



Effectiveness of Digital Instructional Modules on Health-Related Physical Fitness Among Secondary School Adolescents in Low and Middle-Income Countries: A Systematic Review

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Abstract

The persistent decline in adolescents' physical fitness has emerged as a pressing global public-health concern, with low- and middle-income countries (LMICs) facing additional structural constraints in delivering effective school-based physical education. Digital instructional modules have been proposed as flexible, scalable, and personalised alternatives, yet evidence of their impact on objectively measured health-related physical fitness in LMIC contexts remains fragmented. This study aimed to synthesise empirical evidence on the effectiveness of digital instructional modules in improving health-related physical fitness among secondary-school adolescents (aged 15–18 years). A systematic review was conducted following the PRISMA 2020 guidelines using a PICO-based search of Scopus (2021-2026), complemented by ERIC and DOAJ. Of 354 initial records, ten studies met the eligibility criteria and were appraised using the Joanna Briggs Institute (JBI) critical-appraisal tools. Thematic synthesis revealed four intervention typologies: (i) synchronous online classes, (ii) blended learning, (iii) flipped learning, and (iv) mobile-application-based learning, including digitally delivered high-intensity interval training (HIIT). Synchronous, blended, and flipped designs produced the most consistent improvements in cardiorespiratory endurance, muscular strength, and moderate-to-vigorous physical activity (MVPA), whereas mobile-app interventions yielded variable results unless embedded within structured pedagogy. Effects were largely short-term, with sustainability contingent on intrinsic motivation, habit formation, and teacher mediation. Digital technology should therefore be conceptualised as a pedagogical enabler rather than a stand-alone solution. The review contributes a context-sensitive framework for integrating digital modules into physical education in LMICs, particularly Indonesia, and offers policy and pedagogical recommendations for sustainable implementation.

Keywords: adolescent physical fitness; digital instructional modules; physical education; low- and middle-income countries; blended learning; systematic review.

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Introduction

Declining physical fitness among adolescents has become one of the defining public-health challenges of the twenty-first century. Global surveillance data indicate that more than four in five school-aged adolescents fail to meet the World Health Organization recommendation of at least 60 minutes of moderate-to-vigorous physical activity (MVPA) per day (Aubert et al., 2022; Gao & Lee, 2022). Parallel to this insufficiency in activity, cardiorespiratory fitness (CRF) a strong independent predictor of cardiometabolic and mental-health outcomes has declined at an estimated rate of 1.5-2 per cent per decade over the past four decades (Aoyama & Morisaki, 2025; Šagát et al., 2023). Accumulating cohort evidence links low adolescent CRF to elevated risks of type 2 diabetes, cardiovascular disease, and reduced life expectancy in adulthood (Ballin et al., 2025; Huang et al., 2024) underscoring the long-term societal costs of inaction.

These global trends are amplified in low- and middle-income countries (LMICs), where structural constraints further weaken the protective role of school-based physical education. Unfavourable teacher

student ratios, scarce sport facilities, restricted instructional time, and limited access to validated fitness-assessment tools collectively undermine the quality of physical-education programmes (Cagas et al., 2025; Mburu et al., 2025). In Indonesia, fewer than 30 per cent of secondary-school students meet daily MVPA recommendations, with markedly larger gaps in rural and low-socioeconomic settings (Aubert et al., 2022). The COVID-19 pandemic exacerbated these inequities by disrupting in-person instruction and intensifying sedentary behaviour during remote learning (Nqweniso et al., 2025; Zhong et al., 2022). Together, these conditions highlight an urgent need for scalable, context-sensitive instructional innovations that can mitigate structural barriers and improve adolescents' health-related physical fitness in LMIC settings.

Conceptually, school-based physical education remains the most strategic vehicle for reaching the entire adolescent population, as it offers universal access, curricular continuity, and trained instructional personnel (Bibić et al., 2025). Yet, the conventional one-size-fits-all model has shown limited capacity to accommodate students' heterogeneous abilities, motivational profiles, and learning preferences. The integration of digital technologies into physical education has therefore been advanced as a means of expanding pedagogical repertoire, individualising learning, and extending instructional time beyond the classroom (Chai, 2025; Chen et al., 2022). Web-based modules, mobile applications, flipped classrooms, and synchronous online lessons offer mechanisms for differentiated instruction, real-time feedback, and self-paced learning that conventional formats rarely afford (Ajlouni et al., 2023; Fitri & Fernandes, 2021). For LMICs, where face-to-face contact hours are constrained, such tools may function as a pedagogical multiplier rather than a substitute.

Despite expanding interest, two persistent gaps limit the policy relevance of the current evidence base. First, most published syntheses on technology-enhanced physical education have emphasised motivation, engagement, and cognitive learning outcomes rather than objectively measured fitness indicators such as CRF, muscular strength, or body composition (Chai, 2025; Kuzik et al., 2022). Without anchoring effectiveness in validated health-related fitness outcomes, claims about technology's contribution to adolescent health risk remaining conjectural. Second, available evidence is disproportionately drawn from high-income contexts, where infrastructure, teacher digital competence, and household connectivity differ substantially from LMIC realities (Chai, 2025; Murtagh et al., 2023). Transferring findings without contextual scrutiny risks producing implementation models that are technologically appealing but pedagogically unsustainable in resource-constrained schools.

Theoretically, this review is grounded in two complementary perspectives. Self-Determination Theory (Pan & Ryan, 2024) provides a motivational lens explaining why digital interventions that support autonomy, competence, and relatedness are more likely to produce durable behavioural change. The Technological Pedagogical Content Knowledge (TPACK) framework (Hikmah et al., 2023; Singh et al., 2024) offers a pedagogical lens emphasising that the effectiveness of digital tools depends on teachers' capacity to integrate technological, pedagogical, and content knowledge into coherent instructional design. Together, these frameworks reframe digital modules not as autonomous technological artefacts but as components of an integrated pedagogical system in which design quality and teacher mediation are decisive.

Within this conceptual frame, a digital instructional module is defined in the present review as a structured digital learning resource designed for use within or alongside formal physical-education instruction, encompassing LMS-based e-modules, web platforms, educational mobile applications, flipped-classroom materials, and synchronous online lessons that contain explicit instructional content and pedagogical scaffolding (Murdianto, 2021; Pradnyadewi & Wideasavitri, 2023). Passive monitoring tools for example, pedometers or step-tracking applications without instructional design are excluded from this definition because they lack a clear pedagogical pathway from technology use to fitness improvement (Sabillah & Nasrulloh, 2022).

The Indonesian context lends additional urgency to this inquiry. As one of the largest adolescent populations in the Global South and an active adopter of digital-transformation policy through the Merdeka Belajar curriculum (Hadi et al., 2023). Indonesia provides a strategically important setting in which evidence-informed integration of digital modules could shape national physical-education practice. However, without robust synthesis grounded in objectively measured outcomes, policy initiatives risk being driven by enthusiasm for technology rather than by demonstrable effects on student fitness.

This systematic review therefore addresses a clearly delimited research question: How effective are digital instructional modules in improving objectively measured health-related physical fitness among secondary-school adolescents (15-18 years) in LMIC contexts, and which intervention features and contextual factors moderate their effectiveness? The review offers three contributions. Conceptually, it advances a pedagogy-centred interpretation of digital effectiveness, anchored in SDT and TPACK. Methodologically, it applies PRISMA 2020 with explicit quality appraisal, transparent search reporting, and a thematic-synthesis approach. Practically, it generates context-sensitive recommendations for LMIC physical-education policy and classroom practice, with particular attention to Indonesia

Method

Research Design

A systematic review was conducted following the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines (Page et al., 2021). The review protocol was developed a priori to ensure transparency, reproducibility, and methodological rigour. A systematic review was considered the most appropriate design because the research question concerns the synthesis of empirical evidence across heterogeneous interventions, populations, and outcome measures, and because no prior synthesis has examined objectively measured fitness outcomes of digital instructional modules within LMIC secondary schools (Chai, 2025; Kuzik et al., 2022).

Review Question and PICO Framework

The review was guided by the following question: Are digital instructional modules more effective than conventional physical-education delivery in improving objectively measured health-related physical fitness among secondary-school adolescents (15–18 years) in LMICs? The Population, Intervention, Comparator, Outcome (PICO) framework operationalised this question as follows:

Table 1. PICO Framework

P (Population)	Secondary-school adolescents aged 15–18 years enrolled in physical-education classes, originally restricted to LMIC settings (World Bank classification) and subsequently extended post-hoc to include HIC studies with clear LMIC transferability (see section on Protocol Adjustments).
I (Intervention)	Digital instructional modules embedded within physical-education programmes, including LMS-based e-modules, web-based platforms, educational mobile applications, flipped classrooms, blended learning, synchronous online lessons, and app-based HIIT delivered with pedagogical scaffolding.
C (Comparator)	Conventional (in-person, non-digital) physical-education instruction or another active comparator.
O (Outcomes)	At least one objectively measured health-related physical-fitness component (cardiorespiratory endurance, muscular strength, muscular endurance, flexibility, body composition, or MVPA) assessed with validated instruments (e.g., FitnessGram, EUROFIT, Indonesian TKJI, accelerometry, 20-m shuttle-run).

Information Sources and Search Strategy

The primary database was Scopus, selected for its broad multidisciplinary coverage of peer-reviewed journals in education, health, and sport sciences and for its comprehensive indexing of LMIC scholarship. To strengthen LMIC representation, supplementary searches were performed in ERIC (educational research), the Directory of Open Access Journals (DOAJ), and Garuda (Indonesian national index). The search was conducted in April 2026 and applied to the title, abstract, and keyword fields (TITLE-ABS-KEY) using a PICO-aligned Boolean string: TITLE-ABS-KEY ("secondary school"OR "high school"OR "adolescent*"OR "student*") AND ("e-module"OR "electronic module"OR "digital module"OR "web-based learning module"OR "mobile-based learning"OR "online learning module" OR "interactive digital module"OR "flipped classroom"OR "blended learning") AND

("physical fitness"OR "physical education"OR "health-related fitness"OR "cardiorespiratory*"OR "physical activity")) AND PUBYEAR > 2020 AND PUBYEAR < 2027 AND LIMIT-TO (DOCTYPE, "ar") AND LIMIT-TO (LANGUAGE, "English").

The 2021-2026 publication window was selected for three reasons. First, this period coincides with the rapid global expansion of digital learning following the COVID-19 pandemic, during which instructional technology in physical education matured beyond pilot stages. Second, it captures the most recent generation of mobile and LMS-based platforms, ensuring contemporary relevance for policy and practice. Third, restricting the window mitigates technological obsolescence bias, whereby pre-2020 digital tools differ substantially from current platforms in interface, pedagogy, and accessibility. Reference lists of all included studies and relevant reviews (Chai, 2025; Sargent & Calderón, 2021) were screened for additional eligible reports.

Eligibility Criteria

Inclusion and exclusion criteria were specified a priori (Table 2). Eligible designs were limited to those permitting valid causal inference about intervention effectiveness: randomised controlled trials (RCTs), quasi-experimental designs, and pre-test/post-test designs with a comparison group. This restriction reflects the review's focus on effectiveness rather than feasibility or acceptability. Studies were required to report at least one objectively measured fitness outcome to ensure that conclusions about physiological effects rest on validated instruments rather than self-report. Single-group descriptive studies, qualitative inquiries, opinion pieces, and conference abstracts were excluded.

Table 2. Inclusion and Exclusion Criteria

Aspect	Inclusion	Exclusion
Design	RCT, quasi-experimental, or pre-test/post-test with control group	Single-group, qualitative, descriptive, review, editorial, or conference abstract
Population	Adolescents aged 15–18 years in secondary schools	Outside the 15–18 age range, university or primary-school populations
Intervention	Digital instructional module with pedagogical content (e-module, web-based, mobile-app, blended, flipped, synchronous online, app-based HIIT)	Passive monitoring tools (e.g., step-trackers, pedometers, social media) without instructional content
Comparator	Conventional physical-education instruction or active comparator	No comparator reported
Outcomes	≥1 objectively measured health-related fitness component using a validated instrument	Only self-reported outcomes or no fitness measure
Context	LMICs (primary); HICs included post-hoc where transferable	HIC-only studies with no LMIC relevance
Publication	Peer-reviewed journal article, 2021–2026, English or Indonesian	Grey literature, theses, non-peer-reviewed sources

Protocol Adjustment: Post-Hoc Inclusion of HIC Studies

Initial screening revealed a paucity of LMIC studies meeting the design and outcome criteria. To preserve analytic depth without inflating the evidence base, the protocol was transparently amended to admit HIC studies whose intervention designs, school contexts, and infrastructure assumptions were

judged transferable to LMIC settings (e.g., low-equipment HIIT protocols, web-based modules requiring only basic devices). The decision and its rationale were documented during screening, and study origin (LMIC vs HIC) is reported explicitly in the synthesis to allow readers to weigh transferability. This amendment is consistent with PRISMA 2020 guidance on transparent reporting of protocol deviations.

Study Selection

Records were exported to Mendeley for deduplication and then to Rayyan for blinded title-and-abstract screening by two reviewers working independently. Full texts of potentially eligible studies were retrieved and assessed against the eligibility criteria. Disagreements were resolved by discussion and, where necessary, by a third reviewer. The selection flow, presented in Figure 1, followed PRISMA 2020. Of 354 records identified, 197 were excluded by automation tools (duplicates and clearly off-topic records). The remaining 157 records were screened by title and abstract; 145 were excluded for not meeting the eligibility criteria. Twelve full-text reports were sought, two of which could not be retrieved. Ten studies were assessed in full text and all ten satisfied the eligibility criteria, forming the final synthesis ($k = 10$).

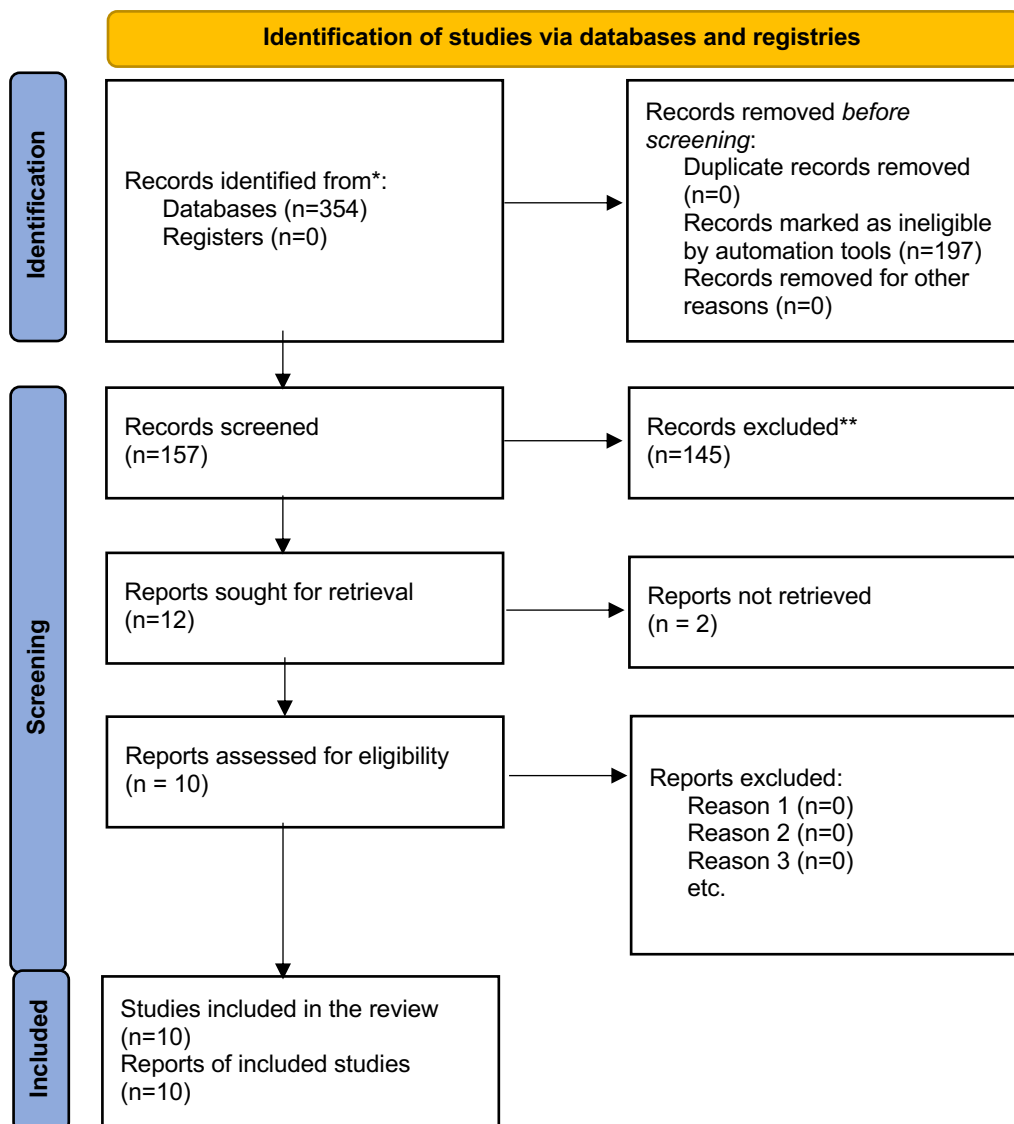


Figure 1. PRISMA 2020 Flow Diagram of Study Selection (k=10 studies included)

Data Extraction

A standardised extraction form was piloted on three studies and refined before full extraction. Two reviewers independently extracted: bibliographic data; country and income classification; sample characteristics, intervention type and dose; comparator; outcome measures and instruments; key findings; and effect direction. Discrepancies were reconciled through consensus. Authors of two studies were contacted for clarification regarding sample composition; one responded.

Quality Appraisal and Risk-of-Bias Assessment

Methodological quality was appraised using the Joanna Briggs Institute (JBI) critical-appraisal tools, applying the RCT checklist (13 items) for randomised studies and the quasi-experimental checklist (9 items) for non-randomised designs (Tufanaru et al., 2020, as cited in JBI Manual for Evidence Synthesis). Each item was rated Yes/No/Unclear/Not Applicable. Two reviewers independently completed the appraisal; inter-rater agreement was substantial ($\kappa = 0.78$), and discrepancies were resolved through discussion. Studies meeting ≥ 70 per cent of applicable items were classified as high quality; 50-69 per cent as moderate; and < 50 per cent as low. Of the ten included studies, six were rated high quality, three moderate, and one low. The low-quality study was retained but its findings are interpreted with explicit caution in the synthesis. Common sources of bias included incomplete reporting of allocation concealment, limited blinding (an inherent constraint in physical-education trials), and short follow-up periods.

Data Synthesis

Owing to heterogeneity in intervention types, outcome measures, and durations, a thematic synthesis was conducted rather than meta-analysis. Three-stage approach line-by-line coding, development of descriptive themes, and generation of analytical themes interventions were grouped by modality (synchronous online, blended, flipped, mobile-app, app-based HIIT). Within each group, the direction, magnitude, and consistency of effects were compared, and moderating factors (teacher engagement, duration, pedagogical design, contextual constraints) were identified. Patterns, consistencies, and contradictions are reported and interpreted in the Results and Discussion.

Bibliometric Mapping

To complement the thematic synthesis, a bibliometric co-occurrence analysis of author keywords from the included studies was conducted using VOSviewer (version 1.6.20). The analysis aimed to identify the conceptual structure, dominant themes, and emerging trends within research on digital-based physical education and adolescent physical fitness. By mapping co-occurrence relationships among keywords, the analysis provides a visual representation of how key concepts are interconnected across the reviewed literature. In the network visualization, node size reflects the frequency of keyword occurrence, while the connecting lines indicate the strength of relationships between terms.

Additionally, overlay visualization was employed to examine temporal developments in the literature, where node colours represent the average publication year of studies and illustrate shifts in research focus over time (Figure 2). This bibliometric analysis serves as a complementary interpretive layer that supports, but does not replace, the thematic synthesis of intervention effectiveness. Through this combined approach, the study provides a broader understanding of both the effectiveness patterns and the evolving research landscape of digital instructional interventions in physical education.

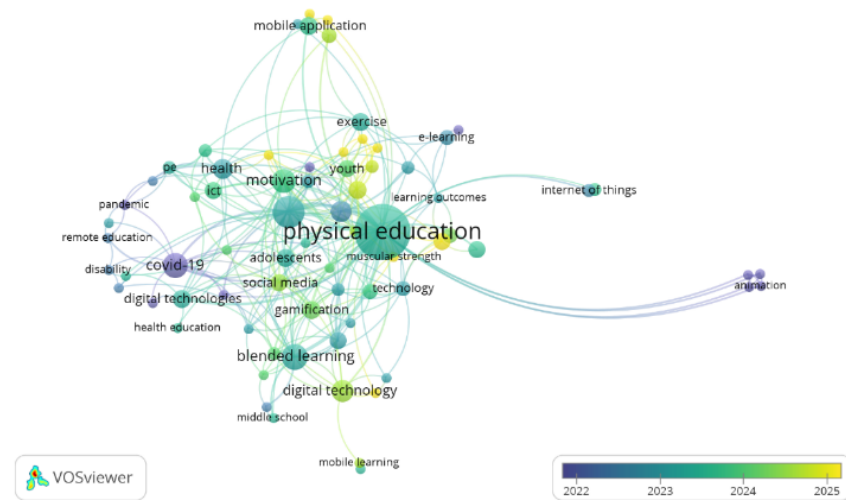


Figure 2. VOSviewers Overlay visualization of keyword co-occurrence in the included studies

Results and Discussion

Result

Ten studies published between 2021 and 2025 met the predefined eligibility criteria and were included in the final synthesis, representing a combined sample of approximately 2,400 secondary school adolescents (Table 2). The methodological designs consisted of six randomized controlled trials (RCTs), three quasi-experimental studies, and one longitudinal cohort study with comparison conditions, indicating that most included studies employed relatively rigorous approaches to evaluate intervention effectiveness. In terms of geographical distribution, three studies were conducted in low- and middle-income countries (LMICs), while seven studies originated from high-income countries (HICs). The inclusion of HIC studies was carried out under the post-hoc transferability criterion due to the limited availability of eligible studies from LMIC settings, although this may limit the generalizability of findings to developing-country contexts.

The duration of interventions ranged from six to twenty weeks, with a median intervention period of ten weeks. Based on instructional characteristics, the interventions were categorized into four main typologies: synchronous online physical education classes ($k = 2$), blended and flipped learning approaches ($k = 2$), mobile application-based interventions including fitness and step-tracker applications ($k = 5$), and digitally delivered high-intensity interval training (HIIT) programs ($k = 1$). Across all studies, at least one objectively measured physical fitness outcome was assessed using validated instruments, including indicators of cardiorespiratory endurance, muscular strength, body composition, and physical activity levels. Overall, the findings demonstrate increasing research interest in the integration of digital instructional strategies within physical education, although the forms and effectiveness of interventions varied considerably across studies.

Table 3. Summary of the ten included studies

Author (Year)	Country (Income)	Design	Digital Intervention	Duration	Key Findings	Effect
Lee et al., (2021)	South Korea (HIC)	RCT	Synchronous online PE class (Tabata)	10 weeks	Improvements in muscular strength, balance, and muscle mass	Positive

Latino et al., (2021)	Italy (HIC)	RCT	Synchronous e-learning module	8 weeks	Gains in physical fitness, motivation, and concentration	Positive
Chaloupský et al., (2021)	Czech Republic (HIC)	Longitudinal	Blended learning with fitness tracker	3 years	Increased participation and PA motivation	Positive
Maněnová et al., (2022)	Czech Republic (HIC)	Quasi-experimental	Mobile-app in PE	10 weeks	Higher intrinsic motivation and motor performance	Positive
Killian et al., (2022)	USA (HIC)	Quasi-experimental	Flipped learning	1 semester	Increased MVPA duration	Positive
Mateo-Orcajada et al., (2024)	Spain (HIC)	Longitudinal	Mandatory step-tracker app	10 weeks	Improvements in PA, body composition, fitness	Positive
Ponce-Ramírez et al., (2024)	Spain (HIC)	Quasi-experimental	Mobile step-tracker (unsupported)	10 weeks	No significant difference; low adherence	Neutral
Mateo-Orcajada, Ponce-Ramírez, et al., (2024)	Spain (HIC)	RCT	Step-tracker vs conventional	10 weeks	Limited muscular-strength gains on selected indicators	Partial
Mateo-Orcajada, Vaquero-Cristóbal, et al., (2024)	Spain (HIC)	RCT	Mandatory vs non-mandatory step-tracker	20 weeks	Gains in early phase, not sustained at follow-up	Temporary
Vanhelst et al., (2025)	France (HIC)	RCT	App-based personalised HIIT (METs-Up)	6 weeks	Improved CRF and reduced BMI	Positive

Note. CRF = cardiorespiratory fitness; MVPA = moderate-to-vigorous physical activity; BMI = body mass index; HIC = high-income country; PA = physical activity

Discussion

This systematic review synthesised ten experimental and quasi-experimental studies on the effectiveness of digital instructional modules in improving objectively measured health-related physical fitness among secondary-school adolescents. Three interrelated insights emerge from the synthesis: digital modules are effective when embedded in coherent pedagogical design; their effectiveness varies systematically with intervention modality and teacher mediation; and their effects are predominantly short-term, raising critical questions about sustainability. The following discussion interprets these findings through the lenses of SDT and TPACK and considers their implications for LMIC physical-education systems.

Pedagogy, Not Technology, Drives Effectiveness

The most theoretically consequential finding is that the technological modality itself does not determine fitness outcomes; the pedagogical structure surrounding the technology does. Synchronous, blended, and flipped designs converge in offering structured guidance, teacher feedback, and clear learning tasks, whereas unsupported mobile-application use lacks these elements and consistently underperforms. This pattern challenges techno-centric narratives of digital transformation and aligns with Fawns, (2022) entangled pedagogy perspective, which holds that technology and pedagogy co-constitute the learning experience and cannot be analytically separated. The TPACK framework offers a complementary lens: effective integration depends on teachers' capacity to coordinate technological,

pedagogical, and content knowledge into coherent design. Where this coordination is weak as in the unsupported step-tracker trials even technologically sophisticated tools fail to produce health benefits.

Why Some Modalities Work and Others Falter

The differential effectiveness across modalities can be explained by three mechanisms. First, social presence the perceived immediacy of teacher–student interaction is highest in synchronous and blended designs and lowest in autonomous mobile-app use; it appears to mediate both motivation and skill acquisition. Second, instructional time allocation differs by modality: flipped learning systematically reallocates time from cognitive transmission to active practice, an arrangement particularly advantageous in LMIC schools with constrained physical-education contact hours. Third, feedback specificity is highest when teachers observe and correct movement in real time, and lowest when feedback is generic and algorithmic, as in commercial step-trackers. Together, these mechanisms explain why two interventions employing the same technology can produce divergent outcomes depending on pedagogical design.

Sustainability and the Internalisation of Motivation

The fragility of intervention effects beyond the implementation period is best understood through Self-Determination Theory. Effects that depend on external structure mandatory app use, scheduled sessions, instructor monitoring tend to dissipate when those structures are withdrawn (Mateo-Orcajada, Ponce-Ramírez, et al., 2024). Sustained behaviour change requires the internalisation of motivation: the transformation of externally regulated participation into autonomously regulated engagement through experiences of autonomy, competence, and relatedness (Işıkgöz, 2025; Murray et al., 2020). Practically, this implies that digital modules should be designed to foster choice, mastery experiences, and social connection rather than to enforce compliance. The persistent gap between short-term efficacy and long-term maintenance also points to a methodological priority for future research: trials should incorporate follow-up assessments of at least six to twelve months post-intervention.

The Teacher as the Critical Pedagogical Agent

Teacher involvement emerges as the single most consistent predictor of intervention success across the included studies. This finding repositions the teacher not as a peripheral facilitator in digital learning but as the central pedagogical agent whose digital competence, instructional design, and relational skill mediate technology's effects on student fitness. Investments in teacher capacity particularly in TPACK-aligned professional development should therefore be considered a non-negotiable component of any digital physical-education initiative (Mu'arifin & Kurniawan, 2021; Nugraha et al., 2024). In LMIC contexts where teachers are often the most stable element of the educational ecosystem (whereas devices, software, and connectivity may be unreliable), prioritising teacher development is also a strategically sound investment of scarce resources.

Implications for LMIC Contexts and Indonesia

Three implications follow for LMIC physical-education systems, with particular relevance to Indonesia. First, blended and flipped designs should be prioritised over fully online or unsupported app-based models, as they balance pedagogical benefits with realistic infrastructure demands. Second, the Merdeka Belajar curriculum's emphasis on flexible, learner-centred pedagogy offers a policy window for integrating digital modules; however, implementation should be accompanied by structured teacher development programmes that build TPACK competencies specific to physical education. Third, evidence generation should be localised: LMIC-based trials with objectively measured outcomes and longer follow-up periods are urgently needed to address the geographic imbalance in the current evidence base.

Strengths and Limitations

Strengths of this review include adherence to PRISMA 2020, explicit PICO operationalisation, dual independent screening and appraisal, transparent reporting of protocol amendments, and a thematic synthesis attentive to both consistencies and contradictions. Limitations should also be acknowledged. The relatively small number of included studies ($k = 10$) reflects the nascent state of the LMIC evidence

base and constrains the generalisability of findings. The post-hoc inclusion of HIC studies, although transparently documented, introduces transferability questions that future LMIC-based research must resolve. Heterogeneity in interventions and outcomes precluded meta-analysis; the thematic synthesis is interpretive rather than quantitative. Finally, restriction to English- and Indonesian-language sources may have excluded relevant evidence published in other languages

Conclusion

Digital instructional modules can meaningfully improve health-related physical fitness among secondary-school adolescents, but their effectiveness is pedagogically rather than technologically determined. Synchronous, blended, and flipped designs produce the most consistent gains; mobile-application interventions succeed only when embedded in structured pedagogy with teacher mediation; and effects rarely persist after programme withdrawal. Theoretically, the review reframes digital modules as components of an entangled pedagogical system in which design quality, teacher digital competence, and motivational internalisation are decisive a position grounded in Self-Determination Theory and TPACK. Practically, it offers LMIC policymakers and educators, particularly in Indonesia, a clear directive: invest in blended and flipped designs, prioritise teacher professional development, and design for the internalisation of motivation rather than for short-term compliance. Future research should generate LMIC-based experimental evidence, employ longer follow-up periods to evaluate sustainability, and develop pedagogical frameworks specific to digital physical education in resource-constrained settings.

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