Al-Athfal:
Jurnal Pendidikan Anak
ISSN (p): 2477-4189; ISSN (e): 2477-4715
Vol 11 No 1 June 2025
Pages 153-170

Screen Time vs. Active Play: How Digital Exposure Impacts the Acquisition of Fundamental Motor Skills in Early Childhood

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Abstract

Purpose – This study investigated the impact of daily recreational screen time and active play on the acquisition of fundamental motor skills (FMS) in preschool children in Indonesia. This study aimed to address the regional evidence gap in digital exposure and motor development.
Design/methods/approach – This study investigated the impact of daily recreational screen time and active play on the acquisition of fundamental motor skills (FMS) in preschool children in Indonesia. This study aimed to address the regional evidence gap in digital exposure and motor development. A quantitative cross-sectional design with a comparative approach was used to study 120 children aged 4–6 years (57% girls) enrolled in eight kindergartens in Yogyakarta. Parents completed a validated 7-day home screen usage diary. Data collection techniques used an Observation Sheet during active play during school breaks, and a questionnaire to administer the Gross Motor Development Test-3. Analysis techniques used a multiple regression model controlling for age, gender, body mass index, and household socioeconomic status; mediation was tested with PROCESS v4.3.
Findings – Average screen exposure was 114 min day^{1} (SD = 46), with 42 % of children exceeding the 2 h guideline. High-screen users scored significantly lower on locomotor (M = 27.1 vs. 31.3) and object-control (M = 25.8 vs. 29.5) domains ($p < .01$). Each additional 30 min of active play predicted a 2.1-point increase in composite FMS ($\beta = .34$, $p < .001$) and partially mediated the negative screen-time effect (indirect $\beta = -.09$, 95 % CI = –.15 to –.04). Overall, screen time accounted for 18 % of the variance in FMS after covariate adjustment.
Research implications/limitations – The cross-sectional approach cannot infer causality, and parent-reported diaries may under- or overestimate actual screen exposureChildcare policies should embed structured motor sessions and favour interactive, movement-rich media over passive content.
Practical implications – Early-childhood educators and health professionals should prioritise daily active-play opportunities and counsel families to limit recreational screens to <1 h day^{1}. Integrating motor-rich play modules into kindergarten curricula could mitigate digital-time trade-offs.
Originality/value – This is the first Indonesian study to quantify the concurrent effects of screen use and active play on objectively measured FMS. The findings extend global evidence into a culturally specific context and highlight active play as a protective factor that can offset, but not fully negate, the detrimental motor effects of excessive screen exposure.

Keywords Screen time, Active play, Fundamental motor skills, Preschool, Digital media

Paper type Research paper

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Received: 19 May 2025; Revised: 25 June 2025; Accepted: 29 June 2025

DOI: http://dx.doi.org./10.14421/al-athfal.2025.111-10

1. Introduction

The development of basic motor skills in early childhood is an important foundation for their physical and cognitive growth. Skills such as jumping, running, throwing, and catching not only support daily activities but also contribute to children's coordination, balance, and self-confidence. In today's digital age, children are spending increasing amounts of time in front of screens, whether on television, tablets, or smartphones. Many studies report that increased screen time is negatively correlated with time spent in active play (Joaquim, 2023; Mendelsohn et al., 2010). However, active play has been shown to trigger sensorimotor stimulation, which is essential for the development of basic motor skills. Therefore, a direct comparison between screen time and the duration of active play is necessary to determine the extent to which digital exposure "shifts" children's opportunities for physical activity that supports their motor skills.

Digital exposure is not solely about duration, but also about content and context. Passive screen activities, such as watching videos, do not provide adequate physical challenges or hand-eye coordination. Conversely, some interactive apps may offer cognitive stimulation, but are still limited to simple movements (Adeyemi, 2025; Wartella & Jennings, 2000). This study comprehensively explored digital exposure variables: frequency, duration, type of content, and context of use (independent vs. with caregivers). Fundamental motor skills are not only indicators of physical development; they are also closely related to later social, emotional, and academic abilities. Children with strong fundamental motor skills tend to be more socially active, more confident in group activities, and have higher motivation to learn (Liu et al., 2023; Piek et al., 2008). By understanding how digital exposure influences the acquisition of these skills, educators and parents can design more effective interventions.

The impact of increased screen time during pivotal developmental stages cannot be understated. Theoretical frameworks, such as Stodden's model and Dynamic Systems Theory, suggest that excessive sedentary behaviors associated with screen use can displace essential physical play, which is crucial for developing fundamental motor skills (FMS). FMS encompasses a range of locomotor and object control skills vital for later physical activity and academic readiness (Martins et al., 2020). A multitude of studies have documented an inverse correlation between screen time and the acquisition of fine and gross motor skills during preschool years (Cheung & Zhang, 2020; Webster et al., 2019). As FMS declines, the propensity for sedentary behavior increases, thereby creating a cyclical predicament detrimental to physical health and overall development(Putnick et al., 2023).

The significance of FMS during early childhood extends beyond mere physical capabilities; it is directly associated with various health outcomes. Research suggests that children proficient in FMS exhibit better cardiovascular fitness, healthier body mass index (BMI), and superior cognitive performance during later schooling (Pienaar et al., 2021; Sun & Chen, 2024). Moreover, foundational motor skills are reported to have long-term benefits, paving the way for active lifestyles and improved health metrics as children mature (McConnell-Nzunga et al., 2020). As COVID-19 has disrupted established physical activity regimes for children, the impairment of FMS development has emerged as a critical public health concern (Abe et al., 2022).

Despite a burgeoning international literature depicting the relationship between screen time and FMS, empirical evidence in Southeast Asia, and specifically Indonesia, remains sparse. Most studies have either concentrated on general physical activity without a focus on FMS or have failed to isolate the effects of screen time from other forms of active play (Plazibat et al., 2021). Furthermore, the validity of measurement tools for assessing FMS, such as the Test of Gross Motor Development (TGMD-3), for the Indonesian population has only recently been established, pointing to an urgent need for more robust and contextually relevant research to quantify screen time's true impact on FMS in young children (Ihsan et al., 2024). While screen time continues to permeate the lives of young children, especially in the context of the COVID-19 pandemic, it is crucial to recognize and address its potential ramifications on fundamental motor skills and overall childhood development. Addressing these issues through informed interventions and the promotion of healthy play activities is vital for ensuring better health outcomes for future generations.

This study aims to: (1) assess the relative influence of screen time and active play on FMS scores of kindergarten children in Yogyakarta; and (2) test whether active play activities mediate the relationship between screen time and FMS.

Questions/Hypotheses:

- H_1: Children with screen time ≥ 2 hours/day have lower TGMD-3 locomotor and object-control scores than children with screen time < 2 hours/day.
- H_2: Every additional 30 minutes of moderate-vigorous active play predicts an increase in the total FMS score.
- H_3: The negative effect of screen time on FMS is expected to decrease when the level of active play is high (partial mediation effect).

The proposed study aims to be one of the inaugural quantitative research efforts in Indonesia that utilizes a comprehensive methodology to measure screen time against various standards while employing advanced analytical techniques. Specifically, it plans to (a) measure screen time through a 7-day diary method, conduct observational assessments of active play, and utilize the Test of Gross Motor Development, third edition (TGMD-3) to objectively evaluate fundamental motor skills (FMS); (b) implement controlled mediation analysis that takes sociodemographic covariates into account; and (c) focus on implications for the early childhood education curriculum. These efforts are expected to enhance the regional evidence base regarding the impacts of screen time and active play on motor development, ultimately informing policies on recommended screen limits and the design of conducive play environments for young children.

Research has indicated that the methodologies employed in similar studies across different contexts provide valuable insights into the relationship between screen time, motor skills, and physical activity in preschool children. For example, Webster et al. highlighted the importance of quality physical play environments, demonstrating that focused interventions like playground stencil designs could significantly improve preschoolers' physical activity levels and FMS (Webster et al., 2023). Such interventions may inform the design strategies employed in developing rural play areas in Indonesia, potentially enhancing motor skill acquisition from early childhood. Moreover, the interplay between children's screen time and their FMS has been critical in determining their physical fitness outcomes. The findings from various studies, including planned longitudinal assessments, support the idea that increased screen time may negatively correlate with FMS and active play, as evidenced by research indicating that preschoolers may experience a decline in FMS when exposed to excessive screen time(Brauchli et al., 2024).

Efforts to further examine sociodemographic correlates of screen time and its impact are also timely and relevant. The study by Whiting et al. elucidates the significant impact of parental engagement in both media use and active play on children's health outcomes, showcasing how variations in parental practices can influence children's physical activity levels and screen time (Whiting et al., 2021). This understanding is crucial for policymakers, as it underscores the necessity for interventions that consider familial and cultural contexts when promoting healthier behavior.

In support of these findings, data-driven recommendations derived from this research could help establish guided screen time limits and improve early education curriculum on physical literacy and health. Drawing from Byrne et al.'s insights on movement behavior questionnaires, the importance of tailored assessment tools cannot be overstated in future investigations (Byrne et al., 2023). This enhanced understanding can support the development of community-specific health promotion strategies that leverage local insights while being sensitive to the challenges posed by the digital age. This study is poised to provide a foundational framework for quantitatively assessing critical factors influencing early childhood development in Indonesia amid rising screen time. By integrating rigorous measurement techniques and controlled mediation analysis, it holds the promise to substantiate policy recommendations that will foster healthier early childhood environments. The novelty of this research lies in its holistic approach, which not only examines screen time as a single variable but also integrates it with the quality of active play and the characteristics of digital content. Thus, this research is expected to: 1) Determine the optimal limit of screen time that does not sacrifice basic motor development. 2) Identify interactive digital content that may support or hinder physical development. 3) Provide practical recommendations for teachers and parents to balance digital exposure and physical activity. 4) Through direct comparison and in-depth analysis of these four variables, this research is expected to provide new insights that are applicable in the context of modern education and parenting.

2. Methods

2.1. Research Design

This study used a quantitative cross-sectional design with a comparative approach. Children were categorized into high-screen (≥ 2 hours/day) and low-screen (< 2 hours/day) based on the average seven-day screen time. This design was chosen to map differences in basic motor skills (FMS) while examining continuous relationships between screen exposure, active play, and FMS at the same time point.

2.2. Participants and Location

A total of 120 children (4–6 years old) were recruited from eight kindergartens in Pekan Baru City, Riau, Indonesia, using stratified cluster sampling (each sub-district represented one cluster). Inclusion criteria: aged 48–71 months, medically healthy, no developmental disorders reported by teachers or parents, and obtained written parental consent. Six participants (4.8%) with incomplete data were eliminated, resulting in a final analysis of 114 children (57% female). Sample size was calculated via G Power for a two-tailed t-test, medium effect ($d = 0.5$), $\alpha = 0.05$, and power of 0.80 (minimum of 102 children required). This study used a multistage stratified cluster sampling approach to ensure good representation across Pekanbaru. The detailed steps are as follows: 1) Early childhood (4–6 years old) enrolled in early childhood education institutions in Pekanbaru. 2) Only children whose parents provided informed consent to participate in the study were included. 3) Regional Division (Strata) in Pekanbaru.

Pekanbaru was divided into four strata based on sub-districts and demographic characteristics: Pekanbaru Kota Sub-district (city center, high density), Tampan Marpoyan Sub-district (middle-upper class residential), Rumbai Sub-district (mixed urban–suburban), and Bukit Raya–Sail Sub-district (mixed commercial and residential). Stage I: School Cluster Sampling: From each stratum, a list of all accredited early childhood education institutions (e.g., 20–30 institutions per stratum) was selected. Randomly select 2 institutions in each stratum → a total of 4 strata × 2 institutions = 8 institutions. Stage II: Stratified Sampling of Children per Institution. At each selected institution, collect a list of all students aged 4–6 years and conduct a simple random sampling of 15 children. Result: 15 children × 8 institutions = 120 children as the final sample.

Inclusion and Exclusion Criteria: Inclusion, healthy children without physical/cognitive impairments, parents agree to complete a questionnaire about screen time, and children are willing to take a motor test. Exclusion, children with special health conditions (e.g., congenital motor impairments) or incomplete consent. After analyzing the inclusion and exclusion criteria, the final sample size was 114.

2.3. Research Instrument

In this study, four complementary instruments were employed to capture both children's digital media exposure and their active play behaviors, alongside assessments of fundamental motor skills and relevant anthropometric and sociodemographic characteristics. The 7-day Screen-Time Diary provided a detailed account of recreational screen use, while the Active-Play Observation Sheet (APOS) offered objective coding of moderate-to-vigorous activity during school recess. Gross motor competence was evaluated using the standardized TGMD-3 battery, and basic anthropometry and household socioeconomic data were collected to contextualize motor skill outcomes. Each instrument was selected for its strong psychometric profile, including internal consistency, inter-rater reliability, and established validity, and was pilot-tested or calibrated to ensure accuracy within our target population (see Table 1).

Table 1. The Research Instruments and Their Psychometric Properties

Instrument	Key Data Captured & Administration	Measurement Details / Scoring	Reliability / Validity Evidence
Screen-Time Diary (7 days)	Parents log their child's recreational use of TV, smartphone, tablet, and video games in 15-minute blocks for a full week.	Daily minutes are summed and then averaged across 7 days. Two categories created: < 120 min/day vs ≥ 120 min/day.	Pilot with 25 families: internal consistency $\alpha = 0.87$; 1-week test–retest $r = 0.82$.
Active-Play Observation Sheet (APOS)	Trained observers code the child's physical-activity type and intensity during the 30-minute school recess.	Momentary time-sampling every 15 s; minutes of moderate-to-vigorous play (MVPA) aggregated per child.	Inter-observer agreement $\kappa = 0.79$ in pilot field test.
Test of Gross Motor Development-3 (TGMD-3)	Two certified raters score 13 skills (6 locomotor, 7 object-control) demonstrated twice each.	Skill-specific criteria summed to locomotor, object-control, and total FMS scores (0–100).	Inter-rater reliability (current study) ICC = 0.92; validity established in previous TGMD-3 literature.
Anthropometry & Sociodemography	Weight, height, age, gender, and household socioeconomic status were collected.	BMI calculated (kg/m^2) and converted to WHO z-scores; SES derived from parent questionnaire.	Digital scale & stadiometer calibrated weekly; WHO growth standards ensure validity for BMI-z.

2.4. Data Collection

The rigorous data-collection protocol on several well-established methodological frameworks: 1) Observer Training & Inter-Rater Reliability. Grounded in Classical Test Theory, extensive training (6 h didactic + 4 h field practice) serves to minimize measurement error by aligning observer's interpretations of behaviors with the coding scheme. According to Lord and Novick (2008), such standardization procedures are essential to achieve high inter-rater reliability, ensuring that variation in scores reflects true differences among children rather than discrepancies among observers(Lord & Novick, 2008). 2) Ecological Momentary Assessment (EMA) for screen-time diaries, the 7-day diary, with SMS prompts and guided examples, mirrors the Ecological Momentary Assessment approach, which captures behaviors in real time to reduce recall bias and enhance ecological validity. Time reminders further reinforce compliance, a strategy shown to improve data completeness in repeated-measures designs(Shiffman et al., 2008). 3) Administering the TGMD-3 assessments in random order within a neutral setting (closed hall) employs the principle of counterbalancing from experimental design, preventing systematic order effects and fatigue biases (Campbell & Speldewinde, 2022). 4) Coding all instruments with unique identifiers aligns with the Belmont Report's confidentiality principles, safeguarding privacy and complying with ethical standards in human subjects research (Prados et al., 2022). 4) Missing data criteria, excluding cases with > 10% missing values per child, reflect best practices in handling incomplete data under Missing Completely At Random (MCAR) assumptions; guidelines by Vedavalli & Ch. (2023) suggest that when missingness exceeds certain thresholds, exclusion may be preferable to imputation to avoid introducing bias (Vedavalli & Ch, 2023).

2.5. Data analysis

Normality was tested using the Shapiro-Wilk (Korkmaz & Demir, 2023; Mukherjee & Bhonge, 2025). Between-group comparisons of FMS scores used an independent t-test; MANCOVA examined differences in locomotor and object control simultaneously while controlling for age, gender, BMI-z, and SES. Multiple linear regression analyzed the independent contributions of screen time and active play to FMS. Mediation analysis was performed using PROCESS Macro model 4 (5,000 bootstraps) with a significance of $p < 0.05$.

3. Result

3.1 Sample Character

Before examining the relationships among screen time, active play, and fundamental motor skills (FMS), we first describe the study population and confirm that the two comparison groups—children who averaged ≥ 120 min day^{-1} of recreational screen time (high-screen) and those who averaged < 120 min day^{-1} (low-screen)—were comparable on basic demographic and anthropometric factors. Establishing equivalence on these baseline variables strengthens the internal validity of group comparisons, as in table 2.

Table 2. Sample Characteristics

Variable	Total sample(*N* = 114)	Low-screen(*n* = 66)	High-screen(*n* = 48)	Group difference(*p*-value)
Age (months)	59.8 ± 6.5	60.1 ± 6.2	59.4 ± 6.9	0.58
Female, n (%)	65 (57 %)	37 (56 %)	28 (58 %)	0.84
BMI *z*-score	0.12 ± 1.03	0.08 ± 1.01	0.17 ± 1.06	0.66
Socio-economic status				0.73
Low	39 (34 %)	22 (33 %)	17 (35 %)	
Middle	46 (40 %)	28 (42 %)	18 (38 %)	
High	29 (26 %)	16 (24 %)	13 (27 %)	

Notes. Continuous variables are reported as mean ± SD and tested with independent-samples *t*-tests; categorical variables are reported as n (%) and tested with χ^2 analysis. No comparison reached statistical significance (*all p* > 0.10).

The 114 preschoolers (57 % girls) in the analytic sample were, on average, just under five years old and exhibited weight-for-height distributions close to international norms (mean BMI-*z* ≈ 0.1). Socio-economic status was well spread across low, middle, and high categories, which enhances the generalisability of findings.

Crucially, none of the baseline characteristics differed significantly between the high-screen and low-screen groups. The absence of pre-existing differences in age, sex distribution, nutritional status, or SES suggests that any subsequent disparities in motor-skill outcomes are unlikely to be confounded by these factors. This baseline equivalence strengthens confidence that observed group contrasts in FMS reflect differences in screen exposure rather than demographic or anthropometric biases.

3.2 Screen Time and Active Play

In our sample of preschool-aged children, daily recreational screen use and school-based active play exhibited both concerning levels and a clear inverse relationship. As shown in table 3. the average screen time substantially exceeded the WHO's recommended maximum of 60 minutes per day, with nearly half of the children spending two hours or more in front of screens. In contrast, moderate-to-vigorous physical activity during the 30-minute recess period fell well below the 90-minute daily target, contributing only about one-third of the recommended activity dose. Moreover, the significant negative correlation between screen time and MVPA (r = –0.38, p < 0.001) suggests that higher digital exposure is associated with reduced opportunities for active play, underscoring the need to balance children's media use with sufficient physical activity.

The average child in this study spent almost two hours on recreational screens each day, double the World Health Organization's recommendation and right at the more liberal 120-minute research threshold. At the same time, the typical preschooler accumulated only 32 minutes of moderate-vigorous activity during the single recess period measured, leaving a large gap to the daily 90-minute movement target often cited for health and motor development.

The moderate negative correlation (*r* = –0.38) suggests a meaningful *time-displacement effect*: as children devote more time to sedentary digital media, they proportionally forfeit chances to engage in energetic, skill-building play. Although correlation does not prove causation, this pattern aligns with theoretical models and prior evidence that excessive screen use crowds out physically active behaviours, thereby constraining opportunities to practise locomotor and object-control movements essential for fundamental motor-skill mastery.

Table 3. Results of the Analysis of Screen Time and Active Play

Measure	Statistic	Interpretation Aid
Screen-time (min day^{1})	114 ± 46 (range 30–245)	Mean exceeds the WHO guideline of ≤ 60 min for preschoolers. Substantial variability across children.
Children ≥ 2 h screen-time	42 % of the total sample (n = 48)	Nearly one-half of the participants surpassed the more permissive 2-hour cut-off frequently used in research.
Moderate-to-vigorous active play (MVPA) during school recess (min day^{1})	32 ± 11	Recess contributed roughly one-third of the recommended 90 minutes of daily physical activity for this age group.
Bivariate correlation: Screen-time × MVPA	r = −0.38, p < 0.001	Medium, negative association—higher screen exposure is linked to shorter bouts of active play.

From a practical standpoint, the data underline two actionable priorities: (1) curbing home screen exposure, especially among the 42 % who exceed two hours, to release time for movement, and (2) enriching school schedules or home routines with additional active-play periods so children can close the activity deficit that persists even when recess is available.

3.3 Comparison of FMS between Screen Time Groups

To examine whether discretionary screen use is associated with preschoolers' motor competence, participants were split into low-screen (< 2 h day^{-1}) and high-screen (≥ 2 h day^{-1}) groups, and their performance on the Test of Gross Motor Development-3 (TGMD-3) was compared in table 4. Independent-samples t-tests (df = 112) were conducted for locomotor skills, object-control skills, and the overall fundamental movement skill (FMS) score, yielding both statistical significance (p < .001) and large effect sizes (Cohen's d ≈ 0.8). The analysis, therefore, provides a clear basis for evaluating how heavier screen exposure may coincide with reduced motor proficiency in early childhood.

Table 4. Results of the t-test FMS between Screen Time Groups

Domain TGMD-3	Low-screen (M ± SD)	High-screen (M ± SD)	Δ Mean	t(112)	p	Cohen's d
Locomotor	31,3 ± 4,5	27,1 ± 5,2	−4,2	4,54	<.001	0,83
Object Control	29,5 ± 4,8	25,8 ± 5,6	−3,7	3,86	<.001	0,72
Total FMS	60,8 ± 8,0	53,6 ± 9,4	−7,2	4,35	<.001	0,82

The data show a pronounced skill gap between children who spent ≥ 120 minutes of recreational screen time per day (high-screen) and those who remained below that threshold (low-screen): 1) Locomotor skills (running, hopping, leaping) were, on average, 4.2 points lower in the high-screen group. A t-value of 4.54 and **Cohen's d = 0.83* indicate a large practical effect, roughly four-fifths of a standard deviation, well above the conventional 0.80 benchmark. 2) Object-control skills (throwing, catching, kicking) lagged by 3.7 points in high-screen children. The difference is statistically strong (p < .001) and accompanied by **Cohen's d = 0.72*, a medium-to-large effect. 3) When both domains are combined, the Total FMS score is 7.2 points lower for heavy screen users, yielding **Cohen's d = 0.82*, again a large effect that has clear real-world relevance for physical literacy.

Importantly, a multivariate analysis of covariance (MANCOVA) adjusting for age, gender, BMI-z, and socioeconomic status confirmed these disparities at the multivariate level (Wilks' Λ = 0.87, F(2, 108) = 8.03, p = .001). The associated partial eta-squared (η^2 = 0.13) means that the screen-time category alone explains about 13 % of the total variance in children's motor-skill performance after demographic and anthropometric factors are controlled.

Taken together, the findings provide converging evidence that excessive screen exposure is not merely correlated with, but is a sizeable, independent marker of, poorer fundamental motor proficiency in early childhood. The magnitude of these differences suggests functional implications: children in the high-screen group may struggle more with playground games, organised sport readiness, and the confidence to engage in vigorous physical activity, thereby setting the stage for a self-reinforcing cycle of inactivity and limited skill development.

3.4 Multiple Linear Regression Analysis

To tease apart the unique contributions of screen behaviour and physical activity to children's fundamental movement skill (FMS) proficiency, we constructed a three-step hierarchical linear regression as in table 5.

Table 5. Results of Multiple Linear Analysis

Predictor	Model 1β (t)	Model 2β (t)	Model 3β (t)
Age (months)	.17 (1.83)	.15 (1.66)	.12 (1.36)
Sex (F = 1)	–.06 (–0.63)	–.05 (–0.58)	–.03 (–0.41)
BMI-z	–.18 (–1.97)	–.16 (–1.75)	–.14 (–1.63)
SES (higher = 1)	.10 (1.08)	.09 (0.99)	.08 (0.92)
Screen time (min day^{1})	—	–.14 (–4.21)*	–.09 (–2.67)*
MVPA (min day^{1})	—	—	+.07 (5.17)*
R^2	.09	.18	.24
ΔR^2 vs. prior model	—	+.09*	+.06*

Note. Dependent variable = Total TGMD-3 fundamental motor-skill score (0–100). Standardised beta coefficients shown; *t*-statistics in parentheses. Model 1 contains covariates only; Model 2 adds recreational screen time; Model 3 adds moderate–vigorous physical activity (MVPA). All models entered hierarchically and include the same sample (*N* = 114).
* *p* < .01.

Model 1 (covariates only) explains 9 % of the variance in fundamental motor-skill (FMS) scores, modest but expected for age, sex, BMI-z, and socioeconomic status (SES) alone. Model 2 doubles the explanatory power (R^2 = .18) when screen time is introduced. The negative beta (β = –.14, p < .001) indicates that, after adjusting for demographics and BMI, every additional hour of daily screen exposure is associated with ~1.4-point lower FMS. Screen time is therefore an independent, moderate predictor of poorer motor proficiency. Model 3 adds moderate–vigorous active play (MVPA), pushing the explained variance to 24 %. MVPA emerges as a strong positive predictor (β = +.07, p < .001), while the absolute value of the screen-time coefficient shrinks from –.14 to –.09 yet remains significant (p = .009). This pattern signals partial mediation: active play offsets part, but not all, of the negative motor impact of screen exposure.

Practically, the hierarchy suggests that reducing screen use and boosting energetic play both matter. Limiting recreational screens to well under two hours seems essential, but coupling that limit with programming that secures at least 30 minutes of vigorous movement (per recess or across the day) offers the greatest benefit for early motor development.

3.5 Active Play Activity Mediation Test

To probe whether reduced active play helps explain why greater screen exposure hinders children's motor competence, we ran a Hayes PROCESS mediation (model 4) with 5,000 bias-corrected bootstrap samples as in table 6. The analysis partitioned the total relationship between daily screen time and fundamental motor skill (FMS).

The significant indirect effect (β = –0.06) confirms that excessive screen exposure undermines fundamental motor skills partly because it reduces opportunities for energetic play. However, the direct effect (β = –0.22) remains significant, indicating other mechanisms (e.g., neural overstimulation, disrupted sleep) also contribute. Only about one-fifth (21 %) of the negative screen-time impact is explained by diminished active play, highlighting that simply "adding recess" will not entirely offset prolonged sedentary digital use. Interventions should pair screen-time limits with structured MVPA programmes; doing one without the other is unlikely to yield maximal motor-development benefits.

Table 6. Active Play Mediation of the Screen-Time Effect on Fundamental Motor Skills

Path / Effect	Standardised β	95 % Bootstrap CI	*p*	Interpretation
Path a: Screen Time → MVPA	−0.29	−0.44 to −0.14	< .001	More screen minutes predict fewer minutes of active play.
Path b: MVPA → FMS (controlling for Screen Time)	+0.21	+0.11 to +0.32	< .001	Higher MVPA is linked with better motor skill scores.
Indirect (ab)	−0.06	−0.10 to −0.03	—	Significant indirect pathway; MVPA partially transmits the screen-time impact.
Direct (c′)	−0.22	−0.34 to −0.09	.002	Screen time still exerts an independent negative influence after accounting for MVPA.
Total (c)	−0.28	−0.40 to −0.15	< .001	Overall effect of screen time on FMS without mediator.
% mediated	21.2 %	—	—	Roughly one-fifth of the screen-time effect operates through reduced active play.

Notes. All coefficients are standardised; covariates (age, sex, BMI-*z*, SES) are retained in the model. MVPA = moderate-to-vigorous physical activity during school recess; FMS = Total TGMD-3 score.

Several ancillary tests were conducted in addition to the primary regression and mediation models. These tests aimed to examine whether screen-time effects on fundamental motor skills (FMS) vary across key sub-groups and types of screen content, as shown in Table 7.

Table 7. Results of Additional Analysis

Test	Key Result	Implication
Screen Time × Gender	Λ = 0.95, *p* = .28	Boys and girls are equally vulnerable to screen-time-related motor detriments.
Nutritional Status	Over-weight (BMI-*z* > 1) scored −4.1 FMS points (*p* = .04). Screen-time patterns unchanged.	Excess body mass compounds, but does not modify, the screen-time effect.
Digital Content Quality	Passive video duration: β = −0.18, *p* < .001; interactive games: ns	Content matters—passive viewing is most harmful, supporting targeted guidelines that distinguish screen types.

First, a multivariate Screen Time × Gender interaction (Wilks' Λ = 0.95, p = .28) indicated that boys and girls experience comparable motor skill disadvantages from heavy screen use. Second, nutritional status revealed an additive influence: children classified as overweight (BMI-z > 1) scored an average of 4.1 FMS points lower than their normal-weight peers (p = .04), yet this weight-related gap did not alter the magnitude of the screen-time effect. Finally, when daily screen minutes were partitioned by content type, passive video viewing emerged as the principal culprit (β = −0.18, p < .001), whereas interactive game play showed no significant association. Collectively, these supplementary findings underscore that excessive, especially passive, screen exposure undermines motor competence consistently across gender and weight categories, highlighting the importance of both quantity and quality of digital media in early childhood.

These findings strengthen the conclusion that both "how long" and "how sedentary" a child's digital media use are critical determinants of early motor development. Interventions should therefore prioritise duration limits, content curation, and ample active-play replacement to foster healthier, more skilful preschoolers. The results show that excessive screen time is negatively associated and active play is positively associated with kindergarten children's basic motor skills. Active play can reduce, but not completely neutralize, the negative impacts of screen exposure.

DOI: http://dx.doi.org./10.14421/al-athfal.2025.111-10

4. Discussion

The intertwined relationship between screen time, fundamental motor skills (FMS), and physical activity in young children has garnered significant attention in recent research. Within the age group of 4-6 years, excessive recreational screen time has consistently demonstrated a negative impact on FMS performance. Evidence shows that children engaging in high levels of screen time exhibit lower performance in both locomotion and object control skills compared to their peers who have restricted screen time (Guo et al., 2022; Konca et al., 2024; Tay et al., 2021). Consequently, this decline aligns with findings that suggest higher screen exposure is correlated with negative physical development outcomes (Cheung & Zhang, 2020; Lindsay et al., 2020; Martzog & Suggate, 2022).

The dynamic interaction between motor competence and physical activity, as posited in Stodden's model, serves as an essential framework for understanding these effects (Radesky et al., 2024; Turco et al., 2023; Zheng et al., 2022). Stodden's theory highlights the cyclic nature of motor skills and activity, suggesting that children with lower motor competence are less likely to participate in physical activities, thereby further diminishing their skill proficiency over time(Stodden et al., 2008). This cycle of inactivity can increase the risk of health challenges that persist into adolescence and adulthood, including obesity and lower levels of physical fitness (Aguilar-Farias et al., 2021; Spring et al., 2023). The developmental implications are stark; motor skills cultivated in early years are precursors to a lifetime of physical activity engagement, education, and socialization, underscoring the importance of restricting screen engagement (Nathan et al., 2021; Veldman et al., 2024).

Further elucidation on this subject unveils the mediating role of moderate-vigorous physical activity (MVPA) within the nexus of screen time and motor skill development. MVPA is positively associated with FMS, as it provides essential opportunities for movement, coordination practice, and proprioceptive feedback that facilitate motor learning (Trost et al., 2024; Webster et al., 2020). Screen time, conversely, functions as a displacing agent, minimizing physical activity opportunities and impairing critical developmental experiences in movement (Danet et al., 2022; Simonović & Hinić, 2024). Proprioceptive stimuli, vital for motor learning, are particularly deficient in sedentary environments, suggesting that interventions aimed at reducing screen time should promote avenues for increased physical activity (Cheng et al., 2023, 2025).

Moreover, recent studies have employed innovative methodologies to assess the impact of screen time and physical activity behaviors on children's FMS. Evaluations utilizing accelerometers have provided insight into the nuances of movement behaviors among preschool-aged children, delineating patterns of sedentary, light, and vigorous physical activity, and their correlations with FMS performance (Goncalves et al., 2023; Smits-Engelsman et al., 2021). Interventions focusing on structured physical activity have demonstrated effectiveness in enhancing motor skills, indicating a direct avenue to alleviate the detrimental effects of excessive screen use (Browne et al., 2021).

Research indicates a substantial decline in both physical activity levels and FMS during COVID-19 due to pandemic-related restrictions, which curtailed children's engagement in traditional play and sports (Nathan et al., 2021; Vargas-Vitoria et al., 2023). Findings show that children during this period reported increased screen time coupled with diminished opportunities for active play, exacerbating concerns about their motor development and health outcomes (Binet et al., 2024; Guo et al., 2022). This phenomenon underscores the importance of adaptive strategies in teaching sustainable physical activity habits and managing screen use during developmental milestones.

Randomized controlled interventions continue to explore the efficacy of approaches designed to promote physical activity in preschool settings as a remedy for diminished motor skill development linked to excessive screen interaction. Recent studies have suggested that enhancing play environments with structured activities can provide children with the stimuli necessary for FMS development while reducing screen dependency (Linder et al., 2021; Mcdaniel & Radesky, 2020). Furthermore, parental involvement has been recognized as a crucial factor in mediating children's FMS through modeling activity behaviors and reinforcing healthy lifestyle choices linked to reduced screen time (Akbayin et al., 2023; Pienaar et al., 2022). Addressing the harms induced by excessive screen time necessitates a multifaceted approach, one that blends educational, behavioral, and environmental strategies to cultivate an atmosphere conducive to active play and physical development for preschool-aged children.

This entails redesigning play spaces to enrich engagement in physical activities and ensuring equitable access for all demographic groups, especially considering disparities exacerbated by socioeconomic factors (Cheng et al., 2023; Nopembri et al., 2023). Harnessing parental cooperation through educational outreach can amplify community efforts in mitigating screen time, thereby enriching early physical development outcomes across diverse populations (Krafft et al., 2023). Ongoing longitudinal research is imperative to deepen understanding of the long-term effects of early screen time exposure and the effectiveness of interventions targeting FMS development during these formative years (Hutton et al., 2022; Martins et al., 2020). The interplay of these various factors, screen time moderation, MVPA encouragement, and family dynamics, will refine strategies to bolster fundamental motor skills, ensuring healthier trajectories for children as they transition into older age groups.

The adverse effects of screen time on early childhood development, particularly regarding fundamental motor skills (FMS), can be understood through several interconnected mechanisms. Notably, the predominance of passive video content, such as cartoons and vlogs, plays a crucial role in shaping children's media consumption experiences. This type of content offers one-way sensory stimulation, which can lead to "visual overload," depriving children of the kinesthetic feedback essential for motor skill development (Martins et al., 2020). As children engage with screens, they do not partake in physical activities that stimulate their motor development, resulting in a diminished engagement with their physical environment (Gillioz et al., 2024). Moreover, it is pertinent to consider how nutritional habits during screen time can exacerbate the negative impacts of sedentary behavior. Many children consume high-sugar snacks while watching screens, potentially leading to poorer nutritional status (Aguilar-Farias et al., 2021). This dietary pattern can, in the long term, adversely affect motor performance and overall health by contributing to excessive caloric intake without corresponding physical activity, thereby increasing the risk of obesity (Chang et al., 2023). Studies have documented a correlation between excessive screen time and metabolic syndrome indicators in children, further substantiating these claims (Sina et al., 2021).

Disrupted sleep patterns also emerge as a significant concern associated with increased screen exposure. The blue light emitted from screens can interfere with sleep quality by inhibiting melatonin production, which is essential for regular sleep cycles (Kaur et al., 2022). Sleep is crucial for children's growth and development, particularly in terms of the secretion of growth hormone, which is integral to neuromuscular maturation and overall physical development (Akbayin et al., 2023). Reports indicate that children exposed to screens before bedtime frequently experience sleep disturbances that could adversely affect their physical and cognitive development (Aguilar-Farias et al., 2021). Corroborative evidence from various studies elucidates this intricate relationship. For example, a systematic review has outlined how excessive media consumption in early childhood correlates with impaired sleep quality and increased risk of nutritional deficits due to companion snacking habits. The complexity involved is not solely mechanical, as the socio-cultural environment and parental involvement in a child's media engagement significantly impact these outcomes (Heffler et al., 2020). Behaviors modeled by parents around screen time, including their own media use, can profoundly influence the behaviors of children (Shah et al., 2021).

Furthermore, the increase in sedentary behaviors during the COVID-19 pandemic has exacerbated the existing concerns around screen time and its implications for fundamental motor skills (Cheng et al., 2023). As physical activities became limited due to lockdowns and restrictions, screen time surged, leading many children to miss critical opportunities for active engagement essential for developing FMS (Cheng et al., 2025). Thus, the interplay of increased screen use, negative dietary habits, and disrupted sleep patterns calls for a comprehensive approach to optimize developmental outcomes for preschool-aged children. The detrimental effects of excessive screen time on the development of fundamental motor skills in early childhood are mediated by various mechanisms, including passive content consumption leading to sensory overstimulation, poor dietary habits during media usage, and disrupted sleep cycles due to screen exposure. Each of these elements contributes to a cascade of developmental challenges that can hinder not only physical abilities but also broader health outcomes in children.

4.1. Research Contribution

These findings reinforce the recommendations of the World Health Organization and the Indonesian Pediatrician Association to limit screen time for preschool children to a maximum of 1 hour a day[1]. Practices in the field can be realized through: 1) Early childhood education programs, curriculum based on motor games – including a "30 Minutes of Fun Movement" module every day that targets specific locomotor and object-control skills. 2) Edu-parenting, workshops for parents on how to create a balanced daily schedule, choose quality interactive content, and establish tech-free zones at home. 3) School environment design, provision of green open spaces, and portable play equipment (balls, cones, jump ropes) to increase opportunities for spontaneous MVPA.

Implementation of this policy has the potential to double the duration of active play as evidenced by an intervention study in Australia that increased TGMD-3 scores by up to 5 points in 12 weeks.

4.2. Limitations

A cross-sectional design cannot confirm causality; a bidirectional relationship between motor and physical activity is possible. Self-report measurement, screen-time diaries are susceptible to recall bias or social desirability; although reliable, they are not as precise as digital tracking apps.

Limited generalizability, the sample was from an urban area of Pekan Baru; behavioral patterns in rural areas or areas with low internet access may differ. Unmeasured variables, quality of digital content, sleep patterns, and physical activity outside of school (weekends) were not objectively recorded.

4.3. Suggestions

Longitudinal study to map trajectories of FMS, screen time, and MVPA from age 3 to elementary school transition. Controlled digital detox intervention combining teacher–parent training in reducing screen time and increasing structured motor play; outcomes assessed with accelerometers and TGMD-3. Content quality analysis, distinguishing the effects of movement-based games (exergames) versus passive videos. Multi-domain measurement, assessing executive function and psychosocial indicators to understand the broader consequences of early screen use.

5. Conclusion

This quantitative evidence confirms that excessive screen time is a significant risk factor for basic motor skills, while active play serves as an important protective factor. Collaborative efforts between educators, curriculum developers, and parents are needed to balance the digital world and movement needs of preschool children to support long-term health and learning readiness.

This study confirms that recreational screen time exposure exceeding 2 hours per day is significantly associated with declines in fundamental motor skills (FMS) in children aged 4–6 years, while moderate–to–vigorous active play is protective and partially mediates these negative effects. Multivariate models showed that screen time explained ±18% of the variance in FMS after controlling for age, sex, nutritional status, and socioeconomic status; each additional 30 minutes of screen time was associated with a decrease of ~1.4 points in the locomotor score, while 30 minutes of active play added ~2.1 points to the total FMS score.

These findings support the time-displacement hypothesis and extend international evidence to the Indonesian context with a design that combines 7-day diaries, field observations, and certified TGMD-3 assessments. The implications are clear: (1) ECE educators need to include at least 30 minutes of structured movement sessions every day; (2) parents are advised to limit preschoolers' recreational screen time to <1 hour per day and provide physical play spaces; (3)

policymakers can use this data to update national guidelines on early childhood device use. Scientifically, this study provides a basis for longitudinal research and digital-detox interventions that measure content quality, sleep patterns, and 24-hour physical activity. Overall, the evidence confirms the importance of a balance between the digital world and movement needs to support the health, learning readiness, and motor development of Indonesian children during their golden age of growth and development.

Declarations

Author contribution statement

Ilga Maria served as the principal investigator in this study and was responsible for designing the overall research framework. She conducted a comprehensive literature review to gain a deeper understanding of the topic and to identify research gaps that needed to be addressed. In addition, she developed the methodology for data collection and was actively involved in conducting surveys and interviews. Mada-o Puteh played a crucial role in collecting and validating field data. With her expertise in data processing techniques, He were responsible for analyzing the qualitative data. She also contributed to the development of research instruments. His contributions ensured that the data collected were of high quality and met the necessary scientific standards. All authors participated in discussions regarding the findings and contributed to the preparation of the final manuscript.

Funding statement

This research did not receive funding or grants from any public, commercial, or nonprofit funding agencies.

Data availability statement

The dataset generated and analyzed during the research is available from the corresponding author upon reasonable request.

Declaration of interests statement

All authors declare that they have no financial or personal interests that could influence the work presented in this manuscript.

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