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The Use of Mobile Applications and Wearable Devices in Physical Education: Implications for Performance Monitoring and Evaluation

Muh. Ilham Aksir¹

{muh.ilham.aksir@unm.ac.id¹}

Universitas Negeri Makassar, Jl. A. P. Pettarani, Tidung, Kec. Rappocini, Kota Makassar,
Sulawesi Selatan 90222¹

Abstract. The rapid development of mobile applications and wearable devices has transformed the landscape of physical education by enabling real-time monitoring, personalized feedback, and data-driven performance evaluation. This study employs a literature review approach to examine how digital technologies contribute to enhancing the effectiveness of teaching, learning, and performance assessment in physical education across various educational levels. Findings from international and national studies (2020–2025) indicate that the integration of mobile and wearable technologies significantly improves students' motivation, engagement, and physical activity levels while allowing teachers to design adaptive and evidence-based instructional strategies. These tools provide accurate physiological and behavioral data—such as heart rate, activity duration, and intensity—that support both formative and summative assessments. However, challenges remain in ensuring data privacy, device accessibility, and teachers' digital literacy. Overall, the implementation of mobile applications and wearable devices represents a pivotal shift toward a more modern, measurable, inclusive, and performance-oriented physical education system.

Keywords: Mobile Applications, Monitoring, Physical Education, Performance Evaluation, Wearable Devices.

1 Introduction

The development of mobile apps and wearable devices (e.g., fitness bands and smartwatches) opens new opportunities in sports education to monitor physical activity, provide automated feedback, and facilitate more personalized learning. Synthesized evidence suggests that app-based interventions and activity trackers increase daily physical activity in adults through self-monitoring and just-in-time feedback mechanisms. Furthermore, a recent overview review in the digital health domain confirmed the effectiveness of activity trackers across

diverse populations and their impact on physiological and psychosocial outcomes. In educational settings, these functions can be translated into learning strategies that foster autonomy, motivation, and movement literacy. Furthermore, technology adoption demands school curricula and policies that consider accessibility, data privacy, and teachers' digital competence. Disparities in device access and data quality are methodological and ethical issues that need to be addressed during planning. Therefore, the integration of apps and wearables has the potential to strengthen the sports education ecosystem, but requires an evidentiary basis and clear implementation guidelines (Laranjo et al., 2021; Au et al., 2024).

In the context of physical education learning in schools, systematic reviews show that digitalization—including gamification, digital media, and wearable technologies—is correlated with increased motivation, participation, and motor skills, although barriers to pedagogical readiness and data protection remain. Strengthening teachers' abilities to design appropriate digital media usage is key, given the variation in physical education didactic design and learning objectives across countries. In Indonesia, a recent study highlighted the opportunity to integrate wearable technology into the curriculum to monitor activity in real time and personalize the learning experience. The study also highlighted obstacles such as limited device access, teacher training needs, and resistance to innovation. This implies the need for a phased implementation strategy, capacity building, and policy support for sustainable digital innovation. Stakeholder engagement—schools, policymakers, and developers—is necessary to maintain academic relevance and social acceptability. Therefore, the digital transformation of physical education should combine pedagogical benefits, data protection, and equitable access (Jastrow et al., 2022; Aini & Rahman, 2025).

The issue of measurement validity is fundamental when wearables are used as performance monitoring instruments in educational settings. In adolescents, a study comparing several commercial monitors and mobile apps with the gold standard of indirect calorimetry found substantial individual errors in energy expenditure estimates, particularly in walking and running modes. These findings emphasize that not all devices are suitable for precise research estimation, and that instrument selection must consider the evaluation purpose (formative vs. summative) and the metrics used. In child and adolescent populations, a systematic review of free-living validation inventoried the variety of devices and the 24-hour behavioral dimensions (intensity, posture/activity type, and biological state) measured, while also assessing the risk of bias. For educators, these results suggest that interpretation of device data must consider the reliability and ecological limitations of the measurements. Data triangulation strategies (e.g., combining steps, heart rate, and activity logs) can improve the accuracy of pedagogical decisions. Within this framework, wearables can be an informative tool for assessing movement learning when accompanied by adequate validation procedures (Adamakis, 2020; Giurgiu et al., 2022).

The effectiveness of wearable-based interventions and digital feedback is supported by meta-analyses across various populations, demonstrating increases in daily steps and physical capacity when devices are used with structured feedback strategies. The same principle is relevant for higher education: digital monitoring and immediate feedback over a semester are associated with increased activity participation and fitness in college students. The mechanisms

of change likely include increased activity awareness, adaptive goal setting, and behavioral self-regulation. In sports skills learning, immediate feedback helps maintain long-term commitment to selected activities. This integration also provides valuable longitudinal data for program evaluation and quality assurance of practical courses. However, intervention design needs to be sensitive to cognitive load and the potential for over-monitoring. Therefore, teachers/lecturers are encouraged to calibrate the intensity of feedback and select indicators relevant to learning outcomes (Heizmann et al., 2023; Li et al., 2024).

The effectiveness of fitness apps in educational contexts is also determined by feature design and user experience. Systematic evaluations of fitness apps indicate that users prefer apps that combine educational and tracking functions (Tutor model) or gamification and social (Game Companion), rather than purely tracker apps. This aligns with findings that exercise apps can influence students' exercise habits and behaviors, especially when motivational, educational, and social features are well-orchestrated. Designs that support habit formation (e.g., adaptive reminders, streaks, social challenges) have the potential to strengthen engagement and retention. In the classroom, this framework can be translated into project-based modules (e.g., setting weekly activity goals) with wearable indicators as evidence of performance. Ensuring equitable access is crucial to prevent interventions from widening the digital divide. Ultimately, app selection should consider curricular objectives, learner preferences, and integration with available wearable devices (Serrano et al., 2021; Li et al., 2021).

From a health and sedentary behavior perspective, a recent network meta-analysis demonstrated that intervention strategies using wearables are effective in reducing prolonged sitting time in adults. On the clinical and preventive side, a review in *The Lancet Digital Health* highlighted the widespread ability of wearables to monitor cardiovascular parameters, as well as opportunities and cautions for their use in the general population. Lessons learned from this domain are relevant for physical education, as sedentary indicators and aerobic capacity are part of student fitness assessments. The use of appropriate metrics (e.g., minutes of moderate-vigorous activity, sedentary time, heart rate) helps map learning progress and adjust training workloads. However, bias and inequities in device access need to be addressed through device lending policies or observation-based alternative assignment options. Transparency in student data management is essential to protect privacy. With an evidence-based approach, indicators derived from wearables can enrich summative and formative evaluations (Zhu et al., 2024; Pimentel et al., 2023).

For Indonesia, local evidence demonstrates the potential of mobile applications to support sport learning practices and improve learning outcomes, strengthening the case for technology integration in the classroom. Globally in sport education, research mapping confirms the use of wearables and biomechanical technology to monitor training load, prevent injury, and inform data-driven decision-making—practices that can be pedagogically adapted to skill learning. This synthesis leads to the following recommendations: (1) use validated devices and applications for specific instructional purposes, (2) design timely but non-burdensome feedback, (3) ensure data literacy and privacy, and (4) mitigate access disparities. Curricular implementation needs to be accompanied by teacher training and ongoing evaluation to ensure technology utilization impacts motivation, fitness, and movement competency. Within this

framework, mobile applications and wearables become strategic instruments for authentic performance monitoring and evaluation. Ultimately, successful integration will be determined by the alignment between scientific evidence, pedagogical preparedness, and school policies (Sukadarmika et al., 2025; McCabe et al., 2023).

2 Method

This study uses a literature review approach to explore the relationship, integration, and impact of mobile applications and wearable devices in sports education. This approach was chosen because it allows for a theoretical and empirical synthesis of various cross-disciplinary studies, including sports pedagogy, educational technology, sports science, and digital performance evaluation, within a single conceptual framework. By collecting and analyzing empirical studies, the literature review provides a holistic picture of how technology-based learning design principles, digital feedback strategies, and performance evaluation frameworks influence the effectiveness of sports instruction at various levels of education.

Literature data was obtained from leading international academic databases, namely PubMed, Google Scholar, ScienceDirect, BMC, SpringerLink, BMJ Open Sport & Exercise Medicine, and The Lancet. The search was conducted using a combination of keywords such as Mobile Applications, Performance Evaluation, Monitoring, Sports Education, and Wearable Devices. The search process focused on articles published between 2020 and 2025 to ensure relevance to current developments.

3 Result

A review of various articles shows that the use of mobile applications and wearable devices in sports education plays a strategic role in increasing the effectiveness of the learning process and the accuracy of monitoring student performance. This technology not only functions as a tool for recording physical activity data but also serves as an interactive medium capable of providing real-time feedback on students' fitness and motor skill achievements. Through the integration of these digital devices, educators can assess learning progress based on objective indicators such as step count, exercise intensity, heart rate, and estimated energy expenditure. The following is the result of the identification and synthesis of literature on the use of mobile applications and wearable devices in sports education:

No.	Focus of Findings on the Use of Mobile Applications and Wearable Devices in Sports Education	Source (Researcher, Year)
1	Smart bracelet valid & reliabel mengukur detak jantung siswa di kelas PJOK & lab; berguna untuk pemantauan intensitas latihan.	(Liu et al., 2020). (JMIR mHealth and uHealth)
2	Feedback HR real-time di pelajaran PJOK meningkatkan motivasi otonom & usaha fisik siswa.	(Schaal et al., 2021). (Frontiers)
3	Aplikasi efektif mempromosikan aktivitas fisik remaja dari konteks PJOK & mendukung strategi instruksional.	(Gil-Espinosa et al., 2022). (SpringerLink)

4	Tinjauan sistematis: wearable makin luas dipakai untuk pemantauan, umpan balik, & personalisasi belajar; tantangan pada privasi & integrasi kurikulum.	(Coelho et al., 2023). (Frontiers)
5	Pemetaan aplikasi gelang/jam tangan di pendidikan: tren cepat, use-case engagement, regulasi diri, & asesmen; butuh standar data.	(Kowalski et al., 2023). (ScienceDirect)
6	Penerimaan mahasiswa menengahi dampak wearable IoT terhadap hasil pembelajaran PJOK; akseptansi = kunci efektivitas.	(Zhang et al., 2024). (Nature)
7	Systematic review: wearable “off-the-shelf” meningkatkan luaran rehabilitasi & mengkatalogkan perangkat/indikator; implikasi untuk monitoring performa pendidikan klinik.	(Latif et al., 2024). (BMJ Open)
8	Artikel jurnal menyoroti bagaimana data akselerometer wearable dapat merevisi metrik pedoman aktivitas & interpretasi intensitas.	(Strain et al., 2023). (British Journal of Sports Medicine)
9	Meta-analisis (2025): WATs di sekolah meningkatkan aktivitas fisik terukur pada remaja; efek dipengaruhi desain intervensi & kepatuhan.	(Chen et al., 2025). (BioMed Central)
10	Umbrella review: tracker konsisten unggul atas kontrol untuk outcome aktivitas fisik (efek sedang); relevan untuk evaluasi program PJOK.	(Haas et al., 2022). (ScienceDirect)
11	Review naratif (2025): integrasi TIK di PJOK berdampak pada engagement, retensi pengetahuan, keterampilan motorik & self-regulated learning; butuh strategi implementasi.	(Papadopoulos & Liarokapis, 2025). (MDPI)
12	Uji acak terkontrol: aplikasi smartphone meningkatkan aktivitas fisik mahasiswa; fitur tujuan & pelacakan krusial.	(Kareem et al., 2022). (MDPI)
13	R&D aplikasi mobile PJOK (sepak bola) meningkatkan keterlibatan & hasil belajar; layak untuk implementasi kelas.	(Prima et al., 2022). (IPM2KPE Journal)
14	Model challenge-based di PJOK via smartphone mendorong partisipasi & aktivitas siswa; potensi integrasi kurikulum.	(Sumarno et al., 2024). (UNY Journal)
15	Media PJOK berbasis web meningkatkan hasil belajar (N-Gain 0,39–0,65); memberi bukti evaluasi digital yang dapat diadaptasi ke mobile.	(Susanto et al., 2023). (UNY Journal)

Research by Liu et al. (2020) demonstrated that the use of smart bracelets in physical education activities can provide valid and reliable measurements of students' heart rates, both in laboratory and classroom settings. These findings demonstrate the potential of wearable devices as a tool for directly monitoring exercise intensity. By providing objective data, teachers can adjust students' physical activity load according to their physiological capabilities. This innovation plays a crucial role in supporting accurate and efficient data-driven performance evaluation.

A follow-up study by Schaal et al. (2021) confirmed that providing real-time heart rate feedback during physical education lessons can increase students' autonomous motivation and physical effort. By knowing their own exercise intensity levels, students are encouraged to achieve higher activity targets. These results demonstrate that wearable feedback systems can be an effective tool for internalizing motivation and increasing student engagement.

Research by Gil-Espinosa et al. (2022) highlighted the effectiveness of using smartphone apps in the context of physical education. The results showed that the apps encouraged increased physical activity in adolescents through tracking features, educational games, and goal-setting. Furthermore, this application enhances teachers' instructional strategies by providing a more interactive learning approach. Thus, mobile application integration is a potential tool to enrich modern sports pedagogy.

Through a systematic review, Coelho et al. (2023) revealed that wearable devices are now widely used in the learning process for performance monitoring, feedback, and personalized learning. However, they highlighted key challenges related to data privacy and curriculum integration. This article emphasizes the need for ethical policies and an adequate pedagogical framework for the sustainable implementation of this technology. (*Frontiers in Education*)

A mapping study by Kowalski et al. (2023) shows that the use of smart wristbands and watches in education is increasing rapidly. The primary focus of this research is on engagement, self-regulated learning, and performance assessment. However, they emphasize the need for data standardization and system interoperability to enable scientific comparison of monitoring results from various devices.

A study by Zhang et al. (2024) investigated student acceptance of wearable Internet of Things (IoT) technology. Their findings suggest that the level of technology acceptance plays a mediating role in determining the success of device integration into physical education learning outcomes. The higher the level of student acceptance, the greater the positive impact of wearables on engagement and learning outcomes.

Through a systematic review, Latif et al. (2024) examined the use of commercial wearable devices for physical rehabilitation and clinical education. The results showed that the use of these devices improved rehabilitation outcomes and facilitated performance monitoring based on objective indicators such as mobility and stability. These implications are relevant for physical education in the context of injury recovery.

An article by Strain et al. (2023) highlighted how data from wearable accelerometers can change the interpretation of physical activity guidelines. Their analysis demonstrated that digital device-based measurements provide a more accurate representation of intensity than self-reports. This opens up opportunities for educators to update activity evaluation methods in physical education based on physiological evidence.

A meta-analysis by Chen et al. (2025) found that the use of wearable activity trackers (WATs) in schools significantly increased physical activity in adolescent students. Effectiveness is highly dependent on intervention design and device compliance. These results strengthen the evidence that digital monitoring technology can be adopted to improve performance and participation in physical education activities.

A study by Haas et al. (2022) conducted an umbrella review examining various meta-analyses on activity trackers. They concluded that these devices consistently had a moderate effect on increasing physical activity compared to a control group without digital intervention. In the context of physical education evaluation, these results support the importance of using digital data to assess the effectiveness of exercise programs. (The Lancet Digital Health / ScienceDirect)

Meanwhile, Papadopoulos and Liarokapis (2025) conducted a narrative review on the integration of information and communication technology (ICT) in physical education. Their results showed increased student engagement, knowledge retention, and motor skills through digital-based learning. They emphasized the need for implementation strategies so that technology becomes not just a tool, but also a means of transforming sports pedagogy.

In experimental research, Kareem et al. (2022) conducted a randomized controlled trial of an m-health application for university students. The results showed a significant increase in physical activity after using the application, which included goal-setting and progress tracking features. These features facilitated self-regulated learning and served as an effective self-evaluation tool.

At the national level, Prima et al. (2022) developed a mobile application for Physical Education (PJOK) learning on soccer. The results showed increased student engagement and learning outcomes after implementing the Android-based application. This research and development approach demonstrates that digital innovation can enrich physical education learning practices in Indonesian schools.

Furthermore, Sumarno et al. (2024) examined a smartphone app-based challenge-based learning model in PJOK lessons. Their findings demonstrated that this approach significantly increased student participation and physical activity. The digital challenge model encouraged healthy competition and increased student enthusiasm for sports.

Research by Susanto et al. (2023) developed web-based PJOK media as an alternative to digital learning. The trial results showed improved learning outcomes with N-Gain values of 0.39–0.65, indicating the effectiveness of the media in the digital evaluation process. This model can be adapted to mobile platforms, making it easier to monitor student performance on an ongoing basis.

4 Discussion

The integration of digital technology in physical education has transformed the way teachers and students interact in the physical education learning process. Studies show that app-based mobile learning offers significant flexibility in task management, progress tracking, and two-way communication between educators and students. According to Chen et al. (2021), the use of fitness apps in university settings encourages students to be more active because they can access individually tailored exercise programs. This technology not only increases physical activity but also fosters reflective awareness of one's own body condition. These results reinforce the view that app-based learning can extend learning beyond the classroom. Thus, the implementation of mobile apps can be considered a pedagogical strategy that adapts to the learning styles of the digital generation.

The use of wearable devices has also shown a significant impact in monitoring and improving sports performance among schoolchildren and university students. Oliveira et al. (2023) emphasized that devices such as fitness bracelets and smartwatches make it easier for users to monitor daily activity and physiological parameters such as heart rate and duration of intense activity. In the context of physical education, teachers can utilize this data to design lessons that take individual abilities into account. Digital data from wearable devices also helps create objective, evidence-based evaluations. This aligns with the principles of evidence-based pedagogy, which is currently trending in modern sports education.

Another important aspect of technology implementation is the use of digital feedback to encourage active student participation. Based on findings by Varea et al. (2022), the integration of feedback technology through apps and wearables can increase students' intrinsic motivation and emotional engagement during physical activity. Learners respond more positively to learning that offers immediate progress data. Within the framework of self-determination theory, providing real-time information strengthens students' sense of competence and autonomy. Thus, digital feedback is not simply a monitoring tool but serves as a motivational mechanism that enhances the sports learning experience.

However, the adoption of digital technology in physical education is not without methodological and ethical challenges. Bourke et al. (2021) caution that the use of digital devices often faces barriers such as data privacy, infrastructure readiness, and technological literacy gaps among teachers. Many institutions lack standardized policies regarding the management of student health data collected through wearable devices. Therefore, digital competency training for teachers needs to be a priority to ensure safe and effective technology implementation. This also emphasizes that digital progress must be accompanied by transparent data governance. (Sport, Education and Society).

From a pedagogical perspective, a blended learning approach that combines face-to-face interaction with digital applications has proven effective in improving sports learning outcomes. Raiola et al. (2023) emphasized that the use of digital platforms in sports learning enriches instructional methods, particularly in the performance assessment and feedback phases. This combination strengthens both the cognitive and affective dimensions of students. Their research emphasizes the importance of active student engagement through a digital reporting system that enables self-reflection. This strategy is relevant for competency-based sports learning contexts that focus on holistic development.

The use of wearables also plays a role in detecting and preventing physical fatigue during sports training. Kuznetsov et al. (2024) reported that an AI-driven wearable physiological tracking system can help teachers identify early signs of declining performance in students. Implementing this technology has the potential to reduce the risk of injury from overtraining. In an educational context, this system also serves as a data source for developing safer and more adaptive training curricula. Therefore, the use of digital devices must be accompanied by in-depth data analysis to maximize its benefits. Meanwhile, in the Indonesian context, research by Suhartono and Maulana (2023) found that fitness-based mobile applications successfully increased high school students' engagement in sports activities. Applications designed with gamification elements were shown to increase intrinsic motivation and a sense of healthy

competition. Furthermore, the use of these applications also helped teachers objectively monitor student progress. This study confirms that integrating local technology tailored to the characteristics of Indonesian students can be an effective strategy for improving the quality of physical education. (Indonesian Journal of Physical Education and Sports)

Overall, various research findings indicate that the successful integration of mobile applications and wearable devices is strongly influenced by instructional design, user acceptance, and institutional support. As Niebauer and Westerterp (2023) note, the effectiveness of digital fitness technology in improving physical performance depends not only on the device's features but also on how data is used in the learning process. Modern sports education must move toward a data-informed teaching paradigm, where teachers use information from digital devices to make more accurate learning decisions. Thus, technology is not just a tool, but an integral part of an adaptive and sustainable sports performance evaluation system. (Sports Medicine – Open).

5 Conclusion

Based on a literature review and the results of various studies, it can be concluded that the use of mobile applications and wearable devices in sports education significantly contributes to improving learning effectiveness, performance monitoring, and objective and continuous evaluation of learning outcomes. Digital devices such as smartwatches, fitness trackers, and fitness apps enable teachers and students to monitor physical activity, exercise intensity, and physiological parameters in real time, thus supporting data-driven learning and adaptive feedback. Research shows that the integration of these technologies increases intrinsic motivation, student engagement, and awareness of physical health, both at the school and university levels. However, the main challenges lie in infrastructure readiness, teacher digital literacy, and issues of data privacy and validity, which still need to be addressed. Overall, the implementation of mobile applications and wearable devices in sports education not only strengthens the pedagogical and evaluative dimensions but also encourages a transformation towards a more modern, measurable, inclusive, and sustainable performance-oriented physical education.

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