Applying self-determination theory in Physical Education: a systematic review

La aplicación de la teoría de la autodeterminación en Educación Física: una revisión sistemática

Authors

Tong Zhou [1]
Shunan Zhang [2]
Jordi Colomer [3]
Dolors Cañabate [3]

[1] Korea University, Republic of Korea
[2] Sungkyunkwan University, Republic of Korea
[3] University of Girona, Spain

Corresponding author: Dolors Cañabate, dolors.canyabate@udg.edu

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Abstract

Introduction: Self-Determination Theory (SDT) was used as a lens to explore the profound impact of primary and secondary physical education students' motivation on their learning experiences, academic performance, and long-term exercise habits. In recent years, the application of SDT in the field of physical education has made great strides. However, several critical gaps remain unaddressed: 1) the differential effects of autonomy, competence, and relatedness support on specific learning outcomes have not been systematically quantified; 2) the moderating role of cultural contexts on SDT effectiveness lacks comprehensive analysis; and 3) the long-term sustainability of SDT-based interventions in diverse PE settings remains underexplored.
Methodology: In this study, we used bibliometric methods, following the PRISMA principle, screening the subject terms from the Web of Science, Scopus, Dialnet, Redalyc, and Google Academic databases and analyzing a total of 105 papers to comprehensively explore the effects of SDT on physical skills, physical activities, affective attitudes and cognitive learning.
Results: The study found that there is a large agreement at considering that intrinsic motivation positively affects students' behaviour, self-identity, self-perception, and transformation of experiential knowledge. Also, intrinsic motivation was strongly associated with positive outcomes such as motor skill development, physical activity engagement, emotional attitudes, and cognitive learning. In contrast, introjected and external regulation were linked to short-term engagement but lower long-term adherence.
Discussion: The adoption of SDT-informed teaching strategies was shown to foster autonomy-supportive environments and enhance student motivation. SDT offers a robust theoretical framework for improving PE pedagogy, informing curriculum design, instructional strategies, and assessment systems.
Conclusions: This review systematically analyzes current research trends and learning outcomes in different fields, including the role of motivation in skill acquisition and cognitive learning, cross-cultural validity, and the lack of longitudinal data on SDT-based interventions, and discusses possible challenges and prospects in the future.

Keywords

Self-determination theory; physical education; intrinsic motivation; extrinsic motivation; autonomy.

Resumen

Introducción: La Self-Determination Theory (SDT) se propone como aliciente para explorar el profundo impacto de la motivación del alumnado de educación física de primaria y secundaria en sus experiencias de aprendizaje, rendimiento académico y hábitos de ejercicio a largo plazo. En los últimos años, la aplicación de la SDT en el campo de la educación física ha hecho grandes avances, sin embargo, varias lagunas críticas siguen sin abordarse: 1) no se han cuantificado sistemáticamente los efectos diferenciales del apoyo a la autonomía, la competencia y la relación en resultados de aprendizaje específicos; 2) el papel moderador de los contextos culturales en la eficacia de la SDT carece de un análisis exhaustivo; y 3) la sostenibilidad a largo plazo de las intervenciones basadas en la SDT en diversos entornos de educación física es un campo por explorar.
Metodología: En este estudio, se utilizaron métodos bibliométricos, siguiendo el principio PRISMA, filtrando los términos temáticos de las bases de datos principales de Web of Science, Scopus, Dialnet, Redalyc y Google Académico y analizando un total de 105 artículos para explorar exhaustivamente los efectos de la SDT en las habilidades físicas, la actividad física, las actitudes afectivas y el aprendizaje cognitivo.
Discusión: La adopción de estrategias de enseñanza basadas en la SDT ha demostrado que fomenta la autonomía y la motivación de los estudiantes. La SDT ofrece un marco teórico sólido para mejorar la pedagogía de la educación física, informando el diseño curricular, las estrategias de instrucción y los sistemas de evaluación.
Conclusiones: Esta revisión analiza sistemáticamente las tendencias actuales de la investigación y los resultados del aprendizaje en diferentes campos, incluyendo el papel de la motivación en la adquisición de habilidades y el aprendizaje cognitivo, la validez transcultural y la falta de datos longitudinales sobre las intervenciones basadas en la SDT, y discute los posibles retos y perspectivas en el futuro.

Palabras clave

Teoría de la autodeterminación; educación física; motivación intrínseca; motivación extrínseca; autonomía.

Introduction

Physical Education (PE) aims to cultivate the physical and mental well-being of students and shape their holistic character development. Through structured PE learning programs, students engage in high-level physical activities that promote not only fitness but also cognitive and social development. High-quality PE combined with meaningful PE activities has resulted in not only students' physical and mental health improving, fundamental motor skills and cognitive (Siedentop & Van der Mars, 2022; Vazou et al., 2019). As educational theories, programs and practices continue to evolve, students have explored a myriad of PE educational settings addressed to enhance their self-identity, self-knowledge, and making connections between experience and knowledge (Lodico et al., 2010; Meltzer, 2018).

Among diverse theoretical frameworks, Self-Determination Theory (SDT) has gained considerable attention. Initially proposed by psychologists Edward L. Deci and Richard M. Ryan in 1985, SDT provides insights into individual motivation, human behavior, and the intrinsic sense of control within motivation (Deci & Ryan, 2012b). The theory posits that individuals have an innate drive to explore, grow, while simultaneously seeking to satisfy three fundamental psychological needs: autonomy, competence, and relatedness. Recent meta-analyses confirm that supporting these basic needs significantly predicts positive educational outcomes across diverse contexts (Vasconcellos et al., 2020; Liu et al., 2023).

Whilst several motivational theories have been applied to the teaching of physical education, such as Eccles' Expected Value Theory which focuses on task value and expected beliefs (Shang et al., 2023), and Nickels' Achievement Goal Theory which emphasises an achievement versus mastery orientation (Lochbaum et al., 2023), in contrast SDT has unique strengths in that SDT provides a more comprehensive framework that addresses both intrinsic and extrinsic motivation through three universal psychological needs (Ryan & Deci, 2020). And SDT includes autonomy and relatedness as equally important determinants of motivation.

In educational settings, SDT has become a highly-regarded framework, providing educators with evidence-based strategies to enhance students' self-management and intrinsic motivation. The application of SDT in PE contexts holds particular promise given the unique experiential nature of physical education. As Chen et al., (2020) note, SDT-informed PE practices foster greater enjoyment, engagement, and long-term adherence to physical activity outcomes that extend well beyond the classroom setting. As a means of improving physical fitness and psychological abilities, sports and physical activities not only provide a constructive learning platform for students but also have a positive impact on socialization (Owen et al., 2014). However, the reality is that in most PE overemphasize outcome goals, thus neglecting students' intrinsic motivation and basic psychological needs, leading to many students developing aversions to physical activities (Pangrazi & Beighle, 2012).

The application of SDT has proven to be particularly valuable in explaining motivation for sport participation, physical activity persistence, health behaviours, and performance in different contexts (Di Domenico et al., 2024; Namaziandost et al., 2024). And, with the widespread use of artificial intelligence, SDT has begun to incorporate ChatGPT (Li et al., 2024; to facilitate students' self-regulated learning as well as to further explain students' STEM interests and identity development (Chiu, 2024).

Despite growing interest in SDT applications in PE, existing systematic reviews present several limitations that warrant a more comprehensive analysis. Current reviews have focused on narrow aspects of SDT implementation (White et al., 2021), limited geographic contexts (Guo et al., 2023), or specific age groups without considering developmental differences across educational levels. Moreover, no previous review has systematically examined the measurement properties of SDT instruments used in PE contexts or analyzed the sustainability of intervention effects across different cultural settings. Taken together, there is a lack of research examining the effects of SDT on student outcomes across the different learning outcome areas analyzing the effects of SDT and integrating the use of measurement tools. Unlike previous reviews that focused on isolated aspects of SDT in PE (e.g., de Bruijn et al., 2022; White et al., 2021), the present study adopts a comprehensive approach that integrates theoretical developments, measurement issues, and practical applications across educational levels. By identifying patterns, inconsistencies, and unexplored territories in the existing literature.

Therefore, this systematic review aims to address three specific research objectives.

1) To systematically analyze publication trends and methodological characteristics of SDT research in PE among adolescents from 2010-2024;

2) To quantitatively synthesize the effects of SDT-based interventions on adolescents' physical, affective, and cognitive outcomes in PE settings;

3) To evaluate the cross-cultural validity and measurement consistency of SDT instruments used in diverse educational contexts.

The present systematic review makes several distinct contributions that differentiate it from existing literature in this field. Unlike previous reviews that have examined SDT applications in isolation or within limited contexts, this study adopts a comprehensive multi-dimensional approach that simultaneously integrates theoretical foundations, methodological rigor, and practical outcomes across diverse educational settings. Importantly, this review introduces a novel analytical framework that specifically addresses the measurement validity and cross-cultural applicability of SDT instruments in PE contexts an aspect largely overlooked in prior systematic reviews while also employing a longitudinal perspective to examine the sustainability of intervention effects beyond immediate post-intervention periods. Furthermore, this study uniquely incorporates emerging technological integration aspects, examining how digital tools and AI-enhanced learning environments interact with SDT principles in contemporary PE settings, thereby acknowledging the evolving landscape of physical education. By systematically analyzing publication trends and methodological characteristics over a 14-year period (2010-2024), this review provides unprecedented insights into the evolution of SDT research in PE, identifying methodological improvements, persistent limitations, and emerging research directions that collectively offer a more holistic and forward-looking understanding of SDT's applications in physical education compared to existing fragmented analyses.

Literature review

Definition of SDT

Self-Determination Theory (SDT) has undergone significant development since its introduction. This theory initially focused on intrinsic motivation, emphasizing three innate psychological needs: autonomy, competence, and relatedness. These needs were considered key elements in the development of positive psychology and behavior (Deci et al., 1985).

As research progressed, scholars recognized that external factors also play an important role in motivation formation (Ryan, 2023). This realization led theorists to develop a more nuanced classification of motivation types, including intrinsic, autonomy-supportive, controlled, and external motivation (Deci & Ryan, 2000). This categorization allows for a more comprehensive understanding of the complexity of human motivation.

"Need satisfaction" is a central concept in SDT, which proposes that individuals' motivations and behaviors are designed to satisfy basic psychological needs (Reeve, 2012). These needs include autonomy (the need to make autonomous decisions and behaviors), competence (the need to feel competent and effective in activities), and relatedness (the need to make connections and gain a sense of social belonging) (Deci & Ryan, 2013). SDT suggests that only in environments where these needs can be met can individuals develop higher levels of intrinsic motivation and positive psychology (Ryan & Deci, 2000).

However, it is worth noting that there are limitations to the general applicability of SDT. Different individuals and cultures may have different needs and motivations. For example, controlled motivation was not found to be significantly correlated with physical activity levels in a study of a Spanish physical education program (Fernández-Espínola et al., 2020). This finding highlights the importance of considering cultural differences when applying SDT, especially in educational settings such as physical education.

In light of these findings, research in recent years has endeavored to adapt SDT to different cultural contexts. Scholars have recognized that factors influencing motivation may vary across societies and educational systems (Kokkonen et al., 2020; Linch et al., 2020). This cross-cultural research orientation

not only enriches the theoretical content of SDT, but also provides important guidance for its practical application in multicultural settings.

SDT has gradually incorporated cultural and social factors into its theoretical framework (Ryan & Deci, 2004). Researchers have found that culture and one's own social environment can influence an individual's motivation and behavior (Deci & Ryan, 2012a, 2012b). SDT introduced the concept of Cultural Self-Determination Theory, emphasizing the different expressions of autonomy in various cultures and the role culture plays in shaping motivation and behavior, i.e., the interrelationship between the cultural characteristics of different regions and the self-determination of individuals (Ryan & Deci, 2003).

In sum, SDT has evolved from its initial focus on intrinsic motivation to encompass external motivation, motivation quality levels, needs satisfaction, and cultural factors (Ryan & Vansteenkiste, 2023). This timeline, along with the changes in key elements and introductions to representative papers and books, can help scholars understand the developmental trajectory and changes in SDT, thus providing more in-depth learning resources.

SDT in Physical Education

PE as an integral part of school education programs continually explores how to incorporate SDT to enhance students' engagement and enthusiasm for sports activities (Taylor et al., 2010). A qualitative analysis has confirmed the relationships between various elements of SDT theory in the context of PE, laying the theoretical foundation for exploring the relationship between children and adolescents' motivation and physical activity (Owen et al., 2014). However, the current state of PE often places excessive emphasis on skills and competition, neglecting individual differences and needs among students (Ntoumanis et al., 2021). As a consequence, there has been a gradual shift towards the application of student-centered PE activities in educational settings (Nogg et al., 2021; Ntoumanis et al., 2021).

Educators can support students' autonomy needs by encouraging autonomy, providing decision-making opportunities, and listening to students' voices (Taylor & Lonsdale, 2010). By encouraging PE students to participate in the goal-setting process and providing opportunities for autonomy and decision-making, educators can promote students' autonomy needs satisfaction, thus enhancing their intrinsic motivation and active participation (Cheon et al., 2014). Educators can provide timely feedback on progress and achievements while allowing students to participate in reward selection and decision-making processes to enhance their autonomy needs satisfaction. By emphasizing the creation of a supportive environment to fulfill individuals' autonomy, competence, and relatedness needs, educators can shape an environment conducive to self-determination by providing challenging yet manageable tasks, creating a positive team atmosphere, and promoting cooperation opportunities (Sparks et al., 2017). The complexity of teaching environments in various sports disciplines presents challenges in designing PE environments (Chow et al., 2021).

SDT classifies motivation into different quality levels, including intrinsic motivation, integrated regulation, and extrinsic motivation (Abós et al., 2021). In PE, educators can strive to foster and support students' intrinsic motivation, helping students to find activities that are intrinsically interesting, meaningful, and consistent with their personal values and identity. SDT posits that fulfilling individuals' basic psychological needs is crucial for positive motivation and psychological well-being (Ryan & Deci, 2003). Positive engagement behaviours can be effectively promoted by meeting the psychological needs of students and may impact on student achievement with the design of instructional interventions in SDT (White et al., 2021).

To translate SDT into practical applications, teacher training and intervention programs have emerged (Sparks et al., 2017). These programs aim to provide PE teachers with the knowledge and skills required to understand the basic principles of SDT and apply them in practice. Training content may cover autonomy support skills, strategies for inspiring intrinsic motivation, and practical approaches to meeting basic needs (Aelterman et al., 2012).

SDT is gradually being used for a wider range of cultures and individuals' characteristics (Ryan & Vansteenkiste, 2023). The overall application of SDT in educational settings demonstrates the developmental progression of SDT in PE, i.e., evolving from a focus on autonomy support to encompass motivation quality levels and the significance of need satisfaction. Specific programs focus on teacher training

and the development of professional intervention programs, as well as considering diversity and cultural factors (Teixeira et al., 2020). These applications contribute to enhancing student motivation, engagement, and psychological well-being, thus creating a positive environment for physical education development. Existing research has shown that integrating SDT into PE significantly improves students' active participation, motivation, and sports skills (Aelterman et al., 2014; Zamarripa et al., 2021). Moreover, for students who were previously resistant to sports activities, SDT can help them gradually develop a positive self-concept in sports and change their attitudes toward PE (Sparks et al., 2017). Therefore, SDT clearly helps instill positive exercise habits and foster the right sports values in students.

Method

Scoping literature analysis methods are integrated into the analysis of scientific sources using narrative analysis techniques(Byrne, 2016). To ensure the quality of the research and adhere to the PRISMA (Page et al., 2021), including the number of search strategy, screened, assessed for eligibility, and included in the review. This systematic review protocol has been registered on INPLASY (DOI: 10.37766/inplasy2025.3.0101). The registration number is INPLASY202530101. This protocol was performed in accordance with the preferred reporting items for systematic reviews. Ethical approval is unnecessary because this is a literature-based study.

Search strategy

The first stage of the search strategy consisted of retrieving data from the major core databases, Web of Science, Scopus, Dialnet, Redalyc, and Google Academic (Birkle et al., 2020), which are recognised as important and reliable sources of high quality publications in the field of physical education, by entering search strings constructed on the basis of IC-1 in the following databases. We started with a simple string with the search formula: TS= (("SDT" OR "Self-Determination Theory") AND ("PE" OR "Physical Education")), with a timeframe set from 1900 to July 15, 2023. The search retrieved a total of 1412 records across all databases. In order to answer the research question1 this study conducted a bibliometric analysis of the 825 records initially screened for areas of research concentration and publication trends using VOSviewer. To answer research questions 2 and 3 after a two-stage screening process described below, 105 studies met all inclusion criteria and were included in the final systematic synthesis and qualitative analysis.

Eligibility criteria

Inclusion criteria(IC) were essential for assessing the validity, applicability and comprehensiveness of the reviews (Page et al., 2021). Notably, the exclusion criteria were designed to be incremental. For example, if an article is rejected by exclusion criterion 1, it is automatically excluded, and no further validation of the other exclusion criteria takes place.

For inclusion criteria(IC), the title, abstract, or keywords of the paper contained one of the following: studies that explicitly utilize Self-Determination Theory (SDT) as a theoretical framework (IC-1), studies conducted within physical education settings (school-based PE classes, PE teacher education, PE curricula) (IC-2), studies involving students/pupils as primary participants(IC-3), empirical studies with clearly described methodology(IC-4).

Exclusion criteria(EC), not a dissertation(EC-1), not written in English(EC-2), this study does not consider theories outside of SDT(EC-3), this study does not consider scenarios outside of the physical education setting(EC-4), intervention protocols (Participant recruitment clearly described; Sample size justification provided; Data collection procedures detailed; Measurement instruments validated; Statistical analysis methods appropriate; Intervention protocols specified) (EC-5), duplicate publications of the same study(EC-6).

Data collection process

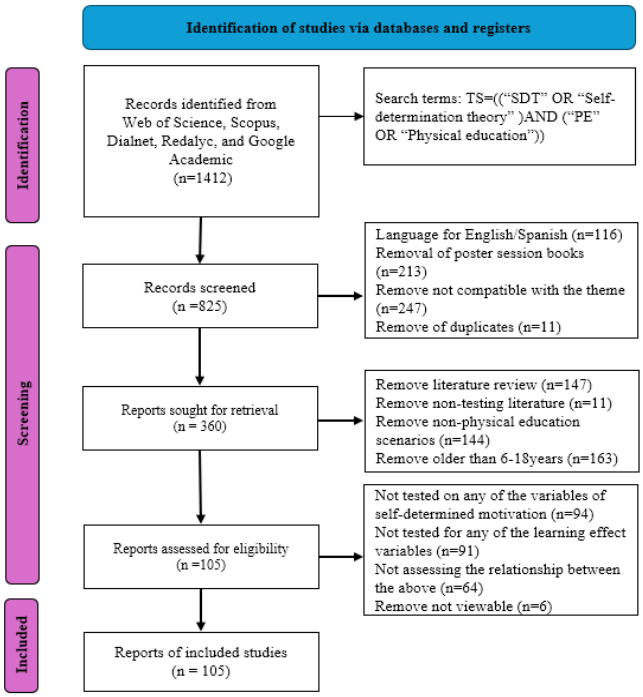
In order to conduct a systematic literature review, a data extraction form was developed to ensure that all relevant data were collected. The first thing that was collected was basic information about the literature, including type of publication, year of publication and keywords. Regarding the methodological characteristics of the study, we recorded whether the study used experimental research, intervention

research or mixed methods. For data collection methods it was recorded whether questionnaires, interviews, observations or experimental measurements were used.

Data extraction and coding

For participant information, categorisation was based on educational stage (primary, middle, high school: 6-18 years old), while sample size, gender ratio, and participant exercise level/experience were collected. For the SDT theoretical constructs, the focus was on the measurement of the three basic psychological needs (autonomy, competence, and relational needs), as well as the assessment of the type of motivation (intrinsic motivation, extrinsic motivation, and unmotivated) and the need for support (autonomy support, structural support, and relational support). Measurement instrument aspect records the measurement instruments used. In terms of physical education contexts, we collect the types of courses (general physical education classes, specialized sports classes, extracurricular physical activities), the content (motor skills, physical training, physical theory, integrated activities) and the teaching methods (traditional teaching, innovative teaching models, blended teaching). The outcome section of the study records needs satisfaction/frustration outcomes, motivational relevance outcomes, behavioural performance outcomes, mental health outcomes, and learning effectiveness outcomes. In addition, we focus on other features such as cultural contextual considerations, theoretical innovation points, practical implications, research limitations, and future recommendations. The specific process of data selection is illustrated in Figure 1.

Figure 1. PRISMA flow diagram for systematic reviews.



Quality assurance and reliability

Inter-rater reliability assessment was implemented as a critical component of the screening process to ensure consistency and minimize selection bias throughout the systematic review. The assessment was conducted across two distinct phases, each employing rigorous procedures to quantify agreement between independent reviewers and establish protocols for resolving disagreements. Prior to commencing the full screening process, both primary reviewers (Author 1 and Author 2) underwent calibration exercises using a randomly selected subset of 100 records (approximately 12% of the total sample) to establish baseline agreement and refine interpretation of inclusion and exclusion criteria.

During the title and abstract screening phase, both reviewers independently evaluated all 825 unique records against the predetermined eligibility criteria. Inter-rater agreement was quantified using Cohen's kappa coefficient, which accounts for agreement occurring by chance alone. The initial screening yielded a kappa coefficient of 0.89 (95% CI: 0.85-0.93), indicating excellent agreement according to established interpretation guidelines.

The conflict resolution process followed a structured hierarchy, beginning with direct discussion between the two primary reviewers for minor disagreements involving interpretation of specific criteria. Major disagreements, defined as those involving fundamental questions about study eligibility or requiring extensive discussion, were escalated to a third reviewer (corresponding author) who provided independent assessment and facilitated consensus formation. All disagreements and their resolutions were systematically documented in a dedicated screening database, enabling tracking of decision-making patterns and ensuring transparency in the selection process. Weekly consensus meetings were conducted throughout the screening period to address challenging cases, discuss emerging patterns in disagreements, and maintain consistency in criterion application. The overall inter-rater reliability across both screening phases yielded a combined kappa coefficient of 0.90 (95% CI: 0.87-0.93).

As this study was conducted mainly in the form of a systematic review, the following methods were used while analysing the literature in a specific way to ensure the quality of the literature and to avoid bias.

Quantitative analysis

The manuscripts were analysed to extract information about the year of publication and type of publication. We created visual representations of the keywords (Godin, 2006) used predominantly in the examined papers using the VOSviewer (Van Eck & Waltman, 2010), an open source software package developed for bibliometric and scientometrics analyses.

Quality assessment

The overall quality assessment of the full papers was carried out using a scoring system. In this system, a score of 1 is the lowest and a score of 3 is the highest (Peixoto et al., 2021).

Quality assessment was conducted using a comprehensive evaluation framework adapted from established systematic review guidelines to accommodate the diverse methodological approaches identified in the included studies. Given the heterogeneity of study designs encompassing experimental, quasi-experimental, cross-sectional, and mixed methods approaches, evaluates five critical domains of methodological rigor. Each domain was assessed using a three-point scale (0 = criterion not met, 1 = criterion partially met, 2 = criterion fully met), resulting in an overall quality score ranging from 0 to 10 points.

The assessment framework evaluated study design appropriateness and methodological justification, examining whether the chosen research design aligned with the stated research objectives and theoretical framework. Sample characteristics and recruitment procedures were assessed for adequacy, representativeness, and statistical power considerations, with particular attention to sample size calculations and demographic diversity. Data collection and measurement quality focused on the psychometric properties of instruments used, validity and reliability evidence, and appropriateness of measurement tools for the target population and cultural context. Statistical analysis and reporting standards were evaluated based on the appropriateness of analytical methods for the research questions and data type, completeness of statistical reporting, and adherence to established reporting guidelines. Finally, bias assessment and limitation acknowledgment examined the authors' recognition of potential sources of bias, transparency in reporting limitations, and consideration of threats to internal and external validity.

Studies scoring 8-10 points were classified as high quality, demonstrating robust methodological approaches with minimal risk of bias. Moderate quality studies (5-7 points) showed adequate methodological rigor with some limitations that did not substantially compromise the validity of findings. Low quality studies (0-4 points) exhibited significant methodological concerns that limited confidence in the reported results. Two independent reviewers conducted all quality assessments, with disagreements resolved through discussion and consultation with a third reviewer when necessary. The quality assessment results were used both as a descriptive characteristic of the included literature and to inform sensitivity analyses exploring the robustness of findings across studies of varying methodological quality.

Results

Trends in the publication of SDT in PE and keyword clustering

Following the review, a total of 825 articles spanning the period from 2001 to July 15, 2023, were selected and included in the publication trend analysis. The publication trend analysis in Figure 2. reveals that the first article appeared in 2001, with the highest number of publications reaching 109 in 2020. Overall, there has been an upward trend in publications. The publication peak in 2020 can be attributed in part to the shift in students' intrinsic needs and motivations due to the impact of COVID-19 (Leyton-Román et al., 2021).

Figure 2. Publication trends of SDT in PE

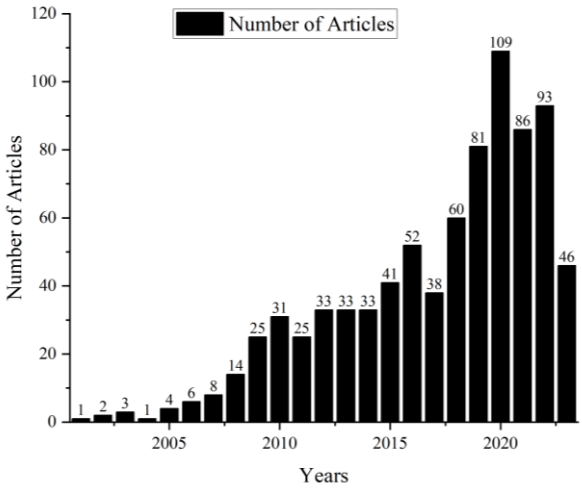
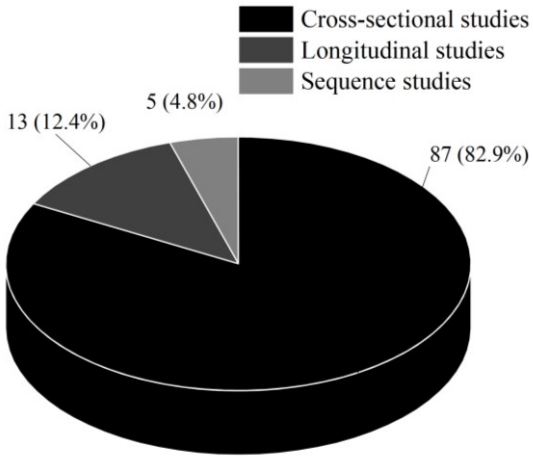


Figure 3 provides details of the specific review of the 105 studies showing that of these studies 87 were cross-sectional, 13 longitudinal and 5 sequence studies. The age range of the participants varied, with an average age ranging from 9.5 years (Vaquero-Solís et al., 2022) to 18 (Hosseini et al., 2022).

Figure 3. Specific types of research



By analyzing the frequency of keywords and the strength of connections we can understand when the current research is mainly focused on which specific directions. Therefore, in the preliminary stage of literature selection we analysed the keywords of all 825 studies. Through the analysis of keywords in

801 articles using VOSviewer, the results were sorted based on the frequency of keyword occurrence and the average strength of connections between associated keywords. This study has summarized the most significant top 20 keywords in terms of their frequency and connection strength (see Table 1).

Table 1. The top five most frequently occurring keywords

Rank	KW	T	AS	Rank	KW	T	AS
1	Self-determination theory	625	9..0	11	Exercise	112	9.7
2	Physical education	385	9.2	12	Behavior	107	9.1
3	Motivation	333	9.1	13	Satisfaction	105	9.8
4	Intrinsic motivation	313	9.5	14	Need satisfaction	102	9.9
5	Autonomy support	211	9.7	15	Validation	100	9.8
6	Students	179	9.4	16	Intervention	99	10.0
7	Autonomy	136	9.7	17	Adolescents	98	9.3
8	Sport	135	9.6	18	Competence	97	9.9
9	Basic psychological needs	126	9.9	19	Model	91	9.3
10	Self-determination	123	9.5	20	Physical activity	90	9.8

Notes：Keywords=KW，Times=T，Average strength=AS，Average strength = Total strength /Times

Through an author review, it was found that there are 825(654 quantitative studies and 171 qualitative studies) on the application of SDT in PE. The application of SDT in PE primarily focuses on five main areas: autonomy support, instructional environment design, satisfaction of intrinsic needs, instructional interventions, and the impact of diverse cultures in Figure 4.

The results from Table 1 indicate that the top five most frequently occurring keywords are Self-determination theory (625), Physical education (385), Motivation (333), Intrinsic motivation (313), and Autonomy support (211). In terms of average strength, the keyword Intervention has the highest average strength at 10.0, suggesting that SDT's application in PE primarily involved intervention-based studies. Following that, needs satisfaction and competence both have an average strength of 9.9, mainly due to the emphasis of SDT on exploring the satisfaction of intrinsic needs and individual motivation.

The VOSviewer analysis of 825 studies directly addresses our first research objective by revealing publication trends and research concentration areas within SDT applications in PE. This bibliometric analysis identifies five primary research clusters that inform our systematic synthesis: (1) autonomy support and instructional design (represented by keywords: autonomy support, intervention, model), (2) psychological needs satisfaction (basic psychological needs, need satisfaction, competence), (3) motivational outcomes (intrinsic motivation, self-determination, behavior), (4) target populations and contexts (students, adolescents, physical education), and (5) measurement and validation approaches (validation, satisfaction, exercise).

These keyword clusters guided our subsequent thematic analysis of the 105 core studies and provided a framework for understanding the evolution of SDT research priorities in PE contexts. The high connection strength of "intervention" (AS=10.0) particularly supports our focus on intervention-based studies in the systematic synthesis, while the prominence of "need satisfaction" and "competence" keywords validates our emphasis on the three basic psychological needs as organizing principles for the results section.

Quality assessment results

Quality assessment results revealed substantial variation in methodological rigor across included studies (Table 2). Thirty-one studies (29.5%) achieved high quality ratings (8-10 points), demonstrating robust methodological approaches with validated instruments, appropriate statistical analyses, and comprehensive reporting. Most studies (n=52, 49.5%) received moderate quality ratings (5-7 points), typically due to limitations in sample representativeness, incomplete reporting of psychometric properties, or inadequate consideration of potential confounding variables. Twenty-two studies (21.0%) received low quality ratings (0-4 points), primarily due to small sample sizes (<30 participants), use of non-validated instruments, or significant methodological concerns that limited confidence in findings.

Table 2. Quality assessment results

Quality Level	N	%	Characteristics
High (8-10 points)	31	29.5	Robust methodology, validated instruments, adequate sample size
Moderate (5-7 points)	52	49.5	Some methodological limitations, but adequate overall quality
Low (0-4 points)	22	21	Significant methodological concerns, limited validity

Longitudinal studies demonstrated higher average quality scores (M=7.8, SD=1.6) compared to cross-sectional studies (M=6.2, SD=2.1), reflecting more rigorous design requirements and comprehensive reporting standards. Sequential studies showed moderate-to-high quality (M=7.4, SD=1.9). Common methodological strengths included use of validated SDT instruments and appropriate statistical analyses, while frequent limitations included convenience sampling, limited cultural diversity, and insufficient reporting of effect sizes. These quality variations were considered in sensitivity analyses exploring the robustness of findings across studies of different methodological rigor.

Learning outcomes in PE and the measurement tools

Based on the application of SDT in PE, a substantial body of prior research demonstrating the positive or negative effects of different types of motivation already exists. Motivation in PE has a direct link to various key parameters. Through a literature review, the discussions regarding SDT and student learning outcomes primarily center around sports skills, physical activity, emotional attitudes, and cognitive learning. Therefore, this study will focus on the impact different motivation types within the SDT framework have on sports skills, physical activity, emotional attitudes, and cognitive learning.

Autonomous motivation and adolescents' motor skills and MVPA

Motor skills are measured using instruments such as the Progressive Aerobic Cardiovascular Endurance Running (PACER), the Motor Quotient (MQ), the Test of Athletic Performance (TAP), and the Bruinckers-Ozerecki Test of Athletic Performance, Second Edition (BOT-II). The development of youth motor skills is a core component of PE and an essential feature of physical literacy, which is critical for promoting student participation in physical activity (Sun et al., 2017).

Research has found that motor skills have a significant impact on PA program intensity and motivation to participate (Yli-Piipari et al., 2020). However, there are inconsistent findings regarding the relationship between fundamental motor skills (FMS) and motivation in physical education (van Aart et al., 2017). One study found no significant positive correlation between the two, and even a negative correlation among male students (Sun & Chen, 2010). This discrepancy may stem from the complexity of the physical education teaching environment, where students' learning goals vary from one teaching situation to another.

Gender differences also play an important role in the relationship between motor skills and autonomous motivation (Jess et al., 2016). Gråstén & Watt (2017) found girls' motor skills are positively related to intrinsic motivation, while boys' autonomous behaviors are related to physical skills in a task-oriented atmosphere. This suggests that boys and girls have different perceptions of physical education, leading to differences in levels of physical skills and autonomous motivation.

Research has shown that physical activity is an effective measure to prevent obesity, prolonged screen-time sedentary behaviors, and cardiovascular diseases (Elagizi et al., 2020). Among the 118 studies included in this research, 30 cross-sectional studies, seven longitudinal studies, and one sequential study have all demonstrated the impact of self-determination motivation on physical activity among adolescents. In the review, various measurement tools were commonly used, including the Physical Activity Questionnaire for Children (PAQ-C), Physical Activity Questionnaire for Older Children (PAQ-OC), Leisure-time Exercise Questionnaire (LTEQ), Accelerometer, Behavioral Regulation in Exercise Questionnaire (BREQ-II), Body Image States Scale (BISS), and the ActiGraph series of physical fitness expenditure measurement devices.

These studies mainly occurred during PE classes and leisure time. In PE classes, Carriedo et al. (2023) found that an increase in students' autonomous motivation could increase their willingness to engage in physical activities. In a three-phase cross-sectional study, students' physical activity increased up to 73.7%, and it was found that students' intrinsic motivation had a positive impact on physical activity. A cross-sectional study by Jankauskiene et al. (2022) discovered that students' autonomous motivation had a positive impact on self-perception and willingness to engage in physical activity, particularly among girls' awareness of external body image.

In the context of physical education, Koka et al. (2020) studied the relationship between students' autonomous motivation for physical activities, the extracurricular environment's impact on autonomous motivation for physical activities, willingness for future physical activities, and actual participation in extracurricular activities. They used the BREQ-II with 234 students and found that teacher-controlled

behaviors had a negative impact on students' autonomous motivation. However, depending on the teacher's motivational style and atmosphere, one study found that teachers with a need-supportive style were positively correlated with students' autonomous motivation and participation (De Muynck et al., 2021). Furthermore, interventions with a game-based teaching approach have a positive impact on students' active participation in PE classes and leisure-time physical activities (Sotos-Martínez et al., 2022).

A substantial body of research has shown that the ActiGraph series of physical activity expenditure measurement devices can effectively reflect students' physical activity levels. It emphasizes the importance of objectively measuring physical education levels to ensure reliable results (Fernández-Hernández et al., 2021). Chen et al. (2020) found that by measuring the moderate-to-vigorous physical activity (hereafter, MVPA) of middle school students, task-involved teaching and autonomy support were positively correlated with autonomy, relatedness, and competence, and they could positively influence students' autonomous motivation. These factors were also predictive of students' MVPA time in PE classes. Additionally, Wang & Chen (2022) compared the time spent on MVPA between middle school and elementary school students at different age levels. In addition, the relationship between intrinsic motivation and MVPA was stronger for middle school students than for elementary school students, suggesting a need to enhance intrinsic motivation development in physical education classes for elementary school students.

Autonomous motivation and adolescents' emotional attitudes

The domain of emotional learning in PE includes students' attitudes, activity interests, exercise motivation, and self-concept (Williams & Lacy, 2018). While PE emphasizes physical activity, it also highlights the development of emotional learning in students (Haerens et al., 2019). This study's exploration of autonomous motivation in the field of emotional learning primarily focuses on pleasure and boredom, effort and engagement, attitudes toward PE, novelty satisfaction, and future willingness to engage in physical education and physical activities.

Autonomous motivation, and pleasure and boredom in physical learning are mainly measured using tools such as the Basic Emotion State Scale (BESS), Intrinsic Motivation Inventory (IMI), Athlete Burnout Questionnaire (ABQ), Physical Activity Enjoyment Scale (PACES), Emotional Intelligence Questionnaire (EIQ), Questionnaire on Emotional State in PE (QESP), and the Sport Satisfaction Instrument (SSI) series, among others.

Pleasure and boredom are the primary affective responses of students during physical education learning (Cuevas-Campos et al., 2020). This view is widely supported by SDT, which hypothesises that the extent to which students' basic psychological needs are met is highly correlated with the pleasure or boredom they experience during physical activity, a theoretical assumption that has been validated in several studies.

However, the role of affective experiences in the process of motivation formation does not appear to be a simple linear relationship. a study by Baños et al. (2020) found that boredom did not mediate the relationship between autonomy support and students' autonomous motivation. On the contrary, Karagiannidis et al.'s (2015) study noted that autonomous motivation plays a mediating role between autonomy support and students' feelings of pleasure and boredom in a physical education setting.

Autonomous motivation and effort and engagement in PE

When examining the relationship between autonomous motivation and students' effort and engagement in PE, researchers primarily employ measurement tools such as the Sport Satisfaction Instrument (SSI), Engagement Versus Disaffection with Learning Scale (EVDLS), and Intrinsic Motivation Inventory (IMI), among others.

Bechter et al. (2019) through a controlled experimental study with a five-week teaching strategy intervention, found that students in the intervention group displayed higher levels of autonomous motivation and effort, leading to positive learning outcomes. Drawing from the SDT theoretical framework, Chu et al. (2019) discovered through multiple regression analysis that autonomous motivation is a significant predictor of effort for both boys and girls. On the other hand, Aelterman et al. (2012) found that students with high levels of autonomy were positively correlated with participation in physical activities and physical engagement, whereas students with controlled motivation and high levels of amotivation exhibited lower levels of engagement.

Autonomous motivation and attitude in PE

Measurement tools for assessing students' attitudes in PE primarily include the Activity-Feeling States Scale (AFS), Basic Psychological Needs in Exercise Scale (BPNES) series, Multidimensional Sportsmanship Orientation Scale (MSOS), and the Psychological Need Satisfaction in Exercise (PNSE) series, among others.

Students' attitudes towards physical education are highly correlated with their learning outcomes and also affect their willingness to sustain physical activity in the future (Primo et al., 2023). Maldonado et al. (2019) further confirmed that students' attention in the Mexican physical education environment was highly and was positively correlated with by autonomous motivation (f^2=0.64) and, to a lesser extent, by controlled motivation (f^2=0.02) and amotivation (f^2=0.09). The study particularly emphasized the motivating effect of teachers adopting an autonomy-supportive approach on students' attention. Moreover, Chamorro et al. (2021) tested a model of motivation antecedents for passion in sports and found that autonomous motivation had a direct or indirect influence on both types of passion (harmonious passion and obsessive passion). This challenges previous findings, such as those of Langdon et al. (2014), which did not identify a direct relationship between students' autonomous motivation and their attitudes in high school physical education courses. Haerens et al. (2019), in a quality assessment of students facing upcoming exam standards, found that teachers with different motivational styles had independent relationships with students, affecting their autonomous satisfaction, competence satisfaction, and relatedness satisfaction. However, specific relationships between motivation types and attitudes were not elucidated.

Autonomous motivation and novelty

For the measurement of novelty the Novelty Need Satisfaction and Frustration Scale (NNSFS) and the Novelty Need Satisfaction Scale (NNSS) have been used. Novelty in PE learning is defined as the need to experience a physical activity that has not been previously experienced or excluded activity in everyday life (González-Cutre et al., 2016). Novelty as a new factor introduces it into SDT, especially in the satisfaction of students' Basic Psychological Needs (BPNs), where autonomous motivation, competence, and relevance support have a positive predictive effect on novelty satisfaction and Basic Psychological Needs (BPNs) in a supportive environment (Aibar et al., 2021). In PE, novelty satisfaction showed a positive correlation with intrinsic motivation (González-Cutre et al., 2016), as well as a positive correlation with activity intention (Fernández-Espínola et al., 2020). Therefore, given the complexity of PE learning environments and the potential for students to discover and create new contexts during the learning process in PE in demand-supported environments, novelty needs more focus and validation (González-Cutre & Sicilia, 2019). To date, research on PE setting novelty as an important element in motivational modelling and BPN is in its preliminary stages (Aibar et al., 2021).

Autonomous motivation and future physical activity intentions

In assessing students' intentions to participate in physical activity in the future, researchers have used a variety of measurement tools. Among them, Theory of Planned Behavior (TPB) is the most widely used framework. In addition to this, tools such as the Behavioral Regulation of Exercise Questionnaire (BREQ-II), the Intentions to Participate in Physical Activity Inventory (IPA) series, and the Leisure-Time Exercise Questionnaire (LTEQ) have also been frequently used.

The results of a large number of studies, especially those based on the Theory of Planned Behavior, reveal a positive association between students' perceived autonomy support and autonomous motivation. This finding has been validated in several studies. For example, Sanchez-Oliva et al. (2014) found that autonomous motivation had a significant positive effect on future intentions to engage in physical activity (r=0.69, p<0.01) in a survey of 1,692 students in 2014. In contrast, controlled motivation showed a slight negative effect (r=-0.12, p<0.05), while unmotivated motivation, while also showing a negative effect, was not statistically significant. This trend has been corroborated in other studies, and is further supported by the self-reported questionnaire conducted by Vaquero-Solís et al. (2022) with 502 children. Not only did their study find that autonomous motivation had a positive effect on both intention and actual participation in physical activity, but that this effect did not differ significantly between genders. More importantly, their study pointed out that the motivational states acquired by students in

physical education classes could be translated into physical activity intentions and practices in different contexts in daily life, highlighting the long-term impact of school physical education.

In addition to motivational factors, personal traits also play an important role in shaping physical activity intentions. In an interesting study, it was found that individuals with high EQ tended to exhibit stronger self-determined motivation, along with greater psychosocial resilience and a higher sense of well-being(Méndez Giménez et al., 2020). These factors were strongly associated with stronger intentions to engage in physical activity, suggesting that we should also focus on the development of personal traits such as emotional intelligence when promoting students' participation in physical activity.

Autonomous motivation and adolescents' cognitive learning

In the context of cognitive learning, studies primarily employed tests such as Written Tests (WT), Standardized Knowledge Tests (SKT), Health-related Fitness Knowledge (HRFK), and the Concentration Scale Developed for PE (CSDPE).

When assessing the efficacy of physical education, cognitive learning is essential because it provides students with the opportunity to develop healthy values concerning physical activity. In the actual study, only four reviews on cognitive learning were identified, with tests like the Written Test (WT), Standardized Knowledge Test (SKT), Health-related Fitness Knowledge (HRFK), and the Concentration Scale Developed for PE (CSDPE) mainly being employed. Shen et al. (2009) found, through a curriculum intervention, that autonomous motivation in the early stages of learning produced lower cognitive learning outcomes compared to controlled motivation. Moreover, autonomous motivation did not have a positive impact on cognitive learning outcomes during the semester. Haslem et al. (2016) conducted cognitive measurements with 280 high school students but did not find any significant correlations between any of the motivational types in SDT and students' cognitive learning in PE.

Conversely, Langdon et al. (2014) found that during a volleyball technical skills lesson for high school students, autonomous motivation was directly correlated with volleyball knowledge test scores. This relationship was particularly strong when teachers provided clear learning objectives. This highlights the high relevance of designing physical education lessons with clear objectives and tasks to produce cognitive learning for students.

Discussion

Trends in the publication volume of SDT in physical education

In this study, we conducted a systematic analysis of the trends and developments of SDT in the context of PE through a bibliometric analysis of 825 articles from the Web of Science, Scopus, Dialnet, Redalyc, and Google Academic database, spanning from 2001 to July 15, 2023. The results revealed an overall increasing trend in the number of relevant articles, with the peak being reached in 2020 followed by a subsequent leveling off in 2021-2023. This increase may be associated with the seminal work by Ryan & Deci (2020), who emphasized the predictive power of SDT in different educational levels and cultural backgrounds and highlighted the dynamic relationship between teachers and students, with teacher motivation styles showing positive correlations with students' satisfaction of intrinsic needs. Moreover, Sturm et al. (2020) emphasized the significance of this theoretical framework and provided empirical evidence on the relationships between basic psychological needs across different cultural school environments.

Consensus of SDT in physical education

Keyword clustering, which showcases the primary themes in the field, offers insights into the specific directions within the current domain. In our study, the research themes primarily revolved around autonomy support, instructional environment design, satisfaction of intrinsic needs, instructional interventions, and the diverse cultural impacts, consistent with the findings of (Sun et al., 2017). Furthermore, 82% of the articles pertained to quantitative research, employing experimental or correlational methods to examine the relationships between SDT constructs and PE outcomes (Burgueño et al., 2020; Gerani et al., 2020). It should be noted that the predominance of correlational studies limits our ability to establish causal relationships between SDT constructs and outcomes. Subsequently, this review

delves into 105 studies on how SDT is associated with student learning outcomes, mainly in the domains of motor skills, physical activity, affective attitudes and cognitive learning.

In the evolution of SDT, it has been confirmed that the different sequences of motivation contained within it have been validated and individual differences have been acknowledged within the field of PE. For instance, Maldonado et al. (2019) found that through the shaping of the instructional environment, autonomous support was positively correlated with autonomous motivation, whereas controlled motivation and amotivation showed negative relationships. Changes in student attention correlate strongly with intrinsic motivation and to a lesser extent with controlled and non-motivated motivation.

Self-Determination Theory proposes a classification of motivation that is not only a theoretical construct, but also a key mechanism for understanding students' participatory behaviours in physical education. Ryan & Deci (2000) proposed a unified taxonomy of motivation along a continuum from external conditions to intrinsic motivation, demonstrating unique pathways of integration and interrelationships in physical education contexts.

Firstly, Intrinsic Motivation, the highest autonomous form of motivation, manifests itself in students' participation in physical activity purely for the pleasure and satisfaction of the activity itself. In the literature analysed in this study, Intrinsic Motivation is highly correlated with students' autonomous participation, sustained effort, and positive emotions in physical education classes (Gil-Arias et al., 2021; Zhou et al., 2025). Intrinsic motivation appears to be strengthened when students experience challenge, novelty, and a sense of competence in an activity, which in turn is associated with their active participation in and out of the classroom.

Second, Integrated Regulation is manifested when students fully incorporate the value of physical activity into their self-identification system. In the context of physical education, this typically occurs in the upper grades as they identify with a healthy lifestyle and view physical activity as a core component of their personal identity. Maldonado et al. (2019) showed that when teachers demonstrated the value of integrating physical activity into their lives through narrative and role modelling, students were more likely to develop Integrated Regulation, which was associated with adherence to physical activity without direct supervision. physical activity.

Thirdly, Identified Regulation is manifested in physical education when students recognise the importance and personal value of physical activity, even though the activity itself may not always be enjoyable. This review found that when teachers explicitly explained the health value and skill development implications of the activity, students' Identified Regulation was significantly enhanced, which in turn was correlated with their active participation and willingness to engage in extracurricular physical activity (Burgueño et al., 2020; Alfonzo Marín et al., 2025; Ventaja-Cruz et al., 2025).

Fourth, Introjected Regulation involves students' participation in physical activity out of intrinsic pressures (e.g., avoiding guilt, maintaining self-esteem). The analyses in this study suggest that although Introjected Regulation is associated with participation in the short term, it is often associated with anxiety and lower enjoyment of the activity, making it difficult to sustain long-term participation (Raven & Pels, 2021). An overemphasis on performance evaluations and social comparisons in physical education may reinforce this type of conditioning, potentially hindering students' development of healthy perceptions of physical education.

Finally, External Regulation is reflected in students' participation in physical activity purely due to external factors (e.g., grades, rewards, and punishments). The quantitative analyses in this review showed that teaching strategies that rely solely on external regulation are often associated with decrease in the quality of student participation and lower long-term participation rates (Sun et al., 2017). However, in appropriate contexts, external regulation can also serve as an initial catalyst participation, creating conditions for subsequent development of more autonomous forms of motivation.

Furthermore, the positive impact of autonomous motivation on physical activity and emotional attitudes during the learning process has been documented. Teachers, as guides in PE, play a crucial role in creating a supportive learning environment. Strategies such as employing teaching models, tailoring the curriculum based on student preferences, and supporting their basic psychological needs, are associated with the development of autonomous motivation among students, potentially enhancing the effectiveness of PE (Gil-Arias et al., 2021; Raven & Pels, 2021; Jerez-López et al., 2025). This also aligns with the

recommendations of Bryan & Solmon (2007) to, 'explore and develop students' motivation and future exercise intentions in various contexts, that adds value to our understanding of the relationships between teaching strategies and outcomes in different interventions and specific environments.

Reconciling contradictory findings in motor skills and motivation

While some studies support a positive relationships between autonomous motivation and motor skill development, some contradictory findings warrant further investigation. Aart et al., (2017) reported that all basic psychological needs, except autonomy for girls, had moderate to strong correlations with autonomous motivation, and no positive significant relationships were found between basic psychological needs and FMS, nor between autonomous motivation and FMS, whereas moderate but negative correlations were found between teacher relatedness and balance skills, and between autonomous motivation and balance skills for boys. These contradictory findings may stem from several theoretical and methodological considerations.

First, the complexity of the physical education environment leads to different achievement goal orientations, which may moderate the relationship between motivation and skills. In a highly competitive or performance-oriented environment, students with lower motor ability may experience decreased autonomous motivation due to social comparison, leading to the observed negative correlation. Second, gender-specific socialization patterns in physical education may have led to these differential findings. While girls' motor skill development appears to be consistently associated with intrinsic motivation (Antunes et al., 2024), boys may be more influenced by family and peer approval, and negative correlations were found between age and all dimensions of motivation, which may disrupt the pathway between autonomous motivation and skill acquisition.

In addition, measurement timing and context may also explain these inconsistencies. Cross-sectional studies may capture temporary states rather than stable motivational tendencies, and the specific sports or activities assessed may activate different motivational orientations in different ways. These conflicting findings suggest that the relationship between autonomous motivation and motor skills is more nuanced than originally proposed by SDT, requiring consideration of contextual moderators and individual difference variables.

Cultural, educational differences and physical education context

The effectiveness of physical education interventions based on SDT shows significant differences in different cultural and educational contexts. In their study, Beyers et al. (2024) explained the development of autonomy in adolescent students from the micro-environment (such as parents) and the macro-environment (including cultural factors), clarifying autonomous motivation from two aspects. The results show that students' autonomy as independence and autonomy as a function are of great significance to the social adaptation and development of adolescents. And a cross-cultural study of 658 Belgian and Greek adolescents using the measurement methods of Soenens et al. (2007) and Fousiani et al. (2014) showed that the promotion of independence by mothers and fathers can predict higher levels of independent decision-making in adolescents. However, more comparative studies are needed to confirm the different cultural differences.

On the other hand, Wang & Chen (2022) demonstrated that the intrinsic motivation-MVPA relationship was stronger in middle school students than in elementary school students, indicating that the application of SDT principles should be targeted at different developmental stages. This suggests that it may not be appropriate to apply SDT strategies to all educational stages without age-appropriate adjustments.

Theoretical gaps and future theoretical development

Our analysis reveals several theoretical gaps within SDT applications in PE that warrant further investigation. First, the motivational continuum shows inconsistent validation across different age groups, particularly regarding the stability of integrated regulation in younger students. The developmental appropriateness of certain motivational regulations remains unclear. Second, the interaction between cultural collectivism/individualism and basic psychological needs satisfaction requires theoretical refinement. Current SDT applications may not adequately account for cultural variations in need expression and satisfaction. Third, the potential role of novelty as a fourth basic psychological need lacks sufficient

theoretical integration within the SDT framework, despite emerging evidence of its importance in physical education contexts. Fourth, the differential relationships between motivation and outcomes for boys and girls suggest that SDT may require gender-sensitive theoretical modifications.

These findings suggest that SDT theory may benefit from age-specific theoretical modifications that account for developmental differences in motivation regulation, cultural adaptation frameworks that specify how basic needs manifest across different educational contexts, integration of technological mediation effects on basic psychological needs satisfaction, and gender-sensitive pathway models that acknowledge differential socialization effects.

Future directions for SDT in physical education

First, there is a relative scarcity of research regarding the effects of autonomous motivation in promoting the acquisition of sports skills within the school context. This may be attributed to the predominant focus on fun and game-oriented approaches, emphasizing students' full engagement in class and the joy derived from experiencing PE. Miller et al. (2016) found that game-centered teaching effectively promotes the learning of sports skills. However, the measurement of the impact of autonomous motivation on sports skill acquisition is limited, with only 11 relevant studies identified in this review. Additionally, van Aart et al. (2017) pointed out the need for authentic and effective measurement tools for sports skills, as the current tools require further validation. Inaccurate measurement tools could lead to incorrect conclusions concerning the relationship between autonomous motivation and sports skill acquisition.

Second, there is a divergence of opinions regarding the relationship between autonomous motivation and sports-related cognitive learning. Our review identified only two studies reporting a positive correlation. The field of sports-related cognitive learning has not received sufficient attention, primarily because PE curricula often prioritize physical exercises over cognitive learning. If PE teachers do not have explicit objectives for cognitive learning during the teaching process, students may pursue other learning goals, potentially diminishing the impact of autonomous motivation on cognitive learning. There is a need to further explore the interrelationships between different types of motivation on cognitive learning in sport within the SDT framework.

Currently, there is a running debate on, and a need for more research regarding, novelty satisfaction, which functions as a particular addition to the basic psychological needs theory within the framework of SDT.

Finally, as summarized by Ryan & Deci (2020), the development of SDT should not only align with the needs of the times but also adapt to the intrinsic requirements of students. Prolonged screen use and virtual space utilization pose significant challenges to modern students (Fransson et al., 2020). Therefore, it is imperative to explore integrating SDT into smart technologies, such as Virtual Reality (VR) and Artificial Intelligence (AI). Zhou et al. (2023) listed the computer technologies that are currently useful in PE, although it is unclear if these technologies can be successfully incorporated into the SDT framework.

Implementation challenges and specific guidance

Implementation challenges and practical guidance for SDT-Based Physical Education Despite theoretical support for the application of SDT, several practical challenges limit its effective implementation in physical education settings.

Teacher preparation and competency challenges. Moving from traditional teacher-led teaching methods to approaches that support autonomy requires significant retraining. Many physical education teachers lack specific training in SDT principles, which may result in superficial implementation and failure to meet students' basic psychological needs. The complexity of supporting autonomy, competence, and relatedness while maintaining classroom management and safety standards poses significant challenges to practitioners.

Systematic and assessment barriers. Traditional physical education assessment systems often emphasize standardized skill performance and comparative assessment, which is directly contrary to the principle of SDT that recognizes individual progress. The "need-motivation-outcome" model proposed in

this review requires a systematic reconstruction of assessment practices, which may face institutional resistance and policy constraints.

Conclusions

This review reveals emerging evidence for the relevance of SDT constructs in physical education contexts, while highlighting significant gaps in our theoretical understanding and empirical evidence. The relationships between basic psychological needs, motivational regulations, and PE outcomes appear complex and context-dependent, requiring more nuanced theoretical frameworks and rigorous empirical investigation. Future research should prioritize longitudinal designs, cultural adaptation, and the development of validated measurement tools to advance both theoretical understanding and practical applications of SDT in physical education.

Research limitations

There are several limitations of this study that need to be noted: Firstly, despite the systematic literature screening process we used, there is a possibility that some relevant studies may have been missed due to the selection of databases and non-English language literature. Second, cross-study comparisons are challenging due to differences in measurement tools and methodologies used across studies. Third, this study failed to analyse in depth the moderating effect of cultural context on the effectiveness of SDT application, which may limit the cross-cultural applicability of the findings. Finally, most of the included studies were cross-sectional in design and lacked long-term follow-up data, making it difficult to conclusively demonstrate the lasting effects of SDT interventions.

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Authors' and translators' details:

Tong Zhou	zhou941002@korea.ac.kr	Autor/a
Shunan Zhang	970205@g.skku.edu	Autor/a
Jordi Colomer	jordi.colomer@udg.edu	Autor/a
Dolors Cañabate Ortíz	dolors.canyabate@udg.edu	Autor/a