Innovations in Adapted Physical Education: A Systematic Literature Review

(Inovasi dalam Pendidikan Jasmani Adaptif: Sorotan Literatur Sistematik)

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ABSTRACT

This systematic literature review synthesizes contemporary evidence on innovations in adapted physical education (APE), with particular emphasis on pedagogical, technological, and interdisciplinary developments that enhance inclusive educational outcomes. Following the PRISMA 2020 framework, a comprehensive search was conducted across major databases, including Scopus, Web of Science, PubMed, ScienceDirect, and SpringerLink, covering publications from 2013 to 2023. A total of 505 records were identified, of which 50 empirical studies met the inclusion criteria after rigorous screening and quality appraisal. Data were analysed using a multidimensional thematic framework encompassing pedagogy, technology integration, innovation systems, and health-related outcomes. The findings reveal a significant shift toward personalized and inclusive pedagogical models supported by emerging technologies such as augmented reality, virtual reality, and artificial intelligence. These innovations demonstrate positive effects on learner engagement, motor skill development, and accessibility. Additionally, interdisciplinary linkages across the education, health, and policy domains strengthen APE's role in promoting physical activity participation and social inclusion. However, the review identifies critical limitations, including fragmented theoretical foundations, uneven implementation across geographic contexts, and insufficient evidence regarding long-term effectiveness and scalability. This review contributes to the literature by consolidating dispersed evidence and highlighting the need for theoretically grounded, context-sensitive, and sustainable innovation frameworks in APE. Future research should prioritize longitudinal designs, cross-cultural comparative studies, and participatory approaches that actively involve stakeholders, particularly individuals with disabilities, in co-design processes. Strengthening these areas is essential for advancing equitable, evidence-based, and scalable APE practices within diverse educational systems.

Key Words: Adapted Physical Education; Inclusive Education; Innovation; Physical Activity; Technology Integration

ABSTRAK

Sorotan literatur sistematik ini mensintesis bukti kontemporari berkaitan inovasi dalam pendidikan jasmani adaptif (Adapted Physical Education, APE), dengan penekanan khusus terhadap perkembangan pedagogi, teknologi, dan interdisiplin yang meningkatkan hasil pendidikan inklusif. Berpandukan kerangka PRISMA 2020, pencarian komprehensif telah dijalankan merentasi pangkalan data utama termasuk Scopus, Web of Science, PubMed, ScienceDirect, dan SpringerLink bagi penerbitan dari tahun 2013 hingga 2023. Sebanyak 505 rekod telah dikenal pasti, dan daripada jumlah tersebut, 50 kajian empirikal memenuhi kriteria inklusi selepas melalui proses saringan serta penilaian kualiti yang ketat. Data dianalisis menggunakan kerangka tematik multidimensi yang merangkumi aspek pedagogi, integrasi teknologi, sistem inovasi, dan hasil berkaitan kesihatan. Dapatan kajian menunjukkan berlakunya peralihan yang signifikan ke arah model pedagogi yang lebih diperibadikan dan inklusif dengan sokongan teknologi baharu seperti realiti terimbuh (augmented reality), realiti maya (virtual reality), dan kecerdasan buatan (artificial intelligence). Inovasi ini menunjukkan kesan positif terhadap penglibatan pelajar, perkembangan kemahiran motor, dan kebolehcapaian. Selain itu, hubungan interdisiplin merentasi domain pendidikan, kesihatan, dan dasar memperkukuh peranan APE dalam menggalakkan penyertaan aktiviti fizikal serta inklusi sosial. Walau bagaimanapun, sorotan ini turut mengenal pasti beberapa kekangan kritikal termasuk asas teori yang berpecah-pecah, pelaksanaan yang tidak sekata merentasi konteks geografi, serta kekurangan bukti berkaitan keberkesanan jangka panjang dan kebolehskalaan. Sorotan ini menyumbang kepada literatur dengan menghimpunkan bukti yang sebelum ini tersebar serta menekankan keperluan terhadap kerangka inovasi APE yang berasaskan teori, sensitif terhadap konteks, dan mampan. Penyelidikan masa hadapan disarankan untuk memberi keutamaan kepada reka bentuk longitudinal, kajian perbandingan rentas budaya, serta pendekatan partisipatori yang melibatkan pihak berkepentingan secara aktif,

khususnya individu berkeperluan khas, dalam proses reka bentuk bersama. Pengukuhan aspek-aspek ini adalah penting bagi memajukan amalan APE yang lebih adil, berasaskan bukti, dan boleh diskalakan dalam pelbagai sistem pendidikan.

Key Words: Pendidikan Jasmani Adaptif; Pendidikan Inklusif; Inovasi; Aktiviti Fizikal; Integrasi Teknologi

INTRODUCTION

Adapted physical education (APE) occupies a pivotal position at the nexus of pedagogy, inclusivity, and health, with a specific mandate to address the diverse needs of individuals with disabilities and other physical challenges. As a subdiscipline of physical education, APE has transitioned from a marginal specialization to a multifaceted, evolving field characterized by the integration of innovative instructional strategies, assistive technologies, and interdisciplinary collaboration (Sherrill, 2004). This evolution has been reinforced by the increasing global recognition of physical activity as a fundamental human right, positioning APE as a critical mechanism for ensuring equitable access to both education and health-enhancing opportunities (Messing et al., 2021). Despite notable progress, the field continues to face systemic challenges, including inequitable resource distribution, inconsistent implementation across regions, and the absence of a unified framework to guide innovation and best practices. Accordingly, this study aims to critically examine the landscape of APE innovations, with particular emphasis on their pedagogical, technological, and contextual dimensions.

The trajectory of APE development mirrors broader transformations in educational philosophy and the global disability rights movement. Earlier models were predominantly grounded in segregationist or compensatory paradigms; however, contemporary approaches increasingly emphasize inclusion, universal design, and learner-centered pedagogies (Barber et al., 2024). These developments are consistent with international policy frameworks, notably the United Nations Convention on the Rights of Persons with Disabilities, which advocates for equitable participation in physical, educational, and recreational domains (Stein et al., 2009). In parallel, rapid technological advancements ranging from wearable monitoring systems to immersive virtual reality environments have significantly expanded the instructional repertoire available to APE practitioners, facilitating more individualized and engaging learning experiences (Kang & Kang, 2019). Importantly, such innovations extend beyond technical enhancements, reflecting broader pedagogical shifts that incorporate socio-emotional learning and culturally responsive teaching within APE curricula (Mado & Salim, 2025).

Despite these advancements, several critical gaps persist within the literature. The theoretical foundations underpinning APE innovations remain fragmented, with limited integration across disciplines such as education, technology, and health sciences (Whiten et al., 2004). Furthermore, although technology-based interventions are increasingly prevalent, empirical evidence regarding their long-term effectiveness and scalability across diverse educational contexts remains insufficient (Pradhan et al., 2012). Regional disparities, particularly in low-resource environments, further complicate implementation, underscoring the need for contextually adaptive models that account for infrastructural and socio-cultural constraints (Der Hoek et al., 2024). Additionally, the potential synergies between APE and broader societal systems—including healthcare provision and urban design are underexplored, despite their capacity to enhance holistic outcomes (Woolf, 2023).

In response to these issues, the present review seeks to synthesize and critically appraise the fragmented body of knowledge on APE innovations. The primary objective is to consolidate insights across pedagogical, technological, and policy domains, thereby fostering a more integrated and coherent understanding of innovation within APE. Through this synthesis, the study aims to inform both scholarly discourse and practical implementation,

while highlighting the broader societal relevance of APE as a mechanism to promote equity, reduce barriers to physical activity, and support lifelong health and well-being among marginalized populations.

METHODOLOGY

Review Protocol

The systematic literature review followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines (Page et al., 2021) to ensure methodological rigor and transparency. Five databases and search engines were selected for their relevance to research in education, health, and technology.

PubMed was prioritized for its extensive coverage of health-related interventions and outcomes in adapted physical education. Scopus provided interdisciplinary breadth, capturing studies at the intersection of pedagogy and innovation. ScienceDirect was included for its strong repository of education-focused research, while SpringerLink offered access to high-quality journal articles in sports science and inclusive education. Google Scholar served as a supplementary tool to identify gray literature and emerging studies not yet indexed in formal databases.

The search strings combined terms related to adapted physical education ("adapted physical education," "adapted PE," "modified physical education") with innovation-related keywords, while excluding review articles, surveys, and meta-analyses to focus on primary research. Temporal filters restricted results to studies published between 2013 and 2023, ensuring relevance to contemporary practices.

Thematic Framework for Analysis

The review adopted a multidimensional framework to categorize innovations in adapted physical education, reflecting the field's interdisciplinary nature. Innovation in Education examined curricular and instructional advancements tailored to diverse learners. Physical Education Pedagogy focused on teaching methodologies, such as universal design for learning and differentiated instruction. Technology in Education encompasses digital tools, assistive devices, and immersive technologies such as virtual reality.

Innovation in Business and Industry explored partnerships and market-driven solutions, while Innovation Theories and Principles examined conceptual models that guide APE practices. Physical Activity and Health evaluated outcomes related to fitness, motor skills, and psychosocial well-being. Regional and Urban Innovation addressed contextual adaptations and policy-driven initiatives.

Inclusion and Exclusion Criteria

Studies were included if they (1) reported empirical findings on innovations in APE, (2) were peer-reviewed, (3) were published in English, and (4) aligned with at least one of the predefined research dimensions. Exclusion criteria eliminated studies lacking methodological clarity, those focused solely on general physical education without adaptation components, and non-empirical commentaries. The time frame (2013–2023) ensured the inclusion of recent advancements while maintaining historical context.

Study Selection Process

The initial search yielded 505 records, reduced to 400 after duplicate removal. Title and abstract screening excluded 286 studies as irrelevant, leaving 71 full-text articles for eligibility assessment. Of these, 21 were excluded for insufficient focus on APE innovations or failure to meet methodological criteria, leaving 50 studies for final synthesis. The PRISMA flowchart (Figure 1) illustrates this process.

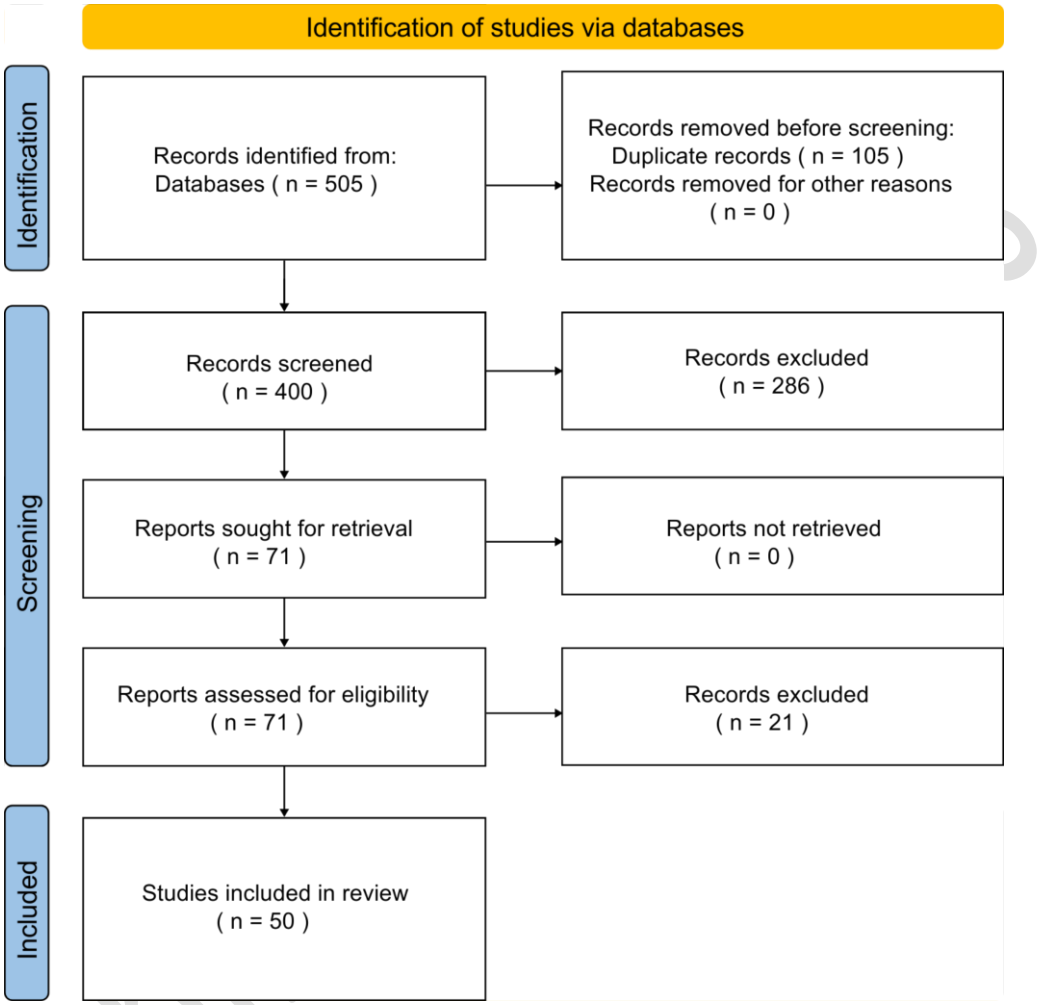

FIGURE 1. PRISMA flowchart of study selection

Potential biases included database selection bias, as some regional studies might be underrepresented in global repositories. Moreover, the exclusion of non-English publications could overlook innovations in non-Anglophone contexts. To mitigate these limitations, iterative searches and cross-referencing of bibliographies were employed.

FINDINGS AND DISCUSSION

Research Trends

The temporal distribution of publications reveals distinct patterns in the evolution of research on adapted physical education (APE) innovation. Early scholarship (pre-2016) accounts for 30% of the analyzed literature, reflecting foundational work that established core pedagogical and theoretical frameworks. However, a notable decline occurred between 2018 and 2019, with only 5 publications identified, suggesting potential stagnation or a shift in research priorities during this period. The resurgence of interest post-2020 is particularly striking, as 16

studies emerged between 2020 and 2024, indicating renewed academic engagement with APE innovation, possibly driven by global disruptions to education systems and accelerated technological adoption during the COVID-19 pandemic.

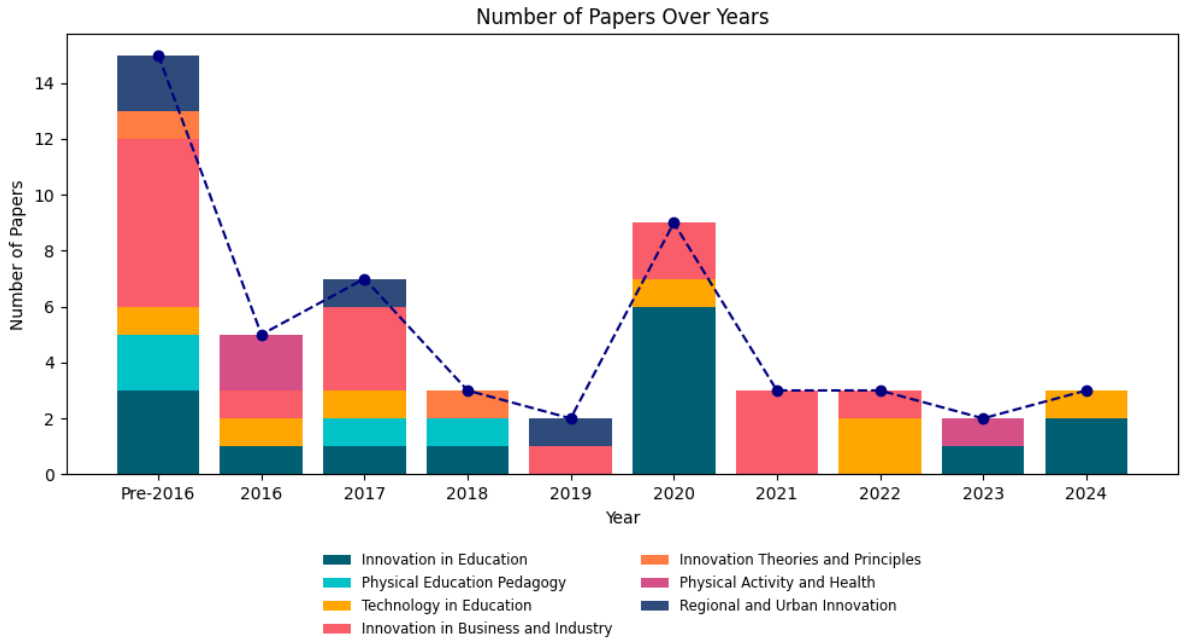

FIGURE 2. Research trends in the domain of adapted physical education innovation

Thematic analysis demonstrates uneven development across research dimensions. Innovation in Education dominates recent scholarship, with 60% of its publications appearing after 2020, highlighting growing recognition of APE's role in broader educational transformation. Conversely, Physical Education Pedagogy exhibits limited temporal progression, with all four studies concentrated between 2016 and 2018, implying either saturation of traditional pedagogical inquiry or a pivot toward more interdisciplinary approaches. Technology in Education shows intermittent but escalating attention, with half of its publications appearing in the last four years, mirroring the increasing integration of digital tools in special education contexts.

The sustained presence of Innovation in Business and Industry throughout the decade (14 studies total) underscores APE's connections to economic and organizational systems, though its peak in pre-2016 literature (43% of category publications) may reflect early-stage commercialization efforts that later stabilized. Notably, Physical Activity and Health emerge as a comparatively understudied dimension despite its intrinsic relevance, with only three publications identified, all of which are post-2016. This scarcity suggests untapped potential for research linking APE innovations to measurable health outcomes. Regional and Urban Innovation maintains a consistent but modest representation throughout the timeline, underscoring the persistent need for context-specific adaptation models in APE implementation.

Innovation in Education: Pedagogical and Technological Transformations

The systematic review identified significant innovations in education that have reshaped adapted physical education (APE), particularly through pedagogical shifts and technological integration. These advancements reflect broader trends in educational reform, where

personalized learning, digital tools, and interdisciplinary approaches converge to address diverse learner needs.

A prominent theme is the digital transformation of APE, accelerated by the COVID-19 pandemic. Studies such as Siripongdee et al. (2020) demonstrate that blended learning models incorporating IoT-based technologies facilitate remote instruction, ensuring continuity of instruction for students with disabilities. Similarly, augmented reality (AR) applications, as explored by Sanabria & Arámburo-Lizárraga (2017), enhanced collaborative creativity and motor skill development through immersive, interactive experiences. The rise of artificial intelligence (AI) in education further expanded possibilities, with Ejjami (2024) proposing AI-driven curriculum adaptations to meet individualized learning goals. Generative AI tools like ChatGPT and Midjourney, examined in (Yu, 2023) and (Chiu, 2024), introduced new dimensions to content creation and accessibility, though ethical and pedagogical challenges remain.

Pedagogical innovations also emerged in teacher education and professional development. Research by Scull et al. (2020) and Kidd & Murray (2020) highlighted how teacher educators adapted practicum learning to online formats during the pandemic, while Frost (2016) emphasized the role of teacher leadership in systemic innovation. The Maker Movement, discussed in (Peppler & Bender, 2013) and (Schön et al., 2014), exemplified student-centered learning, fostering creativity through hands-on projects. Comparative studies, such as those by Byers et al. (2018), revealed that innovative learning environments positively influenced student attitudes and outcomes compared to traditional methods.

Institutional and policy-level innovations were equally critical. The adoption of Education 5.0 in Zimbabwe, as analyzed by Muzira & Bondai (2020), illustrated how national frameworks can drive technological and infrastructural investments in APE. Entrepreneurship education adaptations during the pandemic, as detailed in Ratten (2020), underscored the need for resilience in curriculum design.

TABLE 1. Taxonomy of Innovations in Education Relevant to APE

Innovation Focus	**Implementation Context**	**Key Technologies/Methods**	**Sources**
Digital Transformation	Online Learning & Remote Education	Blended Learning, IoT Integration	(Siripongdee et al., 2020)
		AR for Collaborative Creativity	(Sanabria & Arámburo-Lizárraga, 2017)
	AI in Education	AI-Based Curriculum Development	(Ejjami, 2024)
		Generative AI (ChatGPT, Midjourney)	(Yu, 2023), (Chiu, 2024)
Pedagogical Shifts	Teacher Education & Professional Development	Online Practicum Learning	(Scull et al., 2020), (Kidd & Murray, 2020)
		Teacher Leadership & System Change	(Frost, 2016)
	21st Century Skills	Career & Life Skills Development	(Kivunja, 2015)
	Student-Centered Learning	Maker Movement & Creative Learning	(Peppler & Bender, 2013), (Schön et al., 2014)
		Comparative Analysis (Traditional vs. Innovative)	(Byers et al., 2018)
Institutional & Policy Innovations	Higher Education Reforms	Education 5.0 Adoption	(Muzira & Bondai, 2020)

Innovation Focus	Implementation Context	Key Technologies/Methods	Sources
	Entrepreneurship Education	Pandemic-Driven Changes	(Ratten, 2020)
	Generational Learning	Experiences with Gen Z	(Hernández-de-Menéndez et al., 2020)

The synthesis reveals that innovations in education are increasingly characterized by hybrid models combining technology and pedagogy. However, disparities in implementation persist, particularly in low-resource settings where infrastructural limitations hinder adoption. The Maker Movement and generative AI represent disruptive innovations, yet their long-term efficacy in APE requires further empirical validation. Regional adaptations, such as Zimbabwe's Education 5.0, demonstrate how policy frameworks can catalyze systemic change, though scalability remains a challenge.

The intersection of these innovations with APE highlights opportunities for personalized, inclusive learning while underscoring the need for equitable access and robust theoretical grounding. Future research should explore how these advancements translate into measurable health and educational outcomes for diverse learners.

Pedagogical Innovations in Physical Education

The systematic review reveals significant advancements in pedagogical approaches within physical education, particularly those emphasizing innovation and adaptability. These developments are characterized by three primary strands: technology-integrated pedagogy, models-based practice, and game-centered approaches. Each represents distinct yet interconnected dimensions of contemporary physical education pedagogy, addressing both theoretical and practical challenges in the field.

Technology-integrated pedagogy has emerged as a critical area of innovation, though its implementation often faces pedagogical stagnation. As highlighted by Casey et al. (2017), while digital technologies (DigiTech) are increasingly prevalent in physical education, their integration often lacks pedagogical depth or innovative application. This study argues that technology's potential to transform physical education remains underutilized, with many practitioners adopting tools without rethinking underlying teaching paradigms. The disconnect between technological availability and pedagogical innovation suggests a need for more robust frameworks guiding technology integration in ways that meaningfully enhance learning experiences.

Models-based practice (MBP) represents another key innovation, though its adoption and efficacy remain debated. Research by Casey (2014) critically examines MBP as either a transformative approach or an impractical ideal in physical education. The study notes that while MBP is widely advocated, its implementation often encounters practical barriers, including teacher preparedness and curricular constraints. Nevertheless, MBP continues to be regarded as innovative, particularly in its potential to move beyond traditional, sport-skill-focused instruction. Complementing this perspective, Casey and MacPhail (2018) explore the adoption of MBP, emphasizing its theoretical foundations and practical applications. The study underscores the importance of aligning pedagogical models with specific learning objectives, suggesting that MBP can enhance student engagement and skill acquisition when appropriately tailored

Game-centered approaches, particularly Teaching Games for Understanding (TGfU), constitute a third major innovation in physical education pedagogy. The study by Stolz and Pill (2014) revisits the relevance of TGfU, exploring its adaptability to diverse educational

contexts. TGfU shifts the focus from technical skill drills to tactical understanding and decision-making, fostering deeper engagement and long-term participation in physical activity. However, the study also calls for a critical reassessment of TGfU's applicability, noting that its effectiveness may vary depending on student demographics and instructional settings.

TABLE 2. Taxonomy of Pedagogical Innovations in Physical Education

Pedagogical Approach	Key Focus	Sources
Technology-Integrated Pedagogy	Digital technology integration and pedagogical innovation in physical education	(Casey et al., 2017)
Models-Based Practice (MBP)	Theoretical frameworks and practical implementation of model-based approaches	(Casey, 2014), (Casey & MacPhail, 2018)
Game-Centered Approaches	Teaching games and sport for understanding (TGfU) in physical education	(Stolz & Pill, 2014)

The synthesis of these studies underscores the dynamic nature of pedagogical innovation in physical education. While technology offers new possibilities, its impact is contingent on pedagogical alignment rather than mere adoption. Model-based practice and game-centered approaches demonstrate potential for redefining instruction, yet their success depends on contextual adaptation and teacher support. Collectively, these innovations reflect a shift toward student-centered, inclusive, and theoretically grounded practices, though challenges in implementation and scalability persist. Future research should further explore the interplay between these approaches and their long-term effects on student outcomes.

Technology Integration in Adapted Physical Education

The integration of technology in adapted physical education (APE) has emerged as a transformative force, offering novel solutions to longstanding challenges in accessibility and engagement. This section examines how various technological innovations are being implemented in APE contexts, focusing on their pedagogical applications and empirical outcomes. The analysis reveals distinct patterns in adoption, with augmented reality (AR), virtual reality (VR), mobile technologies, and blended learning models demonstrating particular promise for enhancing inclusive physical education experiences.

Augmented reality applications have shown significant potential in APE settings, particularly for skill acquisition and motor development. A study (Liu et al., 2022) investigated AR-based school physical education training and demonstrated its effectiveness in creating interactive, visually supported learning environments for students with diverse abilities. Similarly, Sanabria & Arámburo-Lizárraga (2017) employed the gradual immersion method with AR to develop collaborative creativity, highlighting how this technology can foster social interaction while addressing individual learning needs. These findings suggest that AR's capacity to overlay digital information onto physical spaces makes it particularly valuable for adapting traditional physical activities to varied ability levels.

Virtual reality has gained traction in higher-education APE programs, with Marks & Thomas (2022) documenting its adoption over five teaching semesters in a purpose-designed laboratory. The study revealed that VR technology facilitated safe, controlled environments for practicing complex motor skills and enabled precise measurement of performance and feedback. Cloud-based VR solutions, as explored in Vemuri et al. (2024), further extended these benefits by enabling remote access and collaborative virtual spaces, potentially overcoming geographical and resource limitations in APE provision.

The integration of mobile technology has reshaped APE delivery methods, particularly in secondary education contexts. Research by Montrieux et al. (2015) examined tablet implementation through a qualitative explorative study, finding that mobile devices enhanced personalized instruction and real-time assessment capabilities. The portability and versatility of tablets allowed educators to customize activities and provide immediate visual supports, addressing diverse sensory and cognitive needs.

The COVID-19 pandemic accelerated the adoption of blended learning models incorporating Internet of Things (IoT) technologies in APE. A study (Siripongdee et al., 2020) evaluated this approach, demonstrating how IoT-enabled devices could bridge the gap between physical and digital learning spaces during periods of restricted mobility. Smart wearables and motion sensors facilitated remote monitoring of physical activity, while adaptive software platforms enabled tailored exercise prescriptions.

TABLE 3. Taxonomy of Technological Innovations in Adapted Physical Education

Technology Category	Implementation Context	Key Features	Empirical Outcomes	Sources
Augmented Reality (AR)	School-based PE training	Interactive visual overlays, skill demonstration	Improved motor skill acquisition, enhanced engagement	(Liu et al., 2022), (Sanabria & Arámburo-Lizárraga, 2017)
Virtual Reality (VR)	Higher education laboratories	Immersive simulations, performance analytics	Safe skill practice environment, precise feedback mechanisms	(Marks & Thomas, 2022), (Vemuri et al., 2024)
Mobile Technology	Secondary education	Tablet-based instruction, real-time assessment	Personalized learning supports, increased accessibility	(Montrieux et al., 2015)
Blended Learning with IoT	Pandemic-responsive education	Wearable sensors, adaptive software	Remote activity monitoring, individualized exercise programming	(Siripongdee et al., 2020)
Smart Learning Environments	Institutional transformation	Integrated digital-physical systems	Enhanced learning personalization, data-driven instruction	(Kinshuk et al., 2016)

The transition to smart learning environments represents a broader paradigm shift in the integration of APE technology. Study (Kinshuk et al., 2016) argued that current technological applications in education require revolutionary rather than evolutionary changes and proposed comprehensive frameworks for developing intelligent, adaptive systems. This perspective aligns with growing recognition that technology integration in APE must move beyond tool adoption to fundamentally rethink pedagogical approaches and learning space design.

The synthesized evidence suggests that while technological innovations offer substantial benefits for APE, their effectiveness depends on thoughtful implementation aligned with pedagogical goals. AR and VR demonstrate particular promise for motor skill development, while mobile technologies and IoT solutions enhance accessibility and personalization. However, the field requires further research into longitudinal outcomes, equitable access, and the development of theoretical frameworks to guide technology integration in diverse APE contexts.

Innovation in Business and Industry: Implications for Adapted Physical Education

The intersection of business and industry innovations with adapted physical education (APE) reveals a complex landscape of product development, digital transformation, and organizational strategies that have potential applications in educational settings. While these innovations originate in commercial contexts, their adaptation to APE could address persistent challenges in accessibility, scalability, and engagement.

A dominant theme in the literature is the role of product and process innovation in driving competitive advantage. Study (Dereli, 2015) distinguishes between product innovations (new offerings) and process innovations (improved production/delivery methods), both of which could inform APE equipment design and program implementation. For instance, LEGO Education's agile-stage-gate hybrid model (Cooper & Sommer, 2016) demonstrates how rapid prototyping and iterative development common in industry could accelerate the creation of adapted physical activity tools. Similarly, servitization and mass customization capabilities (Qi et al., 2020) offer pathways to tailor APE solutions to individual needs while maintaining cost efficiency.

Digital technologies are reshaping innovation processes in ways that could benefit APE. The integration of IoT and big data in logistics (Witkowski, 2017) parallels opportunities for monitoring student progress in APE through wearable sensors and analytics. Open innovation processes facilitated by digital tools (Urbinati et al., 2020) might enable collaborative problem-solving among APE stakeholders, while UX design challenges in machine learning (Dove et al., 2017) highlight considerations for developing accessible APE technologies. The transformation of innovation work through digital tools (Marion & Fixson, 2021) further underscores the need for APE professionals to adapt to evolving technological landscapes.

TABLE 4. Business and Industry Innovation Themes with APE Applications

Innovation Category	Key Concepts	Potential APE Applications	Sources
Product/Process Innovation	Agile development, servitization	Rapid prototyping of adapted equipment	(Dereli, 2015), (Cooper & Sommer, 2016), (Qi et al., 2020)
Digital Transformation	IoT, big data, open innovation	Wearables for progress monitoring	(Witkowski, 2017), (Urbinati et al., 2020)
Organizational Innovation	Hybrid models, paradox navigation	Cross-sector APE partnerships	(Jay, 2013)
Crisis-Driven Innovation	Pandemic adaptations, small business	Resilient APE program delivery	(Akpan et al., 2021), (Lee & Trimi, 2021)
Urban/Smart Innovation	Smart City policies	Inclusive community recreation planning	(Caragliu & Bo, 2019)

Organizational innovations offer frameworks for addressing systemic APE challenges. Hybrid organizations' capacity to navigate paradoxes (Jay, 2013) could inform institutions balancing inclusive education mandates with resource constraints. The sharing economy's regulatory challenges (Ranchordás, 2015) parallel debates over equitable access to APE technologies, while convergence innovation during crises (Lee & Trimi, 2021) provides models for rapid APE adaptation, as seen in pandemic-driven virtual programming.

Regional and urban innovation strategies are also relevant. Smart City policies (Caragliu & Bo, 2019) often include accessible recreational infrastructure, suggesting opportunities to align APE with broader urban planning initiatives. Similarly, the character of innovative places (Feldman, 2014), emphasizing entrepreneurial ecosystems, could inspire community-based APE programs that leverage local resources and expertise. The business sector's approach to disruptive innovation (Karimi & Walter, 2015) and radical business model change (Kraus et al., 2022) raises critical questions for APE: When should the field adopt

incremental improvements rather than pursue transformative redesigns? How can APE innovations achieve sustainable scale? While these industry-derived concepts require careful adaptation to educational contexts, they offer valuable lenses for rethinking APE's future.

Notably, the evolution of the TRL (Technology Readiness Level) scale in public-sector innovation (Héder, 2017) offers a potential framework for assessing the maturity of APE technology, from basic research to widespread implementation. This could help bridge the gap between commercial innovation pipelines and educational adoption timelines. The synthesis suggests that APE can draw strategically from business and industry innovations while maintaining its pedagogical and inclusive foundations. Future research should investigate specific mechanisms for translating these innovations into educational practice, addressing unique APE requirements related to equity, adaptability, and measurable outcomes.

Theoretical Foundations of Innovation in Adapted Physical Education

The systematic review identified two pivotal theoretical frameworks that inform innovation in adapted physical education (APE): complexity theory and diffusion of innovations theory. These theories provide distinct yet complementary lenses for understanding how innovations emerge, spread, and become institutionalized within APE systems.

Complexity theory, as articulated by Matei & Antonie (2015), offers a valuable perspective for analyzing APE innovation as a complex adaptive system. The study emphasizes how social networks facilitate the scaling of innovations across organizational levels, a process particularly relevant to APE, where interventions often must bridge classroom, institutional, and community contexts. This theoretical approach highlights the nonlinear dynamics of change in APE, where small pedagogical or technological adaptations can trigger disproportionate systemic effects. The concept of "crossing scales" introduced in the study suggests that successful APE innovations require intentional network-building strategies to transition from isolated pilot programs to widespread practice.

The diffusion of innovations theory, examined in Dearing & Cox (2018), provides a complementary framework for understanding the adoption challenges specific to APE. The study's focus on healthcare innovation diffusion offers parallel insights for APE, where evidence-based practices frequently face implementation barriers despite demonstrated efficacy. Key principles from this theory such as the innovation-decision process, adopter categories, and innovation attributes (relative advantage, compatibility, complexity, trialability, and observability) help explain why certain APE innovations gain traction while others stagnate. The study's finding that innovations in healthcare often spread slowly despite their potential benefits resonates with similar patterns observed in APE implementation.

TABLE 5. Innovation Theories and Their Application to Adapted Physical Education

Theoretical Framework	Core Concepts	Relevance to APE Innovation	Sources
Complexity Theory	Complex adaptive systems, scaling through networks	Understanding APE innovation ecosystems and multi-level change processes	(Matei & Antonie, 2015)
Diffusion of Innovations	Innovation attributes, adopter categories, diffusion channels	Analyzing barriers and facilitators to APE innovation adoption	(Dearing & Cox, 2018)

The juxtaposition of these theories reveals critical tensions in APE innovation. Complexity theory emphasizes emergent, bottom-up change processes that align with APE's need for contextual adaptation, while diffusion theory provides structured models for

intentional dissemination that could enhance implementation fidelity. Together, they suggest that effective APE innovation strategies must balance flexibility to accommodate local conditions with sufficient standardization to enable scaling.

The theoretical analysis also surfaces important gaps in current APE innovation research. Neither framework fully accounts for the unique intersection of disability, education, and physical activity that characterizes APE. Future theoretical development could productively integrate these innovation theories with critical disability studies and inclusive education frameworks to create more nuanced models of change in APE contexts. Additionally, the reviewed studies focus primarily on innovation processes rather than outcomes, highlighting the need for theoretical work that connects innovation mechanisms to measurable impacts on student learning and participation.

The application of these theories to APE practice suggests several implications. Complexity theory underscores the importance of building robust professional networks to support the diffusion of innovation, while diffusion theory provides concrete strategies for designing more adoptable APE interventions (e.g., enhancing trialability through short-term pilots). Both theories reinforce the value of understanding APE innovation as occurring within broader ecological systems, with policy, culture, and resource availability as key determinants of success.

Physical Activity and Health: Innovations in Measurement and Promotion

The intersection of physical activity and health in adapted physical education (APE) has seen significant advances in both assessment methods and intervention strategies. Recent innovations have focused on enhancing measurement precision, expanding accessibility, and developing scalable promotion frameworks that address diverse populations.

A critical development is the establishment of comprehensive fitness reference values for children and adolescents. The study by Ortega et al. (2023) analyzed nearly 8 million test results across 34 countries, creating updated fitness maps and country rankings. This large-scale benchmarking enables physical education teachers to more accurately identify students who require adapted interventions. The research highlights how standardized fitness assessments can inform individualized APE programming while providing macro-level insights into regional health disparities. Such data-driven approaches facilitate evidence-based decision-making in APE by linking physical activity metrics to health outcomes.

Population-level physical activity promotion has emerged as another key area of innovation. Research by Reis et al. (2016) proposed a framework for scaling up interventions globally, emphasizing the need for "smarter approaches" that integrate school-based modules with broader community strategies. The study identifies five core components for creating healthy school environments, including adapted physical education programming, which can serve as a foundation for lifelong engagement in physical activity. This systems-oriented approach demonstrates how APE innovations can extend beyond classroom settings to influence public health outcomes.

Technological advancements are reshaping how physical activity is monitored and promoted in APE contexts. While the study by King et al. (2016) lacked an abstract, its focus on leveraging citizen science and information technology suggests novel participatory models for physical activity data collection and intervention design. Such approaches could democratize APE innovation by involving students, families, and communities in co-creating solutions tailored to local needs and capabilities.

TABLE 6. Innovations in Physical Activity Measurement and Promotion

Innovation Focus	Key Advancement	Application in APE	Sources
Fitness Assessment	European reference values and country rankings	Standardized evaluation for adapted programming	(Ortega et al., 2023)
Scalable Interventions	Global framework for physical activity promotion	Systems approach integrating school and community	(Reis et al., 2016)
Participatory Technologies	Citizen science and IT-driven monitoring	Community-engaged APE program development	(King et al., 2016)

The synthesis reveals three critical trends in physical activity and health innovations relevant to APE. First, big data approaches are transforming assessment practices, enabling more precise identification of students needing adapted services. Second, multi-level intervention frameworks demonstrate how APE can connect with broader public health initiatives. Third, emerging technologies facilitate participatory models that increase stakeholder engagement in APE innovation.

These advancements collectively address longstanding challenges in APE implementation, particularly regarding equitable access and outcome measurement. The European fitness landscape study (Ortega et al., 2023) provides tools for early identification of at-risk students, while the global scaling framework (Reis et al., 2016) offers strategies for sustainable program implementation. However, gaps remain in understanding how these innovations perform across diverse cultural contexts and disability categories. Future research should explore the longitudinal health impacts of technology-enhanced and community-engaged APE models.

The integration of these innovations into APE practice requires consideration of implementation barriers, including resource limitations and professional training needs. The reviewed studies collectively suggest that successful adoption depends on aligning technological capabilities with pedagogical goals while maintaining focus on inclusive participation. As the field progresses, these physical activity and health innovations hold potential to bridge the gap between adapted education and population health objectives.

Regional and Urban Innovation in Adapted Physical Education

The intersection of regional development policies and urban planning with adapted physical education (APE) presents unique opportunities for creating inclusive physical activity ecosystems. This subsection examines how spatial and policy-level innovations can enhance accessibility and participation in APE programs, drawing upon insights from regional innovation studies.

Regional innovation policies have increasingly recognized the importance of inclusive education and health promotion as drivers of social and economic development. The study by McCann and Ortega-Argilés (2013) traces the evolution of regional innovation policy into mainstream public policy, demonstrating how empirical and theoretical advancements have shaped approaches to inclusive service delivery. This research highlights the potential for APE to be integrated into regional development agendas, particularly through intersectoral collaboration among the education, health, and urban planning sectors. The concept of knowledge spillovers, as explored in Aghion & Jaravel (2015), further suggests that innovations in APE can benefit from regional innovation ecosystems, where complementary R&D efforts create synergies to address complex accessibility challenges.

Urban environments present both barriers and opportunities for APE implementation. While metropolitan areas often concentrate specialized resources and expertise, smaller communities demonstrate a remarkable capacity for the diffusion of innovation. Research by Meili and Shearmur (2019) challenges the urban-centric bias in innovation studies, providing evidence that small towns and rural areas can develop context-appropriate solutions for

inclusive physical activity. This finding is particularly relevant for APE, as it suggests that innovative practices can emerge outside traditional centers of expertise, often through community-driven adaptations of existing resources.

TABLE 7. Regional and Urban Innovation Factors Influencing APE Implementation

Innovation Dimension	Key Characteristics	Implications for APE	Sources
Policy Integration	Mainstreaming of innovation policies	Aligning APE with regional development goals	(McCann & Ortega-Argilés, 2013)
Knowledge Networks	Absorptive capacity and spillover effects	Leveraging regional expertise for APE R&D	(Aghion & Jaravel, 2015)
Geographic Distribution	Innovation in non-urban contexts	Adapting APE to rural resource constraints	(Meili & Shearmur, 2019)
Smart City Applications	Technology-enabled urban infrastructure	Designing inclusive public activity spaces	(Angelidou, 2017)

Smart city initiatives represent a promising avenue for scaling APE innovations through technological integration. The study examining smart city characteristics across fifteen cities (Angelidou, 2017) suggests that urban digital transformation can create more accessible physical activity environments. While the abstract was unavailable, the title implies potential applications of smart infrastructure, such as sensor-equipped public spaces and adaptive mobility solutions that could remove barriers to participation in APE programs.

The synthesis reveals three critical considerations for regional APE innovation. First, policy alignment can secure sustainable funding and institutional support for APE programs. Second, knowledge networks enable the flow of innovative practices across educational and community settings. Third, geographic context shapes both the challenges and creative solutions for APE implementation, requiring flexible models that account for urban-rural disparities.

These findings underscore the importance of place-based approaches to APE innovation, where solutions are co-designed with local stakeholders to address specific community needs. The regional innovation perspective complements classroom-focused pedagogical advancements by situating APE within broader social and physical ecosystems. Future research should explore how these macro-level innovations translate into measurable improvements in access and participation for individuals with disabilities across different regional contexts.

DISCUSSION

The synthesis of findings across the eight thematic dimensions points to a dynamic yet fragmented trajectory of innovation within adapted physical education (APE). In relation to the study's objectives, the evidence indicates that contemporary APE innovation is increasingly shaped by interdisciplinary convergence particularly across the domains of pedagogy, technology, and policy. However, this progression remains uneven, with persistent deficiencies in theoretical anchoring and equitable implementation. Three dominant patterns are evident: the persistent tension between technological advancement and meaningful pedagogical integration, the decisive influence of contextual factors on the diffusion of innovation, and the limited integration of APE within broader health and urban development systems.

From a technological standpoint, the findings reveal a duality of opportunity and limitation. While prior studies highlight the transformative affordances of augmented reality

(Liu et al., 2022), virtual reality (Marks & Thomas, 2022), and IoT-enabled environments (Siripongdee et al., 2020), their application within APE frequently lacks pedagogical depth. This observation reinforces the critique articulated by Casey et al. (2017), whereby technology adoption in education often occurs without parallel shifts in instructional design or epistemological orientation. More disruptive paradigms, such as the Maker Movement (Peppler & Bender, 2013) and generative AI applications (Yu, 2023), demonstrate stronger potential to reconfigure APE practices. Nonetheless, their long-term effectiveness remains underexplored. Consequently, the implications for theory and practice are clear: technological integration in APE must be guided by robust pedagogical frameworks, rather than treated as an isolated or instrumental goal.

The analysis further underscores the critical role of contextual adaptation in the successful implementation of APE innovations. Significant disparities emerge between technologically advanced urban environments, often supported by smart-city infrastructures (Angelidou, 2017), and resource-constrained rural settings that rely on locally embedded solutions (Meili & Shearmur, 2019). This divergence aligns with innovation diffusion theory (Dearing & Cox, 2018), particularly its emphasis on the inherent tension between scalability and contextual responsiveness. In this regard, complexity theory (Matei & Antonie, 2015) offers a valuable interpretive lens, suggesting that APE innovation ecosystems should be conceptualized as adaptive, networked systems that balance standardization with localized flexibility. Empirical evidence indicates that policy coherence (McCann & Ortega-Argilés, 2013) and knowledge spillovers (Aghion & Jaravel, 2015) are critical enablers of such balanced diffusion processes. For policymakers, this highlights the need to design flexible frameworks that support contextual innovation rather than enforce uniform implementation models.

Another key finding concerns the insufficient integration of APE across adjacent sectors, particularly public health and urban planning. Although physical activity interventions have demonstrated clear health benefits (Ortega et al., 2023), their alignment with APE remains limited. Similarly, inclusive urban design initiatives seldom incorporate APE considerations (Angelidou, 2017), indicating a structural disconnect. This fragmentation runs counter to the inherently interdisciplinary nature of disability inclusion and limits the scalability of APE impact. Insights from organizational and innovation literature, such as hybrid organizational forms (Jay, 2013) and open innovation ecosystems (Urbinati et al., 2020), offer practical models for enhancing cross-sector collaboration. These approaches could inform the development of integrated APE systems that bridge education, health, and urban development agendas.

Theoretically, the findings call for developing a more cohesive and integrative APE innovation framework. Current scholarship tends to oscillate between technologically deterministic perspectives and pedagogically conservative approaches, with limited attention to transformative change processes. A theoretically robust framework should incorporate principles from complexity theory to account for multi-level system dynamics while integrating perspectives from critical disability studies to ensure that innovation efforts promote genuine inclusion rather than reproducing ableist structures. Addressing the "knowing–doing" gap identified by Dearing and Cox (2018) is essential in this regard, as it would enable more effective translation of innovation knowledge into practice.

From a practical perspective, the implications are substantial. Educators must be equipped with advanced technological pedagogical content knowledge (TPACK) tailored specifically to APE contexts, enabling them to integrate digital tools meaningfully into instruction. For policymakers, establishing regional innovation hubs could facilitate collaboration among educators, technologists, and urban planners, fostering co-designed, contextually relevant solutions. Furthermore, industry-derived strategies such as agile

development methodologies (Cooper & Sommer, 2016) and servitization models (Qi et al., 2020) offer scalable yet flexible approaches adaptable to the APE domain.

Despite these contributions, several limitations of the study should be acknowledged. The exclusion of non-English publications may have led to the omission of significant innovations from non-Anglophone contexts. Additionally, the reliance on peer-reviewed sources may have excluded valuable insights from gray literature and practitioner-based evidence. While the thematic synthesis provides a structured analytical lens, it may also constrain alternative interpretations of the data. These limitations suggest that future research should adopt more inclusive and methodologically diverse approaches, including the integration of practitioner knowledge and multilingual sources.

Future research directions should therefore prioritize several key areas. Longitudinal investigations are needed to evaluate the sustained impact of technological interventions in APE beyond short-term engagement outcomes. Comparative cross-cultural studies would enhance understanding of how innovations can be effectively adapted across diverse contexts. The development and empirical validation of APE-specific innovation frameworks would strengthen theoretical foundations. Importantly, participatory approaches particularly those involving individuals with disabilities as co-designers should be emphasized to ensure that innovations are responsive to user needs and grounded in lived experiences

Overall, the evidence positions APE at a critical juncture, where the convergence of pedagogical innovation, technological advancement, and policy development presents substantial opportunities for transformation. However, realizing this potential requires a shift from fragmented, isolated initiatives toward integrated, system-level strategies. Advancing APE in this direction will not only enhance educational inclusivity but also contribute to broader societal goals related to health, equity, and accessible urban development.

CONCLUSION

This systematic literature review consolidates current evidence on innovation in adapted physical education (APE), identifying a field with considerable interdisciplinary promise but constrained by fragmentation in both theoretical development and practical implementation. In line with the study objectives, the synthesis confirms that APE innovation is increasingly shaped by the convergence of technological advancements, evolving pedagogical approaches, and broader policy transformations. These developments create significant opportunities to enhance inclusive education. Nevertheless, the findings also reveal a persistent disconnect between the design of innovative interventions and their equitable adoption, particularly within under-resourced and marginalized contexts.

Two key implications emerge for both practice and future scholarship. First, effective APE innovation depends on a deliberate alignment between technological tools and pedagogical frameworks, ensuring that instructional objectives remain central rather than being overshadowed by technological novelty. Second, the observed regional disparities highlight the necessity for context-responsive models that can adapt to local conditions while upholding core principles of inclusion. Accordingly, future research should emphasize longitudinal investigations to evaluate sustained impacts of APE innovations, comparative cross-cultural studies to identify transferable adaptation strategies, and participatory methodologies that actively involve individuals with disabilities in co-design processes.

Overall, the evidence positions APE innovation not merely as a technical endeavor but as a broader social imperative requiring coordinated, cross-sectoral collaboration spanning education, health, urban planning, and technology domains. Addressing the identified gaps and leveraging emerging best practices will be essential for advancing more equitable, effective, and sustainable APE systems.

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