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Assessment of body composition and bioimpedance in runners with Down syndrome: insights derived from a four-case study

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Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/ Ritchie B. Tongo)

Abstract

Down syndrome (DS) is a genetic disorder that comes with a range of health challenges, including reduced cardiorespiratory fitness. For individuals with DS, accurate body composition assessment is challenging due to their unique body shapes. However, it is a critical component in early obesity detection and for developing targeted lifestyle interventions. The study involved four male DS runners who underwent anthropometric measurements and bioelectrical impedance vector analysis (classic and specific approaches) before and after completing the 14-kilometer race. Various equations were employed to estimate body composition. Additionally, somatotype analysis was conducted and bioelectrical changes evoked by the race were compared. Considerable variability in the body composition and race performance of DS individuals was revealed. Different equations for estimating fat mass yielded varying results (from 4.2 to 33.3%). Notably, the amount of fluids showed unique patterns among the participants. Participant 1 stood out with a remarkably high phase angle (9.8°), while the others had comparatively lower average values (4.5-6.3°). Bioelectrical impedance vector analysis indicated normal fluid loss during the race (T2 = 92.2; $p < .0001$). Intriguingly, Participant 1, who achieved the fastest race time, experienced the most significant fluid loss but displayed a greater intracellular water retention. This study underscores the importance of developing tailored body composition assessment methods for individuals with DS. Developing precise assessment tools will contribute to enhancing the well-being of this population as they pursue active lifestyles. These findings shed light on the intricate relationship between body composition, hydration, and performance in individuals with DS.

Keywords: bioelectrical impedance vector analysis, body composition, fat mass, intellectual disabilities, sport.

Introduction

Down syndrome (DS) is the most prevalent genetic disorder leading to intellectual disability worldwide (Franceschi et al., 2019). DS is associated with a host of health challenges that profoundly impact the quality of life and cardiorespiratory fitness of affected individuals (Seron et al., 2014). These challenges stem from factors such as cardiovascular diseases, muscle hypotonia, susceptibility to overweight/obesity, low bone mass, elevated body mass index (BMI), among others (Franceschi et al., 2019; Glasson et al., 2002). The predisposition to obesity in individuals with DS is exacerbated by their generally sedentary lifestyle (Florentino Neto et al., 2010), primarily due to the physical and physiological complexities associated with this condition. Nevertheless, exercise therapy has shown promise in normalizing autonomic function and mitigating the development of comorbidities (Cilhoroz et al., 2022). The utilization of appropriate body composition analysis methods may serve as a valuable tool for early obesity detection, facilitating the development of targeted lifestyle interventions aimed at preventing chronic diseases.

Numerous techniques exist for assessing body composition, including dual-energy X-ray absorptiometry (DXA), bioimpedance analysis (BIA), and kinanthropometry, among others. However, body composition significantly varies between individuals with and without DS (González-Agüero et al., 2017). This presents a challenge as many of the methods used to estimate fat mass percentage (%FM) are developed for the general population (Nickerson et al., 2023). This incongruity highlights the need for analyses tailored to the unique body shapes and morphologies of individuals with DS, as proposed by Rossato et al. (2018), based on the sum of four skinfolds (triceps, subscapular, biceps, and suprailiac), age, BMI, and gender. More recently, Nickerson et al. (2023) introduced a new equation based on mid-axilla and suprailium skinfolds, derived from a sample of 20 participants of varying ages and genders. The adoption of these specialized assessment methods could enhance the accuracy of body composition measurements in individuals with DS.

Bioelectrical impedance vector analysis (BIVA) emerges as an alternative approach for assessing body composition. It employs qualitative analysis by plotting participants within reference population ellipses using raw bioelectrical parameters, specifically resistance (R) and reactance (Xc), along with their derived components, impedance/vector length (Z) and phase angle (PhA) (Piccoli et al., 1994). BIVA offers a solution to the potential inaccuracies of predictive equations in populations with distinct characteristics by comparing participants' vector positions to tolerance ellipses representing reference population values, requiring minimal elaborations. Two BIVA approaches exist, each tailored to standardizing bioelectrical parameters: classic BIVA, adjusting for height (R/H, Xc/H, Z/H) to account for conductor length and assess body fluids, and specific BIVA, further adjusting for height and cross-sectional areas of the arms, trunk, and legs (Rsp, Xcsp, Zsp) to mitigate the impact of body volume and estimate %FM (Campa et al., 2022a). Consequently, Z/H inversely correlates with total body water (Piccoli et al., 1994), while Zsp positively correlates with %FM (Toselli et al., 2020). PhA is considered an indicator of cellular health and cell membrane integrity, inversely linked to the extracellular/intracellular water (ECW/ICW) ratio, regardless of the BIVA approach (Marini et al., 2020). Notably, there exists a substantial lack of published research on BIVA in individuals with DS, with only a handful of conference posters available.

Hence, this preliminary study investigates the morphological characteristics of a sample of DS runners, employing anthropometric and BIVA (classic and specific). Furthermore, it aims to provide an initial comparison of bioelectrical values with the general population while also exploring potential bioelectrical changes induced by a 14-km race in individuals with intellectual disabilities.

Material and methods

Participants

This observational and descriptive study involved four male participants DS who were active runners. The participants took part in the "*Volta a la Cerdanya Ultrafons*®" 2013, a 14-kilometer race with an elevation gain of 489 meters. Inclusion criteria for the study were as follows: (a) participants aged 18 years or older with DS, and (b) the absence of injuries or clinical conditions at the time of the study. The competition was mixed-gender for individuals with and without disabilities. However, among the participants with disabilities, only males participated.

The study was conducted in accordance with the Declaration of Helsinki. All runners voluntarily participated and provided written informed consent before their participation. The research received prior approval from the Ethics Committee of the Catalan Sports Council (Approval No: 0099 S/690/2013).

Procedures

Anthropometric and bioelectrical measurements were conducted the morning before the race (PRE), under fasting conditions, and after participants had defecated and urinated. After completing the race, taking a shower, and towel drying, the same bioelectrical measurements

were performed (POST). Throughout all measurements, participants were seated in a thermally neutral room and were not allowed to consume food or beverages. Immediately after completing the race, participants indicated their individual rate of perceived exertion (RPE) on a 10-point scale.

Anthropometry

Anthropometric measurements followed the standard criteria established by the International Society for the Advancement of Kinanthropometry (ISAK) (Stewart et al., 2011). The following measurements were recorded: body mass (BM), basic measurements (height, sitting height, and wingspan), nine skinfolds (triceps, subscapular, biceps, pectoral, iliac crest, supraspinal, abdominal, front thigh, and medial calf), seven girths (relaxed and flexed arm, waist, hip, mid-thigh, calf maximum, and ankle), and four breadths (humerus, wrist, femur, and ankle). Measurements were performed by an ISAK-accredited technician at Level 3 and recorded in millimeters on a modified ISAK proforma. Height was measured using a telescopic measuring rod (Seca 220®, Birmingham, UK; measuring range: 85-200 cm; accuracy: 1 mm), and BM was measured using a calibrated scale (Seca 710®, Birmingham, UK; capacity: 200 kg; accuracy: 50 g).

Skinfold thickness was measured on the right side of the body using a calibrated caliper (Holtain Limited, Sussex, UK; range: 0-80 mm, resolution: 0.20 mm, pressure: 10 g/mm^2, accuracy: 99%). Girths were measured using a flexible anthropometric steel tape measure (Lufkin Executive®, Lufkin, TX, USA, accuracy: 1 mm). Breadths were obtained using a pachymeter (Holtain Limited, Sussex, UK; precision: 1 mm). Each measurement was conducted twice, and if the differences between skinfold measurements exceeded 5% or exceeded 1% for other measurements, a third measurement was performed. The final value for data analysis was the mean of two measurements or the median of three measurements, as appropriate.

Body mass index (BMI) was calculated as BM/H^2 (kg/m^2) and categorized as underweight (< 18.5 kg/m^2), normal (18.5-24.9 kg/m^2), overweight (25-29.9 kg/m^2), or obese (≥ 30 kg/m^2). Body adiposity index (BAI), based on the relationship between hip circumference and height, and relative fat mass (RFM), based on the relationship between waist circumference and height, were also determined. BAI categories included healthy (8-21%), overweight (21-26%), and obese (> 26%), while RFM was classified as fitness (14-17%), normal (18-24%), and obese (> 25%). Waist-to-hip ratio (WHtR) and waist-to-height ratio (WHR) cut-offs values of diagnostic overweight and obesity indices were placed at 0.56 and 0.87, respectively. Sum of six skinfolds (triceps, subscapular, supraspinal, abdominal, mid-thigh and calf maximum) and eight skinfolds (triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, mid-thigh and calf maximum) were calculated, and equations by Durnin and Womersley (1974), Jackson and Pollock (1978), and Rossato et al. (2018) were applied to estimate %FM. The Siri equation (Siri, 1993) was applied to determine FM in the aforementioned equations in basis of body density.

Selected anthropometric measures were used to determine the somatotype components and draw the somatochart following Carter and Heath (1990), which defines the shape and composition of the human body through three numbers represented by endomorphy, mesomorphy, and ectomorphy.

Bioelectrical impedance analysis

R and Xc were measured using a BIA 101 Anniversary Sport Edition analyzer (Akern Srl, Florence, Italy), which emitted a 400 µA alternating sinusoidal current at 50 kHz. Prior to measurements, the device was calibrated with a known impedance circuit provided by the manufacturer (R = 383 ± 10 Ω, Xc = 45 ± 5 Ω). Bioelectrical variables were obtained by trained examiners, following the standard foot-to-hand electrode placement for tetrapolar measurements described by Kyle et al. (2004). Z was calculated as $\sqrt{(R^2 + Xc^2)}$, and PhA was determined as tan-1 (Xc/R · 180°/π). For classic-BIVA, R, Xc, and Z were adjusted by height (R/H, Xc/H, Z/H), while specific-BIVA included adjustments for height and cross-sectional areas of the arm, trunk, and leg (Rsp, Xcsp, Zsp). The BIA equation proposed by Kotler (1996) was used to estimate %FM.

Statistical analysis

Descriptive data are presented as mean ± standard deviation. Selected anthropometric measures were used to determine somatotype components following the methods of Carter and Heath (1990), and participants were plotted in point graphs for both classic and specific approaches, with reference to a sample of healthy Italo-Spanish young adults (Ibáñez et al., 2015). Changes in bioelectrical values between PRE and POST were computed as delta percent values (Δ%). RXc paired graphs and paired one-sample Hotelling's T^2 test were employed to assess differences between PRE and POST bioelectrical values. The significance level was set at $p < .05$. Data analysis was performed using SPSS (Chicago, IL, USA, ver. 21) and BIVA software (Piccoli & Pastori, 2002).

Results

The comprehensive anthropometric profile of the four individuals with DS participating in the study is presented in Table 1, both individually and collectively. The age range among the participants is notably diverse, ranging from the youngest at 19 years old (Participant 1) to the eldest at 42.9 years old (Participant 4). In other basic measurements, there are largely similar values with minor differences observed. However, Participant 1 stands out with a substantially lower sum of skinfolds in both the six and eight skinfold measurements. Notably, there are variations in the calculated %FM across different equations. The most prevalent somatotype components among the participants are mesomorphy (observed in all participants) and endomorphy (except for Participant 1), as illustrated in Figure 1.

Table 1
Anthropometric profile of the 4 DS participants.

Participant		1 (●)	2 (▲)	3 (■)	4 (◆)	Average ± SD (○)
	Age (years)	19.0	22.6	31.4	42.9	29.0 ± 10.6
	BM (kg)	62.4	73.6	70.7	65.0	67.9 ± 5.1
	Height (cm)	158.8	156.2	160.7	161.9	159.4 ± 2.5
	Sitting Height (cm)	91.4	88.5	89.6	92.3	90.5 ± 1.7
	Wingspan (cm)	156.7	151.0	156.8	156.2	155.2 ± 2.8
Skinfolds (mm)	Triceps	5.0	15.0	13.0	13.4	11.6 ± 4.5
	Subscapular	7.0	25.0	26.0	19.0	19.3 ± 8.7
	Biceps	3.0	11.4	12.0	5.2	7.9 ± 4.5
	Pectoral	4.0	19.4	19.0	8.4	12.7 ± 7.7
	Iliac crest	8.0	25.2	28.0	24.0	21.3 ± 9.0
	Supraspinal	5.0	16.4	13.0	9.6	11.0 ± 4.9
	Abdominal	6.4	28.0	14.0	13.2	15.4 ± 9.1
	Front thigh	8.0	26.4	27.0	23.0	21.1 ± 8.9
	Medial calf	4.0	16.0	15.0	9.6	11.2 ± 5.5
Girths (cm)	Relaxed arm	25.5	33.2	31.7	29.5	30.0 ± 3.3
	Flexed arm	28.0	33.9	32.3	31.2	31.4 ± 2.5
	Waist	66.5	85.6	85.5	78.5	79.0 ± 9.0
	Hip	92.5	102.9	95.9	93.5	96.2 ± 4.7
	Mid-thigh	48.5	56.3	55.0	52.5	53.1 ± 3.4
	Calf maximum	33.3	37.2	35.0	35.2	35.2 ± 1.6
	Ankle	21.0	23.4	21.2	22.0	21.9 ± 1.1
Breadths (cm)	Humerus	6.5	6.4	6.0	6.6	6.4 ± 0.3
	Wrist	5.4	5.0	5.1	5.5	5.3 ± 0.2
	Femur	9.9	9.1	9.6	9.5	9.5 ± 0.3
	Ankle	6.6	6.4	7.0	6.9	6.7 ± 0.3
Proportionality	BMI (kg/m^2)	24.7	30.2	27.4	24.8	26.8 ± 2.6
	SitH/H ratio	0.58	0.57	0.56	0.57	0.57 ± 0.01
	BAI (%)	28.2	34.7	29.1	27.4	29.8 ± 3.3
	RFM (%)	29.7	33.6	30.5	29.4	30.8 ± 2.0
	WHtR	0.42	0.55	0.53	0.48	0.50 ± 0.06
	WHR	0.72	0.83	0.89	0.84	0.82 ± 0.07
Body composition	Σ6 skinfolds (mm)	37.0	124.0	122.0	98.6	95.4 ± 35.2
	Σ8 skinfolds (mm)	46.4	163.4	148.0	117.0	118.7 ± 51.9
	%FM - Durnin and Womersley	10.4	27.7	28.1	24.4	22.6 ± 8.3
	%FM - Jackson and Pollock	4.2	20.9	18.1	14.9	14.5 ± 7.3
	%FM - Rossato	6.6	30.0	33.3	32.4	25.6 ± 12.7
	%FM - Kotler	5.3	10.2	8.0	6.4	7.5 ± 2.1
Somatotype component	Endomorphy	1.7	6.0	5.4	4.5	4.4 ± 1.9
	Mesomorphy	5.4	5.7	4.5	4.9	5.1 ± 0.5
	Ectomorphy	0.9	0.1	0.4	1.0	0.6 ± 0.4

BAI, body adiposity index; BM, body mass; BMI, body mass index; FM, fat mass; RFM, relative fat mass; SitH/H, sitting height/standing height; SD, standard deviation; WHR, waist-to-height ratio; WHtR, waist-to-hip ratio; Σ6 skinfolds, sum of six skinfolds: triceps, subscapular, supraspinal, abdominal, thigh and calf; Σ8 skinfolds, sum of eight skinfolds: triceps, subscapular, biceps, iliac crest, supraspinal, abdominal, thigh and calf.

The race results, along with the PRE and POST bioelectrical values, are summarized in Table 2. A substantial discrepancy is evident in the race time of Participant 1 (99.5 minutes) compared to the remaining participants (170.8-208.5 minutes). None of the participants fall within the 95% classic tolerance ellipse or the 75% specific tolerance ellipse concerning the reference Italo-Spanish population, as indicated in both the classic (Figure 2A) and specific (Figure 2B) approaches.

The high-intensity nature of the race (7.8 ± 0.5 out of 10-point RPE scale) is reflected in a decrease in body mass (BM) ranging from 1.0% to 1.7%, coupled with an upward trend in Z/H (2.1% to 3.3%) and PhA (3.6% to 6.3%) across all four participants. These changes are statistically significant, as demonstrated in Figure 2C ($T^2 = 92.2$; $p < .0001$).

Figure 1
Somatotype of the 4 DS male participants. White circle symbol represents the average value.

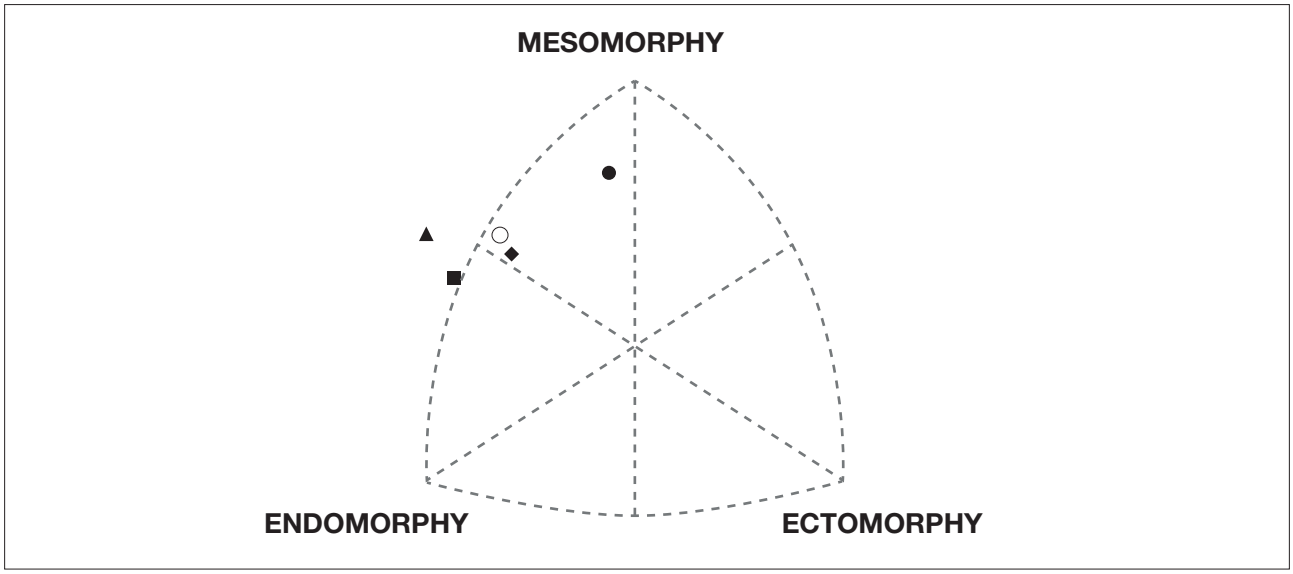

Figure 2
Classic (A) and specific (B) point graphs plotting the 4 DS male participants in the reference population tolerance ellipse. White circle symbol represents the average value. (C) Classic BIVA paired graph of the changes produced by the 14-km race.

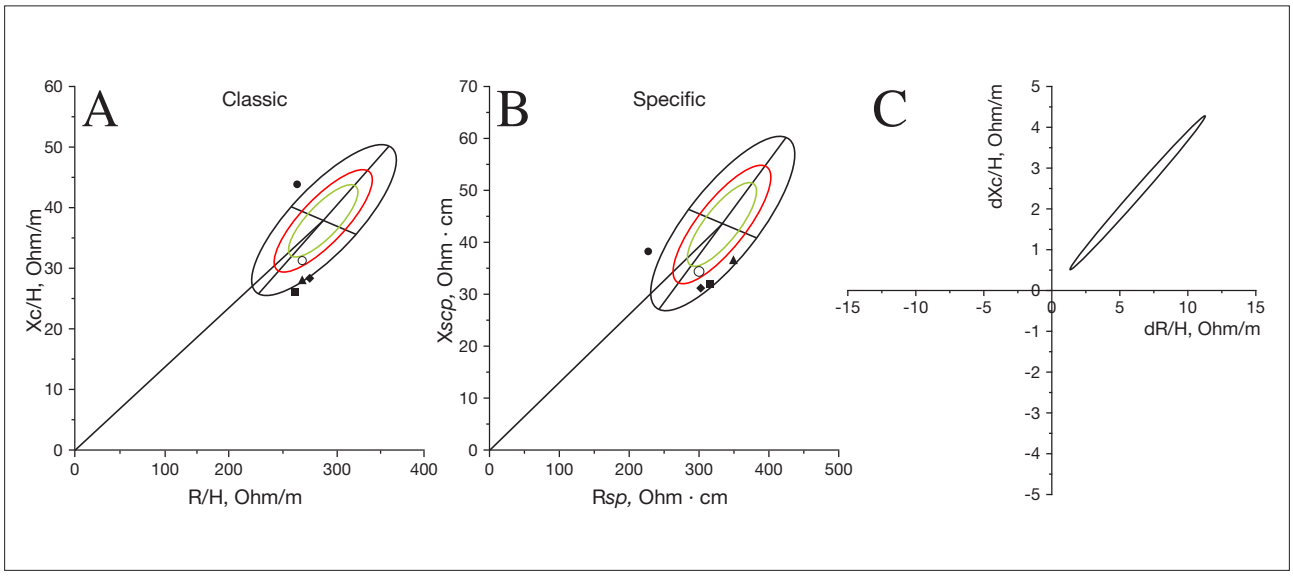

Table 2
Race time, RPE and bioelectrical characteristics and changes produced by the 14-km race.

Participant	Time (min)	RPE	BM (kg)			R/H (Ω/m)			Rsp (Ω·cm)	Xc/H (Ω/m)			Xcsp (Ω·cm)	Z/H (Ω/m)			Zsp (Ω·cm)	PhA (°)		
			PRE	POST	Δ%	PRE	POST	Δ%		PRE	POST	Δ%		PRE	POST	Δ%		PRE	POST	Δ%
1	99.5	7.0	62.4	61.8	-1.0	253.9	262.4	3.2	226.7	43.7	46.9	6.7	39.0	257.7	266.6	3.3	230.0	9.8	10.1	3.6
2	170.8	8.0	73.6	72.4	-1.7	259.7	265.1	2.0	347.9	28.0	29.9	6.4	37.5	261.2	266.7	2.1	349.9	6.1	6.4	4.5
3	208.5	8.0	70.7	69.6	-1.6	251.8	258.9	2.7	315.9	25.9	28.4	8.9	32.5	253.1	260.4	2.8	317.6	5.9	6.3	6.3
4	195.4	8.0	65.0	64.1	-1.4	267.1	273.2	2.2	302.5	28.3	30.4	7.1	32.0	268.6	274.9	2.3	304.2	6.0	6.4	4.9
Average	168.5	7.8	67.9	67.0	-1.4	258.1	264.9	2.5	298.3	31.5	33.9	7.3	35.3	260.2	267.1	2.6	300.4	7.0	7.3	4.8
SD	48.6	0.5	5.1	4.9	0.3	6.9	6.1	0.5	51.4	8.2	8.7	1.1	3.5	6.5	5.9	0.6	50.7	1.9	1.9	1.1

BM, body mass; PhA, phase angle; POST, assessment after the race; PRE, assessment before the race; R/H, height-adjusted resistance; Rsp, specific resistance; SD, standard deviation; Xc/H, height-adjusted reactance; Xcsp, specific reactance; Z/H, height-adjusted impedance; Zsp, specific impedance; Δ%, delta percentage change

Discussion

The present study provides a comprehensive exploration of morphological profiles and bioelectrical changes in individuals with DS who participated in a demanding 14-km trail-race. Several critical insights and observations were derived from this research. First and foremost, it is imperative to acknowledge the significant variability in anthropometric and bioelectrical characteristics among the four participants with DS. Notably, Participant 1 exhibited unique attributes, including younger age, lower FM, and a higher PhA. Remarkably, Participant 1 also achieved the best race time by a considerable margin compared to the other participants. Secondly, the methods employed for estimating %FM demonstrated substantial disparities, underscoring the importance of using population-specific equations for individuals with DS. The bioelectrical values before the race fell outside the normal range when compared to individuals without disabilities, but all of them displayed a normal trend of fluid loss, as indicated by bioelectrical changes, which is a common response to endurance exercise.

Before delving into the analysis, it is essential to consider the age variability among the four participants, which varies from 19 to 42.9 years. This variation is particularly relevant given that DS is associated with premature aging, alongside functional and cognitive deterioration (Bittles et al., 2007). Therefore, it is unsurprising that both anthropometric and bioelectrical measurements differed among participants, especially in Participant 1 since is notably younger than the others.

Anthropometric assessment

Our participants exhibited a BMI of 26.8 ± 2.6 kg/m^2 (Table 1), which closely aligns with the findings of a previous study involving male adolescents and young adults with DS (mean BMI: 26.1 ± 4.1 kg/m^2) (Bandini et al., 2013). Interestingly, recent research has suggested an inverse relationship between BMI and cardiorespiratory fitness in adults with DS (Bittles et al., 2007). BMI is a simple measure of body composition that does not directly assess adiposity, but various equations based on it have been developed to estimate %FM. However, research by Esco et al. (2016) revealed that these equations are inadequate for individuals with DS, likely due to the distinct regional distribution of adipose tissue in this population (Fedewa et al., 2019). Consequently, specific equations tailored to individuals with DS are imperative for accurate assessments.

In our study, different equations yielded highly variable %FM results, with some equations producing unrealistic values. For instance, while BMI categorized Participants 1 and 4 as normal weight and Participants 2 and 3 as overweight, both BAI and RFM categorized all participants as "obese". On the one hand, a recent study indicated that BAI may not be an adequate parameter because it overestimates %FM due to the low height of participants with DS (Fedewa et al., 2019; Rossato et al., 2017). On the other hand, RFM, although also height-based, appears to offer greater accuracy for both individuals with and without DS (Fedewa et al., 2019). Interestingly, Participant 1, who had the least subcutaneous tissue based on skinfold measurements, exhibited a higher BAI and RFM than Participant 4 and similar to Participant 3. Conversely, waist-to-height ratio (WHtR) and waist-to-hip ratio (WHR) did not classify any participants as overweight or obese, except for RFM in the case of Participant 3. These discrepancies among different assessment methods highlight the challenges of accurately determining %FM and associated health risks in individuals with DS.

As mentioned, existing equations for estimating FM based on skinfold anthropometric data for general population, such as those of Durnin and Womersley and Jackson and Pollock, are not suitable for individuals with DS. In these equations there is a notable difference between the 4 participants, with Participant 1 standing out again, since it presents 10.4% according to Durmin and Womersley and 4.2% according to Jackson and Pollock, demonstrating that these values are not correct, especially in the second equation. González-Agüero et al. (2017) developed a prediction equation for individuals with DS, specifically targeting adolescents aged 12 to 18, so this equation may not be applicable to adults. Therefore, Rossato et al. (2018) created a new equation for adults aged 18 to 47, so it fits our group. Nevertheless, this equation still resulted in significant variations among participants in our study, with Participant 1 showing markedly lower FM (6.6%) compared to the others (> 30%). Nickerson et al. (2023) in a recent study, and seeing the limitations of the current equations, proposed a new and more complete equation, which could not be replicated in this study because we lacked the anthropometric data required. Furthermore, a prediction equation based on bioelectrical values (Kotler et al., 1996) was used, and undoubtfully underestimated FM significantly (5.3-10.2%). This underestimation aligns with previous research findings (Esco et al., 2017), although a different device was used in our study.

Somatotype analysis (Figure 1) revealed that the mesomorphy component predominated in all participants, which is intriguing given that individuals with DS are typically characterized by lower muscle mass (Artioli et al., 2017). The endomorphic component was the second most prevalent, considerably higher than ectomorphy, which aligns more closely with expectations. The literature regarding the somatotype of participants with DS is almost null, with only one article by Bronks and Parker (1985) being identified. In such study, there was also a predominance of the endomorphic component, with 62% of the participants classified as mesomorphic-endomorphic. These results suggest an in-depth revision of this method for this specific population.

Bioelectrical assessment

In the classic point graph (Figure 2A), Participant 1 was positioned in the upper left quadrant of the reference population, while Participants 2, 3, and 4 were situated in the lower right quadrant, however, none of them fell within the 95% tolerance ellipse. The interpretation of these results suggests that the runners' total body water, indicated by Z/H, was generally within the normal range, but intriguingly the PhA values exhibited noteworthy alterations. A higher PhA, which indicates better cell function due to its inverse relationship with the ECW/ICW ratio, is important for health and sports performance, as discussed by Sardinha (2018). Considering the reference percentile bioelectrical values for athletes developed by Campa et al. (2022b), Participant 1 PhA value (9.8°) surpasses the 95th percentile of the endurance athletes, which stands at 9.1°, signifying an unusually high PhA. In contrast, the PhA values of the remaining participants fell considerably below the 5th percentile of the reference values (6.3°). While these results align when comparing individuals with DS among themselves, comparing Participant 1 to the general population appears less logical.

In the specific point graph (Figure 2B), all participants appeared in the lower half of the tolerance ellipse, indicating lower levels of FM, with none falling within the 75% tolerance ellipse. Interpreting specific BIVA results requires caution due to the unique body volume characteristics of individuals with DS, where the normalization of this approach may render the values less suitable. It is crucial to consider that these are active individuals who may possess lower FM than their sedentary counterparts, although not necessarily less FM than individuals without DS.

During the race, participants experienced a modest BM decrease by 1.4 ± 0.3% (Table 2), accompanied by an increase in Z/H and PhA by 2.7 ± 0.6% and 5.8 ± 1.4%, respectively. These alterations reflect a notable loss of body fluids, primarily in the extracellular water compartment, as illustrated in Figure 2C. These changes fall within the expected range for endurance races, consistent with findings from previous studies (Castizo-Olier et al., 2018; Nescolarde et al., 2020). Notably, Participant 1, who achieved the fastest race time, exhibited the most significant increase in Z/H (3.3%) but the smallest rise in PhA (3.6%), suggesting a higher retention of intracellular water. This observation is noteworthy as intracellular water is recognized for its association with power and strength (Silva et al., 2014), potentially contributing to Participant 1's superior performance.

Further research and study limitations

Physical exercise is known to positively influence cardiometabolic risk profiles, muscle strength, and aerobic capacity in both the general population and those with Down syndrome (Paul et al., 2019). Therefore, it is essential to conduct appropriate assessments to improve physical fitness and overall health, particularly in individuals with disabilities, where the rates of overweight and obesity are notably higher than in the general population (Pitchford et al., 2018). Future research should include larger, more varied samples across genders and ages. Until then, our study's results are preliminary, particularly for active adult males with DS.

Some limitations should be acknowledged. There is a lack of detailed data on participants' physical condition and dietary habits before and during the study. The small sample size of four participants, while a logistical challenge, limits the generalizability of the findings. Furthermore, the absence of a gold standard for determining FM prevents a definitive determination of which body composition method most accurately reflects reality. Future research should aim to address these limitations and provide a more comprehensive understanding of body composition and health in individuals with DS.

Conclusions

This study provides valuable insights into the morphological profiles and bioelectrical changes of individuals with DS following a demanding 14-km race. The findings emphasize the necessity of employing population-specific equations for accurate assessments of FM in individuals with DS and the importance of standardized approaches for evaluating health risks. Classic BIVA indicated a normal pattern of water loss due to the physical demands of the race.

As individuals with DS continue to engage in physical activities and sports, it is crucial to conduct appropriate assessments to enhance their physical fitness and overall health. Future research should expand on these findings and address the limitations identified in this study to provide a more comprehensive understanding of body composition and health in individuals with DS.

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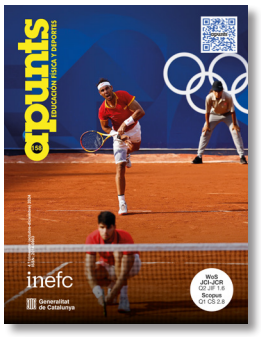

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Validating a Questionnaire to Assess Secondary Physical Education Teachers' Perception of Implementing Body Expression

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Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/ Ritchie B. Tongo)

Abstract

Despite the acknowledged benefits of Corporal Expression, it remains a significantly under-taught subject among Physical Education teachers in Spain. Various reasons are cited for this, including ambiguous objectives and methodologies, entrenched stereotypes regarding expressive motor skills, particularly feminine associations, and inadequate training. This study aims to assess the current state of Corporal Expression teaching in Catalonia's secondary education.

To achieve this objective, a questionnaire evaluating teachers' perceptions regarding the implementation of Corporal Expression was adapted from an existing instrument used in the Andalusian community. Rigorous validation processes were conducted, including an expert panel assessment utilizing the Delphi method, quantitative and qualitative evaluations validating its logic, criteria, content, and construct. Additionally, a pilot test (n = 40) in a distinct population, a Test-Retest assessment (n = 20) to ensure stability, and an exploratory factor analysis involving 418 teachers (42.8 % female) were conducted to validate its internal consistency and reliability.

The study's findings indicate a Kaiser-Meyer-Olkin (KMO) coefficient of .827, demonstrating a strong level of suitability, along with Bartlett's test of sphericity and Chi-square values affirming the continuity of factor analysis. Consequently, the Physical Education Teachers' Opinion Questionnaire designed for assessing Body Expression in Secondary Education was validated successfully. This validated questionnaire can serve as a robust tool for evaluating and understanding teachers' perspectives on implementing Corporal Expression in secondary education settings in Catalonia.

Keywords: Corporal Expression, dance, Delphi method, factor analysis, stereotypes, teaching-learning process.

Introduction

Body Expression, often referred to as Corporal Expression (CE), encompasses Creative Movement and Dance within educational curricula across primary, secondary, and high school levels. However, studies reveal a significant discrepancy in the teaching of CE, with a reported range of only 9 % to 27 % of teachers addressing all CE contents (Conesa-Ros & Angosto, 2017). Notably, the majority of teachers, over 70 %, seem to omit CE from their instructional focus (Conesa-Ros & Angosto, 2017). Concerningly, even prospective Physical Activity and Sport Sciences students, in teacher training programs, express more confidence in teaching sports than in delivering CE content (Cañadas et al., 2019).

Despite recognizing the importance of CE experiences, educators express several limitations hindering its comprehensive teaching. These include shortcomings in teaching guides (Lorente-Catalán et al., 2013), structural deficiencies in the selection and approach of CE content outlined in educational regulations (Cuéllar & Pestano, 2013; Gil, 2016), complexity in CE methodology (Montávez, 2012), and inadequate initial and continuing teacher training (Conesa-Ros & Angosto, 2017; Gil-Ares & Armada-Crespo, 2023; Rojo-Ramos et al., 2023; Sánchez-Sánchez & López-Pérez, 2019). Moreover, prejudices regarding expressive motor skills, gender stereotyping, and a negative perception among male teachers further limit CE instruction (Calvo et al., 2011).

While existing literature highlights gender disparities and prejudices influencing CE instruction (García et al., 2015; Lafuente & Hortigüela, 2021; Robles et al., 2013), contradictory findings, such as those in studies by Rodríguez-Fernández et al. (2019), indicate no significant gender-based differences. Nonetheless, CE remains prioritized in initial training for primary school teachers (Cañadas et al., 2019).

This study aims to validate a questionnaire, aligning with previous research methodologies utilized by Montávez (2012), Archilla (2013), Villard (2014), Gil (2016), and Armada (2017), which employed surveys to investigate CE. Similar to the approaches of Banyeres (2015) and Espinel (2017), who utilized questionnaires in social science research, this study seeks to validate a questionnaire as a tool for acquiring essential insights into secondary Physical Education (PE) teachers' perceptions concerning CE implementation in Catalonia, as well as knowing if they use Body Percussion (BP) to teach this content. This validation process intends to enable an accurate description of the reality experienced by this specific population, shedding light on the current status of CE instruction in secondary schools within Catalonia.

Methodology

According to Ato et al. (2013), the study design is instrumental. Evidence oriented to the content and evidence regarding the internal structure will be shown by: 1) content validity (construct and quantitative and qualitative assessment by expert judges), 2) reliability (construct and temporal stability) and 3) internal consistency and Exploratory Factor Analysis (also inspired by the classification established by American Educational Research Association, American Psychological Association, & National Council on Measurement in Education, 2018).

Participants

The process of designing, applying, and validating the instrument unfolds across three distinct moments:

1) Content validity (construct and quantitative and qualitative assessment by expert judges): This first step encompasses the design and adaptation of the instrument. It involves the selection of an expert panel based on specific inclusion and exclusion criteria. The panel consisted of ten individuals with expertise in higher education subjects or performing arts, all directly related to the research (refer to Table 1). The data collection involved these experts, followed by an analysis of their responses.

Table 1
Selection and exclusion criteria to create the panel of expert judges who will validate the content.

Selection criteria						Exclusion criteria	
Professors, if possible, of the subject of Corporal Expression at any national university (Spain), preferably in Catalonia, with a PhD (if possible) or linked to research. Research teacher (if possible) with a link to the performing arts (theatre, dance, circus...). Voluntary participation in research						Failure to meet selection criteria	
Code (pseudonym)	Gender	Age	Teaching experience	Autonomous Community	Highest qualification	Experiences linked to C	Linked to Research
E1 (Mary)	Female	63	University (>30 years)	Catalonia	PhD	Director, coordinator, tenured faculty at CE	Yes
E2 (Sophia)	Female	46	University (>15 years)	Catalonia	PhD	Director, coordinator, artist and teacher in CE	Yes
E3 (Anny)	Female	56	University (>30 years)	Catalonia	PhD	Collaborator in the field of CE (10 years)	Yes
E4 (Charles)	Male	62	University (25 years)	Castilla la Mancha	PhD	Full Professor of CE	Yes

Table 1 (Continuation)
Selection and exclusion criteria to create the panel of expert judges who will validate the content.

Code (pseudonym)	Gender	Age	Teaching experience	Autonomous Community	Highest qualification	Experiences linked to C	Linked to Research
E5 (John)	Male	46	University (>15 years)	Madrid	PhD	Director, artist and teacher	Yes
E6 (Peter)	Male	34	University (<10 years)	Andalusia	PhD	Coordinator, choreographer and teacher	Yes
E7 (Nataly)	Female	55	University (>30 years)	Catalonia	PhD	Expert in didactics and in the master's degree in secondary education	Yes
E8 (Joseph)	Male	63	University (>30 years)	Catalonia	PhD and Professor	Director, artist and teacher at CE	Yes
E9 (Rebecca)	Female	46	Extracurricular school (>20 years)	Catalonia	Bachelor's degree	Director, coordinator, artist and teacher	Yes
E10 (Helen)	Female	42	University (<10 years)	Catalonia	University degree	Director, coordinator, artist and teacher in CE	Yes

2) Reliability (construct and temporal stability): This moment of the research entails two pivotal stages. Firstly, the construct analysis through a pilot test involved 40 primary and secondary school teachers in the Balearic Islands. Subsequently, the population for conducting the test-retest and assessing instrument stability comprised 20 secondary stage PE teachers in the same community. Both samples were selected purposively and non-probabilistically, emphasizing convenience, accessibility, and resemblance to the final target population. This choice aimed to prevent potential contamination due to belonging to a different community than the intended final questionnaire administration.

3) Internal consistency and Exploratory Factor Analysis: The final study population encompassed secondary PE teachers in Catalonia during the 2018-2019 academic year, totaling n = 5,629, according to the Department of Education of the Catalan Government. Although not all registered individuals responded, a final sample of n = 418 (56.9 % men, 42.8 % women, and 0.2 % non-binary) completed the questionnaire. The age range varied from 20 to over 60 years, with the majority falling between 40 and 59 years (65.3 %). All provinces of Catalonia were represented, with Barcelona constituting 64.8 % and the remaining provinces contributing approximately 10% each, ensuring a confidence rate of 95 %. Ethical considerations aligned with the Declaration of Helsinki (2017), ensuring participants' anonymity, informed consent, and ethical treatment throughout the research process, duly approved by the clinical research ethics committee of the Catalan Sports Administration.

Materials and Instruments

Construction of the Instrument

To develop the instrument for this study, initial consideration was given to replicating the questionnaire designed by Villard (2014), specifically tailored for PE teachers at the secondary level in a different autonomous community (Andalusia). However, due to shifts in educational legislation —from a curriculum structured around conceptual, procedural, and attitudinal contents (Organic Law 2/2006) to a competency-based curriculum (LOMCE - Law 8/2013)— a decision was made to create an adapted questionnaire. The modifications also accounted for variations in educational content across different autonomous communities, aligning with the current curriculum in Catalonia (marked by Decree 187/2015) and included an extension to assess the knowledge and implementation of BP in their classes.

Simultaneously, various sources on questionnaire construction were reviewed, comparing different question types (multi-response, Likert scale, scale, dichotomous, and open-ended), presentation methods, and wording. Efforts were made to avoid excessive length in the questionnaire, taking into consideration the characteristics of the target population and respondents' situations.

The questionnaire aimed to address hypotheses regarding CE and to explore potential limitations and challenges faced by specialized PE teachers at the secondary stage in Catalonia when teaching CE content. It sought to determine if these educators believed their initial training related to CE was insufficient, if they perceived ambiguities in the curriculum's guidance regarding CE content, and if they employed BP in teaching CE, among other aspects.

Procedure

The present study was evaluated favorably by the clinical research ethics committee of the Catalan Sports Administration (12/2019/CEICEGC) and follows all ethical standards and guidelines in educational research and in the field of sports and exercise sciences, as well as the criteria of the Declaration of Helsinki and the codes of research integrity.

The classical Delphi method was employed to achieve consensus among experts regarding specific problems (Cabero & Infante, 2014). This research involved three rounds as Rodríguez-Rivadulla et al. (2019) and its study, constituting an initial round within itself. This approach aligned with theories by Cabero and Infante (2014) and George and Trujillo (2018), supporting the Delphi method's efficacy across three or more rounds, except for the modified Delphi EFTE (Estimate, Feedback, Talk, Estimate), which can be conducted in two rounds.

The expert panel quantitatively and qualitatively evaluated: the completeness and clarity of construct definitions, the relevance and appropriateness of construct-defining dimensions, and the relevance, appropriateness, completeness, and sequence of items defining these dimensions. Quantitative analysis involved calculating arithmetic means (M) and Standard Deviations (SD), discarding values below 7 (representing 70 % agreement) and modifying items with values of 7-8 based on qualitative comments. Items rated 9-10 were retained. Excel (16.49) and SPSS (18.0) were used for calculations. The same procedure was applied to evaluate the instrument's logical order, question count and duration, adequacy of response options, and data collection effectiveness.

Data Analysis

1) Content validity (construct and quantitative and qualitative assessment by expert judges)

Following an examination of the expert panel's feedback, a questionnaire comprising 46 items across four dimensions was proposed: Dimension 1 (DIM1) focused on socio-demographic data, consisting of 10 items; Dimension 2 (DIM2) gauged self-perceived competencies in teaching CE, comprising 8 items; Dimension 3 (DIM3) explored beliefs about CE with 14 items; and Dimension 4 (DIM4) addressed BP as a CE content with 14 items (refer to Table 2).

Table 2
Final dimensions of the construct based on the experts' evaluations.

Dimension	Subdimensions	No. questionnaire items
DIM1 Identification, initial training and teaching experience	• Gender	1
	• Date of birth	2
	• Academic qualification	3
	• Year of completion of studies	4
	• University where you studied	5
	• Studies related to the teaching specialty (Initial training)	6
	• Current professional status	7
	• Years teaching PE classes	8, 9
	• Years working in CE	10
DIM2 Self-perception of competencies to teach CE in secondary school	• Sufficient initial training to teach CE content	11
	• Specificity of the curriculum	12
	• Continuous training	13, 14
	• Resources used to develop CE	15
	• Previous personal experience	16
	• Feelings when teaching CE content	17
	• Degree of motivation to teach CE content	18
DIM3 Beliefs about CE	• Importance of CE content	19, 20, 23, 24
	• Transfer for life	21, 22
	• Contents you develop or not to teach CE	23, 24, 25, 26
	• Difficulties in teaching CE	27, 28
	• Student perception of gender "load" according to content	29
	• Degree of student satisfaction with CE classes according to gender	30, 31, 32
DIM4 Body Percussion as CE content	• BP knowledge	33
	• Use of BP	34
	• BP Gender Load	35
	• BP as a CE content in PE	36
	• Content that develops physical fitness	37
	• Content that improves coordination	38
	• Content that improves body awareness	39
	• Content that develops sense of rhythm	40
	• Content that introduces dance	41
	• Content that encourages participation and collaboration to create choreographies by students	42
	• Content to increase positive emotions	43
	• Content to improve personal relationships	44
	• Content that fosters teamwork	45
	• Content that facilitates inclusion	46

2) Reliability (construct and temporal stability)

The pilot test underwent validation alongside a readability test, yielding Flesch-Szigriszt index values of 66.89, a word correlation of 22.78, and a Fernández Huerta index of 71.87, indicating relatively easy readability.

The Test-Retest analysis to assess stability employed Google Forms for data collection, with subsequent analysis conducted using Excel (16.49), SPSS (18.0), and the JASP program version 0.10.2. Statistical calculations aimed to ascertain differences or similarities between responses from two distinct questionnaire administrations. Table 3 is a sample of the present descriptive analyses after rank tests and statistical contrasts.

Table 3
Results obtained in the Test-Retest in Dimension 3, which refers to the contents of Body Expression (items 19 to 27).

	Descriptive statistics								
	N	*M*	DS	Min.	Max.	(Median)	Ties	Z	*P*
M1D3p19	20	3.65	0.671	2	4	4.00	17	0.577	0.564
M2D3p19	20	3.70	0.571	2	4	4.00			
M1D3p201	20	3.70	0.657	2	4	4.00	18	1.414	0.157
M2D3p201	20	3.80	0.523	2	4	4.00			
M1D3p202	20	3.75	0.550	2	4	4.00	19	1.000	0.317
M2D3p202	20	3.80	0.523	2	4	4.00			
M1D3p203	20	3.80	0.410	3	4	4.00	14	1.633	0.102
M2D3p203	20	3.60	0.598	2	4	4.00			
M1D3p204	20	3.80	0.410	3	4	4.00	14	0.816	0.414
M2D3p204	20	3.70	0.571	2	4	4.00			
M1D3p21	20	3.75	0.444	3	4	4.00	17	0.577	0.564
M2D3p21	20	3.80	0.410	3	4	4.00			
M1D3p231	20	1.00	1.257	0	3	0.00	13	0.434	0.665
M2D3p231	20	1.05	1.191	0	3	0.50			
M1D3p232	20	0.45	0.887	0	3	0.00	16	0.000	1.000
M2D3p232	20	0.45	0.999	0	3	0.00			
M1D3p233	20	0.50	0.946	0	3	0.00	14	0.425	0.671
M2D3p233	20	0.60	1.142	0	3	0.00			
M1D3p234	20	0.50	0.827	0	2	0.00	14	0.816	0.414
M2D3p234	20	0.30	0.801	0	3	0.00			
M1D3p235	20	0.65	0.933	0	3	0.00	11	0.965	0.335
M2D3p235	20	1.00	1.298	0	3	0.00			
M1D3p236	20	0.75	1.070	0	3	0.00	13	0.513	0.608
M2D3p236	20	0.60	1.142	0	3	0.00			
M1D3p237	20	0.40	0.821	0	3	0.00	15	0.680	0.496
M2D3p237	20	0.25	0.786	0	3	0.00			
M1D3p238	20	0.40	0.821	0	3	0.00	13	0.342	0.733
M2D3p238	20	0.50	1.000	0	3	0.00			
M1D3p239	20	1.00	1.257	0	3	0.00	11	0.725	0.468
M2D3p239	20	0.80	1.196	0	3	0.00			

NOTE: M1: Moment 1 (Test), M2: Moment 2 (Retest), D: Dimension, p: question, *N*: Number of participants, M: Mean, SD: Standard Deviation, Min: minimum value, Max: maximum value, Z: Z value, *p*: significance, * items whose significance is $p < .05$. The Wilcoxon test was performed on Likert scale items (values from 0 to 4) and the McNemar test with dichotomous and/or Mc Nemar-Bowquer with categorical variables (Test for repeated measures).

3) Internal consistency and Exploratory Factor Analysis

Dimensional analyses commenced with Dimension 1 socio-demographic data collection, not subject to consistency analysis. For Dimensions 2, 3, and 4, statistical calculations involved validation criteria such as homogeneous means, nonzero standard deviations, item-total correlations exceeding .30, skewness below 2, and kurtosis below 7.

Elimination criteria were applied to refine all Dimensions, resulting in an increase in Cronbach's Alpha from .675 to .734 upon reducing items from 9 to 4 (Dimension 2 – Table 4).

Table 4
Initial solution of the nonparametric tests in Dimension 2 following criteria for item elimination.

Items	Mean	Standard Deviation	Item-total correlation corrected	Cronbach's alpha if the element is removed	Skewness (ET = 0.119)	Kurtosis (ET = 0.238)	Eliminate
q11	2.29	0.917	.154	.630	0.065	–0.418	1
q12	2.28	0.938	.219	.617	–0.327	0.076	2
q13	2.12	0.915	.497	.559	0.569	–0.408	
q14M	2.02	1.286	.330	.593	–0.770	–1.211	
q14F	1.04	0.314	.184	.627	2.375	14.966	3
q15F	1.80	0.879	.182	.624	0.841	–0.063	4
q16	3.28	0.778	.171	.625	–0.876	0.371	5
q17	2.81	0.954	.622	.527	–0.435	–0.574	
q18	7.36	2.039	.535	.536	–1.008	1.220	

Reliability statistics		
Cronbach's alpha	Cronbach's alpha based on typed items	No. of elements
.626	.620	9

Analysis of the Final Proposal as items of Dimension 2 - Perceived Competence to teach Body Expression in secondary schools					
Items	Average of the scale if the element is eliminated	Variance of the scale if the element is eliminated	Item-total correlation corrected	Squared multiple correlation	Cronbach's alpha if the element is removed
q13	12.19	11.041	.566	.472	.587
q14M	12.29	10.466	.384	.418	.654
q17	11.50	10.673	.599	.470	.566
q18	6.95	6.015	.514	.482	.652

Reliability statistics		
Cronbach's alpha	Cronbach's alpha based on typed items	No. of elements
.675	.734	4

Note: q: question, numbers 13-18: question identifier number. As criteria for the elimination of items, homogeneous means, standard deviation far from zero, item-total correlation greater than .30, skewness less than 2 and kurtosis less than 7 were considered as criteria for the elimination of items.

In Dimension 3, items 22, 24, 25, 26, and 32 were eliminated due to being open-ended questions. Restructuring and item reduction (from 21 to 8 items) bolstered its internal consistency (Cronbach's Alpha from .698 to .703) (Dimension 3 – Table 5).

Table 5
Initial solution of the nonparametric tests in Dimension 3 following criteria for item elimination.

Items	Mean	Standard Deviation	Item-total correlation corrected	Cronbach's alpha if the element is removed	Skewness (ET = 0.119)	Kurtosis (ET = 0.238)	Eliminate
q19	3.430	0.690	.340	.490	–1.057	0.625	
q20_1	3.650	0.569	.329	.495	–1.875	4.563	7
q20_2	3.580	0.625	.343	.492	–1.593	3.384	7
q20_3	3.540	0.629	.360	.491	–1.382	2.423	
q20_4	3.500	0.663	.355	.490	–1.512	2.642	
q21	3.400	0.786	.205	.501	–1.272	1.572	7
q23_1	0.940	1.190	.093	.515	0.745	–1.047	6
q23_2	0.970	1.080	.382	.472	0.577	–1.109	
q23_3	0.690	1.070	.245	.493	1.136	–0.315	7
q23_4	1.160	1.161	.132	.509	0.300	–1.472	7
q23_5	0.530	0.970	.457	.465	1.235	–0.112	
q23_6	0.810	1.086	.300	.484	0.875	–0.835	
q23_7	0.840	1.119	.224	.495	0.644	–1.227	7
q23_8	0.570	0.990	.393	.473	1.244	–0.061	
q23_9	0.430	0.913	.509	.461	1.641	1.098	
q23_10	0.950	1.183	.226	.494	0.802	–1.006	7
q23_11	0.930	1.160	.291	.484	0.723	–1.190	7
q27	2.490	1.063	-.009	.528	–0.392	–0.148	7
q28F	2.350	1.102	-.026	.532	0.426	–0.715	7
q30	5.980	1.914	.079	.532	1.328	–0.237	2
q31	8.560	0.990	.186	.502	–1.299	–0.314	4

Reliability statistics

Cronbach's alpha	Cronbach's alpha based on typed items	No. of elements
.517	.387	84

Analysis of the Final Proposal as items of Dimension 3 - Opinion on the Corporal Expression contents.

Items	Average of the scale if the element is eliminated	Variance of the scale if the element is eliminated	Item-total correlation corrected	Squared multiple correlation	Cronbach's alpha if the element is removed
q19	10.740	17.155	.254	.482	.694
q20_3	10.690	16.802	.324	.835	.683
q20_4	10.690	16.619	.333	.835	.681
q23_2	13.070	14.598	.378	.172	.673
q23_5	13.500	14.255	.461	.397	.651
q23_6	13.310	14.122	.438	.239	.657
q23_8	13.480	14.612	.405	.343	.665
q23_9	13.65	14.301	.518	.486	.638

Reliability statistics

Cronbach's alpha	Cronbach's alpha based on typed items	No. of elements
.698	.703	8

Note: q: question, numbers 19-23: question identifier number. As criteria for the elimination of items, homogeneous means, standard deviation far from zero, item-total correlation higher than .30, skewness lower than 2 and kurtosis lower than 7 were considered.

Regarding Dimension 4 (Table 6), despite initially retaining all items, recommendations led to the elimination of items 33, 34, 35, 37, and 40, eventually raising the Cronbach's Alpha to .917

Following independent dimensional analyses, the Exploratory Factor Analysis was performed as a final statistical validation procedure.

Table 6
Initial solution of nonparametric tests in Dimension 4 following criteria for item elimination.

Items	Mean	Standard Deviation	Item-total correlation corrected	Cronbach's alpha if the element is removed	Skewness (ET = 0.119)	Kurtosis (ET = 0.238)	Eliminate
q33	2.04	0.887	.272	.902	0.769	0.611	3
q34	0.25	0.431	.246	.899	1.181	–0.608	2
q35	3.00	0.196	-.039	.902	0	23.419	1
q36	2.93	1.106	.691	.884	–0.861	0.016	
q37	2.01	1.162	.484	.896	–0.06	–0.795	4
q38	3.50	0.814	.687	.884	–2.15	5.504	
q39	3.11	0.944	.729	.882	–1.123	1.249	
q40	3.74	0.630	.646	.888	–3.609	16.511	5
q41	3.10	0.895	.624	.887	–1.136	1.634	
q42	3.22	0.893	.726	.882	–1.39	2.377	
q43	3.08	0.956	.754	.880	–1.123	1.302	
q44	3.08	0.986	.704	.883	–1.149	1.129	
q45	3.42	0.811	.717	.883	–1.786	4.084	
q46	3.28	0.900	.692	.884	–1.587	3.075	

Reliability statistics		
Cronbach's alpha	Cronbach's alpha based on typed items	No. of elements
.896	.884	14

Analysis of the Final Proposal as items of Dimension 4 - BP Percussion as CE

Items	Average of the scale if the element is eliminated	Variance of the scale if the element is eliminated	Item-total correlation corrected	Squared multiple correlation	Cronbach's alpha if the element is removed
q36	25.79	32.470	.643	.480	.914
q38	25.22	34.670	.674	.536	.910
q39	25.61	32.923	.737	.586	.905
q41	25.62	34.480	.620	.430	.913
q42	25.50	33.469	.728	.557	.906
q43	25.64	32.409	.778	.645	.902
q44	25.64	32.475	.743	.647	.905
q45	25.30	34.032	.751	.676	.905
q46	25.44	33.365	.733	.643	.906

Reliability statistics		
Cronbach's alpha	Cronbach's alpha based on typed items	No. of elements
.917	.919	9

Note: q: question, numbers 33-46: question identifier number. As criteria for the elimination of items, homogeneous means, standard deviation far from zero, item-total correlation greater than .30, skewness less than 2 and kurtosis less than 7 were considered as criteria for the elimination of items.

Exploratory Factor Analysis

Table 7 displays the final proposed questionnaire, revealing a cumulative variance explained by 5 factors close to 60% (58.71%). Employing the maximum likelihood extraction method and Varimax normalization with Kaiser rotation, convergence was achieved within 4 iterations, mirroring studies by Domínguez-Alonso et al. (2018).

The Kaiser-Meyer-Olkin measure demonstrated a coefficient value of .827, considered acceptable and satisfactory (Arias et al., 2020). Bartlett's test of sphericity provided significant results ($p < .001$) and an approximate chi-square of 4,476.068, affirming the continuity of the factor analysis. Subsequently, the final questionnaire was validated, comprising 21 items across 5 dimensions.

Table 7
Matrix of rotated factors.

Item	New item	1	2	3	4	5
D2q13	D5q20	.107	–.002	.021	.212	.9
D2q14M	D5q21	–.006	.035	–.016	.125	.689
D2q17	D4q18	.076	.075	.015	.653	.205
D2q18	D4q19	.183	.003	.06	.969	.149
D3q19	D2q10	–.028	.711	.016	.076	.042
D3q20_3	D2q11	.032	.957	.034	–.019	0
D3q20_4	D2q12	.029	.946	.056	.022	–.002
D3q23_2	D3q14	.013	.127	.397	.014	.08
D3q23_5	D3q13	–.002	–.034	.699	.015	–.04
D3q23_6	D3q15	.007	.094	.505	.029	.016
D3q23_8	D3q16	.024	–.064	.646	.006	–.037
D3q23_9	D3q17	0	–.088	.832	–.009	–.05
D4q36	D1q1	.649	.048	.01	.134	.026
D4q38	D1q2	.693	.022	–.011	.03	.017
D4q39	D1q3	.742	–.014	.042	.07	.076
D4q41	D1q4	.634	–.003	.01	.044	.067
D4q42	D1q5	.757	.03	.005	–.021	.055
D4q43	D1q6	.816	–.014	–.019	.08	–.015
D4q44	D1q7	.802	–.02	.014	.055	–.025
D4q45	D1q8	.808	–.002	.043	.028	–.032
D4q46	D1q9	.801	–.013	–.006	–.009	–.013

Note: D: Dimension, q: question, numbers 13-46: question identifier number. The boxes marked in grey indicate the conglomeration by factors, giving rise to 21 items distributed in 5 factors.

Results

Based on the results, the questionnaire was restructured. Following sociodemographic data, items related to BP as CE content (New Dimension 1), the significance given to CE (New Dimension 2), CE contents focused on dance (New Dimension 3), perceived competence in teaching CE (New Dimension 4), and Continuing Education (New Dimension 5) were organized, totaling 21 items, leaving the 19 significant from table 7 and 7 questions to identify the sample for the final questionnaire.

The questionnaire underwent validation via the Delphi method by a panel of 10 experts. A pilot test was conducted in a different community ($n = 40$), and instrument stability was assessed through a Test-Retest ($n = 20$) with a minimum 7-day interval. Statistical validation criteria for item elimination included means homogeneity, nonzero standard deviations, item-total correlations > .30, skewness < 2, and kurtosis < 7.

Each dimension obtained Cronbach's Alpha values: DIM1 (.675), DIM2 (.698), and DIM3 (.917). The final questionnaire, administered among PE teachers specialized in compulsory secondary education in Catalonia ($n = 418$), exhibited a cumulative variance explained by 5 factors of almost 60 % (58.71 %). The instrument demonstrated acceptable reliability and validity indicators.

The validated instrument, titled the Questionnaire of Opinion of Physical Education Teachers in the Teaching-Learning Process of Corporal Expression (QUOPET-CE), consists of 26 items distributed across three parts: Identification of the sample (12 items, of which 7 are sociodemographic and two correspond to factor 5 of Table 7, dimension not differentiated and included to identify the sample), dimension 1 (BP as CE content) with 9 items, and dimension 2 created from the union of the factors 2, 3 and 4 of Table 7 (perceived competence for teaching of CE content in secondary education) with 5 items where 2 were eliminated (D3p23_2 and D3p23_6) as analyses in Table 7 recommend and were maintained with its subsections items D3p20 and D3p23 (see Annex).

Items 11 and 12, corresponding to Factor 5, were suggested as additional identification data. Dimension 1 comprised items from Factor 1, while Factor 2, Factor 3, and Factor 4 items were distributed across other sections.

Discussion

Over time, CE has gained increasing relevance in the educational domain; however, its implementation in teaching curricula remains relatively limited compared to other subjects (Monfort & Iglesias, 2015). Existing literature on teachers' perceptions and potential limitations in integrating CE into their teaching primarily focuses on primary education contexts (Lafuente & Hortigüela, 2021; Montávez, 2012; Rodríguez-Fernández et al., 2019). In instances where research covers the secondary stage, studies have typically focused on regions other than Catalonia, examining either student or teacher perceptions (Archilla, 2013; Arias et al., 2021; Armada, 2017; Conesa-Ros & Angosto, 2017; Villard, 2014). This study aimed to understand the current status of CE in ESO (Compulsory Secondary Education) in Catalonia specifically from the viewpoint of teachers. Therefore, the first step was to validate a questionnaire tailored to this population.

The methodology followed in the design and validation of questionnaires, as observed in previous studies like Espinel (2017), Banyeres (2015), López and Sanz (2021), and Villard et al. (2013), was reviewed. Villard's questionnaire was adapted for Catalonia's population and aligned with the current educational laws of the region. Additionally, a new dimension was introduced in the questionnaire to encompass the burgeoning artistic language of BP within CE in PE (Garcías de Ves, 2021a, 2021b, 2021c; Garcías de Ves et al. 2022). The validation process encompassed content, logic, and criteria, employing the Delphi method with 10 experts in the field. Subsequently, a pilot test and test-retest were conducted to ensure the stability of the questionnaire. The calculated Kaiser-Meyer-Olkin (KMO) coefficient (.827), considered satisfactory and close to very good according to Arias et al. (2020), indicated the questionnaire's suitability for the study population. Bartlett's test of sphericity and chi-square values affirmed the continuity of factor analysis, reinforcing the questionnaire's validation.

The final validated questionnaire comprised 26 items distributed across 2 dimensions. This differs from the Villard (2014) questionnaire, which consisted of a total of 30 items. The refined proposal encompassed a reduced number of questions with a focused emphasis on dance and the incorporation of BP in PE. Moreover, it aimed to investigate teachers' confidence, motivation, and the perceived importance of CE in their PE classes.

This study lays the foundation for analyzing the responses obtained from the teaching staff, providing insights into the educational landscape surrounding CE in Catalonia's secondary education, thus contributing to the broader understanding of CE's role and integration within the educational framework.

Conclusion

Despite the acknowledged benefits and potential of CE, it remains one of the least emphasized subjects among PE teachers in Spain. Several reasons contribute to this phenomenon within this demographic, including ambiguous objectives and methodologies, prevalent prejudices and gender stereotypes associated with expressive motor skills, and insufficient training among other factors.

To address this issue, an existing questionnaire utilized in Andalusia was adapted and subjected to rigorous statistical testing for validation. The process involved the application

of the expert panel (Delphi method) for quantitative and qualitative assessments to validate the instrument's logic, criteria, content, and construct. Additionally, a pilot test was conducted in a distinct population (n = 40), followed by a Test-Retest analysis (n = 20) to ascertain its stability. An exploratory factor analysis was performed across all dimensions with a sample size of 418 teachers, of which 42.8 % were women. The validation process resulted in a Kaiser-Meyer-Olkin (KMO) coefficient of .827, indicating proximity to a very good fit. Moreover, Bartlett's test of sphericity and Chi-square values affirmed the continuity of the factor analysis, thereby validating the Physical Education Teachers' Opinion Questionnaire for the teaching-learning of Body Expression in Secondary Education.

Consequently, the primary objective of this study, aimed at understanding the current status of CE in Catalonia's secondary education, commenced with the validation of an instrument designed to gather teachers' perceptions regarding the implementation of this content.

This study encountered several limitations, notably the challenge of obtaining a sufficiently representative sample size to validate the questionnaire thoroughly. Although having carried out in a specific community, it cannot be extrapolated and generalized to other communities unless some specific items such as the contents of the curriculum are modified (item 24). Moving forward, addressing these limitations will be crucial for ensuring a more comprehensive understanding of the perceptions and challenges faced by PE teachers in incorporating CE within their educational practice.

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Annex

Questionnaire of Opinion of Physical Education Teachers in the Teaching-Learning Process of Corporal Expression (QUOPET-CE)

Identification, initial training and teaching experience

0. Which province does the centre you work in belong to?
0.1. Barcelona
0.2. Girona
0.3. Lleida
0.4. Tarragona

1. Gender
1.1. Male
1.2. Female
1.3. Non-binary

2. Date of birth (day/month/year)

3. Academic qualification
3.1. Degree in Physical Activity and Sport Sciences (before 2009)
3.2. Degree in Physical Education Teaching
3.3. Degree in Physical Activity and Sports Sciences (from 2009)
3.4. Other. Please indicate.

4. In what year did you complete your undergraduate and/or graduate studies?
4.1. Before 1981
4.2. Between 1982 and 1998
4.3. Between 1999 and 2011
4.4. From 2012 onwards

5. Where did you complete your degree in Physical Activity and Sport Sciences?
5.1. INEFC Barcelona
5.2. INEFC Lleida
5.3. University of Vic
5.4. Ramon Llull - Blanquerna
5.5. EUSES - University of Girona
5.6. EUSES - URV (Campus Terres de l'Ebre)
5.7. TecnoCampus - Pompeu Fabra
5.8. Other. Please indicate.

6. How did you specialize in teaching (multiple answer)?
6.1. Teaching Itinerary
6.2. CAP (Certificate of Pedagogical Aptitude)
6.3. Master's Degree in Secondary and Bachelor's Degree Teacher Education
6.4. Other. Please indicate.

7. Current professional situation
7.1. Temporary replacement
7.2. Vacant interim
7.3. Trainee civil servant
7.4. Provisional civil servant with temporary assignment
7.5. Civil servant with definitive assignment
7.6. Other. Please indicate.

8. Years completed teaching PE at secondary school in a CHARTER SCHOOL
8.1. None
8.2. Between 1 and 3 years
8.3. Between 4 and 6 years
8.4. Between 7 and 9 years
8.5. Between 10 and 14 years
8.6. More than 15 years

9. Years completed teaching PE at secondary school in a PUBLIC SCHOOL
9.1. None
9.2. Between 1 and 3 years
9.3. Between 4 and 6 years
9.4. Between 7 and 9 years
9.5. Between 10 and 14 years
9.6. More than 15 years

10. Years completed working on Corporal Expression (CE) in secondary school PE classes
10.1. None
10.2. Between 1 and 3 years
10.3. Between 4 and 6 years
10.4. Between 7 and 9 years
10.5. Between 10 and 14 years
10.6. More than 15 years

11. How many courses related to CE content have you attended?
11.1. None
11.2. Between 1 and 3 courses
11.3. Between 4 and 6 courses
11.4. More than 6 courses

12. When was the last specialized course in Corporal Expression taken?
12.1. Before starting the degree / bachelor's degree
12.2. During the degree / bachelor's degree
12.3. At the end of the degree / bachelor's degree

DIMENSION 1: Body Percussion (BP) as a content of Corporal Expression (CE).

Express your degree of agreement according to a Likert scale where:
0 represents you do not know and do not answer
1 represents you strongly disagree
2 represents you somewhat agree
3 represents you agree
4 represents you strongly agree

Body Percussion (BP) can be a content...

13. ...of CE in PE classes.
0 1 2 3 4

14. ...for the improvement of coordination.
0 1 2 3 4

15. ...for the improvement of body knowledge (body awareness).
0 1 2 3 4

16. ...to introduce dance.
0 1 2 3 4

17. ...to encourage participation and collaboration in the creation of choreographies by the students.
0 1 2 3 4

18. ...to increase positive emotions.
0 1 2 3 4

19. ...to improve personal relationships.
0 1 2 3 4

20. ...to promote teamwork.
0 1 2 3 4

21. ...to facilitate inclusion.
0 1 2 3 4

DIMENSION 2: Perceived competence to teach CE content in secondary education.

Express your degree of agreement according to a Likert scale where:
0 represents you do not know and do not answer
1 represents you strongly disagree
2 represents you somewhat agree
3 represents you agree
4 represents you strongly agree

22. Are the contents of CE fundamental in PE (according to Likert scale).
0 1 2 3 4

23. Is it important to teach the dimension of corporal expression and communication in the following courses? (indicate according to Likert scale).

23.1. In 3rd course
0 1 2 3 4

23.2. In 4th course
0 1 2 3 4

24. The Curriculum (Decree 187/2015), in the dimension of corporal expression and communication proposes, among others, the following contents. From your perspective, are they relevant (indicate according to Likert scale)?

24.1. Dances and popular dances from all over the world, with a special attention to those of Catalonia.
0 1 2 3 4

24.2. Rhythm and movement: partner dancing.
0 1 2 3 4

24.3. New dance trends
0 1 2 3 4

25. Do you feel confident teaching the contents of CE in secondary school during the course? (indicate according to Likert scale).
0 1 2 3 4

26. What do you consider to be your degree of motivation to teach CE contents? (from 0 to 10, with 0 being the minimum and 10 the maximum).
0 1 2 3 4 5 6 7 8 9 10

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Integrating knowledge in higher education: using body experiences to enable transdisciplinarity based on Dynamic Systems Theory general concepts

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Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/ Ritchie B. Tongo)

Abstract

This study aimed to evaluate the effectiveness of learning Dynamic Systems Theory (DST) general concepts for enhancing integrative knowledge and transdisciplinarity among higher education students of sports sciences. Two class groups of first-cycle students were assigned to the experimental (EG, n = 147) and control (CG, n = 140) groups, respectively. The EG followed a specific intervention consisting of learning DST general concepts and experiencing their transdisciplinarity, while the CG followed the regular lessons. Integration and transfer of knowledge were evaluated through questionnaires and oral presentations. Post intervention, the EG group significantly improved their integrative and transdisciplinary knowledge, while the CG showed no change. Learning DST concepts using body experiences and applying them to sports science phenomena effectively fostered integrative knowledge among higher education students.

Keywords: complex systems, education innovation, embodied learning, sports sciences, transfer of knowledge, university.

Introduction

In the traditional educational curricula, subjects are often taught in isolation and disconnected from each other (Hristovski et al., 2020). By failing to recognise the interconnectedness of knowledge across disciplines, learners miss opportunities to apply what they have learned to real-world problems (Adams, 2015; Bautista et al., 2018). Research shows that students who were taught in a fragmented manner had limited transferability of knowledge to new contexts (Ball, 2000). More concretely, standard instructional practices in undergraduate teaching, such as traditional lectures, laboratory, or recitation courses, are ineffective at helping students to master and retain important concepts of the disciplines over the long term (Wood & Gentile, 2003). Moreover, these practices do not adequately develop the integration of knowledge and collaborative problem-solving competencies needed to face the problems of the modern world.

In contrast, students who received a more integrated education (e.g., problem-based learning or inquiry learning) demonstrated higher levels of understanding of the topic and could better apply their knowledge effectively (Hmelo-Silver et al., 2007). However, the use of subject-specific vocabulary in different disciplines makes it challenging to implement transdisciplinary approaches (Hristovski, 2013; Hristovski et al., 2020). A transdisciplinary approach to education focuses on solving problems that require the interconnection of knowledge across disciplines, blurring the boundaries to generate new knowledge (McGregor, 2015). For example, in sports sciences, experts such as physiologists, psychologists, sociologists, biomechanics, sports coaches, and data analysts may face communication barriers due to differences in scientific terminology and approaches. In such cases, a common scientific language could facilitate their understanding, which is crucial for the progress of science and society.

To understand and unify approaches in science, general concepts and principles that can explain different phenomena (e.g., fatigue, injuries, performance, etc.) are needed. The Dynamic Systems Theory (DST) offers a comprehensive set of interconnected general concepts and principles that have been empirically identified (Hristovski, 2013; Hristovski et al., 2014, 2019). Using DST concepts can help to understand phenomena and dynamic processes from a broad spectrum of scientific disciplines (i.e., from elementary particles and fields to sociology) and integrate knowledge. This includes sports sciences (Balagué et al., 2017; Vázquez, 2017; Hristovski, 2013) with its multilevelness and multidimensionality. In this sense, DST has the potential to provide a basic understanding of diverse phenomena from various academic disciplines.

When researching the effectiveness of transdisciplinary educational interventions, short questionnaires completed by students are commonly used (Takeuchi et al., 2020; Lage-Gómez & Ros, 2021). In particular, questionnaires tailored to the content appear to be the most suitable since assessing objectively knowledge transfer is challenging. In this case, the utilization of constructed-response items, also known as open-ended questions, are assessment items that require generating a response rather than selecting it from a set of options. These questions offer students valuable opportunities to justify their answers and prove to be a beneficial learning approach (McCarthy, 2005). Open-ended questions are commonly used in various forms of assessments, such as educational exams, surveys and interviews. Liu et al. (2011) proposed applicable criteria for particularly assessing knowledge integration through short questionnaires.

On the other hand, learning by experiencing first can be more effective in consolidating theory for students. For example, body movement experiences have been used to study concepts in mathematics, physics, biology, music, or culture (e.g., interdisciplinary physical education [Cone et al., 2009]) or transdisciplinary concepts in primary and secondary education (Almarcha et al., 2022; Almarcha et al., 2023). These experiences have shown better outcomes when working in groups because of the extent of collaborative peer learning (Magin, 1982). One example of practical experience to explain theoretical subjects in university settings is the study conducted by Hernández (2019), where students learned the kinematics of bicycle physics by riding a bicycle. Another university experiment showed that a centre for "learning how to learn", based on learning through teaching, reduced attrition and improved tuiton and student skills (Wankowski, 2007).

The Synthetic Understanding through Movement Analogies (SUMA) educational framework arises from the need to help acquiring general DST concepts and integrate disciplines through embodied learning (Hristovski et al., 2020). That is, the understanding of concepts and principles through somatosensory, perceptual and re-experiencing actions without segregating action and thinking processes as two unrelated realms (Niedenthal, 2007; Stolz, 2015; Skulmowski & Rey, 2018). Based on this framework, we hypothesised that learning through embodied experiences will positively affect acquiring general DST concepts and their transfer role among phenomena in university settings.

This research aimed to evaluate the educational potential of experiencing some DST concepts (see Table 1) for enhancing integration and transfer of knowledge among higher education students of sports sciences. This

Table 1
Dynamic Systems Theory (DST) general concepts[1] used during the sessions followed by the experimental group (all the proposed concepts are retrieved or derived from SUMA educational framework [Hristovski et al., 2020]. The derived concepts are marked by an asterisk).

DST Concepts	Definition
Self-organization	Spontaneous process where some form of overall order arises from local or global interactions between parts of an initially disordered system.
Synergies*	Spontaneous formation of structural and functional couplings among components, which reciprocally compensate each other with respect to the context, to achieve task goals.
Emergence	Radical novelty in the higher-level behavior of systems resulting from interactions in the lower-level components within those systems.
Nestedness*	Larger to smaller emergent levels of organization. Smaller modules, each of them providing a certain function, are used within larger modules that perform more complex functions.
Dynamic system	System changing over time.
Stability	Resilience to perturbations. The necessary and sufficient condition for the existence of any system's behavior/structure.
Instability	The behavior/structure of a system which tends to vanish and switch to a stable state.
Phase transition	The spontaneous qualitative change of the system as a result of the instability of the previous state.
Attractor	Behavioral or structural states toward which, under some specific context, the system converges over time.
Repeller	Unstable state of system's behavior.
Constraint/context	Boundary conditions, limitations that apply restrictions to the degrees of freedom of a system.

[1] Synergies and nestedness are not truly DST concepts but are derivable from them and have a wide explanatory scope within the bio-psycho-social sciences.

study aimed to evaluate the effectiveness of learning DST concepts (see Table 1) for enhancing integrative knowledge and transdisciplinarity among higher education students of sports sciences.

Methods

Participants

Two hundred eighty-seven first-cycle degree program students of sports sciences aged between 18 and 36 years old (M = 20.07 ± 3.85) from the same faculty participated in the study. Two class groups with no significant differences in average sex, age, and educational interest were selected for the study. A total number of 147 students (37 women and 110 men) were assigned to the experimental group (EG) and 140 (34 women and 106 men) to the control group (CG). The female representation reflected the gender distribution of the whole degree program. Students were not previously introduced to or familiar with DST concepts. Once the intervention was explained, the students gave informed consent to participate. The institution and the local research ethics committee approved the research (072015CEICEGC). The data was coded anonymously to ensure confidentiality, adhere to university ethics, and comply with relevant guidelines and the principles of the Declaration of Helsinki.

Procedure

The study was conducted in the university faculty and integrated into the teaching general program. The intervention lasted 12 weeks and had a frequency of two theoretical lessons and one practical lesson per week of 90 minutes each. It was led by an experienced teacher who applied DST concepts and two researchers working in the same field.

During class time, on the first day and at the end of the intervention program, all participants filled out a demographic form and the Integrative Knowledge Questionnaire (see Evaluation section). Then, the EG followed the intervention, while the CG did not participate. Both groups continued with the university-programed lessons.

Intervention program

The intervention program consisted of two phases: a) preparatory and b) team's work oral participation in a symposium.

a) Preparatory.

The preparatory phase consisted of three learning phases (adapted from Hristovski et al., 2014, and Kolb, 1984):

1. Embodied learning: Experiencing the general DST concepts (see Table 1) through physical activities (11 sessions). For example, the stability, instability, and phase transition concepts were experienced through the dynamics of task-related and task-unrelated thoughts during an incremental cycling task, or the intra- and interpersonal

synergies of body components were experienced through a cooperative dyadic task on a slackline.

2. Far-transfer transdisciplinary: During each practical session, the teacher guided the students to answer specific questions to relate the body experiences with the general DST concepts (11 sessions). For instance, when the students recorded their thoughts during an incremental cycling task, they were asked to explain how they related the changes in their thought patterns with stability, instability, and phase transition, among others.

3. Theoretical lessons on general DST concepts (11 sessions). The theoretical lessons consisted of explaining each DST concept by providing examples of different phenomena.

b) Team's work participation in a symposium.

With the purpose of applying and experimenting the transdisciplinarity of general DST concepts, students prepared team works to be presented in a symposium. Student groups with common theoretical and practical interests (4-5 members) selected a topic or phenomenon related to health, sports performance, or education to be explained using DST general concepts. Moodle platform chats were used to avoid topic overlaps when selecting topics. Once the topics were assigned to the teams, students worked collaboratively to submit an abstract (including authors, title and references) to participate in the symposium. When the abstract was accepted by the teachers, they could present their works orally. A period of two weeks was left for correcting and resubmitting abstracts. During the process, the teachers offered additional support, providing regular tutoring and follow-up discussions to ensure that every team could satisfy the rubric of the oral presentations (see Table 2).

The symposium program was scheduled for six sessions covering the following general topics: nutrition, health, injuries, performance, team sports, and education. Each presentation lasted 12 min plus 10 min of questions. After each presentation, all students and teachers scored the oral presentations and discussions following a rubric (Hafner & Hafner, 2003) (see Table 2), and added a comment to justify the score.

Evaluation

Knowledge Integration Questionnaire

Students had to answer the following questions:

1. Do you think it is scientifically interesting to explain any natural phenomenon using the same general DST concepts?

2. (2.1) Can you identify common DST principles in biological, psychological, and sociological processes? (2.2) Which ones?

3. Can you use the general DST concepts to explain a phenomenon such as a social revolution? Please justify it.

4. And for explaining an organic injury? Please justify it.

The content validity of the questionnaire was established by two researchers with 30 years of experience in using DST concepts and evaluated by a researcher from the SUMA project (Hristovski et al., 2020). The assessed inter-item reliability of the questionnaire, measured through Cronbach's alpha, was $\alpha = .92$.

Table 2
Rubric embedded in the form to evaluate the team presentations.

	Punctuation				
Items	Excellent (4)	Good (3)	Adequate (2)	Deficient (1)	Percentage of qualification
Integration of concepts	Good domain of the concepts and respond coherently to the questions.	Understand the explained phenomenon but have difficulties to link some concepts.	Need some rectifications about the usage of the concepts.	Have no understanding of the concepts.	40 %
Collaborative work	The presentation shows planification and collaborative work. All the members participate actively.	The presentation shows planification, but some members present deviations from the group's framework.	The presentation shows some planification, but with different levels of participation among the members.	There is no collaboration or even no participation by the members.	40 %
Originality and quality	Original topic. Adequate and attractive visual support.	Original topic. Adequate but few attractive visual support.	Non-original topic. Adequate visual support.	Non-original topic. Inadequate visual support.	20 %

Evaluation of the team presentations

All students were required to assess the work of the other teams using an online form linked to a rubric. The rubric had three items —"integration of concepts", "collaborative work", and "originality and quality"— each of which was evaluated on a 4-point scale ranging from 1 (deficient) to 4 (excellent). Table 2 displays the rubric items and the percentage of grades used to evaluate the team presentations.

Students' satisfaction survey

Post intervention, a students' satisfaction survey was administered to collect the acquired competencies in integrating and transferring knowledge and the collaborative learning benefits.

Data Analysis

Knowledge Integration Questionnaire

Descriptive statistics were used to interpret the quantitative data. The percentages of Yes/No answers for questions 1 and 2.1 and the correct/incorrect answers in 2.2, 3 and 4 in pre- and post-intervention were calculated for the EG and CG. A Chi-square test of independence was performed to compare the differences between the groups, while McNemar's test was used to compare the results for each question within groups.

Evaluation of the team presentations

The mean and standard deviation (SD) of the students' and teachers' marks (out of 10) associated with the first item of the rubric (use of general DST concepts to explain the phenomenon under study) was calculated to evaluate their integrative and transdisciplinary knowledge. The mean and SD of the students' and teachers' marks (out of 10) associated with the other three items were respectively calculated. The mean final marks provided by students and the consensual marks of the teachers for each presentation were compared through Spearman's rank correlation. For all statistical analyses, SPSS 23.0 (SPSS, Chicago, IL, USA) was used and the significance alpha level was set at $p < .01$.

Students' satisfaction survey

The percentage of responses to every question of the students' satisfaction survey was calculated.

Results

Knowledge Integration Questionnaire

Table 3 displays the percentage of responses for both groups. Before the intervention, as neither group had knowledge of the general DST concepts, almost no student could answer questions 2.2, 3, and 4. However, both groups shared similar responses in questions Q.1 ($\chi^2 = 0.119$, $p = .827$), Q.2.1 ($\chi^2 = 0.733$, $p = .858$) and Q.4 ($\chi^2 = 0.289$, $p = .966$). Contrarily, post intervention the differences between groups were significant in every question Q.1 ($\chi^2 = 81.428$, $p < .001$), Q.2.1 ($\chi^2 = 152.821$, $p < .001$), Q.2.2 ($\chi^2 = 186.998$, $p < .001$), Q.3 ($\chi^2 = 163.596$, $p < .001$), and Q.4 ($\chi^2 = 181.583$, $p < .001$).

When comparing differences within groups, the CG did not differ between pre and post Q.1 ($\chi^2 = 3.00$, $p = .083$), Q.2.1 ($\chi^2 = 2.00$, $p = .157$), Q.2.2, Q.3 and Q.4 ($\chi^2 = 1.00$, $p = .317$). In contrast, the EG presented significant differences in Q.1 ($\chi^2 = 77.00$, $p < .001$), Q.2.1 ($\chi^2 = 111.00$, $p < .001$), Q.2.2 ($\chi^2 = 118.00$, $p < .001$), Q.3 ($\chi^2 = 109.00$, $p < .001$), and Q.4 ($\chi^2 = 116.00$, $p < .001$).

Table 3
Percentages of responses to the Knowledge Integration Questionnaire.

Questions	CG (n = 140)		EG (n = 147)	
	Pre	Post	Pre	Post
	Yes	Yes	Yes	Yes/correct
1. Do you think it is scientifically interesting to explain any natural phenomenon with the same concepts?	44 (31 %)	47 (34 %)	49 (33 %)	126 (86 %)* †
2.1 Can you identify common principles of CAS and general concepts of DST in biological, psychological and sociological processes?	23 (16 %)	25 (18 %)	22 (15 %)	133 (90 %)* †
2.2 Which ones?	1 (0.71 %)	1 (0.71 %)	2 (1.36 %)	118 (80 %) †
3. Can you use the general concepts (attractors, instability, variability, synergies, etc.) to explain a phenomenon such as a social revolution?	1 (0.71 %)	1 (0.71 %)	2 (1.36 %)	109 (74 %)* †
4. And for explaining an organic injury?	1 (0.71 %)	1 (0.71 %)	2 (1.36 %)	116 (79 %)* †

Notes: *Significant differences when compared with the post-CG data. † Significant differences when compared with the pre-EG data. CG = control group, EG = experimental group; CAS = complex adaptive systems, DST = dynamic systems theory. 2.2 question was a descriptive response to confirm 2.1 question.

Table 4
Percentages of responses to the students' satisfaction survey.

	Students' responses (*n* = 114)				
Survey questions	Not at all	A little	Neutral	Very	Very much
1. Are you satisfied with what you learned in the course?	10 (8.78 %)	5 (4.38 %)	11 (9.65 %)	60 (52.63 %)	28 (24.56 %)
2. Would you like to keep learning these concepts as well as their application at different levels?	6 (5.26 %)	7 (6.4 %)	18 (15.79 %)	55 (48.25 %)	28 (24.56 %)
3. Do you think that collaborative learning (symposium, co-evaluation, etc.) has helped you to go deeper into the course's knowledge?	8 (7.02 %)	5 (4.38 %)	16 (14.04 %)	35 (30.70 %)	50 (43.86 %)

Evaluation of the team presentations

A total number of 54 works with different topics of interest were evaluated. Integration of knowledge (item 1) was assessed with a mark of 8.43 ± 0.88 (Min = 5.35, Max = 9.70), the team's collaborative work (item 2) with a mark of 8.91 ± 0.45 (Min = 7.55, Max = 9.55), and the originality of the work (item 3) with a mark of 8.52 ± 0.55 (Min = 6.72, Max = 9.47). Teachers' and students' final marks (7.36 ± 1.65 and 8.18 ± 0.96, respectively) showed a positive correlation (*rho* = 0.8, $p < .01$) and confirmed the objectivity of the judges.

Students' satisfaction survey

The survey was responded by 114 students, of which 77.19 % were satisfied with the intervention, 72.81 % expressed the will to continue learning to apply DST concepts to different psychobiological and sociological phenomena, and 74.56 % expressed that collaborative learning helped them to deepen their knowledge (see Table 4 for further information).

Discussion

The intervention results revealed that by experiencing the general DST concepts, students could integrate and transfer knowledge effectively, leading to an increased interest in explaining natural phenomena using the same concepts. Their grades supported this outcome and demonstrated their ability to apply the general DST concepts to the selected topics of interest. The positive correlation between the marks awarded by the students and teachers confirmed the objectivity of the assessment. Additionally, the students agreed that the team's collaborative dynamics was an efficient strategy for achieving the purpose of the intervention.

The intervention significantly impacted the EG's integration and transfer of knowledge abilities. Meanwhile, the CG showed no improvement, which can be attributed to their lack of exposure to learning DST concepts. In turn, the increase of integrative and transfer knowledge abilities of EG can be attributed to several aspects of the intervention program. First, the sessions were designed to experience the DST concepts through embodied learning, which have gained some popularity in education due to their effectiveness in enhancing cognitive abilities and improving knowledge retention (Clary & Wandersee, 2007; Schwartz-Bloom et al., 2011; Spintzyk et al., 2016). When general concepts were embodied, explained and identified in different phenomena, the capacity to transfer knowledge among disciplines improved. It is worth mentioning that transdisciplinarity was based on DST concepts but not transferred by themselves. DST concepts connect two or more different phenomena and hence transfer the knowledge from the source phenomenon to the target phenomenon. Transdisciplinarity is realised when students connect different phenomena in the later parts of the learning. Hence, the reflective observation of these experiences involved the comprehension, abstract conceptualisation, transference, and retention of the general DST concepts. These results are consistent with those reported by Almarcha et al. (2022, 2023) in primary and secondary school.

The symposium's organization created an ideal environment for students to understand different phenomena, transfer the knowledge to topics that are of personal interest, and thus acquire transdisciplinary competencies. According to Cabrera et al. (2017), allowing students to work on a meaningful topic contributes to improving their motivation. Prince (2004) agreed that optimal learning comes from active engagement with the material being taught.

Also, a collaborative, supportive and pleasant classroom atmosphere contributed to the emergence of students' questions and arguments, which can often be more valuable than the lessons themselves. Classroom interactions between teachers and students seem more effective than traditional teaching methods and active learning situations in promoting participatory engagement (Bartlett & Ferber, 1998; Smith & Cardaciotto, 2011; Yoder & Hochevar, 2005).

The Knowledge Integration Questionnaire and satisfaction survey results showed that students believed they had improved their knowledge integration and transfer skills, became more interested in science, had a positive experience with collaborative learning, and that working on

a relevant topic had boosted their motivation and creativity. The satisfaction survey data showed that the discussions and tutoring during the entire learning process helped students consolidate their learning. As Ko and Mezuk (2021) found, the teachers' tutorial guidance and internal group discussions seemed key to the intervention's success.

Despite the strengths of this study, some limitations must be considered. First, the long-term effects of the intervention, such as the future professional implications of learning these concepts at the university, have yet to be evaluated. Also, as suggested by Hristovski et al. (2020), according to the SUMA framework, most educational interventions ignore the importance of embodied experiences in learning. Future interventions may enhance the learning process of general DST concepts using an embodied learning approach, as highlighted in this and previous studies (Almarcha et al., 2022, 2023; Hristovski et al., 2014).

Additionally, we did not conduct a gender analysis of the results due to the small number of female participants compared to male participants. We suggest incorporating interviews throughout the academic program to better understand how students develop knowledge transfer competencies during the intervention.

Future research should continue to investigate the potential of general DST concepts not only at any education level, but also in professional fields like interdisciplinary sports teams.

Conclusion

The intervention highlighted that learning DST concepts using body experiences and applying them to sports science phenomena effectively fostered integrative knowledge among higher education students. This transdisciplinary knowledge can potentially provide a shared understanding among different disciplines either for sports sciences (e.g., physiology, biomechanics, psychology, etc.) or other areas of knowledge.

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Facilitators and barriers for the inclusion of students with disabilities in Physical Education in Colombia, Chile, Spain and Peru

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Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/Ritchie B. Tongo)

Abstract

The objective of this study was to analyse the barriers and facilitators that students with disabilities encounter in Physical Education and sports in Chile, Colombia, Spain and Peru. An exploratory, correlational and cross-sectional study was designed, involving 362 children and adolescents with disabilities from Chile (41.1%), Colombia (14.6%), Spain (11.6%) and Peru (32.5%), who completed the questionnaire "Barriers and Facilitators of Sports in Children with Physical Disabilities" (BaFSCH) in its Spanish-translated version. Concerning the results, 72.7% practice physical activity at school, with a higher tendency in Colombia (88.7% χ^2 = 11.17, p = .02), where 72.0% participate in Physical Education classes while 38% practice physical activity and sports workshops. The main facilitators of inclusion are parents and guardians, along with friends in the school environment, while barriers are associated with accidents or falls and/or their disability and/or impairment. Additionally, biological sex (OR = 1.893, IC = 1.19-3.00, p = .007) is associated with being a facilitator for physical activity, whereas having an intellectual disability (OR = .437, IC = .20 - .94, p = .03) and a physical disability (OR = .298, IC = .15-.58, p = .0002) are associated with barriers to inclusion. This research revealed that Physical Education classes are fundamental for engaging in physical activity within the educational setting for children and adolescents with disabilities, as well as the environment, which acts as a protective factor at the environmental level.

Keywords: barriers, facilitators, inclusive sport, physical education, sport at school.

Introduction

Physical activity in the school context for children and adolescents with disabilities (CAD) has become a topic of increasing importance for institutions that set international guidelines on the matter. The United Nations, through the International Charter of Physical Education, Physical Activity and Sport (2015), suggests inclusion as one of the fundamental pillars to be considered within the guidelines and processes developed at political levels for its implementation. This is further validated in the Kazan Action Plan (United Nations Educational, Scientific and Cultural Organisation, 2017), where ministers and senior officials responsible for physical education and sports in member countries explicitly state that "inclusive participation requires opportunities to be provided at all levels of participation, regardless of ability, potential disability, ethnicity, gender, language, religion, political or other opinion, national or social origin, property status, birth or other grounds." In a synergistic manner, the Sustainable Development Goals Agenda highlights the importance of physical activity and sports as a strategy for inclusion (United Nations, 2015), consistently argued in Goal 4, "Quality Education," which aims to generate processes that guarantee participation within the framework of diversity in school spaces, fostering equal access while eliminating any disparities that may exist.

This has transcended and deepened in the local policies of various countries, leading to a number of initiatives. In Chile, in terms of legislation, the School Inclusion Law No 20,845 (Ministry of Education, 2015a) establishes the right of all students to receive an inclusive education, which involves adapting curricula and infrastructure to meet the individual needs of each student, including CAD. Decree No 83 (Ministry of Education, 2015b) mandates that schools providing special education at the preschool and primary levels must use the standard curriculum and adapt it to the individual needs of students based on their disability. However, this decree does not extend to secondary education, meaning that educational institutions at this level are not required to use the conventional curriculum.

Regarding Colombia, it is important to first mention that the practice of physical activity and sports is addressed in Article 52 of the Colombian Constitution of 1991 (Superior Council of the Judiciary, 2015), and that Articles 13, 47, 54, 68 and 93 recognise and highlight the importance of providing access and guaranteeing all rights to people with disabilities. Subsequently, Law 181 (Colombian Congress, 1995), which defines the National Sports System, outlines the different types of sport from formative sports to high-performance sports, and Articles 3, 11 and 42 emphasise the need to implement physical education, sports and recreation programmes for people with disabilities, as well as to create an inclusive curriculum and increase accessibility to sports facilities, ensuring the participation of this population. These initiatives proposed by the National Sports System are revisited in Law 361 of 1997, amended by Law 1316 of 2009, and later in Law 1346 of 2009 (Colombian Congress, 2009), which ratifies the United Nations Convention on the Rights of Persons with Disabilities (United Nations, 2006) in Colombia. Additionally, over the years, from 2011 to the present, development plans in the health and sports sectors mention the promotion of physical education, physical activity, school sports and community social sports as part of the policies, and they develop actions with inclusion criteria (Ministry of Health and Social Protection, 2022). On the other hand, in the education sector, it is important to highlight Law 115 of 1994, which reaffirms education as a right for all individuals regardless. Thus, in the field of physical education, the 20th century saw the beginning of the implementation of actions developed through adapted physical education, which includes a series of content transformations with a universal and differential approach aimed at the population with disabilities, including those with learning, movement, communication and behavioural deficiencies, providing theoretical, technical and human resources that favour teaching-learning process (López & Pardo, 2012; López & Villamizar, 2018).

In Spain, the current Organic Law 3/2020, of 29 December, which amends Organic Law 2/2006, of 3 May, on Education (Ministry of Education and Vocational Training, 2020), highlights two main objectives concerning the promotion of the participation of students with special educational needs in regular educational settings. First, it aims to avoid the segregation of students, and second, to strengthen the system's inclusive capacity. With regards to Physical Education, the application of this new law is directly reflected in all components of the new curriculum, especially in primary education, although to a lesser extent in secondary education. In the first case, Specific Competence 3 appears: "Develop self-regulation and interaction processes within the framework of motor practice, with an empathetic and inclusive attitude [...]," which is further detailed in various evaluation criteria and basic knowledge.

In Peru, through the Ministry of Education, in the Directorate of Initial Teacher Training, it was proposed in 2020 to include the course of Inclusive Physical Education in the curriculum of higher pedagogical education; however, there is still a gap in the inclusion and integration of CAD in Physical Education programmes, which only some universities address. It is also worth noting the total absence of the Physical Education course in special basic education

centres (Ministry of Education of Peru, 2020). On the other hand, the Peruvian Sports Institute, the National Paralympic Association of Peru, the Peruvian Sports Federation of People with Intellectual Disabilities and the National Sports Federation of People with Physical Disabilities promote training courses, awareness and competitions for CAD, but with limited impact due to the financial constraints of the entities and the country.

These initiatives and modifications developed by the states and their governments serve as facilitators from the perspective of and under the social model of disability, which understands people and their relationship with the environment as the primary interaction mediating the process of social inclusion (United Nations, 2001). This allows us to attempt to understand how these adjustments may have generated changes in the population and whether they have had any impact.

Based on the above, the objective of this research is to analyse the barriers and facilitators that students with disabilities themselves report in Physical Education in particular and sports in general in the four indicated countries.

Method

Participants

A total of 362 children and adolescents with disabilities participated, with an average age of 14 ± 1.8 years. The gender distribution was 37.6% girls, 61.3% boys, and 1.1% others. Of the participants, 57.7% had a disability from birth or earlier, while 42.3% developed a disability after birth or in later stages. The details of the sample are included in Table 1.

Design

A cross-sectional exploratory study with correlational characteristics was conducted.

Tools

The "Barriers and Facilitators of Sports in Children with Physical Disabilities" (BaFSCH) questionnaire (Muñoz Hinrichsen et al., 2021) was used, which was designed by

Table 1
Description of the general characteristics of the participants.

Variables	Chile 149 (41.1%)	Colombia 53 (14.6%)	Spain 42 (11.6%)	Peru 118 (32.5%)	Total *N* = 362
Age	14 ± 5.3	15 ± 3.7	15 ± 2.8	13 ± 4.1	14 ± 1.8
Biological sex					
Boy	57.7%	52.8%	69.0%	66.9%	61.3%
Girl	41.6%	47.2%	26.2%	32.2%	37.6%
Other	0.7%	0%	4.8%	0.8%	1.1%
When did your condition start?					
When I was born or before	56.4%	79.2%	52.4%	51.7%	57.7%
After birth/as a grown-up	43.6%	20.8%	47.6%	48.3%	42.3%
How do you travel to school?					
I walk or I use my wheelchair	17.4%	20.8%	47.6%	16.9%	21.3%
In a means of transport adapted for me	12.1%	11.3%	14.3%	10.2%	11.6%
In a means of transport that is not adapted for me	70.5%	67.9%	38.1%	72.9%	67.1%
What is your condition?					
I'm missing a body part	0.7%	0.0%	4.8%	11.9%	4.7%
I have difficulty understanding instructions	13.4%	11.3%	11.9%	18.6%	14.6%
I can't hear well	8.1%	0.0%	16.7%	11.0%	8.8%
I have trouble moving	10.1%	3.8%	7.1%	17.8%	11.3%
I can barely see or can't see at all	18.1%	60.4%	4.8%	10.2%	20.2%
I lack strength to move	4.0%	0.0%	4.8%	7.6%	4.7%
Other condition	42.3%	24.5%	35.7%	16.9%	30.7%
I have spasticity	3.4%	0%	14.3%	5.9%	5.0%

NB: Data expressed in percentages

Jaarsma et al. (2015) and adapted from a self-constructed questionnaire for Paralympic athletes previously published (Jaarsma et al., 2014). The items on barriers and facilitators were divided into personal and environmental factors according to the International Classification of Functioning (World Health Organisation, 2001). The elements related to sports participation and disabilities were grouped according to the components of the Theory of Planned Behaviour (Ajzen, 1991): those corresponding to "Attitude," which is an individual's personal evaluation of a behaviour; "Subjective Norms," which are related to the normative expectations of others; and "Perceived Behavioural Control," which relates to the presence of factors that may hinder performance.

Procedure

This study employed a quantitative, cross-sectional and exploratory methodology, with a non-probability convenience sampling approach to gather data from the research teams in Chile, Colombia, Spain and Peru. The study was approved by the Ethics Committee of Diego Portales University in Chile (code 12-2022) and the Polytechnic University of Madrid in Spain (issued on 12 January 2022). To begin, the research teams contacted educational institutions in their respective countries. Due to the high level of complexity and the challenge of achieving uniformity, the sample was selected based on the research teams' access to institutions, facilitated by the support of each country's Ministry of Education, which helped in establishing contact with the administrators or managers of the institutions. For this reason, and to maximise the number of participants, all eligible individuals from integrated or inclusive schools were included, excluding only those from special schools to ensure a context with diversity in physical education and/or sports activities.

Subsequently, each institution was asked for permission to administer the questionnaires to students with disabilities. Finally, with the consent of the parents, guardians and/or caregivers of the participants, and the consent of the participants themselves, the data collection process was carried out between October 2022 and March 2023.

Statistical Analysis

In the first part, a comparative analysis of the participants was conducted based on their country of residence (Chile, Colombia, Spain, Peru) using the responses obtained from the tool. The data are presented with descriptive statistics for the study variables, where the number of participants is shown as frequency (n) and percentage (%), and age is presented as means (m) and standard deviation (±). All responses related to the questionnaire items are presented as percentages (%). The chi-square (χ^2) hypothesis test was used to establish the difference between the expected and observed frequencies.

Subsequently, upon observing homogeneous behaviour in the sample, participants were grouped by biological sex, onset of their condition, use of assistive devices, type of disability and mode of transportation to school. The Odds Ratio test was used to analyse the association of two variables related to the practice of physical activity at school.

GraphPad version 8 (San Diego, CA, USA) and the Statistical Package for the Social Sciences (SPSS Inc., version 25.0, Chicago, IL, USA) were used for the statistical analysis. The significance level was set at $p < .05$, with a 95% confidence interval.

Results

In the first part of the analysis by country of origin, regarding the question "Do you practice physical activity at school?", 72.7% of the total participants did, while 27.3% did not ($\chi^2 = 11.17$, $p = .02$). The lowest participation was observed in Peru, with 66.9%, and the highest in Colombia, with 88.7% (Figure 1A). The most common activity was Physical Education class, with 72%, followed by sports workshops (activities occurring two or more times a week where sports are practiced), with 16%, and physical activity workshops (activities occurring two or more times a week based on play or controlled physical exercise), with 12% (Figure 1).

Participation in clubs or workshops outside of school was lower, at 67.7%, while those who do participate made up 32.3% of the total. It is also noteworthy that 47.5% of participants started participating in physical activity and/or sports less than a year ago (83% in Colombia), except in Spain, where 50% have been participating for more than three years (Table 2).

The main facilitators for inclusion and participation in physical activity and/or sports at school were identified as parents and guardians, friends of CAD and developmental actions in educational settings. Physical Education teachers and personal initiatives were not considered significant facilitators (Figure 2A).

When exploring the main motivations for participating in physical activity or sports, the primary factors highlighted were the personal benefits for CAD, a general enjoyment of sports and family encouragement (Figure 2B).

Figure 1
Data expressed in percentages by country of residence.

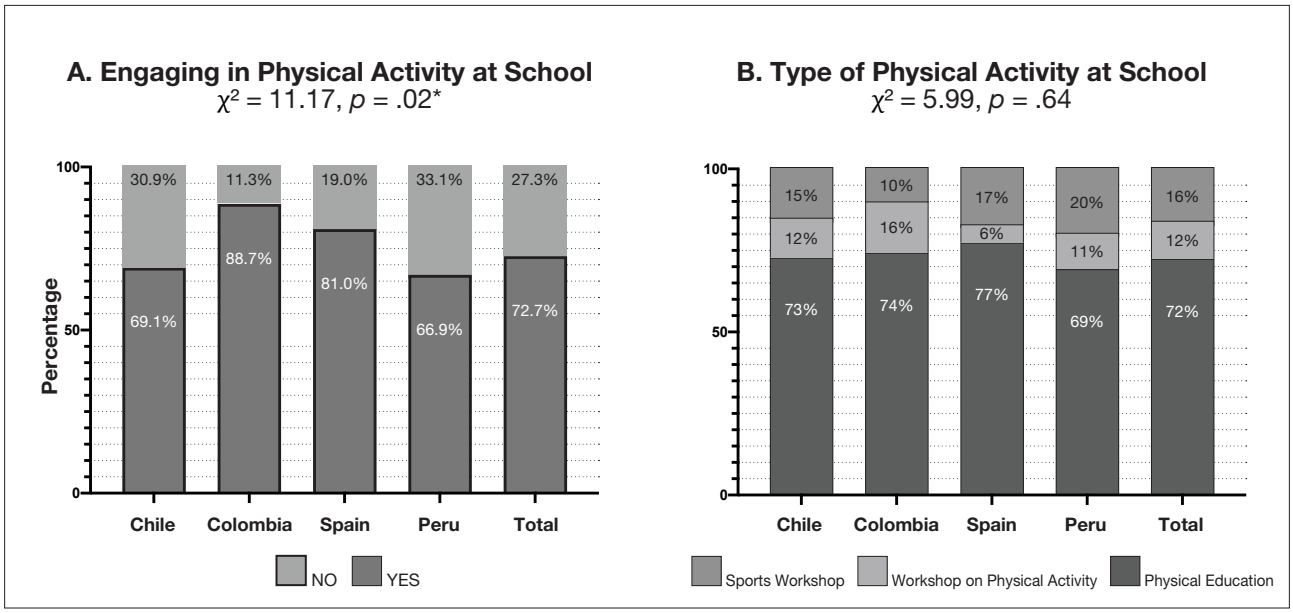
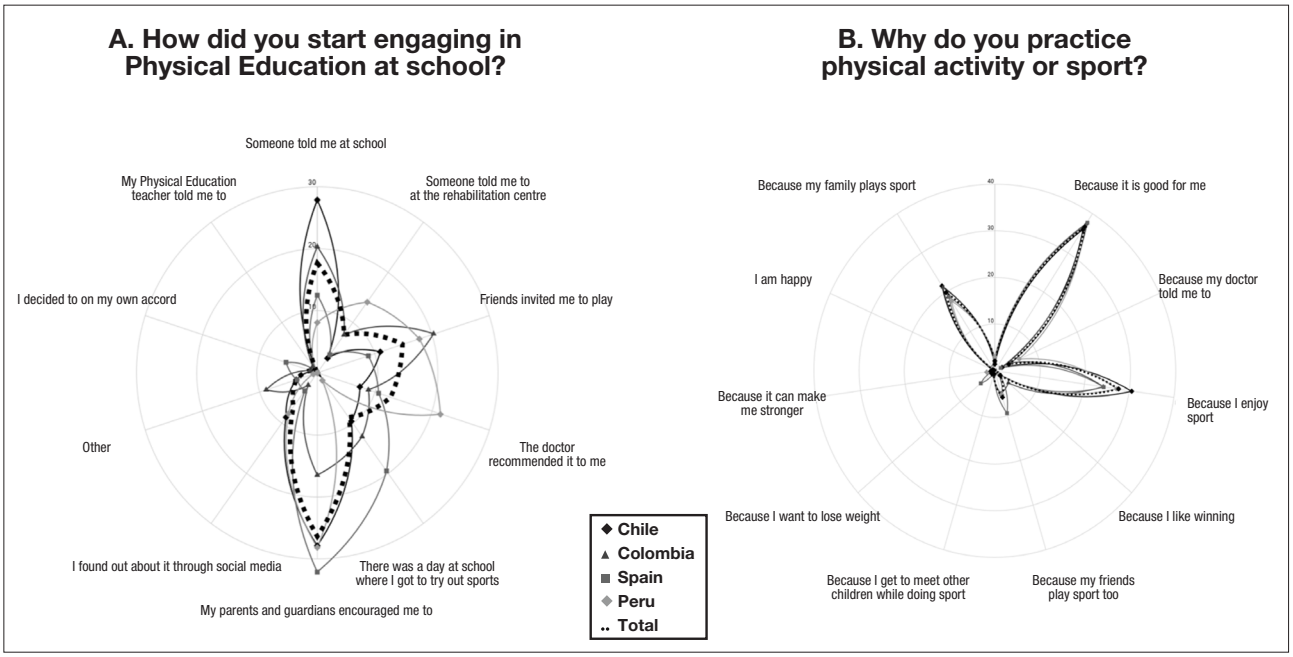


Figure 2
Data expressed in percentages by country of residence.



When asked, "What do you not like about sports?", 44.1% of participants indicated, "I like everything about sports," with Chile showing the highest percentage at 51.5%. The most common difficulties mentioned were "I have problems due to my disability," affecting 19.8% of participants, notably higher in Spain at 23.5%, and "I am afraid of falling," cited by 14.8% (Table 2).

For the group of participants who do not practice physical activity, the most common responses to "Why do you not practice physical activity at school?" were "I am afraid of falling and getting hurt," with 27.3%, particularly noted by participants from Peru at 41%; "I have problems due to my disability," with 21.2%, especially noted in Chile at 28.3% and "I do not like sports," with 21.2%, notably in Colombia at 33.3% (Table 2). Most participants who do not practice physical activity/sports at school also do not participate outside of school, with 81.8%, and Chile (87%) and Peru (87.2%) showing the lowest participation (Table 2).

In the second analysis of the study, it was observed that having an intellectual disability (OR = .437, CI = .20-0.94, p = .03) or a physical disability (OR = .298, CI = .15-.58, p = .0002) was significantly associated with a reduced likelihood of practicing physical activity and/or sports in the school context, thus considered a barrier (Figure 3).

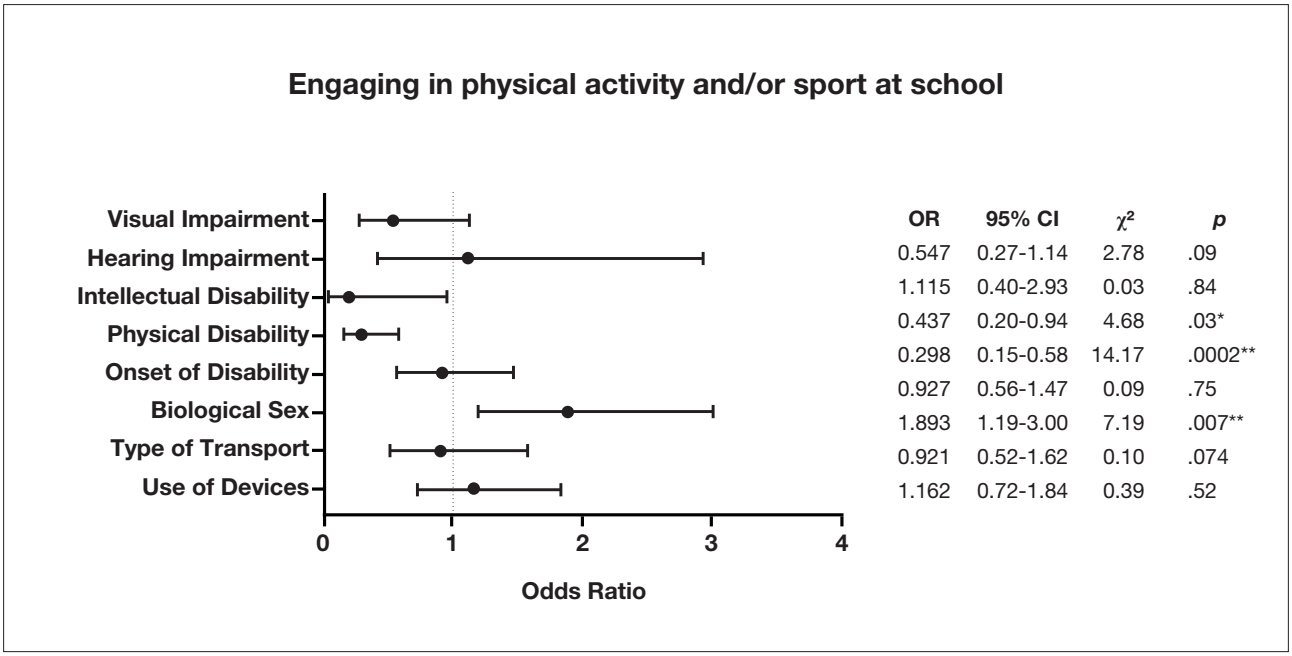
In contrast, biological sex (OR = 1.893, CI = 1.19-3.00, p = .007) was associated with an increased likelihood of practicing physical activity and/or sports in the school context (Figure 3), specifically among "Boys," who had a higher participation rate of 77.48% compared to "Girls," at 64.49%, indicating it as a facilitator.

Table 2
Analysis of facilitators and barriers to physical activity and physical education at school by country of residence.

Questions for those who practice physical activity/sport at school					
Question	Chile n = 103	Colombia n = 47	Spain n = 34	Peru n = 79	Total n = 263
Are you a member of any sports clubs or workshops outside school?					
No	77.7%	68.1%	50.0%	62.0%	67.7%
Yes	22.3%	31.9%	50.0%	38.0%	32.3%
How long have you been engaging in physical activity/sport?					
Between 1 and 3 years	31.1%	6.4%	26.5%	38.0%	28.1%
More than 3 years	25.2%	10.6%	50.0%	20.3%	24.3%
Less than one year	43.7%	83.0%	23.5%	41.8%	47.5%
What don't you like about sports?					
It is difficult for my parents to take me	0.0%	2.1%	0.0%	1.3%	0.8%
I am too busy with other activities	6.8%	0.0%	5.9%	2.5%	4.2%
I like everything about sports	51.5%	40.4%	38.2%	39.2%	44.1%
There are no children my age to play sport with	3.9%	0.0%	2.9%	3.8%	3.0%
I don't like it when others have to help me	1.9%	4.3%	2.9%	6.3%	3.8%
Other people think I am strange	3.9%	6.4%	0.0%	2.5%	3.4%
I get tired	0.0%	2.1%	0.0%	3.8%	1.5%
Playing sports is expensive	4.9%	0.0%	2.9%	2.5%	3.0%
I'm afraid of falling and hurting myself	9.7%	19.1%	23.5%	15.2%	14.8%
I have problems because of my disability	16.5%	21.3%	23.5%	21.5%	19.8%
I have to travel far to get to a sports club	1.0%	4.3%	0.0%	1.3%	1.5%
Questions to those who do not practice physical activity/sport at school					
Question	Chile n = 46	Colombia n = 6	Spain n = 8	Peru n = 39	Total n = 99
Why don't you practice physical activity at school?					
My school excludes me	0.0%	16.7%	50.0%	23.1%	14.1%
There are no children my age	6.5%	0.0%	12.5%	0.0%	4.0%
I don't like to be helped	4.3%	0.0%	0.0%	0.0%	2.0%
I don't like sports	32.6%	33.3%	12.5%	7.7%	21.2%
I can't find a sport	10.9%	16.7%	0.0%	10.3%	10.1%
I'm afraid of falling and hurting myself	17.4%	33.3%	12.5%	41.0%	27.3%
I have problems because of my disability	28.3%	0.0%	12.5%	17.9%	21.2%
Do you practice physical activity or sport outside school?					
No	87.0%	66.7%	37.5%	87.2%	81.8%
Yes	13.0%	33.3%	62.5%	12.8%	18.2%

NB: Data expressed in percentages

Figure 3
Engaging in physical activity and/or sport in the school context.



NB: OR = Odds Ratio, CI = Confidence Interval, χ^2 = Chi Square, $p < .05$*, $p < .01$**

Discussion

The aim of this research is to analyse the barriers and facilitators for students with disabilities in Physical Education. The results of the study are significant, with 72.7% of the students surveyed reporting active participation in PE lessons. Moreover, the experiences of these students appear to be positive (see Table 2), and the main barriers to participation are intrinsic to the participants themselves (19.8% express dislike for physical activity due to issues related to their disability, and 14.8% fear injury). This aligns with Jaarsma's (2014) study, which identifies disability as a frequently mentioned barrier, especially for those with greater severity. Conversely, the results contrast with recent reviews that explored the experiences of students with disabilities in PE (Haegele & Sutherland, 2015; Holland & Haegele, 2021), which concluded that these students still face discrimination and exclusion, primarily from teachers and non-disabled peers. Additionally, only 32.3% practice extracurricular physical activities or sports, highlighting the need to continue promoting inclusive PE through programmes that encourage sports participation among people with disabilities, such as the "Inclusive Sport in School" programme (Ocete et al., 2016). Furthermore, ongoing teacher training remains a significant barrier to promoting inclusion in PE (Wilhelmsen & Sørensen, 2017), as reflected in our research where the teacher is not mentioned as a facilitator.

Regarding the participation of children with disabilities in extracurricular sports, the majority of the population in the study countries (50%-77.7%) do not belong to a sports club or attend workshops outside of school, which may be related to barriers to accessing government or non-governmental services and programmes. These barriers have been studied by various authors, such as Lagos et al. (2022), who conducted a literature review and found environmental and contextual barriers related to the lack of adapted and inclusive activities, as well as opportunities to access them, due to architectural and attitudinal barriers and inadequate professional training, which influences the design and implementation of programs and projects offered in different countries. This, in turn, aligns with Jaarsma's (2014) findings, which highlighted transportation, dependence on a helper and social acceptance as environmental barriers that limit participation.

The barriers identified by Lagos et al. (2022) were also found by Rincón et al. (2022), who concluded from their mixed-methods study that the main barriers to physical activity were related to personal conditions interconnected with the disability situation, as identified in the current study (e.g., "I have problems due to my disability" 16.5% to 23.5%), as well as social and contextual conditions related to a lack of understanding of concepts like cerebral palsy, disability and physical activity, inadequate professional

training, poor communication with government entities offering programmes, as well as inaccessible and unadapted environments.

Similarly, Camargo et al. (2023) conducted a narrative review of research in South American countries related to disability and physical activity, identifying that the main barriers for physical activity among children and adolescents in school and outside school were related to physical accessibility, attitudinal barriers and a lack of training for professionals in adapted physical activity and sports.

On the other hand, regarding participation in sports by CAD, schools, as mentioned by Simões et al. (2018) and Camargo et al. (2023), are recognised as promoters of inclusion in sports, which encourage participation in sports, fostering "processes of adaptation, social participation and skill development without restricting the participation of students with disabilities, demonstrating the realisation of inclusive work" (p. 965). This aligns with our findings, where most surveyed CAD, especially in countries like Chile and Colombia, express that they "like everything about sports" (38.2%-51.5%), which may be related to actions taken within schools that enable them to experience and engage in sports, generating motivation for participation.

Concerning the question "How did you start practicing physical activity?", the main answers correspond to "Someone told me to at the rehabilitation centre", together with "Someone told me to at school" or "The doctor recommended it". This is consistent with what Muñoz-Hinrichsen and Martínez Aros (2022) suggest, that "Physical activity should be understood as a social determinant for the rehabilitation of people with disabilities, thus providing a basis for developing plans and programmes focused on international guidelines for community-based rehabilitation with an ecological model. In this sense, we question whether university curricula related to rehabilitation include courses on sports for CAD or adapted physical activity, given the very low recommendation indicator". On the other hand, the item "My parents and guardians encouraged me to" received 26.4% of responses. Although many studies suggest addressing inclusion and awareness issues in sports and physical activity for children with disabilities at school, it is crucial to also consider social plans for parents, as they often influence decisions regarding their children and young people with disabilities. Paz-Maldonado (2021) notes: "Awareness and understanding within the community often allowed people with disabilities to participate in sports activities for the first time as part of outreach visits" (p. 7), indicating that there is still much to be done in terms of disability and inclusion, and that some awareness activities can create and enable better experiences for inclusion.

Regarding the question "Why do you practice physical activity or sports?" the item "Because it is good for me" stands out with 36.7%, indicating a positive and significant perception of physical activity and sports, which is encouraging for the continued promotion of sports and physical activity among CAD. This aspect is strongly related to motivation as a personal characteristic of the participants, which becomes an important facilitator in physical activity, emphasising the relevance of this variable and supporting students in this area (Jaarsma et al., 2014).

The item "Because my family does sports," with 20% of responses, is also a good indicator for continuing to promote the importance of physical activity in CAD from the family level. As Lagos et al. (2022) highlight, family is a key actor, alongside their environment and early stimulation from a young age. The item "Because I like to win" has the lowest percentage, likely because participants view sports as beneficial through regular practice and from a health or recreational perspective, rather than a competitive one. It thus becomes a space for socialisation and inclusion in the community, since it is a secure environment that facilitates effective participation, increasing the opportunity for physical activity and sports within the educational setting (Carbone et al., 2021).

Regarding the characteristics of CAD who did not participate in physical activity and sports at school, these can be analysed in various ways. On one hand, given that Physical Education is considered to be a key setting for learning and practicing movement and sports during childhood, it is incongruent that instances of exclusion occur in these activities, which are likely due to insufficient teacher training (Tanure Alves et al., 2017).

Goodway and Robinson (2015) point out that the lack of resources, adaptations, materials and suitable spaces in schools impedes the participation of children with disabilities in motor activities, potentially leading to an inability to find a suitable sport. Block et al. (2013) note that children with disabilities require specific adaptations and individualised support for participation in physical activities. The lack of resources and adequate personnel can hinder the provision of these supports, leading to their exclusion from school physical activities.

The implementation of safety protocols and appropriate spaces can help address these concerns and enable safe participation (Rimmer et al., 2007). A child's lack of interest in sports might be influenced by various factors, such as physical limitations, social barriers, lack of access to inclusive programmes, fear of failure or previous negative experiences. It is important not to assume that all children with disabilities dislike sports without considering their individual experiences (Ross et al., 2016).

The main limitations of this research include the need for a larger number of participants to achieve population representativeness, opening avenues for new work with governmental institutions to explore various regions in greater depth. It would be interesting to gather parents' opinions to compare the information and identify additional variables that may not be included in the analysis. Collecting data in other countries in the region is necessary to broaden the analysis.

It is worth considering that, despite the fact that the various organisations propose physical activity, sport and physical education as one and the same, there are important differences, which is why it would be important to address them in an appropriate manner and under the nomenclature proposed at the international level with the aim of providing a contextualised approach to each of them.

Conclusions

The results obtained in this research highlight the positive impact that educational policies are having in countries on inclusion processes within physical activity contexts for CAD. Specifically, Physical Education at school appears to be the ideal environment for students with disabilities to share space, materials and activities with their non-disabled peers inclusively, thereby increasing their levels of physical activity. It can be concluded that being a boy versus a girl is associated with being a facilitator for engaging in physical activity and sports at school, whereas having physical and intellectual disabilities are barriers to optimal performance.

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European approach to the importance of sports management competencies in women's semi-professional teams

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Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/Ritchie B. Tongo)

Abstract

The competencies and skills of a good sports manager have always been a controversial and diverse topic depending on the country and the context in which it is analysed. That is why this research aims to show which are the most valued competencies by sports managers in several European countries, taking into account gender differences. A total of 209 sports managers from semi-professional women's teams participated in the research. They completed a questionnaire in which different dimensions were evaluated, assessing the importance of the different competencies of a sports manager. The results showed that greater importance was given to skills related to the management of sports facilities and less to human resources management. Differences related to gender were scarce, with significant differences found only in the competence of Strategic Planning Management. In conclusion, it is difficult to agree on the importance of the competencies of a good sports manager, while agreeing on the need for analysis in the areas of finance, event management, planning and management of sports facilities.

Keywords: athletes, Europe, females, skills, sport manager.

Introduction

In Europe, various public sport policies were established under the motto "Sport for All" with the aim of promoting regular sports participation for all individuals without discrimination. These policies were developed to encourage healthy lifestyles and overall well-being (Dichter et al., 2019; Dyreson, 2011). The topic and necessity of professionalizing sports organizations was instantly brought up by this new paradigm of global sports development (Girginov, 2010; López-Carril et al., 2019). The Council of the European Union (EU) has approved statements regarding the significance of sports in fostering active social inclusion. These statements highlight three main areas of focus for enhancing social inclusion through sports: ensuring access to sports for all individuals, maximizing the potential of sports to strengthen communities, social unity, and development, and facilitating international sharing of strategies and approaches (Hylton & Totten, 2013), among which we can include gender equality in sport. Specifically, in terms of equality, at the EU level there are numerous regulatory instruments and public policy documents such as the Recommendations of the Expert Group on Good Governance on Gender Equality in Sport (2016), where it is stated that "policy makers and stakeholders in sport should develop a more comprehensive understanding of the value of gender equality to improve the governance and performance of sport organizations, both from a social and economic point of view". Likewise, the EU Roadmap for Sport 2017-2020 promotes gender equality in sport, as well as the benefits and challenges of the digital single market for better financing and commercialization of sport in its second priority related to the economic dimension of sport. From this perspective, the need arises to analyse which are the main competencies and skills that a future professional must possess or improve in order to manage and work in sports organisations (Sesinando et al., 2022).

Despite these policies, some research highlights that the attributes associated with a successful manager are still linked to masculinity, making it difficult for women to access leadership positions (Campuzano, 2019). This indicates a resistance to gender balance in sports governance, also due to the sports capital and habits of board members, and their ability to use this to normalize judgments that may exclude women (Knoppers et al., 2021; Pérez-Chuecos & Rodríguez-Ferrán, 2021). Additionally, other barriers they face include difficulty in achieving a work-life balance; social and traditional roles; preconceived ideas about women in management positions; gender discrimination; the existence of male predominance in sports and cultural environments, as well as the devaluation of women's skills (Albu & Grigore, 2020).

Recent studies indicate that sport management as a multidisciplinary field encompasses various areas such as sports economy, sports law, leadership, accounting, sports marketing, event planning, auditing, public policies, and many others (Teixeira et al., 2019; Zanatta et al., 2018). However, there is a great variety regarding the manager's competencies, due to the different cultures and contexts in which sports management takes place. Previous investigations attached greater importance to certain skills such as sport-related theory and foundations, foreign language and learning ability and management techniques (Ko et al., 2011). Competencies that are deemed most important in the United States include budgeting, setting priorities, delegation skills, planning, and personnel evaluation (Case & Branch, 2003), while in Portugal, highlighted competencies include planning, resources management, leadership, specialized knowledge, and ethical behavior (Joaquim et al., 2011). Strategic planning skills and relationship marketing were other skills suggested by Brazilians researchers (Sordi & Theobald, 2017). In this research, we used a validated questionnaire (Isai, 2015) to identify the competencies perceived as essential by the sport managers from different European countries among which the following stand out, some of them coinciding with previous investigations (Quero-Calero et al., 2022): Sport Facility, Marketing and Financial, Strategic Planning, Research, Human Resources and Event Management.

In accordance with the above, there is no clear consensus on the skills and competencies that a sports manager should possess to ensure better economy of resources, even less so for managers of women's teams. For this reason, the general aim of this research was to analyse the perceived importance of sport management competencies of managers/directors of semi-professional women's sports teams. The specific objectives were as follows: a) to find out the differences between genders with respect to the perceived importance of sport management competencies, and b) to determine the differences between managers from different European countries with respect to the perceived importance of sport management competencies.

Method

This study is cross-sectional, descriptive, and quantitative. All participants were also asked to provide written informed consent before participating in the study, which had been previously approved by the ethics committee of the Catholic University of Murcia (Spain) following current legislation (CE112002), in accordance with the code from the World Medical Association and the Declaration of Helsinki.

Participants

A total of 209 managers/directors of semi-professional women's sports teams participated in the survey (Z = 95 %; e = 6.8 %), with 57.9 % of them being women (n = 121) and 42.1 % being men (n = 88) and mean age 38.89 ± 9.00. The majority (84.2 %) of respondents had a college degree (50.2 % had a bachelor's, 26.8 % had a master's, and 7.2 % had a PhD). In terms of origin, there were 44 respondents from Spain (n = 21.1 %), 44 from Bulgaria (n = 21.1 %), 41 from Germany (n = 19.6 %), 40 from Italy (n = 19.1 %), and 40 from Croatia (n = 19.1 %).

Based on the sample's accessibility and willingness to engage in the study, non-probability through convenience sampling was used. The following were the inclusion requirements: older than 18 years, manage or direct a semi-professional women's sports European team and more than a year's worth of experience in this job.

Instruments and material

The questionnaire created by Isai (2015) was used to examine how important various competencies were thought to be by sport managers. There were 24 items total in the tool, which were broken down into six distinct factors: F1 *Sport Facility Management* (7 items), F2 *Marketing and Financial Management* (6 items), F3 *Strategic Planning Management* (4 items), F4 *Event Management* (3 items), F5 *Human Resources Management* (2 items), and F6 *Research* (2 items). The response options ranged from 1 (not at all important, unnecessary) to 7 points (very important, crucial) on a Likert scale. Cronbach's alpha was used to analyse the instrument's internal consistency (F1 α = .90; F2 α = .87; F3 α = .92; F4 α = .92; F5 α = .90; and F6 α = .88), considered as high (Corbetta, 2007).

Procedure

Data collection took place over a six-week period (from 1 June to 12 July 2020). Participants received the survey electronically through the Google Forms® survey platform. As long as participants met the requirements for inclusion and there was no financial or academic incentive for them to participate, there were no restrictions on participation. Anonymity was also ensured during the data processing and analysis.

Data analysis

Using the Lilliefors significance correction of the Kolmogorov-Smirnov test, the distribution of the data was analysed, and a value of less than .05 was obtained. As a result, non-parametric statistical tests were employed for the corresponding analysis of the data because the data did not adhere to the normality assumptions. Two different sorts of analysis were done in order to address the study's goal. The quantitative variables' descriptive analysis (mean and standard deviation) came first. Second, Mann-Whitney U and Kruskal-Wallis H were used to analyse the variables in relation to the respondent's gender and home country, respectively. The SPSS® Statistics v.27.0 software suite was used to conduct the statistical analysis.

Results

According to the perceived significance of the competencies that make up the elements of the questionnaire, the study's findings are shown below: F1 *Sport Facility Management* has seven items, followed by F2 *Marketing and Financial Management*, six items, F3 *Strategic Planning Management*, four items, F4 *Event Management*, three items, for F5 *Human Resources Management*, and two items for F6 *Research*. The link between the variables was also examined in regard to the respondent's gender and country of origin.

Concerning the general descriptive results, the competencies to which managers gave most importance are those related to *Sport Facility Management* (F1; 6.21 ± 0.67). On the contrary, those related to *Human Resources Management* (F5; 5.73 ± 1.08) were the worst rated by respondents (Table 1).

Regarding the perceived importance of each of the items that make up the factors, sport managers gave the highest value to the competencies related to *Implementing actions to prevent incidents and accidents* (F1; 6.48 ± 0.78) followed by *Developing strategies for minimizing the impact of potential risks* (F1; 6.46 ± 0.72). On the contrary, the least rated were those concerning *Defining and setting up quality standards for employees* (5.71 ± 1.12) and *Fostering data analysis for research purposes* (5.71 ± 1.16), followed by *Evaluating employee performance based on results* (5.76 ± 1.15).

The results according to the gender of the respondents (Table 2) showed that male sport managers gave a higher mean score in the rating of perceived importance in all the factors analysed. However, statistically significant differences (U = 4,394.00; p = .028; r = .152) with respect to the female gender were only found in F3 (*Strategic Planning Management*).

Table 1
Descriptive results of the perceived importance of sport management competencies.

Factors	$\overline{X}$ ± SD	Min	Max
1. Sport Facility Management	6.21 ± 0.67	3.57	7.00
Implementing a proper plan for preserving equipment	6.07 ± 0.91	3	7
Implementing appropriate means of storing equipment and supplies	6.07 ± 0.82	4	7
Implementing actions to prevent incidents and accidents	6.48 ± 0.78	3	7
Developing actions to prevent misuse of facilities	6.06 ± 0.90	2	7
Developing strategies for minimizing the impact of potential risks	6.46 ± 0.72	2	7
Maintaining and repairing facilities	6.04 ± 0.99	3	7
Conducting routine inspections of facilities and equipment	6.31 ± 0.80	3	7
2. Marketing and Financial Management	6.11 ± 0.75	1.83	7.00
Applying accounting principles in the organization and developing a financial plan	6.23 ± 0.94	1	7
Analyzing financial reports for decision making	6.00 ± 0.93	2	7
Preparing and defending a budget proposal	6.00 ± 0.92	2	7
Preparing financial reports	5.83 ± 1.09	1	7
Utilizing sponsorships to support sport activities	6.34 ± 0.88	1	7
Preparing and defending sponsorship proposals	6.27 ± 1.00	1	7
3. Strategic Planning Management	6.09 ± 0.75	4.25	7.00
Translating strategies into clear objectives, tactics, and action plans	6.11 ± 0.82	4	7
Using indicators to measure advance of strategies and helping decision making	6.07 ± 0.82	3	7
Managing the implementation and organization of project activities	6.08 ± 0.87	3	7
Managing work teams to effectively achieve the project goals	6.13 ± 0.80	4	7
4. Event Management	6.11 ± 0.87	3.67	7.00
Scheduling sport activities (sport competitions, sport clinics, conferences, seminars, etc.)	6.24 ± 0.86	4	7
Conducting an event needs assessment	5.87 ± 1.10	4	7
Coordinating event's units such as planning, communication, booking, etc.	6.22 ± 0.84	3	7
5. Human Resources Management	5.73 ± 1.08	2.50	7.00
Evaluating employee performance based on results	5.76 ± 1.15	1	7
Defining and setting up quality standards for employees	5.71 ± 1.12	2	7
6. Research	5.88 ± 1.02	1.00	7.00
Establishing strategic alliances with universities	6.06 ± 0.98	1	7
Fostering data analysis for research purposes	5.71 ± 1.16	1	7

Table 2
Descriptive results of the perceived importance of sport management competencies according to gender.

Factors	$\overline{X}$ ± SD	Gender		*U*	*r*	*p*
		Female	Male			
1. Sport Facility Management	6.21 ± 0.67	6.17 ± 0.63	6.27 ± 0.72	4,685.00	.103	.135
2. Marketing and Financial Management	6.11 ± 0.75	6.11 ± 0.66	6.12 ± 0.87	4,943.50	.061	.374
3. Strategic Planning Management	6.09 ± 0.75	6.00 ± 0.75	6.22 ± 0.73	4,394.00	.152	.028*
4. Event Management	6.11 ± 0.87	6.03 ± 0.88	6.21 ± 0.85	4,620.50	.115	.095
5. Human Resources Management	5.73 ± 1.08	5.68 ± 1.05	5.81 ± 1.13	4,883.00	.072	.297
6. Research	5.88 ± 1.02	5.86 ± 0.92	5.91 ± 1.14	4,984.50	.056	.421

Note. Significance level *$p < .05$ **$p < .01$ ***$p < .001$.

Table 3
Descriptive results of the perceived importance of sport management competencies according to country.

Factors	Country					*H*	E_R^2	*p*
	Spain	Italy	Croatia	Bulgaria	Germany			
1. Sport Facility Management	6.16 ± 0.63	6.06 ± 0.43	6.90 ± 0.22	6.22 ± 0.81	5.73 ± 0.49	83.793	.403	< .001***
2. Marketing and Financial Management	6.02 ± 0.83	6.13 ± 0.42	6.72 ± 0.41	6.00 ± 1.00	5.74 ± 0.50	53.112	.255	< .001***
3. Strategic Planning Management	6.06 ± 0.65	5.68 ± 0.61	6.83 ± 0.39	6.35 ± 0.67	5.55 ± 0.59	81.337	.391	< .001***
4. Event Management	6.27 ± 0.81	5.38 ± 0.66	6.89 ± 0.29	6.45 ± 0.65	5.52 ± 0.80	98.829	.475	< .001***
5. Human Resources Management	5.97 ± 0.73	4.85 ± 0.84	6.88 ± 0.33	6.10 ± 0.85	4.84 ± 0.91	110.761	.533	< .001***
6. Research	5.89 ± 1.15	5.15 ± 0.69	6.88 ± 0.35	6.30 ± 0.75	5.17 ± 0.72	102.259	.492	< .001***

Note. Significance level *$p < .05$ **$p < .01$ ***$p < .001$.

Finally, with regard to the results according to the surveyed sport managers' home country, statistically significant differences were detected in all the factors analysed (F1 $H = 83.793$, $E_R^2 = .403$, $p < .001$; F2 $H = 53.112$, $E_R^2 = .255$, $p < .001$; F3 $H = 81.337$, $E_R^2 = .391$, $p < .001$; F4 $H = 98.829$, $E_R^2 = .475$, $p < .001$; F5 $H = 110.761$, $E_R^2 = .533$, $p < .001$; F6 $H = 102.259$, $E_R^2 = .492$, $p < .001$) (Table 3).

Regarding the most highly rated competencies, Spanish managers gave a higher importance to the competence related to *Event Management* (6.27 ± 0.81), as did respondents from Bulgaria (6.45 ± 0.65). The Italians rated more positively the competencies related to *Marketing and Financial Management* (6.13 ± 0.42) as well as respondents from Germany (5.74 ± 0.50). Finally, and matching the highest value given to one of the competencies, Croatian managers considered the most important one to be *Sport Facility Management* (6.90 ± 0.22). In relation to the lowest rated competencies, Bulgarian (6.00 ± 1.00) and Croatian (6.72 ± 0.41) sport managers considered these to be related to *Marketing and Financial Management*. For Italy (4.85 ± 0.84) and Germany (4.84 ± 0.91), they agreed on the lowest value for perceived importance to *Human Resources Management*. Finally, the Spanish managers (5.89 ± 1.15) considered less important the competencies related to *Research*.

Discussion

The areas of concern for sport managers are diverse and call for a variety of difficult-to-define skills because they differ depending on the organization's structure, the culture, and the

national policies (Lis & Tomanek, 2020). The primary goal of this study was to examine how directors and managers of semi-professional women's sports teams in Europe perceive the importance of sport management competencies.

Six competency elements (sport facility management, marketing and financial management, strategic planning management, event management, human resources management, and research) for sport managers in Guatemalan sport organizations were included based on the study of Isai (2015). In this regard, the sport managers surveyed gave a higher importance to the competencies related to *Sport Facility Management*, while those related to *Human Resources Management*, were given a lower score. In the same line, previous research highlighted facility maintenance management as one of the competencies most valued by sport club managers to perform a competent work, as well as equipment management and risk management (Batista et al., 2016; Eksteen et al., 2013). In relation to the latter, the items most highly valued by respondents within the Sport Facility Management factor were *Implementing actions to prevent incidents and accidents* followed by *Developing strategies for minimising the impact of potential risks*. In this respect, in the research carried out by Case and Branch (2003), sport facility managers gave greater importance to the competencies related to safety and security needs assessment and risk management for the development of their functions. Regarding the importance of the competence related to *Human Resources Management*, previous studies show contradictory results since, for example, while the research by Koustelios (2005) on the managerial competencies of sport club managers in Greece, coincides in indicating this competence as the least valued, the study by Eksteen et al. (2013) of sports club managers in South Africa, places generating job descriptions, managing employee training and managing induction of employees as some of the competencies that are given greater importance. Despite the results obtained, sport managers should improve or acquire human resources skills (Sordi & Theobald, 2017), as it is one of the specific managerial activities in which they invest more time (Whisenant & Pedersen, 2004).

In relation to the gender of sports managers, there is a growing number of women occupying positions of leadership, high responsibility, and expertise, thus making the issue of gender equal representation a topical subject (Piggott & Pike, 2020; Swanson et al., 2020). Nevertheless, research from earlier studies shows that male gender is still prominent among professionals active in sports management despite a recent surge in female sport managers (Azevêdo & Spessoto, 2009; Batista et al., 2016; Da Cunha Bastos et al., 2006; De Miranda et al., 2017; Dragos & Cristea, 2016; Eksteen et al., 2013; Filho et al., 2013; Ko et al., 2011; Retar et al., 2013; Ross & Schurger, 2007; Santos et al., 2022; Sarmento et al., 2006; Sesinando et al., 2022; Tripolitsioti, 2005), coinciding with the gender stereotypes associated with the sporting context (Granda Vera et al., 2018; Martínez-Abajo et al., 2020). In this study, there are more women than men, a circumstance that coincides with other studies such as those conducted by Mohammadi et al. (2016) and Mohammadi and Dehkordi (2013). This could be due to female sport organization employees having more positive attitudes towards women managers, which can help overcome the barriers faced by women in advancing to top managerial positions (Chullen et al., 2017; Koca & Öztürk, 2015; Sertkaya et al., 2013).

In relation to the importance given to the competencies according to gender, men give on average higher scores to all the factors than women, and both genders coincide in the highest and lowest scores, with no differences with respect to the overall results. In this case, statistical differences are only detected with respect to the *Strategic Planning Management* competency, which is scored significantly higher by men. Gender differences are also not significant in terms of the time sport managers spend on specific management activities (Whisenant & Pedersen, 2004). While earlier studies have identified gender-specific obstacles that women encounter in their career paths, especially gender bias and inadequate institutional support, and the lack of respect and acknowledgment, some participants have reported that gaining credibility in a work culture dominated by men has been a significant challenge (Ross & Schurger, 2007).

Finally, the last objective was to determine the differences between managers from different European countries with respect to the perceived importance of sport management competencies. In this respect, there are statistical differences between countries in relation to the scores given to each of the competencies analysed. Specifically, the most rated competencies are *Event Management* for Spain and Bulgaria, *Marketing and Financial Management* for Italy and Germany and *Sport Facility Management* for Croatia. On the contrary, the less rated are *Marketing and Financial Management* for Bulgaria and Croatia, *Human Resources Management* for Italy and Germany and *Research* for Spain. Previous research suggests that variations in competencies required and those perceived as significant by practitioners and academics can be attributed to cultural and contextual differences (Ko et al., 2011). Therefore, it is important to consider the specific context of competency studies in sport management as there are significant differences between national cultures and results cannot be generalized to other countries. Studies reveal a difference in assessed competencies among managers of different nationalities, which can be attributed to cultural differences (Boutet et al., 2000; Chong, 2008).

Conclusions

Based on the provided search results, it is evident that the importance of sport management skills for directors and managers of semi-professional women's sports teams in Europe places more emphasis on competencies related to managing sports facilities and less on those related to managing human resources. Gender differences are only significantly different with regard to competencies related to strategic planning management, with men giving greater importance to these competencies than women. Additionally, significant differences in the scores awarded can be detected between the countries where sport managers work, although Italy and Germany coincide in the most and least important management competencies.

The results of this research will enable the development and implementation of sports and educational policies tailored to the socio-cultural context of the country, as well as to the specific needs of semi-professional female sports team managers. Similarly, the obtained results serve as a starting point for future research in the field.

Nevertheless, the study has some limitations, such as the small number of participating countries, which is essentially due to the consortium of countries that participated in the European project. It would be recommendable for future research to increase the number of participating countries. Another limitation of this research would be the fact that no comparisons have been made between managers of female and male teams. Furthermore, educational courses and further studies focusing on the competencies of sport managers would be advisable, not only among managers and directors, but also among athletes and all parties involved in sport, in order to be able to detect weaknesses and strengths to be taken into account by sports managers of women's teams.

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Analysis of the submaximal intensity periods during the competitive microcycle in professional football players

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Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/ Ritchie B. Tongo)

Abstract

The study aimed (a) to determine the conditional demands of external load based on the submaximal intensity periods (SubMIP) during the competitive micro-cycle, (b) to compare the number and duration of SubMIP events demanded in the different sessions carried out in the competitive micro-cycle and, additionally, (c) to compare these demands based on the SubMIP depending on the specific position occupied by the football players during the competitive micro-cycle. A total of 77 training sessions were analyzed during 15 competitive micro-cycles and 15 official league matches during the 2019-20 season (Azerbaijan Premier League) obtaining a total of 1,037 individual records from 22 players. Data were collected using GPS devices. To determine the percentage of the number of daily SubMIP events with respect to those found in the competition, these events were also relativized based on the individual profile showed by player in competition. The main findings of the study were the existence of significant differences ($p \leq .05$) in each of the variables between training days/competition and positions based on the SubMIP. Metrics such as distance at speed > 19.8 km/h (HSR), distance at speed > 25.2 km/h (Sprint), acceleration density (AccDens) and distance at high metabolic intensity > 25.5 W/kg (HMLD) accumulated values > 50 % of the number of SubMIP events on some days of the microcycle. However, other metrics displayed much lower ranges (less than 15 %) compared to the competition in terms of the number of events and time above the threshold established in meters per minute (Mmin) and mean metabolic power (MetPow) variables. These new findings suggest that it is appropriate to explore new alternatives for load control in team sports.

Keywords: GPS, physical demands, soccer, team sports, training load.

Introduction

The tools for monitoring athletes' internal and external load are part of the assessment in contemporary training methodology (Jaspers et al., 2017). In outdoor team sports the global positioning system (GPS) provides valuable data to coaches and researchers, enriching the understanding of training and competition sessions (Oliva-Lozano et al., 2022).

During the last seasons there has been an increase in physical demands in football matches (Barnes et al., 2014), being an aspect to be considered in the daily and weekly training schedules to achieve high levels of individual and collective performance (García et al., 2022; Jaspers et al., 2017; Reilly, 2005). On that context it is critical to manage optimal training load in terms of frequency, intensity, and volume (Akenhead et al., 2016; Gabbett et al., 2016) attending to individual competition demands (Illa et al., 2020b).

This study provides relevant information on the conditional demands across different variables in team sports during the competitive micro-cycle, in a similar manner to previous research (Diaz-Seradilla et al., 2022; García et al., 2022; Martin-Garcia et al., 2018). Recent studies have described microcycles based on different variables (with absolute values or relative to competing demands) (Akenhead et al., 2016; Diaz-Seradilla et al., 2022; Martin-Garcia et al., 2018), also studying the effect of the duration of the microcycle on the accumulated training load (Clemente et al., 2019; Oliva-Lozano et al., 2022) or comparing different training and matches micro-cycles structures (e.g., four training sessions and one official competition match) (Diaz-Seradilla et al., 2022), and how the distribution of the load can affect the result of the match (Chena et al., 2021).

Research into maximum intensity periods (MIPs) in football has grown, with studies in competition (Oliva-Lozano et al., 2020) and training (Dios-Álvarez et al., 2024) finding a link between the duration of the analyzed time window and the intensity displayed by players (Rico-González et al., 2022). However, considering the intermittence profile manifested in team sports (Johnston et al., 2014), the analysis based on absolute values or MIPs may not capture the full extent of a players activity (Carling et al., 2019; Gabbett et al., 2016), particularly during sub-maximal intensity periods. The exclusive use of information provided by MIPs for the purpose of prescribing training (Novak et al., 2021) limitation has raised the need for new ways to measure athletes' load during training and competition. Specifically, the MIP reports a single event that does not assess the demand to which players are subjected in sub-maximal intensity periods. In this sense, the high demands (sub-maximal) that are presented repeatedly (Carling et al., 2019), question the exclusive use of the information provided by the MIPs for the purpose of prescribing training (Novak et al., 2021).

For all these reasons, it seems opportune to research for new alternatives to quantify athletes' load during training and competition (Caro et al., 2022). Similar studies have been conducted in other sports such as futsal (Illa et al., 2020a; Johnston et al., 2020) and in training sessions (Illa et al., 2020b). Showing considerable variations for each metric during matches, with total distance and acceleration actions being the most demanding at sub-maximal intensities (80-90 % and > 90 % of MIP) compared to the rest of the variables analyzed (Illa et al., 2020). Regarding intensity distribution with respect to the MIP during competitive matches in Australian rugby and football, Johnston et al. (2020) concluded that the activity distribution decreased as it approached maximum values.

In relation to the analysis of the competitive micro-cycle, Illa et al. (2020a) found differences between training and competition days, specifically in Player Load metric, distance, high-intensity decelerations, and accelerations (Illa et al., 2020b).

In football, the competition has been studied from this approach (Caro et al., 2022), showing differences primarily in individual performance, especially in the variables of distance covered at speed > 19.8 km/h (HSR), acceleration density (AccDens), mean metabolic power (MetPow), meters per minute (Mmin) and in distance covered at high metabolic intensity > 25.5 W/kg (HMLD). There are also differences between halves in AccDens, MetPow and Mmin variables and between positions in MetPow and Mmin, in number of sub-maximal intensity (SubMIP) events and in time above the sub-maximal threshold (Caro et al., 2022).

The study aimed (a) to determine the conditional demands of external load based on the SubMIP periods during the competitive micro-cycle, (b) to compare the number and duration of SubMIP events demanded in the different sessions carried out in the competitive micro-cycle and, additionally, (c) to compare these demands based on the SubMIP depending on the specific position occupied by the football players during the competitive micro-cycle.

Method

Participants

Fourteen male professional footballers from the same Azerbaijan Premier League team participated in this study (73.74 ± 5.92 kg, 1.79 ± 0.05 meters, 23.86 ± 3.58 years). To qualify for the analyses, players needed to have completed at least three matches and all sessions of the analyzed micro-cycle. Thus, players in Return-To-Play processes, those doing specific post-training work (top-up), or those facing unusual circumstances (e.g., suspension from the next competitive

match) were excluded. Daily data was recorded post each session or match. All participants were part of another published retrospective study (Caro et al., 2022).

All participants were informed of the study's risks and benefits and provided consent as per the Declaration of Helsinki (Fortaleza, 2013), approved by the Catalan Sports Council's Ethics Committee for Clinical Research, number 035/CEICGC/2021.

Experimental Approach

We analyzed 77 training sessions across 15 competitive micro-cycles and 15 official league matches during the 2019-20 season, totaling 1,037 individual records. Data were collected via GPS devices.

During matches, the team consistently employed a 1-5-3-2 formation, with positions being three central defenders (CD), two wing defenders (WD), two midfielders (MID), one attacking midfielder (OMID), and two forwards (FW).

Micro-cycle structure

The micro-cycle was adjusted according to the competitive calendar. The day after a match was a recovery (MD+1R) or compensation (MD+1C) day, followed by a rest day. Workload days (MD-4 and MD-3) were four and three days pre-match, with "tapering" days (MD-2 and MD-1) two days pre-match. Only micro-cycles following this structure, as validated in previous studies (Martin-Garcia et al., 2018; Oliva-Lozano et al., 2022), were considered to maintain consistency. Training sessions primarily utilized game-based drills in which the dimensions of the game space, the number of participating players, the series duration and other rules were modified to achieve the desired objectives.

During MD+1R, the focus was on recovery for players who participated > 60' in the match, involving low-intensity aerobic work, progressive runs up to 70% of subjective individual speed, mobility exercises, and myofascial massage with foam rollers. Those who played < 60' performed compensatory work to meet the competition's conditional load, incorporating gym strength work, small position games (< 50 m² per player) (Martin-Garcia et al., 2020), and sprints at maximum intensity were therefore carried out, as suggested in previous studies (Martin-Garcia et al., 2018).

MD-4 involved specific on-field strength work (exercises with dynamic correspondence with football, CoD, accelerations and decelerations, etc.), small-position games (< 50 m² per player) and small-sided games (SSGs) played in reduced space (< 50 m² per player), with the aim of stimulating the players neuromuscularly through acceleration, braking and direction changes (Martin-Garcia et al., 2018, 2020). MD-3 focused on tactical work using tasks involving a large number of players in a large space (> 150 m² per player), aiming to recreate competition context and facilitate high and very-high speed actions (Martin-Garcia et al., 2018).

MD-2 focused on collective tactical aspects using tasks in small spaces and analytical tactical situations (11 x 0). On MD-1, the focus was on individual tactical performance using rounds, analytical tactics, positional tactical work, and set pieces. Volume and intensity varied throughout the competitive micro-cycle, as shown in Table 1.

Table 1
Average data of training sessions and match.

Day type	*n*	Distance	HSR	VHSR	Acc	Dcc	m/min
MD+1R	48	1,910.43 ± 248.46	48.89 ± 60.31	4.56 ± 11.73	1.67 ± 2.054	1.25 ± 1.97	73.04 ± 14.03
MD+1C	37	5,695.19 ±1,527.96	276.64 ± 235.26	69.98 ± 96.44	49.47 ± 14.84	43.61 ± 17.10	78.19 ± 15.03
MD-4	188	5,089.92 ± 830.17	224.69 ± 221.26	22.64 ± 36.42	45.53 ± 15.15	31.67 ± 14.22	68.92 ± 14.62
MD-3	223	5,832.92 ± 922.15	231.46 ± 108.59	48.96 ± 41.89	55.4 ± 16.69	45.60 ± 15.89	70.95 ± 9.92
MD-2	211	4,202.95 ± 853.25	134.37 ± 123.49	20.13 ± 34.09	42.03 ± 13.19	31.47 ± 12.46	62.96 ± 11.15
MD-1	222	2,802.71 ± 594.03	65.00 ± 67.62	7.26 ± 15.18	32.53 ± 11.77	23.62 ± 10.60	55.11 ± 8.59
MD	108	10,482.95 ± 958.25	671.30 ± 270.42	124.55 ± 89.91	65.33 ± 15.58	78.32 ± 19.01	110.12 ± 9.19

n: individual records, Distance: Distance in meters, HSR: Distance traveled > 19.8 km/h, VHSR: Distance traveled > 25.3 km/h, Acc: number of accelerations above 3 m/s², Dcc: number of decelerations below -3 m/s², m/min: meters per minute

Instruments

External load was monitored using GPS devices (STATSPORTS® APEX ProSeries, Northern Ireland), recording load during training and matches. The devices had a configurable sampling frequency of 10 Hz to 18 Hz, included a 600 Hz accelerometer, a 400 Hz gyroscope, and a 10 Hz magnetometer, with a weight of 45 g and dimensions of 33 x 80 x 15 mm. The validity and reliability of the device reported an error of between 1-2 % in the distance for different validation tests (400 m and 128.5 m circuit) and maximum speed in the 20 m test (Beato et al., 2018). The players wore a special vest designed to place the device at the top of the back, between the shoulder blades (Beato et al., 2018; Gimenez et al., 2020).To ensure inter-device reliability, players used the same GPS throughout all recordings (Jennings et al., 2010) and data was managed by the same experienced individual.

Procedures

During each training session and match, the following variables were analyzed: distance traveled at speeds > 19.8 km/h (HSR [High Speed Running]), > 25.2 km/h (Sprint), acceleration density (AccDens), mean metabolic power (MetPow), meters per minute (Mmin) and distance traveled at high metabolic intensity > 25.5 W/kg (HMLD [High Metabolic Load Distance]), in line with previous research (Caro et al., 2022).

Data Acquisition and Processing

Devices were turned on 15' before sessions and matches. Correct device operation was verified using live application offered by the devices (STATSPORTS® Apex Live). Raw data was exported using the brand's software (STATSPORTS® 3.0.03112) and processed in Excel (MICROSOFT®, Redmond, WA, USA), filtering records at 10 Hz using a fourth-order, double-pass Butterworth filter to minimize anomalies. For each variable, the mean of the three highest MIPs in competition was calculated to get a value relative to 100% individual (Caro et al., 2022; Illa et al., 2020a).

Data was processed using R language script through R Studio software (RSTUDIO®, Boston, Massachusetts, USA), applying a threshold of 85 % of the maximum individual average for each variable (Caro et al., 2022). Number and duration of SubMIP events were extracted for each training day individually. The information was stored in a database for statistical analysis. To determine the percentage of daily SubMIP events relative to competition, these events were also relativized based on the individual profile shown by the player in competition.

Statistical analysis

Data were presented as mean ± standard deviation. Prior to statistical analysis, the Shapiro-Wilk test confirmed that the data did not follow a normal distribution. Given this result, a mixed linear model (GLM) was employed for each variable, considering the types of day and player positions. When significant differences were found ($p < .05$), post hoc tests using estimated marginal means (EMMs) were conducted to determine where these differences resided. Intra-session reliability was determined using Guttman's Lambda 6 test with 95 % confidence intervals (Oosterwijk et al., 2016). To interpret the magnitude of differences found in the mixed linear model analysis, a standardized effect size (ES) was calculated as the ratio of the estimated effect divided by its standard error. This provides an indication of the practical significance of the observed effects. The effect sizes were evaluated in the context of the study, highlighting those contrasts that showed the most substantial differences. All statistical tests were performed using R software version 4.0.2 R Studio software (RSTUDIO®, Boston, Massachusetts, USA) with the "lme4", "lmerTest", and "emmeans" packages for fitting mixed models and conducting post hoc comparisons.

Results

There were 1,037 individual records analyzed (Table 2), distributed in MD+1R (48), MD+1C (37), MD-4 (188), MD-3 (223), MD-2 (211), MD-1 (222) and MD (108). Determining their reliability by calculating Guttman's Lambda (G6) and coefficient of variation (CV) interval values for the different days: MD+1C (G6 95 % [CI] = 0.94-0.99; CV 95 % CI = 0.89-3.33), MD-4 (G6 95 % [CI] = 0.96-0.98; CV 95 % CI = 0.86-5.01), MD-3 (G6 95 % [CI] = 0.91-0.95; CV 95 % CI = 0.74-4.65), MD-2 (G6 95 % [CI] = 0.87-0.98; CV 95 % CI = 0.97-10.01), MD-1 (G6 95 % [CI] = 0.83-0.96; CV 95 % CI = 1.14-9.13), MD (G6 95 % [CI] = 0.99-0.99; CV 95 % CI = 0.59-2.02). The lower means are found in MD+1R in all the variables except in HSR, the lower HSR mean is found on day MD-1 (Table 2).

Table 2
Mean and Standard Deviation for each of the Day Types by Position.

Position	*n*		AccDens	Duration Acc Dens	MetPow	Duration MetPow	Mmin	Duration Mmin	HSR	Duration HSR	Sprint	Duration Sprint	HMLD	Duration HMLD
CD	15	MD+1 R	0.33 ± 0.62**	0.4 ± 0.77**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.2 ± 0.41	0.22 ± 0.45	0 ± 0	0 ± 0	0.13 ± 0.35	0.14 ± 0.37
WD	12		0.25 ± 0.45*	0.36 ± 0.65**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
MID	6		0.6 ± 1.34	1.08 ± 2.41	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.2 ± 0.45	0.21 ± 0.47	0 ± 0	0 ± 0	0 ± 0	0 ± 0
OMID	7		0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.17 ± 0.41	0.17 ± 0.42	0 ± 0	0 ± 0	0 ± 0	0 ± 0
FW	8		0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.13 ± 0.35	0.13 ± 0.37	0 ± 0	0 ± 0	0 ± 0	0 ± 0
CD	12	MD+1 C	0.33 ± 0.82**	0.37 ± 0.91**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.33 ± 0.52	0.355 ±0.55	0.17 ± 0.41	0.18 ± 0.45	0 ± 0	0 ± 0
WD	9		0.92 ± 1.78	1.42 ± 2.96	0.08 ± 0.29	0.09 ± 0.31	0.08 ± 0.29	0.09 ± 0.32	0.42 ± 0.51	0.72 ± 1.25	0.17 ± 0.39	0.42 ± 1.18	0.33 ± 0.49	0.43 ± 0.68
MID	6		1.89 ± 2.52	2.96 ± 4.02	0.22 ± 0.44	0.28 ± 0.56*	0.11 ± 0.33	0.16 ± 0.49	0.33 ± 0.71	0.5 ± 1	0.33 ± 0.5	0.64 ± 1.18	0.22 ± 0.44	0.38 ± 0.76
OMID	4		2.5 ± 5	4.45 ± 8.9	0.5 ± 0.58	0.56 ± 0.66	0.25 ± 0.5	0.41 ± 0.81	0.5 ± 0.58	0.78 ± 1	0.25 ± 0.5	1.3 ± 2.61	0.25 ± 0.5	0.5 ± 1
FW	6		0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0.25 ± 0.5	0.26 ± 0.52	0 ± 0	0 ± 0	0 ± 0	0 ± 0
CD	58	MD-4	2.33 ± 1.83**	3.71 ± 3.33*	0.22 ± 0.62**	0.41 ± 1.33**	0.41 ± 0.8**	1.39 ± 2.83**	0.29 ± 0.62	0.76 ± 1.74	0.21 ± 0.45	0.66 ± 1.52	0.29 ± 0.77	0.85 ± 2.36
WD	43		1.93 ± 1.78*	2.86 ± 2.92	0.02 ± 0.15*	0.03 ± 0.17*	0.09 ± 0.37**	0.17 ± 0.74**	0.12 ± 0.5	0.27 ± 1.26	0.09 ± 0.29	0.21 ± 0.7	0.07 ± 0.34	0.20 ± 1.11
MID	21		3.1 ± 2.88	4.73 ± 4.58	0.24 ± 0.77**	0.32 ± 1.03**	0.29 ± 0.78**	0.59 ± 1.55**	0.29 ± 0.78	0.93 ± 3.14	0.19 ± 0.40	0.55 ± 1.24	0.33 ± 0.91	0.94 ± 3.17
OMID	26		4.62 ± 2.38	8.76 ± 5.47	0 ± 0**	0 ± 0	0.08 ± 0.27**	0.1 ± 0.35**	0.19 ± 0.63	0.41 ± 1.53	0.15 ± 0.37	0.4 ± 0.98	0.15 ± 0.61	0.66 ± 2.46
FW	40		1.68 ± 1.58	2.33 ± 2.39	0 ± 0**	0 ± 0	0.08 ± 0.35**	0.18 ± 0.87**	0.2 ± 0.61	0.47 ± 1.44	0.08 ± 0.27	0.11 ± 0.39	0.15 ± 0.58	0.51 ± 1.94
CD	65	MD-3	4.22 ± 2.8	7.2 ± 5.45	0.18 ± 0.43**	0.22 ± 0.52**	0.34 ± 0.62**	0.4 ± 0.75**	0.18 ± 0.39	0.27 ± 0.64	0.31 ± 0.53	0.93 ± 1.69	0.09 ± 0.29	0.10 ± 0.32*
WD	51		3.29 ± 2.4	5.43 ± 4.81	0.06 ± 0.24**	0.07 ± 0.29**	0.04 ± 0.2**	0.0 ± 0.27**	0.04 ± 0.2	0.08 ± 0.42*	0.24 ± 0.47	0.4 ± 0.9	0.02 ± 0.14	0.02 ± 0.15*
MID	25		4.04 ± 3.8	7.59 ± 7.15**	0.24 ± 0.52**	0.29 ± 0.62**	0.28 ± 0.54**	0.34 ± 0.66**	0.28 ± 0.46	0.38 ± 0.71	0.44 ± 0.51	1.32 ± 1.68	0.08 ± 0.28	0.09 ± 0.30
OMID	32		6.66 ± 3.4	11.93 ± 7.33*	0.03 ± 0.18*	0.03 ± 0.18*	0.13 ± 0.49**	0.15 ± 0.58**	0.13 ± 0.34	0.19 ± 0.54	0.41 ± 0.61	0.77 ± 1.19	0 ± 0	0 ± 0
FW	50		2.6 ± 2.08	3.65 ± 3.3	0.08 ± 0.27**	0.09 ± 0.33**	0.15 ± 0.5**	0.19 ± 0.64**	0.08 ± 0.27	0.09 ± 0.3	0.08 ± 0.27	0.1 ± 0.37	0.02 ± 0.14	0.02 ± 0.15*

n: individual records, same position significant differences with MD in post hoc test. *: $p < .05$, **: $p < .001$

Table 2 (Continuation)
Mean and Standard Deviation for each of the Day Types by Position.

Position	*n*		AccDens	Duration Acc Dens	MetPow	Duration MetPow	Mmin	Duration Mmin	HSR	Duration HSR	Sprint	Duration Sprint	HMLD	Duration HMLD
CD	61	MD-2	1.59 ± 1.37**	2.59 ± 2.36**	0.18 ± 0.62**	0.24 ± 0.8**	0.16 ± 0.58**	0.3 ± 0.98**	0.02 ± 0.13	0.08 ± 0.63	0.02 ± 0.13	0.05 ± 0.42	0.02 ± 0.13	0.08 ± 0.63*
WD	50		1.14 ± 1.05**	1.58 ± 1.56**	0.02 ± 0.14*	0.04 ± 0.26**	0.02 ± 0.14**	0.04 ± 0.25**	0 ± 0	0 ± 0	0.02 ± 0.14	0.04 ± 0.27*	0.02 ± 0.14	0.03 ± 0.19*
MID	22		1.86 ± 1.42	2.66 ± 2	0.05 ± 0.21**	0.06 ± 0.3**	0.09 ± 0.29**	0.11 ± 0.37**	0.05 ± 0.21	0.05 ± 0.22	0.05 ± 0.21	0.09 ± 0.42	0 ± 0	0 ± 0
OMID	30		2.7 ± 1.7	3.91 ± 2.92	0.03 ± 0.18*	0.04 ± 0.2*	0.13 ± 0.35**	0.18 ± 0.47**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
FW	48		0.88 ± 1**	1.27 ± 1.59**	0 ± 0**	0 ± 0	0.02 ± 0.14**	0.02 ± 0.16**	0.04 ± 0.2	0.08 ± 0.39	0.04 ± 0.2	0.08 ± 0.39	0.02 ± 0.14	0.04 ± 0.28*
CD	62	MD-1	0.71 ± 0.99**	1.11 ± 1.58**	0.04 ± 2	0.05 ± 0.25	0.06 ± 0.24**	0.08 ± 0.34**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
WD	54		1.23 ± 1.24**	1.89 ± 2**	0 ± 0*	0 ± 0*	0.06 ± 0.30**	0.07 ± 0.37**	0.02 ± 0.13	0.02 ± 0.17*	0.05 ± 0.21	0.12 ± 0.53	0.02 ± 0.13	0.02 ± 0.17*
MID	24		0.8 ± 1.05*	1.32 ± 2.07*	0.02 ± 0.14**	0.03 ± 0.21**	0.06 ± 0.41**	0.08 ± 0.59**	0.04 ± 0.19	0.06 ± 0.3	0 ± 0	0 ± 0	0.02 ± 0.14	0.03 ± 0.19
OMID	31		0.96 ± 1.04**	1.23 ± 1.37**	0.04 ± 0.2*	0.04 ± 0.21*	0.04 ± 0.20**	0.05 ± 0.25**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
FW	51		1.97 ± 1.58**	2.99 ± 2.42**	0.03 ± 0.18**	0.04 ± 0.2**	0.06 ± 0.36**	0.09 ± 0.51**	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0	0 ± 0
CD	37	MD	4.65±3	5.41 ± 5.158	2.62 ± 2.0	3.42 ± 2.73	3.11 ± 2.71	4.11 ± 3.65	0.24 ± 0.49	0.41 ± 0.86	0.22±0.42	0.42 ± 0.81	0.43 ± 0.8	0.59 ± 1.09
WD	21		3.86±2.2	4.508±3.387	1.62 ± 1.91	2.05 ± 2.35	1.90 ± 1.95	2.61 ± 3.03	0.48 ± 0.60	0.77 ± 0.97	0.43±0.81	0.82 ± 1.56	0.67 ± 0.97	0.95 ± 1.40
MID	17		3.18±1.24	3.649±2.029	4.94 ± 3.03	6.49 ± 3.95	4.76 ± 2.77	6.14 ± 3.5	0.29 ± 0.47	0.43 ± 0.71	0.18±0.53	0.35 ± 1.04	0.41 ± 0.62	0.51 ± 0.77
OMID	10		5.1 ±2.96	6.877±4.638	2.2 ±1.14	3.11 ± 1.43	3.4 ±1.78	4.95 ± 2.17	0.3 ±0.48	0.41 ± 0.69	0.1 ±0.32	0.2 ±0.62	0.5 ±0.71	0.67 ± 0.95
FW	23		3.13±1.14	3.363±1.886	3.74 ± 2.36	4.54 ± 2.87	4.74 ± 2.85	6.11 ± 3.78	0.35 ± 0.88	0.54 ± 1.34	0.35±0.49	0.64 ± 0.91	0.48 ± 0.67	0.65 ± 0.92

n: individual records, same position significant differences with MD in post hoc test. *: $p < .05$, **: $p < .001$

The number of SubMIP events and their duration was higher in MD for MetPow [number of events compared to MD+1C ($p < .001$; ES = 4.182), MD-4 ($p < .001$; ES = 4.541), MD-3 ($p < .001$; ES = 4.22), MD-2 ($p < .001$; ES = 4.739), MD-1 ($p < .001$; ES = 6.143) and between MD-1 and MD-3 ($p < .001$; ES = –1.922) also in their duration in comparison MD with MD+1C ($p < .001$; ES = 3.694), MD-4 ($p < .001$; ES = 3.605), MD-3 ($p < .001$; ES = 3.71), MD-2 ($p < .001$; ES = 3.961), MD-1 ($p < .001$; ES = 5.344) and between MD-1 and MD-2 ($p < .05$; ES = –1.383), MD-3 ($p < .05$; ES = –1.634) and MD-4 ($p < .05$; ES = –1.739)]. Mmin [number of events comparing MD with MD+1C ($p < .001$; ES = 4.379), MD-4 ($p < .001$; ES = 3.158), MD-3 ($p < .001$; ES = 3.319), MD-2 ($p < .001$; ES = 4.013), MD-1 ($p < .001$; ES = 4.355), and between MD-1 and MD-3 ($p < .05$; ES = –1.036), MD-4 ($p < .05$; ES = –1.196) and MD-2 compared with MD-4 ($p < .05$; ES = –0.854) also in their duration comparing MD with MD+1C ($p < .001$; ES = 4.182), MD-4 ($p < .001$; ES = 4.541), MD-3 ($p < .001$; ES = 4.22), MD-2 ($p < .001$; ES = 4.739), MD-1 ($p < .001$; ES = 6.143) and comparing MD-1 and MD-3 ($p < .05$; ES = –1.922)] for the variable HMLD [(number of events compared MD to MD+1R ($p < .05$; ES = 3.902), MD-4 ($p < .001$; ES = 1.412), MD-3 ($p < .001$; ES = 3.421), MD-2 ($p < .001$; ES = 5.573), MD-1 ($p < .001$; ES = 5.675) also comparing MD-1 to MD-4 ($p < .001$; ES = –4.262) and MD+1C ($p < .001$; ES = –4.299), MD-2 compared with MD-4 ($p < .001$; ES = –4.16) and MD+1C ($p < .001$; ES = –4.197) and the comparison of MD-3 to MD-4 ($p < .001$; ES = –2.009) and MD+1C ($p < .001$; ES = –2.046) also in their duration, MD to MD+1R ($p < .001$; ES = 2.947), MD-3 ($p < .001$; ES = 2.565), MD-2 ($p < .001$; ES = 3.096), MD-1 ($p < .001$; ES = 3.975) also differences found comparing MD-1 to MD+1C ($p < .001$; ES = –3.18) and MD-4 ($p < .001$; ES = –3.848), MD-2 compared with MD+1C ($p < .001$; ES = –2.3) and MD-4 ($p < .001$; ES = –2.968), MD-3 to MD+1C ($p < .001$; ES = –1.769) and MD-4 ($p < .001$; ES = –2.437) and MD-4 compared with MD+1R ($p < .05$; ES = 2.819)] (Figure 1).

Differences were found between MD and with respect to practically all training days in number of events for AccDens. Compared with [MD+1C ($p < .001$; ES = 0.79), MD+1R ($p < .001$; ES = 1.904), MD-4 ($p < .001$; ES = 0.332), MD-2 ($p < .001$; ES = 0.736) and MD-1 ($p < .001$; ES = 0.969). In duration of these MD events with respect to MD+1C ($p < .05$; ES = 0.418), MD+1R ($p < .001$; ES = 1.325), MD-3 ($p < .001$; ES = –0.192), MD-2 ($p < .001$; ES = 0.406) and MD-1 ($p < .001$; ES = 0.558)]. No differences were found in AccDens number of MD events with respect to MD-3 and duration of events in MD with respect to MD-4. There were also differences in this same variable in the number of events between MD-3 and the rest of the training days [MD+1C ($p < .001$; ES = 0.786), MD+1R ($p < .001$; ES = 1.9), MD-4 ($p < .001$; ES = 0.327), MD-2 ($p < .001$; ES = 0.732), MD-1 ($p < .001$; ES = 0.965) and between MD-4 and MD-1 ($p < .001$; ES = 0.637), MD-2 ($p < .001$; ES = 0.404), MD+1R ($p < .001$; ES = 1.572) and MD+1C ($p < .001$; ES = 0.458)], also between MD-1 [to MD-2 ($p < .001$; ES = –0.233) and MD+1R ($p < .001$; ES = 0.934), MD-2 to MD+1R ($p < .001$; ES = 0.1.16) and MD+1C to MD+1 R ($p < .001$; ES = 1.113)]. Finally, differences were found between the duration of the AccDens events between MD-3 and the rest of the days [MD+1C ($p < .001$; ES = 0.611), MD+1R ($p < .001$; ES = 1.518), MD-4 ($p < .001$; ES = 0.263), MD-2 ($p < .001$; ES = 0.598) and MD-1 ($p < .001$; ES = 0.751), also between MD-4 and MD+1C ($p < .001$; ES = 0.348), MD+1R ($p < .001$; ES = 1.254), MD-2 ($p < .001$; ES = 0.335) and MD-1 ($p < .001$; ES = 0.487), comparing MD-1 with MD-2 ($p < .001$; ES = –0.152) and MD+1R ($p < .001$; ES = 0.767), MD-2 with MD+1R ($p < .001$; ES = 0.919) and MD+1C to MD+1R ($p < .001$; ES = 0.906)] (Figure 1).

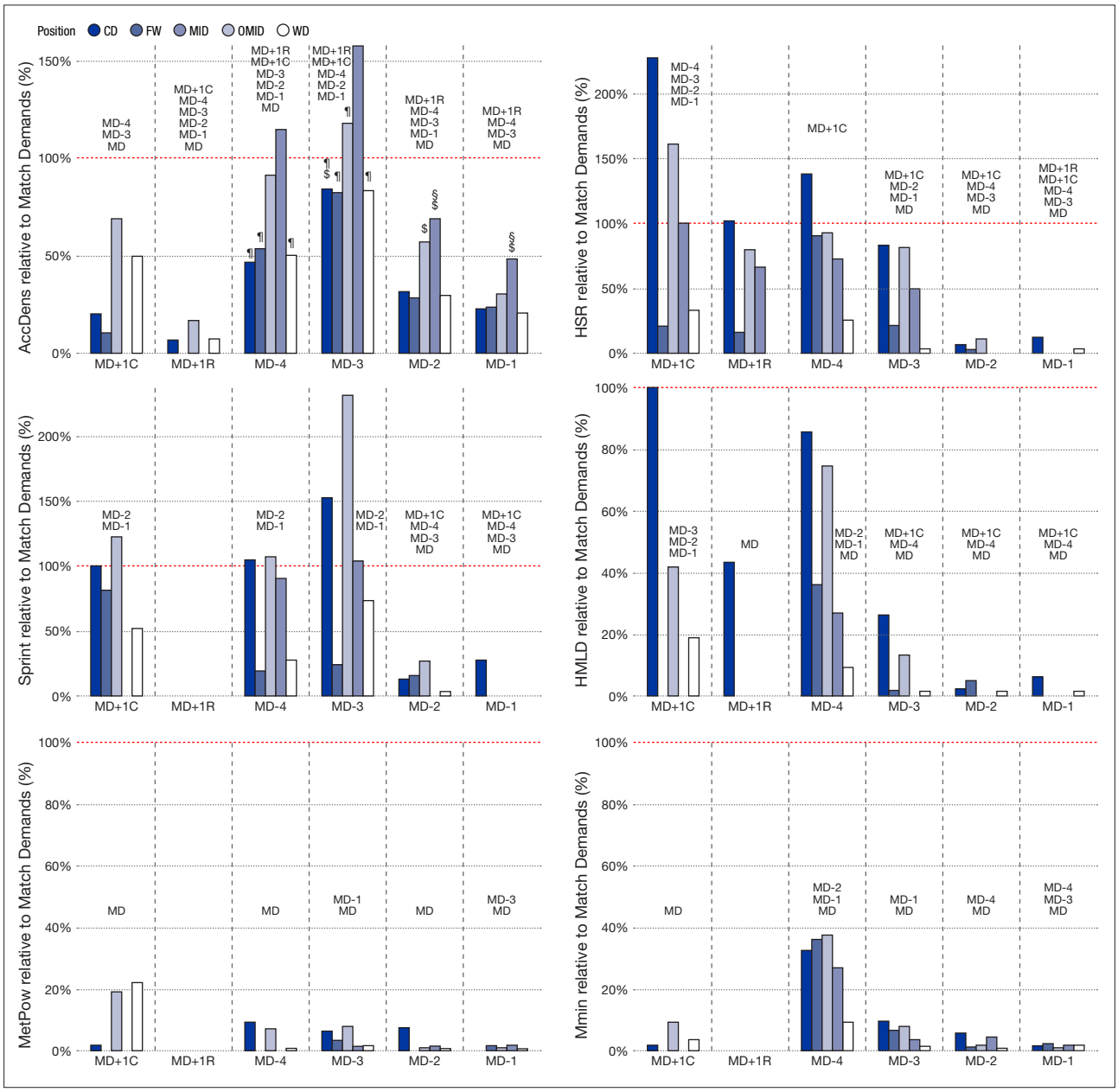
Regarding the number of events and duration of these events in the HSR variable, significant differences were found in the comparison of the MD days with respect to MD-3 ($p < .001$; ES = 1.271), MD-2 ($p < .001$; ES = 3.887) and MD-1 ($p < .001$; ES = 4.303) in number of events and to MD-3 ($p < .001$; ES = 0.992), MD-2 ($p < .001$; ES = 2.415), MD-1 ($p < .001$; ES = 3.15) and MD+1R ($p < .05$; ES = 1.441) in their duration (Figure 1). Also between MD-1 with respect to MD-4 ($p < .001$; ES = –3.772), MD-3 ($p < .05$; ES = –3.032), MD+1C ($p < .001$; ES = –4.513) and MD+1R ($p < .001$; ES = –2.822), between MD-2 in comparison with MD-3 ($p < .05$; ES = –2.616) , MD-4 ($p < .001$; ES = –3.356) and MD+1C ($p < .001$; ES = –4.097) and comparing MD-3 with MD+1C ($p < .05$; ES = –1.480) in number of events. Regarding the duration of the events significant differences were found comparing MD-1 with respect to MD-4 ($p < .001$; ES = –3.291), MD-3 ($p < .05$; ES = –2.158) and MD+1C ($p < .001$; ES = –3.358), between MD-2 in comparison with MD-3 ($p < .05$; ES = –1.423), MD-4 ($p < .001$; ES = –2.556) and MD+1C ($p < .001$; ES = –2.624), between MD-3 with MD-4 ($p < .001$; ES = –1.133) and MD+1C ($p < .001$; ES = –1.2) also significant differences were found comparing MD+1R with MD-4 ($p < .05$; ES = 1.582), and MD+1C ($p < .05$; ES = –1.649) (Figure 1).

For Sprint, significant differences in number of events and duration were found between MD with respect to MD-1 ($p < .001$; ES = 4.528, $p < .001$; ES = 2.607) and MD-2 ($p < .001$; ES = 3.193, $p < .001$; ES = 1.577), between MD-1 in comparison with MD-3 ($p < .001$; ES = –4.499, $p < .001$; ES = –2.803), MD-4 ($p < .001$; ES = –3.831, $p < .001$; ES = –2.46) and MD+1C ($p < .001$; ES = –4.098, $p < .001$; ES = –2.497) and comparing MD-2 with MD-3 ($p < .001$; ES = –3.163, $p < .001$; ES = –1.773), MD-4 ($p < .001$; ES = –2.496, $p < .001$; ES = –1.43) and MD+1C ($p < .05$; ES = –2.762, $p < .001$; ES = –1.467).

Based on the post hoc analysis used to determine the differences between MD and same position for events in the AccDens variable, significant differences were observed between CD in MD+1C, for MD+1R significant differences were found in CD, WD and FW, in MD-4 for CD and WD, in MD-2 for CD, WD and FW and in MD-1 for all positions (Table 1). For MetPow variable significant differences were found on all days for all positions except on days MD+1 and on MD-1 for CDs. For the MMin variable, significant differences were found for all days and for all positions except for days MD+1. No significant differences were found for any position in the high-speed variables (HSR and Sprint) nor for HMLD respect MD and any of the training days.

In the analysis of the positions and training days, only the AccDens variable showed significant differences between positions for the same training day. Notably, OMID exhibited significant differences compared to WD and forwards FW on MD-1 ($p < .05$; ES = 0.712, $p < .001$; ES = 0.807) and MD-2 ($p < .001$; ES = 0.679, $p < .001$; ES = 0.93). On MD-3, OMIDs differed significantly from CD ($p < .001$; ES = 0.359), WD ($p < .001$; ES = 0.553), MID ($p < .05$; ES = 0.344), and FW ($p < .001$; ES = 0.678), and on MD-4, from CD ($p < .001$; ES = 0.539), WD ($p < .001$; ES = 0.686), and FW ($p < .001$; ES = 0.63). Additionally, on MD-3, CD showed significant differences when compared to FW ($p < .05$; ES = 0.318).

Figure 1
% of SubMip Events in Relation to the Competition.



*Significant differences (p<.05 based on Bonferroni Post-Hoc) in SubMip events between: Day type and positions within the same day type. * CD, $: FW, #: MID, $: OMID, §: WD*

Discussion

The objectives of this study were (a) to determine the conditional demands of external load based on the SubMIP periods during the competitive micro-cycle, (b) to compare the number and duration of SubMIP events demanded in the different sessions carried out in the competitive micro-cycle and, additionally, (c) to compare these demands based on the SubMIP depending on the specific position occupied by the football players during the competitive micro-cycle. The main findings of the study were the existence of significant differences in each of the variables between training days/competition matches and positions based on the SubMIP analysis (number of events and time above threshold). Values exceeding 50% of those shown in competition were noted. This was especially evident in HSR, Sprint, AccDens, and HMLD, observed across various days of the micro-cycle, in number of events and in time above the sub-maximal threshold. Values were also shown in much lower ranges (< 15 %) than those of the competition in the number of events and time above the threshold determined in the Mmin and MetPow variables.

The study of sub-maximal intensity periods in competitive matches is a novel subject (Caro et al., 2022). However, any differences in the characteristics of these periods between competitive matches and the various training sessions during the competitive micro-cycle remain largely unknown.

When analyzing the SubMIP of high-speed variables like HSR or Sprint, results demonstrated values similar (without significant differences) to competition for all positions in various training sessions. For the HSR variable on MD+1C and MD-4 sessions, no significant differences were found in relation to competition. In the case of the Sprint variable, no significant differences were noted compared to competition during MD+1C, MD-4, and MD-3 sessions. Unlike previous studies that examined men's and women's football absolute and/or relative load values in these variables (Martin-Garcia et al., 2018; Oliva-Lozano et al., 2022), reporting values from 45 % to 65% of high-speed meters on the training days with the highest stimulation of this variable (MD-4 and MD-3), compared to competition. These findings suggest players can replicate sub-maximal efforts made in competition in HSR and Sprint variables across training sessions.

Moreover, during MD+1R sessions, SubMIP events accumulated for HSR variable, despite these sessions being aimed at athletes' recovery. This accumulation is influenced by the design of this session type, which includes progressive runs up to 70 % of subjective maximum speed with short recovery (five progressive 40-meter runs with a 40" rest between series). This repetitive action in a short time frame impacts this variable, especially for players whose MIP for HSR is not high, easily reaching 85 % (Caro et al., 2022). This observation could explain why CDs show values exceeding 80 % of competition demands and MIDs approach 50 % in the number of HSR SubMIP events during MD+1R sessions, whereas WDs record no events in the same drill. These findings underline the significance of acknowledging different profiles, based on various MIP and SubMIP relationships. These relationships are determined by individual MIP values and the specific physical demand of the position.

Differences were also observed in the SubMIP analysis relative to competition demands in variables such as MetPow and Mmin. During the micro-cycle, these variables displayed lower values, peaking at only 15 % of the competition levels on the days with the highest training load (MD-4 and MD-3), in both event count and duration. This contrasts with the analysis by values relative to competition (> 50 %) on days of highest training load (MD-4 and MD-3) (Chena et al., 2021; Martin-Garcia et al., 2018). It is important to note that the MetPow and Mmin variables, along with AccDens, present higher SubMIP values in competition, as shown in Caro et al. (2022).

Contextualizing analyses in relation to the nature of the variables, the differences found between continuous variables like AccDens, Mmin or MetPow, and high-speed variables or HMLD that are only displayed when the player exceeds each of their respective thresholds, are worth noting. As seen earlier, variables like AccDens, Mmin or MetPow are more prevalent during competition (Caro et al., 2022) but show lower percentages during training sessions. It could be understimulating players in variables such as Mmin and MetPow, these variables show significant differences in all training compared to competition. The nature of the variable and its connection to the training task can elucidate events that occur in MD+1R, where significant HSR values are achieved with only a few sub-maximal intensity progressive runs, yet not a single Mmin or MetPow event is recorded.

Days before competition (MD-1 and MD-2) displayed lower values in relation to the player's maximum individual percentage (referring to competition), thus adhering to the trend reflected during the competitive micro-cycle when more "classic" analyses are conducted (Chena et al., 2021; Diaz-Seradilla et al., 2022; Oliva-Lozano et al., 2022). This trend might be influenced by the intentional reduction of training load usually done prior to competition (Oliva-Lozano et al., 2022), which, as our study results show, also appears in relation to SubMIP periods. A study in futsal showed, based on high- and very-high intensity scenarios, that the most demanding day was MD-2 in various variables (Illa et al., 2020b). Given that futsal is a different sport with distinct conditional demands and potentially different load distributions, direct comparisons between studies might not be entirely relevant. However, to our knowledge, this is the only study that addresses the topic of SubMIP during a competitive micro-cycle in a team sport.

In terms of positional analysis, previous research that examined various external load variables in both absolute and relative terms has shown differences between player positions during competitive micro-cycles variables (Diaz-Seradilla et al., 2022; Martin-Garcia et al., 2018). This contrasts with the findings from studies focused on SubMIP periods. The SubMIP periods appear to be influenced by the nature of the data, which are individualized according to the competitive profile. Therefore, a specific stimulus of the sport during training will do events are distributed relatively uniformly across all positions. The only difference observed between positions was in the AccDens variable.

This study has some limitations. Results derive from a single team with a specific work methodology, examining micro-cycles that included only one match and had a similar structure. To assert that this study's results can be generalized to other contexts, more research in this direction should be conducted, as there is no related literature to our knowledge. Likewise, the sample size could be expanded to corroborate the identified differences. A significant limitation of this study is the interpretation of variables that exhibited averages of zero and a standard deviation of zero on MD+1R days. In these instances, no significant differences were observed, which could be due to the lack of variability in the data. This phenomenon presents a methodological challenge, as the complete lack of variability (with all values being zero) restricts the capacity of statistical analyses to identify significant differences.

Conclusions

This study demonstrated significant differences between training sessions and competition matches during a competitive micro-cycle when analyzed using SubMIP. Significant differences were found between training days in certain variables, particularly in AccDens and Sprint, as well as notable differences between competition and various training days in MetPow, Mmin, and HMLD (in some of the analyzed positions).

Lastly, differences were found between training days, positions, and competition. In some cases, the results of this study diverge from those obtained in previous research that used relative values in comparison to competition. This suggests that the current approach to training load control analysis may be incomplete.

Practical Applications

The differences shown between the results of SubMIPs and other load quantification methods underscore the need to find new alternatives for load control in team sports.

This study introduces a novel perspective for the analysis of training and competition load. SubMIP analysis can be a valuable complement to the analysis methods currently in use, especially due to its approach to the intermittent nature of team sports.

During training sessions conducted in the competitive micro-cycle of a match, players appear understimulated in variables such as MetPow, Mmin, and HMLD from a SubMIP event perspective. This raises questions about the necessity of accumulating certain SubMIP event values in specific variables during the competitive micro-cycle for effective competition.

Analyzing maximum intensity periods could give insights into a singular maximum demand event occurring during sessions/matches (Caro et al., 2022; Gabbett et al., 2016). Associating intensity solely with these peak events might lead to an oversight of the effects of intermittent variable intensity efforts (such as maximum, sub-maximal, moderate, and pauses) on athlete fatigue (Carling et al., 2019; Johnston et al., 2014). In this context, game phases with high intensity, even if not reaching match peak, should be a key training focus, as they may relate to match fatigue accumulation and adaptive processes pursued in training sessions. However, it should be noted that the SubMIP threshold directly relates to the player's individual MIP, which is decisive in results and their interpretation.

Given the existing uncertainties in determining the optimal workload throughout the week (coupled with the importance of understanding the nature of the data), new lines of research are opened to establish SubMIP as a valid and reliable tool for training load control.

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Front cover:
Rafa Nadal and Carlos Alcaraz of Spain in action against Tallon Griekspoor and Wesley Koolhof of Netherlands during their men's doubles second round tennis match at the Paris Olympic Games on July 30, 2024. (Photo by EFE/EPA/Ritchie B. Tongo)

The book *Nuevas tendencias en el entrenamiento en tenis. Modelo basado en la acción de juego*, belonging to the Motriu Actual collection and published by the National Institute of Physical Education of Catalonia (INEFC) and the University of Lleida (UdL), is a significant contribution to the field of physical activity and sports sciences in general and tennis in particular. The authors, Ernest Baiget and Miquel Moreno, experts in the field, present a work that is not only academically rigorous and with updated content, but also of great practical use for coaches, physical trainers and students.

The Motriu Actual collection is characterized by publishing texts that combine information with research, and this book is no exception. With a clear and accessible approach, the authors manage to connect with a wide audience interested in improving tennis performance. The book explains the scientific bases and practical applications of a solid methodology for tennis training, highlighting the importance of understanding this process as a complex interaction between scientific foundations and practical experiences. Throughout the text, the most relevant evidence on teaching and training systems and models is reviewed and updated, covering technical, tactical and conditional factors of tennis.

One of the most notable contributions of this work is the paradigm shift it proposes towards more integrative and comprehensive models, focused on improving the playing action of tennis. This holistic perspective is crucial for developing training strategies that are effective and tailored to the individual needs of players. The use of abundant self-explanatory graphic material, such as images and tables, facilitates the understanding of the concepts and allows an immediate practical application of the methodological proposals. This makes the book a valuable tool for both academic learning and implementation on the track or gym. Furthermore, the theoretical framework presented serves as a reference for professional development, providing coaches and physical trainers with a solid foundation on which to build their training programs. The book is positioned both as an essential reference work and guide in the field of tennis.

In conclusion, *Nuevas tendencias en el entrenamiento en tenis. Modelo basado en la acción de juego* is a work that stands out for its scientific quality and its practical applicability, contributing significantly to the advancement of knowledge in sports training.