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· 健康教育与健康促进 ·

身体活动改善儿童青少年健康相关生活质量 Meta 分析

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【摘要】 目的 系统评价身体活动(PA)对儿童青少年健康相关生活质量(HRQoL)的影响及其关联程度,为优化儿童青少年健康促进策略提供循证依据。**方法** 检索 Medline(PubMed)、EMBASE、the Cochrane Library、SCIELO、PEDro、中国知网、万方和维普数据库,收集建库至 2025 年 1 月 1 日关于儿童青少年 PA 与 HRQoL 的文献。根据 Cochrane ROB 工具及特定评价体系评估文献质量,Stata 16.0 软件用于 Meta 分析。描述性研究采用相关值(r)及 95%置信区间(CI)为效应指标,借助倒方差法进行合并,标准化均数差(SMD)和 95%CI 计算干预性研究的合并效应量。**结果** 共纳入 22 篇文献(27 303 名健康儿童青少年),包括 9 篇描述性研究和 13 篇干预性研究。描述性研究分析结果显示,PA 水平与 HRQoL 呈正相关(r=0.27,95%CI=0.21~0.32,P<0.01)。干预性研究分析表明,PA 对总体 HRQoL(SMD=0.10,95%CI=0.05~0.16)、生理功能(SMD=0.16,95%CI=0.08~0.23)和心理功能(SMD=0.17,95%CI=0.10~0.25)均有改善效果(P 值均<0.01)。亚组分析发现,身体活动对儿童青少年总体 HRQoL、生理功能和心理功能方面的影响,在干预时长<6 个月(SMD 值分别为 0.13,0.18,0.20)、频率≥5 次/周(SMD 值分别为 0.13,0.19,0.24)、有补充方案(SMD 值分别为 0.10,0.18,0.23)时达到改善效益最大化(P 值均<0.01)。**结论** PA 是影响健康儿童青少年 HRQoL 的重要因素,系统化的 PA 干预对提升 HRQoL 具有促进作用。

【关键词】 运动活动;生活质量;健康促进;Meta 分析;儿童;青少年

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Meta-analysis of physical activity on the improvement of health-related quality of life among children and adolescents/*LIU Shanjie**, *LI Gai*, *SONG Yunfeng*, *OUYANG Lingqing*, *XU Chi*. * *Key Laboratory of Selection and Functional Assessment of Athletes, General Administration of Sport(Hubei Institute of Sports Science), Wuhan*(430205), *Hubei Province, China*

【Abstract】 Objective To systematically review the effect of physical activity (PA) on health-related quality of life (HRQoL) among children and adolescents and the magnitude of association, so as to provide an evidence-based support for optimizing health promotion strategies for children and adolescents. **Methods** Medline (PubMed), EMBASE, the Cochrane Library, SCIELO, PEDro, CNKI, Wanfang and VIP databases were searched to collect literature on PA and HRQoL in children and adolescents, which were published up to January 1, 2025. Cochrane ROB tool and specific evaluation system were used to assess literature quality, Stata 16.0 software was used for Meta-analysis. For descriptive studies, correlation(r) and 95% confidence interval(CI) were used as effect indicators, and the inverse variance method was used to merge the data. Standardized mean difference(SMD) and 95%CI were used to calculate the combined effect size of intervention studies. **Results** A total of 22 studies involving 27 303 healthy children and adolescents were included, including 9 descriptive studies and 13 intervention studies. The results of descriptive analysis showed that PA level was positively correlated with HRQoL (r=0.27, 95%CI=0.21-0.32, P<0.01). The analysis of intervention studies showed that PA had significant effects on overall HRQoL (SMD=0.10, 95%CI=0.05-0.16), physical functioning (SMD=0.16, 95%CI=0.08-0.23), and mental functioning (SMD=0.17, 95%CI=0.10-0.25) (P<0.01). Subgroup analysis found that the effects of physical activity on overall HRQoL, physiological function, and psychological function in children and adolescents were maximized when the intervention duration was less than 6 months (SMD=0.13, 0.18, 0.20), the frequency was≥5 times per week (SMD=0.13, 0.19, 0.24) and there was a supplementary plan(SMD=0.10, 0.18, 0.23) (P<0.01). **Conclusion** PA is an important factor affecting the HRQoL of healthy children and adolescents, and the systematic PA intervention has a effect on improving the HRQoL.

【Keywords】 Motor activity; Quality of life; Health promotion; Meta-analysis; Child; Adolescent

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健康相关生活质量(health-related quality of life, HRQoL)聚焦于生理健康、心理状态及社会功能对个体生活质量的影响,是疾病发生风险和健康预后的重要预测指标[1]。低 HRQoL 与肥胖、龋齿及神经发育障碍等疾病的发病率升高相关[2],且全球儿童青少年的 HRQoL 水平呈下降趋势[3]。HRQoL 的维持与提升对健康维护及公共卫生体系发展具有重要战略意义[1,4]。

身体活动(physical activity, PA)作为可干预的保护性因素,通过生物-心理-社会综合机制对 HRQoL 的改善作用备受关注[5]。尽管已有研究证实 PA 与 HRQoL 的关联性,但现有证据存在一定局限,部分研究混合了临床与健康群体,可能影响结果的普适性[6];其次,多数结论源于观察性研究[7],难以建立因果关联;最后,虽然 PA 干预被证实可提升自尊[8]、幸福感[5]等,但直接针对 HRQoL 及核心维度的干预效应仍缺乏系统评价。本文旨在系统回顾截至 2025 年 1 月 1 日的有关研究,为优化儿童青少年健康促进策略提供循证依据。

1　资料来源与方法

严格按照《系统综述和荟萃分析优先报告的条目》(Preferred Reporting Items for Systematic Reviews and Meta Analysis, PRISMA)[9]声明和 Cochrane 手册[10]进行,方案在国际前瞻性系统评价注册库(International Prospective Register of Systematic Reviews, PROSPERO)注册(CRD42025641293)。

1.1　检索策略　检索 Medline(PubMed)、EMBASE、the Cochrane Library、SCIELO、PEDro、中国知网、万方和维普数据库中关于儿童青少年 PA 与 HRQoL 的文章。检索时间为建库至 2025 年 1 月 1 日。中文主题词为("身体活动"OR"运动"OR"锻炼"OR"体育")AND("健康相关生活质量"OR"HRQoL"OR"生活质量"OR"幸福")AND("儿童"OR"青少年"OR"幼儿"OR"学生"OR"学童");英文主题词为("physical activity" OR "exercise" OR "sport" OR "physical education" OR "well-being") AND("health-related quality of life" OR "HRQoL" OR "quality of life") AND("child" OR "adolescent" OR "youth" OR "pediatric" OR "school children")。

1.2　纳入与排除标准　纳入标准:(1)研究对象为无任何临床诊断的儿童(1~<12 岁)和青少年(12~18 岁),性别与种族不限;(2)有计划、有组织、结构化地参加 PA 干预;(3)以连续单位[如分钟、步数、代谢当量(metabolic equivalent, MET)等]测量 PA,或结果变量为 HRQoL 的运动干预研究[随机对照试验(randomized controlled trial, RCT)或准实验设计]。

排除标准:(1)以达到或未达到身体活动建议来衡量 PA 水平的研究;(2)定性描述,缺乏数据支撑的会议摘要及综述类研究;(3)非中文、非英文及重复刊发的文献资料。

1.3　筛选与资料提取　2 名研究人员独立筛选、获取、交叉核对文献信息,如有分歧则征求第 3 名研究者的意见。每项研究提取的资料包括作者、发表年份、样本量、参与者人口统计学特征、研究设计、研究持续时间、PA 和 HRQoL 的测量方法和水平。纳入的文献借助 EndNote 20 软件进行管理。

1.4　文献质量评价　采用双人独立评价模式进行方法学质量评估。针对描述性研究,依据 Lundahl 等[11]构建的 13 条目评价体系(0~18 分量表)实施质量分级,量表总分与研究质量呈正相关;干预性研究运用 Cochrane ROB 工具进行评价,根据符合标准的程度将研究划分为低、中、高 3 个偏倚风险等级。若有分歧则征求第 3 名研究者或相关领域专家的意见。

1.5　统计学分析　采用 Stata 16.0 软件量化 PA 改善 HRQoL 的效果。计数资料用频数或百分率描述。描述性研究采用相关值(r)及 95%置信区间(CI)作为效应量(effect size, ES)指标,ES 反映变量之间的关联强度,借助 Fisher's z-r 转换与倒方差法进行合并;RCT 结局指标均为连续性变量,且测量方法不完全一致,故采用标准化均数差(standardized mean difference, SMD)和 95%CI 计算合并效应量。根据 χ^2 检验和 I^2 统计量评估研究间的异质性,$I^2 \geq 50\%$、$P<0.1$ 说明异质性较高,采用随机效应模型,且需进行敏感性分析,并将可能影响效应量的调节变量进行亚组分析。若异质性较低($I^2<50\%$, $P>0.1$),则采用固定效应模型合并效应量。最后检验纳入文献的发表偏倚。

2　结果

2.1　文献检索结果　经系统检索及筛选,最终从 4 208篇文献纳入 22 篇文献,包括 9 篇描述性研究和 13 篇干预性研究。

2.2　纳入研究的文献基本信息和质量评价　9 篇描述性研究[12-20]中,横断面研究 6 项[12-13,15-16,18-19](66.67%),相关研究 1 项[14],另有 2 项[17,20]采用非随机试验的对照组数据。研究对象为跨地域的 17 884 名健康儿童青少年(男生占比 50.33%,9 001 名),年龄范围 3.90~15.04 岁。PA 的客观测量以运动传感器包括 ActiGraph GT3X+[15]、ActiGraph MTI/CSA 7164[17]等三轴加速度计以及 ACCUSPLIT[14]、Yamax Digiwalker SW-351[19]等计步器为主;主观量表涵盖青少年体育活动问卷(Physical Activity Questionnaire for Adolescents, PAQ-A)[13]、7 d 身体活动回顾问卷(7-day Physical Activity Recall, PAR 7-day Recall)[20]等。

HRQoL 通过儿童生活质量量表(Pediatric Quality of Life Inventory, PedsQL)[12] 及其 4.0 版本(PedsQL 4.0)[14,16-17,19-20]、儿童健康多维测评系统(KIDSCREEN-10, KIDSCREEN-27)[15] 及欧洲五维健康量表(European Quality of Life 5 Dimension, EQ-5D)[12] 等标准化工具进行评估。根据文献评价标准,9 项描述性研究的平均分为(9.44±1.89),提示文献质量较好。

13 项干预性研究(12 项 RCT[2,21-31]、1 项准实验研究[32])共 9 419 名 2.5~12.03 岁儿童青少年(干预组 4 961 名)参与了 PA 对 HRQoL 影响的研究,其中 1 项研究为单一女性样本[22]。HRQoL 评估采用多元化工具:PedsQL[32] 及其 4.0 版本[22,28-29,31]、KIDSCREEN-27[21,23-24,26,30]、九维儿童健康效用指数(Child Health Utility 9 Dimension, CHU9D)[2]、儿童健康问卷(Child Health Questionnaire, CHQ)[25,27]。PA 主要采用加速度计进行量化评估[21,24,26-28],2 项研究辅以家长报告法[29,31]、1 项研究以自我报告量表[22] 测量。干预方案设计呈以下特征:(1)干预周期为 2~12 个月;(2)实施频率为每周 1~5 次;(3)核心策略包括①常规课程体系内增设结构化体育活动;②系统性运动技能指导与训练;③户外运动促进计划。补充性干预措施涉及健康、营养等教育课程,家长协同干预机制及健康生活方式宣教等复合策略[21-24,28-29,32]。然而,所有研究均未报告 PA 的强度信息,2 项对干预频率的报告不全面[24,30]。对照组均正常参加学校常规体育活动。根据 Cochrane ROB 偏倚风险评价结果,13 项干预性研究的质量评价较高。

2.3　描述性研究 Meta 分析　研究间[12-20] 的异质性较高(I^2=89.3%, P<0.1),故采用随机效应模型进行 *ES* 指标合并。如图 1 所示,健康儿童青少年的 PA 水平与 HRQoL 呈正向关联。经 Fisher's z-r 转换,相关系数合并效应值 r(95%*CI*)= 0.27(0.21~0.32), P<0.01。

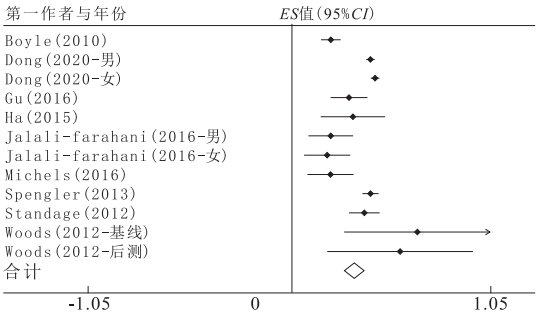


图 1　儿童青少年 PA 与 HRQoL 关系

Figure 1　Relationship between PA and HRQoL among children and adolescents

以样本类型(儿童、青少年)为特征进行亚组分析。结果显示,儿童组 I^2=59.3%, P<0.05, r(95%*CI*)=0.27(0.12~0.42);青少年组的 I^2=94.2%, P<0.01, r(95%*CI*)=0.26(0.20~0.34), P<0.01。

2.4　干预性研究 Meta 分析

2.4.1　总体 HRQoL　13 项研究[2,21-24,28-29,31-32] 探讨了 PA 对儿童青少年 HRQoL 的影响。如图 2 所示,PA 改善总体 HRQoL 的效果有统计学意义(*SMD*=0.10, 95%*CI*=0.05~0.16, P<0.01)。异质性检验结果显示,各独立研究间的异质性可以忽略不计(I^2=34.8%, P>0.1)。

以样本年龄[学龄前儿童(3~6 岁)、学龄儿童和青少年)、PA 干预时长(<6 个月, ≥6 个月)、PA 干预频率(<5 次/周, ≥5 次/周)和补充干预(有、无)为特征进行亚组分析。结果表明,所有亚组的异质性均可忽略不计(I^2 值均<50%)。干预时长<6 个月(*SMD*=0.13, 95%*CI*=0.06~0.21);干预频率≥5 次/周(*SMD*=0.13, 95%*CI*=0.06~0.20);有(*SMD*=0.10, 95%*CI*=0.03~0.17)、无补充方案(*SMD*=0.13, 95%*CI*=0.01~0.27)与学龄儿童和青少年(*SMD*=0.10, 95%*CI*=0.03~0.16)亚组的 *SMD* 相对更高(P 值均<0.01),干预效果更好。

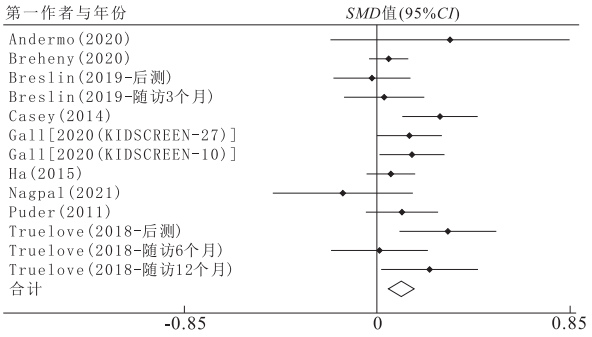


图 2　PA 对儿童青少年总体 HRQoL 影响

Figure 2　Effect of PA on overall HRQoL of children and adolescents

2.4.2　HRQoL-生理功能　14 项研究[21-28,30-32] 探讨了 PA 对儿童青少年 HRQoL-生理功能的影响。如图 3 所示,PA 对生理功能有改善效果(*SMD*=0.16, 95%*CI*=0.08~0.23, P<0.01)。异质性检验结果显示,各独立研究间的异质性较高(I^2=53.8%, P<0.1)。剔除 Resaland 等[30] 和 Breslin 等[21] 偏倚性较大的数据后,其余各独立研究间的异质性可以忽略不计(I^2=36.0%, P>0.1),且干预效果稳定(*SMD*=0.19, 95%*CI*=0.12~0.26, P<0.01)。

以样本年龄、PA 干预时长和频率及有无补充干预为特征进行亚组分析。结果表明,学龄前儿童(I^2=64.1%)、干预时长<6 个月(I^2=65.2%)、干预频率≥5 次/周(I^2=70.5%)和有补充干预(I^2=62.8%)亚组异质性较高(P 值均<0.01),其余亚组的异质性可以忽略不计(P 值均>0.1)。干预时长<6 个月(*SMD*=

0.18, 95% *CI* = 0.08 ~ 0.29)、频率≥5 次/周(*SMD* = 0.19, 95% *CI* = 0.04 ~ 0.34)、有补充方案(*SMD* = 0.18, 95% *CI* = 0.07 ~ 0.29)亚组的 *SMD* 相对更高(*P* 值均< 0.01),干预效果更好。

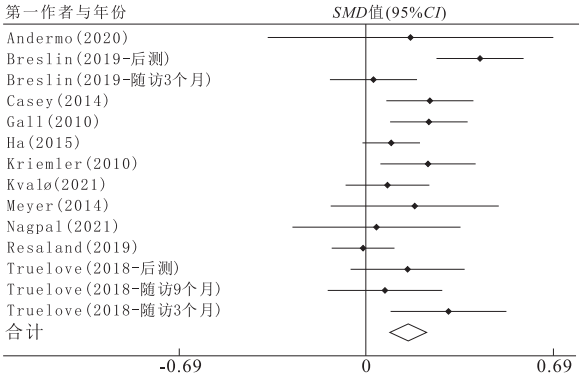


图 3　PA 对儿童青少年生理功能影响

Figure 3　Effect of PA on physiological functioning among children and adolescents

2.4.3　HRQoL-心理功能　14 项研究[21-28,30-32]探讨了 PA 对儿童青少年 HRQoL-心理功能的影响。如图 4 所示,PA 改善心理功能的效果有统计学意义(*SMD* = 0.17, 95% *CI* = 0.10 ~ 0.25, *P*<0.01)。异质性检验结果显示,各独立研究间的异质性较高(I^2 = 58.7%, *P*< 0.1),逐项剔除偏倚性较大的数据后,异质性仍较高。因此,以样本年龄、PA 干预时长和频率及有无补充干预为特征进行亚组分析。结果表明,学龄儿童和青少年(I^2 = 64.2%)、干预时长<6 个月(I^2 = 64.8%)、≥6 个月(I^2 = 54.1%)和有补充干预(I^2 = 62.4%)亚组异质性较高(*P* 值均<0.01),其余亚组的异质性可以忽略不计(I^2 值均< 50%)。学龄前儿童(*SMD* = 0.22, 95% *CI* = 0.07 ~ 0.36)、干预时长<6 个月(*SMD* = 0.20, 95% *CI* = 0.09 ~ 0.31)、干预频率≥5 次/周(*SMD* = 0.24, 95% *CI* = 0.12 ~ 0.35)、有补充方案(*SMD* = 0.23, 95% *CI* = 0.12 ~ 0.35)亚组的 *SMD* 相对更高(*P* 值均< 0.01),干预效果更好。

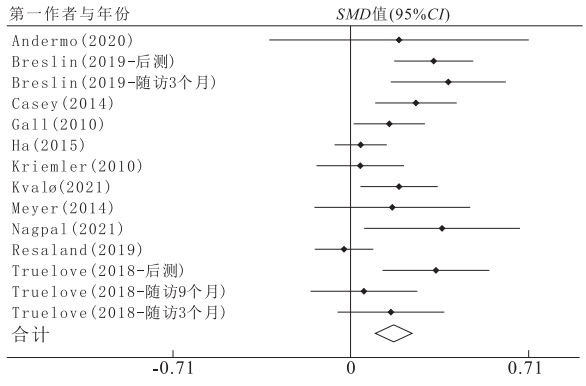


图 4　PA 对儿童青少年心理功能影响

Figure 4　Effect of PA on mental functioning of children and adolescents

2.5　纳入文献的发表偏倚　相关性分析、总体 HRQoL 及 HRQoL-生理功能的合并分析结果无明显发表偏倚。HRQoL-心理功能发表偏倚风险可能较高。

3　讨论

本研究发现,PA 与 HRQoL 存在正向关联,干预效果在总体 HRQoL、生理功能及心理功能维度均呈现小至中等效应量。进一步分析表明,优化干预效果的关键要素包括:控制干预周期在 6 个月以内,以保持参与者依从性;维持每周≥5 次的运动频率,符合世界卫生组织推荐标准;当干预方案整合健康生活方式宣教及家长指导监督时,在生理功能改善与心理健康指标维度会产生协同增效作用[33-34],故建议采用健康教育课程与家庭-学校协同干预模式相结合的综合方案。

本研究结果与 Marquez 等[6]在患病儿童青少年群体中的研究具有一致性,提示 PA 对 HRQoL 的促进作用可能具有跨人群普适性。然而,当前针对 PA 干预在改善 HRQoL 及其不同方面有效性的证据好坏参半[33],可能由于部分综述未考量被试习惯性 PA 时间的增加,而主要侧重于专门化教育干预或环境改变,或许导致了各研究结果微有不同。

基于神经生物学、社会心理与行为科学的整合视角,Lubans 等[35]构建了阐释 PA 促进 HRQoL 的多维机制模型。从神经生物学角度,规律性与习惯性的 PA 可诱导中枢神经系统发生结构性重塑与功能性调整[36]:其一,通过促进脑区血管新生提升神经元营养供给效率;其二,刺激内源性阿片肽系统释放 β-内啡肽,兼具镇痛效应与积极情绪激活功能;其三,调控多巴胺、5-羟色胺等单胺类神经递质的突触传递效能,从而完善心理功能。在社会心理作用路径上,群体性运动项目通过满足个体社会归属感与能力认同感等核心心理需求,改善身体意象感知并强化自主生活能力,促进身心健康。基于行为科学视角,睡眠质量的提高对个体情绪调节具有促进作用。研究表明,较高水平的 PA 与睡眠质量呈正相关,而良好的睡眠质量可通过神经可塑性机制维持并强化前额叶皮质控制网络与边缘系统关键脑区之间的功能连接[37],这种神经环路的优化能够有效降低负性情绪偏倚,增强情绪调控能力及适应性应对策略[38],从而在提升儿童青少年 HRQoL 方面产生积极效应。

本研究尚存在一定的局限性:首先,纳入的 RCT 普遍存在干预方案报告不完整现象[15,30],特别是 PA 强度阈值、过程评估指标等关键实施要素的描述缺失。其次,干预方案设计多样性、PA 评估工具标准化不足以及 HRQoL 测量工具的跨文化差异,都可能共同导致异质性增大。最后,尽管严格限定健康人群纳

入标准,但基线数据中未系统筛查亚临床状态、心理社会因素等潜在混杂变量,可能影响 PA 与 HRQoL 关系的准确评估。

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参考文献

[1] TAN S Y X, PADMAPRIYA N, BERNARD J Y, et al. Cross-sectional and prospective associations between children's 24-h time use and their health-related quality of life: a compositional isotemporal substitution approach[J]. Lancet Reg Health West Pac, 2023, 41: 100918.

[2] BREHENY K, PASSMORE S, ADAB P, et al. Effectiveness and cost-effectiveness of the daily mile on childhood weight outcomes and wellbeing: a cluster randomised controlled trial[J]. Int J Obes (Lond), 2020, 44(4): 812-822.

[3] BERMEJO-CANTARERO A, SANCHEZ-LOPEZ M, ALVAREZ-BUENO C, et al. Are physical activity interventions effective in improving health-related quality of life in children and adolescents? A systematic review and Meta-analysis[J]. Sports Health, 2024, 16(6): 877-885.

[4] LE N, BELAY Y B, LE L K, et al. Health-related quality of life in children, adolescents and young adults with self-harm or suicidality: a systematic review[J]. Aust N Z J Psychiatry, 2023, 57(7): 952-965.

[5] TEUBER M, LEYHR D, SUDECK G. Physical activity improves stress load, recovery, and academic performance-related parameters among university students: a longitudinal study on daily level[J]. BMC Public Health, 2024, 24(1): 598.

[6] MARQUEZ D X, AGUIAGA S, VÁSQUEZ P M, et al. A systematic review of physical activity and quality of life and well-being[J]. Transl Behav Med, 2020, 10(5): 1098-1109.

[7] WU X Y, HAN L H, ZHANG J H, et al. The influence of physical activity, sedentary behavior on health-related quality of life among the general population of children and adolescents: a systematic review[J]. PLoS One, 2017, 12(11): e0187668.

[8] TIKAC G, UNAL A, ALTUG F. Regular exercise improves the levels of self-efficacy, self-esteem and body awareness of young adults[J]. J Sports Med Phys Fitness, 2021, 62(1): 157-161.

[9] HUTTON B, SALANTI G, CALDWELL D M, et al. The PRISMA extension statement for reporting of systematic reviews incorporating network Meta-analyses of health care interventions: checklist and explanations[J]. Ann Intern Med, 2015, 162: 777-784.

[10] HIGGINS J, THOMAS J, CHANDLER J, et al. Cochrane Handbook for Systematic Reviews of Interventions Version 6.5[EB/OL]. (2024-08-22)[2025-01-01]. https://training.cochrane.org/handbook.

[11] LUNDAHL B W, KUNZ C, BROWNELL C, et al. A Meta-analysis of motivational interviewing: twenty-five years of empirical studies[J]. Res Soc Work Pract, 2010, 20(2): 137-160.

[12] BOYLE S E, JONES G L, WALTERS S J. Physical activity, quality of life, weight status and diet in adolescents[J]. Qual Life Res, 2010, 19: 943-954.

[13] DONG X, DING M, CHEN W, et al. Relationship between smoking, physical activity, screen time, and quality of life among adolescents[J]. Int J Environ Res Public Health, 2020, 17(21): 8043.

[14] GU X, SOLMON M A. Motivational processes in children's physical activity and health-related quality of life[J]. Phys Educ Sport Pedagogy, 2016, 21(4): 407-424.

[15] HA A S, NG J Y Y. Autonomous motivation predicts 7-day physical activity in Hong Kong students[J]. Appl Psychol Health Well Being, 2015, 7(2): 214-229.

[16] JALALI-FARAHANI S, AMIRI P, CHIN Y S. Are physical activity, sedentary behaviors and sleep duration associated with body mass index-for-age and health-related quality of life among high school boys and girls? [J]. Health Qual Life Outcomes, 2016, 14: 30.

[17] MICHELS N, SUSI K, MARQUES-VIDAL P M, et al. Psychosocial quality-of-life, lifestyle and adiposity: a longitudinal study in preschoolers (Ballabeina study)[J]. Int J Behav Med, 2016, 23: 383-392.

[18] SPENGLER S, WOLL A. The more physically active, the healthier? The relationship between physical activity and health-related quality of life in adolescents: the MoMo study[J]. J Phys Act Health, 2013, 10(5): 708-715.

[19] STANDAGE M, GILLISON F B, NTOUMANIS N, et al. Predicting students' physical activity and health-related well-being: a prospective cross-domain investigation of motivation across school physical education and exercise settings[J]. J Sport Exerc Psychol, 2012, 34(1): 37-60.

[20] WOODS J D. NOURISH-C: implementing a family based weight loss intervention in a church community[M]. Richmond, VA: Virginia Commonwealth University, 2015.

[21] BRESLIN G, SHANNON S, RAFFERTY R, et al. The effect of sport for LIFE: all island in children from low socio-economic status: a clustered randomized controlled trial[J]. Health Qual Life Outcomes, 2019, 17: 1-12.

[22] CASEY M M, HARVEY J T, TELFORD A, et al. Effectiveness of a school-community linked program on physical activity levels and health-related quality of life for adolescent girls[J]. BMC Public Health, 2014, 14: 649.

[23] GALL S, WALTER C, DU RANDT R, et al. Changes in self-reported physical activity predict health-related quality of life among South African schoolchildren: findings from the DASH intervention trial[J]. Front Public Health, 2020, 8: 492618.

[24] HA A S, BURNETT A, SUM R, et al. Outcomes of the rope skipping 'STAR' programme for schoolchildren[J]. J Hum Kinet, 2015, 45: 233-240.

[25] KRIEMLER S, ZAHNER L, SCHINDLER C, et al. Effect of school based physical activity programme (KISS) on fitness and adiposity in primary schoolchildren: cluster randomised controlled trial[J]. BMJ, 2010, 340: c785.

[26] KVALØ S E, NATLANDSMYR I K. The effect of physical-activity intervention on children's health-related quality of life[J]. Scand J Public Health, 2021, 49(5): 539-545.

[27] MEYER U, SCHINDLER C, ZAHNER L, et al. Long-term effect of a school-based physical activity program (KISS) on fitness and adiposity in children: a cluster-randomized controlled trial[J]. PLoS One, 2014, 9(2): e87929.

(下转第 815 页)

lescents: a cross-sectional study[J]. Environ Health, 2012, 11(1): 86.

[20] HARRIS M H, OKEN E, RIFAS-SHIMAN S L, et al. Prenatal and childhood exposure to per- and polyfluoroalkyl substances (PFAS) and child executive function and behavioral problems[J]. Environ Res, 2021, 202: 111621.

[21] ENGLAND-MASON G, LIU J, MARTIN J W, et al. Postnatal BPA is associated with increasing executive function difficulties in preschool children[J]. Pediatr Res, 2021, 89(3): 686-693.

[22] VUONG A M, YOLTON K, WEBSTER G M, et al. Prenatal polybrominated diphenyl ether and perfluoroalkyl substance exposures and executive function in school-age children[J]. Environ Res, 2016, 147: 556-564.

[23] CHOI G, VILLANGER G D, DROVER S S M, et al. Prenatal phthalate exposures and executive function in preschool children[J]. Environ Int, 2021, 149: 106403.

[24] SPIEGEL J A, GOODRICH J M, MORRIS B M, et al. Relations between executive functions and academic outcomes in elementary school children: a Meta-analysis[J]. Psychol Bull, 2021, 147(4): 329-351.

[25] KIM J I, LEE Y A, SHIN C H, et al. Association of bisphenol A, bisphenol F, and bisphenol S with ADHD symptoms in children[J]. Environ Int, 2022, 161: 107093.

[26] BORNEHAG C G, ENGDAHL E, UNENGE H M, et al. Prenatal exposure to bisphenols and cognitive function in children at 7 years of age in the Swedish SELMA study[J]. Environ Int, 2021, 150: 106433.

[27] WU D, WU F, LIN R, et al. Impairment of learning and memory induced by perinatal exposure to BPA is associated with ERα-mediated alterations of synaptic plasticity and PKC/ERK/CREB signaling pathway in offspring rats[J]. Brain Res Bull, 2020, 161: 43-54.

[28] NADERI M, SALAHINEJAD A, ATTARAN A, et al. Chronic exposure to environmentally relevant concentrations of bisphenol S differentially affects cognitive behaviors in adult female zebrafish[J]. Environ Pollut, 2020, 261: 114060.

[29] TIWARI S, PHOOLMALA, GOYAL S, et al. Bisphenol-F and bisphenol-S (BPF and BPS) impair the stemness of neural stem cells and neuronal fate decision in the hippocampus leading to cognitive dysfunctions[J]. Mol Neurobiol, 2024, 61(11): 9347-9368.

[30] LUCACCIONI L, TREVISANI V, PASSINI E, et al. Perinatal exposure to phthalates: from endocrine to neurodevelopment effects[J]. Int J Mol Sci, 2021, 22(8): 4063.

[31] STEVENS S, BARTOSOVA Z, VÖLKER J, et al. Migration of endocrine and metabolism disrupting chemicals from plastic food packaging[J]. Environ Int, 2024, 189: 108791.

[32] 刘忠瑞, 孙立文, 李洋洋, 等. 塑料食品包装材料中双酚 A 的迁移量检测[J]. 食品安全质量检测学报, 2018, 9(10): 2350-2355.
LIU Z R, SUN L W, LI Y Y, et al. Determination of migration quantity of bisphenol A from plastic packaging materials of food[J]. J Food Saf Qual, 2018, 9(10): 2350-2355. (in Chinese)

[33] HONG S, WU S, WAN Z, et al. Associations between multiple metals exposure and cognitive function in the middle-aged and older adults from China: a cross-sectional study[J]. Environ Res, 2024, 263: 120038.

[34] CARVALHO C F, SANTOS-LIMA C, SOUZA-MARQUES B, et al. Executive functions in school-aged children exposed to airborne manganese: a multilevel analysis[J]. Environ Res, 2022, 210: 112940.

[35] SOETRISNO F N, DELGADO-SABORIT J M. Chronic exposure to heavy metals from informal E-waste recycling plants and children's attention, executive function and academic performance[J]. Sci Total Environ, 2020, 717: 137099.

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(上接第 810 页)

[28] NAGPAL T S, GOLDFIELD G S, DA SILVA D F, et al. The effects of intervening with physical activity in the early years (ages 3-5) on health-related quality of life: a secondary analysis of the Activity Begins in Childhood (ABC) trial[J]. Qual Life Res, 2021, 30: 221-227.

[29] PUDER J J, MARQUES-VIDAL P, SCHINDLER C, et al. Effect of multidimensional lifestyle intervention on fitness and adiposity in predominantly migrant preschool children (Ballabeina): cluster randomised controlled trial[J]. BMJ, 2011, 343: d6195.

[30] RESALAND G K, AADLAND E, MOE V F, et al. Effects of a physical activity intervention on schoolchildren's health-related quality of life: the active smarter kids (ASK) cluster-randomized controlled trial[J]. Prev Med Rep, 2019, 13: 1-4.

[31] TRUELOVE S, JOHNSON A M, VANDERLOO L M, et al. Preschoolers' health-related quality of life following the implementation of a childcare physical activity intervention[J]. Appl Physiol Nutr Metab, 2018, 43(5): 453-459.

[32] ANDERMO S, HELLÉNIUS M L, LIDIN M, et al. Effectiveness of a family intervention on health-related quality of life: a healthy generation, a controlled pilot trial[J]. BMC Public Health, 2020, 20(1): 809.

[33] CONTARDO AYALA A M, PARKER K, MAZZOLI E, et al. Effectiveness of intervention strategies to increase adolescents' physical activity and reduce sedentary time in secondary school settings, including factors related to implementation: a systematic review and Meta-analysis[J]. Sports Med Open, 2024, 10(1): 25.

[34] DOBBINS M, HUSSON H, DECORBY K, et al. School-based physical activity programs for promoting physical activity and fitness in children and adolescents aged 6 to 18[J]. Cochrane Database Syst Rev, 2013 (2): CD007651.

[35] LUBANS D, RICHARDS J, HILLMAN C, et al. Physical activity for cognitive and mental health in youth: a systematic review of mechanisms[J]. Pediatrics, 2016, 138(3): e20161642.

[36] 湾明月, 夏锐, 林慧颖, 等. 身体活动对大脑可塑性影响的研究进展[J]. 中国康复理论与实践, 2020, 26(9): 1071-1075.
WAN M Y, XIA R, LIN H Y, et al. Advance in physical activity for brain plasticity[J]. Chin J Rehabil Theory Pract, 2020, 26(9): 1071-1075. (in Chinese)

[37] ZHENG M, RANGAN A, OLSEN N J, et al. Longitudinal association of nighttime sleep duration with emotional and behavioral problems in early childhood: results from the Danish Healthy Start Study[J]. Sleep, 2021, 44(1): zsaa138.

[38] CHAUHAN S, NORBURY R, FAβBENDER K C, et al. Beyond sleep: a multidimensional model of chronotype[J]. Neurosci Biobehav Rev, 2023, 148: 105114.

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