [–.197, .101] .506	–.132 [–.274, .013] .091	–.014 [–.168, .128] .857
Child MPA (%)	.042 [–.110, .184] .593	.009 [–.138, .160] .910	–.106 [–.256, .059] .175	.150 [.001, .289] .053	–.026 [–.180, .124] .742	–.010 [–.159, .138] .903	–.094 [–.234, .048] .228	–.037 [–.190, .112] .637	–.014 [–.154, .137] .860
Child VPA (minutes)	.020 [–.140, .165] .798	.017 [–.131, .166] .827	–.021 [–.175, .135] .784	.101 [–.055, .264] .194	–.018 [–.164, .132] .816	.032 [–.119, .187] .687	.040 [–.118, .190] .611	–.087 [–.233, .061] .264	.008 [–.149, .160] .916
Child VPA (%)	.010 [–.143, .160] .901	–.032 [–.176, .114] .680	–.072 [–.224, .100] .355	.121 [–.034, .274] .120	–.031 [–.179, .119] .688	–.016 [–.164, .138] .839	.022 [–.128, .172] .775	–.039 [–.189, .104] .615	.016 [–.139, .179] .842

Table 0.7. Parent question 9 Partial out Spearman correlations between child-reported social support (parental, peer, teacher) and children's MPA and VPA outcomes.

	Peer Support	(Parent) Take you to exercise	(Parent) Watch you take part in exercise	(Parent) Exercise or play sports with you	(Parent) Tell you to exercise	(Parent) Tell you that exercise is good for your health	(Teacher) Talk about exercise in lessons	(Teacher) Organize or play games apart from PE	(Teacher) Tell you to exercise or play sports
Child MPA (minutes)	.044 [–.116, .198] .570	.095 [–.071, .246] .226	–.006 [–.155, .155] .935	.120 [–.038, .268] .123	.024 [–.130, .180] .756	.069 [–.074, .217] .376	–.064 [–.200, .086] .412	–.137 [–.286, .017] .079	–.009 [–.160, .142] .904
Child MPA (%)	.048 [–.104, .194] .539	.013 [–.143, .167] .866	–.095 [–.261, .065] .225	.150 [–.004, .295] .054	–.019 [–.172, .150] .811	.009 [–.132, .152] .910	–.08 3 [–.222, .069] .290	–.025 [–.167, .121] .749	–.025 [–.167, .130] .750
Child VPA (minutes)	.027 [–.139, .171] .726	.029 [–.137, .176] .712	–.014 [–.185, .156] .858	.098 [–.058, .252] .211	–.015 [–.170, .132] .851	.040 [–.109, .196] .607	.034 [–.117, .183] .661	–.087 [–.237, .063] .267	.008 [–.139, .168] .921
Child VPA (%)	.016 [–.143, .172] .833	–.026 [–.187, .122] .736	–.060 [–.222, .109] .444	.120 [–.042, .271] .123	–.024 [–.185, .122] .760	.003 [–.141, .155] .965	.032 [–.121, .178] .678	–.027 [–.182, .121] .728	.004 [–.147, .163] .955

Table 0.8. STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No.	Recommendation	Page No.	Relevant text from manuscript
Title and abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract	1	"Intensity-Specific Associations Between Support and Accelerometer-Derived Physical Activity in 9–12-Year-Olds: A Cross-Sectional European Study"
		(b) Provide in the abstract an informative and balanced summary of what was done and what was found	1	
		Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	1-2	

Objectives	3	State specific objectives, including any prespecified hypotheses	2	"We will examine correlations between each support source and objectively measured MVPA separately and in aggregate. We hypothesize that parental modelling will show the strongest associations with children's MPA, that peer support may relate more to VPA, and that teacher support alone will make a minimal contribution to total daily movement."
Methods				
Study design	4	Present key elements of study design early in the paper	3	"This cross-sectional study was conducted in primary schools across three European countries… between September 2023 and October 2024."
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3	"…conducted in primary schools across three European countries (Ireland, Belgium and the Czechia) between September 2023 and October 2024."
Participants	6	(a) Cross-sectional study—Give the eligibility criteria, and the sources and methods of selection of participants	3	"Children aged 9.0–11.9 years… without diagnosed conditions… recruitment was school-based… families returned signed consent forms."
		(b) Cohort study—For matched studies, give matching criteria and number of exposed and unexposed	NA	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	3–4	"Activity counts were reintegrated to 60-s epochs and classified using Evenson et al.'s (2008) cut-points (moderate ≥ 2296 cpm; vigorous ≥ 4012 cpm), and support subscale scores were computed as the mean of their respective items (1–4 scale)."

Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	3-4	Accelerometer Protocol- Support assessment Protocol
Bias	9	Describe any efforts to address potential sources of bias	4	"Missing questionnaires were recovered by phone… outlier dyads (μ±2σ) removed
Study size	10	Explain how the study size was arrived at	4	"A power analysis was conducted using G*Power version 3.1.9.7 (Faul et al., 2007) for a two-tailed Spearman rank-order correlation with α = .05 and 1–β = .80. It indicated that a sample of N = 150 parent–child dyads would be sufficient to detect a minimum correlation of r = .23."
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	4	"Questionnaire responses for parental, peer, and teacher support were coded on an ordinal scale (1 = 'Hardly ever or never' to 4 = 'Every day'), and subscale scores were computed as the mean of their respective items."
Statistical methods	12	(a) Describe all statistical methods, including those used to control for confounding	5	"To identify potential confounders, bidirectional associations between each support variable, PA outcome and candidate covariates were examined… only variables showing p < .05 associations with both an independent and a dependent variable were retained for adjustment. Regression models were then estimated with and without these covariates to assess their impact on effect estimates."
		(b) Describe any methods used to examine subgroups and interactions	5	"To identify potential confounders, bidirectional associations between each support variable, PA outcome (MVPA

				minutes/day, % of total) and a set of candidate covariates (e.g., Parent and child age, Parent and child sex, socioeconomic status, country of origin) were examined."
		(c) Explain how missing data were addressed	4	"Missing or incomplete questionnaires were first addressed on site by researcher assistance; any forms still unfinished or unreturned prompted a follow-up phone call. Instruments that remained incomplete after these recovery steps were excluded from analysis."
		(d) Cross-sectional study—If applicable, describe analytical methods taking account of sampling strategy	NA	Convenience, school-based sample
		(e) Describe any sensitivity analyses	NA	No sensitivity analyses were performed beyond outlier exclusion
Results				
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	5	"There was originally 172 dyads resulting in a final sample size of 135 after removing dyads that did not meet SOP criteria (Annex) or were outliers."
		(b) Give reasons for non-participation at each stage	5	"Dyads removed because they did not meet SOP criteria (e.g., insufficient wear time) or were outliers (values outside $\mu \pm 2\sigma$)."
		(c) Consider use of a flow diagram	5	Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	5-6	"Sample characteristics and accelerometry outcomes for the 135 child–parent dyads included in the final analysis are presented in Table 1."

		(b) Indicate number of participants with missing data for each variable of interest	5	Figure 1
Outcome data	15*	Cross-sectional study—Report numbers of outcome events or summary measures	6	"Outcome measures for MVPA and intensity-specific PA are reported in Tables 2 and 3."
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	6-7	"Partialling out whether the child had their own bedroom did not materially alter any of the observed associations."
		(b) Report category boundaries when continuous variables were categorized	NA	Continuous variables were analyzed without categorization.
		(c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA	This correlation study did not produce risk estimates.
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	6	"Reliability analyses of the three support subscales revealed variable internal consistency (McDonald's ω = .70 for peer support; ω = .53 for parental support; ω = .36 for teacher support)."
Discussion				
Key results	18	Summarise key results with reference to study objectives	8	Discussion
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or	8-9	Limitations

		imprecision. Discuss both direction and magnitude of any potential bias		
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	8	Discussion
Generalisability	21	Discuss the generalisability (external validity) of the study results	8-9	Limitations
Other information				
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	9	"Data collection was funded by the European union, COST Action CA19101 DE-PASS project. "

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org

Table 15. Children Social Support Questionnaire

Question	Hardly ever or never	Once in a while	Often	Every Day
During a normal week how often does your parent or caregiver...				
10.1. Take you to exercise or play sports	☐1	☐2	☐3	☐4
10.2. Watch you take part in exercise or sports	☐1	☐2	☐3	☐4
10.3. Exercise or play sports with you	☐1	☐2	☐3	☐4
10.4. Tell you to exercise or play sports	☐1	☐2	☐3	☐4
10.5. Tell you that exercise is good for your health	☐1	☐2	☐3	☐4
During a normal week how often….	**Hardly ever or never**	**Once in a while**	**Often**	**Every Day**
10.6. Do your friends exercise or play sports with you?	☐1	☐2	☐3	☐4
10.7. Do you ask your friends to play out with you?	☐1	☐2	☐3	☐4
10.8. Do your friends ask you to play out with them?	☐1	☐2	☐3	☐4
During a normal week how often does your teacher…	**Hardly ever or never**	**Once in a while**	**Often**	**Every Day**
10.9. Talk about exercise in lessons	☐1	☐2	☐3	☐4
10.10. Organise or play games with you apart from Physical Education	☐1	☐2	☐3	☐4
10.11. Tell you to exercise or play sports	☐1	☐2	☐3	☐4