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Is Artificial Intelligence an educational resource in Physical Education? A Systematic Review

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Ana Alonso and Oriol Cardona achieve their qualification for the new Olympic sport of ski mountaineering by taking second place at the 2025 World Championships in Boí Taüll.
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Abstract
Artificial Intelligence (AI) is breaking into Physical Education (PE) at an accelerated pace. Although the studies carried out are very recent, we present in this article a first exploration of the initial impact that AI is having on PE. Through a systematic review according to PRISMA standards, we examined the scientific literature on recently published studies between 2019 and 2024 that analysed how AI can contribute to improving learning in PE. For this purpose, a search was carried out in the specialised databases ERIC, ProQuest, Scopus and Web of Science (WoS), in which a total of 241 articles were found. After applying the established inclusion and exclusion criteria, a total of 10 studies were included and analysed according to three categories: scientific evidence on the use of AI in PE, areas of implementation of AI in PE, and educational use of AI in PE. The results showed a lack of research on the application of AI in PE, especially at primary and secondary eduation stages in Europe, suggesting that its integration is still embryonic. They also highlighted the potential of AI, such as video and voice analytics, Intelligent Computer Assisted Instruction (ICAI) and the Internet of Things (IoT) to personalise learning in PE, improve student satisfaction, physical performance and teaching effectiveness. However, it emphasises the need for further studies to explore the real impact of AI on the learning and development of PE competences.

Keywords: Artificial Intelligence, Digital Technology, Learning, Physical Education.

Introduction

In the contemporary era, characterised by unprecedented technological advances, education faces transformational challenges and opportunities. Artificial Intelligence (AI) has begun to significantly influence various sectors, including education. As AI advances, its integration in the field of education and thus in Physical Education (PE) emerges as a promising field of study, offering potential to improve the way we teach and assess the area's competencies. In this context, this article presents a systematic review of the existing literature on the application of AI in PE, which is interested in exploring how AI is being used to improve learning and assessment in this field.

In this sense, the incursion of digital technology in the field of PE in recent decades has been increasing by implementing digital technologies in PE through mobile applications (Gil-Espinosa et al., 2020; Lavay et al., 2015; Pulido González et al., 2016); accelerometers, GPS trackers and wearable technology to record physical activity (Marttinen et al., 2019); and the use of video for movement analysis (Koekoek et al., 2018). In addition, we can find the implementation of active video games that promote physical activity (Birinci et al., 2021; de Lima et al., 2020; Salgado & Scaglia, 2020). Nonetheless, despite these advances, the specific field of AI in PE still seems to remain relatively unexplored. This gap in research highlights the potential of AI to personalise learning, collect data, provide real-time feedback and offer a variety of learning tools to foster students' interest and maintain their motivation to learn (Lee & Lee, 2021). Therefore, it is an opportune moment to find out the current trends in the use of AI in this area.

Similarly, the adoption of AI in education has recently gained momentum, with tools such as ChatGPT and DALL-E generating both fascination and concern among the education community (Delgado et al., 2024). As a result, educational institutions are adapting to the emerging capabilities of generative AI. This development has triggered debates on several critical issues such as preparedness, ethics, trust, impact and added value of AI in education, as well as the need for regulation, governance, research and training to manage its rapid evolution (Grassini, 2023). Nevertheless, AI not only encompasses the field of generative AI, but also opens the door to the fields of Machine Learning, Deep Learning and Natural Language Processing (NLP) (World Commission on the Ethics of Scientific and Technological Knowledge, COMEST, 2019, p3).

In order to harmonise all this technological profusion, regulatory measures are being implemented such as: the UNESCO guide for policy makers on AI in education (UNESCO, 2021) and the European Commission's proposal to create a regulatory framework for AI (UNESCO, 2009). However, it remains to be seen whether these regulations taken by the actors in the education system have a real regulatory effect (Bond et al., 2024). Nonetheless, there are also important ethical considerations that need to be addressed when introducing AI in PE. Aspects such as data privacy and biases in AI algorithms are crucial issues that require careful attention to ensure responsible and beneficial implementation of these technologies (Moncada, 2024).

Using a systematic review methodology, this work analyses recent studies exploring the integration of AI in PE. To this end, practical applications of AI are examined, which includes personalised AI-based training systems, the use of motion analysis to improve sport technique, interactive learning platforms and the automatic assessment of physical performance. In addition, the potential benefits of these technologies, such as improved accuracy of assessments, increased student motivation and personalisation of learning, are discussed.

In this emerging and constantly changing context, where the scope of AI in PE is unknown, a systematic review is proposed with the following objectives: (1) To examine the existing scientific evidence on uses of AI that contribute to improving student learning in PE; (2) To understand the areas of implementation of AI in PE; and (3) To analyse emerging trends in the use of AI in PE.

In pursuit of these objectives, the study aims to provide a current view, in this decade, of how AI is being applied and can be developed in PE to improve learning processes in the subject and to clearly guide future lines of research and pedagogical practice in this emerging field.

Methodology

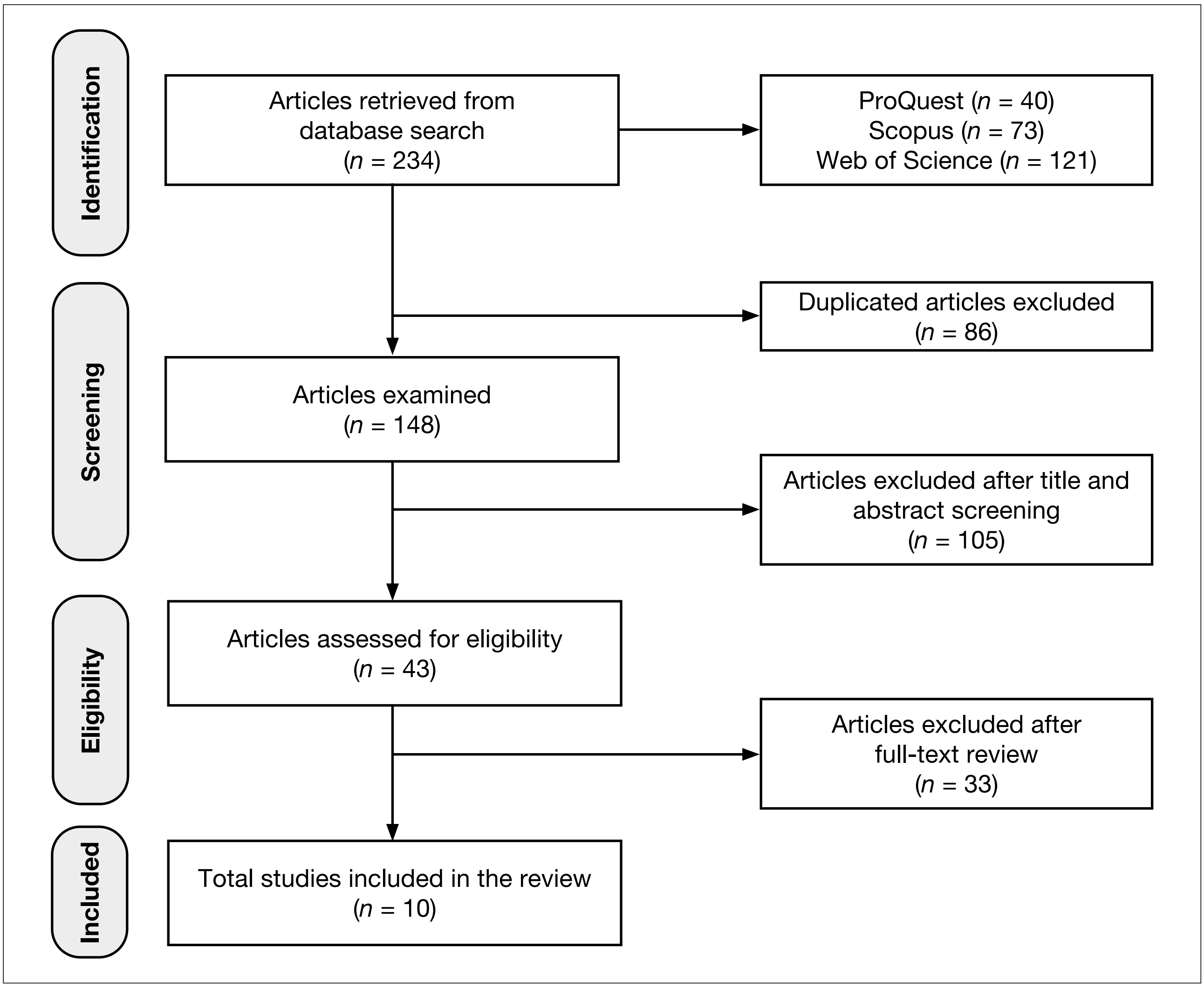
This study follows a systematic review design as per the guidelines and standards established in PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) (Moher et al., 2009), approved by the Blanquerna-URL Research Ethics Committee (ID 2223011D).

In order to locate and identify relevant studies, a bibliographic search was carried out in the different databases in the field of Health Sciences and Sport Science, specifically in ProQuest, Scopus and Web of Science (WoS). The search for publications was conducted on articles published between January 2019 and February 2024, using the following descriptors selected by the authors: "physical education" and "artificial intelligence". These search descriptors must appear in the Title, Abstract or Keyword fields.

Table 1
Inclusion and exclusion criteria.

Inclusion criteria	Exclusion criteria
Empirical studies in the field of PE using AI	Review articles, book chapters, posters, thesis and conference proceedings
Studies reporting on the effects of using AI in PE learning	
Studies published in peer-reviewed journals	
Written studies in English or Spanish	
Full text available	

Figure 1
PRISMA flow chart of the articles included in the review after the screening process.



Selection procedure

The selection of data for this article was made by the principal investigator, according to inclusion and exclusion criteria which are summarised in Table 1.

The selection process continued with the identification, screening and eligibility phases outlined in Figure 1. These phases attempt to ensure the proper selection of items by applying the above criteria (Table 1) with these successive procedures: (1) removal of duplicate articles; (2) exclusion of irrelevant descriptive studies; and (3) extraction of relevant data from the final filtered articles. The online study selection software Rayya (Ouzzani et al., 2016) was used and with the consensus of the three investigators, 10 studies that met the inclusion criteria were selected for review.

Table 2
Summary of selected articles.

Author/s (year)	Journal	Country	Methodology	Educational stage	Results/Conclusions
Ba & Liu (2022)	*Scientific Programming*	China	Quantitative	University	Experimental verification shows that the intelligent neural network-based FNN algorithm can provide a more objective basis for teacher performance evaluation.
Guo (2022)	*Scientific Programming*	China	Quantitative	College and University	Intelligent Computer Assisted Instruction (ICAI) reduces teacher stress and improves the accuracy of PE assessments.
He et al. (2024)	*Heliyon*	China	Quantitative	University	The interactive AI system constructed in this article can play a significant role in the teaching of 400 m running.
Hu (2020)	*Computer-Aided Design and Applications*	China	Quantitative	University	AI-assisted badminton teaching improves communication and exchange between students, increases self-confidence in the learning process and has a positive effect on badminton learning.
Liu (2022)	*Applied Mathematics and nonlinear sciences*	China	Quantitative	College	Students can learn the basic fitness movements independently and effectively, and the teacher can offer more personalised attention to the students.
Sang & Chen (2022)	*Frontiers in public health*	China	Quantitative	College	The method of teaching PE based on human-computer interaction through speech recognition can improve the quality of PE teaching.
Wu et al. (2022)	*Wireless Communications & Mobile Computing*	China	Quantitative	College and University	The majority of students showed satisfaction with the smart PC-assisted educational delivery system in PE classes, although teachers' adoption of the system varied significantly.
Yang et al. (2020)	*Sustainability*	China	Quantitative	Primary school	By combining the advantages of traditional PE and intelligent information technology, the ability to provide personalised attention to students in PE classes is improved. Moreover, the use of educational robots in PE improves students' learning attitude and interest in PE.
Yu et al. (2023)	*Electronics*	China	Quantitative	College and University	The application of the Internet of Things (IoT) and AI has great potential to improve the quality of PE teaching and its efficiency.
Zhang et al. (2022)	*Frontiers in public health*	China	Quantitative	College	The use of virtual simulation technology with AI and the Kinect algorithm combined with teacher education can improve the learning of PE.

Selection analysis

Once the studies selected and included in the review had been organised, the following data were extracted, organised by journal of publication, country of origin of the article, methodology, educational stage and results obtained, which are presented in Table 2.

Results

The content analysis of the selected articles was carried out using the three following categories: scientific evidence of the use of AI in PE, areas of implementation of AI in PE and educational use of AI in PE.

Scientific evidence on the use of AI in PE

The papers of this systematic review have been published in different journals in other fields of Health and Sport Science; most of them (6) of technological and mathematical subjects such as Applied Mathematics and nonlinear sciences, Electronics, Computer-Aided Design and Applications, Scientific Programming and Electronics; and only two (2) of Health and Sport Science: *Frontiers in public health*; and two (2) of general scope: *Heliyon* and *Sustainability*. With regard to the stage of education, nine of the ten articles in the systematic review were carried out at university or college level. All studies used a quantitative methodological approach, mainly through surveys, evaluations and tests. It is important to note that only the study by Ba & Liu (2022) employed advanced statistical analysis, while the other articles were limited to descriptive statistical analysis (frequency tables, percentages and simple graphs). This methodological limitation must be considered when interpreting the results of our review.

Areas of AI implementation in PE

Regarding the AI used in PE, this varies from study to study. In this systematic review, studies using video and speech recognition, Intelligent Computer Aided Instruction (ICAI) and Internet of Things (IoT) were grouped together.

Sang and Chen (2022) and Yang et al. (2020) introduced speech recognition using intelligent robots to assist PE teachers. In this way, using the voice recognition system, the robot can answer the students' questions and gather their feedback. With this human-computer interaction, students' individual development and autonomous learning ability were enhanced (Sang & Chen, 2022). On the other hand, two studies focused on video recognition-based AI using the Kinect algorithm (Zhang et al., 2022) and Kinect v2 (He et al., 2024) to analyse motion. In the same direction, Liu (2022) used motion recognition by recording fitness movements to give feedback to students immediately.

Three articles focused on ICAI. Wu et al. (2022) conducted a survey on the application of wireless sensors and ICAI technology in PE, targeting students and teachers. Hu (2020) used intelligent computer-assisted badminton teaching where teachers create effective teaching programmes according to teaching objectives and carry out targeted teaching, which can effectively improve badminton lessons. Guo (2022) used the ICAI system to be able to select questions for students to answer, to be able to monitor the PE lessons and to be able to evaluate students' behaviour in the different tasks set.

Finally, two articles focused on the use of IoT. Ba & Liu (2022) used AI to assess students' performance and predict their results in PE tests. Meanwhile, Yu and Yang (2023) combined AI and IoT to study the application mode of practical and innovative teaching in university PE through data analysis with the application of algorithms.

Educational use of AI in PE

As can be seen in Table 2, it was possible to find similarities between the different articles in relation to the educational use of AI in PE. First of all, some papers put emphasis on assessing students' satisfaction with the integration of AI technologies in their learning process. Yang et al. (2020) investigated student interest and attitude towards learning in PE lessons by means of a questionnaire, comparing the results with a control group and obtaining higher satisfaction in students who used AI. Along the same lines, He et al. (2024) analysed student satisfaction through a questionnaire including satisfaction with the experience, interest in the sessions, attractiveness of the interactive teaching system and promotion of learning and observed a better satisfaction on the group that used video analysis with AI. Zhang et al. (2022) and Hu (2020) observed that the use of virtual simulation technology improves student interest and motivation in PE lessons. Wu et al. (2022) conducted a survey on the opinion of PE teachers and students, and found that 40% of students were very satisfied with the use of the smart PC in PE lessons and 67% were satisfied with the use of the smart CC-AS in PE lessons. However, this was not an experimental intervention, but rather a survey of teachers' and students' opinions.

Secondly, other studies focused on evaluating the results obtained in sport tests or events with the use of AI in PE. He et al., (2024) analysed the improvement of 400-m sprint performance observing better results in the post-test having received systematic training with AI support. On a similar note, Yu & Yang (2023) concluded that the implementation of a new model of PE by introducing AI can improve students' physical test scores. Focusing on sports, Hu (2020) used a badminton test to compare the results of the control group and the experimental group, with better results in the experimental group. Finally, Ba & Liu (2022) used IoT in their study, focusing on the intelligent algorithm based on the feedforward neural network (FNN) and thus can effectively predict students' score in the national college PE exam.

Thirdly, some studies focused on improving the dynamics of PE classes, such as efficiency, communication and personalisation. In relation to the efficiency of PE classes, Yu and Yang (2023) found that a PE model incorporating IoT and AI improves teaching efficiency compared to the traditional PE model, although this improvement is observed after two weeks. On the same note, Guo (2022) concluded that the integration of AI in PE management can improve the efficiency of student learning. On the other hand, Liu (2022) and Sang and Chen (2022), in their studies on an intelligent teaching system for basic movements in PE and the use of a voice recognition assistant respectively, concluded that AI can improve communication in PE by providing more feedback and personalisation of students' learning and thus promoting their autonomy.

Discussion

Scientific evidence on the use of AI in PE

Regarding the characteristics of the articles included in the review, it should be noted that all the publications in the systematic review are from China. The concentration of research on the application of AI in PE in China, as evidenced in our systematic review, can be attributed in part to the country's unique educational structure, which actively integrates PE at higher education levels, including schools and universities, and to differences in its pedagogical models.

The authors suggest that PE at university educational stages provides fertile ground for innovation and research at the intersection of technology and PE. Nine of the ten articles in the systematic review have been conducted at these stages, with a result similar to other systematic reviews (Zhou et al., 2023). Engagement with PE at these educational stages creates significant opportunities for the development and application of AI solutions aimed at improving the quality of teaching and learning in this field.

In line with this, the review also highlighted the almost non-existent research on AI in PE at primary and secondary level. This absence is particularly striking given the relevance of PE in the educational curriculum and its potential to benefit from AI applications, such as personalising learning, analysing physical performance and promoting healthy lifestyles (Lee & Lee, 2021). Nevertheless, the selected university studies and the results we have observed from them may have transferability to secondary or primary school.

Another critical finding of this systematic review is the variability in the quality of the included studies. It is important to note that many of the reviewed studies present descriptive statistical analyses and questionable research quality. For example, the work of Sang and Chen (2022) relied mainly on authors' opinions and surveys, without advanced statistical analysis. Moreover, in some cases, interventions are not well detailed (Liu, 2022; Zhang, 2021), which makes replicability and accurate evaluation of results difficult. The possible introduction of bias due to reliance on self-reported data and the lack of rigour in statistical analyses also merits attention. The lack of consideration of confounding variables in many studies may affect the reliability of the findings, introducing additional distortions in the results. Despite these limitations, the integration of AI in PE shows promising potential.

Areas of AI implementation in PE

Concerning the areas of implementation of AI in PE, the results of this systematic review underline its diversity and potential by demonstrating different areas of implementation of AI in PE to enhance learning in this field. The use of voice and video recognition, ICAI and IoT illustrates an innovative landscape where technology not only facilitates interaction between students and teachers, but also promotes more autonomous and personalised learning. For example, the use of intelligent robots that respond to questions through voice recognition represents a significant advance in human-computer interaction, offering a richer learning experience tailored to the individual needs of students. (Sang & Chen, 2022). In addition, the implementation of technologies such as Kinect for motion analysis and the combination of AI with IoT for the study of practical applications in PE show how the integration of these tools can offer a more accurate and detailed approach to physical performance and sport activity. (He et al., 2024; Yu & Yang, 2023). The ability to provide immediate and personalised feedback to students, based on detailed analysis of their movements, highlights the potential of these technologies to transform the teaching of PE, allowing for more objective and individually tailored assessment.

Educational use of AI in PE

The results on the satisfaction and increased interest of students in AI-assisted PE classes are indicative of how emerging technologies can revitalise traditional teaching and learning methods. However, it is important to keep in mind that the real goal of incorporating AI in PE goes beyond mere student satisfaction and should focus on objectively improving subject-specific learning.

On the other hand, findings related to academic performance highlight that the potential of AI can lead to significant improvements in both students' physical performance and their academic achievement related to PE. In line with this, AI technologies, such as motion analysis and IoT-based systems, can provide detailed assessments and real-time feedback. (Ba & Liu, 2022; He et al., 2024; Liu, 2022; Sang & Chen, 2022; Yang et al., 2020; Zhang et al., 2022). This focus on personalisation, precision in teaching and evaluation of PE can not only increase the effectiveness of training sessions, but also motivate students by providing them with a clearer understanding of their own progress and areas for improvement.

Finally, studies focusing on classroom effectiveness, communication and personalisation underline the importance of integrating AI into the dynamics of the EF classroom to improve teaching efficiency and foster greater student interaction and engagement. The ability of AI to provide instant and personalised feedback is a significant added value, promoting learner autonomy and greater understanding of PE concepts (Lee & Lee, 2021).

However, the promising educational future through the integration of AI in PE is not without ethical and practical challenges. Specifically, it is crucial to consider the privacy of student data, avoid biases in AI algorithms and understand the potential impact on the teacher-student relationship. Addressing these challenges effectively is essential to ensure that AI actually benefits the educational process and does not introduce new inequalities or ethical problems. Continued exploration of how AI can influence PE teaching is not only necessary, but essential to ensure that AI is used in a way that maximises the benefit to students and contributes to the improvement of PE learning.

Conclusions and future lines of research

Through the results obtained and despite the growing interest in the integration of advanced technologies in education, this review has revealed a scarcity of research, specifically addressing the use of AI in PE, particularly in the primary and secondary stages of education in the European context. In the same vein, it was observed that the studies found in the first search of the review focused exclusively on investigating the different AI tools in PE, but none of them explored whether the use of AI influences the teaching of PE. This was an inclusion criterion and, for this reason, studies were not included in the review.

This reality not only highlights the need for more research in this area, but also suggests that the adoption of AI in PE teaching is at a very embryonic stage and probably without significant educational experiences to investigate. This leaves ample room to explore how AI can enrich and transform pedagogical practices in this field. Along these lines, Celik et al. (2022) concluded that AI offers teachers different opportunities to improve the planning, implementation and evaluation of their teaching.

Regarding the areas of AI implementation in PE, video and speech recognition and analytics, ICAI and IoT are possible areas of AI that can contribute to the improvement of PE by providing personalisation of learning and enriching the learning experience with real-time data and feedback. It remains to be seen whether the education system as a whole finds these resources necessary to achieve its objectives or whether the system already has the resources.

Concerning the educational use of AI in PE, the results show that AI can improve the satisfaction, outcomes and effectiveness of PE sessions. While these aspects are important to validate the acceptability and feasibility of AI in the classroom, there is a clear lack of studies that delve deeper into the direct impact of AI on students' learning and improvement of specific PE competences. This gap in research suggests that, while AI advances may be positively received by the educational community, there is still much to be explored in terms of the actual usefulness of AI in PE learning.

Against this background, the present review invites future research to venture into the exploration of AI in PE, especially in primary and secondary education. It is imperative that future studies focus not only on technical and satisfaction aspects, but also on assessing how AI can transform PE learning. Future research should adopt multidisciplinary methodologies to address these questions, working closely with educators, technologists and students to design and evaluate pedagogically sound classroom implementations of AI tailored to the specific needs of the PE domain. This step should be taken into account insofar as there has recently been a strong debate on the appropriateness of the use of digital devices in the classroom in schools (Moncada, 2024; UNESCO, 2021). Future studies could benefit from a more diversified approach with a specific focus on primary and secondary education. In addition, it is essential that the interventions are specified in detail to facilitate their replicability, and that the process of data collection is clearly described. It is also important that studies include both qualitative and quantitative data, as this can contribute to a more complete, comprehensive and holistic view of the study problem. (Castañer et al., 2013).

Another limitation of the present work is the incipient stage of academic development of this field of study, which implies a relatively sparse in advance literature base, limiting the ability to carry out a comprehensive analysis with a broad empirical basis. Another limitation of the study lies in its focus on the use of AI in PE and does not consider other emerging digital technologies such as Virtual Reality or Augmented Reality whose use in PE can help to improve this subject (Zhou et al., 2023).

In summary, this systematic review underlines the lack of scientific literature with much more verifiable evidence on the use of AI in PE and represents a significant opportunity to enrich the field of PE by incorporating AI. Future studies can address the identified gaps and explore new research directions in order to define where the use of AI can improve the quality of FE.

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Impact of the Attitudinal Style on High School Students' Motivation in Physical Education

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Ana Alonso and Oriol Cardona achieve their qualification for the new Olympic sport of ski mountaineering by taking second place at the 2025 World Championships in Boí Taüll.
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Abstract

The main aim of the study was to deepen examination of the emerging Attitudinal Style (AS) pedagogical model and assess its impact on the motivation of high school students. The sample consisted of 80 high school students, 47.5% female and 52.5% male, aged between 14 and 16 years (M = 14.97; SD = 0.43), from two different schools. Two teachers participated, one at the intervention school (n = 42) and one at the control school (n = 40). The methodology was a quasi-experimental design with pretest and posttest evaluation. Over the course of four consecutive learning units (24 sessions, 3 months), the teacher at the intervention school implemented an AS program, whereas the teacher at the control school employed a mixed method. The Perceived Locus of Causality Scale in Physical Education-2 was used to assess students' motivation levels. The results showed that the intervention school exhibited significantly higher levels of intrinsic motivation regulation (pre: 2.47 ± 0.18, post: 3.85 ± 0.18, $p < .001$), integrated regulation (pre: 2.26 ± 0.21, post: 3.36 ± 0.20, $p < .001$), and identified regulation (pre: 2.47 ± 0.20, post: 4.00 ± 0.20, $p < .001$). Likewise, levels of amotivation were significantly lower in the intervention school (pre: 1.67 ± 0.17, post: 0.59 ± 0.16, $p < .001$) compared to the control school. The students therefore experienced significantly higher motivation in physical education classes following the implementation of the AS.

Keywords: educational outcomes, pedagogical models, quasi-experimental design, School-based intervention, secondary education.

Introduction

In the context of Physical Education (PE), motivation is the primary key to influencing students' learning success (Chen, 2001; Cenic et al., 2019). Motivation is also useful for researching different consequences, such the behavior of students following educational goals or the intention to be active in the future (Castillo et al., 2020). To understand motivation, Self-Determination Theory (SDT) (Ryan & Deci, 2017; 2020) breaks down motivation into different types (Chen, 2001). These include amotivation, (where an individual lacks intention for action), external regulation (where action is taken under the duress of external agents), introjected regulation (where actions are taken to evade internal pressures), identified regulation (where an individual exhibits high volition to take action), integrated regulation (where activities are assimilated with personal values and interests), and autonomous motivation (where actions are driven by personal interests). This theory has been widely used in PE, showing potential effectiveness in the use of intervention programs to increase the variety of motivation outcomes in students (Vasconcellos et al 2019; Pérez-González et al., 2019; Kelso et al., 2020; Diloy-Peña et al., 2021).

However, many children present high levels of amotivation (Aniszewski et al., 2019) making the teaching-learning process difficult (Ryan & Deci, 2017; 2020). This may be due to inappropriate learning models and less innovative learning patterns, resulting in students who are less enthusiastic about learning (Syahidah et al., 2023). Therefore, in an effort to improve the teaching-learning process and increase motivation, researchers have been seeking out innovative methods to improve these capacities in students (Kelso et al., 2020). These innovative methods, such as pedagogical models (PMs) (Casey & Kirk, 2021; Sánchez-Alcaraz et al., 2021; Pérez-Pueyo et al., 2021; Camerino et al., 2023), diverge from focusing solely on content or the teacher, and strive to align learning outcomes with student needs and teaching styles (Casey, 2016). Therefore, PMs emerged from the combination of context, subject matter, and teachers' and students' expectations and behaviors conceived of as a whole construct (Casey, 2016). Increasing opportunities for students to learn collaboratively may also yield benefits in terms of motivation (Barkley et al., 2014; McKeachie et al., 2006). The Attitudinal Style (AS) is one learning strategy that is considered to be able to foster motivation (Pérez-Pueyo, 2016).

Attitudinal style as an emerging pedagogical model for enhancing motivation in physical education

The AS focuses on attitudes as the central element of the teaching and learning process, with the primary objective of promoting higher motivation towards PE and enhancing learning outcomes (Pérez-Pueyo et al., 2020). Its long-term implementation in the classroom aims to increase student motivation and cultivate a positive attitude towards practice (Pérez-Pueyo, 2016). To achieve this, the model encourages autonomy and student participation in the classroom, and aims to improve social relationships and enhance perceived competence and self-efficacy. All of this is fostered within a task-oriented climate where collaboration and cooperation are essential and commonplace in the learning process. In this context, the AS draws from SDT, which has been shown to positively influence autonomous motivation (intrinsic motivation, integrated regulation, and identified regulation) within the context of PE (Vasconcellos et al., 2019).

In terms of application, the model does not focus solely on a motor dimension but on the comprehensive development of the five types of abilities defined by Coll (1991). Of those, the work of the affective-emotional dimension (generation of positive emotions and experiences in students in the classroom) plays a leading role in the model (Pérez-Pueyo, 2016). In this sense, Fierro-Suero et al. (2023) have shown the importance of considering both motivation and emotions to understand the consequences of what happens in PE classes. This interrelation occurs within a complex system of co-regulation between students and teachers (Meyer and Turner, 2006; Castillo et al., 2020). The session design addressed three components: intentional bodily activities, sequential organization towards attitudes (SOA), and final assemblies (see Table 1). However, the author does not perceive this design as rigid (Pérez-Pueyo et al., 2020).

The model is based on five pillars: critical reflection by the teacher on educational practice, intentional work on motivational aspects to create positive experiences, using motor skills as a means, from a critical perspective regarding the more mechanistic view of PE, and questioning demonstration as an essential resource in the classroom (Pérez-Pueyo et al., 2021). In this way, the teacher becomes a facilitator of learning, adapting educational practices to accommodate various learning paces and student characteristics.

Table 1
Characteristics and main components of AS.

Intentional bodily activities	Sequential organization towards attitudes	Final assemblies
1) Use of motor skills as a means and not as an end. 2) Engage the student and foster individual and/or group responsibility. 3) Assist the student in recognizing and surpassing their limits. Connect to self-evaluation and/or peer evaluation processes.	1) Students begin activities in pairs or trios based on affinity. 2) Progress to groups of four, eight, twelve, and finally the whole class. 3) This organization is not rigid but varies based on the content or the type of assembly.	1) The final assemblies conclude the process followed so far by showcasing both individual and group progress through a project.

Note: Own elaboration.

In the existing literature, numerous informative publications provide a detailed guide on how to implement the AS in the classroom, but we found no research thoroughly examining whether the model leads to improvements in student motivation, that being the primary objective.

Considering the lack of studies on the subject, research is needed to establish how AS affects the motivation of PE students. Therefore, the objective of this study was to analyze the impact of an AS intervention in high school PE classes on student motivation variables and to compare these effects with those of a mixed methods intervention. Building upon these premises, the primary hypothesis proposed that after exposure to an AS methodology, students would experience significant improvement in different motivation outcomes within PE classes.

Method

Design and participants

This study used a quasi-experimental design with pretest and posttest evaluation with the control school (CS) (Cohen et al., 2011). The participants came from two different public high schools in Spain with similar mid-level sociodemographic profiles. The teachers who participated in the study were two career teachers with similar teaching experience (2–4 years), aged between 26 and 31 years. One teacher taught at the intervention school (IS) and the other at the CS. The IS teacher had extensive prior training on the application of AS, having several informative publications on the application of the model. However, this was their first year teaching the participating students, and those students had never been exposed to the AS. This led to the justification of examining to what extent the methodology may or may not influence student motivation. In addition, the IS teacher underwent a period of continuous training on how to implement the educational program and subsequent analysis by a qualified specialist in the field. On the other hand, the CS teacher had prior experience in directive teaching styles and had recently completed a short-term training on various PMs. However, they did not have experience in applying the latter.

The student sample was selected for accessibility and convenience, and for access to data and the opportunity offered by the two schools to implemented the proposed LU. It originally consisted of 96 students between the two schools with grades representing the four years of high school or secondary education. Inclusion criteria for study participation (for both groups) were (a) regular attendance in PE classes (≥90%) and (b) completion of all the questionnaires. None of the participating students had any previous experience with AS. The final sample consisted of a total of 82 students, of which 42 belonged to the IS (M = 14.93; SD = 0.36) and 40 to the CS (M = 15.01; SD = 0.51).

Instruments

Motivation. The Perceived Locus of Causality Scale in Physical Education-2 (PLOC-2) (Ferriz et al., 2015) was used to assess the students' motivation levels. The questionnaire started with the following sentence: "I participate in the Physical Education classes…" and the scale included 24 items grouped into six factors: intristic motivation (i.e., "Because it is fun"), identified regulation (i.e., "Because it is in agreement with my way of life"), introjected regulation (i.e., "Because I want the teacher to think that I am a good student"), external regulation (i.e., "Because I will have problems if I don't do it"), integrated regulation (i.e., "Because it aligns with my way of life"), and amotivation (i.e., "But I don't really know why"). Participants answered according to a Likert-type scale ranging from 0 (totally disagree) to 5 (totally agree). All the constructs scored positively except for the amotivation construct, which scored negatively.

The pre- and post-Cronbach's α values ranged between .69 and .93, with integrated regulation obtaining the highest value of internal consistency. Regarding the different subscales: intrinsic motivation .67 and .86, identified regulation .70 and .87, introjected regulation .64 and .84, external regulation .54 and .80, integrated motivation .80 and .91, and amotivation .51 and .79, respectively.

Table 2
Intervention weeks, sessions, and learning units/content (intervention school/control school).

Weeks	Lessons	Methodology		Learning Unit
		Intervention school	Control school	
1–2 weeks	4	Attitudinal Style	Cooperative Learning	Physically emotional challenges
3–6 weeks	8		Direct Instruction	Collective physical condition classes
7–10 weeks	8		Direct Instruction and Service-learning	Injury prevention and first aid
9–12 weeks	4		Direct Instruction	Diet and nutrition

Design and Procedure

To conduct this research, the first step was to obtain permission from the University of León Ethics Committee (ETICA-ULE-048-2023). Subsequently, the directors of the two schools were contacted to request their collaboration. Lastly, informed consent was obtained from the parents of all study participants. The study adhered at all times to the relevant ethical values in research involving human beings: informed consent, right to information, protection of personal data, guarantees of confidentiality, non-discrimination, gratuity, and possibility to withdraw from the study in any of its phases (McMillan & Schumacher, 2001). The participating groups completed the previously described questionnaire on two occasions (prior to the intervention and three months post-intervention) in a calm environment, and were given 20 minutes to do so. The participants responded anonymously, which also contributed to ensuring data processing confidentiality. The importance of responding honestly to the questions was emphasized, assuring that answers would not influence their evaluation in any way.

Ethical recommendations established by various international educational research bodies were followed at all times, maintaining the anonymity of the sample and using the obtained data exclusively for the purposes of this research (American Psychological Association, 2020).

School-based intervention

An intervention program (see Table 2) was conducted at both schools over three months: two 50-minute sessions per week, 4 LUs and 24 sessions. The IS experienced AS in all the LUs, whereas the CS experienced a mix methods approach. Nevertheless, both groups covered the same LU during at the same period of time in accordance with the current Spanish Education Law. In this way, different blocks of content and basic knowledge proposed in the Spanish curriculum were addressed: (1) Active and healthy life (Injury Prevention and First Aid; Diet and Nutrition), (2) Organization and management of physical activity (Collective Physical Condition classes), (3) Problem-solving in motor situations (Physically Emotional Challenges), and (4) Emotional self-regulation and social interaction (transversal across all LUs).

A) Attitudinal style

The teacher responsible for teaching classes at the IS had previous experience in implementing AS in secondary education (four years) and had also published several informative publications about the practical application of the model in the classroom. Once the intervention program was designed, it was sent to experts in the applied methodology. In this sense, the fidelity of the design was strengthened through an extensive description of the curricular elements of the proposed LU, the evaluation of the different parts of the LU (session model, type of groupings, main components, among others), and their adaptation to the context. Once the experts approved the intervention program, online meetings were held once a week for the 12 weeks of intervention. In this regard, contact was also maintained with the CS teacher throughout the entire intervention program to verify adherence to the proposed program.

On the other hand, to consolidate AS implementation, multiple videos of the final assemblies of the various LUs were disseminated. The different stages of the units were tracked through a digital diary maintained by the teacher and shared with the experts via the OneDrive platform. In the digital diary, the teacher noted what happened during the different sessions, the main reflections, and the teaching-learning activities carried out in the session. The purpose was to provide qualitative feedback and improvement suggestions from the experts, rather than to serve as a tool for quantitative analysis. Nevertheless, it was also used to analyze the factors influencing the implementation of the model, which is reflected in the results section.

B) The mixed methods program

A directive methodology was employed in almost all the LUs, specifically direct instruction (Mosston & Ashworth, 1986). Within the contents of Collective Physical Condition classes and Diet and Nutrition, the students replicated the instructions provided by the teacher. Progression in the action is predicated on motor logic, with execution being the paramount feature, rather than the role that each group member plays. On the contrary, in the AS, the progression of activities not only addresses motor patterns, but also the motivational and relational dimensions, which are considered to be key factors (Pérez-Pueyo, 2016).

In relation to the Physically Emotional Challenges and Injury Prevention and First Aid course content, cooperative learning (CL) (Johnson & Johnson, 1999) and service learning (SL) (Dewey, 1938) models were used. It is worth noting that the teacher did not undergo prior training in these latter models beyond autonomous learning.

Therefore, despite the LUs covering the same content, the educational goals in each of the groups were different, largely defined by the type of methodology used.

Data analyses

The statistical software SPSS v.23.0 was used for the analysis. Prior to conducting the primary analyses, the data normality and homogeneity were evaluated. The Kolmogorov-Smirnov and Levene tests indicated that the data exhibited normality ($p > .05$) and homogeneity ($p > .05$) independently for the IS and CS. Frequencies, means, and standard deviations were calculated for the study variables.

To examine the effects of this school-based intervention, a 2x2 (time x group) multivariate repeated measures analysis of covariance was conducted on the variables included in the research (before and after the school-based intervention). Multiple paired *t*-tests with the Bonferroni correction were calculated for the continuous variables to determine intra-group (i.e., between IS and CS) and inter-group (i.e., pre-post) differences. Cramér's V was used to describe the degree of association between the IS and CS. Effect sizes were assessed using partial Eta squared (η_p^2) for continuous variables. Effect sizes were considered small, moderate, or large, when the η_p^2 was above .01, .06 and .14, respectively.

Results

Interaction effects

Table 3 shows the differences between the experimental and control groups before and after the intervention (between-school differences), pre-and post-test (within-school differences), and interaction effects. No significant differences were found in the time x group interaction effects for motivational regulation (Wilks' Lambda = 0.866; F (6, 75) = 1.935; $p = .086$; $\eta_p^2 = .134$). However, within-school and between-school effects showed some significant differences in the behaviours assessed.

Within-school effects

Before the intervention, no significant differences were found between the CS and IS for most of the study variables, with the exception of amotivation, which was significantly higher in the CS ($p < .01$, see Table 3). After the school intervention, significant differences were found between the IS and CS for intrinsic motivation regulation, integrated regulation, identified regulation, and amotivation ($p < .001$), which was significant higher in the IS.

Table 3
Descriptive statistics of the study variables for the intervention and control schools in pre-and post-test: Within- and between-school differences and interaction effects.

Groups study variables	Test time	Control school	Intervention school	Contrast within-school differences (pre-and post-test)				
		M ± *SD*	*M* ± *SD*	Mean Diff.	SD	*F*	*p*	η_p^2
Motivational regulations: Wilks' Lambda = 0.866; *F* (6, 75) = 1.935; *p* = .086; η_p^2 = .134								
Intrinsic motivation (range: 1–5)	Pre	2.82 ± 0.21^{a}	***3.06 ± 0.20^{a}***	–-0.24	0.29	0.707	**.403**	.009
	Post	2.47 ± 0.18^{a}	***3.85 ± 0.18^{b}***	–1.38	0.25	29.57	***<.001***	.270
Integrated regulation (range: 1–5)	Pre	2.69 ± 0.23^{a}	***2.53 ± 0.22^{a}***	0.16	0.32	0.243	.624	.003
	Post	2.26 ± 0.21^{a}	***3.36 ± 0.20^{b}***	–1.10	0.30	13.550	***<.001***	.145
Identified regulation (range: 1–5)	Pre	2.82 ± 0.22^{a}	***3.36 ± 0.22^{a}***	–0.55	0.31	3.058	.084	.037
	Post	2.47 ± 0.20^{a}	***4.00 ± 0.20^{b}***	–1.53	0.28	29.931	***<.001***	.272
Introjected regulation (range: 1–5)	Pre	2.13 ± 0.20^{a}	2.02 ± 0.20^{a}	0.10	0.29	0.131	.718	.002
	Post	2.08 ± 0.21^{a}	2.54 ± 0.21^{a}	–0.45	0.29	2.359	.128	.029
External regulation (range: 1–5)	Pre	2.24 ± 0.21^{a}	2.17 ± 0.21^{a}	0.07	0.29	0.058	.810	.001
	Post	2.08 ± 0.20^{a}	2.26 ± 0.19^{a}	–0.18	0.27	0.398	.530	.005
Amotivation (range: 1–5)	Pre	1.14 ± 0.19^{a}	0.83 ± 0.19^{a}	0.62	0.27	5.184	***<.01***	.061
	Post	1.67 ± 0.17^{a}	0.59 ± 0.16^{a}	1.08	0.24	21.156	***<.001***	.209

Note. SD = Standard deviation; Diff. = Difference; CI = Confidence interval. The values with significant differences are presented in bold. Interaction effects are detailed next to each variable. The comparison between schools for each variable is indicated with different superscripts (^{a}no differences, ^{b}differences) in pre-and post-test. A mean is significantly different from another mean if they have different superscripts.

Between-school effects

Overall, no significant changes were found among the CS students for any of the motivational regulations assessed. In contrast, the IS students showed better intrinsic motivation regulation ($p < .01$, see Table 3), integrated regulation ($p < .01$), and identified regulation ($p = .033$) after the school-based intervention.

Discussion

The aim of the study was to analyze the effect of use of the emerging PM AS on the motivation levels of secondary education students. To this end, we measured different motivation dimensions (intrinsic motivation and identified regulation, introjected regulation, external regulation, and amotivation).

The main study findings indicate that AS implementation had a positive influence on various dimensions of student motivation. These results align with previous research that used PMs and motivating teaching styles, addressing students' basic psychological needs (competence, autonomy, and relatedness) to enhance motivation and engagement in the classroom (Sierra-Díaz et al., 2019; Franco et al., 2023; Moreno-Murcia et al., 2024).

On the other hand, contrary to the results reported by López-Urán et al. (2022), which indicated a tendency toward amotivation after the model's implementation, prior publications focusing on the application of AS (Hortigüela-Alcalá et al., 2016; 2018) demonstrated that its use in the classroom leads to an increase in students' self-concept and improvements in the teacher-student relationship. All these variables contribute positively to increasing autonomous motivation (Pavlović et al., 2021; Van Doren et al., 2021).

In relation to the effectiveness of the intervention program, significant differences favoring the IS were found between the IS and the CS regarding autonomous motivation (intrinsic motivation, integrated and identified regulation) and amotivation.

These findings align with systematic reviews and meta-analyses conducted by Kelso et al. (2020) and Vasconcellos et al. (2019), which demonstrate a positive effect of SDT-based intervention programs in PE on intrinsic motivation and integrated and identified regulation. In this regard, although CS was applied in two units, CL and SL, whose effectiveness has been demonstrated (Yang et al., 2021; Pérez-Ordás et al., 2021), it is important to note, as Casey (2024) points out, that these approaches should not be implemented in isolation or be expected to yield immediate results. Therefore, the impact on motivation levels may have been influenced by their application in a single unit. In this sense, the hybridization between DI and SL may have diluted the effectiveness of SL due to the potential tensions that arise when these models are combined. As discussed in the works of Casey & Kirk (2024) and Casey (2024), it is essential to reflect on how hybridizations are carried out and how they are adapted to the needs of the group to avoid pedagogical contradictions.

Regarding the amotivation variable, for which significant differences favoring the IS were found between the IS and the CS, it is important to highlight that non-significant effects were observed in the meta-analyses conducted by Kelso et al. (2020) and Vasconcellos et al. (2019) when applying PMs. In this context, the improvement in the students' amotivation levels may be attributed to the emphasis on attitudes as a central element in fostering a task-oriented motivational climate, rather than an ego-oriented one (Pérez-Pueyo, 2016).

In terms of external and introjected regulation, due to its inherent characteristics, AS prioritizes the development of autonomous motivation and a focus on learning goals. As a result, external and introjected regulation are influenced to a lesser extent. This same pattern can also be observed in other PMs, such as CL (Sierra-Díaz et al., 2019).

Conclusion

The results of this research indicate that the use of the emerging PM AS over a period of 3 months (4 LUs) has a positive effect on most motivational dimensions when compared to a group in which a mixed methodology was applied. In this regard, the teaching and learning implications, as well as the theoretical foundations of AS, align with the postulates of SDT and the enhancement of basic psychological needs. This is achieved by focusing on the holistic development of students through a task-oriented motivational climate, where students are the protagonists of the teaching-learning process from a collaborative approach. In this regard, implementation of the AS in the classroom should begin with laying down a solid foundation, involving students in the process and in joint problem-solving, and long-term implementation throughout the school year to boost improvement in motivation levels.

Regarding the study limitations, we recognize the need for longer intervention programs that incorporate repeated pre-test and post-test measurements. This would facilitate the analysis and comparison of the model's long-term effects. Furthermore, it would be pertinent to explore potential differences in motivation variables based on gender, exercise habits, physical activity, and socioeconomic status. In this regard, qualitative research focused on measuring motivation could help to understand in-depth the perceptions and opinions of both teachers and students.

This article may be of interest to PE teachers. It reflects on the impact that AS can have on student motivation and may help to refocus pedagogical approaches around the development of motivational dimensions.

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A multivariate analysis of physical fitness and competitive performance in young handball players

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Ana Alonso and Oriol Cardona achieve their qualification for the new Olympic sport of ski mountaineering by taking second place at the 2025 World Championships in Boí Taüll.

Abstract
Handball as a team sport requires certain attributes of physical fitness. Higher upper and lower body power values must be developed throughout the entire player training process. The aim of the present study was to characterise the jumping and throw kinetics of nine young talented handball players during three sport seasons (Season 1: 14.1 ± 0.9 age; 70.6 ± 5.9 kg; 171.6 ± 10 cm; Season 2: 15.1 ± 0.9 age; 74.7 ± 6.5 kg; 177.7 ± 8.2 cm; Season 3: 16.1 ± 0.9 age; 78.3 ± 6.7 kg; 179.9 ± 6.7 cm) and assess possible relationships with competitive performance. The physical fitness tests performed were the squat jump (SJ), the counter movement jump (CMJ), the Abalakov test (ABK) and the 3-kg medicine ball throw, analysing jump heights and throwing distance. We designed a 3-season follow-up study with two checkpoints for each season. The athletic performance of each player was established individually by determining a competitive ranking that was contrasted from a bivariate and multivariate perspectives, with somatic characteristics and the physical fitness tests performed. All physical fitness tests improved throughout the three seasons, although differently between the preseason and postseason. The 3-kg medicine ball throw test was moderately correlated with sports performance and, together with the Abalakov test, explained it with a low predictive power. We concluded that, despite the improvement in the jumping and throwing ability over three seasons, this does not seem to have a sufficiently consistent relationship with the competitive level of this group of young talented handball players. Further research is needed to control for parameters of biological age and cognitive complexity.

Keywords: conditional tests, sport talent, sports performance, strength, young players.

Introduction

Handball is an intermittent and complex situational sport regulated by the International Handball Federation (IHF, 2017). According to the playing position, handball players have a specific anthropometric (Karcher & Buchheit, 2014; Martínez-Rodríguez et al., 2020) and physical fitness profile (Aguilar-Martínez et al., 2012; Font et al., 2023; Karcher & Buchheit, 2014; Schwesig et al., 2017).

Although research on the anthropometric and physical fitness profile has been widely studied in professional handball players (Karcher & Buchheit, 2014), it has not been so widely studied in young talents during their formative stage and how this relates to their competitive performance (Lidor et al., 2005; Matthys et al., 2011; Matthys et al., 2013a; Matthys et al., 2013b; Zapartidis et al., 2009).

From an early age to the elite, modern and current handball requires high values of strength, power and speed to perform technical and tactical skills at maximum intensity during training and matches (Buchheit et al., 2009; Gorostiaga et al., 1999; Karcher & Buchheit, 2014; Matthys et al., 2011; Zapartidis et al., 2009). For example, the importance of the sprints over short distances is well characterised, and these are low in percentage terms vs. the total volume of meters travelled during a match (Font et al., 2021b), yet paradoxically decisive and defining when resolving situations with utmost efficiency (Ghobadi et al., 2013) and with a high risk of injury (Mónaco et al., 2019).

The process of handball training in formative stages, and hence in relation to identifying sports talent, necessarily involves aspects including monitoring and developing maximal strength, power and speed values in both lower and upper limbs (Lidor et al., 2005; Mohamed et al., 2009). Accordingly, the categorisation of strength training in this sport is usually recognised as it relates to shots, jumps, or hand-to-hand contact with an opponent (Karcher & Buchheit, 2014).

Most of the physical fitness tests used in handball are generic. Generic tests have been carried out to obtain the speed profile of the players (Krüger et al., 2014), the metabolic profile of the players (Schwesig et al., 2017), the heart rate needs of young players in competition (Ortega-Becerra et al., 2020), the strength values in classic exercises such as the bench press or the squad (Ingebrigtsen et al., 2013) or the power in jumps such as the countermovement jump (Massuça et al., 2015; Matthys et al., 2013a). These conditional tests are important as fitness has been shown to influence the way players approach training and their performance (Manzi et al., 2010). Their main drawback is that the inherent specificity of the technical movement is lost, which unquestionably has a direct impact on the greater or lesser effectiveness of a specific technical-tactical action that is the final goal, pursued by any coach (Schwesig et al., 2017; Wagner et al., 2016).

There is also research that has focused on knowing the metabolic profile in specific tests made up of handball movements on the court in order to improve the conditional profile of the players and at the same time to evaluate them (Michalsik & Wagner, 2021; Wagner et al., 2016).

By contrast, the benefits of this type of fundamental/generic test are (Font, et al., 2021a; Irurtia et al., 2010): 1) they make it possible to locate the conditional component (strength, power, speed) by isolating or minimising the influence of the specific technical component, thus being able to clearly separate the evolution of one or the other parameter; 2) they allow a distribution that is simple and therefore applicable in both young and professional players; 3) this latter characteristic enables these tests to be used in the application of a longitudinal comparison that establishes an individual's level of conditional evolution over time; and 4) they allow comparison between different sports.

The identification of sports talent in handball is therefore a burgeoning area of current scientific and professional interest (Matthys et al., 2011). As far as we know, there are not many studies which, with a longitudinal design and using basic physical fitness tests have examined the evolution of the conditional characteristics of young talented handball players, trying to relate and/or explain these with their sports performance. The purpose of this study was to analyse the physical fitness kinetics of a group of young talented handball players throughout three sports seasons with two checkpoints (preseason and postseason). Basic jumps corresponding to Bosco's battery and 3-kg ball throw were applied in order to analyse the physical fitness characteristics of the lower and upper limbs, respectively. Finally, the possible relationship and/or explanation of the competitive performance of each player was analysed according to the level of performance in those tests.

Methodology

Study Design

This is a follow-up study that applies correlation (bivariate) and multiple regression analysis (multivariate) by setting a series of independent variables (physical fitness tests) and a dependent variable (sports performance). The independent variables ($n = 6$) were: body mass (kg), height (cm), throwing a 3-kg Medicine Ball (MB, m), Squat Jump (SJ, cm) Counter Movement Jump (CMJ, cm), and CMJ Abalakov (ABK, cm). The dependent variable was sports performance based on the score obtained by each player arising from their participation and sports achievements throughout the timeframe analysed in their club by expert coaches at national team levels (Table 1).

Table 1
Sport score to assess the athletic performance of each player.

Club		National Team (Friendly Tournaments, European and World Cups, Training Camps)		Region Team	
Training 1st Team	20	Champion with National Team	18	Spanish Championship	10
Spanish Championship	18	2nd with National Team	16	2nd Spanish Championship	9
2nd Spanish Championship	9	3rd with National Team	14	3rd Spanish Championship	8
Technification Group	7	Participation in a World Championship	12	Participation in the final phase	6
Region Championship	6	Participation in a European Championship	12	Participation in the preparation phase	5
		Preparation for the World Cup	10		
		Preparation for the European Cup	10		
		Friendly Tournament	8		
		Training Camp	6		

Table 2
Number of handball players analysed per sport season and ranges of chronological age.

Age (years)	Season 1 (n = 9)	Season 2 (n = 9)	Season 3 (n = 9)
12 to 14	6	0	0
13 to 15	2	6	0
14 to 16	1	2	6
15 to 18	0	1	3

Participants

Nine male players in formative teams of a top European handball club (Season 1: 70.6 ± 5.9 kg; 171.6 ± 10 cm; Season 2: 74.7 ± 6,5 kg; 177.7 ± 8.2 cm; Season 3: 78.3 ± 6.7 kg; 179.9 ± 6.7 cm) were used to examine the evolution of the physical fitness tests conducted in the 2013–2014 (Season 1), 2014–2015 (Season 2) and 2015–2016 (Season 3). The inclusion criteria were: a) belonging to the youth academy of the same handball club; and b) having actively competed during the season analysed. On the other hand, the exclusion criteria were: a) having been injured or being convalescent at the time and for up to two weeks before being analysed; and b) not having done any of the tests in the three seasons. Table 2 shows the chronological age ranges of the players in relation to the competitive categories in which each of them competed during the three seasons examined.

Throughout the study, the moral and ethical commitment to confidentiality in the handling of personal data was respected. The club, as the owner of the rights of the players, allowed the technician, in this case the author of this research paper, to use this information to promote the scientific progress of this sport. In addition, these tests were used throughout different seasons to assess the assimilation of conditional work by the players of the formative teams. Finally, each player signed the corresponding informed consent document accepting their participation in the study and their right to abandon it at any time.

This study complied with the rules and recommendations proposed at the Helsinki Conference for research in humans (Harriss & Atkinson, 2015). The data came from daily monitoring of all the players in the team throughout every sport season. Consequently, the approval of an ethics committee was not required (Winter & Maughan, 2009).

Material and Instruments

All the tests (body mass, height, MB, SJ, CMJ, ABK) were performed on the same day with a random chronological order between MB and the jump tests. Each season was recorded during the preseason (at the beginning of the preparation, with a minimum of 4 weeks before the first official competition) and (2) postseason (right after the last official competition). All the tests were performed for the whole sample and always in the same handball training sports hall by a single researcher, the author of this study.

Body mass and height were measured by a Seca 220® telescopic stadiometer (measuring range: 85-200 cm, precision: 1 mm) and a previously calibrated Seca 710® scale (capacity: 200 kg, precision: 50 g). Physical fitness tests were performed prior to the activation phase as a guided warm-up. In the case of the jumps, these tests are widely used in handball and their high reliability is also reported in young players (Font, et al., 2021a; Oliveira et al., 2014); only the best of three attempts made by each athlete was recorded. The jump tests used were tailored to the protocols described in the international literature (Font, et al., 2021a; Ingebrigtsen et al., 2013; Massuça et al., 2015). Their choice is justified by the considerations put forward by Gorostiaga et al. (2005) in relation to the characteristics of jumping in handball: a) squat jump (SJ); b) counter movement jump (CMJ); c) Abalakov (ABK). They were carried out using the Chronojump® contact platform and jump monitoring equipment (Chronojump Boscosystem, Barcelona, Spain). The hardware was connected to a computer which displayed the vertical jump height (cm) using free software (2.0.2., Chronojump Boscosystem Software, Barcelona, Spain) (Cadens et al., 2023; Font, et al., 2021a). The previously established recommendations for young handball players (Fernández-Romero et al., 2017) were followed for throwing the 3 kg medicine ball with three throws and recording only the best one.

Statistical Analysis

Basic descriptive statistics (average and standard deviation) were used to express evolution over three seasons together with the evolution of each of the physical fitness tests applied at the rate of two control points per season. The Shapiro-Wilks test confirmed the non-normality of the distribution. Therefore, non-parametric statistics were applied: a) the Wilcoxon test was used to check for possible differences between each macrocycle; and b) the highest value of each player was chosen for each season and the Friedman test was used to analyse differences between seasons. If significant differences were found, the Wilcoxon signed-rank test was used again. The degree of correlation between each of the tests analysed and between them and sports performance was examined using Spearman's rank correlation coefficient. Finally, multiple regression analyses were carried out to assess how far the independent variables explained the dependent variable (sports performance). The level of significance was $p < .05$. All statistical analyses were conducted using SPSS version 23.0 (SPSS Statistics, IBM Corp., Armonk, NY, USA).

Results

Figures 1 ,2, 3 and 4 show the evolution of the physical fitness tests (MB, SJ, CMJ, ABK) over the three seasons examined, respectively. Additionally, the significant differences between the two macrocycles analysed for each season are shown.

Table 3 shows the comparison between seasons of all the variables analysed, in this case based on the best values recorded in each test.

Body mass correlates significantly with performance (r = .39, p = .04). By contrast, the only physical fitness test that registers a significant correlation, albeit slight, with sports performance is the 3-kg medicine ball throw test: r = .43; p = .02. The multiple regression analysis selects two variables as explanatory factors of performance to generate the following equation: - 28.773 + (4.613 · 3 kg ball throw) + (1.348 · ABK) with very low predictive power of $R^2_{adjusted}$ = .16; p = .04.

Figure 1
Evolution of the 3-kg medicine ball throw.

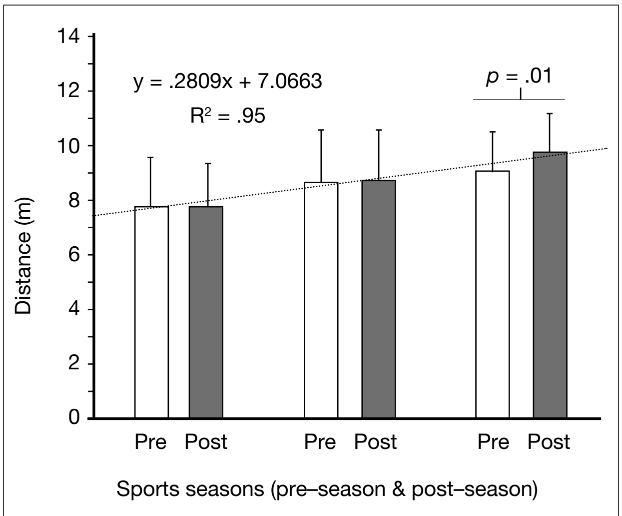

Figure 2
Evolution of the squat jump (SJ).

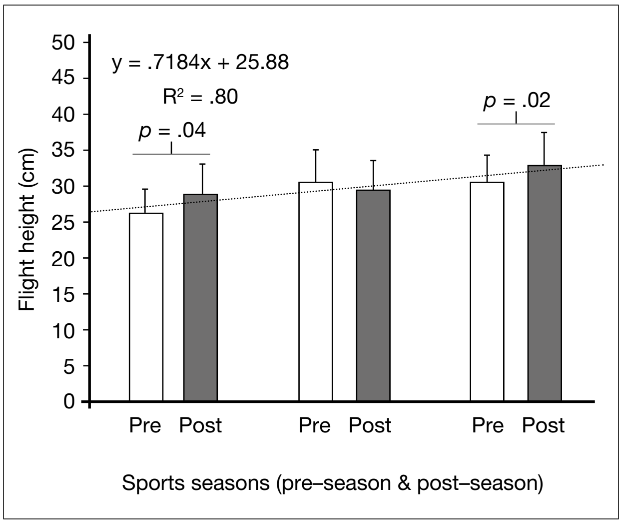

Figure 3
Evolution of the counter movement jump (CMJ).

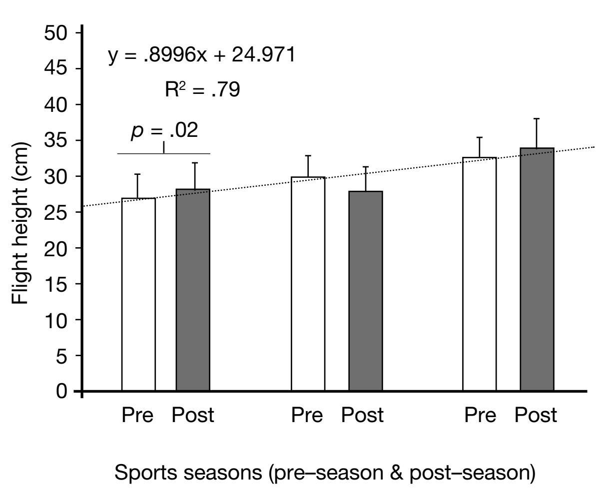

Figure 4
Evolution of the abalakov (ABK).

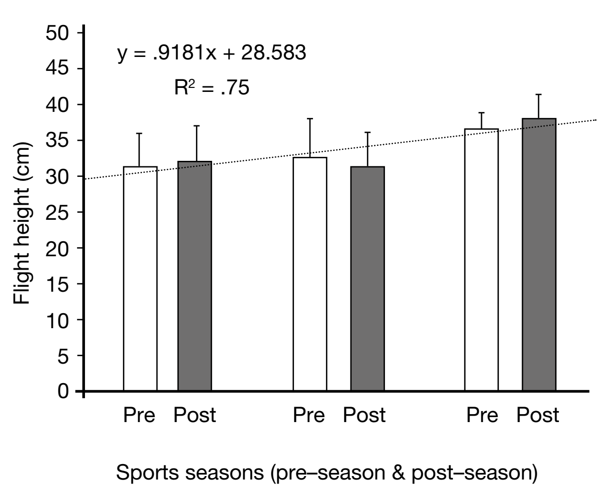

Table 3
Comparison between seasons of all the variables analysed.

n = 9	Sports seasons			Friedman test	
	Season 1	Season 2	Season 3	X^2r	*p*
Body mass (kg)	70.6 ± 5.9	74.7 ± 6.5	78.3 ± 6.7	16.222	.0001
Height (cm)	171.6 ± 10.0	177.7 ± 8.2	179.9 ± 6.7	17.543	.0001
MB (m)	7.9 ± 1.6	8.9 ± 1.8*	9.8 ± 1.4†	16.222	.0001
SJ (cm)	29.4 ± 3.9	31.4 ± 4.5	33.3 ± 4.2‡	3.486	.18
CMJ (cm)	28.4 ± 3.6	30.3 ± 2.7*	34.1 ± 4.0†	11.556	.003
ABK (cm)	33.3 ± 4.2	33.5 ± 5.0	38.2 ± 3.1‡†	14.000	.001

MB: throwing medicine ball (3 kg); SJ: squat jump; CMJ: counter movement jump; ABK: Abalakov; *significant differences between the 13–14 and 14–15 seasons; † significant differences between the 14–15 and 15–16 seasons; ‡ significant differences between the 13–14 and 15–16 seasons. X^2r: Friedman test statistic; *p*: significance value set at $p < .05$.

Discussion

Few longitudinal studies have examined the evolution of the components of physical fitness in young handball players up to the earliest ages of elite sport. Although the increase in all parameters over time is confirmed, the relationship between each of them and with athletic performance is very low. Furthermore, when a multivariate analysis is applied by introducing all the variables, the statistical model is not able to explain sports performance with sufficient predictive power.

Only one longitudinal study (Matthys, et al., 2013b) and two cross-sectional studies are known to have analysed the anthropometric and physical fitness profile of young handball players (Matthys et al., 2012;Matthys, et al., 2013a). In the first, 94 players aged 13 to 16 years were classified as elite and non-elite competitive level. They were monitored for three years without observing significant differences in any of the physical fitness tests monitored, except for the CMJ, with better performance in elite players compared to non-elite players. Regarding the cross-sectional studies, based on biological age criteria and stratifying the 472 players by playing positions, authors confirmed the linear evolution of some physical fitness tests including the ABK. However, in addition to the design itself, the main limitation of these studies (which also affects ours) is the absence of any monitoring of training load. Consequently, apart from evaluating the increase or not of the analysed variables, to date the exact reasons why these improvements occur and their relationship, greater or lesser, with competitive performance are unknown.

In this context, it has now been shown that the kinetics of the physical fitness of young handball players over time is linear in the ages prior to peak height velocity (PHV) and exponential during the PHV (Matthys, et al., 2013a). Unfortunately, the present study, despite the high athletic level of the study sample, could not apply biological age indicators. However, although it is essential to have a biological age parameter in any training process during childhood and adolescence that determines the maturity status of each young athlete in order to be able to interpret the results, there are precedents in handball where no significant differences were noted among players of more or less advanced maturity status in a series of physical fitness tests (Lidor et al., 2005). Thus, the greatest increases in physical fitness occur in the older age groups (15–16 years), most likely conditioned by a hormonally hyperactivated biological status (Malina et al., 2015; Matthys, et al., 2013b). Therefore, although all players increase their physical strength and power, it is those in the highest competitive sport category who register the greatest values and increases (Matthys et al., 2012; 2013a; 2013b).

On the other hand, when the focus is placed on the different tests used, assessment of the evolution of conditional behaviour between upper limbs, in this case throwing the medicine ball (MB), and lower limbs (SJ, CMJ, ABK) also confirms differences which endorse the importance of conducting strength-power work between limbs using a range of action strategies (Gorostiaga et al., 1999, 2005). In relation to the upper body, the MB test records the highest increases in this study with a solid linear evolution over the three seasons as shown by a coefficient of determination of 95%. This links with previous studies which, even obtaining similar results, nevertheless, emphasise the need to perform tests that assess handball skills, in this case directly related to the handball throwing technique (Lidor et al., 2005) or even adding a tactical opposition action to the shot (Rivilla-García et al., 2011). From this point of view, it is evident that to perform a jump throw (typical of the situational context of a handball match) it will be necessary to register optimal power values in the lower body and thus achieve the greatest number of offensive advantages when overcoming the defensive blocking (Gorostiaga et al., 1999, 2005).

In all cases, as different analysis components are added to the same test (direct magnitudes of speed, acceleration, distance, qualitative elements of technical execution, inclusion of tactical efficiency indicators, etc.), the complexity of its analysis increases, and with it the interpretation of its results (Zapartidis et al., 2009). This is the main reason why the MB is used as a physical fitness test to assess throwing function in youth club players. This test provides coaches and technical staff with an accessible way of assessment to obtain basic information about their players' throwing capabilities, even though it is not the most specific way to do so (Aguilar-Martínez et al., 2012). In relation to the lower body, a good part of the previous studies has evaluated their players using a vertical jump. Mohamed et al. (2009) examined various 14 and 16-year-old elite and non-elite players and observed that the elite ones obtained better results than their non-elite counterparts. In turn, 16-year-old players performed better than 14-year-old ones. These results, which in point of fact seem quite logical, again match the ones recorded in this study where the largest increases take place in the last sports season and therefore at the players' oldest age. However, this logic should be approached with some caution since other studies, this time cross-sectional, did not register differences in SJ or CMJ when comparing under-16 and under-18 elite players (Ingebrigtsen et al., 2013).

Finally, from a multivariate perspective, the contribution and/or relationship of each of the variables analysed with respect to the sports performance of each player is low. Firstly, the body mass and sports performance relationship seem to be explained by some previously documented logical reasons (Malina et al., 2015). Indeed, the increase in body mass of young athletes is directly influenced by the increase in their height and also in the peripubertal period by the increase in their muscle mass. When all the variables are analysed as a whole, only MB and ABK can be selected as indicators of the performance of the players, albeit with low predictive power. However, the technical component of both tests, which is higher than the other tests analysed, might suggest the influence on the results of a coordinative component, which is to some extent beyond the scope of the proposed objective as the intention was to analyse only physical conditional aspects using these tests.

Conclusions

Both anthropometric variables (body mass and height) and the physical fitness tests (MB, SJ, CMJ, ABK) show a tendency to increase linearly throughout the three seasons examined. Nevertheless, it is in the last sports season when the increases augment to a greater degree, probably due to the occurrence of PHV, even though this is not a factor controlled in this study. None of the variables analysed has a sufficiently high relationship with the sports performance of the players either individually or based on the contribution made by all of them as a whole. However, MB (upper body) and ABK (lower body) are selected by the multiple regression model. These tests are made up of a more demanding technical execution pattern, something which needs to be analysed in subsequent studies. More research is needed to address all the aspects discussed here in the construction of their design, mainly indicators of biological age, control of training load and a multidimensional perspective of performance. Sports performance is multifactorial. If the aim is to improve it, exclusively analysing anthropometric and/or conditional parameters seems not to be enough for team sports. In all cases complex longitudinal follow-up needs to be conducted and coaches will need the support of an expert methodologist in order to do this. The identification of sports talent increasingly calls for perfect synergy between experience and science.

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A proposal for load monitoring in basketball based on the joint use of four low-cost tools

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Abstract

In this article, conducted within a professional basketball club that simultaneously played in the ACB League and the Basketball Champions League, the joint use of four low-cost tools for load monitoring is presented: Integral analysis system of training tasks (SIATE), session rating of perception exertion (sRPE), heart rate monitoring (TRIMP) and the athlete's subjective perception of well-being (Wellness questionnaire). Using a structural equation modeling approach, we analyse the relationships generated between the results obtained with each of these tools (the scores of the seven players who met the inclusion criteria over the 31 weeks of the season), determining which variables can predict the objective internal load scores obtained from TRIMP corresponding to the day of highest load of the week. This is the first study that relates these four low-cost load monitoring tools. Using a structural equation model, in which all relationships were statistically significant, the relationship between the scores obtained in TRIMP and SIATE, sRPE and Wellness variables was verified, which supports the joint use of the four proposed low-cost tools.

Keywords: integral analysis system of training tasks, session rating of perceived exertion, structural equation modelling, TRIMP, Wellness.

Introduction

Sport performance is the result of a complex interaction between factors that influence an athlete's ability to reach their full potential. The control of training loads is a fundamental component in the optimisation of performance and the prevention of injuries in athletes of all disciplines and skill levels. The vast majority of trainers do not have access to inertial or tracking devices (GPS/LPS) due to their high cost. In this context, the need to explore and develop low-cost tools that can provide accurate and reliable data on individual and squad fitness arises.

In this article, the joint use of four low-cost tools for load control is presented: the Integrated System for the Analysis of Training Tasks (SIATE), the session Rate of Perceived Exertion (sRPE), heart rate monitoring (TRIMP method) and the subjective perception of the state of well-being by the athlete (Wellness questionnaire).

SIATE (Ibáñez et al., 2016) was used to monitor the external load (objective aspect). SIATE has its origin in the load monitoring proposal made by Coque (2008, 2009) for the Spanish national senior men's basketball team. It is a monitoring system characterised by being universal, standardisable, modular and flexible (Ibáñez et al., 2016). Reina et al. (2019) demonstrated the close correlation between external load control using SIATE and data analysed using tracking devices (objective external load), which included variables such as accelerations, decelerations, distance travelled and Player Load, calculated as the square root of the sum of the instantaneous rate of change in acceleration in the three planes of motion (Bredt, et al., 2020).

For the monitoring of the internal load (subjective aspect) and based on the Borg scale or Rate of Perceived Exertion (RPE), Foster's (2001) index or session Rate of Perceived Exertion (sRPE) was used, which was obtained by multiplying the player's RPE by the training time. It is a reliable tool for monitoring and controlling training loads, having been found to be strongly correlated with external load variables (Casamichana et al., 2013; Clemente et al., 2019; Gallo et al., 2015; Moreira et al., 2012; Svilar et al., 2018). Despite their subjective nature, the RPE and sRPE variables are more consistent against both acute and chronic loads and show a greater sensitivity than other objective measures such as blood creatine kinase levels (Saw et al., 2015) or heart rate response during training (Moussa et al., 2019).

Heart rate proved to be a gold standard for monitoring objective internal load (Manzi et al., 2010) by providing real-time information on the body's physiological response and thus offering instant feedback on the athlete's cardiovascular response. In the present study, the Training Impulse (TRIMP) (Banister et al., 1991), as an indicator of the load obtained from the heart rate, was used to quantify the load accumulated by a player during a training session. TRIMP is the result of multiplying the duration of the exercise by its intensity (expressed as a percentage of the maximum heart rate). The general formula for this calculation is: $\text{TRIMP} = \sum^{n}_{i=1}(\text{Duration}_i \text{ x Intensity}_i \text{ x } e^{0.64 \text{ x Intensity}_i})$, where Duration is the duration of the excercise; Intensity is the intensity of the excercise expressed as a percentage of the individual's maximum heart rate; and e is the base of the natural logarithm (2.71828). Finally, the intensity is associated with a weighting factor that varies according to the authors consulted (Foster et al., 2001; Puente et al., 2017 ; Saldanha et al., 2017; Torres-Ronda et al., 2016).

Lastly the Wellness questionnaire, which has its origins in the Hooper y Mackinnon index (1995), was used. This questionnaire provides information on five variables: sleep, stress, motivation, fatigue level and illness. The development of a well-being passport derived from multiple well-being measures is a tool to determine the level of performance that can be expected from the athlete (Clemente et al, 2017). Their easy implementation into daily routines (just 1 minute) allows the use of Wellness questionnaires as a monitoring tool (Jones et al., 2017). Well-being values are used as prescriptive parameters of external load given the negative impact of low ratings on external load (Gallo et al., 2015). The resulting reduction in training volume and frequency (tapering) will lead to a decrease in internal load, which will result in an increase in the assessment of well-being (Botonis et al., 2019).

The combined use of the data collected with the low-cost monitoring tools that make up this load monitoring proposal enables informed decision making. Thus, the objectives of the present work are: a) to present a proposal for monitoring loads in basketball consisting of the joint use of four low-cost tools that allow coaches and trainers who cannot afford expensive tracking devices to optimise the control and management of sporting performance; and b) to determine which variables can predict the objective internal load scores obtained from TRIMP, relating to the session with the highest load of the week, analysing the results obtained by each of the low-cost tools that constitute the load monitoring proposal.

Methodology

Participants

A non-experimental cross-sectional comparative study was carried out using a repeated measures design. The data supporting this study was collected in a professional men's basketball club which, in the season under study, played two competitions simultaneously: the ACB League (Spanish Basketball Association) at national level and the Basketball Champions League at international level. The squad, composed of 20 players, held 232 group training sessions and played a total of 48 official competition matches. The inclusion criteria to be part of the sample that support the results of this article were similar to those used in this type of work (Clemente et al., 2019): a) presenting of medical authorisation to practice in a professional context; b) having completed 80% of the mesocycles of the season; and c) having completed 80% of the sessions of the corresponding mesocycle. Those participants from the squad who did not meet these inclusion criteria were excluded, so that the final sample consisted of the seven players who met all the pre-set requirements. We worked with the scores of these players in the session with the highest weekly load in the 31 weeks (microcycles) of the season, which means 217 scores for each low-cost tool, with which a structural equation model can be conveniently developed (Wolf et al., 2013).

This work was carried out in accordance with the Declaration of Helsinki. It has the authorisation of the club and the informed consent of the participants, as well as the approval of the Research Ethics Committee of the University of La Rioja (file no. 76529).

Instruments and procedure

In the proposed use of SIATE, the tasks performed and the useful time spent on each task were recorded during all the group's training sessions. This tool consists of six "primary" variables: degree of opposition, task density, number of simultaneous performers, competitive factor, game space and cognitive involvement. Each of the tasks is scored according to the six dimensions mentioned above, with a maximum score of 5 points and a minimum score of 1 point (see Table 1 and Figure 1). "Secondary" variables are derived from these "primary" variables, such as the task load, obtained from the sum of the value assigned to each of the six primary parameters (ranging from 5 to 30 points) and the task load per useful practice time, the result of which was expressed in arbitrary units (AU). The latter parameter more accurately reflects the actual task load (Reina et al., 2019; Fuster et al., 2021). As for the SIATE thresholds, the theoretical maximum load was taken as a reference, which corresponds to that of the match or competition (García et al., 2022; Torres-Ronda et al., 2016), where the useful playing time in an official basketball match is forty minutes and the score assigned to the "5x5 continuous" task is the highest possible with 30 points (1200 AU). With this reference, four types of session were established according to the load: low load sessions (recovery), corresponding to values below 50% of the match load, with loads below 600 AU; medium load sessions (maintenance), with loads between 50-69% of the match load, between 600-799 AU; high load sessions (development), corresponding to a load between 70-89% of competition, between 800-999 AU; and competitive sessions, between 1000-1200 AU.

Table 1
Values assigned to each facet of the Task according to SIATE.

Opposition	Density	Performers	Competition	Space	Cognitive	Value
1x0 / 2x0 / 3x0 /4x0 / 5x0	Gentle jogging	<20 % [1-2]	Non-competing	Free throw / Static	Individual	1
4x1 / 5x2 /	Smooth continuous rhythm	21-40 % [3-5]	Technique	1/4 field	1x1/ 2x0 / 2x1 / 2x2	2
3x1 / 4x2 / 5x3	Work/rest ratio: 1/2 - 1/4	41-60 % [5-7]	Opposition without competition	1/2 field	3x0/ 3x1/ 3x2/ 3x3	3
2x1 / 3x2 / 4x3 / 5x4	Work/rest ratio: 1/1	61-80 % [7-9]	Reduced opposition + score	The whole field	4x0/ 4x1 / 4x2 / 4x3 / 4x4	4
1x1 / 2x2 / 3x3 / 4x4 / 5x5	Work/rest ratio: 1/0 - 2/1	81-100 % [10-12]	Scoreboard and full equipment	The whole field and continuity	5x0 / 5x1 / 5x2 / 5x3 / 5x4 / 5x5	5

Figure 1
Example of assigning values per facet in SIATE.

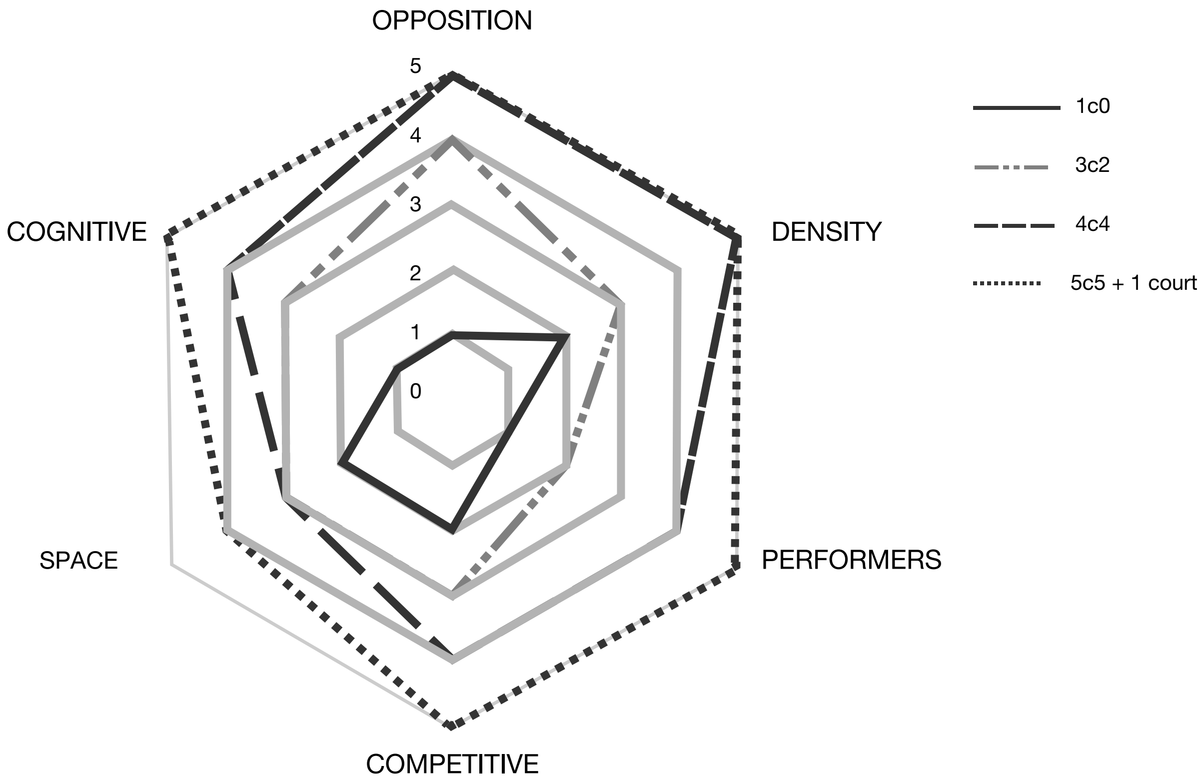


Table 2
Example of sRPE quantification in a training session.

Participant	Muscle RPE	Cardiovascular RPE	RPE Total	Effective time (min)	sRPE
Player 1	3	3	3	111.0	333 UA
Player 2	4	6	5	108.0	540 UA
Player 3	3	5	4	102.0	408 UA
Player 4	5	5	5	111.0	555 UA
Player 5	3	7	5	111.0	555 UA
Player 6	5	5	5	110.0	550 UA
Player 7	4	6	5	108.0	540 UA

Each player's RPE data was collected during all training sessions in the 15–45-minute post-training window using the Teambuildr LLC platform, although there are other free tools available for data collection, such as Google questionnaire, Survey Monkey or Pollfish, and even the WhatsApp application. Thanks to this tool, each player answered the questions: a) How hard was the session on a muscular level?; and b) How hard was the session on a cardiovascular level? Taking into account the following rating scale: extremely light = 1, very light = 2, light = 3-4, moderate = 5-6, intense = 7-8, very intense = 9, and maximum effort = 10. The value obtained is expressed in AU. The RPE is the result of the average of muscle RPE and cardiovascular RPE. For the computation of the sRPE, the useful training time expressed in minutes, taking into account substitutions and not including the initial and final part of the session (Reina et al., 2019; Scanlan et al., 2014), was multiplied by the total RPE of the player (see Table 2).

Heart rate recording, collected during the highest weekly load training session according to SIATE, was conducted using Polar HR10 devices, linked to Polar Team computer programme (v. 1.9.1) installed and active on a tablet. In this load monitoring proposal, TRIMP was calculated by adding the values obtained by multiplying the time (in minutes) that the player spent in each training zone by the associated weighting coefficient. Following the proposal of Stagno et al. (2007) during our intervention (see Table 3), a different weighting coefficient was assigned to each of the five zones of cardiovascular compromise: Z1, between 65-71% of HRmax (weighting coefficient = 1.25); Z2, between 72-78% of HRmax (1.71); Z3, from 79-85% of HRmax (2.54); Z4, from 86-92% of HRmax (coefficient 3.61); and Z5, from 93-100% of HRmax (5.16). These heart rate zones were established on an individual basis according to the parameters of the stress test performed at the medical examination at the beginning of the season.

Regarding the application of the Wellness questionnaire, the athletes completed daily, using the digital platform Teambuildr and up to one hour before the start of the session, a questionnaire with five dimensions: a) Energy: how are you in terms of energy?; b) Muscular: how are you in terms of muscle?; c) Injury: do you feel limited by injury or illness?; d) Mood: what is your level of stress or motivation?; and e) Sleep: how would you rate your sleep? The lowest response value, equal to 1, is linked to the factor that restricts performance, while the highest, equal to 10, is assigned to the factor that benefits performance. The total Wellness score (see Table 4) corresponds to the sum of the scores obtained in each of the dimensions, with a maximum of 50 points and a minimum of 5.

Table 3
Example of TRIMP quantification per player in a training session.

Cardiovascular zone (Weighting coefficient)	Z1 (1.25)	Z2 (1.71)	Z3 (2.54)	Z4 (3.61)	Z5 (5.16)	TRIMP
Player 1	15	10	13	23	7	**188**
Player 2	25	14	21	7	0	**134**
Player 3	40	19	7	3	1	**116**
Player 4	33	6	11	12	7	**159**
Player 5	63	3	1	0	0	**86**
Player 6	34	13	12	8	1	**129**
Player 7	8	10	12	15	24	**236**

Table 4
Example of quantification of the Wellness questionnaire of a training session.

PLAYER	Energy	Muscular	Injury	Mood	Sleep	Wellness
Player 1	9	5	9	8	8	39
Player 2	10	10	10	10	8	48
Player 3	7	5	7	7	9	35
Player 4	9	8	9	9	9	44
Player 5	6	6	6	10	8	36
Player 6	7	9	7	10	7	40
Player 7	8	9	8	10	8	43

Data analysis

In order to satisfy the objective of analysing the relationships generated between the results obtained by each of the low-cost tools that constitute the load monitoring proposal, determining which variables can predict the TRIMP scores in the highest load session of the week, the relationship between the TRIMP scores and the Wellness, SIATE, sRPE and RPE variables was calculated using Structural Equation Models and Pearson correlations. Following Cohen's criteria (Gignac & Szodorai, 2016), values $r = .10$, $r = .30$ and $r = .50$ were considered small, medium and large in magnitude, respectively. Correlation values with an associated probability less than or equal to .05 were qualified as statistically significant.

In the analysis of the predictive model, the Robust Weighted Least Squares estimator and Chi-square values were used. Model adequacy was estimated using the following goodness-of-fit indices: comparative fit index (CFI), Tucker-Lewis index (TLI), root mean square error of approximation (RMSEA) and standardised root mean square residual (SRMR) (Schreider et al., 2006). A good model fit is considered to exist if the RMSEA value is less than .05, the SRMR less than .08 and the CFI and TLI indices greater than .95 (Hu and Bentler, 1999).

The data have been entered into a log sheet (Microsoft Excel v15) customised by the researchers. The software SPSS 28.0 and MPLUS 7.2 were used for data analysis.

Results

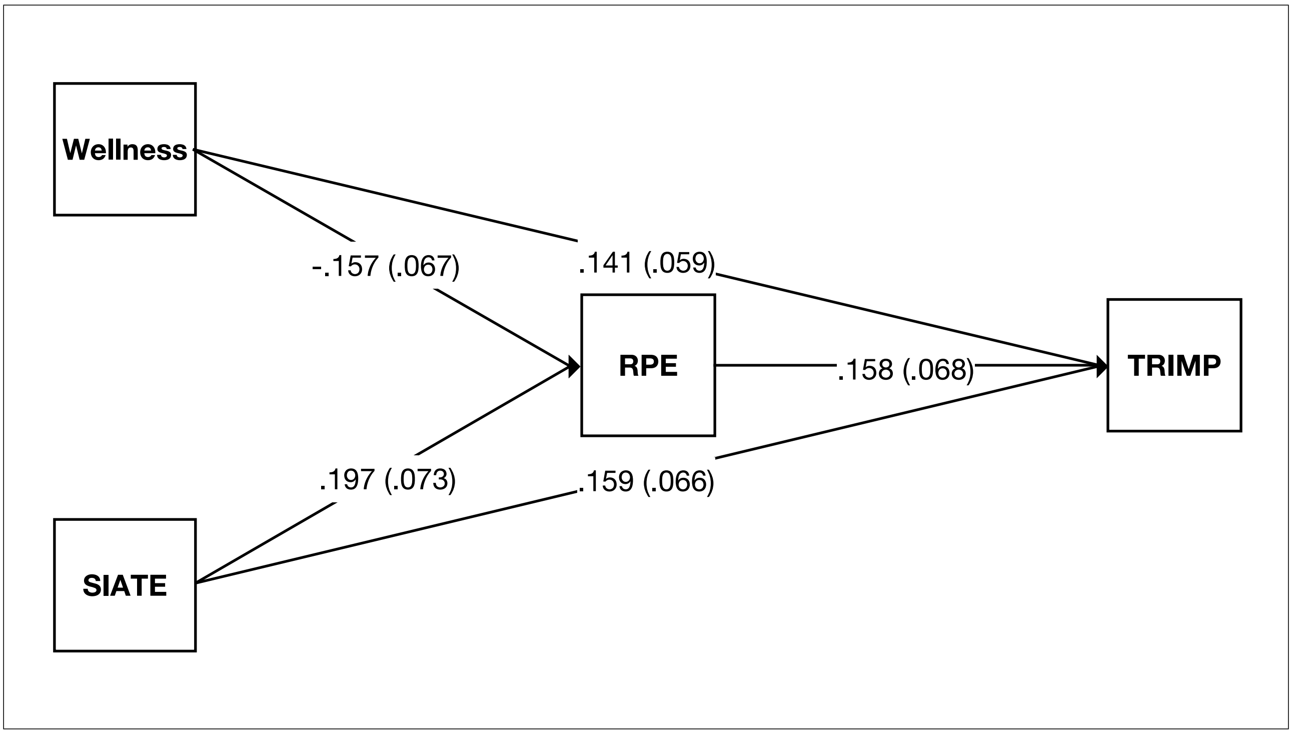
Initially, an attempt was made to perform a structural equation model incorporating the relationship between TRIMP scores (Mean = 151.43; Standard deviation = 41.38) and the Wellness (Mean = 40.70; Standard deviation = 3.20), sRPE (Mean = 639.62; Standard deviation = 153.77) and SIATE variables (Mean = 2015.29; Standard deviation = 435.60) but no significant correlations were obtained, except for the association between sRPE and SIATE ($r = .467$; $p < .001$). However, when incorporating the Wellness, RPE (Mean = 6.95; Standard deviation = 1.23) and SIATE variables, statistically significant relationships were obtained between all related variables. The CFI and TLI fit indices of this Structural Equation Model are both equal to 1. The RMSEA value is less than .001 and the SRMR value is .056. These values corroborated the good fit of the model presented in Figure 2.

The scores of the Wellness questionnaire (.141) and the Integral System of Analysis for Training Tasks (SIATE) (.159), directly influence the objective internal load values collected through the TRIMP as an indicator of the cardiovascular stress that the task exerts on the player.

TRIMP is also indirectly modulated by scores on the RPE variable. The effect of SIATE on TRIMP, mediated by RPE, is obtained by multiplying the correlation coefficients of the relationship mediated by RPE and adding the direct coefficient: On the other hand, the effect of Wellness on

Figure 2

Structural Equation Model showing the relationship between TRIMP and the Wellness, RPE and SIATE variables. The value of each correlation is given and, in brackets, the measurement error.



TRIMP, mediated by RPE, is: (–.157 x .158) + .141 = .116. The negative correlation between Wellness and RPE reflects the fact that the higher the sRPE score, the harder the session and therefore the lower the perceived well-being (score on the Wellness questionnaire).

Discussion

The management of training loads is essential to improve performance and avoid injuries in athletes of any level and discipline. Most coaches and trainers do not have access to tracking devices due to their high cost. This article satisfies, first of all, the objective of presenting a load monitoring proposal consisting of the joint use of four low-cost tools that optimise the control and management of sports performance in basketball. In this regard, SIATE, sRPE and Wellness are variables that can be implemented in an Excel-type record sheet, which facilitates their use in all types of sport contexts. TRIMP is collected by heart rate sensors whose associated cost is affordable for the vast majority of technicians and sports organisations.

The use of the SIATE control tool, the task load per useful practice time expressed in minutes, for the monitoring of the external load (objective aspect), allows the monitoring of the real load of the tasks developed in the training session and allows its adaptation to adjust to the programming, keeping within the limits established for each type of session: regenerative (< 50%), maintenance (50-69%), development (70-89%), and competition (90-100%).

For the monitoring of the internal load (subjective aspect), the session Rate of Perceived Exertion (sRPE) was, taking into account the Acute: Chronic Workout Ratio model (ACWR) (Hulin et al., 2016), according to which the risk of injury increases when the acute load fluctuates significantly. Weekly sRPE values can vary from 2000 to 5000 AU depending on the competitive density, number of sessions, duration of sessions, number of players, etc. (Piedra et al., 2021). A 10% weekly increase in RPE or sRPE alone can explain 40% of the injuries occurring during the following week (Piggott et al., 2009). It is therefore recommended that load planning is developed by comparing the sum (individual or collective) of sRPE values between consecutive microcycles and keeping the inter-weekly variability of sRPE values below the theoretical 10% (Gabbett, 2016).

The objective internal load monitoring by heart rate was performed in the highest load session of the week according to SIATE, which involves exposing the player to loads similar to those of competition (Berkelmans et al., 2018), and implies an optimisation in the management of the team and players' sporting performance, reducing the effort required for data collection (Foster et al., 2017). The TRIMP was calculated by adding the values obtained by multiplying the time (in minutes) that the player spent in each training zone by the associated weighting coefficient. The analysis of the TRIMP data focused on a comparison of post-training values: a) intra-session between players; and b) inter-session for the same player. When a player's values deviate from those of the rest of the group for several consecutive sessions, programming adjustments are considered appropriate (Buchheit & Laursen 2013).

Regarding the well-being questionnaire, and taking into account that the performance of players with low scores in the Wellness questionnaire can be negatively affected (Gallo et al., 2017), special attention is paid (Govus et al., 2018) to the questionnaires that have: a) less than 25 total points, and b) two or more parameters below 5 points. When any of the situations described above arose, a joint assessment was made by the staff of the player's availability for the work session and the training load was adjusted to reduce the risk of fatigue or injury. And the fact is that, irrespective of the number of matches played during the week, tapering strategies have been shown to increase the Wellness profile on match days and reduce RPE and sRPE values (Manzi et al., 2010)

The second objective of the article focuses on analysing the relationships that are generated, in the session with the highest load of the week, between the results obtained by each of the low-cost tools that constitute the load monitoring proposal, determining which variables can predict the objective internal load scores obtained from the TRIMP.

For the development of the structural equation presented in the article, the first variable whose mediating effect between Wellness and SIATE and TRIMP scores analysed was sRPE, but when it was observed that the resulting solution did not present adequate goodness-of-fit indices, it was decided to replace it with RPE. This could be due to the fact that the scores in the sRPE are those corresponding to the RPE, but multiplied by the training time (Foster, 2001), which increases the range of scores to be analysed and modifies the value of the correlations obtained in the model.

It is noteworthy to mention that all the relationships shown in the structural equation model (Figure 2) were statistically significant, despite the small sample size, which clearly shows the relationship between the TRIMP scores and the SIATE, RPE and Wellness variables. However, one of the limitations of this study is the low correlation values obtained between the variables that make up the Structural Equation Model. One of the reasons is the small sample size which decreases the power of contrast (ability of the test to find high correlations) of the tests performed. It is our intention in future work to replicate the study with larger sample sizes to see if the amount of correlation increases in this case. Although the correlations are not as numerous as the researchers would have liked, this does not detract from their practical significance. This is the first paper linking these four low-cost tools and the theoretical or substantive implications of the fact that all the relationships shown in the structural equation model were statistically significant should be highlighted and considered in the overall research design.

It should be added that the results of the present study reinforce those obtained in studies that have not found, in basketball, a relationship between some of the variables analysed : sRPE and TRIMP (Aoki et al., 2017; Manzi et al., 2010); and sRPE and Wellness (Clemente et al., 2019; Edwards et al., 2018). It also supports the relationship found between the data collected through the SIATE tool and other objective internal load data such as heart rate or collected by inertial devices (Gómez-Carmona et al., 2019; Reina et al., 2019). The joint use of the four proposed low-cost tools is thus validated.

Conclusion

Two objectives were pursued in this study, which was carried out in the context of a professional basketball club. The first consisted of presenting a proposal for monitoring loads in basketball made up of the joint use of four low-cost tools: the Integrated System for the Analysis of Training Tasks (SIATE), the subjective perception of the effort of the session (sRPE), the monitoring of heart rate (TRIMP) and the subjective perception of the state of well-being of the athlete (Wellness questionnaire). This proposal can allow coaches and trainers who cannot afford expensive tracking devices to optimise the control and management of the sporting performance of their team and players.

The second objective was to analyse the relationships generated, in the session with the highest load of the week, between the results obtained by each of the low-cost tools that make up the load monitoring proposal, determining, by means of a structural equation model, which variables can predict the objective internal load scores obtained from the TRIMP. Although the amount of correlations is not high, since the sample size reduces the power of contrast of the tests carried out, the relationship between the scores obtained in the TRIMP and the SIATE, RPE and Wellness variables was confirmed, a fact that supports the proposal for the joint use of these four low-cost load monitoring tools and recommends further research in this area.

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Observational analysis of an extreme skateboarding modality: downhill skateboarding

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Ana Alonso and Oriol Cardona achieve their qualification for the new Olympic sport of ski mountaineering by taking second place at the 2025 World Championships in Boí Taüll.
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Abstract

Competitive downhill skateboarding is an extreme form of skateboarding that consists of going down a steeply sloping, winding road closed to traffic at maximum speed on a skateboard. The behaviours of riders in a downhill skateboarding race, where they can reach speeds of over 100 km/h, have never been studied. The objective of the work was to build an observation instrument that would allow us to record their behaviours in competition and to perform a statistical analysis of ANOVA variance and chi-square to detect the variability of this behaviour according to the positioning of the riders during the race, together with the analysis of T-Patterns. The free software LINCE PLUS and Theme 6 EDU were implemented to record 23 participants in finals, semifinals and consolation finals of the Kozakov circuit (Czech Republic) between 2015-2022 in the Open category. Although no significant differences were detected in the actions based on the competitors' race positioning ($p > .05$) or in the T-Patterns, there is a significant relationship with the type of curve line ($p > .05$). In other words, the competitors followed the same line through the curve regardless of their race positioning; however, each curve was approached differently depending on its specific characteristics. The observation tool (OSKATE) can be useful in preparing for competitions in this high-speed sport, and others such as skiing and motor sports, to adapt to the conditions of different competition circuits.

Keywords: LINCE PLUS, longboard, Mixed Methods, systematic observation, T-Pattern detection.

Introduction

Downhill skateboarding, an extreme form of skateboarding, represents an exciting and risky sporting challenge that tests different abilities such as strength, balance and coordination as in snowboard-cross (Platzer et al., 2009; Vernillo et al., 2018), along with the ability to manage stress, maintain concentration and make quick decisions in changing conditions, as in other risky sports (Reid & Lightfoot, 2019).

Skateboarding had its origins around the 1950s in California, when creative surfers used pieces of broken surfboards, to which they added axles and skate wheels that allowed them to surf the streets when waves were scarce (Amtmann et al., 2013). Over the years, significant changes were made to the material, including changes in board shape, axle geometry, and wheel sizes, which resulted in different modes depending on the configuration of the skateboard parts (Prentiss et al., 2011), until what is now downhill skateboarding.

Downhill skateboarding is an extreme form of skateboarding, which consists of going down a road in the shortest possible time with boards made of wood, fiberglass and carbon fibre about 76 cm long and 23 cm wide, 78 mm wheels and 100-120 mm axles. Competitions, according to the organising entity, may have equipment limits: boards up to 122 cm long, axles less than 305 mm, wheels between 65-110 mm and a maximum weight of 6 kg. Competitions have timed qualifying rounds and then 4-on-4 opposition races up to the finals. Also known as downhill longboarding, the term downhill skateboarding (DHSk8) has recently become popular. After the dissolution of the International Downhill Federation (IDF) in 2023 (founded in 2012), the World Downhill Skateboarding Championship (WDSC) and the World Skate Games (WSG) are currently the international competitions.

Although there is some work on skateboarding, we found that there are few scientific studies on downhill skateboarding. We can find descriptive studies on the most common injuries (Russell et al., 2019); training and physical preparation proposals to improve the competitor's posture (tuck) (Pereira da Silva et al., 2017); research on bioenergetics, propelling oneself at different speeds (Amtmann et al., 2013; Board & Browning, 2014); and work on aerodynamics with different helmets (Hart et al., 2010).

The requirements of this sport specialty are focused on perceptual-motor decision mechanisms (balance, proprioception...) (Castañer & Camerino, 2022), and also contextual (characteristics of the environment in which it is practiced: asphalt, temperature, curve, opponents...). Downhill skateboarding requires skills such as air braking, turning, sliding, and taking lines. In addition, the ability to perform a complete and quick stop is crucial (Kamberg, 2017). The control of these technical skills is very relevant, both to win and to simply survive and continue practicing this risky sport.

In this sport, as well as in other high-speed sports such as alpine skiing or motor sports, visuomotor conditions play an important role, as they are a tool for anticipation of the trajectory to be followed (Tuhkanen et al., 2021), and thus cause control of body direction. But in competition, when faced with an unforeseen event due to the opponents' fault, this glance and anticipation of the trajectory can no longer be easily developed. Therefore, it seems logical that during a race, riders have different behaviours depending on their visibility, the position of the rivals and their own position during the race.

Experts in high-speed sports use specific cognitive strategies and predictive brain processes to improve their performance (Lappi, 2022). Lappi (2022) explores cognitive hierarchy in high-speed sports, such as motor racing. He highlights three levels: navigation (route selection), guidance (definition of the desired route) and control (sensorimotor coordination). The main idea is that these levels process information differently, with a novelty in the interpretation of central concepts, such as landmarks and waypoints, integrated by means of chunking. Chunks can be understood as meaningful patterns stored in working memory and transferred to long-term memory. With experience, these chunks enable rapid identification of complex situations with many elements, which increases the ability to encode information despite the limitations of working memory and attention. This model can also be applied in downhill skateboarding, where prior visuomotor preparation and decision making can play a key role in the performance of the practitioners. Although chunks can help to act in complex situations, the field of view and proximity to opponents can affect this decision making.

In addition, practicing this sport involves psychological stress, an effect that varies during the race, as in other risk and opposition sports (Reid & Lightfoot, 2019). This mental stress is pervasive among athletes, along with a perception of risk and risk taking that directly influences decision making (Powell, 2007). This stress, which affects the physiology and functioning of the body, can make movements less fluid and inefficient (Reid & Lightfoot, 2019), which can lead to technical and decision errors. However, the response to certain unfavorable situations is highly individual and experience may be one of the reasons for decreased performance (Barthel et al., 2020).

In summary, downhill skateboarding is a sport in which competitors' motor patterns, visuomotor conditions, anticipatory mechanisms, decision making and emotional control can play a crucial role, since, as in motorsports (Lappi, 2022), a small mistake can make you win or lose the race.

Since the competition analysed is of high level and it is assumed that all athletes have a highly developed technique, this work focuses on analysing whether the positioning of the competitors during a downhill skateboarding race affects their actions, as well as investigating the existence of a recurrent motor pattern in this competitive modality.

Thus, the main objective was to create an instrument, using observational methodology, to identify riders' behaviours based on their race positioning and throughout the entire descent. This would allow for recording and analysing the relationship between different behaviours, including braking zone, braking type, line, stability, tuck, and interactions with rivals. The behaviours of the riders participating in the study were recorded a posteriori using this instrument for descriptive and inferential statistical analysis with analysis of ANOVA variance and chi-square, to be complemented with a T-Patterns analysis. This can provide a deeper understanding of the dynamics of competition in the sport, offering riders guidance to improve their competition strategy and preparation.

Methodology

Observational design

A P/I/M (punctual, idiographic and multidimensional) observational and intra-session design was used for the study, as there was no temporal follow-up of participants across seasons (Anguera et al., 2011). Punctual because it analysed only the semifinals and finals of the Open category of the competition at the Kozakov circuit (Czech Republic); idiographic because all participants were analysed as a unit; and multidimensional because different dimensions were analysed in relation to running position, body orientation and other biomechanical and behavioural aspects.

Participants

A total of 23 riders between 18 and 32 years of age were analysed, of which 22 were male and 1 female. They were analysed through 20 video recordings of about 3 minutes from different competitions (finals, semi-finals and consolation finals) on the Kozakov circuit between 2015 and 2022. The category was Open, the highest one, open to everyone. The recordings chosen were public (IDF's YouTube or Facebook). Therefore, following the ethical principles guidelines described by the American Psychological Association, as they were published on the internet and recorded in a natural setting, informed consent did not have to be requested from participants (American Psychological Association, 2017). It was recorded during the months of February and March 2024.

The inclusion criteria for the videos analysed were as follows: at least one participant was followed during the entire descent, from the start of the race until they crossed the finish line; the image quality was sufficiently good; and at least two competitors participated in the recording. The exclusion criterion for the choice of recordings and competitors was the unobservability of the analysed rider's actions during the entire descent. If the competitor appeared in more than one video and met the inclusion criteria, the most recent one was selected.

Materials and instruments

The recording instrument was LINCE PLUS (Soto et al., 2019, 2022) in version 1.3.2. for Mac Os Catalina 10.15.7.

Table 1 shows the observation instrument with examples of some of the criteria and categories. For the T-Patterns analysis, the criteria of stance, tuck time and body orientation on the curve were eliminated because they did not provide meaningful or consistent sequential information, as they are static or vary independently of the key behavioural sequences analysed in this study.

The study of T-Patterns in sport is conceived as a method of observational data analysis that, by means of a mathematical algorithm, makes sequentially and temporally ordered behaviours visible (Bakeman & Quera, 2011; Camerino et al., 2014). T-Patterns can also be defined as events that occur concurrently or sequentially more frequently than would be randomly expected if all events were independently distributed (Anguera et al., 2023). It is a way to discover, systematise and analyse regular structures of behaviour (Magnusson, 2020). The study of T-Patterns has been very useful in different sports and educational contexts (Castañer et al., 2020; Prieto et al., 2016).

Table 1
Observational instrument for the observational analysis of downhill skateboarding (OSKATE).

Criteria	Categories	Code	Description
1. Stance	Goofy Regular	GOOF REGU	Front right leg Front left leg
2. Race position	1st 2nd 3rd 4th	ONE TWO THREE FOUR	Rider in first place Rider in second place Rider in third place Rider in fourth place
3. Start	Maximum Medium-low	MAX MEDL	Fast start, powerful pushes. First fast and short, then with more ADM > 9 Slow push start, with few pushes (<10), or simply letting gravity take over down the slope
4. Tuck time 	Start of tuck End of tuck	STUCK ETUCK	Start of the tuck position End of the tuck position
5. Braking zone	Far from curve Before curve Entering curve Leaving curve Counter-curve	FAR BC EC LC COUNT	Braking is performed during a straight line or area without sharp curves and away from the curve. No main curve visible Braking is performed on a straight section or an area without sharp curves, before taking the curve line Braking is carried out in continuity with taking the curve. 1st half of the curve, before the apex Braking is performed at the end of the curve. 2nd half of the curve, after apex Braking is performed on the opposite side of the main curve. If the curve is toeside, a heelside slide is performed before reaching it

Table 1 (Continuation)
Observational instrument for the observational analysis of downhill skateboarding (OSKATE).

Criteria	Categories	Code	Description
6. Braking action	Carving Airbrake	CARV AIRB	Braking action due to loss of directionality. The rider steers the board sideways so as not to have such a straight trajectory Air friction braking by opening the arms like a bird and adopting a more upright posture
	Carving + Airbrake	CAIR	Combination of braking action due to loss of directionality and air friction
	Footbrake	FOOT	Braking by contacting with one foot on the ground
	Gloves slide	GLOV	Sliding with gloved hands on the floor
	Standup slide	STAN	Sliding without putting hands on the ground
7. Orientation of the body in the curve	Toeside Heelside	TOE HEEL	The body and toes are oriented to the inner third of the curve The back and heels are oriented to the inner third of the curve

Table 1 (Continuation)
Observational instrument for the observational analysis of downhill skateboarding (OSKATE).

Criteria	Categories	Code	Description
8. Lines	Inner third	INN	The entire line in the inner third of the curve
	Outer third	OUT	The entire line in the outer third of the curve
	Outer-Inner-Outer	OIO	Combination of outer third on curve entry, inner third at the apex, and outer third on exit
	Outer-Central-Outer	OCO	Combination of outer third at curve entry, central third at apex and inner outer on exit
	Outer-Central-Central	OCC	Combination of outer third at curve entry, central third at apex and central third on exit
	Outer-Inner-Central	OIC	Combination of outer third at curve entry, inner third at apex and central third on exit
	Inner-Central-Outer	ICO	Combination of inner third at curve entry, central third at apex and outer third on exit
	Inner-Inner-Outer	IIO	Combination of inner third at curve entry, inner third at apex and outer third on exit
	Central	CENT	The entire line in the central third of the curve
	Central-Central-Outer	CCO	Combination of central at curve entry, central at apex and outer on exit
	Central-Central-Inner	CCI	Combination of central at curve entry, central at apex and inner on exit
	Central-Inner-Central	CIC	Combination of central third on corner entry, inner third at apex and central third on exit
9. Posture and stability in curve	Tuck lean	TUCKL	Taking the curve line without breaking the tuck position
	Stable	ST	Board without sideways swings and arms tucked in the back/lower back or open without swings
	Small board oscillations	SMBO	Small rebalancing of the feet for more precise steering
	Arms oscillations	AROS	Arms rebalancing for more precise steering
	Board and arm oscillations	BAOS	Very evident foot and arm imbalances
	Speedwobble	SPEED	Temporary loss of control of the board, abrupt side-to-side oscillations of the board
10. Interaction with rivals	Stays behind	STBE	Rider slows down to avoid colliding with the opponent and stays behind him
 	Slipstream	SLST	The rider takes advantage of the opponent's slipstream to get closer
	Overtaking inner third curve	OVIC	The rider overtakes the opponent on the inner third of the curve
	Overtaking outer third curve	OVOC	The rider overtakes the opponent on the outside of the curve
	Overtaking straight section	OVS	The rider overtakes the opponent in a straight section
	Contact on straight section	CONSS	The rider gently contacts the opponent on a straight section
	Contact in curve	CONCUR	The rider gently contacts the opponent in a curve, without interfering with the opponent's line
	Dodge (rider down)	DOD	The rider dodges the opponent who has fallen in the middle of the road

Procedure

The design of the observational instrument and its validation process were carried out in three successive stages: first, a review of the literature and selection of the main criteria and categories to be included in the instrument, followed by the elaboration of a proposal for an observation instrument with experts in observational methodology and in the sports specialty studied. Finally, we moved on to a content validity check of the observational instrument created through a panel of experts, to ensure that we measured what we intended to.

This third validation phase was carried out using the (Anguera & Blanco, 2003) authority criterion expressed by the judgment of a panel of 13 experts. These people had more than 4 years of experience in international competitions, some with world podiums and, among others, qualifications such as Skateboarding Level 1 Technician or graduates in Physical Activity and Sports Sciences. Through a survey developed with Google Forms, experts evaluated each of the 10 criteria of the observation instrument, assigning a validation response (YES or NO) to each of the 46 categories of the instrument. The main objective of this phase was to validate the instrument using a methodology based on the percentage of positive coincidences, considering YES-YES responses as an indicator of positive consensus on the validity of the criteria.

To analyse the data, the percentage of positive coincidences (n = 3289), corresponding to affirmative coincident responses among the experts, was calculated out of the total possible coincidences (n = 3588). This percentage was obtained by contrasting the responses of each expert (n = 46) with those of the other experts (n = 12) individually. Thus, a proportion of positive coincidences of 91.7% was obtained, which reflects a high level of agreement among the experts in the validation of the proposed criteria.

To ensure the accuracy of the results, a 95% confidence interval was calculated using the binomial model applied with the binom.test() function of RStudio (© 2009-2021 RStudio, PBC v.1.4.1717). The results provided a confidence interval ranging from 90.7% to 92.6%, which reaffirmed the robustness of the observed coincidence rate and, therefore, the validity of the observation instrument. After validation of the instrument and a period of training in its use, an expert in the sport and one of the authors of the study made a total of 63 records in the analysis of two different descents. Inter-observer reliability was calculated by comparing the expert's records with those of the author through LINCE PLUS and a kappa statistical index of .983 was obtained. As for intra-observer reliability, the author repeated the recording on two occasions, with a 10-day interval, and obtained a kappa index of .988. Once the reliability process was completed, data from all participants were recorded through LINCE PLUS. Subsequently, the results were exported in .csv and .txt for further analysis.

Data analysis

The descriptive data, referring to the count of the qualitative variables of the study (the criteria and categories of the observation instrument [OSKATE]), are presented with frequencies and percentages (Table 2). For the quantitative variables of the study (tuck time, tuck duration, number of braking actions and records), the normality of the data distribution is checked and the trend, variation and the minimum and maximum values are presented (Table 3). For those with symmetrical distribution, the mean and standard deviation are presented; for those with asymmetrical distribution, the median and its interquartile range are presented.

To analyse the relationship between quantitative variables and final positioning, the normality assumption was tested with the Saphiro-Wilk test and its homoscedasticity with the Levene test (Table 3). To test the dependence of the variables, an analysis of ANOVA variance was performed, obtained through the nonparametric Kruskal-Wallis test, and the results were compared according to the final position of the competitor and adding the magnitude of the effect through eta squared (η^2), with $\eta^2 < .1$ trivial effect; $.1 < \eta^2 < .25$ small effect; $.25 < \eta^2 < .37$ medium effect; and $\eta^2 > .37$ major effect (Table 3).

To conduct a comparative statistical analysis of behaviour based on race positioning, the relationship between the following qualitative variables was analysed: race positioning, start, tuck time, braking zones and types, curve orientation and lines, posture and stability during the curve, curve number, and interaction with rivals. The assessment of the dependence between the different qualitative variables was performed using contingency tables with the chi-square test with Yates correction (χ^2cc), estimating the intensity of association using Cramer's V (V), with V ≥ .04 small effect, V ≥ .13 moderate effect, and V ≥ .22 large effect (Table 4).

The significance level in all tests was $p < .05$ and were run with JASP computer software version 0.18.1 (Jasp Team, 2024) and Microsoft Excel version 16.66.1, both programs for MacOs Catalina 10.15.7.

Finally, to perform a T-Patterns analysis, we exported the log in .txt format to Theme6Edu software version 08 (Magnusson, 2017) with the following search criteria: a) presence of at least 3 T-Patterns; b) redundancy reduction setting of 90% for the occurrence of similar T-Patterns, c) significance level of .001, and d) Fausto option enabled to critical interval mode.

Data was published in the Research Data Repository (CORA) at the following URL: https://doi.org/10.34810/data1346 (Aixa-Requena, 2024).

Results

Descriptive and inferential statistics

In the results presented in Table 2, it can be seen how 100% of the riders made a maximum start; 78% of them were regulars (left leg in front). The total shares were fairly evenly distributed among those finishing in 1st, 2nd or 3rd position (~30). The majority of the braking actions were performed when taking the curve (53%) and sliding with gloves on the ground (81%). Most of the curve lines followed an

Table 2
Descriptive data of category frequencies.

Criteria	Categories	Code	Frequency	Percentage
Stance	*Goofy*	GOOF	5	21.74
	Regular	REGU	18	78.26
Start	Medium-low	MEDL	0	0
	Maximum	MAX	23	100
Actions by position	1st	ONE	255	30.69
	2nd	TWO	292	35.14
	3rd	THREE	256	30.81
	4th	FOUR	28	3.37
Braking zones	On straight section far from curve	FAR	10	8.62
	On straight section right before curve	RBC	9	7.76
	Entering curve	EC	62	53.45
	Leaving curve	LC	3	2.59
	Counter-curve	COUNT	32	27.59
Braking action	Carving	CARV	2	1.72
	Airbrake	AIRB	8	6.90
	Carving + Airbrake	CAIR	9	7.76
	Footbrake	FOOT	0	0
	Gloves slide	GLOV	95	81.90
	Standup slide	STAN	2	1.72
Lines	Inner third	INN	1	0.84
	Outer third	OUT	0	0
	Outer-Inner-Outer	OIO	77	64.71
	Outer-Central-Outer	OCO	7	5.88
	Outer-Central-Central	OCC	3	2.52
	Outer-Inner-Central	OIC	23	19.33
	Inner-Central-Outer	ICO	0	0
	Inner-Inner-Outer	IIO	0	0
	Central	CEN	1	0.84
	Central-Central-Outer	CCO	2	1.68
	Central-Central-Inner	CCI	0	0
	Central-Inner-Central	CIC	5	4.20

Table 2 (Continuation)
Descriptive data of category frequencies.

Criteria	Categories	Code	Frequency	Percentage
Posture and stability in curve	Tuck lean	TUCKL	2	1.71
	Stable	ST	86	73.50
	Small board oscillations	SMBO	7	5.98
	Arms oscillations	AROS	16	13.68
	Board and arm oscillations	BAOS	5	4.27
	Speedwobble	SPEED	1	0.86
Interaction with rivals	Stays behind	STBE	15	20.27
	Slipstream	SLST	22	29.73
	Overtaking inner third curve	OVIC	7	9.50
	Overtaking outer third curve	OVOC	2	2.70
	Overtaking straight section	OVSS	27	36.49
	Contact on straight section	CONSS	1	1.35
	Contact in curve	CONCUR	0	0
	Dodge (rider down)	DOD	0	0

Table 3
Descriptive and inferential data of global quantitative variables and according to final position.

Variables	Final position	*n*	Trend and Variation	Minimum	Maximum	CI 95%		Levene		ANOVA		
						LL	UL	F (3.19)	*p*	Statistic	*p*	η^2
Tuck time (s)	Global	23	86 (14.50) [a]	14	97							
Tuck time (s)	Global	120	12 (11.25) [a]	1	46							
Braking actions	Global	23	5.04 ± 2.46 [b]	4	9							
Registers	Global	23	37.13 ± 6.88 [b]	19	49							
Registers	1r	6	37.17 ± 4.71 [b]	31	42	33.40	40.93	2.853	.065	2.925	.403	.087
	2n	13	36.69 ± 8.35 [b]	19	49	32.15	41.23					
	3r	2	43 ± 1.41 [b]	42	44	41.04	44.96					
	4t	2	34 ± 1.41 [b]	33	35	32.04	35.96					
Tuck time	1r	6	86 (7.75) [a]	82	92	82.93	90.07	3.130	.050	1.809	.613	.108
	2n	13	78 (28) [a]	14	97	60.63	87.22					
	3r	2	82 (6) [a]	76	88	70.24	93.76					
	4t	2	90.50 (4.50) [a]	86	95	81.68	99.32					
Braking actions	1r	6	5.83 ± 1.33 [b]	4	8	4.77	6.90	2.388	.101	1.481	.687	.078
	2n	13	4.46 ± 3.05 [b]	4	9	2.81	6.12					
	3r	2	5.50 ± 0.71 [b]	5	6	4.52	6.48					
	4t	2	6 ± 1.41 [b]	5	7	4.04	7.96					

Note. [a] Median (IQR). [b] Mean ± Standard deviation. LL = Lower limit. UL = Upper limit.
ANOVA values obtained through the non-parametric Kruskal-Wallis test. $\eta^2 < .1$ trivial effect. $.1 < \eta^2 < .25$ small effect. $.25 < \eta^2 < .37$ medium effect. $\eta^2 > .37$ important effect.

Table 4
Independence between qualitative variables.

Relationship of variable	*n*	χ^2_{cc}	Df	*p*	V
Braking zone – Braking action	116	124.380	16	< .001***	.518
Line – Stability	117	58.143	35	.008**	.315
Position during – Braking zone	116	13.571	12	.329	-
Position during – Braking action	116	8.632	12	.734	-
Position during - Lines	117	13.330	21	.897	-
Position during - Stability	117	18.921	15	.217	-
Position during - Interactions	74	79.910	15	< .001***	.600
Curve number – Braking action	116	26.854	16	.043*	.241
Curve number – Braking zone	116	71.370	16	< .001***	.392
Curve number - Lines	117	38.323	28	.092	-
Curve number - Stability	117	21.542	20	.366	-

Nota. χ^2_{cc} = chi-square with continuity correction or Yates correction.
*p < .05, **p < .01, ***p < .001
V = Cramer's V: V ≥ .04 small effect, V ≥ .13 moderate effect, V ≥ .22 large effect.

outside-inside-outside pattern (64%) and were stable (73%). Regarding interactions with rivals, it is worth highlighting that 48% were overtakes, 29% were slipstreams, and 20% involved staying behind the opponent.

The descriptive data concerning the overall count of the quantitative variables under study can be found summarised in Table 3 with their trend, variation, minimum and maximum. This table shows that the trend of the total tuck time during a run was 86 seconds, with a duration of 12 seconds each time the mentioned posture was performed. Overall, riders braked a total of about 5 times (5.04 ± 2.46) per run and about 37 records (37.13 ± 6.88) were made per competitor.

The same data distributed according to final position can also be seen in Table 3, with the addition of the confidence interval (95% CI) and the data referring to the analysis of variance. In the aforementioned Table 3, it can be seen that there is no variable that has significant differences in the comparison according to the final position (p-ANOVA > .05), nor in the total number of records (statistic = 2.925; p = .403; η^2 = . 087), total tuck time (statistic = 1.809; p = .613; η^2 = .108) or total number of braking actions (statistic = 1.481; p = .687; η^2 = .078), and all with a trivial (< .1)η^2 or small (.1 <η^2 < .25) effect size.

Table 4 shows the interdependence between the different qualitative variables. Of note are those where a significant dependence was detected, such as braking zone and braking action (χ^2_{cc}(16, N = 116) = 124.380; p < .001; V = .518), curve line and stability in the curve (χ^2_{cc}(35, N = 117) = 58.143; p = .008; V = .315), interactions and race position (χ^2_{cc}(15, N = 74) = 79.910; p < .001; V = .600), curve number and braking (χ^2_{cc}(16, N = 116) = 26.854; p = .043; V = .241), and curve number and braking zone (χ^2_{cc}(16, N = 116) = 71.370; p < .001; V = .319). All with a large effect size (V ≥ .22).

T-Pattern analysis

In the observation of the results extracted from Theme6Edu, recurrent and rapid motor patterns during a downhill skateboarding race are evidenced in two types of figures: a) T-Patterns obtained, which Figure 1 illustrates in the form of a dendrogram or tree graph, which indicate the most relevant patterns throughout the different races and participants; and b) representation of one of these patterns detected through a sequence of images of these events and their illustration (Figure 2).

The behavioural dendrogram in Figure 1 shows the two successions of typical patterns that emerged when analysing the participants' behaviours during the competition. These are patterns that follow a temporal succession over a small-time interval. The succession did not differentiate between the positioning of the participants. The mentioned patterns followed a sequence of braking zone – braking action – line – stability – tuck (+ interaction with rivals), as illustrated in Figure 2.

Figure 1
Dendogram of T-Patterns detected in the whole sample in a downhill skateboarding race.

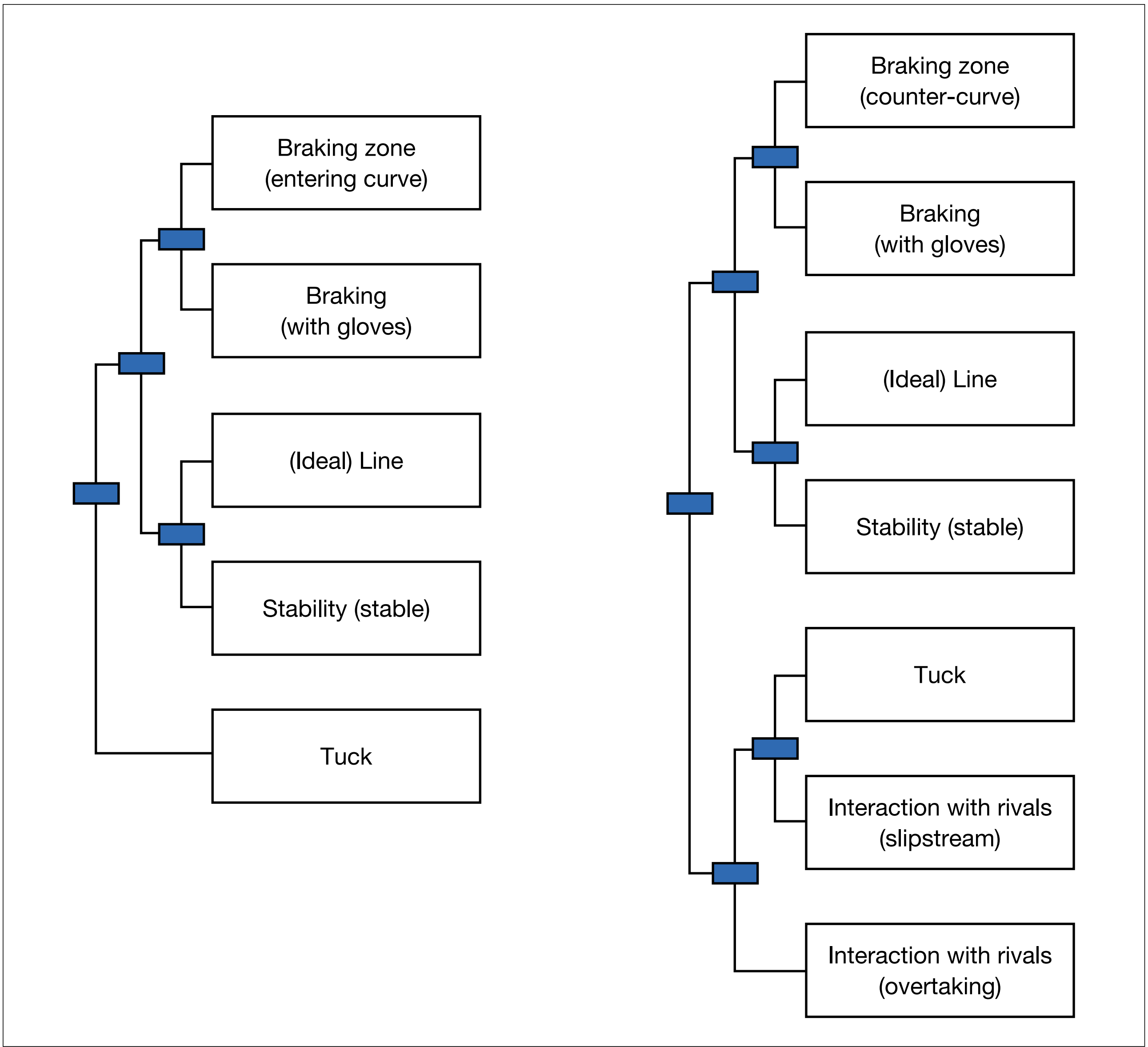


Figure 2
Exemple of a typical competitors' pattern.

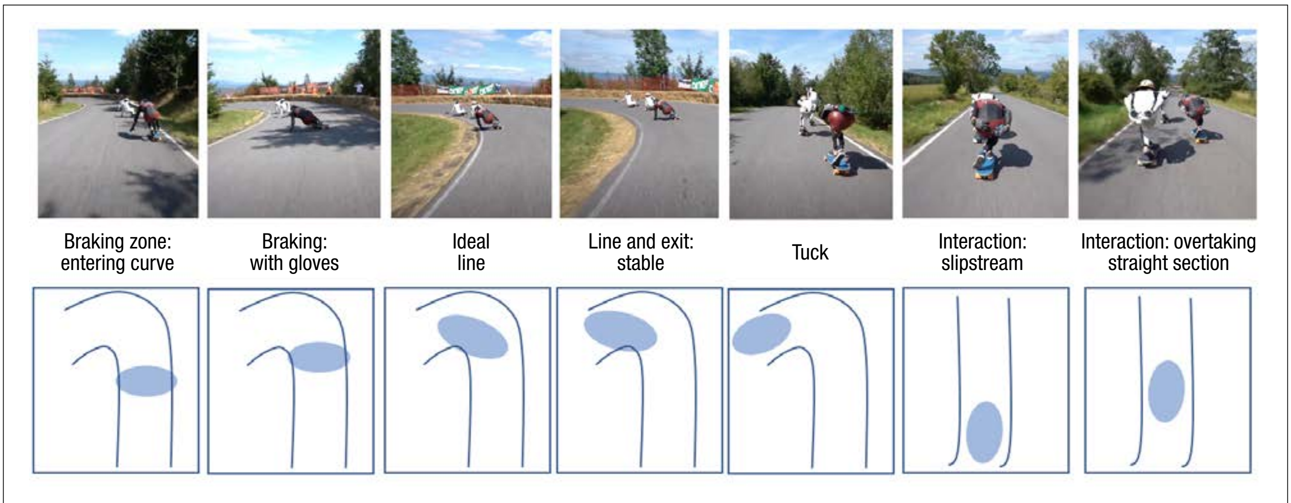
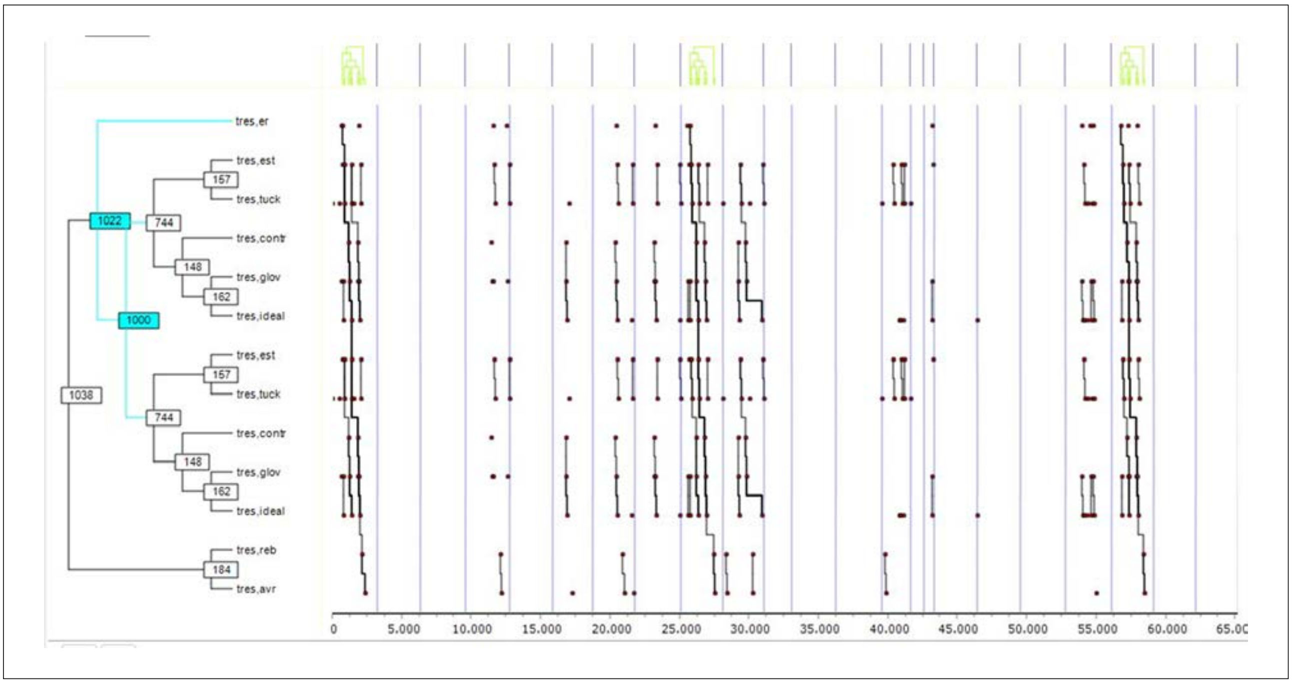


Figura 3
Example of T-Patterns dendogram of a rider in 3rd position.



Finally, we present an example of what typically happens in the race: a linked repetition of the previously mentioned pattern (braking zone – braking action – line – stability – tuck), specifically from a rider in 3rd position (Figure 3).

Discussion

The main objective of the present study was to construct an observation instrument to analyse differences in behaviour according to the positioning of the participants during the race. The data obtained show similar results in the behaviour of competitors according to their positioning. In most cases, the participants braked while entering the curve or counter-curve, with their gloves on the ground, and followed a stable outside-inside-outside line. Therefore, no statistically significant differences have been detected in the actions of the competitors according to positioning, except for interactions, which have shown variations in type and quantity according to positioning; the first and fourth position riders are the riders with the fewest interactions. The T-Patterns also do not vary based on race positioning, and the most typical pattern follows a sequence of braking zone – braking action– line – stability – tuck (+ interaction with rivals). However, variables such as zone, braking type, stability, line and curve did have a dependency relationship between them.

These data may clash with those found in motor sports. For example, riders usually have to adjust their line according to the conditions of the race (position, location of rivals in front or behind, road conditions...), which requires high levels of concentration in order to avoid accidents (Ledesma et al., 2015). Sometimes, this optimal line can be affected by a struggle for position and overtaking (Heilmeier et al., 2018) or even by the psychophysiological state of the competitors (Filho et al., 2015). Therefore, the competition environment should theoretically influence participants' behaviour and their approach strategies for taking curves. However, if there is nothing to prevent them from taking the best line, riders tend to have a very stable curve line pattern, according to their style (Löckel et al., 2022).

This seems to be the case in this research, where, in general, the competitors' behaviour does not vary based on positioning, as there were not many position battles in which rivals interfered with the tracing of an optimal line. For the same reason, in the present work the T-patterns also do not vary according to positioning during the race. The differences in interactions according to position could be explained by the fact that those in first position tended not to interact with rivals and those in fourth position usually fell behind from the start and did not regain position. Therefore, most interactions were in the second and third positions.

Variables such as the braking zone, braking type, stability, line, and curve were interdependent, likely because a different line strategy was used for each curve, regardless of the competitor and their positioning.

A limitation of the study is the inability to determine whether the recorded behaviours are a response to opponents' movements. Because of the lack of visibility of the opponents actions, especially those in front, the full understanding of the dynamics of the runners' actions is restricted. Also, the absence of telemetric data may have limited the full understanding of riders' behaviour.

Thus, the results of this study suggest that the actions in a downhill skateboarding race can vary significantly depending on the context of the competition. This has important implications for the choice of tracks to compete on and the training of competitors. This information can help competitors and coaches to choose the most appropriate training content according to the nature of the competition. For example, if a circuit has few interactions and riders' behaviour does not vary based on positioning, pre-competition training content can be more technical and focused on the ideal curve line. In this case, this will benefit competitors who are not as good at competing in shared spaces, but who excel in the qualifying rounds. Therefore, it can also help in the choice of competitions in which to participate.

Future research could explore other factors such as behavioural analysis based on the actions of rivals, along with telemetric data to get an 'x-ray' of what happens in a downhill skateboarding race.

Conclusions

On the Kozakov track, no statistically significant differences were found in running behaviour and patterns according to the positioning of the competitors. However, variables such as the braking zone, braking type, stability, line, and curve remained interdependent, likely due to the approach strategy for each curve. It is essential to explore other circuits to determine whether this phenomenon is specific to Kozakov or whether it can be generalised to other circuits with similar or different characteristics.

The observation tool (OSKATE) proposed in this paper has proven to be useful for analysing riders' behaviours in competition and can help to adapt training according to their needs. Specialists in this discipline are recommended to use the OSKATE tool.

For future research, the use of more cameras and viewing angles, as well as telemetric data, could substantially improve the understanding of competitors' behavioural patterns, although this would require significant financial investment.

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SPORT PEDAGOGY

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How do coaches convey their instructions? Analyzing content and associated emotions

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Ana Alonso and Oriol Cardona achieve their qualification for the new Olympic sport of ski mountaineering by taking second place at the 2025 World Championships in Boí Taüll.
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Abstract

Imparting technical instruction and feedback is the most commonly seen behavior in coaches. However, research has focused on the pedagogical content of those instructions and neglected how those interactions occur. The aim of this study was to assess how coaches give instruction and feedback to athletes, taking into consideration the content of instructions and the associated emotions. To that end, we observed and recorded the behavior of eight coaches (four women and four men) during female athletes' sports competitions. To do so we used the Assessment of Coach Emotions (ACE) observational tool that evaluates the content, emotion, and the recipient subject of a coach's behavior. We employed lag sequential analysis, the results of which showed that, when giving instruction and feedback, the eight coaches presented similar behavior, and said behavior was preceded and followed by alternating observational behaviors. In addition, the coaches' observed emotions when giving instruction and feedback were 'alert' and 'tense,' while the emotions associated with observation were 'neutral' and 'anxious.' These findings revealed similarities in the behavioral sequences and emotions associated with giving instruction and feedback and with observation in the assessed coaches. This approach provided information that could greatly improve training effectiveness.

Keywords: feedback, lag sequential analysis, non-verbal behavior, observational methodology, verbal behavior.

Introduction

Interactions between coaches and athletes have been a topic of study in sports psychology for decades (Smith & Smoll, 1996; Mesquita et al., 2005) and continue to represent a field of interest today (Porto et al., 2021; Ordeix et al., 2023). One of the main research aims in this field is to describe coaching behavior within different sports and contexts (Davis & Davis, 2016), as its impact on youth sports is fundamental and widely recognized, and significantly affects athletes' development and athletic experience (Bloom et al., 2020). From the perspective of self-determination theory (SDT; Deci & Ryan, 1985), coaches influence the satisfaction or frustration of athletes' basic psychological needs (i.e., autonomy, competence, and relatedness), which in turn predicts direct differences in their physical and psychological wellbeing (Cantú-Berrueto et al., 2016; Deci & Ryan, 2000). Studies show that coaches exhibit a wide range of behaviors when interacting with athletes, and emphasize the importance of instruction, support, reinforcement, and management within their repertoire of behaviors (Erickson & Gilbert, 2013). Specifically, previous research has underscored instruction-based behavior as predominant among coaching actions (Curtis et al., 1979; Ford et al., 2010), which shows that these behaviors are an effective way of supporting the athletes' learning and performance (Petancevski et al., 2022). Over the years, coaching behavior has been studied from various perspectives to demonstrate its impact on the athletic experience of athletes by means of interpersonal communication (LaVoi, 2007), motivational climate (Newton et al., 2000), leadership (Álvarez et al., 2010), and emotions (van Kleef et al., 2019).

A number of observation instruments have been used to assess and evaluate coaches' behaviors (Vierimaa et al., 2016). The results show that coaches exhibit a wide range of behaviors when interacting with athletes, including giving instruction, encouragement, and reinforcement, as well as management behaviors, these being distinctive traits of effective coaches (Erickson & Gilbert, 2013). In this sense, previous research in different sports disciplines has indicated that technical interactions with the team, such as giving instruction and feedback, are the most commonly used coaching behaviors (Cushion & Jones, 2001) and represent an effective way of supporting athlete learning and performance (Petancevski et al., 2022). While it can be argued that giving instruction and feedback is an essential part of coaching (Becker, 2013), effectiveness depends on quality and prudent application, rather than rigid implementation of generic coaching skills (Cushion & Jones, 2001).

In recent decades, research on coaching behavior has been criticized for overly focusing on pedagogical content, thus neglecting more subjective qualities associated with interactive behavior (Horn, 2008). The publication of new instruments has started to meet the demand for observation protocols for more sensitive and contextualized behavior (Corbett et al., 2023). These include increasing research into the emotional processes and dynamic and interpersonal nature of emotion (van Kleef et al., 2019), which emphasizes the essential role of emotions in coach-athlete interactions (Davis & Davis, 2016). The Assessment of Coach Emotions observation tool was developed to be able to evaluate this behavior (ACE; Allan et al., 2016). The ACE tool assesses observable emotions in coaches, as well as the content of their interactions and the recipient subjects with whom they interact (see Allan et al., 2016, for a detailed description). Within this context, Ordeix et al. (2024) recently adapted the ACE tool to the Spanish cultural context (ACE-E) and presented their data on application of the tool. This study notes the importance of taking into account the emotions associated with coaches' behavior and highlights the lack of studies addressing this interaction between content and emotion. The Ordeix et al. (2024) study also differs in that it assessed the coaches' behavior by incorporating fundamental parameters such as frequency and order, as proposed by Anguera & Hernández-Mendo (2015), similar to other recent sports science studies (Flores-Rodríguez & Alvite-de-Pablo, 2023). This approach was achieved through a multivariate analysis known as lag sequential analysis (Bakeman, 1978), which allows for sequential patterns to be detected in observed behaviors. This analysis offers a refined perspective of the study of coaching behaviors, suggesting patterns of behavior and relationships between different coaching action variables, such as instructional behavior or the use of silence, based on descriptive analysis and the rate of behavior per minute. (Cushion & Jones, 2001).

The Ordeix et al. (2024) study assessed the behavior of eight coaches, considering the content of the behavior, emotions, and relationships between the different codes. The results were conjointly presented and polar coordinates analysis was used (Sackett, 1980) to illustrate the usefulness of the ACE-E. This study, on the other hand, used the same sample to individually break down the data using lag sequential analysis. This strategy enabled us to identify patterns and relationships that may not have been evident through conjoint analysis (Sánchez-Algarra & Anguera, 2013). The sample included male and female coaches of women's sports with the aim of obtaining data about this setting, which traditionally has been less studied compared to men's sports (Cushion & Jones, 2001). Therefore, the aim of this study was to analyze the individual behavior of giving instruction and feedback by the participating coaches using a descriptive approach and considering the content and emotions associated with said behavior. To achieve this, three specific objectives were defined: (a) describe the behavior sequences of the eight coaches; (b) examine the repertoire of emotions that are exhibited when giving instruction; and (c) examine the repertoire of emotions exhibited in the behaviors presented before and after giving instruction.

Methodology

Research design

We used observational methodology with a one-off nomothetic multidimensional design according to the criteria defined by Anguera et al. (2011). Nomothetic due to the differential analysis of the plurality of the coaches, and one-off because only a single competition was recorded for each coach. However, the monitoring was intrasessional and multidimensional, as different levels of response collected in the instrument were observed.

Participants

The sample was made up of eight coaches (four women and four men) of female athletes participating in various national sports competitions. The participants (see Table 1 for a detailed summary) were between 18 and 54 years old (*M* = 29.25 years, *SD* = 11.22). All of them had obtained coaching qualifications in their respective sports.

The study participants were selected via convenience sampling and the accessible cases that met the inclusion criteria

Table 1
Participant sociodemographic and training characteristics.

Coach label	Role	Level	Age	Sex	Sport	Experience (years)	Training
M1	Head	Development	26	F	Soccer	9	UEFA A
M2	Head	Development	28	M	Basketball	9	NIVEL 1
M3	Head	Development	33	F	Soccer	3	UEFA PRO
M4	Head	Participation	54	M	Soccer	13	UEFA C
M5	Head	Participation	24	F	Soccer	3	UEFA C
M6	Head	Development	20	M	Volleyball	3	Level 1 RFEVB
M7	Head	Development	31	M	Volleyball	7	Level 1 RFEVB
M8	Assistant	Participation	18	F	Soccer	1	UEFA C

Note. The 'level' column refers to the competitive level of the league in which each coach participates, according to the classification defined by Lyle (2002).

were selected. The criteria mandated that the sample include the same number of men and women, and the participants had to be coaches in any youth sports discipline in Spain.

This study is part of a project that was approved by the ethics committee of the university where the research was conducted.

Instruments

The Spanish adaptation of the Assessment of Coach Emotions (ACE) tool (Allan et al., 2016) was used (ACE-E; Ordeix et al., 2024). The scores provided by the instrument present positive reliability values with Kappa coefficients between .77 and .93 for the study data. Based on continuous coding, the ACE-E instrument assesses three dimensions of coaching behavior: (a) content; (b) emotions; and (c) recipient subject. Each dimension contains different behavior content codes. Specifically, the content dimension refers to the type of behavior (e.g., giving instruction to an athlete) and is made up of 13 codes (organization, keeping control/standards of behavior, hustle, instruction/feedback, encouragement, positive evaluation, negative evaluation, questioning, general communication, communication with others, observation, not engaged, not engaged due to related tasks). The 'instruction/feedback' code is the variable addressed in this study and is defined by the authors of the tool as technical and/or tactical instruction and/or feedback from the coach, directed at the athletes' motor and/or psychological skill execution or performance.

The emotion dimension includes eight codes (happy, affectionate, alert, neutral, tense, anxious, angry, disappointed), while the recipient subject dimension has seven codes (individual, team, assistant coach, family members, referee, self, others). Since this study focuses on the instructions and feedback given by coaches which correspond to the ACE 'instruction/feedback' content code, and since the recipient subject of the majority of this behavior is the female athletes, in this research the recipient code is always the athletes and we specifically focus on the content and emotion codes.

Observation software. The coaches' behavior was logged during competition according to the codes and using the HOISAN program, version 1.6.3 (Hernández-Mendo et al., 2014), which allowed for the duration of each configuration to be recorded in time segments. The type of data used was multi-event, meaning the three categories were coded for each observation (content, emotion, and recipient). The same program was used to perform data quality analysis as well as the lag sequential analysis.

Procedure

The coaches were informed about the study's research objectives, and they were asked to participate on a volunteer basis. They gave their informed consent in a prior meeting in which a short, semi-structured interview was held to collect sociodemographic data and information about their qualifications. The confidentiality of their data was guaranteed, and they were informed of the option to leave the study at any time.

This was followed by the data collection phase, which involved filming one game for each participant. In total, the database includes 500 minutes of audio and video recordings lasting between 60 and 90 minutes for each participant. In all cases, the observations and subsequent analyses were carried out by the initial author, who had previously received training on the tool (100 training hours) and who has 11 years of experience in the field as a coach and sports psychologist.

For more details, we recommend consulting the procedures section in Ordeix et al. (2024).

Data analysis

Sequential analysis. Different lag sequential analyses were conducted to provide a descriptive response to the three specific objectives. This technique allowed us to identify the presence of consistent patterns in the behavior of the evaluated coaches. To do so, we used the recommended cut-off point for values with an adjusted residual of > 1.96 (Bakeman, 1978).

With the aim of describing sequences of behavior for the eight coaches, the instruction/feedback code was selected as the benchmark behavior for analysis, meaning the behavioral category for which the successive interactions were recorded. Specifically, in this analysis the five interactions prior to and five interactions post the benchmark behavior were taken into account (lag -5, +5) and their relationship to the codes that refer to the behavior content (e.g., organization, keeping control/standards of behavior, hustle, instruction/feedback, encouragement, positive evaluation, negative evaluation, questioning, general communication, communication with others, observation, not engaged, not engaged due to related tasks) as paired behaviors.

Subsequently, to examine the repertoire of emotions that occur when the eight coaches give instruction, the same technique was applied, but this time in lag 0 and with the emotion codes (e.g., happy, affectionate, alert, neutral, tense, anxious, angry, disappointed) as paired codes for analyzing simultaneity or co-occurrence of emotions with giving instruction to respond to the second specific objective.

Lastly, to address the third objective, the behaviors identified in the first objective (those that make up the instruction sequence) were selected as the benchmark behavior and the paired emotions to analyze their simultaneity starting at lag 0 in the sequential analysis.

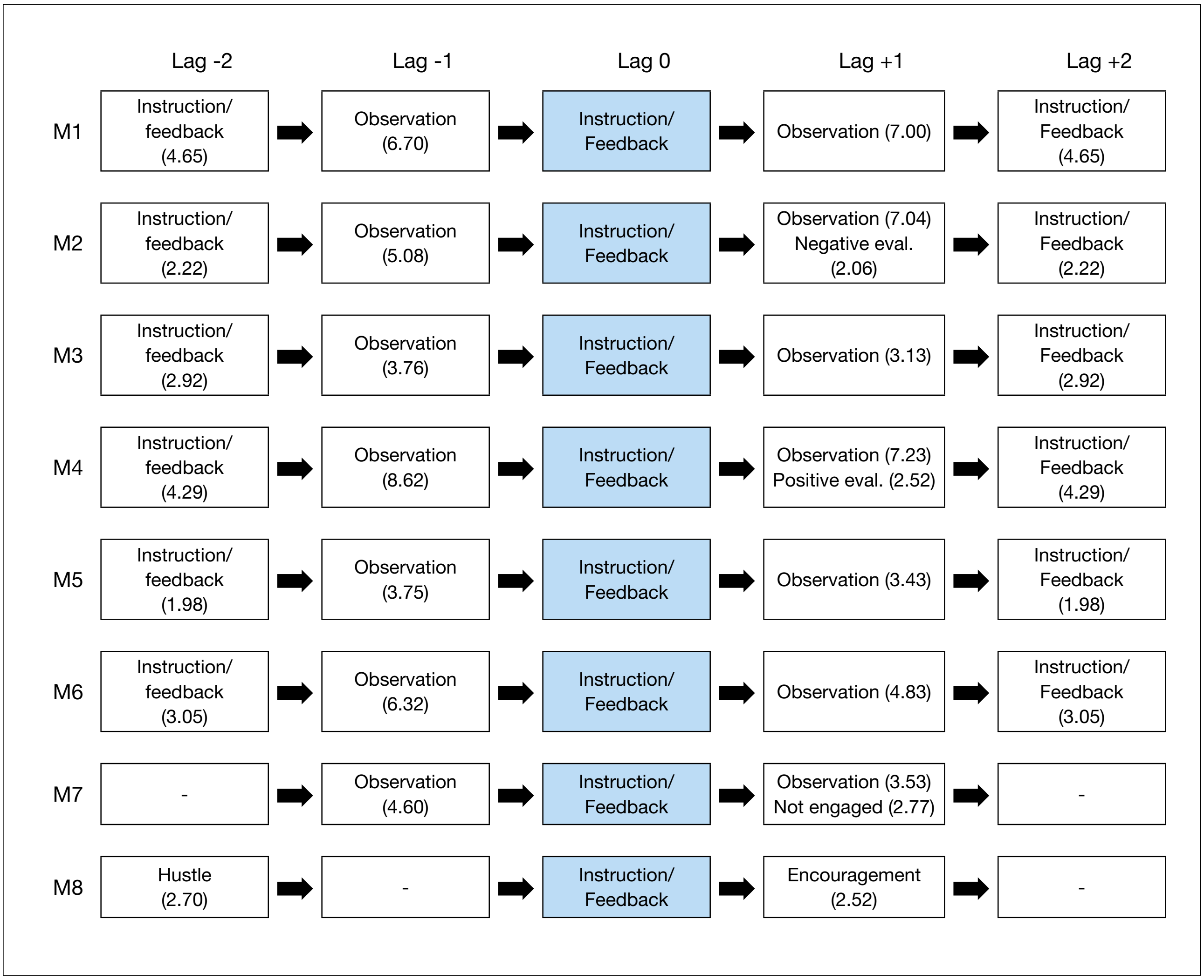
Results

The results are presented below, organized according to the specific study objective to which they respond.

Behavior sequences for the eight coaches

Considering the first specific study objective was to explore the behavior sequences of the eight coaches when giving instruction/feedback, the instruction/feedback content code was selected as the benchmark behavior, which is located at lag 0 in the action chain, and the adjusted residuals were calculated for the behaviors that were considered paired (all the content codes). Based on the positive adjusted residuals greater than 1.96, the behavior patterns were extracted for the eight coaches. Figure 1 shows the lags included because they presented a sequence with values higher than the cut-off point established for the evaluated coaches (from lag -2 to +3). The results reveal little variation among the coaches and represent the basic sequence of the study participants, characterized by the instruction/feedback and observation behaviors, with the exception of coach M8, who did not present a clear behavior sequence and exhibited hustle (lag -2), encouragement (+1), and general communication (+3).

Figure 1
Comparison of the behavior patterns found from the adjusted residuals obtained in the 'instruction and feedback' action for the eight coaches.



Note. The lags with an absolute value-adjusted residual below the cut-off point are identified with a dash. M1 = coach 1, M2 = coach 2, M3 = coach 3, M4 = coach 4, M5 = coach 5, M6 = coach 6, M7 = coach 7, M8 = coach 8.

Analysis of emotions based on instructions and feedback

The second objective was to explore the eight coaches' emotions in relation to giving instruction/feedback. To do this, a sequential analysis was conducted for lag 0, wherein the instruction/feedback code was considered the benchmark behavior, and the emotion codes were considered paired behaviors.

The results (Table 2) showed that in lag 0, where the instruction behavior occurs, the eight evaluated coaches exhibited the emotions 'alert' and 'tense.' The emotion 'angry' was also present in coach M3.

Analysis of the emotions associated with the coach's behavior

The third specific objective was to explore the emotions associated with the behavior content that accompanies giving instruction in the eight coaches. Since the previous results showed that observation is the content that accompanied instruction in the lags prior and subsequent to the behavior of the evaluated coaches, the concurrence of this behavior with the other emotion codes was examined based on the sequential analysis of lag 0, in which the observation code was considered the benchmark behavior, and the emotion codes were considered paired behaviors.

Table 2
Adjusted residuals of the lag sequential analysis for the eight coaches with instruction/feedback as the benchmark behavior and the paired emotion codes.

	Emotion codes							
Coach	Happy	Affectionate	Alert	Neutral	Tense	Anxious	Angry	Disappointed
M1			5.77		6.72			
M2			2.10		3.31			
M3			5.45		3.76		2.74	
M4			12.54		3.41			
M5			4.21		3.61			
M6			7.17		3.32			
M7			3.29		5.10			
M8			6.91		2.53			

Note. Absolute value-adjusted residuals greater than the cut-off point greater than 1.96. M1 = coach 1, M2 = coach 2, M3 = coach 3, M4 = coach 4, M5 = coach 5, M6 = coach 6, M7 = coach 7, M8 = coach 8.

Table 3
Adjusted residuals of the lag sequential analysis for the eight coaches with observation as the benchmark behavior and the paired emotion codes.

	Emotion codes							
Coach	Happy	Affectionate	Alert	Neutral	Tense	Anxious	Angry	Disappointed
M1				6.80				
M2						3.93		
M3				7.82		3.18		
M4				7.39		9.36		
M5				8.50				
M6				6.58		5.43		
M7				7.77				
M8				8.29				

Note. Absolute value-adjusted residuals greater than the cut-off point greater than 1.96. M1 = coach 1, M2 = coach 2, M3 = coach 3, M4 = coach 4, M5 = coach 5, M6 = coach 6, M7 = coach 7, M8 = coach 8.

The results (see Table 3) showed that in lag 0, when the observation behavior occurs, coaches M1, M5, M7 and M8 exhibited the 'neutral' emotion. Coach M2 exhibited the emotion 'anxious,' and coaches M3, M4, and M6 exhibited the emotions 'neutral' and 'anxious.'

Discussion

The aim of this study was to examine the instruction/feedback behavior of eight women's sports coaches during competition by means of descriptive analysis. To do this, the content of the behavior and the associated emotions were taken into account. The results showed that the evaluated coaches presented similar behavior sequences, wherein observation predominated in the sequences before and after giving instructions and feedback. On the other hand, we noted similarities in the emotions related to giving instructions and observation, wherein alert and tense emotions predominated in the former and neutral and anxious emotions in the latter. These findings provide empirical evidence of these relationships, which had not been previously specifically studied along the lines of the study from Ordeix et al. (2023).

First, the behavior sequence was described when giving instruction and feedback, which alternated between observation and instruction. This implies that the coaches first observed, then interacted with the athletes, and then observed again. These results fall in line with, from a more sophisticated analysis, those of Cushion & Jones (2001), who observed that coaches initiate an action and then stay silent, allowing for a period of free play before intervening again, and subsequently falling silent again. This is also in line with the study by Magill (1993), who suggested that silence is essential to the delivery of information, which guarantees careful and measured feedback, and that the effect of their interventions is not diluted by continuous interaction as it allows the athletes to participate in their own sensory feedback. The results showed that the evaluated coaches fill those silences by observing their athletes. This behavioral pattern can be interpreted as a process of prior analysis by the coaches before directly interacting with the athletes since, as described by Cushion & Jones (2001), these periods of observation offer the opportunity to analyze and reflect on the most appropriate interventions during a given interaction. The results from coach M8 deviated from the behavior pattern detected among the other coaches, which could be attributed to their secondary role in the technical team during the analyzed game, as this may have impacted their performance.

Second, we observed similar emotions associated with the instruction or feedback behavior among all eight coaches, with the predominant emotions being 'alert' and 'tense.' The presence of these emotions may suggest that the coaches experienced an emotional burden associated with their role, which could potentially indicate an activation or preparation reaction to their current task, in accordance with the circumplex model of affect from Russell (1980). These emotions are related to the attention and concentration needed to effectively communicate an instruction. These interpretations are in line with the description of these emotions as relatively neutral but maintain a slight positive valence in the case of the 'alert' emotion and a slight negative valence in the case of 'tense,' as per the authors of the tool (Allan et al., 2016). Likewise, the 'angry' emotion exhibited by coach M4 suggests elevated hustle, frustration, or irritation when giving instruction or feedback, which could impact their coaching/teaching style and interactions with the athletes. These findings are important for designing emotional support strategies and professional development targeted at coaches.

Lastly, the emotions associated with observation were explored, which were consistent among all the coaches assessed. The 'neutral' and 'anxious' emotions were most common among the assessed coaches during the observation period. Given that prior research has indicated that coaches dedicate a considerable portion of their activity to silent observation during competitions (Turnnidge, 2017), these findings highlight the importance of analyzing the emotions associated with said behavior. While the 'neutral' emotion predominates in some cases, in other coaches a tendency towards unpleasant emotions can also be observed. These results underscore the importance of individual evaluation that identifies the specific traits of each coach as a way to offer more effective assessment in terms of regulating emotions, since effective emotional regulation is closely tied to decision-making abilities (Harvey et al., 2015). The role of emotions in decision-making is extremely complex, as it can result in both positive and negative results, and a coach's emotional state significantly impacts their decision-making (Laborde et al., 2013).

Inadequate emotional management can have adverse consequences (Stirling, 2013) and impact the effectiveness of the message that is being communicated. This is particularly relevant in intense emotional situations, as athletes view coaches as role models considering that they play such a crucial role in their emotional responses (e.g., Friesen et al., 2013). Previous studies indicate that coaches use different strategies to manage emotional demands. Frey (2007) notes that they use cognitive strategies (e.g., re-evaluation), emotional coping strategies (e.g., social support) and behavioral strategies (e.g., preparation) to manage stress. These strategies show the effort that coaches make to try to balance their resources with the demands they face. This study provides a perspective of how coaches cope with emotional demands and offers a path towards developing a coach assessment program that, on the one hand, takes into account the coaches' communication style, in line with previous research (Cruz et al., 2011; Sousa et al., 2006) and, on the other hand, considers the coaches' emotions, which would allow for the development of individualized emotional management programs.

This study stands out because it examined the behavior of coaches within the context of women's sports, providing scientific evidence and increasing visibility, which is in line with recent studies (Ronkainen et al., 2020). In addition, we used the innovative technique that is lag sequential analysis, which broadens its application beyond studies focused on motor skills in sports science (Font et al., 2022). This technique offers the option to evaluate the dynamic nature of coaches' emotions and improves our understanding of the contextual nuances, enabling us to explore relationships between various categories (Castellano & Hérnandez-Mendo, 2002). On the other hand, the use of HOISAN to conduct the data analysis, according to a common practice in recent observational methodology studies (Amatria et al., 2020; Ordeix et al., 2024), ensured data reliability by means of the direct calculation of Cohen's Kappa coefficient (Hernández-Mendo et al., 2014).

Limitations

The limited number of recordings of each participant restricts generalization of the data obtained, as this was limited to one recording per coach. Having access to recordings from multiple games or competitions would allow us to better assess the consistency of the coaches' behavior in different situations and settings, and would minimize the influence of uncontrolled variables, such as situational factors or measurement errors, which could impact coaches' behavior at certain events and therefore reveal whether their behavior is consistent (Anguera et al., 2011). Likewise, it would be beneficial to broaden the sample to include greater representation of diversity within the sport, such as including coaches from a wider range of disciplines, including individual sports. This study only assessed coaches from three sports disciplines (soccer, basketball, and volleyball). Said diversity would contribute to painting a more representative and comprehensive picture of behavior patterns in the world of sports.

Another important limitation was that the study was confined to an observational methodology and was not supplemented with other quantitative and qualitative data collection techniques. The combination of these methodologies could provide a more holistic approach, which would allow for a more in-depth and detailed analysis of the coaches' behaviors and attitudes, as well as the dynamics found in different sports settings.

Research prospects

For future research, it could be interesting to include the perspectives of the athletes themselves to assess how coaching behavior impacts their sports experience. The failure to evaluate how coaches' actions impact the actual athletes was one of the study limitations we identified, so additional research is needed to examine the impact of said behavior. Similarly, taking into consideration the outcome of the game during the assessment may be useful in determining whether it impacts the coaches' behavior, given that the study by Mason et al. (2020) suggested that feedback associated with enhanced learning and performance seems to be more frequent when the competition scoreboard is in your favor.

Lastly, continuing with this line of research and exploring coaches' instruction or feedback behavior and their emotions in other cultural contexts would be extremely beneficial. Studying these variables in different cultures would allow us to understand how cultural factors impact coaching styles and coaches' emotional management. What's more, using this comparative approach in future research could reveal universal patterns or significant differences in strategies for giving instruction and in how emotion is expressed, thus enriching knowledge of how coaching techniques are adapted in diverse cultural settings.

Conclusions

The study results reveal a common behavior sequence among the evaluated coaches when giving instruction and feedback with observation as associated behavior. Giving instruction and feedback was associated with the 'alert' and 'tense' emotions, while the observation that takes place prior to the previous behavior was characterized by the 'neutral' and 'anxious' emotions. These findings provide empirical evidence of these relationships, which had not been previously studied, and highlight the importance of analyzing the emotions related to coaches' behavior. This emphasizes the need for individual evaluation to provide a more effective assessment of emotional regulation.

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SPORT PEDAGOGY

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Bullying and training: the perspective of university professors in physical education and sport

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Abstract

Bullying is a social problem in sports and physical education (PE) classes. This means PE, physical activity (PA), and sports professionals need to receive specific training in order to prevent, identify, and respond when bullying occurs. With that in mind, university education should offer content that helps these professionals gain the tools and skills needed to deal with the issue. The aim of this study was to determine university professors' perceptions of education on the topic of bullying in Elementary Education with a major in Physical Education (EEPE) and in Exercise and Sports Science degrees (ESS). The study was based on a focus group (FG) with participation of researchers with expertise in bullying who teach university classes within the EEPE or ESS degree. The data were analyzed via thematic analysis using the Atlas.ti® version 9 application. The main results showed that the groups of experts reported little training on the topic of bullying among the students in the aforementioned degrees and noted a lack of training among the university professors in terms of including bullying content within the courses. In conclusion, these results may help broaden knowledge about the lack of training and the need to include bullying content in EEPE and ESS degrees.

Keywords: coaches, harassment between equals, physical activity, training, teachers, university.

Introduction

Bullying is understood as a set of repetitive aggressive, negative behaviors towards an individual by another person or group with the intention of causing harm. Bullying involves an imbalance of power between the people involved (Olweus, 1993), and may involve different types of violent behavior that can be classified as physical bullying, social bullying, verbal bullying, and cyberbullying (Menesini & Salmivalli, 2017). The latter refers to aggressive actions conducted over the internet or via smart phones and social networks (Smith, 2016).

Studies on bullying in schools show this is a social problem that concerns people across the globe. A meta-analysis conducted by Modecki et al. (2014) including results from 80 studies reported victimization rates of 35% for bullying and 15% for cyberbullying. On the other hand, a recent study conducted in 325 educational centers across 17 autonomous communities in Spain reported a general prevalence of bullying victimization of 6.2% (Díaz-Aguado et al., 2023).

In recent years, various studies have analyzed this phenomenon in both sports (Nery et al., 2021; Ríos et al., 2022a) and the specific field of physical education (PE) (Castañeda-Vázquez et al., 2020; Jiménez-Barbero et al., 2019). Some research has highlighted the potential of PE to promote anti-bullying attitudes and behaviors (Benítez-Sillero et al., 2021), such as sports environments, which can represent spaces for socializing and promoting values against violence (Medina & Reverte, 2019). Nevertheless, these same settings can also transform into contexts that pose a risk of violence for those who do not meet the social standards of beauty, competitiveness, and motor skills, among others (Flores et al., 2021; Ríos & Ventura, 2022). For that reason, PE teachers and sports and physical activity (PA) professionals are fundamental to the effective prevention and intervention against victimization (Peterson et al., 2012).

As regards preparing teachers to deal with bullying, the public administration has developed relevant initiatives. These include the Emotional Well-Being in Education program from the Ministry of Education and Professional Training (2023) that, as part of its course of action, aims to promote teaching training in the knowledge and implementation of action protocols in situations involving harassment between equals, cyberbullying, and other manifestations of violence. What's more, Organic Law 8/2021, of 4 June, on the Comprehensive Protection of Childhood and Adolescence Against Violence mentions that higher education centers must promote training, education, and research on the topic. Specifically, it proposes that curricula should include content dedicated to prevention, detection, and intervention to eradicate violence against childhood and adolescence. These directives are specifically aimed at professions that involve regular contact with minors, such as graduates with degrees in Elementary Education and Exercise and Sports Science (ESS). Therefore, it is assumed that all professionals with these university degrees should have received specific training. However, some studies show that current PE teachers note a lack of bullying prevention resources and strategies (Sağin et al., 2022), and that PA and sports professionals have little knowledge about bullying (Ríos & Ventura, 2022).

According to a report from the Help for Children and Adolescents At Risk (2022), this scarce training for active teachers may result in inaction against bullying cases, so initial and ongoing teacher training is considered key to the battle against bullying (Sidera et al., 2019). In that sense, previous research has shown that including bullying content in Elementary Education degree curricula allows university students to identify its characteristics and the agents involved, providing them with strategies to respond to bullying in a more effective manner (Benítez-Muñoz et al., 2017).

On the other hand, future teachers declare an interest in bullying but report difficulties in defining the concept and a lack of knowledge about types of bullying and resources to identify its presence and scope (Mahon et al., 2023). At the same time, future PE teachers express concern about the lack of training on the topic of bullying in university education and highlight the importance of including this in PE teacher training curricula (Ríos et al., 2022a).

In light of the above and the lack of research involving the opinions of university professors on education in bullying, both in general education and the specific setting of PE, PA, and sports, this study was conducted to reveal university professors' perceptions of bullying training taught in the Elementary Education with a major in PE and ESS degrees.

Methodology

This research is framed within the post-positivism paradigm, which is characterized for having a critical realist ontology. This approach defends the existence of an external and objective reality, though our understanding of it is necessarily imperfect and adopts an epistemology based on modified dualism or objectivism (Lincoln et al., 2011).

Participants

The sample included a total of 10 professionals (3 women and 7 men) who are researchers with an expertise in bullying. The participants were selected through a purposeful sampling process (Patton, 2002) since this type of sampling allows for deliberate identification and recruitment of individuals who meet specific criteria, ensuring they provide meaningful and relevant information about the topic under study. The inclusion criteria for participants were as follows: (1) teaches at the university level in EEPE or ESS degrees; (2) has an academic profile related to PE, PA, and sports; (3) conducts research on bullying or cyberbullying within the context of PE, PA, and sports; (4) gave positive informed consent.

The study was approved by the Clinical Research Ethics Committee from the Catalonia Sports Administration (009/CEICGC/2021). The participants were informed about the voluntary nature of the study, that they could leave the study whenever they liked, and that the confidentiality and anonymity of the collected data would be guaranteed. Informed consent was obtained prior to starting the study. The participants were informed that the sessions would be audio recorded to facilitate analysis. Likewise, time was specifically set aside to allow the participants to ask the research team questions prior to the focus group. Each participant was assigned a pseudonym to maintain study confidentiality and anonymity.

Instrument

The data collection technique was a focus group (FG) (Patton, 2002) with a semi-structured script drafted following a bibliographic review of the study topic (Benavides et al., 2022) and taking as reference other studies that assessed expert opinions in an FG (Escamilla, 2016). This technique was deemed the most appropriate for its capacity to explore in-depth the perceptions, opinions, and experiences of a group of experts in a specific topic (Morgan, 1997). In accordance with Geertz (1994), the aim was to delve into the contributions and opinions of a group of experts on the specific topic of bullying and university education and training.

Procedure

The study was conducted within the context of an interuniversity symposium involving university professors, specifically in a space dedicated to discussion of bullying and the education of future PE, PA, and sports professionals. The FG was held in-person in Barcelona in September 2022. The session was coordinated by the authors of the script, who moderated and encouraged all the group members to participate by giving their opinion within a professional, respectful, and safe setting. At the beginning of the session, an introduction was given on the issue of bullying training within university education after which the debate began according to the predesigned semi-structured script.

The FG lasted two hours, offering enough time to debate the primary study topics. The descriptive validity was reinforced by the fact that all the FG data were digitally recorded to later be manually transcribed verbatim by one of the document's authors. Subsequently, the research team jointly verified the transcriptions.

Data analysis

The data interpretation technique was thematic analysis as proposed by Braun et al. (2016). The themes were identified and categorized according to the following phases: (1-2) familiarization and coding; (3-5) theme development, revision, and naming; (6) and writing up. The main themes a) "Training in the topic of bullying in EEPE and ESS degrees," b) "Personal initiative of university professors," c) "Bullying as mandatory content in EEPE and ESS degrees," and d) "Strategies and resources for implementing training" were agreed on jointly by the research team as a whole during a preliminary conversation on the theoretical framework under study. Later, the authors individually conducted a detailed data analysis, and the results were jointly discussed and validated to guarantee theoretical validity and coherence. This collaborative approach bolstered the quality of the analysis by incorporating multiple perspectives into the data interpretation. The code organization and data analysis were carried out using the Atlas.ti® application, version 9.

Results and Discussion

We present below the most notable examples of the primary themes and compare them against the main findings from the theoretical points of reference up to June 2024.

Training on the topic of bullying in EEPE and ESS degrees

A group of experts acknowledged the absence of specific training on the topic of bullying in the aforementioned university degrees. In that regard, one participant stated they had identified this lack of training during their professional experience and through research conducted in recent years: "The students don't receive any training. We've all seen it. In recent research we also found there is no specific training on the topic of bullying in EEPE and ESS degrees" (David). Another expert disclosed that bullying is a topic that concerns students, yet they are not aware of their lack of preparation to address it: "Personally, I've noticed that students are very concerned about the issue but, at the same time, they are not prepared to deal with it" (Sonia).

Consequently, the results showed that future PE teachers and PA and sports professionals lack specific preparation to identify and prevent situations involving bullying in schools or sports environments. In this same vein, Ríos et al. (2022b) noted the importance of incorporating bullying into the educational curricula within the context of PE, PA, and sports. Similarly, the perception that university students are concerned about this social problem is associated with the importance of the attitude that teachers adopt in light of bullying situations. Jiménez-Barbero et al. (2019) point out that both teacher behavior and actions can be decisive in preventing bullying. On the contrary, teachers' failure to act can contribute to these problems spreading.

Likewise, according to the experts, this problem of lack of student training is compounded by a lack of training of the actual professors teaching the university classes, as stated by one of the participants:

> We also have to consider the lack of training of the university professors. Even the professors who are most knowledgeable about and aware of bullying can run into difficulty when preparing a workshop on bullying due to a lack of specific training on the topic. (Ricardo)

Therefore, merely researching the problem is not sufficient to be able to provide specific training to future teachers or professionals. It is evident that teachers are also aware of their lack of training in bullying, which falls in line with the results from a study by Napoleão & Calland (2013), in which teachers described not having received any specific training on the topic of bullying, despite believing it to be an important and necessary topic in continuing professional development.

The experts warned that this lack of training among university professors not only means this content is not included in course syllabi, but it could also impact how bullying is dealt with should it occur among university students in university classes:

> We know that one of the problems is that teachers and coaches don't identify bullying in schools, yet university professors don't have solid tools for this either (…). I remember there were issues with bullying last year in the Education Department and they weren't taken as seriously as they should have been. (Ricardo)

In this case, the results are in line with previous research that highlights bullying as a social problem that has grown within the university setting (Tight, 2023), even among athletes in university leagues (Jewett et al., 2019). One recent study on bullying in Spanish universities showed that this problem is fairly frequent, and the numbers of victims and aggressors in education- and psychology-related degrees have increased in recent years (Royo-García et al., 2020).

Personal initiative of university professors

Based on the uncovered results, we must highlight that the experts who reported including bullying-related content in their coursework did so due to personal interest, concern, or awareness of the issue:

> In our Psychology class for Physical Activity and Sports, we did include bullying-related content over the course of one week. We dedicated two theoretical sessions and two practical sessions to it (…). I have to admit that five or six years ago we didn't teach these sessions on bullying. We do now thanks to concerns and questions that have arisen among the faculty. We believe that students should graduate from their ESS degree with at least the minimum knowledge about bullying. (David)

In another case, one expert mentioned that bullying is discussed as content within a topic that also deals with other types of violence:

> In the Sports Psychology class in the Sports Science curriculum, which is a required course at our university, an entire block is dedicated to children's development in sports. I don't just include the topic of bullying, I include a general topic on violence, abuse, and discrimination. (Manuel)

Similarly, one of the experts mentioned work practicums as an opportunity to bring up topics surrounding bullying with the students:

> Last year we proposed bullying topics during the work practicum (…). For example, one could research the protocols at the school, the protocols at the level of the autonomous community, or prepare interventional practicum sessions with activities aimed at bullying prevention. (Marta)

Based on these examples, we were able to confirm that bullying content is included mainly due to the personal initiative of professors who are aware of the issue and who decide to include the topic in university education. However, this does not guarantee that all students have access to this training. These results align with studies that reference educational experiences on the topic of bullying, such as the studies from Benítez-Muñoz et al. (2009) and Napoleão & Calland (2013), who state the topic of bullying is discussed thanks to the initiative of the teaching staff and university researchers.

Bullying as required content in EEPE and ESS degrees

One of the study results that stood out was the recurring theme that bullying should be required content in EEPE and ESS curricula. One solution for addressing this issue in university education that was discussed was as follows:

> The only way to truly ensure that bullying content is studied is to ensure it is included in the curriculum, with a specific course or class that defines the required content. That's the only way to ensure it is truly studied in all universities. (Miguel)

However, evidence shows that bullying content is not systematically included in education, despite studies that indicate otherwise, such as a study by Ventura et al. (2016), in which the authors found the presence, though negligible, of bullying content in teacher training university curricula in various public universities in Spain and Portugal.

The experts also emphasized the importance that education in bullying delve deep into theoretical content, prevention and detection strategies, and action protocols:

> Any training program should include a theoretical portion that covers the definition, roles, behavior (…) and should also discuss resources to prevent and detect the signs or indications that appear in children or in group dynamics that signal that something is going on (…) and knowing the protocols too. (Sonia)

One recent study on student well-being at elementary schools underlined the importance of teachers being aware of and able to implement actions protocols against bullying and cyberbullying, as this largely contributed to proper functioning of the school's rules for social harmony and getting along (Torrego et al., 2023). Likewise, according to administrative obligations, every school must have an action protocol to aid students who experience harassment or mistreatment. As such, the Departments of Education in each autonomous community must define their own action protocol (*Ministerio de Educación y Formación Profesional*, 2023).

The experts also overwhelmingly emphasized the importance of ensuring compliance with the legislation. They referenced Organic Law 8/2021, of 4 June, on the Comprehensive Protection of Childhood and Adolescence against Violence, which dedicates a full chapter to leisure activities and sport: "We have to talk about the childhood protection law, as well as the requirement to have a childhood and well-being protection delegate" (Marta).

That said, despite the existence of this law, it is understood that the proposed measures are not being implemented. Therefore, action must be taken in this area to guarantee that all sports and education centers have this delegate role in place.

Strategies and resources for implementing training

In terms of the strategies and resources for providing training, the group of experts mentioned multiple aspects. First, one of the participants highlighted the need to complement the motor skills focus of PE classes with a conceptual and reflective approach, and suggested discussing the topic of bullying through cooperative play, body language, role play, and movement stories:

> Sometimes it seems like the aim is to provide purely motor skills-based content in PE classes, yet the conceptual aspect and reflection is also important. In this case the conceptual portion can be related to anti-bullying content. Cooperative play, body language, role play, and movement stories are strategies that can guide this topic. (Marta)

In this same vein, in one study Benítez-Sillero et al. (2021) implemented an anti-bullying intervention program in a PE class using psychosocial content and motor skills. The program included activities such as movement stories, cooperative challenges, body language, motor skills challenges with symbolic roles (victim and aggressor), and team games with implementation strategies to connect the PE curriculum content with social and emotional skills.

On the other hand, the experts suggested strategies for university level education, such as the use of audiovisual material to pique student interest, or presentations on news and media and real cases to raise awareness and impress upon students the impact of bullying: "These days, short videos are what grab the students' attention, documentaries, TV shows (…) that discuss the key information and that show real cases of bullying" (Ricardo). According to another expert: "One way of broaching this topic is to present real cases that have been reported in the news (…) cases of suicide. This grabs the students' attention, as we're talking about a very, very serious issue" (Sonia).

Another suggestion was to seek out alternatives to complement this lack of training, including organizing educational conferences or symposia on the issue: "To approach these social issues that are so profound, we could organize workshops or sessions for educating and raising awareness about bullying" (Felipe).

Another expert presented a methodology that, in their experience, was most effective at addressing the topic in the university environment:

> I've found that an intensive workshop is most effective for me. At the start, we discuss the potential of sports for childhood development and then, in groups, the students make a list of all the types of abuse that they know can occur in sports, and then we hold a final discussion. In general, we discuss each topic and those who participate share their thoughts. (Manuel)

The goal is to adopt provisional training measures or programs until the new curricula can address and encompass content regarding bullying in certain classes that would be required coursework. Only in this way do we believe all students will be sure to receive education on the topic of bullying in the future. Based on the results, the group of experts gave concrete suggestions on content and strategies that should be included in bullying training. The group's proposals were aligned with other educational initiatives for bullying prevention promoted by actual PE teachers in schools, such as the use of cooperative learning (Faus & García, 2020) and working on social and emotional skills (Aguilar et al., 2021).

Additionally, in this situation, we must consider that the people participating in the FG were experts and were knowledgeable about strategies for organizing specific training programs. Nevertheless, it must be said that this characteristic is not transferable to the vast majority of professionals in PE, PA, and sports settings since, as certain studies indicate, PE teachers do not have bullying prevention strategies (Sağin et al., 2022), and youth sports coaches do not have sufficient knowledge of the topic (Ríos & Ventura, 2022).

Conclusions

As stated by the group of experts in bullying in PE, PA, and sports, we can confirm there is no training in the topic of bullying in EEPE or ESS degrees. Likewise, in the case of bullying in the university setting, we recognize the need to educate university professors to recognize and confront situations of bullying. In terms of practical implications, we must urgently and necessarily incorporate bullying training into EEPE and ESS degrees pursuant to the legislation in force. The proposals should consider conceptualization of the phenomenon, legislation, prevention and detection resources, and action protocols. In terms of strategies for implementing said training, the advice is to use materials that help raise awareness among students, such as videos that tell stories of real cases, as these capture student interest and make students aware of the seriousness of the issue. Other suggestions included using practical activities, such as cooperative games, body language, symbolic role play, and movement stories to connect motor skills development with social and emotional skills. Likewise, holding specific educational/reflective conferences and workshops was also proposed. Lastly, these results must also contribute to a greater understanding of the responsibility that universities bear in terms of the importance of providing training in bullying in the PE, PA, and sports setting.

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