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Muscle Strength Training in Fibromyalgia Patients. Literature Review

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Sports practice in childhood favours the growth and emotional health of children. © Kablonk Micro. AdobeStock

Abstract

People with fibromyalgia (FM) suffer from chronic pain and other symptoms, which affect muscle strength and quality of life. The aim of the present review was to describe the characteristics of training programmes that assessed any strength-related variables in people with FM, specifically regarding prescription, findings, participant retention and research team. The search was carried out in the Cochrane, Medline and Redalyc databases, using the keywords: fibromyalgia and strength training. Experimental studies published from 2016 to 2020 were included, of which 16 articles were processed. The main findings were that this type of training was useful and safe, impacting pain control, while improving individual physical condition and functionality. Moreover, the estimated programme adherence rate was above 73% in most publications. Similarly, the programmes evaluated suggested participant acceptance and the achievement of favourable results in the short term. Lastly, it is important to note that the integration of the multidisciplinary team was a constant in this type of project.

Keywords: exercise, health, multidisciplinary care, pain, rheumatic diseases.

Introduction

Fibromyalgia [FM] is an idiopathic disease characterised by widespread chronic pain (Wong et al., 2018), accompanied by a series of symptoms such as sleep disorder, fatigue, excessive anxiety, depression (Andrade et al., 2017a), irritable bowel (Silva et al., 2019), stiffness, and memory-linked problems, attention and ability to concentrate (Bair & Krebs, 2020; Collado-Mateo et al., 2017). This disease affects 3% of the world population (Wong et al., 2018) and is seen more frequently in women than in men, with a ratio of 8 to 1, in an age group between 35 and 60 years (Katz et al., 2010; Silva et al., 2019).

FM generates many expenses for patients due to frequent visits to the doctor (Collado-Mateo et al., 2017), with an average of up to 10 visits per year (Bair & Krebs, 2020). Moreover, due to sleep disorders and pain, patients report a low quality of life (Andrade et al., 2017a), often quit their jobs (Collado-Mateo et al., 2017) and lead a sedentary lifestyle, which causes their functional capacity to decrease (Andrade et al., 2017b; Assumpção et al., 2018).

FM treatment is shaped by a multidisciplinary approach, including pharmacological and non-pharmacological therapy (Collado-Mateo et al., 2017). Pharmacological therapy (antidepressants, opioids, sedatives and anti-epileptic drugs) is as effective as non-pharmacological therapy; however, it has greater side effects and less patient adherence (Izquierdo-Alventosa et al., 2020). Furthermore, non-pharmacological therapy, such as physical exercise, cognitive-behavioural therapy, therapeutic education, relaxation techniques and physiotherapeutic measures, promote a consistent and effective range of benefits for this condition (Collado-Mateo et al., 2017; Da Cunha-Ribeiro et al., 2018; Marín-Mejía et al., 2019).

Physical exercise has proven most efficient among non-pharmacological therapies due to its benefits (Villafaina et al., 2019); all the while, being one of the most promising and profitable solutions (Izquierdo-Alventosa et al., 2020). There is a large variety of physical exercise types; however, the most documented are: aquatic activities, aerobic exercise, flexibility programmes (Marín-Mejía et al., 2019), exergames (Collado-Mateo et al., 2017; Villafaina et al., 2019), yoga, Tai Chi, vibration training (Silva et al., 2019) and strength training (Andrade et al., 2017b; Bair & Krebs, 2020).

Aerobic exercise has been extensively researched and recommended for patients with FM due to the improvement it generates in physical capacity and functionality (Da Cunha-Ribeiro et al., 2018); and in turn, improves several symptoms such as pain, fatigue, sleep quality, depression and general health status (Andrade et al., 2017b). Unlike aerobic exercise, little is known regarding the effective prescription of strength training, and literature remains limited (Da Cunha-Ribeiro et al., 2018). Based on a review by Busch et al. (2013) on strength training in women with FM, which found that the evidence published in that period was of poor quality due to factors such as incomplete description of exercise protocols, inadequate sample size and lack of information on adherence to training and incidence of adverse effects.

In light of the need to further develop evidence to improve the quality of care for people with FM, the following research question arises: what is the effect of strength training on aspects of muscle strength, well-being, symptoms, physical condition and adverse effects in people with FM? In order to describe the characteristics of muscle strength training programmes that assess well-being, symptoms, physical condition and adverse effects in people with FM as variable outcomes, this review of the literature was suggested. As secondary objectives, the adherence rate of participants to the programmes was estimated and the professions of the multidisciplinary team of researchers involved in the projects were identified.

Methodology

A search in Cochrane, Medline and Redalyc databases was conducted for experimental studies. The keywords for the search in English were fibromyalgia and strength training. Experimental studies published between 2016 and 2020 that evaluated the effect of the application of a physical training programme on some strength-related variable in people diagnosed with FM were included. No language restrictions were applied, articles published in English and Portuguese were included. Due to the interest in describing the types of training evaluated in research, a specific construct was assigned to delimit the type of training outcome related to strength. Were excluded: articles that did not describe the characteristics of the experimental training, programmes that did not include the performance of some form of physical exercise, and when access to the full text of the document was impossible. The search for articles was conducted during the month of December 2020.

A physical training programme was considered to include guidance for planned exercise over a period longer than four weeks, specifying the type of exercise, frequency, intensity and duration previously determined to be performed in individuals with FM diagnosis. Adherence rates to the training programmes were found in the authors' report on the number of participants who started and finished per experimental group.

Due to the specification of the interest outcome of training programmes, a qualitative review of the information collected

was carried out. One reviewer led the electronic search of databases in direct coordination with other reviewers; and an analysis on the relevance of the titles and abstract was jointly conducted. Disagreements between reviewers were resolved through dialogue and consensus with two expert advisors. Data analysis was carried out using descriptive tables. The description identified the characteristics of the study population, experimental intervention, control group treatment, evaluation indicators, outcomes, conclusions, adherence to the intervention, adverse effect reporting, and project team collaborators –in accordance with the research methods and/or researchers' statements–.

The level of evidence was assessed using a table adapted to identify grades of recommendation according to the GRADE system (*The Grading of Recommendations Assessment, Development and Evaluation*) by Canfield & Dahm (2011). Lastly, the characteristics of the physical exercise training programmes were described regarding frequency, duration of sessions, total training time, intensity and other specifications. The criteria of the PRISMA statement were considered for the methodological design of the review (Page et al., 2021). Calculating the effect size was not possible due to the heterogeneity of the indicators used in the studies.

Results

A total of 173 articles were identified in the three databases. The selection criteria were reviewed and the final decision was to process 16 articles (Figure 1).

Table 1 describes the characteristics of the participants by experimental group including age, country of origin and quality assessment. Moreover, the description of the evaluation indicators, the load and characteristics of the training programmes evaluated and the main results reported by the authors are presented.

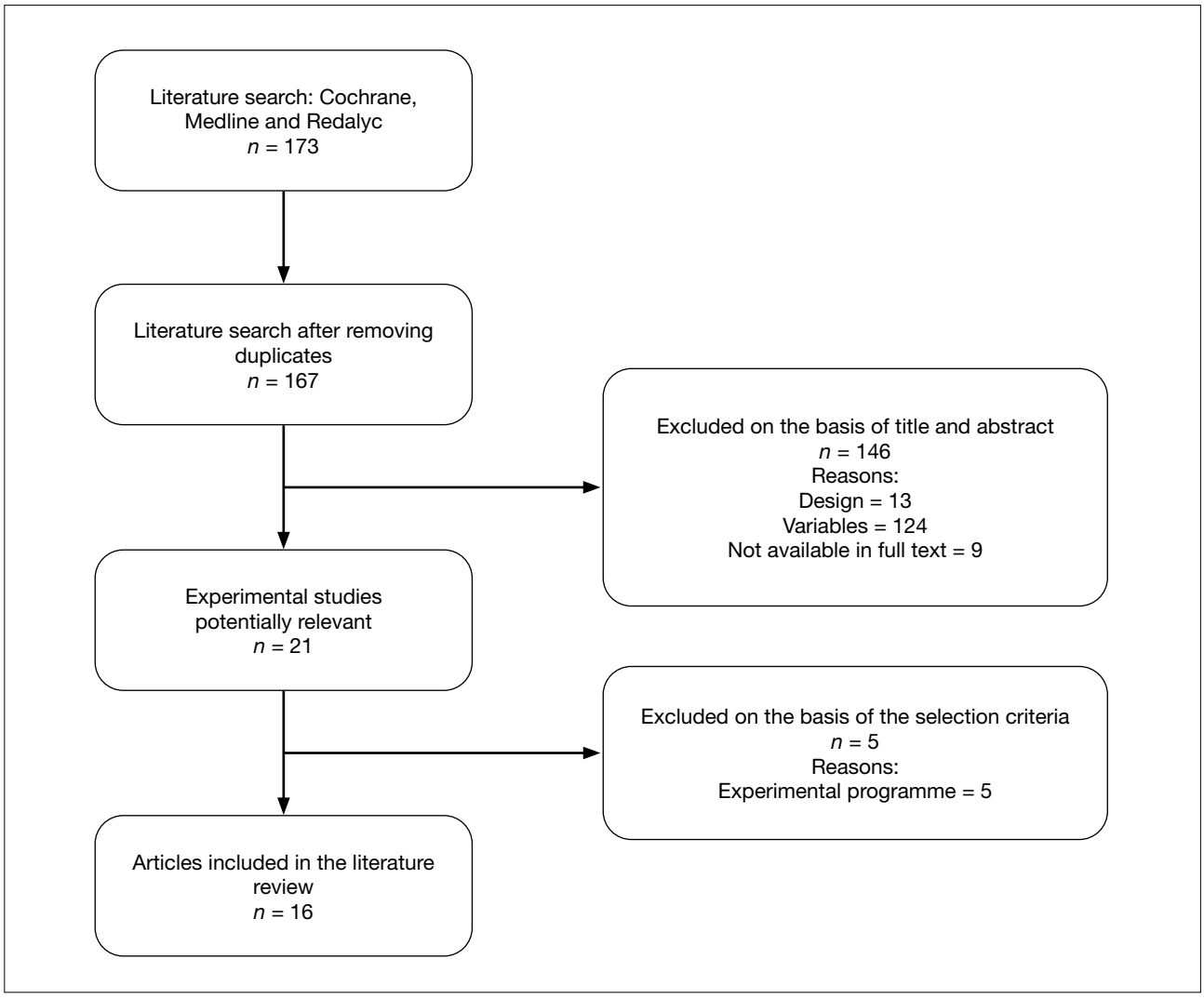

Figure 1
Description of the selection of articles for the literature review process.

Table 1
Description of participants by group, indicators and overall results of articles included in the review.

Authors	Participants	Indicators	EG Programme	Programme description	Results
Kümpel et al., 2016 G: 2A	Women with FM from São Paulo (Brazil) EG: *n* = 20; 54 ± 5.1 years.	VAS Algometry (Somedic Sales AB) FIQ PSQI	F: 2 s/w T: 1 hour D: 15 sessions I: NS Tr: Mat Pilates	Pilates with mat exercises. Participants received individualised guidance, tactile stimulation of the muscle worked on and verbal command.	Improvement in the domains of: pain intensity, fatigue, work absenteeism, sleep quality, depression, anxiety and stiffness ($p < .02$). Improvement in PSQI score ($p = .04$). Decrease in FIQ score ($p < .01$). Pain reduction in the VAS ($p = .01$).
Andrade et al., 2017b G: 1B	Patients with FM from Florianópolis, (Brazil). (96.2% were women). EG: *n* = 31; 54.42 ± 7.16 years. CG (Control Group): *n* = 21; 53.10 ± 8 years.	FIQ PSQI	F: 3 s/w T: 1 hour D: 8 wks. I: individualised load Tr: Strength	10 min warm-up, 40 min main part and 10 min stretching. Exercises: knee extension, knee flexion, bench press, fly, adductors, low rowing, high pulley, elbow extension, lateral raise, push-ups, standing calf raise and crunches. 3 sets of 12 r/ 1 min between sets.	EG: differences in subjective sleep quality, sleep disturbances, daytime dysfunction and total sleep score ($p < .05$). Association between pain intensity and sleep quality ($p < .01$). As pain intensity increased, sleep quality worsened.
Collado-Mateo et al., 2017 G: 1B	Women with FM from Spain. EG: *n* = 42; 52.52 ± 9.73 years. CG: *n* = 41; 52.47 ± 8.75 years.	FIQ EQ-5D-5L VAS	F: 2 s/w T: 1 hour D: 8 wks. I: NS Tr: VirtualEx-FM (exergame)	Warm-up: joint movements of the limbs; dance steps; posture control and ludic coordination, walk following an imaginary footprint track.	EG: improvement in the aspects of mobility, pain and discomfort, anxiety and depression on the EQ-5D-5L ($p < .05$). Improvement in the pain, stiffness, anxiety and wellness aspects of the FIQ ($p < .01$).
Assumpção et al., 2018 G: 1B	Women with FM from São Paulo (Brazil). EG1: *n* = 14; 47.9 ± 5.3 years. EG2: *n* = 16; 45.7 ± 7.7 years. CG: *n* = 14; 46.9 ± 6.5 years.	VAS FIQ SF-36 Algometry (Fischer)	F: 2 s/w T: 40 min D: 12 wks. EG1 I: Moderate discomfort Tr: Stretching EG2 I: (1-2 wks.) no weight; (3-12 wks.) +0.5 kg per wk. before RPE of 13. Tr: Muscle strength.	EG1: active stretching without assistance. At the beginning, 3 r of 30 seconds; from the fifth week onwards, 4 r; and after the ninth week, 5 r. EG2: dumbbells (upper body) and shin guards (lower body). Series of 8 r.	EG1: improvements in pain threshold ($p < .01$), FIQ total score ($p = .04$) and quality of life ($p < .05$). EG2: improvements in pain threshold ($p = .01$), number of sensitive spots ($p = .03$), FM symptoms ($p = .01$), and quality of life ($p < .05$).

Note. EG: Experimental group; CG: Control group; SD: Standard deviation; NA: Not applicable; NS: Not specified; FM: fibromyalgia; F: Frequency; T: time; D: Duration; I: Intensity; Tr: Training; RPE: Rating of Perceived Exertion; HR: heart rate; HRR: heart rate reserve; maxHR: maximum heart rate; s/w: sessions per week; r: repetitions; VAS: Visual Analogue Scale; FIQ: *Fibromyalgia Impact Questionnaire*; PSQI: *Pittsburgh Sleep Quality Index*; EQ-5D-5L: *European Quality of life-5 Dimensions-5 Levels*; 1RM: one repetition maximum; SF-MPQ: *Short-Form McGill Pain Questionnaire*; POMS: *Profile of Mood States*; FS: *Feeling Scale*; SSS: Symptom Severity Scale; GPI: Generalised Pain Index; SART: *Sit-and-Reach Test*; 6MWT: *Six-minute Walk Test*; TUG: *Timed Up and Go*; CST: *Chair-stand Test*; 10-SST: *10 Step Stair Test*; FIQ-r: FIQ revised version; IPAQ: *International Physical Activity Questionnaire*; PCS: *Pain Catastrophizing Scale*; HADS: *Hospital Anxiety and Depression Scale*; BDI-II: *Beck Depression Inventory-Second Edition*; CPAQ-FM: *Chronic Pain Acceptance Questionnaire*; FIQr-PF: FIQR subscale "Physical Function"; 5STST: *Five-Repetition Sit-to-Stand Test*; IEFS: Isometric elbow flexion strength; TNF-α: Tumour necrosis factor alpha; IL-6: Interleukin-6; IL-8: Interleukin-8; IL-1β: Interleukin-1 Beta; PDI: *Pain Disability Index*; KEIS: Knee extension isometric strength; LTPAI: *Leisure Time Physical Activity Instrument*; FABQ physical: *Fear Avoidance Beliefs Questionnaire physical subscale*; MFI-20: *Multidimensional Fatigue Inventory*; IGFBP3: insulin-like growth factor binding protein 3; IGF-1: Insulin-like Growth Factor; IP-10: IFN-γ inducible protein 10; IFN-γ: Interferon gamma; IL-1ra: IL-1 receptor antagonist; SF-36: *Short Form-36 Health Survey*; SF36-PSC: SF-36 physical component; SF-36 mental component SF36-MSC; *L: Project by Larsson et al., 2015; *PL: Experimental protocol of the project by Larsson et al., 2015; *PLC: "Active control" protocol of the project by Larsson et al., 2015.

Table 1 (Continued)
Description of participants by group, indicators and overall results of articles included in the review.

Authors	Participants	Indicators	EG Programme	Programme description	Results
Da Cunha-Ribeiro et al., 2018 G: 2A	Women with FM from São Paulo (Brazil). EG: *n* = 32; 47.8 ± 13.7 years.	1RM: leg press and bench press. RPE (CR-10) VAS SF-MPQ POMS FS	F: 1 s/w T: NS D: 8 wks. (4 familiarisation) I: 1) STD: 60% 1RM. 2) SS: self-selected. 3) SS-VM: self-selected intensity. 4) SS-RPE: self-selected load until score 7 RPE is reached. Tr: Strength	Experimental sessions in a randomised crossover fashion: 1) STD: standardised prescription. 6 series of 10 r. 2) SS: fixed number of series and r. 6 series of 10 r. 3) SS-VM: with volume load (r x series x intensity) adapted for STD. 4) SS-RPE: free number of r until score 7 (very difficult) is reached in RPE.	The load was lower in SS, SS-VM, SS-RPE than in STD, considering that the perceived exertion and volume load were comparable between sessions. Increase in VAS scores at beginning ($p < .01$), and decrease after 48h, 72h and 96h ($p < .01$), remaining elevated compared to previous values. Increase in SF-MPQ values after all exercise sessions ($p = .025$), with gradual decrease over time, reaching baseline levels at 24h. There were no differences between sessions.
Wong et al., 2018 1A	Women with FM from Busan (Korea). EG: *n* = 17; 51 ± 2 years. CG: *n* = 14; 51 ± 2 years.	Autonomous heart modulation using heart rate variability (SA-2000E Medicore) VAS SART 1RM	F: 3 s/w T: 55 min D: 12 wks. I: 40-50% HRR Tr: Tai Chi	10 min warm up, 40 min main part and 5 min cool-down. 10 forms of the classic Yang style.	Decrease in sympathetic balance (LnLF/LnHF), sympathetic tone (LnLF, nLF), pain and fatigue ($p < .05$). Increase in parasympathetic tone (LnHF, nHF), strength and flexibility compared to no change in the control group ($p < .05$). No change in HR and sleep quality.
Marín-Mejía et al., 2019 G: 2A	Women with FM in Colombia. EG: *n* = 18; 48.4 ± 10.1 years. CG: *n* = 19; 46.6 ± 6.7 years.	GPI SSS	F: 2 s/w T: 1 hour D: 12 wks. I: 45-75% HRmax; 0-6 RPE. Tr: Therapeutic dance	Cardiovascular stimulation, coordination and flexibility with different types of recreational dance. The strength stimuli were applied through a combination of muscle strengthening exercises. Adjustment of musical speed and motor patterns every 4 weeks.	Decrease in the number of painful spots ($p < .01$) and symptoms associated with FM ($p < .01$).

Note. EG: Experimental group; CG: Control group; SD: Standard deviation; NA: Not applicable; NS: Not specified; FM: fibromyalgia; F: Frequency; T: time; D: Duration; I: Intensity; Tr: Training; RPE: Rate of Perceived Exertion; HR: heart rate; HRR: heart rate reserve; maxHR: maximum heart rate; s/w: sessions per week; r: repetitions; VAS: Visual Analogue Scale; FIQ: *Fibromyalgia Impact Questionnaire*; PSQI: *Pittsburgh Sleep Quality Index*; EQ-5D-5L: *European Quality of life-5 Dimensions-5 Levels*; 1RM: one repetition maximum; SF-MPQ: *Short-Form McGill Pain Questionnaire*; POMS: *Profile of Mood States*; FS: *Feeling Scale*; SSS: Symptom Severity Scale; GPI: Generalised Pain Index; SART: *Sit-and-Reach Test*; 6MWT: *Six-minute Walk Test*; TUG: *Timed Up and Go*; CST: *Chair-stand Test*; 10-SST: *10 Step Stair Test*; FIQ-r: FIQ revised version; IPAQ: *International Physical Activity Questionnaire*; PCS: *Pain Catastrophizing Scale*; HADS: *Hospital Anxiety and Depression Scale*; BDI-II: *Beck Depression Inventory-Second Edition*; CPAQ-FM: *Chronic Pain Acceptance Questionnaire*; FIQr-PF: FIQR subscale "Physical Function"; 5STST: *Five-Repetition Sit-to-Stand Test*; IEFS: Isometric elbow flexion strength; TNF-α: Tumour necrosis factor alpha; IL-6: Interleukin-6; IL-8: Interleukin-8; IL-1β: Interleukin-1 Beta; PDI: *Pain Disability Index*; KEIS: Knee extension isometric strength; LTPAI: *Leisure Time Physical Activity Instrument*; FABQ physical: *Fear Avoidance Beliefs Questionnaire physical subscale*; MFI-20: *Multidimensional Fatigue Inventory*; IGFBP3: insulin-like growth factor binding protein 3; IGF-1: Insulin-like Growth Factor; IP-10: IFN-γ inducible protein 10; IFN-γ: Interferon gamma; IL-1ra: IL-1 receptor antagonist; SF-36: *Short Form-36 Health Survey*; SF36-PSC: SF-36 physical component; SF-36 mental component SF36-MSC; *L: Project by Larsson et al., 2015; *PL: Experimental protocol of the project by Larsson et al., 2015; *PLC: "Active control" protocol of the project by Larsson et al., 2015.

Table 1 (Continued)
Description of participants by group, indicators and overall results of articles included in the review.

Authors	Participants	Indicators	EG Programme	Programme description	Results
Silva et al., 2019 G: 1A	Women with FM from Santa Cruz (Brazil) EG: *n* = 30; 49.40 ± 8.30 years. CG: *n* = 30; 44.93 ± 10.30 years.	VAS 1RM FIQ SF-36 6MWT TUG	F: 2 s/w T: 40 min D: 12 wks., I: NS Tr: Sophrology	The patients lying on mats were guided by a physiotherapist through a series of phrases such as: "close your eyes", "analyse your breathing and heartbeat to slow it down", etc. Once in a relaxed state, they were asked to think about the negative aspects of their illness and try to see the positive aspects. At the end, they were guided back from the relaxation phase by a set of instructions.	CG: reduction of pain during the assessments ($p < .05$) and increased strength in the tested muscles ($p < .05$). EG: reduction in pain ($p < .05$). Differences with better 6MWT and SF-36 rates for CG only ($p < .05$).
Villafaina et al., 2019 G: 1B	Women with FM from Spain. EG: *n* = 22; 54.27 ± 9.29 years. CG: *n* = 15; 53.44 ± 9.47 years.	CST 10-SST 6MWT FIQ-r IPAQ	F: 2 s/w T: 1 hour D: 24 wks. I: NS Tr: VirtualEx-FM (*exergame*)	1) Warm-up: joint movements of the limbs; 2) Aerobic component: dance steps; 3) Postural control and ludic coordination; 4) Walk following an imaginary path with different types of steps.	*Exergame*: improved CST performance ($p = .003$) and the 6MWT ($p = .003$), with no difference found in the 10-SST. Fitness was maintained in the follow-up assessment (six months; $p = .013$), however, lower body strength and agility showed no residual effect ($p > .05$).
Izquierdo-Alventosa et al., 2020 G: 1A	Women with FM from Spain. EG: *n* = 16; 53.06 ± 8.4 years. CG: *n* = 16; 55.13 ± 7.35 years.	PCS HADS BDI-II PSS-10 CPAQ-FM Algometry (WAGNER Force Dial TM FDK20) FIQr-PF 6MWT 5STST	F: 2 s/w T: 1 hour D: 8 wks. I: Sessions 1-4 were run at 1-2 RPE; sessions 5-16 were set at 3-4 RPE of the CR-10 scale Tr: Strength.	Warm-up: walking at a slow pace and mobilising the main joint structures. Training: sessions 1-4: walking at a comfortable speed for 15 min, 10-exercise circuit for 25 min, and cool-down for 20 min. Sessions 5-16: perform as many r as possible in 1 min during the 10-station circuit exercises for 40 min, and cool-down for 10 min, r between 15 and 25. Load between 0.5 and 2 kg for the upper body, and between 1 and 3 kg for the lower body; a light elastic band and ball were also used.	EG: improvement in all variables studied post-intervention ($p < .05$). CG: showed no significant change in pain threshold, but rather worsened ($p < .05$).

Note. EG: Experimental group; CG: Control group; SD: Standard deviation; NA: Not applicable; NS: Not specified; FM: fibromyalgia; F: Frequency; T: time; D: Duration; I: Intensity; Tr: Training; RPE: Rating of Perceived Exertion; HR: heart rate; HRR: heart rate reserve; maxHR: maximum heart rate; s/w: sessions per week; r: repetitions; VAS: Visual Analogue Scale; FIQ: *Fibromyalgia Impact Questionnaire*; PSQI: *Pittsburgh Sleep Quality Index*; EQ-5D-5L: *European Quality of life-5 Dimensions-5 Levels*; 1RM: one repetition maximum; SF-MPQ: *Short-Form McGill Pain Questionnaire*; POMS: *Profile of Mood States*; FS: *Feeling Scale*; SSS: Symptom Severity Scale; GPI: Generalised Pain Index; SART: *Sit-and-Reach Test*; 6MWT: *Six-minute Walk Test*; TUG: *Timed Up and Go*; CST: *Chair-stand Test*; 10-SST: *10 Step Stair Test*; FIQ-r: FIQ revised version; IPAQ: *International Physical Activity Questionnaire*; PCS: *Pain Catastrophizing Scale*; HADS: *Hospital Anxiety and Depression Scale*; BDI-II: *Beck Depression Inventory-Second Edition*; CPAQ-FM: *Chronic Pain Acceptance Questionnaire*; FIQr-PF: FIQR subscale "Physical Function"; 5STST: *Five-Repetition Sit-to-Stand Test*; IEFS: Isometric elbow flexion strength; TNF-α: Tumour necrosis factor alpha; IL-6: Interleukin-6; IL-8: Interleukin-8; IL-1β: Interleukin-1 Beta; PDI: *Pain Disability Index*; KEIS: Knee extension isometric strength; LTPAI: *Leisure Time Physical Activity Instrument*; FABQ physical: *Fear Avoidance Beliefs Questionnaire physical subscale*; MFI-20: *Multidimensional Fatigue Inventory*; IGFBP3: insulin-like growth factor binding protein 3; IGF-1: Insulin-like Growth Factor; IP-10: IFN-γ inducible protein 10; IFN-γ: Interferon gamma; IL-1ra: IL-1 receptor antagonist; SF-36: *Short Form-36 Health Survey*; SF36-PSC: SF-36 physical component; SF-36 mental component SF36-MSC; *L: Project by Larsson et al., 2015; *PL: Experimental protocol of the project by Larsson et al., 2015; *PLC: "Active control" protocol of the project by Larsson et al., 2015.

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Ernberg et al., 2016 G: 2A	Women with FM from Sweden *L. EG: *n* = 24; 57 ± 9 years. Healthy women CG: *n* = 27; 57 ± 9 years.	HADS SF-36 IEFS (Isobex Dynamometer) KEIS (Steve Strong Dynamometer) 6MWT Algometry (Somedic Sales AB) VAS RPE (Borg Scale 6-20) Vastus lateralis micro dialysis Blood cytokines	*PL	*PL Further intramuscular micro dialysis of the vastus lateralis was applied 220 min before and after training; including 20 min of dynamic muscle contraction exercises in micro dialysis.	EG and CG: dynamic contractions increased pain and fatigue ($p < .01$). Increased levels of IL-6 and IL-8 following dynamic contractions ($p < .01$). TNF-α levels were lower in the EG than in the CG in both sessions ($p < .05$). EG: reduction in pain intensity ($p < .05$); no change in fatigue and cytokine levels. CG: increase in TNF-α ($p < .05$), but no change in IL-1βlevels.
Palstam et al., 2016 G: 2A	Women with FM from Gothenburg, Stockholm and Linköping (Sweden) *L. EG: *n* = 67; 51 ± 9.1 years. Secondary analysis	PDI VAS KEIS (Steve Strong Dynamometer) Grip strength (Grippit) LTPAI FABQ physical	*PL F: 2 s/w T: 60 min D: 15 wks. I: Initial load of 40% 1RM and progressively increased to 70-80% 1RM Tr: Based on Programme by Larsson et al., 2015 (*PL)	*PL Individualised programme: 10 min warm-up, followed by resistance exercises for legs, arms, hands and abdominal stability; ending with stretching. Explosive leg strength exercises were included in the 5th and 8th week. For load progression, they were evaluated every 3-4 wks.	Reduction in disability caused by pain compared to initial values ($p = .006$). Decrease in post-intervention pain intensity ($p = .002$). Increase in KEIS and the amount of physical activity ($p < .01$); as well as PDI and the domains of recreation, social activity and occupation ($p = .001$).
Ericsson et al., 2016 G: 2A	Women with FM from Sweden *L. EG: *n* = 67; 50.81 ± 9.05 years. CG: *n* = 63; 52.10 ± 9.78 years.	MFI-20 VAS PSQI PCS HADS LTPAI 6MWT	*PL	*PL	EG: greater improvement than CG on the physical fatigue subscale of the MFI-20 ($p = .013$). Sleep efficiency was the best predictor of change in the general fatigue subscale of the MFI-20 ($p = .031$). Participating in a strength programme ($p = .01$) and working few hours per week ($p = .005$) were independent predictors of change in physical fatigue.

Note. EG: Experimental group; CG: Control group; SD: Standard deviation; NA: Not applicable; NS: Not specified; FM: fibromyalgia; F: Frequency; T: time; D: Duration; I: Intensity; Tr: Training; RPE: Rating of Perceived Exertion; HR: heart rate; HRR: heart rate reserve; maxHR: maximum heart rate; s/w: sessions per week; r: repetitions; VAS: Visual Analogue Scale; FIQ: *Fibromyalgia Impact Questionnaire*; PSQI: *Pittsburgh Sleep Quality Index*; EQ-5D-5L: *European Quality of life-5 Dimensions-5 Levels*; 1RM: one repetition maximum; SF-MPQ: *Short-Form McGill Pain Questionnaire*; POMS: *Profile of Mood States*; FS: *Feeling Scale*; SSS: Symptom Severity Scale; GPI: Generalised Pain Index; SART: *Sit-and-Reach Test*; 6MWT: *Six-minute Walk Test*; TUG: *Timed Up and Go*; CST: *Chair-stand Test*; 10-SST: *10 Step Stair Test*; FIQ-r: FIQ revised version; IPAQ: *International Physical Activity Questionnaire*; PCS: *Pain Catastrophizing Scale*; HADS: *Hospital Anxiety and Depression Scale*; BDI-II: *Beck Depression Inventory-Second Edition*; CPAQ-FM: *Chronic Pain Acceptance Questionnaire*; FIQr-PF: FIQR subscale "Physical Function"; 5STST: *Five-Repetition Sit-to-Stand Test*; IEFS: Isometric elbow flexion strength; TNF-α: Tumour necrosis factor alpha; IL-6: Interleukin-6; IL-8: Interleukin-8; IL-1β: Interleukin-1 Beta; PDI: *Pain Disability Index*; KEIS: Knee extension isometric strength; LTPAI: *Leisure Time Physical Activity Instrument*; FABQ physical: *Fear Avoidance Beliefs Questionnaire physical subscale*; MFI-20: *Multidimensional Fatigue Inventory*; IGFBP3: insulin-like growth factor binding protein 3; IGF-1: Insulin-like Growth Factor; IP-10: IFN-γ inducible protein 10; IFN-γ: Interferon gamma; IL-1ra: IL-1 receptor antagonist; SF-36: *Short Form-36 Health Survey*; SF36-PSC: SF-36 physical component; SF-36 mental component SF36-MSC; *L: Project by Larsson et al., 2015; *PL: Experimental protocol of the project by Larsson et al., 2015; *PLC: "Active control" protocol of the project by Larsson et al., 2015.

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Description of participants by group, indicators and overall results of articles included in the review.

Authors	Participants	Indicators	EG Programme	Programme description	Results
Bjersing et al., 2017 G: 2A	Women with FM from Sweden *L. Total: *n* = 43; 51 (25 to 64) years. Lean: *n* = 18; 50 (25 to 63) years. Overweight: *n* = 17; 53 (34 to 64) years. Obesity*: n* = 8; 51 (25 to 63) years.	VAS MFI-20 KEIS IEFS Grip strength (Grippit) Blood Cytokines and leptin	*PL	*PL	The levels of free IGF-1 (p = .047), IGFBP3- (p = .025) and leptin (p = .008) decreased in lean women, but not in overweight or obese women. Lean women showed improvement in current pain (p = .039), general fatigue (p = .022) and IEFS (p = 017). Participants who were overweight or obese had improved IEFS (p = .049).
Ernberg et al., 2018 G: 2A	Women with FM from Sweden *L. EG: *n* = 125; 51.2 ± 9.4 years (EG1: n = *67; EG2: n = 58)* Healthy women CG: *n* = 130; 48.2 ± 11.4 years.	VAS PDI SF-36 MFI FIQ HADS PCS IEFS KEIS Grip strength (Grippit) 6MWT Algometry (Somedic Sales AB) Blood cytokines	EG1 *PL	*PL	Baseline IL-2, IL-6, TNF-α, IP-10 and eotaxin values were higher in FM than in CG (p < .041); while those of IL-1β were lower (p < .001). Weak correlations between cytokine levels and clinical variables. After both interventions, IL-1ra increased (p = .004), while IL-1β only increased in the relaxation therapy group (p = .002). Changes in IFN-γ, IL-2, IL-4, IL-6, IL-8, and IL-17A correlated with changes in pain pressure thresholds.
Jablochkova et al., 2019 G: 2A	Women with FM from Sweden * L. EG: *n* = 75; 50.8 ± 9.6 years. *(EG: n = 41; EG2: 34)*. Healthy women CG: *n* = 25; 47.6 ± 12.8 years.	Algometry VAS PCS HADS SF36-PSC SF36-MSC FIQ MFI	EG1*PL	EG1*PL	The brain neurotrophic factor level increased and the nerve growth factor decreased in women from the EG compared to CG participants (p < .01). Neither exercise nor relaxation interventions affected the levels of brain-derived neurotrophic factor or nerve growth factor.

Note. EG: Experimental group; CG: Control group; SD: Standard deviation; NA: Not applicable; NS: Not specified; FM: fibromyalgia; F: Frequency; T: time; D: Duration; I: Intensity; Tr: Training; RPE: Rate of Perceived Exertion; HR: heart rate; HRR: heart rate reserve; maxHR: maximum heart rate; s/w: sessions per week; r: repetitions; VAS: Visual Analogue Scale; FIQ: *Fibromyalgia Impact Questionnaire*; PSQI: *Pittsburgh Sleep Quality Index*; EQ-5D-5L: *European Quality of life-5 Dimensions-5 Levels*; 1RM: one repetition maximum; SF-MPQ: *Short-Form McGill Pain Questionnaire*; POMS: *Profile of Mood States*; FS: *Feeling Scale*; SSS: Symptom Severity Scale; GPI: Generalised Pain Index; SART: *Sit-and-Reach Test*; 6MWT: *Six-minute Walk Test*; TUG: *Timed Up and Go*; CST: *Chair-stand Test*; 10-SST: *10 Step Stair Test*; FIQ-r: FIQ revised version; IPAQ: *International Physical Activity Questionnaire*; PCS: *Pain Catastrophizing Scale*; HADS: *Hospital Anxiety and Depression Scale*; BDI-II: *Beck Depression Inventory-Second Edition*; CPAQ-FM: *Chronic Pain Acceptance Questionnaire*; FIQr-PF: FIQR subscale "Physical Function"; 5STST: *Five-Repetition Sit-to-Stand Test*; IEFS: Isometric elbow flexion strength; TNF-α: Tumour necrosis factor alpha; IL-6: Interleukin-6; IL-8: Interleukin-8; IL-1β: Interleukin-1 Beta; PDI: *Pain Disability Index*; KEIS: Knee extension isometric strength; LTPAI: *Leisure Time Physical Activity Instrument*; FABQ physical: *Fear Avoidance Beliefs Questionnaire physical subscale*; MFI-20: *Multidimensional Fatigue Inventory*; IGFBP3: insulin-like growth factor binding protein 3; IGF-1: Insulin-like Growth Factor; IP-10: IFN-γ inducible protein 10; IFN-γ: Interferon gamma; IL-1ra: IL-1 receptor antagonist; SF-36: *Short Form-36 Health Survey*; SF36-PSC: SF-36 physical component; SF-36 mental component SF36-MSC; *L: Project by Larsson et al., 2015; *PL: Experimental protocol of the project by Larsson et al., 2015; *PLC: "Active control" protocol of the project by Larsson et al., 2015.

In nine of the articles, the control group was instructed not to exercise at all. However, in six studies related to the project by Larsson et al. (2015), an "active control" group was considered. Other authors applied cardiovascular training with isotonic strength stimuli and flexibility exercises (Marín-Mejía et al., 2019), muscle strength training (Silva et al., 2019), relaxation therapy, or the addition of intramuscular micro dialysis in the vastus lateralis part of the thigh (Ernberg et al., 2016) to the control group. The adherence rate for the experimental group was an average 82.76% (SD = 7.55, *r* = 73-97); the control group presented lower values, with 75.93% (SD = 11.83, *r* = 55-88). Four articles included the report of adverse effects such as pain (Da Cunha-Ribeiro et al., 2018; Ericsson et al., 2016; Ernberg et al., 2016; Palstam et al., 2016) in their findings. The multidisciplinary care team in the various studies included: neuroscience doctors, traditional medicine, physiology, physiatry, doctors specialised in sports and pain; specialists in human movement sciences, physical education professionals, kinesiology, dentistry, dance teachers and Tai Chi instructors.

Discussion

The aim of this study was to evaluate the characteristics of training programmes aimed at people with FM in which well-being, symptoms, physical condition and adverse effects in people with FM were assessed as variables. Regarding the characteristics, studies were found in which physical activity is performed in less time according to the physical activity recommendations for adults aged 18 to 64 years, which establish 150 to 300 min of physical activity per week (WHO, 2020); however, those interventions consisting in 2 frequencies of 40 to 60 minutes had an effect on decreasing the intensity of the pain (Assumpção et al., 2018; Collado-Mateo et al., 2017; Da Cunha-Ribeiro et al., 2018; Kümpel et al, 2016; Silva et al., 2019), fatigue and improving the quality of sleep, anxiety and depression (Collado-Mateo et al., 2017; Kümpel et al., 2016). These results increase national CPG recommendations that physical activity is an approved non-pharmacological therapy for reducing chronic pain, improving physical functioning and quality of life in people with fibromyalgia, as well as reporting minimal negative effects (CENETEC, 2018). However, there still exist some differences in the total number of weeks necessary for the effects to show, especially residual effects, which have not been reported in the literature.

A 15-week, progressive, person-centred strength training programme based on self-efficacy principles has a positive effect on perceived recreational, social and occupational disability and, by improving sleep quality, impacts on physical fatigue in women with FM (Ericsson et al., 2016; Palstam et al., 2016). However, producing an anti-inflammatory effect on the vastus lateralis muscle is not sufficient neither at plasma level, nor does it affect pain nociception in FM patients (Ernberg et al., 2016; Jablochkova et al., 2019). This type of training produces greater results in lean individuals, as it can improve upper limb strength in obese or overweight individuals but has no impact on clinical symptoms or metabolic alterations. Adding a dietary intervention could help boost outcomes in FM patients who are overweight or obese (Bjersing et al., 2017; 2A quality).

Two Eastern disciplines have proven to be useful in reducing pain and in some aspects of physical condition (Kümpel et al., 2016; Wong et al., 2018). Applying the Pilates method twice a week helps reducing pain, improving functional capacity and sleep quality (2A quality). A 12-week Tai Chi training is helpful in decreasing pain and fatigue, as well as increasing strength and flexibility in women with FM (1A quality).

Other reports exist on the influence of strength training on sleep, psychological aspects related to depression and quality of life. Eight weeks of strength training may be safe and help reduce sleep disturbance in women with FM (Andrade et al., 2017b; 1B quality). Muscle stretching is known to improve quality of life in women with FM, while strength training decreases depression (Assumpção et al., 2018; 1B quality). An eight-week low-intensity strength training programme helps decrease pain, anxiety, depression, stress levels, while quality of life, and physical condition are improved in women with FM (Da Cunha-Ribeiro et al., 2018; 2A quality). There is evidence to suggest that strength training has the potential not only to decrease pain, but also to increase muscle strength (Izquierdo-Alventosa et al., 2020; Silva et al., 2019; 1A quality).

In addition, there are findings on the efficiency of online exergame-based interventions as they enable adherence to training, help reduce pain, improve physical condition and health-related quality of life (Collado-Mateo et al., 2017; Villafaina et al., 2019; 1B quality). In Colombia, a project has assessed the therapeutic effects of dancing; evidence suggests the positive impact of therapeutic dance in reducing the number of pain spots and symptoms associated with FM (Marín-Mejía et al., 2019; 2A quality).

It can be noted that regarding the scientific quality of the articles consulted, all 16 of them rate the quality of the effects of physical exercise programmes from moderate to high, including strength exercises in people with FM. Regarding the quality of evidence as assessed by the GRADE system, the studies included in this review contain three of the six levels identified by the system. The levels were: 1A. Strong Recommendation, high-quality evidence; 1B strong Recommendation, moderate-quality evidence; 2A weak Recommendation, high-quality evidence. As stated above, the published evidence is of moderate to high quality, which implies the possibility that progress has been made in relation to the concern of Busch et al., 2013, who previously reported this area of opportunity. Thus, the following can be established in people with FM from the state of the art:

The estimated adherence rate to the experimental trainings reviewed is above 73% in most publications, which should be considered for future projects. The causes for refusal were related rather to personal situations than to adverse events related to participation in the interventions. Three studies derived from the project by Larsson et al. (2015) reported the presence of localised thigh pain in participants; however, this effect was associated with an experimental procedure in addition to physical training (intramuscular micro dialysis of the vastus lateralis thigh). It is important that future interventions report adherence to the intervention and insist on follow-up assessments to explore whether a physical activity habit was generated in this portion of the population. Chronic pain is generally related to inability to perform physical activity, therefore, high rates of sedentary lifestyle (López-Mojares, 2019), refusal of the practice and non-adherence to exercise are usually found.

The multidisciplinary team involved in such research projects includes physiotherapists, doctors, dance teachers, physical education, physiology and sports professionals. The presence of pain associated with this pathology justifies the involvement of professionals from the clinical field in this type of project; however, given the advances in techniques and drugs for pain control, the involvement of professionals from other fields can be increasingly justified to help promote complete care for the re-adaptation to physical and social functionality of patients with FM in order to achieve conditions that enable them to be resilient to this pathology.

The main limitation of the analysed publications is that they only considered women in the study population. Although FM affects both sexes, the disease has been reported to be more prevalent in women with a ratio of nine to one (Katz et al., 2010; Silva et al., 2019), which implies that the knowledge generation has been developed primarily with women. The operational and technical difficulties involved in training mixed groups and/or the possibility of obtaining comparable study samples are limiting the study of the male population with FM. It has been reported that, although FM symptoms are similar in both men and women, women have a lower pain threshold than men, while sleep quality in men is the best indicator of pain sensitivity (Miró et al., 2012). This justifies adding indicators related to quality of life and sleep as complementary outcomes to pain management and physical condition in muscle strength training projects (Alves-Rodrigues et al., 2021; Solà-Serrabou et al., 2019).

With regard to the practical implication of this study, the information presented facilitates the literature review for evidence-based practice by physical activity and sport professionals in designing programmes focused on strength development for people with FM. In turn, it contributes to the reaffirmation of the benefit and safety this training modality can bring to patients with the disease. Based on this analysis, it is suggested that future experimental studies to evaluate training programmes in patients with FM should consider among its indicators the use of evaluations and parameters linked to the physical-functional and social capacity of the participants. However, physical training programmes need to be described considering each of their components (intensity, volume, frequency, duration and type of exercise). Also, it would be important to evaluate patterns in research for the dosage of the exercise based on stages or objectives according to the expectations of the participants (among others: pain control, physical-functional stability, social reintegration). Lastly, it would be necessary to report any injuries and/or adverse effects experienced by participants during the intervention programme.

Evidence-based practice is feasible with the information available until now. Among other things, the advancement of knowledge requires the involvement of a multidisciplinary team, the description of training load and quantity, the setting of goals regarding pain control, the promotion of physical-functional stability, or support for successful social reintegration.

Conclusions

In relation to the question of this project, regarding the effects of strength training on aspects of muscle strength,

well-being, symptoms, physical condition and adverse effects in people with FM, the findings suggest the safety and beneficial aspect of this type of training to impact pain control, improvement of individual physical condition and functionality. Although the quality of the evidence is very good, there still exists a lack of reports on adverse events in this type of publication. The existence of a multidisciplinary team in this type of project is a constant in favour of the complete care required for FM patients. In fibromyalgia patients, physical activity must be systematically included in the therapeutic plan, optimising this prescription for maximum benefit.

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Body Dissatisfaction, Mediterranean Diet Adherence and Anthropometric Data in Female Gymnasts and Adolescents

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Abstract

The aim was to analyse and compare body dissatisfaction, Mediterranean diet adherence (MDA) and anthropometric characteristics between acrobatic gymnasts and non-gymnasts. A sample of 151 adolescent girls (81 gymnasts and 70 non-gymnasts) aged between 10 and 19 years was selected. Body dissatisfaction was assessed through the Body Shape Questionnaire (BSQ), MDA was analysed through the Kidmed Test and anthropometric measurements enabled to calculate body mass index (BMI), waist-to-height ratio (WHR) and body fat percentage (BF%). The results indicated that gymnasts achieved significantly higher body satisfaction scores than non-gymnasts. In terms of MDA, 70.4% of gymnasts and 31.4% of non-gymnasts obtained optimal MDA. Gymnasts' body dissatisfaction was related to MDA, BMI and the rest of anthropometric measurements ($p < 0.01$), unlike non-gymnasts, for which only Weight-BMI, Height-Weight, WC-BSQ, WC-BMI, WC-Weight and WC-Height were related. In conclusion, gymnasts have less body dissatisfaction, higher MDA and a healthier BMI than non-gymnasts. Data suggest promoting acrobatic gymnastics within Physical Education programmes, as an extracurricular or competitive activity due to its benefits for both variables.

Keywords: adolescents, anthropometric measurements, body esteem, gymnastics modalities, Mediterranean diet.

Introduction

The relations between body dissatisfaction and MDA have been the subject of some studies in adolescents, indicating that the MDA they have is average and decreasing as they get older, and they have low percentages of body dissatisfaction (Peláez & Vernetta, 2019). The few studies that compare adolescents who practice AG and sedentary adolescents in relation to BI (Peláez et al., 2021) or MDA (Peláez and Vernetta, 2021) show that gymnasts have a better perception of their body image (BI) and better MDA than others, although results can vary depending on the sport (González-Neira et al., 2015; Rubio-Arias et al., 2015). Acrobatic gymnastics (AG) is an aesthetic sport of great technical complexity, in which BI, weight, a low body mass index (BMI) and a low fat percentage along with physical qualities are decisive in obtaining good results. Both socio-motor and aesthetic characteristics qualify it as a highly positive PAS within the context of physical education, and as an extracurricular activity in sport schools or clubs. Thus, practising physical activity on a regular basis has important physical condition and psychosocial benefits for adolescence, which is a time of great vulnerability for body image and where major physical and emotional changes occur. Moreover, the value placed on BI is increasing and particularly affects those involved in certain sports. This preoccupation impacts on eating habits and daily PAS, it can even reach obsession in the practice of sports and the strict control of diets (Valverde & Moreno, 2016). BI in adolescents is one of the most popular topics due to the importance that society gives to beauty and the industry being dedicated to physical appearance (Valles et al., 2020). This BI is the mental representation that each person has of their own body (Bonilla & Salcedo, 2021), which can be influenced by several factors related to lifestyle habits. When the perception of BI does not meet expectations, it is said that the person perceives their body according to their ideals and not according to reality, producing an alteration in it, such as body distortion or dissatisfaction.

In recent decades, having healthy lifestyle habits has become a great concern. Moreover, good nutrition and regular PAS practice have been proven essential for staying in good health and for the prevention of developing potential diseases (Kanstrup et al., 2020). In 2007, the European Commission on Public Health suggested that a balanced diet and sufficient regular physical activity are important factors in fostering and maintaining good health (Moral-García et al., 2021). The Mediterranean diet (MD) is one of the most renowned and studied dietary patterns in the world, considered a balanced diet, rich in fibre, antioxidants and unsaturated fats. It is characterised by a high consumption of fresh fruit and vegetables, whole grains, pulses, nuts, olive oil, moderate consumption of dairy and fish, and low consumption of red meat and deli meats (Serra-Majem et al., 2019). There is ample evidence of its benefits against several diseases and pathologies, as well as a protective role in cognitive impairment, dementia and depression (Dussaillant et al., 2016). This diet is highly recommended for the general population, as well as for athletes, since it can improve their performance (Rubio-Arias et al., 2015). However, in recent years, fewer people adopt this nutritional pattern and rather choose a diet which is high in energy, rich in saturated fat and low in micronutrients (Martini and Bes-Restrollo, 2020). Similarly, the number of adolescents who choose to not adhere to PAS practice is increasing, leading to a rising tendency towards unhealthy habits (Vernetta et al., 2018a). Therefore, it is important to reconcile the practice of PAS with an adequate diet in order to ensure better health. Furthermore, it appears that women who practise more PAS take better care of their diet than men (Castillo et al., 2007). However, there is contradictory evidence in this respect, since, female athletes are prone to have insufficient energy intake compared to normal population groups (Márquez, 2008) and, within female athletes, even more so among those competing in aesthetic sports such as gymnastics, where subjective assessment by judges often generates a preoccupation for weight and having a slim body (Esnaola, 2005).

In light of the above and the diversity of results, further studies are needed. The aim was to analyse and compare body dissatisfaction, MDA and anthropometric data between acrobatic gymnasts and non-gymnasts.

Methodology

Research design

Descriptive and observational study of quantitative methodology with a non-probabilistic, purposive sampling technique.

Participants

The sample consisted of 151 Andalusian female adolescents (81 acrobatic gymnasts and 70 who do not practise any sports). The age category was from 10 to

19 years (13.85 ± 2.45). The selection criteria were: adolescent gymnasts practising acrobatics and adolescents not practising any sports, who did not present body image distortion disorders, and signed the informed consent in order to participate in the research. The study complied with the ethical principles for research involving human subjects established in the Declaration of Helsinki in 1975 and was approved by the Research Ethics Committee of the University of Granada (no. 851/CEIH/2019).

Material and instruments

General data sheet. Questionnaire that allowed us to collect information related to age, school year and whether or not they practised any PAS in order to determine the sample of non-practising participants.

Body Shape Questionnaire (BSQ). Questionnaire validated by Cooper et al. (1987), adapted to the Spanish population by Raich et al. (1996), which measures body dissatisfaction, comprised of 34 items with six response options (1 = never and 6 = always). Their score is sorted into four categories, ranging from no dissatisfaction (less than 81) to extreme dissatisfaction (more than 140). The reliability of the BSQ for this study with the McDonald's Omega statistic was w = 0.807, a value approved and reported by Ventura-León & Caycho-Rodríguez (2017).

Kidmed Test. To estimate the quality of nutritional habits, the MDA Kidmed test by Serra-Majem et al. (2004) was used. It consists of 16 questions with dichotomous answers (yes/no) depending on whether there was consumption or not. The score fits into three categories: < 3 = low AMD, 4-7 = medium MDA and > 8 = optimal MDA.

Anthropometric measurements. Height, weight and waist circumference (WC) were assessed. Height was recorded using a SECA 220 stadiometer accurate to 1 mm and weight was recorded using a TEFAL digital scale accurate to .05 kg. BMI was determined using the Quetelet index (kg/m^2). Being adolescents, the indicators suggested by Cole et al. (2007) were used: grade III thinness (< 16); grade II thinness (16.1 to 17); grade I thinness (17.1 to 18.5); normal (18.5 to 24.9), overweight (25 to 30); and obesity (≥ 30). The WC was measured with a Seca 200 Type non-elastic tape (range from 0 to 150 cm; accurate to 1 mm). From which the waist-to-height ratio (WHR) was found to estimate the accumulation of fat in the core of the body. A ratio greater than or matching .55 would indicate a higher cardiometabolic risk (CMR) (Arnaiz et al., 2010). Regarding the subcutaneous triceps and subscapular skinfolds, a Holtain skinfold caliper was used, with a capacity of 50 mm and accurate to 0.2 mm. Which were used for the calculation of body fat percentage (BF %), performed using the specific references and equations of Slaughter et al. (1988).

Procedure

In order to explain the aim of the study and to ask for their collaboration, the gymnasts' coaches and the principal of a secondary school in Andalusia (Spain) were contacted. When favourable responses were obtained, informed consent was required from the participants' parents or legal guardians. Questionnaires were given to non-AG adolescent girls informing them about the tests. Then, anthropometric measurements were taken following the criteria of the International Society for the Development of Anthropometry specified in the international standards for anthropometric assessment (Marfell-Jones et al., 2012). The measurements for the gymnasts were taken during their training sessions, following these steps: completion of the BSQ, Kidmed and then the anthropometric measurements. One of the authors of this study was present at all times to answer any questions or doubts.

Data analysis

Data were analysed using SPSS, version 22.0 (SPSS Inc., Chicago, IL, USA). Quantitative variables were presented with the average and standard deviation and categorical variables in frequency and percentage. The normality and homoscedasticity of data were verified with the Kolmogorov Smirnov and Levene statistics, respectively. Since a normal distribution could not be observed, the use of a nonparametric analysis was chosen with the application of the Kruskal-Wallis, Mann-Whitney U test, and the association between variables through Spearman's correlation coefficients. Statistical significance was established at $p < .05$.

Results

Table 1 shows the descriptive characteristics of the sample according to whether or not they practice AG.

Table 2 shows that 53% of the total sample was of normal weight, and this percentage was higher among gymnasts (56.8%) than non-gymnasts (48.6%). Furthermore, no gymnast was found at a grade III thinness level, nor at an overweight or obese level, although some non-gymnasts were found at these levels.

Table 3 shows that 75.3% of gymnasts and 41.4% of non-gymnasts presented no body dissatisfaction; gymnasts were the ones who obtained the best percentages in the different categories of the BSQ.

Table 1
Descriptive analysis between gymnasts and non-gymnasts.

BSQ	Gymnasts (n = 81) M ± SD	Non-gymnasts (n = 70) M ± SD	p
Age	13.69 ± 3.05	14.04 ± 1.49	.000
Height (m)	1.54 ± .11	1.61 ± .06	.125
Weight (kg)	46.42 ± 10.25	52.41 ± 10.05	.238
BMI	19.52 ± 4.44	20.11 ± 3.53	.230
WC	59.78 ± 7.09	66.44 ± 8.17	.007
WHR	0.38 ± .03	0.42 ± .06	.521
BF%	19.52 ± 4.44	28.36 ± 2.91	.000

$p < .001$

Table 2
BMI distribution according to the levels set by Cole et al. (2007).

BMI	Gymnasts (n = 81) N(%)	Non-gymnasts (n = 70) N(%)	Total (n = 151) N(%)
Grade III thinness	0 (0)	8 (11.4)	8 (5.3)
Grade II thinness	15 (18.5)	5 (7.1)	20 (13.2)
Grade I thinness	20 (24.7)	14 (20)	34 (22.5)
Normal weight	46 (56.8)	34 (48.6)	80 (53)
Overweight	0 (0)	8 (11.4)	8 (5.3)
Obesity	0 (0)	1 (1.4)	1 (0.7)

Table 3
Body dissatisfaction comparison between gymnasts and non-gymnasts.

BSQ	Gymnasts (n = 81) N(%)	Non-gymnasts (n = 70) N(%)
No dissatisfaction	61 (75.3)	29 (41.4)
Mild dissatisfaction	16 (19.8)	32 (45.7)
Moderate dissatisfaction	2 (2.5)	6 (8.6)
Extreme dissatisfaction	2 (2.5)	3 (4.3)

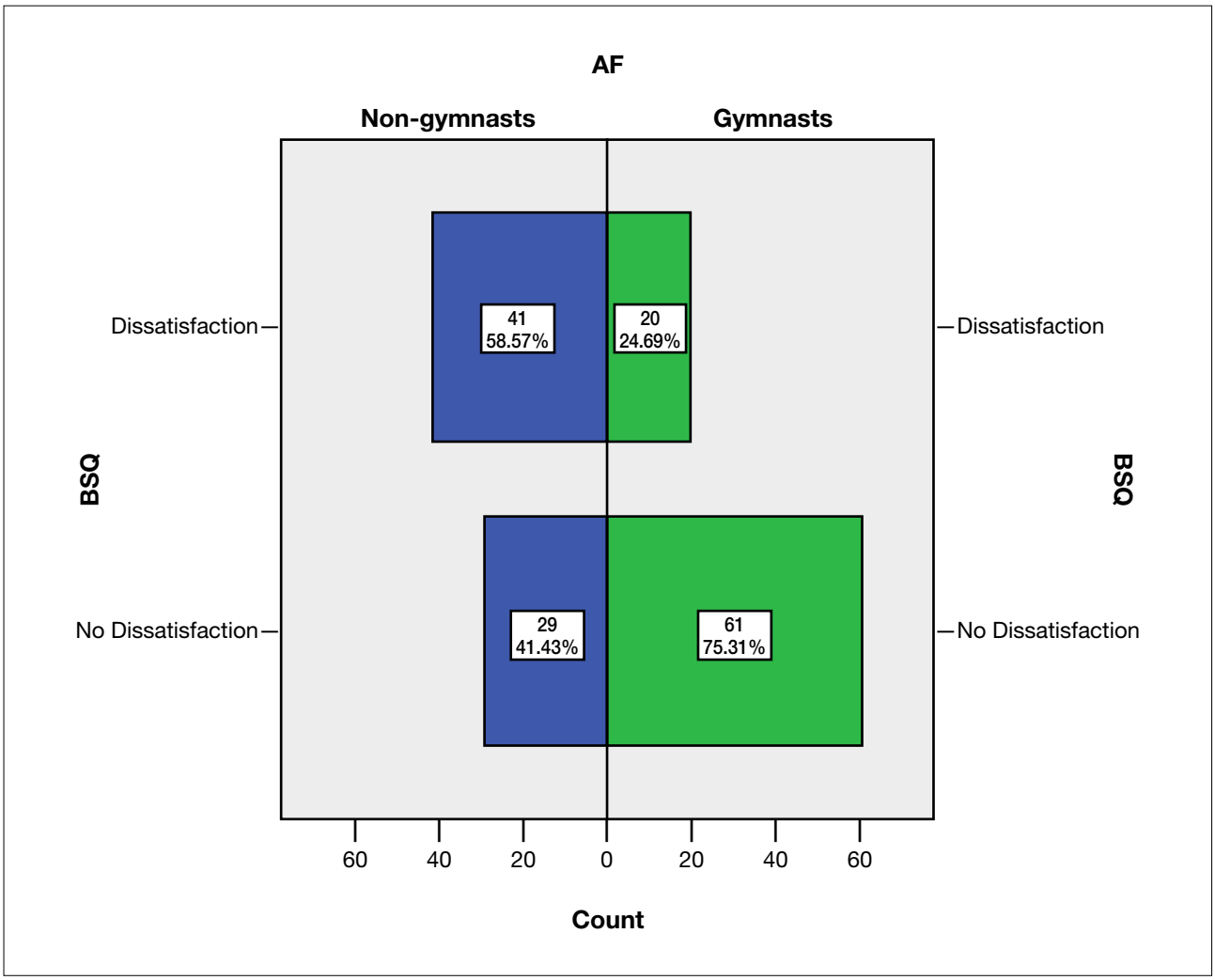

Figure 1
BSQ average ranges in gymnasts and non-gymnasts. Differences shown by the Mann-Whitney U test for independent samples.

Table 4
Comparison of nutritional aspects between gymnasts and non-gymnasts.

Kidmed Test	Gymnasts (*n* = 81) N(%)	Non-gymnasts (*n* = 70) N(%)
Optimal MDA	57 (70.4)	22 (31.4)
Average MDA	22 (26.2)	44 (62.9)
Low MDA	2 (2.5)	4 (5.7)

The Mann-Whitney U statistic showed statistically significant differences in the BSQ between gymnasts and non-gymnasts (U = 1874.500, Z = -4.217, p = .000); average ranges were higher in the different categories of dissatisfaction among non-gymnasts than among gymnasts (see Figure 1).

Regarding MDA results, 52.3% of the total sample presented optimal MDA, and these were higher among gymnasts than non-gymnasts (70.4% vs 31.4%, respectively) (Table 4).

Similarly, the Mann-Whitney U statistic showed statistically significant differences in MDA depending on

the practice of AG (U = 1731.000, Z = -4.685, p = .000) (see Figure 2).

In table 5, the 16 items of the Kidmed were analysed according to whether or not AG was practised. Gymnasts were shown to have a high consumption of fruit, fresh vegetables, pulses and fish, while non-gymnasts had a high consumption of fast foods, industrial pastries, sweets and did not have breakfast, with significant differences between the two groups.

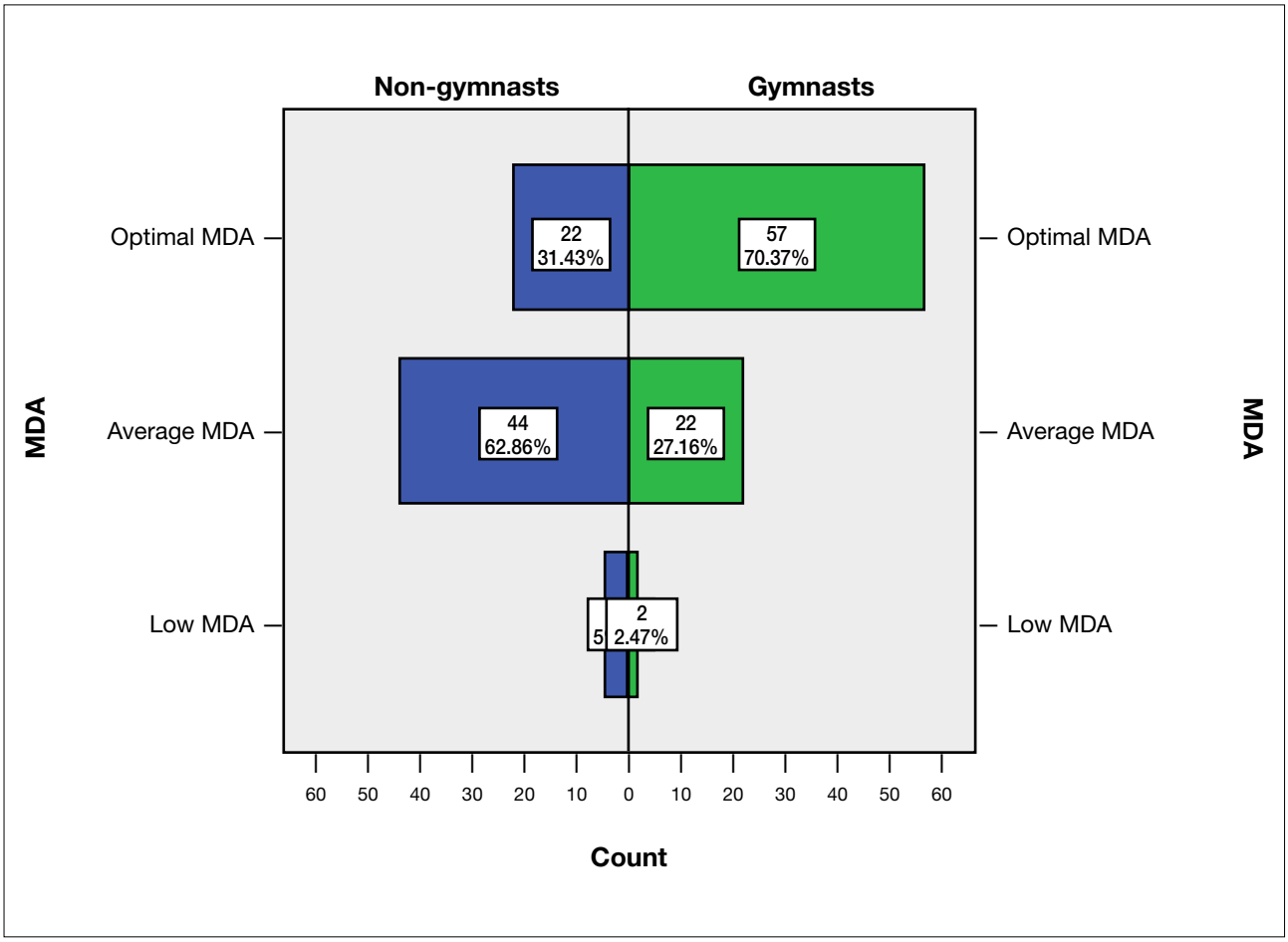

Figure 2
Average ranges of MDA in gymnasts and non-gymnasts. Differences shown by the Mann-Whitney U test for independent samples.

Table 5
Frequency (percentage) of different Kidmed test items depending on PAS practice.

Kidmed test items	Gymnasts (n = 81) N(%)	Non-gymnasts (n = 70) N(%)	p
Have a fruit or drink one fresh juice every day	47 (88.9)	21 (44.3)	.000
Have a second piece of fruit every day	58 (71.6)	10 (14.3)	.000
Eat fresh vegetables (salad) or cooked vegetables regularly once a day	62 (76.5)	20 (28.6)	.000
Eat fresh vegetables (salads) or cooked vegetables more than once a day	39 (48.1)	6 (8.6)	.038
Eat fish regularly (at least 2-3 times a week)	54 (66.7)	35 (50)	.000
Go once or more a week to a “fast-food" (hamburger restaurant type)	2 (2.5)	32 (45.7)	.000
Like pulses and eat them more than once a week	70 (86.4)	40 (57.1)	.000
Eat pasta or rice almost daily (5 days or more per week)	35 (43.2)	36 (51.4)	.313
Eat cereal or derivatives for breakfast	67 (82.7)	47 (67.1)	.027

Table 5 (Continued)
Frequency (percentage) different Kidmed test items depending on PAS practice.

Kidmed test items	Gymnasts (*n* = 81) N(%)	Non-gymnasts (*n* = 70) N(%)	*p*
Eat nuts regularly (at least 2-3 times a week)	47 (58)	25 (35.7)	.006
Use olive oil at home	80 (98.8)	51 (72.9)	.006
Do not have breakfast	10 (12.3)	25 (35.7)	.000
Have one dairy product for breakfast	73 (90.1)	32 (45.7)	.000
Eat industrial pastries, biscuits or cakes for breakfast	9 (11.1)	23 (32.9)	.001
Have two yoghurts and/or 40 g of cheese every day	30 (37)	32 (45.7)	.280
Have sweets several times a day	6 (7.4)	45 (64.3)	.000

Lastly, table 6 shows positive correlations in gymnasts between MDA and BSQ, between BSQ and anthropometric measurements and between the different pairs of anthropometric variables. In non-gymnasts there was no relation between MDA-BSQ variables, although there were positive associations between BSQ and WC, as well as between different pairs of anthropometric variables with each other: Weight-BMI, Height-Weight, WC-BMI, WC-Weight and WC-height.

Table 6
Association between MD, BSQ and anthropometric measurements depending on the practice or non-practice of AG.

BSQ		MD	BSQ	BMI	WEIGHT	HEIGHT	WC	BF%	AGE
	Correlation coefficient		-.410**	-.076	-.047	.020	-.020	-.049	-.139
MD	Sig. (bilateral)		.000	.499	.677	.861	.861	.665	.216
	N		81	81	81	81	81	81	81
	Correlation coefficient	-.110		.440**	.383**	.264*	.338**	.452**	.501**
BSQ	Sig. (bilateral)	.365		.000	.000	.017	.002	.000	.000
	N	70		81	81	81	81	81	81
	Correlation coefficient	-.170	.267*		.900**	.683**	.802**	.793**	.753**
BMI	Sig. (bilateral)	.160	.026		.000	.000	.000	.000	.000
	N	70	70		81	81	81	81	81
	Correlation coefficient	-.115	.280*	.874**		.913**	.856**	.791**	.828**
WEIGHT	Sig. (bilateral)	.343	.019	.000		.000	.000	.000	.000
	N	70	70	70		81	81	81	81
	Correlation coefficient	.079	.114	.040	.474**		.788**	.671**	.767**
HEIGHT	Sig. (bilateral)	.514	.347	.741	.000		.000	.000	.000
	N	70	70	70	70		81	81	81
	Correlation coefficient	-.083	.351*	.779**	.836**	.329**		.794**	.826**
WC	Sig. (bilateral)	.496	.003	.000	.000	.000		.000	.000
	N	70	70	70	70	70		81	81
	Correlation coefficient	.152	.186	.048	.084	.082	.163		.789**
BF%	Sig. (bilateral)	.208	.123	.694	.489	.498	.178		.000
	N	70	70	70	70	70	70		81
	Correlation coefficient	.045	.158	.265*	.272*	.116	.193	.291*	
AGE	Sig. (bilateral)	.714	.192	.027	.023	.337	.109	.015	
	N	70	70	70	70	70	70	70	

**Correlation is significant at the .01 level (2-tailed) Gymnasts Non-gymnasts
*Correlation is significant at the .05 level (2-tailed)

Discussion

The purpose of the study was to compare body dissatisfaction and nutritional aspects between acrobatic gymnasts and non-acrobatic gymnasts. Gymnasts were found to have lower body dissatisfaction, higher MDA, a higher number in normal weight and lower percentages of fat, thus confirming the hypothesis raised.

In terms of body dissatisfaction, gymnasts show less body dissatisfaction than non-gymnasts (40.40% vs. 19.21%), with significant differences. Our data contradicts scientific evidence originating from studies suggesting that this type of athlete is more likely to develop BI and eating disorders as they are preoccupied and even pressured to maintain a slim and aesthetic silhouette (Valles et al., 2020). More specifically, the study by Valles et al. (2020), comparing gymnasts with a control group, showed that elite gymnasts were the ones who reported a greater tendency to wish for a slimmer body, results that differ from the gymnasts in our study, who showed greater satisfaction with their BI than non-gymnasts, with significant differences. However, it is important to note that the study by Valles et al. (2020) does not specify the gymnastic discipline, and it can be interpreted that these higher percentages could be related to the discipline they practised. In fact, several studies comparing gymnasts from different disciplines confirm that rhythmic gymnasts tend to have more body dissatisfaction than artistic gymnasts, as well as lower body esteem than acrobatic gymnasts (Hernández-Alcántara et al., 2009; Vernetta et al., 2018b). Similarly, the study by Mockdece et al. (2016) in artistic gymnasts found significant concern for their BI. However, our results coincide with several studies that generally indicate good body satisfaction in gymnasts, as well as a positive perception of their BI (Ariza-Vargas et al., 2021). Specifically, our results confirm the recent study by Ariza-Vargas et al. (2021), which showed greater body satisfaction among acrobatic gymnasts compared to non-gymnasts.

In terms of MDA, the highest percentages in the optimal level stand out in gymnasts with 70.4% compared to 31.4% for non-gymnasts. Therefore, the percentages of low and medium MDA are higher in non-gymnasts, who need to improve their dietary pattern. Our percentage results in non-gymnasts are far from those reported in other studies carried out in Spanish adolescents from Granada and the southwest of Andalusia, where 53.6% and 73.33% obtained an optimal MDA (Chacón-Cuberos et al., 2018; Moral et al., 2019). However, they are more similar to the 45.2% of adolescent girls from Granada in the study conducted by Melguizo et al. (2021). This greater difference from MDA is due to a lower consumption of vegetables, fruit, fish, milk and pulses, also showing a higher intake of sweets, pastries and processed fast foods than gymnasts, with significant differences. When comparing our gymnasts with athletes from different disciplines, our optimal MDA data are better than the 51% among kayakers in Alacid et al. (2014), 47% of the swimmers in Philippou et al. (2017), 5.9% of female football players (González-Neira et al., 2015). As for female indoor football players, none recorded high MDA, their percentages were low and medium in MDA, 58.33% and 41.67%, respectively (Rubio-Arias et al., 2015). These results may be due to the importance given to the aesthetic component in this type of sport, which is not a common factor in other sports (Alacid et al., 2014; González-Neira et al., 2015). It is also important to note that our optimal MDA scores are higher than 52.2% among rhythmic gymnasts (Vernetta et al., 2018a). These differences in both sports can be seen in the different motor and morphological profiles of each speciality, as rhythmic gymnasts are characterised by an ectomorphic somatotype and acrobatic gymnasts by a mesomorphic-ectomorphic somatotype (Taboada-Iglesias et al., 2017; Vernetta et al., 2018b).

Analysing the results of the 16 items that make up the Kidmed test, gymnasts obtained the best results in the questions with positive connotations, with significant differences between both groups in all items, except “Do you eat fresh vegetables (salads) or cooked vegetables more than once a day", “Do you eat pasta or rice almost daily (5 days or more a week)", “Do you eat cereal or derivatives for breakfast", “Do you eat nuts regularly (at least 2-3 times a week)", “Do you use olive oil at home" and “Do you eat two yoghurts and/or 40 g of cheese every day". These results are opposite in the questions with negative connotations, in which non-gymnasts obtain higher percentages. Similarly, several authors indicate that the adolescent practising sports part of the population shows healthier nutritional habits than those who do not practice any PAS (Peláez & Vernetta, 2021).

Concerning the anthropometric measurements, 56.8% of the gymnasts had a normal weight compared to 48.6% of non-gymnasts. It was among gymnasts that higher percentages in the level II of thinness were found, although there were none in level III of thinness; moreover, 11.4% of non-gymnasts were in the same level. No gymnast was found to be overweight or obese, and the non-gymnast group presented values of 11.4% and 1.4%, respectively. Statistically significant differences were shown between AG practice and BMI, data matching the study by San Mauro et al. (2016) in Spanish adolescent gymnasts, in which these relations are also established, and in the comparative study between Greek gymnasts and non-gymnast adolescents by Tournis et al. (2010), in which statistically significant differences are made between the practice of AG and BMI, such as with weight. In terms of WC and BF%, gymnasts have lower percentages than non-gymnasts, these results may be due to the importance that gymnasts give to both

weight and BI as it is an aesthetic sport in which being thin and good looks are important factors in order to win and succeed (Vernetta et al., 2018b). More specifically, there are statistically significant differences in the BF% between both groups (19.52 gymnasts and 28.36 non-gymnasts), and these data are consistent with other studies in this group of the population such as that of San Mauro et al. (2016) & Tournis et al. (2010), in which the gymnasts' BF% was substantially lower than non-gymnasts. Regarding the WHR variable, none of the groups presented CMR (0.38 gymnasts and 0.42 non-gymnasts), which is below the 0.52 suggested by Arnaiz et al. (2010) to be considered at risk.

Lastly, the results obtained from the correlational analysis emphasise the association of positive signs between the two main variables of the MDA -BSQ study in gymnasts, as well as between all pairs of anthropometric variables with each other, relations already reported in adolescents practising AG in all these pairs of anthropometric measurements (Vernetta et al., 2018b). Among non-gymnasts, only relationships between body dissatisfaction and WC exist ($p < .001$); results reported by Delgado-Floody et al. (2017), who found an association between body dissatisfaction and increased abdominal fat and excess weight. Similarly, our results in non-gymnast adolescent girls match the study by Estrada et al. (2018), who find no relation between both MDA-BSQ variables, although they advocate that higher MDA is important for health promotion.

The main limitations are: the small size of the sample, and the fact that it was made up only of females, which means that results cannot be generalised to the total population of adolescents, whether or not they practise AG, nor to males. Another limitation is the cross-sectional design, with which it cannot be concluded that the observed relations are causal. Therefore, in future research, the sample could be extended to males, as well as establish longitudinal studies and include other variables such as academic performance and even a comparison of samples of AG from different competitive levels.

Conclusions

The main findings show that gymnasts have lower body dissatisfaction, higher MDA and healthier BMI than non-gymnasts, and no gymnast was found to be overweight or obese. Furthermore, higher body satisfaction is related to better MDA and all anthropometric measurements in gymnasts. In non-gymnasts, there is only an association between BSQ and WC, several anthropometric measurements with each other, Weight-BMI, Height-Weight, WC-BMI, WC-Weight and WC-height.

The study shows that the practice of AG has a positive influence on the satisfaction variables with BI and MDA. These data suggest the need to develop specific programmes from Physical Education subjects to improve and increase the satisfaction of BI in non-gymnasts, suggesting didactic units related to gymnastic sports, as there is scientific evidence indicating that the practice of both AG and rhythmic gymnastics improves the perception of body image (Ariza et al., 2021; Vernetta et al., 2018b). Similarly, results highlight the need to offer parents and coaches guidance on healthy eating habits, ensuring they are aware that proper nutrition, and a healthy body composition, are key not only to maintaining health but also to optimising performance in sports.

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Review of Interventions in Physical Activity for the Improvement of Executive Functions and Academic Performance in Kindergarten

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Abstract

Recent research has shown that continued physical activity (PA) has benefits on academic performance in students at different stages, the kindergarten stage being the least studied one. The aim of this research was to study and synthesise the existing relation between PA practice and the improvement of executive functions and academic performance in kindergarten, giving an overview of the current state of the question. To do so, a systematic review was carried out, focusing on identifying the general characteristics and effectiveness of intervention programmes conducted in this educational context. For the development of the study, a search of scientific literature was carried out in the Web of Science (WOS), Scopus and Proquest databases. "Physical activity", "academic achievement" and "preschool" were used simultaneously as key terms, "and" and "or" as Boolean operators, and a valid sample of a total of 18 scientific articles was set for the qualitative synthesis of this study. The results of the study indicate that there is a positive association between the integration of PA in the classroom and the improvement of executive functions and academic results, regardless of the curriculum content studied and the type of PA used. Thus, integrating PA into the classroom (as physically active lessons or active breaks) can be an important strategy to improve early literacy and curriculum content learning, while achieving PA levels close to the daily recommended levels.

Keywords: academic performance, executive functions, kindergarten education, physical activity, systematic review.

Introduction

Increasing the time spent practising physical activity (PA) and minimising sedentary time are important goals for children's health from a very young age (Hnatiuk et al., 2014). Consistent PA practice leads to many benefits for people's overall health (Jaksic et al., 2020; Popović et al., 2020). Despite this evidence, PA levels in kindergarten children remain relatively low (Hnatiuk et al., 2014) and one of the current main factors for sedentary lifestyles in students is the rise and increase in the use of latest information and communication technologies (Ortiz-Sánchez et al., 2021), which leads to excess weight, hypokinetic diseases and cardiovascular pathologies (Fang et al., 2019; Roscoe et al., 2019). It also increases the probability of suffering from other mental or affective and emotional illnesses (Loewen et al., 2019; Wu et al., 2017). Furthermore, from a motor point of view, decreased PA is associated with a low capacity to master motor skills in kindergarten (Lubans et al., 2010; Roscoe et al., 2019). Basic motor skills are typically developed in early childhood and provide the necessary building blocks for future motor skills. If the repertoire of physical-sports activities that the teacher offers for the development of these motor skills is poor, insufficient, and does not result in the exercise of skills, they will not be mastered sufficiently and consequently will lead to a decrease in the repertoire of motor skills (Castañer & Camerino, 1991). In this sense, the conceptual model offered by Stodden et al. (2008) suggests that, as children grow older, those with medium/high-level motor skills, and higher levels of PA, will perform better in their locomotor and object control skills. The literature supports the conceptual model, which, during the kindergarten stage, has a weak association between motor competence and PA, but the development of fundamental motor skill competence is important in order to reduce sedentary behaviour and increase PA. Thus, kindergarten children with better developed motor skills spend much more time on moderate to vigorous PA and much less time on sedentary behaviour than children with less developed motor skills (Williams et al., 2008). These negative aspects result in a decrease in children's quality of life in the long term (Emeljanovas et al., 2018; Hoare et al., 2019).

In addition to the overall health benefits of PA in children (physical condition, cardiometabolic health, bone health, reduction of adipose tissue, mental health, psychosocial and motor skills development; Padial et al., 2021), the WHO (2020) includes improved cognitive outcomes (academic performance and executive function [EF]). Thus, a positive relation is established between PA and academic performance, the latter being understood not only as academic achievement (grades and exam results), but also executive functions (memory, attention/concentration, problem solving, reasoning, decision making and verbal ability; Jarraya et al., 2019), as well as academic skills (behaviour, attendance and time spent on tasks; Vazou et al., 2021), which are highly dependent on the proper development of executive functions. From this perspective, recent reviews such as the one by Romero et al. (2017, p. 257) indicate that "physical activity not only improves overall cognitive functioning, but also improves performance on tasks that require executive functions".

The concept of EF is a multidimensional and evolving concept, due to advances in neuroscience, and is a basic component in explaining human cognition and behaviour (Ardila & Solís, 2008; Portellano & García, 2014). It consists of different components that work together in order to guide cognitive activity (Enríquez, 2014) and whose purpose is related to the ability to organise and plan (Rosselli et al., 2008). Generally, "EFs are defined as a group of mental processes that allow the control and regulation of other skills and behaviours, including those necessary to direct actions towards the achievement of previously established goals" (Gil, 2020, p. 116). Among its different components are: inhibition of reflexes and impulsive responses, speed of information processing, selection of task-relevant goals (planning, resource organisation, working memory), flexibility of goal-directed behaviour, interruption of ongoing activities according to needs, interference control, change of strategies in response to new demands of the environment or to new information received, behaviour monitoring, decision-making, regulation of emotional and behavioural/social responses, application of social cognition, motivation, drive, self-awareness and awareness of others (Gil, 2020; Gioia et al., 2017). Among these, those investigated in the articles found for this review are inhibitory control, behavioural flexibility, self-regulation, attention and working memory.

Another positive relation is that of motor and cognitive development, with motor skills being necessary for learning and later academic performance. The development of both of them occurs simultaneously, and it is between the ages of 5 and 10 years that the most important time for their growth is established (Escolano-Pérez et al., 2020). Motor skills acquired from an early age are related to the cognitive functions that the child will have in later stages (Michel et al., 2016). Furthermore, there is a well-documented relation at the primary school stage that associates the type of activity to cognitive control (Ureña et al., 2020). Thus, the cognitive efforts made when learning complex skills, or new motor skills, generate improvements in cognitive control. The effort made for learning these skills results in

greater cognitive control, which in turn influences greater autonomy and increasingly adaptive behaviour in children. Cognitively involved PA improves self-regulation and cognitive control in kindergarten children (Escolano-Pérez et al., 2020), although there is insufficient evidence of this relation in the early stages.

In order to contribute to research at this stage, the aim of this research was to study and synthesise the existing relation between the practice of PA and the improvement of executive functions and academic performance in kindergarten, giving an overview of the current state of the question. To do so, a systematic review was carried out, focusing on identifying the general characteristics and effectiveness of intervention programmes conducted in this educational context.

Methodology

Once the PA, health, and academic performance terms were seen, a systematic literature review was carried out, as the selection process has been developed according to the Spanish version of the items for publishing systematic reviews and meta-analyses of the PRISMA statement (*Preferred Reporting Items for Systematic reviews and Meta-Analyses*) (Yepes-Núñez et al., 2020), in order to establish an adequate review of the state of the question and evolution of the production.

Eligibility criteria, information sources and search strategy

For the development of the project, a scientific literature search was carried out in the Web of Science (WOS), Scopus and Proquest databases during the months of April and May 2021. Specifically, all databases were considered, with no delimitation of time range. The key terms "physical activity", "academic achievement" and "preschool" were used simultaneously, with "and" and "or" as Boolean operators, and a simple search by title and abstract was added. All areas of research were taken into account. This is how a total number of 9,219 scientific publications were set between the three databases.

The following inclusion and exclusion criteria were used to determine the sample of articles comprising the core body of this study (Figure 1).

In order to apply the inclusion and exclusion criteria, a first reading of the abstract and title was carried out. Which was followed by an in-depth reading of the full text. Then, a third and final screening was carried out in which, based on the abstract, only studies in which intervention programmes had been conducted in kindergarten were selected, limiting the sample to 293 articles. After the inclusion and exclusion considerations, the following figure shows the process, setting a valid sample for this study with a total of 18 scientific articles for the qualitative synthesis.

Selection process and data collection

To organise results found in eligible works, a data extraction form was developed and tested on the sample of included studies (n = 18). Data collection was carried out by the first author and revised by the second author. For any discrepancies, the authors held a discussion in order to reach a consensus. Two tables (Table 1 and 2) were created and the following data were recorded and coded for each eligible article: for general data table 1: (1) Author/s; (2) Year of publication; (3) Country;

	INCLUSION	EXCLUSION
Date of publication	Articles published between 2012 and 2021	Articles published in 2011 and previous years
Evaluation	Peer-reviewed articles published in English or in Spanish	Articles published in these languages not subject to expert assessment
Keywords	Studies containing them in the abstract, title or keywords	Studies that do not contain them in the abstract, title or keywords
Population and sample	Kindergarten pupils (0-6 years)	Pupils in primary education and above
Study cut	Longitudinal	Transversal
Type of research	Studies following an intervention programme	Studies that do not follow an intervention programme (literature review, trial...)

Figure 1
Inclusion and exclusion criteria of the studies selected for review.

(4) Sample; (5) Gender; (6) Age. For table 2 of data specific to the interventions carried out at the kindergarten stage: (1) Author/s; (2) Objective; (3) Time of intervention; (4) Type of study; (5) Type of Physical Activity; (6) Variables; (7) Data collection instruments; (8) Conclusions of the study.

Eligibility assessment was carried out in a standardised and independent manner by two researchers, an expert in Physical Education with a degree in Early Childhood Education and the other with a degree in Early Childhood Education, and experience in conducting scientific research and systematic reviews. Discrepancies were resolved through consensus, with the help of a third researcher in case of disagreement. Studies were included and excluded according to the PRISMA criteria. After searching the databases, duplicate studies were removed. Lastly, based on the eligibility criteria, three steps were followed to select the studies: reading the title, reading the abstracts and reading the full texts.

Assessment of the methodological quality of studies

The risk of bias for each eligible article was assessed by adopting a dichotomous nominal scale of two single values (yes/no), which was developed to assess agreement in the 18 studies of the sample. As scale variables, the inclusion and exclusion criteria indicated in section 4.1 (eligibility criteria). The degree of agreement obtained in the classification of works was 93%, which was obtained by dividing the number of matches by the total number of categories defined for each study, then multiplying by 100.

The extracted studies were organised and archived using Endnote software (X7), while categorisation and analysis were performed using QSR NVivo PRO software (version 12). In accordance with the information presented in the studies, the characteristics (year; location of the study; gender; stage of sport development, based on age and type of sport; social agents investigated; type of research; instruments and software used) and the quality of the studies were analysed quantitatively through the use of descriptive statistics (absolute frequency).

Results

Figure 2 describes the results of the process and sample selection, from the number of records identified in the search to the number of final studies included in the review ($n = 18$), represented in the flow chart below.

Tables 1 and 2 set out the main characteristics of each of the articles that comprise the core body of the systematic review.

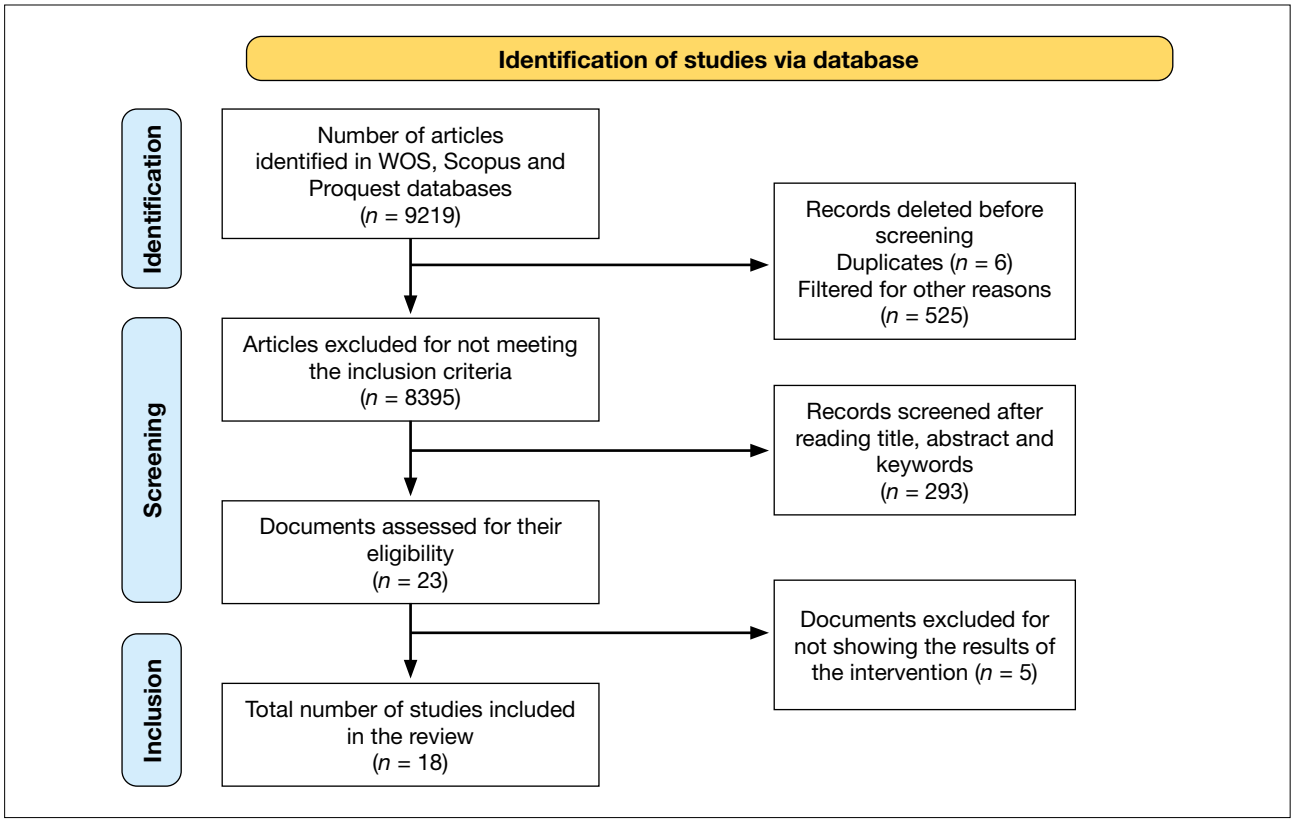

Figure 2
Results of the process and sample selection.

Table 1
General data concerning the studies in the sample.

Art.	Authors	Year	Country	Sample	Gender	Age
1.	Jarraya et al.	2019	Tunisia	45	F: 28 / M: 17	5 years
2.	Kirk & Kirk	2016	U.S.	54	F: 37 / M: 17	4 years
3.	Kirk et al.	2013	U.S.	54	F: 23 / M: 31	3 to 4 years
4.	Kirk et al.	2014	U.S.	72	F: 38 / M: 34	3 to 4 years
5.	Lundy & Trawick-Smith	2021	U.S.	21	F: 12 / M: 9	3 to 4 years
6.	Mavilidi et al.	2016	U	90	F: 45 / M: 45	4 to 5 years
7.	Mavilidi et al.	2017	Australia	90	F: 45 / M: 45	4 to 5 years
8.	Mavilidi et al.	2015	Australia	111	F: 61 / M: 64	4 to 5 years
9.	Omidire et al.	2018	South Africa	20	U	6 years
10.	Padial-Ruz et al.	2019	Honduras	88	F: 48 / M: 44	4 to 7 years
11.	Robinson et al.	2016	U.S.	113	F: 45 / M: 68	4 to 5 years
12.	Shoval et al.	2018	U.S.	160	F: 65 / M: 95	4 to 6 years
13.	Stein et al.	2017	Germany	102	F: 49 / M: 52	5 to 6 years
14.	Toumpaniari et al.	2015	Greece	67	F: 37 / M: 30	4 years
15.	Ureña et al.	2020	Spain	49	F: 33 / M: 16	4 to 5 years
16.	Vazou et al.	2021	U	245	F: 105 / M: 141	3 to 7 years
17.	Wen et al.	2018	China	57	F: 26 / M: 31	3 to 4 years
18.	Xiong et al.	2017	China	39	F: 19 / M: 20	4 to 5 years

Note: Unknown (U); Male (M) and Female (F) Gender.

Table 2
Data concerning intervention programmes.

Art.	Objective	Type of study	Time	Variables	Measuring Instruments	Conclusions
1.	Investigate the effects of yoga on visual attention, visual motor perception, hyperactivity and attention deficit.	Pret-Post (EG1: 15; EG2: 15; CG: 15)	12 weeks 24 ss/30 m	Visual attention, visual motor perception and attention deficit and hyperactivity behaviours	Visual attention test (NEPSY), visuomotor accuracy (NEPSY II), ADHD Rating Scale-IV	Children who participated in the yoga programme improved their executive functions, attention deficit and hyperactivity.
2.	Evaluate the impact of academic lessons, integrating PA, on early literacy, rhyme and alliteration.	Pret-Post-Post (EG: 39; CG: 15)	8 months 300 m/wk	PA, early literacy (picture naming, rhyme and alliteration), teacher satisfaction	IGDI, SOFIT, teacher satisfaction survey	A PA programme led by a teacher is effective in increasing PA and improving early literacy.
3.	Determine the impact of lessons integrating PA on early literacy.	Pret-Post-Post (EG: 24; CG: 30)	6 months 300 m/wk	BMI, PA, early literacy skills, teacher satisfaction	Digital weighing scale, portable stadiometer, IGDI, SOFIT, satisfaction survey	The programme promotes daily PA, improves literacy and reduces BMI increase.
4.	Determine the effect of a low-cost, teacher-led intervention programme.	Pret-Post-Post (EG: 51; CG: 21)	6 months 30 m/day	PA, early literacy, teacher satisfaction	IGDI, SOFIT, teacher satisfaction survey	Academic lessons delivered through PA improve early literacy.
5.	Determine the effects of outdoor games prior to a learning experience on inhibitory control and attention.	Pret-Post (EG: U; CG: U)	2 weeks 2 ss/60 m	PA, inhibitory control, attention, age, gender, socioeconomic status	Behavioural coding scheme, observation scale	The intervention improved attention and inhibitory control in learning sessions.
6.	Investigate the effect of integrated PA on geography tasks and learning.	Pret-Post-Post (EG1: 28; EG2: 29; CG: 30)	3 ss/week	PA, geography learning and children enjoyment	Accelerometer, memory tests, satisfaction questionnaire	The programme improved moderate and intense PA and learning of geography content.
7.	Evaluate the effects of an integrated PA programme on the learning process of science content.	Pret-Post-Post (EG1: 30; EG2: 27; CG3: 29)	4 weeks 4 ss/10 m	PA, science learning and children enjoyment	Accelerometers, memory test, satisfaction questionnaire	Science learning in the integrated and non-integrated PA condition is greater than in the control condition.
8.	Evaluate the effects of a PA programme and body movement on Italian vocabulary learning.	Pret-Post-Post (EG1: 31; EG2: 23; EG3: 31; CG: 26)	4 weeks 2 ss/15 m	PA, foreign languages vocabulary learning	Free and key memory test, accelerometers	Children in the integrated PA condition achieved better learning results in Italian vocabulary.
9.	Evaluate the use of structured motor activities to teach mathematics and languages.	Post test (EG: 20)	30 m/4 days x week	Language comprehension and mathematics, children enjoyment	Recording, research diary, observation sheets, reflective notes, and semi-structured interview	Movement experiences can improve understanding of mathematics and languages content.

Note 1. Pre test (Pret); Post test (Post); Control Group (CG); Experimental Group (EG); Minutes (m); Sessions (ss); U: Unknown.

Table 2 (continued)
Data concerning intervention programmes.

Art.	Objective	Type of study	Time	Variables	Measuring Instruments	Conclusions
10.	Analyse the effectiveness of a programme based on PA and gestures on motivation and learning English vocabulary.	Pret-Post (EG1: 22; EG2: 38; CG: 28)	5 weeks 2 sessions/ week 1h	Vocabulary learning, motivation, socio-demographic variables	"Smiley scale", vocabulary checklist, **ad hoc** questionnaire	PA is an effective motivational resource that improves academic performance and learning English vocabulary.
11.	Examine the effectiveness of the CHAMP programme on motor skills and self-regulation.	Pret-Post (EG: 68; CG: 45)	5 weeks 15 sessions/ 40 m	Motor skills and self-regulation	TGMD-2, Kindergarten Self-Regulation Assessment reward introduction task	The CHAMP group significantly improved motor skills and maintained self-regulation scores.
12.	Prove that integrating movement into the learning environment contributes to improved academic achievement.	Pret-Post (EG1: 61; EG2: 54; CG: 45)	145 days 90 m/day	Languages, mathematics and non-verbal language	MAT, CRT, SPM Matrices, Ordinal number sequencing test	Conscious movement improves academic achievement.
13.	Examine the relations between motor and executive functions, and test the effects of an acute coordinated intervention in Physical Education.	Pret-Post (EG: 48; CG: 53)	25 minutes	PA, executive functions, motor functions and task order	Polar Watch RS800sd, H1 sensor belt, "Simon says", "hearts and flowers task", M-ABC2	No effect of an acute coordinated intervention on executive functions was revealed.
14.	Examine whether learning foreign languages vocabulary through PA and gestures leads to better results and enjoyment for children.	Pret-Post (EG1: 23; EG2: 23; CG: 21)	4 weeks 8 sessions/ 1 hour	Learning foreign languages vocabulary, children enjoyment	"Smiley scale", vocabulary checklist	Instructional methods that combine PA and gestures are learning enhancers.
15.	Verify the effects of PA on self-regulation in a sample of kindergarten children.	Pret-Post (EG1: 12; EG2: 13; EG3: 12; CG: 12)	15 minutes	PA, self-regulation, cognitive control (reactive/ proactive)	HTKS, General Dynamic Coordination Test	More demanding coordination activities improved self-regulation and cognitive control.
16.	Investigate the effectiveness of the "Walkabouts" active breaks programme on attention and behaviour.	Pret-Post (EG: 158; CG: 87)	7 weeks (20 days) 3 times/ week	PA, self-regulation, attention, student and teacher enjoyment	Teacher diary, SOSMART, SWAN	The programme facilitated learning and academic performance by increasing attention and self-regulation.
17.	Investigate the effects of the PA programme (mini-trampoline) on the development of executive functions (EF).	Pret-Post (EG: 29; CG: 28)	10 weeks 20 m/day	PA, inhibitory control, working memory and cognitive flexibility	Accelerometer, SCA, WMS, FIS	The programme was not sufficient to improve executive functions.
18.	Examine the effects of a structured PA programme on EF and perceived physical competence, compared to recess.	Pret-Post (EG: U; CG: U)	3 months 30 m/day	Demographic and anthropometric data, executive functions, perceived physical competence	Demographic questionnaire, executive function measure, Pictorial Scale of Perceived Competence and Social Acceptance	The intervention significantly increased executive functions.

Note 1. Pre test (Pret); Post test (Post); Control Group (CG); Experimental Group (EG); Minutes (m); Sessions (ss); U: Unknown.

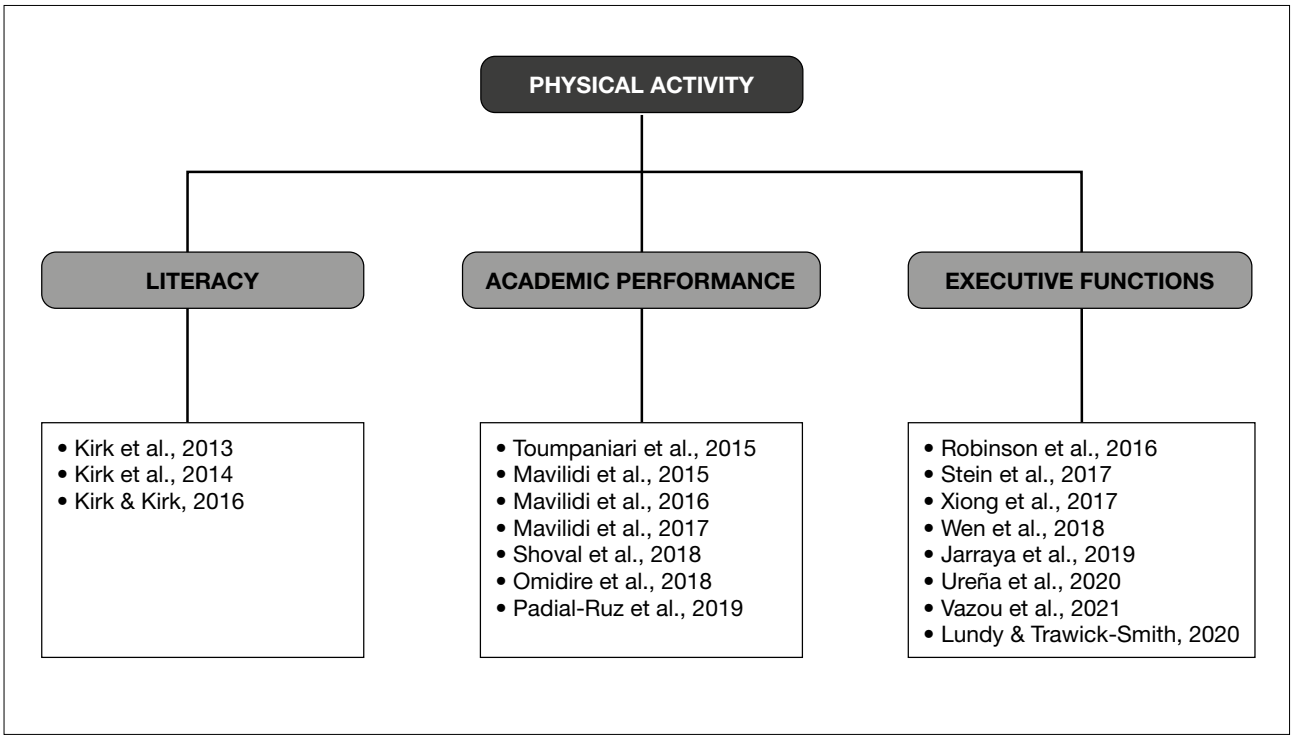

Figure 3
Central themes analysed in the sample.

For the result synthesis, a grouping of the different articles was made, distinguishing between studies in which PA is directly related to literacy, integration of PA in curriculum content and academic performance, and those relating PA to other performance determining factors, such as executive functions (figure 3).

Physical activity and literacy

$n = 3$ studies (16.7% of the total sample) linking PA to literacy in kindergarten were found. All used the same research design, as shown in table 2, with a longer intervention time (8 months) in the Kirk & Kirk (2016) study.

The first two studies (Kirk et al., 2013; Kirk et al., 2014) were designed to cover half of the recommended PA time per day (half an hour divided into two 15-minute slots), while the last one (Kirk & Kirk, 2016) reached 60 minutes per day divided into two 30-minute slots. Regarding the type of PA used for the experimental condition, it only states that they are activities of moderate intensity, such as walking or jumping. Results showed improvement in PA levels of the children who participated in the experimental condition, with 90% adherence (Kirk et al., 2014) and over 95% for the recommended exercise, and also indicated increased PA intensity (Kirk & Kirk, 2016). The literacy lessons were aimed at improving the areas of picture naming, rhyming and alliteration (phonological awareness). All made significant improvements in the areas of alliteration and rhyme, although there was not much difference in picture naming.

Physical activity integrated to the curriculum and academic performance

$n = 7$ studies (38.9% of the total sample) were found to add PA to teaching curriculum content such as languages (Mavilidi et al., 2015; Padial et al., 2019; Toumpaniari et al., 2015), geography (Mavilidi et al., 2016), Spanish (Omidire et al., 2018), mathematics (Omidire et al., 2018; Shoval et al., 2018) and science (Mavilidi et al., 2017; Shoval et al., 2018).

Studies that aimed to determine the effects of incorporating PA and the use of gestures for learning vocabulary in a foreign language ($n = 3$) used a similar design, with a minimum of two experimental conditions. One was based on the integration of PA and gestures for teaching vocabulary (Padial et al., 2019; Toumpaniari et al., 2015). The second, in which they learned new vocabulary through gestures. And a third, in the study by Mavilidi et al. (2015), in which an additional experimental group was included, and movement was used, but not integrated to vocabulary learning.

PA, both in terms of intensity improvement and time in minutes, was only measured objectively in the study by Mavilidi et al. (2015) through the use of accelerometers, a larger number of minutes of PA and a longer time of moderate to vigorous PA were recorded, both in the integrated and non-integrated PA condition, with no significant differences. Generally, results on academic performance show an improvement with the use of integrated PA for learning vocabulary in both English (Padial et al., 2019; Toumpaniari et al., 2015) and Italian (Mavilidi et al., 2015).

As for the rest of the curriculum contents studied (n = 4), PA was only measured objectively in the studies by Mavilidi et al. (2016) and Mavilidi et al. (2017) through accelerometers. These revealed that, in the first study, those who accumulated the most PA were those in the non-integrated condition, while in the second study, the integrated PA condition obtained the best results in the tests. The results, in terms of content learning, indicated that both the integrated and non-integrated conditions showed better results in learning geography content, but it could not be demonstrated that the integrated PA condition performed better than the non-integrated condition (Mavilidi et al., 2016). However, Mavilidi et al. (2017) did obtain better results in science tests using the integrated PA condition than the non-integrated and control conditions. The Shoval et al. (2018) study shows the same result for learning mathematics and that of Omidire et al. (2018), in which they concluded that when learning was performed through games, comprehension, listening, language and mathematics results were much better.

Physical activity and executive functions

n = 8 studies (44.4% of the total sample) were obtained which analyse the effects of motor and PA programmes on EF (figure 4), and a variety of components were studied: Inhibitory control (n = 4); Flexibility (n = 3); Self-regulation (n = 3) and Attention (n = 3); Working memory (n = 2). Only n = 2 of these articles measured the validity of the programmes used for PA improvement in terms of practice time, measured by accelerometers (Wen et al., 2018); and PA time and intensity, measured by SOSMART (Vazou et al., 2021). PA time was significantly increased in the study by Wen et al. (2018), while in the Vazou et al. (2021) study, there was an increase in practice time, but not in activity intensity, which was predominantly low.

The type of PA that was designed for the interventions used motor games in most of the studies. Specifically, coordination games of moderate intensity with little or no movement (Stein et al., 2017), motor games for motor skill development (Xiong et al., 2017), outdoor motor play sessions (Lundy & Trawick-Smith, 2021) and trampoline PA (Wen et al., 2018). The results regarding the improvement of inhibitory control, in n = 2 studies, reveal that children who participated in the intervention condition improved this EF (Lundy & Trawick-Smith, 2021; Xiong et al., 2017), while in the other two groups, the intervention showed no effect on EF (Stein et al., 2017; Wen et al., 2018).

Regarding the observation of effectiveness of PA on Self-regulation, pre and post test designs with a control and experimental group were carried out, except for Ureña et al. (2020), which used 3 experimental groups. The samples of kindergarten pupils (3-7 years) ranged from 49 pupils in the study by Ureña et al. (2020) to 245 in the Vazou et al. (2021) study. The intervention time was of 15 minutes, delivered in a single intervention (Ureña et al., 2020), at 7 weeks / 3 times per week (Vazou et al., 2021). The type of PA designed for the experimental conditions were: motor skills and tasks (Robinson et al., 2016); walking obstacle course, cycling obstacle course and motor story (Ureña et al., 2020); Walkabouts (commercial web-based programme that includes fundamental movements such as jumping, hopping, walking and stretching) (Vazou et al., 2021). Regarding the improvement of self-regulation, results show that the children who participated in the intervention condition improved this EF (Robinson et al., 2016; Vazou et al., 2021). In the first part, all intervention groups improved, while in the second part, in which a new standard was added, significant improvements were only seen in the groups where coordination demand was higher (Ureña et al., 2020).

Regarding the effectiveness of PA on *Attention*, the intervention time was of 12 weeks, with a total of 24 sessions of 30 minutes. The type of PA designed for the interventions was: yoga sessions for one group, and moderate-intensity generic PA for the other. Results on attention indicate an improvement in two of the studies (Lundy & Trawick-Smith, 2021; Vazou et al., 2021) and in the case of Jarraya et al. (2019), the results showed an improvement in attention for the yoga condition over the remaining conditions.

For the observation of effectiveness of PA on the *Working memory* of the two studies that evaluated this component, one obtained improvements in participants from the experimental condition (Xiong et al., 2017), while Wen et al. (2018) found no significant improvements.

Figure 4 summarises the research (n = 18) that obtained improvements or not on the different variables studied.

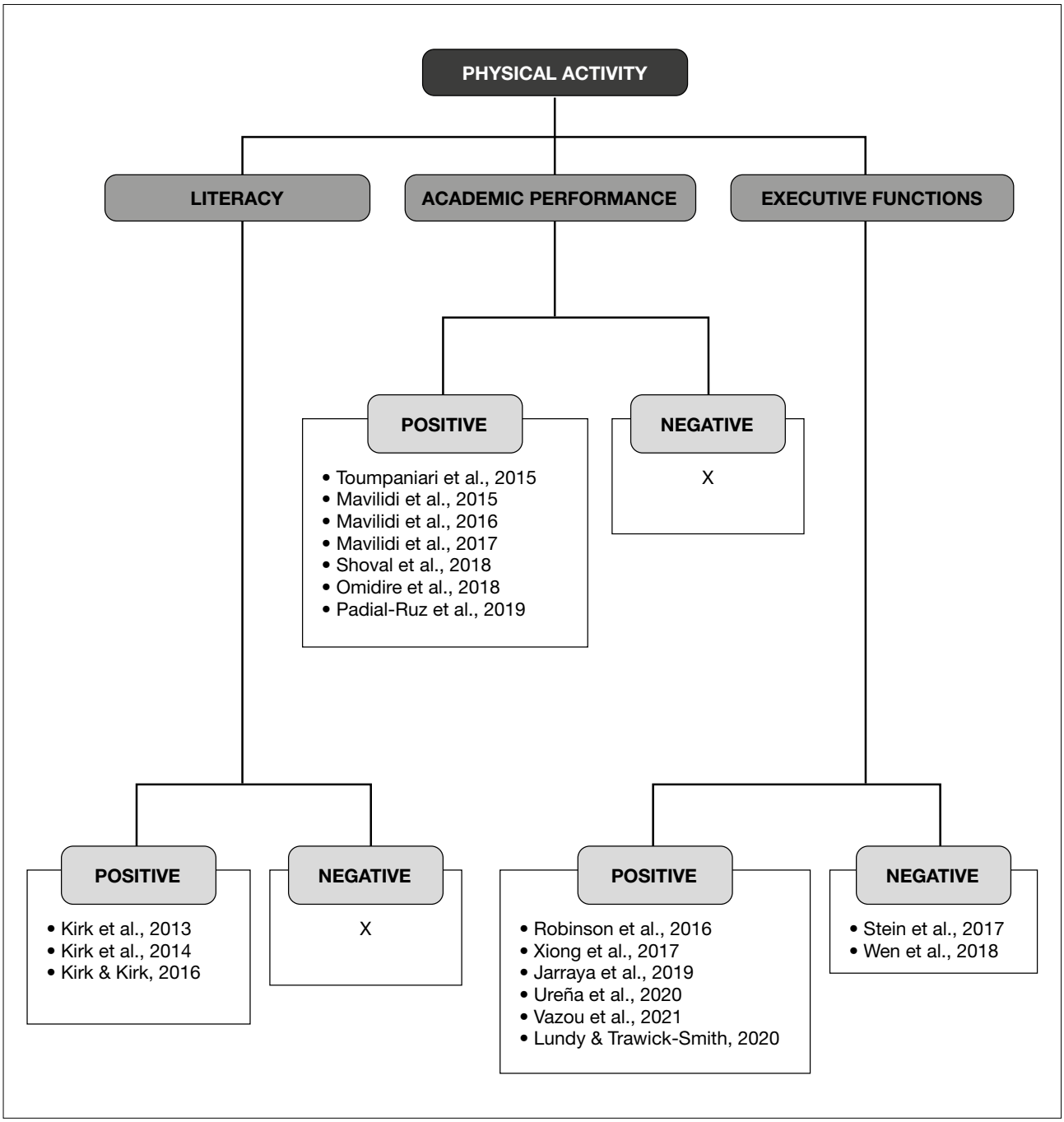

Figure 4
Effect of PA interventions on academic achievement and executive functions.

Discussion

Based on the main objective of this study, it was found that, in the case of *literacy*, the studies reviewed suggest that PA can have a significant influence on children's early literacy skills. Possible reasons, as indicated by Kirk & Kirk (2016), are the improved attention to a task, better long-term memory, children's increased ability to think and process information, and improved classroom behaviour (Davis et al., 2007; Miller & Votruba-Drzal, 2013). Moreover, the idea of incorporating PA to academic content can be a strategy to increase PA in a kindergarten setting (Castelli et al., 2007; Coe et al., 2006). This is important, as improved literacy skills development in early childhood contributes to children's long-term academic success. Children who lack basic skills such as phonological awareness, letter and print knowledge may have difficulty learning to read when they start school (Kirk & Kirk, 2016).

With regard to PA being integrated into the curriculum, for the improvement of academic performance and PA time during classes, all the interventions carried out in the kindergarten stage provide positive results, regardless of the curriculum content studied (foreign languages, mathematics, science, language,...) and the type of PA. Similarly, children who participated in this type of intervention were more physically active (Mavilidi et al., 2016; Toumpaniari et al., 2015) and showed improved cognition, classroom performance and academic results, supporting the theory that PA integrated to the curriculum is educational and can promote health, social and cognitive benefits to students (Omidire et al., 2018). One explanation for this improvement is that children could have been more enthusiastic about the new active teaching methods. Consequently, not only could they have put more physical effort into the exercise, but they could also have been able to invest more mental effort in learning (Sebastiani, 2019). Thus, although few studies exist, there is a positive association between physically active classes and academic results compared to traditional sedentary classes (Omidire et al., 2018; Shoval et al., 2018). Beyond health benefits, they also have positive effects on brain development and learning ability, as well as facilitate children's executive function, which is important for academic achievement (Milne et al., 2018; Tomporowski et al., 2008). Therefore, when considering the integration of PA in the teaching of different curriculum contents as a form of cognitive demand exercise, it is possible that these lessons could result in improved cognitive and academic results, especially when they add psychosocial mechanisms, which increase students' motivation and interest towards learning (Diamond & Ling, 2016; Viciana et al., 2017).

The complex composition of *executive functions* increases the measurement difficulty, particularly among kindergarten children. The positive relation between PA and academic performance has been demonstrated, and its use in teaching is an effective tool for the development of cognitive content (Singh et al., 2012), as games and movement are significant resources for students, which help improve attention and motivation for learning (Janssen et al., 2014). However, not all the articles analysed in this review demonstrated positive effects on some of the EF components, such as cognitive flexibility and working memory, matching previous research such as that of Mierau et al. (2014). These results contradict studies reporting the positive effects of coordinated interventions and aerobic exercise interventions on inhibition (Barenberg et al., 2011; Jäger et al., 2014) and cognitive flexibility (Ellemberg & St-Louis-Deschênes, 2010; Chen et al., 2014), obtained in children over 6 years, adolescents and adults. This may be caused by the attentional and cognitive resources of kindergarten children being more limited than those of older children and because the intensity of the activities performed was not high enough to stimulate cognitive development. Other reasons could have been insufficient sample size and intervention time (Wen et al., 2018).

As in previous reviews carried out at the primary school stage (Chacón-Cuberos et al., 2020), most of the studies analysed in this review show how the practice of PA improves academic performance and the development of executive functions; and although no conclusions can be drawn about the type of PA, its intensity and duration from the articles included in this review, some of the characteristics of PA (table 3) that can produce positive effects on these parameters at the kindergarten stage are:

Table 3
Type of PA used with positive effect on executive functions and academic performance.

Authors	Characteristics
Kirk & Kirk (2016); Mavilidi et al. (2017); Shoval et al. (2018); Ureña et al. (2020)	Integration of PA into lessons; PA integrated into the curriculum; Conscious movement; Physical education with cognitive involvement.
Lundy & Trawick-Smith (2021); Stein et al. (2017)	Exercises and activities of high intensity and duration. Gross motor skills exercises. Motor games.
Padial et al. (2019); Toumpaniari et al. (2015)	Combination of PA and gestures for learning curriculum content.
Jarraya et al. (2019)	Yoga activities.
Mavilidi et al. (2016).	Group games (observing the movements of others can activate neurons related to the same actions).
Omidire et al. (2018); Xiong et al. (2017).	Structured physical activity.
Ureña et al. (2020)	Complex motor skills.

This review contributes to the existing evidence base, to our knowledge it is the first systematic review on physical activity programmes implemented in the kindergarten stage for improving academic performance. The findings must be understood bearing in mind the following limitations. Firstly, the high level of heterogeneity detected in the included studies limits the strength of these findings. Secondly, the limited amount of research measuring the improvement of PA in interventions, the characteristics of this PA being fundamental to support the validity of the results in terms of academic performance and the development of executive functions. Thirdly, methodological limitations, which prevent from making a valid conclusion because of the variety in the sample and the different activities that comprise the interventions, or the duration of implementations. Some interventions were implemented for a short period of time, which is why only short-term results could be observed, without having the possibility to verify the possible continuation of these results or the potential long-term benefits.

Despite all these limitations, the review reflects the efficiency of the interventions conducted, with 88.9% of the studies demonstrating their effectiveness. One of the main advantages of these PA programmes is that they are minimal interventions that can easily be brought into the classroom, since they require little change in the methodology of the stage and a small cost in resources and investment for schools, guaranteeing their sustainability over time. Thus, we consider that the practical application of this review focuses on two areas: The first is the utility for schools, as it provides active methodologies, allowing the physical and motor improvement of the child, enables more adherence to PA from an early age and favours the learning and cognitive development of kindergarten pupils. And the second is researchers, since it provides a basis for all interventions conducted to enable their future replication.

Conclusions

The results of this systematic review indicate that there is a positive association between different strategies for the integration of PA in the classroom and academic results, regardless of the curriculum content studied (foreign languages, mathematics, science, language) and the type of PA practised for the intervention.

Although it is not possible to draw clear conclusions about the type of PA, the intensity and duration that it should have in order to achieve greater effectiveness, the research analysed reveals that the most effective interventions are those that involve a moderate level of PA and, which are also linked to the development of the different curriculum contents, and need at least a minimum of 10 minutes in order to obtain positive results. Thus, the academic lessons delivered using PA can be an important strategy for improving early literacy and curriculum content learning, all the while achieving PA levels close to those recommended daily. Programmes using moderate or vigorous PA intensity reached better scores than the others. Similarly, pupils who benefited from this type of intervention show a higher level of willingness and motivation towards the task.

Regarding the effectiveness of physically active classes, or curriculum-integrated PA on EF, not all the articles reviewed show positive effects on some components such as cognitive flexibility and working memory.

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Validation and Reliability of The Wheeler Jump Sensor for the Execution of the Countermovement Jump

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Abstract

Many coaches have used the vertical jump as an indicator of neuromuscular performance. In this study, a total of 119 high-performance athletes from different sports disciplines were selected in a non-probabilistic and convenient manner. Jump performance was evaluated through the CMJ in a training session using the Chronojump Boscosystem contact platform, the OptoGait photoelectric system and the My Jump 2 mobile application as measurement tools, comparing the results with the values obtained with the Wheeler Jump sensor. Statistically significant validity and reliability were established (Wheeler Jump vs OptoGait ICC .997 - .998, $p < .001$; Wheeler Jump vs My Jump 2 ICC .991 - .995, $p < .001$; Wheeler Jump vs ChronoJump ICC .995 - .997, $p < .001$), thus determining that the Wheeler Jump sensor is a reliable tool that provides professionals and researchers with accurate information regarding changes in the physical performance of athletes.

Keywords: athlete, jumps, optical, plyometrics, sensor, validation.

Introduction

Historically, the vertical jump has been used as an indicator of neuromuscular performance by many coaches of different disciplines in the world (Montalvo et al., 2021). During the decade of the sixties, Professor Rodolfo Margaria was the first person to talk about the relevance of the so-called Stretch-Shortening Cycle (SSC) stating that a concentric contraction preceded by an eccentric one could generate higher levels of strength than an isolated concentric contraction (García-López et al., 2003).

Most sports movements and actions comply with this SSC, thus facilitating concentric contractions or propulsive phases; for that reason, the jump that has been most popular in the sports field as an indicator of neuromuscular efficiency has been the Countermovement Jump (CMJ), which has been described in the literature as a determinant of the elastic explosive manifestation of strength (Garrido-Chamorro & González-Lorenzo, 2004). For the evaluation of the CMJ, the most used protocol has been the Bosco test, performed through a contact platform, which allows the evaluation and characterization of the functional parameters of the jump in each of the athletes and also allows the measurement of the strength of the lower extremities (Tejada & Suarez, 2013).

There is ample scientific evidence regarding the use of the vertical jump as an indicator of sports performance (Tejada & Suarez, 2013). Accordingly, a wide variety of technological tools can be used for the evaluation of this parameter, ranging from those that are exclusively for laboratory use to the use of portable instruments for field evaluation.

In this sense, strength platforms have been considered the most reliable and validated instrument for the evaluation of lower limb strength and power through vertical jumping (Bosco et al., 1983a). Nevertheless, the cost of this instrument continues to be a barrier for most trainers and/or physiotherapists. However, the evaluation of strength from the height of the jump estimated by the time of flight has become a validated, accepted and low-cost technique for the evaluation of neuromuscular efficiency during the jump (Bosco et al., 1983b; Harman et al., 1991).

Some measuring tools or instruments such as contact mats such as the Chronojump Boscosystem (ICC 0.95) (De Blas et al., 2012), and/or photo-optical systems such as the OptoGait (ICC 0.99) (Lee et al., 2014) are used to determine the height of the vertical jump, measuring the time of flight as established by Bosco et al. (1983b).

These optical systems present an advantage compared to force platforms and contact mats; this advantage is to be able to perform the jump assessment on the same surfaces where the athlete competes or trains (Bosquet et al., 2009).

One of the latest technological advances in instruments for the assessment of vertical jump is the mobile application My Jump 2 created by the author Carlos Balsalobre-Fernández (Balsalobre-Fernández et al., 2015a) demonstrating that the CMJ can be measured validly and reliably through the application. In this sense, Gallardo-Fuentes et al. (2016) proved that this application is a tool with high reliability and intersession and intrasession validity to measure vertical jump performance in male and female athletes, on different days.

As an alternative evaluation instrument, the Wheeler Jump photoelectric sensor has been developed. It is a wireless, portable and lightweight system that, through a mobile application, allows to assess the vertical jump estimating the height through the flight time. The novelty of Wheeler Jump is the connectivity via Bluetooth to the cellphone or tablet, making it easier for the trainer to evaluate.

Therefore, in order to make a scientific use of the Wheeler Jump photoelectric sensor, this validation study is carried out comparing it with three scientifically validated evaluation systems: Chronojump Boscosystem (Barcelona, Spain), OptoGait (Bolzano, Italy), and the mobile application My Jump 2. In this sense, the objective of this study was to establish the validity and reliability of the Wheeler Jump sensor for the execution of the CMJ in athletes from different sports disciplines, having as an hypothesis that the results obtained by the Wheeler Jump sensor do not vary from the results obtained with the three evaluation systems with which it was compared.

Methodology

Participants

A total of 119 high-performance athletes from various sports disciplines selected in a non-probabilistic manner participated in this study. A total of 112 men and 7 women were evaluated between January and March 2021. On the day of the evaluation, all the participants were apparently healthy and reported no history of injury. To avoid interference with the experiment, participants were advised not to consume alcohol or caffeinated beverages 24 hours before the test. All jumps were performed during a single training session in order to avoid variations due to the circadian cycle and/or any other confounding variables.

Ethics Statement

The study protocol followed the guidelines of ethical principles of the Declaration of Helsinki and the provisions of resolution 008430 of the Ministry of Health and Social Protection of Colombia. The objectives and risks of the study were explained before starting the evaluation protocol and were accepted by all the participants, who signed the informed consent autonomously. This study was accepted and endorsed by a legally constituted ethics committee according to national and international standards.

Procedure

This observational study consisted of repeated measurements of maximal jump height on subjects during a single testing session. Before the evaluation process, a 10-minute standardized warm-up was performed on a bicycle ergometer (BTL CardioPoint® CPET) with a power load of 80 W and a cadence of 70 to 75 rpm. Subsequently, neuromuscular activation was performed through short high-intensity movements (sprint, zigzag run, and multi-jump). Participants did 5 repetitions of sprints in 5 meters with 1 minute of rest, 5 repetitions of zigzag race in 10 meters, with the same rest time, and 4 series of 5 vertical multi-jumps with knee elevation with 1 minute of rest between each series.

Subjects were then instructed with familiarization jumps to achieve proper jumping technique with an emphasis on maintaining balance while falling. Subjects then performed 5 repetitions of countermovement jumps with a one-minute rest period between jumps. For a correct execution, the subjects placed their hands on their hips and bent their knees at a 90-degree angle and jumped to maximum height in a single movement. Knee angle was monitored in the sagittal plane by real-time video digitizing software.

The CMJ's starting position was standing, torso straight, knees fully extended, feet shoulder-width apart. They were instructed to perform a fast downward movement and then a fast upward countermovement to jump as high as possible (Holsgaard Larsen et al., 2007).

The jump tests were performed using a Chronojump Boscosystem contact mat version 1.6.2 (Barcelona - Spain), in which near-perfect validity values (95% CI = .99-1.00; $p < .001$) (Pueo et al., 2020) were demonstrated; an OptoGait photoelectric system version 1.12 (Bolzano - Italy), which has described statistically significant validity values (95% CI = 0.92-0.99; $p < .001$) (Lee et al., 2014); and My Jump 2 app, which authors have established to be a valid and reliable mobile app ($p < .001$, ICC = .997) (Balsalobre-Fernández et al., 2015a). All evaluations were performed simultaneously and the results were compared with the obtained values with the Wheeler Jump sensor (Figure 1).

The evaluation was carried out during a single day in the morning to guarantee that those evaluated had not had

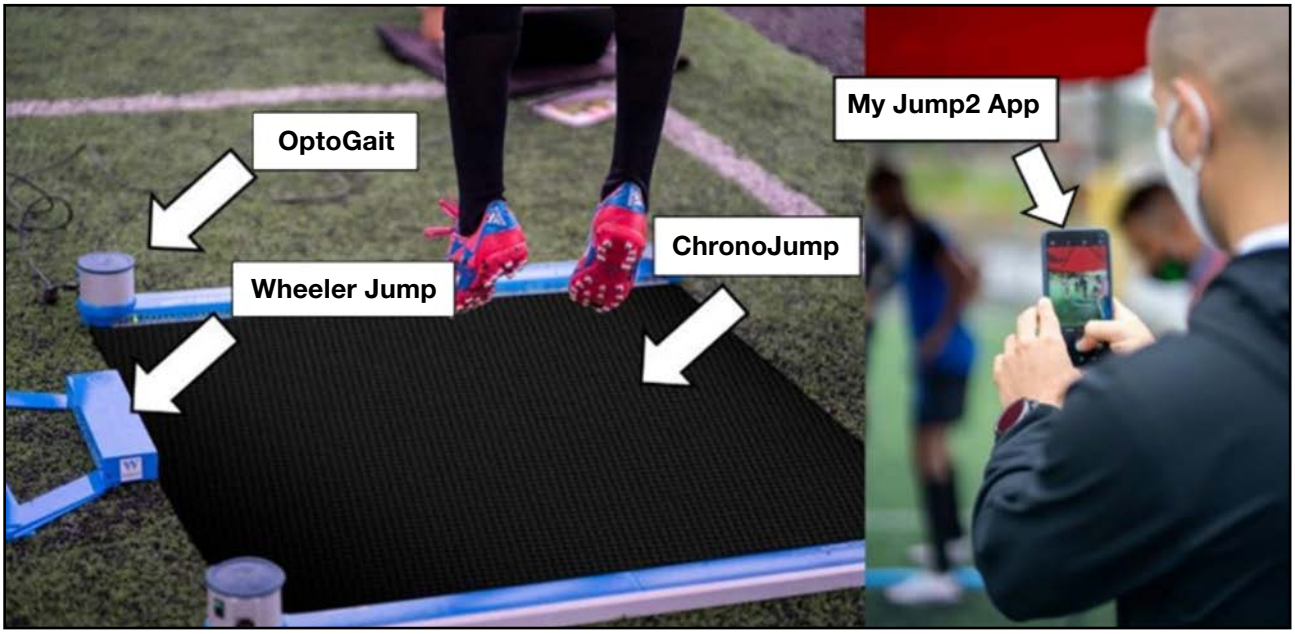

Figure 1
Assessment protocol
Note: assessment protocol with the four measuring instruments.

any type of training 18 hours before the evaluation. The terrain selected to locate the evaluation devices was always flat and without direct contact with the sun so as not to affect the data collection with the instruments used for the evaluation of the jump.

The location of the devices was first done by fixing the Chronojump Boscosystem jump platform to the ground. The OptoGait sensor and Wheeler Jump were placed around the jump platform, and to take the video with the My Jump 2 application, the evaluator stood in front of the athlete with a distance of approximately 2 meters to be able to accurately evaluate each jump.

Statistical analysis

The statistical analysis was performed using SPSS® version 25 and MedCal® version 19.1 software. The descriptive analysis of the data is presented through measures of central tendency, dispersion, and variability, given the quantitative nature of the variables. The normality of the data was determined through the Shapiro-Wilk test, due to the high statistical power of this test concerning other normality tests (Mohd Razali & Bee Wah, 2011); thus determining the nonparametric behavior of the obtained data in the present research ($p < .05$).

Given the non-normal distribution of the data, it was decided to perform a Passing and Bablok regression model (Bilić-Zulle, 2011) to determine the agreement between the Wheeler Jump photoelectric sensor with the comparison devices (OptoGait, Chronojump, and My Jump 2). Similarly, given the non-parametric distribution of the data, the reliability of the instrument was determined using the LIN correlation coefficient of concordance (CCC) (Camacho Sandoval, 2008), the interclass correlation coefficient (ICC), and the Smallest worthwhile change (SWC). Finally, concurrent validity was established with Spearman's correlation coefficient determined from the Passing and Bablok model. All the aforementioned calculations will be accompanied by their respective 95% confidence intervals. Statistical significance was set at the $p \leq .05$ level.

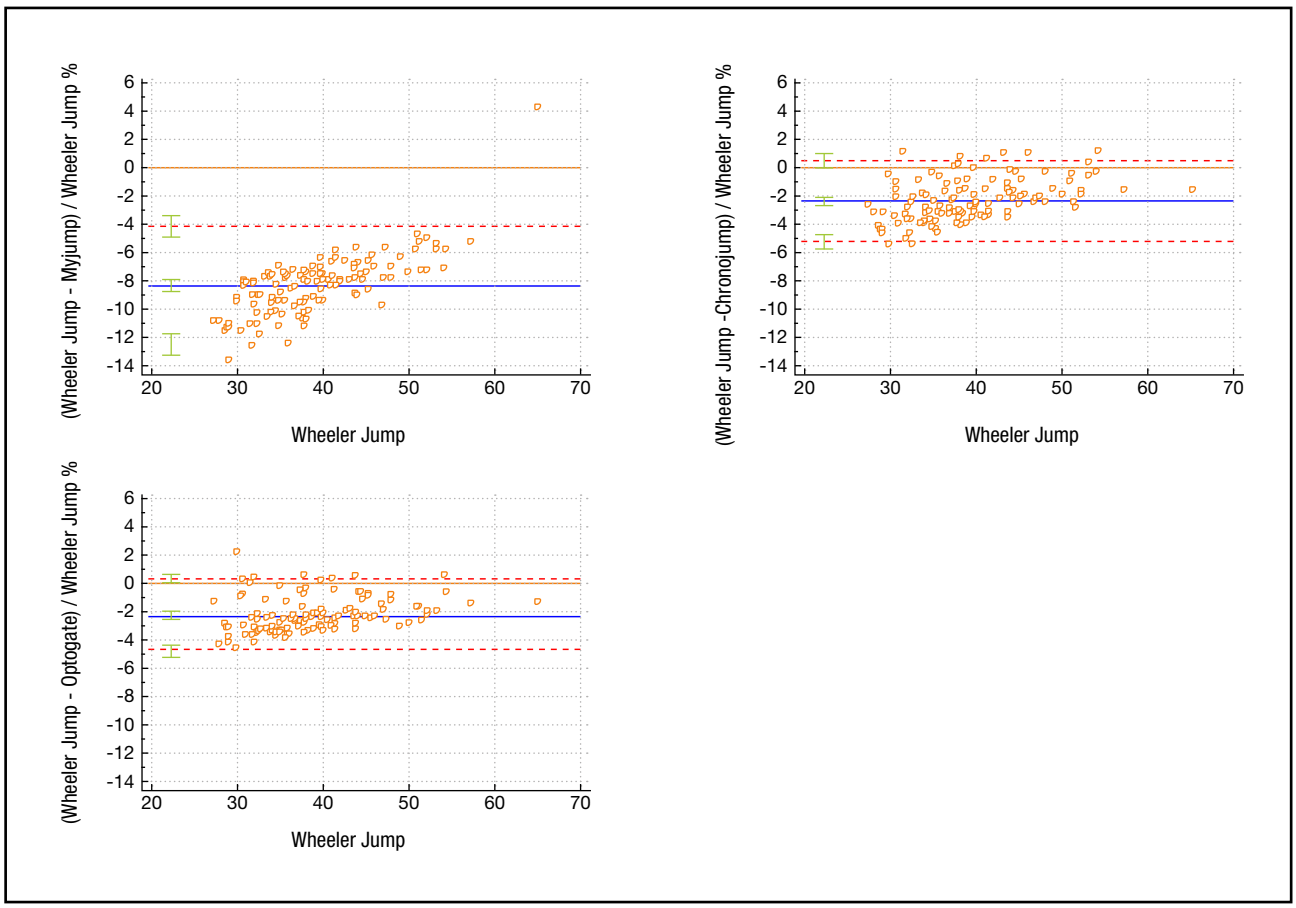

Figure 2
Multiple comparison analysis.
Note: This image shows the differences in measurement between the Wheeler Jump sensor and the other evaluation strategies.

Results

The total number of participants successfully complied with the protocol established for the assessment of strength through the CMJ, achieving the evaluation of a total of 119 athletes from different sports disciplines. The average age was 18.5 ± 1.3 years, highlighting that the average age of sports experience reported by the athletes was 11 years ± 2.4 years; an average weight of 67.36 ± 5.97 kg, an average height of 1.74 ± 0.056 m and an average body mass index of 22.11 ± 1.58 kg/m2 were determined, classifying this population according to the WHO as normal weight.

The average heights of the evaluated jumps with the different measurement instruments were: 39.3 ± 7.1 cm for Wheeler Jump, 42.83 ± 6.9 cm for My Jump 2, 40.26 ± 7.0 cm for Chronojump, and 40.19 ± 7.08 cm for OptoGait, observing a greater discrepancy in the evaluation between the Wheeler Jump sensor and the My Jump 2 app (Figure 2).

The Smallest worthwhile change (SWC) was very homogeneous in the 4 measuring instruments, the SWC for the OptoGait was 1.41 centimeters, for the Chronojump it was 1.402 cm, for the My Jump 2 application it was 1.39 cm, and for Wheeler Jump it was 1.41 cm, thus determining that for the change in jump performance to be significant in any of the 4 instruments, it must be greater than 1.4 centimeters.

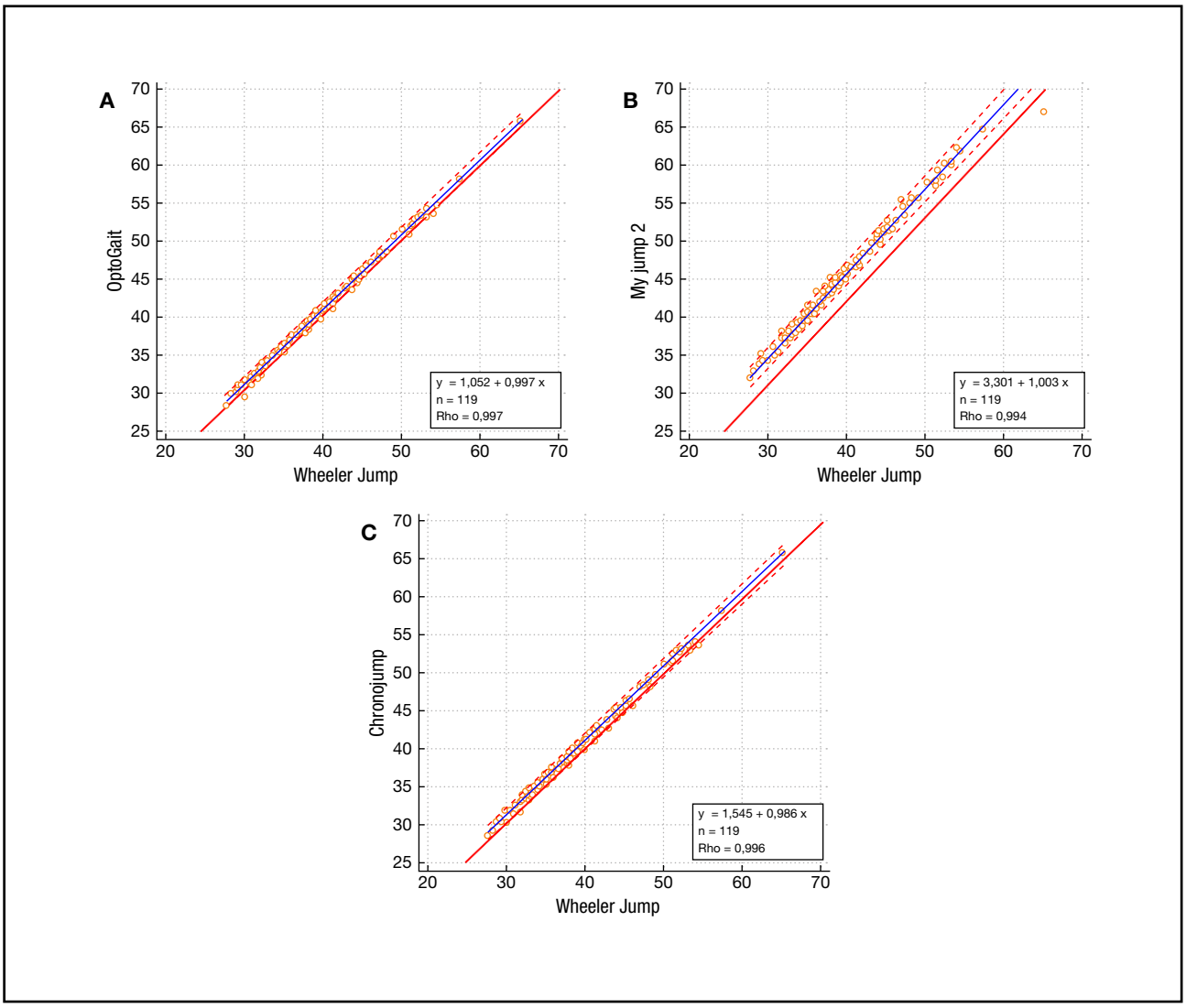

Figure 3
Correlation analysis of Passing Bablok.
A. Passing Bablok regression analysis between OptoGait and Wheeler Jump; B. Passing Bablok regression analysis between My Jump 2 mobile app and Wheeler Jump; C. Passing Bablok regression analysis between Chronojump and Wheeler Jump.
Contrast statistics: Spearman's rho; n = sample; y = dependent variable; x = independent variable.

Table 1
Passing Bablok correlation and regression matrix.

	Wheeler Jump photoelectric sensor					
	Rho (95% CI)	*p* value	ICC	Intercept (95% CI)	Slope (95% CI)	Lin's r (95% CI)
OptoGait	.997 (.996 – .998)	.0001	.997 – .998	1.05 (0.67 – 1.45)	0.99 (0.98 – 1.06)	.997 (.996 – .998)
My Jump 2	.994 (.992 – .996)	.0001	.991 – .995	3.30 (-2.60 – 3.92)	1.002 (0.98 – 1.02)	.887 (.857 – .915)
Chronojump	.996 (.994 – .997)	.0001	.997 – .998	1.54 (0.96 – 2.09)	0.98 (0.97 – 1.01)	.989 (.985 – .992)

Rho: Spearman's Rho; *p*-value: Statistical significance; Lin's r: Lin's concordance coefficient; 95% CI: 95% Confidence Interval; SWC: Smallest worthwhile change; ICC: Coefficient interclass correlation.

Figure 3 shows the different correlations measured from the Passing Bablok regression model between the Wheeler Jump and the different assessment methods, showing almost perfect positive correlations (Wheeler Jump vs My Jump 2 Rho = .994; Wheeler Jump vs OptoGait Rho = .997 and Wheeler Jump vs Chronojump Rho = .996).

From the trend observed in the obtained data, it is valid to mention that the Wheeler Jump photoelectric sensor has obtained a high capacity to correctly predict the results that could be obtained with OptoGait, My Jump 2, and Chronojump; thus, giving it a high validity value.

Moreover, the coefficient of variation calculated by the logarithmic method for the Wheeler Jump sensor in the three established jumps by the assessment protocol was 1.5% (CI 95% 1.39 – 1.80); subsequently, determining a standard error of measurement of 1.33 cm, thus showing excellent levels of reliability and repeatability.

Table 1 shows the values obtained in each of the regression models applied in this study, revealing that, with the three instruments with which the Wheeler Jump sensor was compared, the intercept and the slope of the prediction formula are not statistically significant (due to their confidence interval), thus suggesting that there is a low probability of systematic error and/or proportional differences.

Finally, Lin's Concordance Index was determined to evaluate the reproducibility and concordance between the sensor and the assessment methods used in this research. Considering the reference values established by Lin Li (Lin, 1989), a perfect concordance with OptoGait, a substantial concordance with Chronojump, and a poor concordance with the My Jump 2 app were observed.

Discussion

Vertical jump performance is considered a viable strategy for assessing the maximal explosive power of lower limbs in athletes under field conditions (Bosquet et al., 2009; Gutiérrez-Dávila et al., 2015; Ziv & Lidor, 2010).

To avoid the practical limitations involved in laboratory assessments, portable devices have been introduced to assess jumping performance from flight time (Balsalobre-Fernández et al., 2015b; Copoví Lanusse, 2015); however, despite the widespread use of these portable devices, few independent research studies have addressed the reliability and validity of these tools (Balsalobre-Fernández et al., 2015a; Lee et al., 2014; Pueo et al., 2020).

Therefore, the objective of this study was to determine the reliability and validity of the Wheeler Jump photoelectric sensor for measuring vertical jump height derived from flight time, compared to different scientifically validated assessment tools.

The results showed highly significant reliability and repeatability, and the correlation coefficients demonstrated almost perfect associations between the Wheeler Jump and the other assessment systems used in this study, thus confirming the working hypothesis.

The Passing and Bablok regression model verified that the systematic bias between the results of the different instruments was trivial. Furthermore, the lack of linear correlation shown in the multiple comparison plots (except for the My Jump 2 app) suggests that no differences are expected between the SD of the Wheeler Jump measurements with the Chronojump and OptoGait, demonstrating that the minimal bias between the methods is constant over the range of values; in this sense, the sensor concordance found from

Lin's index was perfect with OptoGait, substantial with ChronoJump, and poor with My Jump 2 app.

These findings partially coincide with those reported by Pueo et al. (2020) who determined the validation of the Chronojump, comparing the obtained data with strength platforms, finding strong concurrent validity and excellent test-retest reliability; however, these same authors report the occurrence of systematic biases between the two devices, a situation that differs from the data reported in this paper.

The differences found between the Wheeler Jump sensor was less than 1 cm compared to Chronojump and OptoGait; however, the difference in relation to the My Jump 2 mobile app was approximately 3.5 cm. This difference may be due to the quality of the camera on mobile devices, which makes it difficult to accurately select the moment of takeoff during the execution of the jump or the expertise in using the mobile application. In this sense, previous studies that compared instruments that evaluate jump performance through time of flight with alternative laboratory-based methods yielded higher magnitudes of error. Contact mats have been reported to overestimate jump height with regard to force platforms in the range of approximately 1.7 cm for SquatJump (SJ) (Kenny et al., 2012), and 2.8 for CMJ (Enoksen et al., 2009). Such an overestimation is probably due to a minimal force required to activate the mechanical circuitry of the mats. Considering the above, wider discrepancies have been found, as is the case of the photocells, which have shown a large systematic bias, varying from 14.49 to 11.08 cm for the SJ with the force platforms despite having high values, reliability and repeatability values (Attia et al., 2017).

Practical Applications

The data presented in this study have demonstrated that the Wheeler Jump sensor is a reliable and valid tool for the evaluation of the CMJ on field conditions, establishing that the findings can be interchangeable with the OptoGait and the Chronojump. Athletes, coaches, and researchers can rely on the use of this technology to assess and monitor vertical jump performance; therefore, we can conclude that this is a reliable tool that provides practitioners and researchers with accurate information regarding changes in athlete's physical performance at a fraction of the value of alternative patented systems.

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Comparing Body Composition in Young Footballers Categorised by Bio-Banding

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Abstract

Bio-Banding (BB) is a new way of categorising young athletes that considers the variation in maturity stage. To date, differences in body composition as an aspect of performance have not been investigated in young footballers categorised by BB. Therefore, the aim of the present study was to describe and compare the body composition of young football players between BB categories. One hundred and twenty-eight young male players (age: 14.88 ± 1.76 years) from a professional football club in Chile participated in this study. Body composition was assessed with anthropometry and compared with ANOVA and Kruskal-Wallis tests. Significant differences were found between BB categories in body mass ($p < .0001$); height ($p < .0001$); muscle mass ($p < .0001$); bone mass ($p < .0001$); adipose tissue mass ($p < .0001$); skeletal muscle mass index ($p < .0001$) and the sum of 6 skinfolds ($p = .0172$). The findings of the present study reveal that the process of growth and maturity can be seen in: (i) the greatest increase in height and body mass, (ii) the increase in muscle mass and bone mass, (iii) the smallest increase in adipose tissue mass and SMI, and to a lesser extent, (iv) the evolution of the sum of 6 skinfolds. As a projection of the research, these results can be applied by clubs and coaches as baseline for changes in body size and composition, in order to include BB in the processes of identification, selection and development of talented young athletes.

Keywords: anthropometry, Bio-Band, maturity, youth sport.

Introduction

Football is a discipline that has been extensively studied with the aim of improving player performance, which depends on technical, tactical, physical, physiological, mental (Stølen et al., 2005) and anthropometric factors (Rodríguez et al., 2019), as well as identification and development processes of young footballers (Sarmento et al., 2018).

In the training and development processes of young footballers, the following factors have been considered: physical condition, for example, plyometrics and changes of direction (Beato et al., 2018; Michailidis et al., 2019), speed (Murtagh et al., 2018), psychological (Olmedilla et al., 2019; Scharfen et al., 2019), technical (Rowat et al., 2017), tactical (Machado et al., 2020; Machado et al., 2019), and anthropometric aspects (Lago et al., 2011; Bernal et al., 2020), such as body size (Malina et al., 2017); even chronological age (CA) has been used as an organisational parameter to assess performance in young players (Barrera et al., 2021). However, when organising youth sport categories based on CA or yearly age groupings, a phenomenon of individual differences in the maturation *timing* and *tempo* of those players can be seen when categorised by CA within the same annual cut-off point, and especially those players around the pubertal stages of development, where growth and maturation can significantly affect changes in performance (Lloyd et al., 2014). One example can be the Relative Age Effect (RAE) phenomenon, characterised by a significant overrepresentation of players born early in their year of birth among young athletes (Brustio et al., 2018), which suggests that being relatively older within an annual sporting cut can provide significant achievement advantages compared to those relatively younger (Cobley et al., 2009).

In order to try to correct the above, several ways of obtaining a biological age indicator have been suggested. Such as: the *skeletal age,* assessed mainly with radiographs and which refers to the degree of biological maturation according to the development of skeletal tissue (Lloyd et al., 2014), the *sexual maturity,* which refers to the development of secondary sexual characteristics and maturation of the reproductive system (Lloyd & Oliver, 2020), and the *somatic age,* which refers to the degree of growth in overall height or specific body dimensions (Lloyd et al., 2014), one of the most common indicators of which is the prediction of the age of *Peak Height Velocity* - PHV (Malina et al., 2004) along with the use of percentages and predictions of adult height (Lloyd et al., 2014).

In order to use some method of biological categorisation for youth sports, Rogol et al. (2018) presented an alternative method that relates the percentages of height reached at a time of observation to an estimate of adult height in the creation of biological bands. This method, known as Bio-Banding (BB), has been used as a non-invasive indicator of biological maturity. BB has already been applied to young footballers, associated with physical and technical factors (Abbott et al., 2019), perceptions in competition (Bradley et al., 2019), participation experiences (Cumming et al., 2017a) and technical and tactical factors (Romann et al., 2020). However, no record of studies associating this new biological categorisation indicator with another performance factor in youth football such as anthropometry, specifically body composition, exists. Therefore, this research sought to address this aspect and, consequently, its objectives were to describe and compare the body composition of young male footballers between BB categories.

Methodology

Participants

128 male youth football players participated in this study, belonging to a professional football club from the first division in Chile, divided in the following categories: U-12; U-13; U-14; U-15; U-16; U-17 and U-19 (table 1). Players had an average of 5.00 ± 2.16 years of experience and trained 5 times a week. All players signed an informed consent form before starting the study and none of them had any objections during data collection.

Table 1
Descriptive characteristics according to CA.

	U-12 (*N*=20)	U-13 (*N*=10)	U-14 (*N*=26)	U-15 (*N*=18)	U-16 (*N*=22)	U-17 (*N*=18)	U-19 (*N*=14)
Age (years)	12.21 ± 0.26	13.11 ± 0.28	14.23 ± 0.25	14.70 ± 0.29	15.67 ± 0.32	16.73 ± 0.31	17.82 ± 0.24
Body mass (kg)	44.37 ± 7.07	49.33 ± 7.70	57.35 ± 8.47	62.32 ± 9.10	64.92 ± 8.86	66.70 ± 7.58	68.31 ± 7.49
Size (cm)	150.82 ± 7.60	161.34 ± 8.48	164.22 ± 9.55	168.38 ± 6.02	173.04 ± 5.40	172.30 ± 5.05	173.30 ± 4.80

Data presented as Means ± SD

Material

Each participant was assessed for body mass and height using a Detecto (USA) model 2391 scale with a height measuring rod included. It has a capacity of 180 kg and an accuracy of 0.1 kg, and 200 cm with an accuracy of 0.1 cm. Seated height was assessed with the same measuring rod and a wooden bench with dimensions of 30 cm x 40 cm x 50 cm. Body perimeters were measured using a Lufkin anthropometric tape (Executive, W606PM, USA) with a measuring range up to 200 cm and accurate to 0.1 cm. Skinfolds were assessed with a Harpenden skinfold caliper (Baty International, RH15 9LR, England) with a measuring range of 80 mm and an accuracy of 0.2 mm. And Campbell 10 and Campbell 20 bone calipers, with a measuring range of 19 cm and 60 cm, respectively, with an accuracy of 0.1 cm each (Rosscraft. SRL. Argentina), were used for the measurement of small and large body diameters.

Procedure

The anthropometric assessments were carried out during preseason week in the hours before the respective training sessions of each youth football category. This assessment followed the standards established by *The International Society for the Advancement of Kinanthropometry* (ISAK) (Esparza et al., 2019) and was conducted by a single Level 3 ISAK anthropometrist. From the above standards, three basic measures were assessed: body mass, height and sitting height; six skinfolds: triceps, subscapular, supraspinal, abdominal, thigh and leg; six bone diameters: biacromial, transverse thoracic, anteroposterior thoracic, biliocristal, humerus and femur; seven perimeters: head, relaxed arm, forearm, thorax, waist, upper thigh and leg. With these measurements, body composition was determined using the 5-component fractionation model (Ross & Kerr, 1991) which considers the following tissue types; muscle, adipose, bone, residual and skin expressed both as an absolute (kg) and as a relative (%) value. Similarly, the sum of 6 skinfolds (triceps, subscapular, supraspinal, abdominal, thigh and leg) expressed in mm and the skeletal muscle mass index (SMI) were calculated. The *Peak Height Velocity* (PHV) was estimated to occur at a certain age using the regression equation presented by Mirwald et al. (2002) and adult height was predicted using the model of Sherar et al. (2005). Once the prediction of adult height with its respective actual percentage was established, the study participants were divided into four BB categories (Rogol et al., 2018): < 85.0% (BB1); 85.0 - 89.9% (BB2); 90.0 - 94.4% (BB3) and ≥ 95.0% (BB4) each representing, respectively, prepubertal stage, early puberty, average puberty and late puberty (Cumming et al., 2017b).

Statistical analysis

The following variables were analysed among the BB categories: age (years), body mass (kg), height (cm), muscle mass (kg), adipose tissue mass (kg), bone mass (kg), SMI and sum of 6 skinfolds (mm), and the mean ± standard deviation, 95% confidence interval and medians with 25th and 75th percentile values were presented.

Regarding the statistical analysis, GraphPad Prism Software version 8.0.2 for Windows, GraphPad Software, San Diego, California (USA) were used. The normality of the data was assessed through the Shapiro-Wilk test and the homogeneity of variances was assessed through the Brown-Forsythe test. To check for differences between groups, Tukey's one-way ANOVA test with multiple comparisons was used where there was normality of data, while Dunn's Kruskal-Wallis test with multiple comparisons was used where there was no normality of data. Moreover, effect size was calculated through eta^2 (η^2) and η_H^2, as appropriate. The minimum level of significance was adjusted to the level of $p < .05$.

Results

Table 2 shows the results of means and standard deviations for the variables of age (years), body mass (kg), residual mass (kg), error (%) between the summed mass of the five separate components and the actual mass recorded on the scale, SMI and PHV age (years), together with the medians and 25th and 75th percentiles for the variables of height (cm), muscle mass (kg), adipose tissue mass (kg), bone mass (kg), skin mass (kg), sum of 6 skinfolds (mm), predicted adult height (cm) and the percentage of actual height (%) relative to predicted adult height for the 128 participants in this study.

Regarding the differences between groups of BB categories, statistically significant differences were found for age ($H = 94.99$; $p < .0001$; $\eta_H^2 = .742$); body mass ($F = 69.79$; $p < .0001$; $\eta^2 = .628$); height ($F = 104.72$; $p < .0001$; $\eta^2 = .717$); muscle mass ($H = 73.31$; $p < .0001$; $\eta_H^2 = .567$); bone mass ($H = 72.81$; $p < .0001$; $\eta_H^2 = .563$); adipose tissue mass ($F = 19.41$; $p < .0001$; $\eta^2 = .320$; SMI ($F = 18.28$; $p < .0001$; $\eta^2 = .307$) and the sum of 6 skinfolds ($H = 10.17$; $p = .0172$; $\eta_H^2 = .058$). (Table 3).

Table 2
Descriptive characteristics of the total sample.

N = 128	Mean ± SD	95% IC
Age (years)	14.88 ± 1.76	14.58; 15.19
Body mass (kg)	59.21 ± 11.42	57.23; 61.19
Size (cm)	167.90 [160.28;173.05]*	164.34; 167.92
Muscle mass (kg)	27.81 [22.72;30.32]*	25.59; 27.73
Adipose tissue mass (kg)	13.89 [12.28;16.40]*	14.02; 15.13
Bone mass (kg)	7.76 [6.74;8.36]*	7.41; 7.87
Skin mass (kg)	3.46 [3.23;3.67]*	3.33; 3.48
Residual mass (kg)	6.93 ± 1.34	6.70; 7.16
Error (%)	0.37 ± 4.10	-0.34; 1.08
Skeletal muscle index	3.47 ± 0.43	3.40; 3.55
Sum of 6 skinfolds (mm)‖	50.35 [42.60;67.25]*	53.02; 58.98
Age of *Peak Height Velocity* (years)	13.91 ± 0.63	13.81; 14.02
Adult height prediction (cm)	176.30 [173.60;180.00]*	175.96; 177.88
% Current size	96.15 [90.70;98.70]*	92.98; 94.89

‖ triceps, subscapular, supraspinal, abdominal, thigh and leg.
*Data presented as median [p25; p75].

Table 3
Groups based on the percentage reached of predicted adult height at the time of observation.

	BB1 <85% (*N*=13) Mean ± SD	(95% IC)	BB2 85 - 89.9% (*N*=18) Mean ± SD	(95% IC)	BB3 90 - 94.9% (*N*=25) Mean ± SD	(95% IC)	BB4 ≥95% (*N*=72) Mean ± SD	(95% IC)	Size effect (η^2)
Age (years) &	12.23[11.99;12.39]	(11.99;12.30)	12.91[12.44;13.47]	(12.66;13.30)	14.33[14.03;14.41]*	(13.99;14.38)	16.00[15.07;17.01]*^#	(15.83;17.26)	.742¥
Body mass (kg)	41.18 ± 4.35	(38.81;43.54)	47.97 ± 6.70*	(44.87;51.06)	56.12 ± 5.66*^	(53.91;58.34)	66.35 ± 7.88*^#	(64.53;74.22)	.628
Size (cm)	146.58 ± 4.09	(144.36;148.81)	156.81 ± 6.21*	(153.74;161.85)	164.16 ± 5.38*^	(162.06;166.27)	172.68 ± 5.67*^#	(171.37;178.35)	.717
Muscle mass (kg) &	16.05[15.19;17.67]	(15.54;17.35)	19.58[17.93;20.34]	(18.46;22.14)	25.45[24.19;28.00]*	(24.50;27.19)	29.70[27.85;32.69]*^#	(29.44;34.43)	.567¥
Adipose tissue mass (kg)	11.69 ± 1.97	(10.62;12.76)	12.55 ± 2.22	(11.53;13.57)	13.03 ± 1.81	(12.32;13.73)	16.14 ± 3.10*^#	(15.42;19.24)	.320
Bone mass (kg) &	5.60[5.05;5.81]	(5.05;5.83)	6.52[6.24;7.09]	(6.29;7.05)	7.14[6.88;7.78]*	(6.95;7.48)	8.21[7.79;8.94]*^#	(8.21;9.36)	.563¥
Skeletal muscle index	3.06 ± 0.37	(2.86;3.25)	3.04 ± 0.43	(2.84;3.24)	3.59 ± 0.41*^	(3.43;3.75)	3.61 ± 0.33*^	(3.54;3.94)	.307
S. 6 Skinfolds (mm) ǁ &	61.20[48.90;77.30]	(54.17;72.55)	47.00[42.68;67.80]	(46.43;61.01)	45.40[38.90;57.00]*	(42.29;52.57)	54.95[43.23;68.63]	(54.08;76.12)	.058¥

ǁ Sum of triceps, subscapular, supraspinal, abdominal, thigh and leg skinfolds
* Statistically significant difference of BB1
^ Statistically significant difference of BB2
# Statistically significant difference of BB3
& Data presented as median [p25;p75]
¥ $\beta\eta_H^2$

Discussion

According to the objectives, and to our knowledge, this is the first study describing and comparing body composition in young male football players according to the 5-component fractionation model categorised through a non-invasive biological indicator such as BB.

With regard to the results observed in the CA within each BB category, significant differences can be seen between BB3 and BB1; and between BB4 and BB1, BB2 and BB3. However, when statistically significant differences are observed between one category of BB and the next, the difference is only apparent between BB3 and BB4 ($\Delta = 13.46\%$; $p < .0001$). Comparatively, these categories could resemble chronological categories in Argentinean youth football players in age groups 14 (14.5 ± 0.2 years) and 16 (16.5 ± 0.2 years), respectively (Holway et al., 2011).

In terms of body mass and height, significant differences between adjacent categories can be observed between BB1 and BB2; BB2 and BB3 and between BB3 and BB4. The results of the two anthropometric variables are similar to those presented by Di Credico et al. (2020), where youth players from Italy were grouped into 3 biological categories (*Pre-PHV*; *Circa-PHV* and *Post-PHV*) and where statistically significant differences were observed between Pre-PHV and Circa-PHV and between Circa-PHV and Post-PHV, except for body mass between Circa-PHV and Post-PHV groups. Similarly, these authors report that these two anthropometric variables and their associations with the years of the *Peak Height Velocity* (YPHV) have significant correlations of $r = .76$ for body mass and $r = .92$ for height. Furthermore, Figueiredo et al. (2009) indicate for these anthropometric variables a similar behaviour to the one reported in the present study, a significant increase in body mass and height in young Portuguese players, aged 11 and 12 years, and 13 and 14 years, divided into three categories by degrees of maturity (*Late*, *On Time* and *Early*). And, with regard to the differences in the height and body mass of the players in the present study between groups by CA, only one significant difference is observed ($\Delta = 6.98\%$; $p = .0033$) in height among the U-12 players (150.82 ± 7.60 cm) and U-13 (161.34 ± 8.48 cm).

Body composition in terms of muscle mass and bone mass variables show significant differences only between adjacent categories BB3 and BB4 (on time puberty and late puberty, respectively). Muscle mass shows a higher value in late puberty, with a median of 29.70 kg (p25 = 27.85 kg; p75 = 32.69 kg), with respect to on time puberty, with a median of 25.45 kg (p25 = 24.19 kg; p75 = 28.00 kg), and bone mass shows a higher value in late puberty, with a median of 8.21 kg (p25 = 7.79 kg; p75 = 8.94 kg), with respect to on time puberty, with a median of 7.14 kg (p25 = 6.88 kg; p75 = 7.78 kg). This is a fact that can be largely associated with the process of puberty, which is characterised by changes in body size, composition and function in response to testosterone, and which results in linear growth and muscle mass development in males (Rowland, 2005) and is reflected, in this case, by a greater percentage increase in body mass between BB3 and BB4 ($\Delta = 18.22\%$) than between BB2 and BB3 ($\Delta = 16.99\%$) and between BB1 and BB2 ($\Delta = 16.49\%$). However, the increase in kilograms of muscle mass is continuous between one category and the subsequent one, as shown by a group of studies in youth football players categorised by CA (Bernal et al., 2020; Hidalgo et al., 2015; Holway et al., 2011; Jorquera et al., 2012); nevertheless, and although the kilograms of bone mass also show a continuous increase between one category and the subsequent one in the present study, it is not consistent with the pattern in the studies already cited, probably due to the difference in the higher average CA of the youth categories compared to the smaller categories in the present study.

Adipose tissue mass, as another variable of body composition, shows a continuous increase between categories. However, no significant differences are observed between BB1 and BB2, nor between BB2 and BB3. It is only possible to observe significant differences between adjacent categories in BB3-BB4 (mean 13.03 kg vs 16.14 kg, respectively, $p < .0001$). This situation can also be associated with the significant increase in height and body mass among these same categories, a condition that is not possible to observe with the analysis of the evolution of the sum of skinfolds as another indicator of body adiposity, which will be mentioned later. Hidalgo et al. (2015) obtain similar results to those presented here, as the researchers find a continuous increase in adipose tissue between the four chronological categories, from 14.2 ± 0.54 to 17.0 ± 1.16 kg. On the other hand, Bernal et al. (2020) report a constant average value of 15.5 kg of adipose tissue mass among the chronological categories of 4th division (15.7 ± 0.4 years), 3rd division (16.7 ± 0.3 years) and U-17 (17.5 ± 0.5 years). Lastly, Holway et al. (2011) report a higher variability of adiposity among CA categories (14 = 15.8 ± 2.8 kg; 15 = 16.4 ± 3.2 kg; 16 = 15.0 ± 3.2 kg, and 17 = 15.7 ± 2.8 kg).

The SMI shows the kg ratio of muscle mass per kg of bone mass, and in this study, only a significant difference can be observed between BB2 adjacent categories (3.04 ± 0.43) and BB3 (3.59 ± 0.41), but not between BB1 and BB2, and between BB3 and BB4. Furthermore, Bernal et al. (2020) report values of 4.0 ± 0.4 for the 4th division (15.7 ± 0.4 years), 4.0 ± 0.3 for the 3rd division (16.7 ± 0.3 years), and 4.1 ± 4.0 for U-17 (17.5 ± 0.5 years).

Lastly, the sum of skinfolds shows an opposite behaviour to adipose tissue mass, as a continuous decrease in total mm is observed in the sum, especially in BB1, BB2 and BB3 categories, a situation that can be found in other studies with a sum of 6 skinfolds (Bernal et al., 2020; Jorquera et al., 2012), while adipose tissue mass shows a continuous increase in kilograms from one category to the next. This condition can be explained, in part, by the Geometrical Similarity theory (Jaric et al., 2005), which indicates that mass-volumes increase with the height cubed; in other words, mass-volumes are understood three-dimensionally, an aspect considered in the determination of adipose tissue mass, muscle mass and bone mass in the 5-component fractionation model (Ross & Kerr, 1991), but not considered in the sum of skinfolds (understood linearly and without considering height). However, Figueiredo et al. (2009) analyse the behaviour of the sum of 4 skinfolds between 2 age groups divided into 3 biological categories. As a result, authors indicate a significant difference only in the youngest age group (11 - 12 years; $p < .01$; $\eta 2 = .13$), while in the older age group (13 - 14 years) no significant difference is found between biological groups. Lastly, in the comparison by Di Credico et al. (2020) on the millimetres of the triceps and subscapular skinfolds in three pubertal stages, significant differences are only observed in the triceps skinfold ($p = .042$) and not in the subscapular skinfold ($p = .143$). Furthermore, the same authors state that, in the associations of these skinfolds with the YPHV, non-significant correlations of $r = -.28$ (weak) for the triceps skinfold and of $r = -.03$ (negligible) for the subscapular skinfold are presented.

As it can be expected, maturity degree significantly affected the size and body composition of youth football players, especially between on time puberty and late puberty in the variables of body mass, height, muscle mass, adipose tissue mass and bone mass, while between early and on time puberty these differences are reduced to the variables of body mass, height and SMI, and between prepubertal and early puberty, only to body mass and height. On the other hand, the statistical analysis showed that the categorisation by BB allows the explanation of the variances of height in 71.7%, body mass in 62.8%, muscle mass in 56.7%, bone mass in 56.3%, adipose tissue mass in 32.0%, SMI in 30.7% and the sum of 6 skinfolds in 5.8%.

The present study also has its limitations and strengths which should be acknowledged. Firstly, this study used a cross-sectional design which does not allow the establishing of cause-and-effect relationships. Secondly, other performance variables or playing positions are not considered. However, this study is the first to describe and compare the body composition of youth football players categorised by BB, using the 5-component fractionation model.

Conclusions

The findings of the study show that, in youth football players categorised by BB, the growth and maturity process can be seen in the following aspects, in order of relevance: (i) the greatest increase in height and body mass, (ii) the increase in muscle mass and bone mass, (iii) the smallest increase in adipose tissue mass and SMI, and, to a much lesser extent, (iv) the evolution of the sum of 6 skinfolds. Based on these data, it is suggested to continue with research that associates this type of categorisation with other aspects of performance in young footballers.

Furthermore, as a projection, the results can be applied by clubs and coaches who need to include BB as a complement to the categorisation by CA, in the processes of identification, selection and development of young talents. Similarly, these data can be useful to select, for their control and follow-up, the variables of body composition, understood as an aspect of performance, that best represent the process of growth and maturity in young football players. The final aim is to develop strategies to optimise body composition.

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Reception-Attack Transition in Volleyball: Analysis of Spike Effectiveness

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Abstract

The aim of this study was to assess the effectiveness of the front receiver's spike according to their participation in the reception-attack transition and the team's rotation, in addition to the interaction between the two. The sample was drawn from 29 matches played between 2012 and 2016 by top-level men's national teams. The variables studied were: the rotation of the receiving team, the existence of reception-attack transition and spike performance. In the data analysis, mean, standard deviation and effectiveness were described, and Pearson's chi-squared and ordinal regression models were used to determine the influence of transition, team rotation and setter position on spike performance. The significance level was set at $p = .05$. The results showed an improved spike performance by the front receiver when they did not transition and the setter was in the back position, especially in the RT1 and RT5 rotations. Improved spike performance was also found when the transition was made by a front setter, compared to a back setter. The worst spike performance occurred when there was transition and the team was in RT6. In conclusion, the spike performance of the front receiver is affected by the interaction between transition and team rotation in K1; either when studying the rotations individually, or comprehensively according to the position of the setter.

Keywords: effectiveness, high performance, K1, performance, receiver, spiker.

Introduction

In volleyball, as in all team sports, there are continuous defence-attack and attack-defence transitions. In sports where space is not shared, given the existence of a net, and where possession is limited by a certain number of contacts, the speed with which the transition is made can become a determining factor in performance. Specifically, in volleyball, possession time is limited to the three permitted contacts. The aim is to control the ball in the first contact (defensive phase), in order to be able to develop the offensive phase in the following contacts (Eom and Schutz, 1992).

The technical actions that are performed throughout rallies are grouped within the different game complexes, which are defined according to the offensive action they are trying to achieve (Hileno et al., 2020). Complex 1 (K1) is played starting with the service reception and continues with the set and attack. The same authors state that, occurring after the serve and in the initial part of each rally, it is the most repeated complex during the game, and its execution is considered the main indicator of success in men's mid and high-level teams (Ugrinowitsch et al., 2014).

One of the parameters that determines K1 transition is the time available to move from the defensive to the offensive phase. This depends, among other things, on the player's readiness to attack (Ugrinowitsch et al., 2014), which is conditioned by previous actions and the distance to the attack end zone (Kitsiou et al., 2020). This aspect is especially relevant to players in the front receiver position, given the double responsibility of receiving and joining the attack (Lima et al., 2021), as their readiness may be reduced or even cancelled out (Paulo et al., 2016); this interferes with the setter's choice of attacker (Marcelino et al., 2014).

Moreover, teams playing with only one setter exhibit six different formations: three with the front setter and three with the back setter (Palao et al., 2005), an aspect that may also influence the transition.

Therefore, the following objective was set: to assess the effectiveness of the front receiver's spike according to their participation in the reception-attack transition and the team's rotation, as well as according to the interaction between the two.

Methodology
Materials and methods

Participants

The sample for this study consisted of 29 top-level competitive matches played between 2012 and 2016 in men's World Cup (W.C.), Olympic Games (O.G.) and World League (W.L.) finals. Non-probability convenience sampling was used. The matches were chosen on the basis of the following criteria:

1. It comprises part of the final stages of one of the following men's competitions played in the 2012-2016 Olympic cycle: O.G. 2012; W.L. 2013, 2014, 2015 and 2016; World Championships 2014 (W.C.); World Cup 2015.
2. The match can be found online in full.
3. The image quality was equal to or higher than 720p.
4. The recording viewpoint was predominantly lateral.

Ethical considerations

This study was approved by the Research Ethics Committee of the European University under reference CIPI/18/181.

Observation design and criteria

The observational design used is found in the nomothetic, punctual and multidimensional quadrant. And the observation criteria, in the corresponding categorisation system (Anguera et al., 2011):

- Transition from reception to spike (TR) - Transition Yes (TRY): the same receiver receives and spikes; Transition No (TRN): the receiver that spikes has not received the serve.
- Team rotation in K1 (RT) - The 6 rotations in the game were considered, numbered from 1 to 6 (RT1, RT2, RT3, RT4, RT5 and RT6), according to the position of the setter (Silva et al., 2016).
- Subsequently, the rotations were grouped according to Position of the Setter (SP) - Front Setter (FSP): group RT2, RT3 and RT4; Back Setter (BSP): group RT1, RT5 and RT6.

- Spike performance (SP) - A 6-category scale was used to categorise this variable, adapted from the FIVB Statistical System designated by the World Coaching Commission in 1979, and based on that proposed by Coleman et al. (1969) and the Schall statistical system (Palao et al., 2009) - Spike error (PSE) (0): the ball goes out, does not go over the net, or the referee considers that the spiker has committed a foul. Bad spike (PBS) (1): the spike is brought under control by the defending team, and they are able to recover the game with all attacking options. It is also considered PBS if the shot is blocked and remains in play in the attacker's court and the support is not able to set up another spike. Poor spike (PPS) (2): the spike is brought under control by the defending team, and they are able to recover the game with all attacking options, but with difficulty performing early on. Average spike (PAS) (3): the spike is brought under control by the defending team, and they are not able to recover the game early on. It will also be considered PAS when the attacker plays against the block and their support allows another shot to be set up. Good spike (PGS) (4): the spike is defended by the opposing team without the possibility of an attack being made (in volleyball this is called "free-ball"). Precise Spike (PPS) (5): the ball bounces in the opponent's court; it rebounds the block and the defending team cannot continue the game (in volleyball this is called "block-out"); or the referee considers that a player of the defending team has committed a foul during the defence.

Subsequently, the strike performance variable was grouped into two: low effective performance (LEP) groups: PSE, PBS and PPS; high effective performance (HEP) groups: PAS, PGS and PPS.

Both groupings were designed to meet the conditions necessary for further analysis.

Procedure

The actions were recorded by a single certified observer with more than 5 years' experience in volleyball performance analysis and team management. Observation criteria were established according to a handbook, including possible borderline cases. In order to estimate the quality of the data, a second expert observer with the same qualifications as the first was trained. Both the intra-observer agreement analysis ($\varkappa \geq .928$) and the inter-observer analysis ($\varkappa \geq .915$) reached quasi-perfect levels of agreement on all variables assessed.

For the calculation of PEKI, the Percentage of Effectiveness formula (Coleman et al., 1969) adapted to the 6-category system described was used:

$$\%\ Ef = \frac{(5(N^{o}A5\text{-}N^{o}A0)+4(N^{o}A4)+3(N^{o}A3)+2(N^{o}A2)+1(N^{o}A1))}{5(N^{o}A\ totals)} \times 100$$

Wherein: *Ef* is Effectiveness, Nº A5 is the number of spikes with a rating of 5, Nº A4 is the number of spikes with a rating of 4, and so on.

Similarly, the arithmetic mean of effectiveness was calculated based on the values given to each of the categories, divided by the total number of actions.

LINCE software, specifically designed for the recording of observational data in sport (Gabin et al., 2012), was used to record the data.

Statistical analysis

Frequency, percentage, mean and standard deviation were used to report the results. Intra and inter-observer agreement was checked with Cohen's Kappa. Firstly, to describe the spike effectiveness, the Mann-Whitney U and Kruskal Wallis H-tests were used due to the violation of parametric assumptions. Cohen's *d* was also calculated from these statistics to report the effect size. 4 proportional odds ordinal regression models were then used to determine the relationship between the criterion variable SP and the predictor variables RT, SP and TR: bivariate model, multivariate model, factor model and interaction model. In all analyses, compliance with the proportionality hypothesis was analysed and the likelihood ratio was used to compare the accuracy of the models and to analyse the impact of each variable. In addition, Odds Ratios and 95% confidence intervals were calculated to interpret the effect of the variables. To assess the variance explained by the models, the Nagelkerke Pseudo r^2 test was carried out. The significance level was set at $p < .05$. Statistical analysis was carried out with IBM SPSS (version 21.0 for Windows; SPSS Inc., Chicago, IL, USA).

Results

A total of 3,687 spike actions were recorded in K1, of which 1,284 were carried out by the front receiver.

In table 1, the frequency and percentage of team spikes in each rotation and according to the position of the setter can be observed (53.78% BSP; 46.22% FSP), in addition to the frequency and percentage of spikes by the front receiver in each rotation and again according to the position of the setter (32.02% BSP; 38.09% FSP).

Of the 1,284 spike actions by players in front receiver positions, only 366 resulted in TRY. The remaining actions ($n = 918$) resulted in TRN, as the receiving pass was made by a player other than the subsequent spiker.

In table 2, the frequency, mean values and standard deviation values of the effectiveness, in addition to the percentage of effectiveness of the front receiver with all data aggregated can be observed. No significant differences in SP according to RT SP and TR were obtained.

Table 1
Total frequency of spikes per rotation.

RT	*n*	% RT	*n* BR spikes	% BR spikes
RT2	558	15.13%	227	40.68%
RT3	563	15.27%	226	40.14%
RT4	583	15.81%	196	33.62%
RT1	623	16.90%	195	31.30%
RT5	638	17.30%	201	31.50%
RT6	722	19.58%	239	33.10%
BSP	1,983	53.78%	635	32.02%
FSP	1,704	46.22%	649	38.09%

Acronyms: RT = Team rotation in KI; *n* = Frequency; BR = Back receiver; RT2 = Rotation with the setter in 2; RT3 = Rotation with the setter in 3; RT4 = Rotation with the setter in 4; RT1 = Rotation with the setter in 1; RT5 = Rotation with the setter in 5; RT6 = Rotation with the setter in 6; BS = Back setter; FS = Front setter.

Table 2
Frequency, Mean and Standard Deviation of SP according to RT and TR.

	n	%Ef	$\overline{X}$ ± Sd	CI95%	*d*	*p*
RT2	227	54.36%	3.42 ± 1.85	3.18; 3.66	.079	.22
RT3	226	49.29%	3.26 ± 1.9	3.01; 3.51		
RT4	196	45.40%	3.21 ± 1.97	2.94; 3.49		
RT1	195	47.48%	3.27 ± 1.92	3; 3.54		
RT5	201	53.63%	3.45 ± 1.83	3.2; 3.71		
RT6	239	36.90%	3.02 ± 2	2.76; 3.27		
BSP	635	45.44%	3.23 ± 1.93	3.08; 3.38	.036	.462
FSP	649	49.89%	3.3 ± 1.9	3.16; 3.45		
TRN	918	50.22%	3.33 ± 1.88	3.21; 3.46	.089	.091
TRY	366	41.36%	3.11 ± 1.99	2.9; 3.31		

Acronyms: RT = Team rotation in KI; *n* = Frequency %Ef = Percentage of Effectiveness; $\overline{X}$ = Mean; Sd = Standard deviation; CI95% = Confidence Interval 95%; RT2 = Rotation with the setter in 2; RT3 = Rotation with the setter in 3; RT4 = Rotation with the setter in 4; RT1 = Rotation with the setter in 1; RT5 = Rotation with the setter in 5; RT6 = Rotation with the setter in 6; BS = Back setter; FS = Front setter; TRN = Transition no; TRY = Transition yes.

Table 3
Frequency, Mean and Standard Deviation of SP according to RT and TR.

	TRN						TRY						*d* TR	*p* TR
RT	*n*	%Ef	$\overline{X}$ ± Sd	CI95%	*d*	*p*	*n*	%Ef	$\overline{X}$ ± Sd	CI95%	*d*	*p*		
RT2	156	55.26%	3.44 ± 1.81	3.15; 3.72	.138	.096	71	52.39%	3.39 ± 1.95	2.93; 3.86	.152	.215	.019	.877
RT3	174	50.11%	3.28 ± 1.88	3; 3.56			52	46.54%	3.19 ± 2	2.64; 3.75			.022	.862
RT4	128	41.88%	3.11 ± 1.99	2.76; 3.46			68	52.06%	3.41 ± 1.93	2.95; 3.88			.145	.283
RT1	134	55.22%	3.47 ± 1.84	3.16; 3.78			61	30.49%	2.84 ± 2.04	2.31; 3.36			.282	.038
RT5	144	60.42%	3.65 ± 1.76	3.36; 3.94			57	36.49%	2.96 ± 1.92	2.46; 3.47			.334	.012
RT6	182	40.11%	3.1 ± 1.98	2.82; 3.39			57	26.67%	2.74 ± 2.08	2.18; 3.29			.133	.284
BSP	460	50.86%	3.38 ± 1.88	3.21; 3.55	.049	.433	175	31.20%	2.85 ± 2	2.55; 3.14	.256	.011	.233	.002
FSP	458	49.56%	3.29 ± 1.89	3.11; 3.46			191	50.66%	3.35 ± 1.95	3.07; 3.62			.047	.527

Acronyms: RT = Team rotation in KI; *n* = Frequency; %Ef = Percentage of Effectiveness; $\overline{X}$ = Mean; Sd = Standard deviation; CI95% = Confidence Interval 95%; RT2 = Rotation with the setter in 2; RT3 = Rotation with the setter in 3; RT4 = Rotation with the setter in 4; RT1 = Rotation with the setter in 1; RT5 = Rotation with the setter in 5; RT6 = Rotation with the setter in 6; BS = Back setter; FS = Front setter. TR = Transition; TRN = Transition no; TRS =Transition yes.

Table 3 shows the frequency results, the mean and standard deviation of the effectiveness and the percentage of effectiveness segregated according to the existence or not of transition. No significant differences were observed in the spike effectiveness according to rotation in cases of TRN ($p = .096$), or in cases of TRY ($p = .215$). Additionally, no significant differences in effectiveness according to SP were observed in cases of TRN ($p = .433$), but such differences were observed in cases of TRY ($p = .011$), where higher performance was achieved with FSP. Finally, greater effectiveness was observed in RT1 ($p = .038$), RT5 ($p = .012$) and in BSP ($p = .002$) in cases of TRN, compared to in cases of TRY.

In order to interpret the differences found in a multivariate context and to be able to assess possible interactions between RT and TR (predictor variables), ordinal regressions were generated. In these, SP was the criterion variable.

Table 4 shows the results of ordinal regressions assessing the relationship between SP and RT and TR. In the bivariate models, no significant relationships were observed between SP and RT ($X^2_5 = 6.99$; $p = .222$; $r^2 = .006$); nor between SP and TR ($X^2_1 = 2.89$; $p = .089$; $r^2 = .002$). However, small increases in attack performance were observed in RT2 (OR = 0.37; CI95% = 0.04; 0.71) and RT5 (OR = 0.4; CI95% = 0.06; 0.75), compared to RT6. The multivariate model slightly improved the estimates, but was not significant either ($X^2_6 = 10.34$; $p = .111$; $r^2 = .008$). The factor model improved the estimates, and was significant ($X^2_{11} = 19,89$; $p = .047$; $r^2 = .016$), it was therefore decided that the interaction between RT and TR should be studied to facilitate the interpretation of the results. This interaction suggests the importance of the TR in spike effectiveness in some rotations. In particular, improved SP was achieved in TRN*RT1 (OR = 0.68; CI95% = 0.11; 1.24), TRN*RT2 (OR = 0.61; CI95% = 0.06; 1.15), TRN*RT5 (OR = 0.85; CI95% = 0.29; 1.41), TRS*RT2 (OR = 0.64; CI95% = 0.01; 1.28) and in TRS*RT4 (OR = 0.65; CI95% = 0.01; 1.3), compared to TRS*RT6 in each case.

Table 4
Spike performance of front receiver in K1(SP), according to the transition (TR) and team rotation in KI (RT).

		Bivariate model		Multivariate model		Factor model		Interaction model	
	n (%)	OR (CI95%)	*p*	OR (CI95%)	*p*	OR (CI95%)	*p*	OR (CI95%)	*p*
Transition									
TRN	918 (72)	0.19 (-0.03; 0.41)	.086	0.21 (-0.01; 0.43)	.064	0.31 (-0.22; 0.85)	.251		
TRY	366 (29)	ref.		ref.		ref.			
Rotation									
RT1	195 (15)	0.25 (-0.1; 0.59)	.162	0.26 (-0.08; 0.61)	.136	0.08 (-0.57; 0.72)	.82		
RT2	227 (18)	0.37 (0.04; 0.71)	.027	0.39 (0.06; 0.72)	.022	0.64 (0.01; 1.28)	.048		
RT3	226 (18)	0.24 (-0.09; 0.57)	.158	0.24 (-0.1; 0.57)	.162	0.45 (-0.24; 1.13)	.199		
RT4	196 (15)	0.21 (-0.14; 0.55)	.237	0.23 (-0.11; 0.58)	.188	0.65 (0.01; 1.3)	.046		
RT5	201 (16)	0.4 (0.06; 0.75)	.022	0.41 (0.07; 0.76)	.019	0.16 (-0.5; 0.82)	.632		
RT6	239 (19)	ref.		ref.		ref.			
Transition * rotation									
TRN*RT1	134 (10)					0.29 (-0.48; 1.06)	.461	0.68 (0.11; 1.24)	.018
TRN*RT2	156 (12)					-0.35 (-1.1; 0.4)	.358	0.61 (0.06; 1.15)	.031
TRN*RT3	174 (14)					-0.27 (-1.05; 0.51)	.496	0.49 (-0.05; 1.03)	.076
TRN*RT4	128 (10)					-0.62 (-1.38; 0.14)	.109	0.34 (-0.22; 0.9)	.231
TRN*RT5	144 (11)					0.38 (-0.4; 1.15)	.342	0.85 (0.29; 1.41)	.003
TRN*RT6	182 (14)					ref.		0.31 (-0.22; 0.85)	.251
TRY*RT1	61 (5)					ref.		0.08 (-0.57; 0.72)	.820
TRY*RT2	71 (6)					ref.		0.64 (0.01; 1.28)	.048
TRY*RT3	52 (4)					ref.		0.45 (-0.24; 1.13)	.199
TRY*RT4	68 (5)					ref.		0.65 (0.01; 1.3)	.046
TRY*RT5	57 (4)					ref.		0.16 (-0.5; 0.82)	.632
TRY*RT6	57 (4)					ref.		ref.	

Acronyms: *n* = Number of recordings in the category; OR = Odds Ratios; *p* = significance value (< .05); TR = Reception-spike transition; TRN = Transition No; TRY = Transition Yes; RT = Team rotation in KI; RT1 = Rotation 1, RT2 = Rotation 2; RT3 = Rotation 3; RT4 = Rotation 4; RT5 = Rotation 5; RT5 = Rotation 5; RT6 = Rotation 6; ref. = Reference category.

Table 5
Spike performance of front receiver in K1(SP), according to setter position (SP) and the existence of a transition (TR).

		Bivariate model		Multivariate model		Factor model		Interaction model	
	n (%)	OR (CI95%)	*p*	OR (CI95%)	*p*	OR (CI95%)	*p*	OR (CI95%)	*p*
TR									
TRN	918 (72)	0.19 (-0.03; 0.41)	.084	0.2 (-0.03; 0.42)	.084	-0.1 (-0.42; 0.21)	.515		
TRY	366 (29)	ref.		ref.		ref.			
SP									
BSP	635 (49)	-0.08 (-0.28; 0.13)	.462	-0.08 (-0.28; 0.12)	.448	-0.51 (-0.89; -0.14)	.007		
FSP	649 (51)	ref.		ref.		ref.			
SP, grouped* TR									
BSP*TRN	460 (36)					0.6 (0.16; 1.05)	.008	-0.01 (-0.32; 0.3)	.949
BSP*TRY	175 (14)					ref.		-0.51 (-0.89; -0.14)	.007
FSP*TRN	458 (36)					ref.		-0.1 (-0.42; 0.21)	.515
FSP*TRY	191 (15)					ref.		ref.	

Acronyms: *n* = Number of recordings in the category; OR = Odds Ratios; *p* = significance value (< .05); TR = Reception-spike transition; TRN = Transition No; TRY = Transition Yes; RT = Team rotation in KI; RT1 = Rotation 1, RT2 = Rotation 2; RT3 = Rotation 3; RT4 = Rotation 4; RT5 = Rotation 5; RT6 = Rotation 6; RT6 = Rotation 6; ref. = Reference category. SP = Setter position; BSP = Back setter position; FSP = Front setter position; SP = Spike performance.

Finally, table 5 presents the results of the ordinal regressions assessing the relationship between SP and SP and TR. In the bivariate models, no significant relationships were observed between SP and SP ($X^2_1 = 0.54$; $p = .462$; $r^2 < .001$); nor between SP and TR ($X^2_1 = 2.89$; $p = .089$; $r^2 = .002$). A significant multivariate model was also not found ($X^2_2 = 3.47$; $p = .176$; $r^2 = .003$). But, again, when evaluating the factor model, a significant relationship was observed between SP and the interaction position of the setter x transition ($X^2_3 = 10.53$; $p = .015$; $r^2 = .009$), again indicating the importance of TR in SP in some specific rotations of the game. The in-depth study of interactions showed worse SP in cases of BSP*TRY (OR = -0.51; CI95% = -0.89; -0.14), compared to cases of FSP*TRY.

Discussion

This study compares the effectiveness of front receivers' spikes, according to their participation or lack thereof in the reception-attack transition, and according to the team's rotation, in addition to the interaction between the two.

Spike efficiency is the strongest predictor of K1 performance (Marelić et al., 2004). Spikes must be adapted to the different interactions that occur in each of the six rotations (López et al., 2022), understanding each of the rotations as differentiated contexts at the beginning of K1 (Palao et al., 2005).

However, when analysing the effectiveness of the front receivers' spikes, no significant differences were observed according to rotation. These results coincide with those provided by other research that analysed K1 spike performance in men's volleyball, although without differentiating the role of the spiker (Laios and Kountouris, 2011; Palao et al., 2005). Similarly, no significant differences were obtained in the performance of the front receiver's spike, according to the front or back position of the setter, although in women's volleyball and in lower categories differences have been found in the overall spike performance depending on the position of the setter (Đurković et al., 2008; Palao et al., 2005). It appears that the greater effectiveness of back receiver's spikes in men's categories (Mesquita and César, 2007) and

the improved effectiveness of this type of spike as the level of the team increases, allows a greater balance in attacking performance to be achieved between the different rotations; especially among the top-ranked high-level men's teams (Silva et al., 2016).

In the course of the K1 sequence, there is a chaining of two actions of maximum motor difficulty: reception and spike. Although Rentero et al. (2015) found no difference in reception performance according to the receiver, they did find that the greater the libero's participation in reception, the better the team's ranking in the men's final in the Olympic Games of 2008. This would support the idea that the libero helps to better develop attacking systems by avoiding cases of transition for spikers.

Different studies carried out at men's high-level have found that front receivers' reception-attack transition can reduce spike effectiveness in K1 (Afonso et al., 2012; Grgantov et al., 2018; Paulo et al., 2016; Valhondo et al., 2018). In addition to the coordination difficulty of linking the two actions, the transition can generate a time deficit for the receiver's incorporation into the attack. On many occasions, the player is forced to receive the ball in unbalanced positions or even as they are falling. Consequently, there is a percentage of actions in which reception can generate a previous muscle fatigue that decreases ability to jump in the spike (Maraboli et al., 2016); and can even prevent the receiving player from joining the KI attack system (Marcelino et al., 2014). This leads to the emergence of a type of serve that seeks to interfere with the reception-attack transition, to reduce the performance of the attacking receiver and to limit the possible attacking combinations (Kitsiou et al., 2020). But not all serves directed at a receiver who has to make the transition interfere with their attack, perhaps only serves directed at certain areas of the court do. Thus, it appears that difficulty increases when reception involves moving the attacker to a position far away from the net (Afonso et al., 2012; Grgantov et al., 2018; Kitsiou et al., 2020); too close to it, or within the spike zone (Hurst et al., 2016).

In the current study, differences close to 9% were obtained in relation to the percentage of spike effectiveness according to transition, although this did not reach statistical significance. It appears that team game models are searching for solutions to the reception-spike transition problem, and one of them is to shorten the transition spatially, as Paulo et al. (2016) describe, observing a tendency for the front receiver to move closer to the net, reducing their responsibility in the receiving system. Other solutions are: the introduction of the opposing player into the system by generating lines of 4 receivers, especially in the case of very powerful serves (Ciuffarella et al., 2013); or designing attacking systems in which the distribution of the setter avoids a player who is in a bad position after receiving the serve being chosen (Barzouka, 2018; Marcelino et al., 2014). This study also considers that the superior level of training of high-level receivers allows them to reduce the potential negative impact of transition on their spike performance.

However, when relating the transition to the position of the setter and spike performance, a 19.4% lower effectiveness was found when the spike occurred with transition and the setter at the back, compared to when the setter was at the front. On the other hand, a 19.6% higher effectiveness was found when spiking with a back setter and without transition, in relation to spikes carried out with transition (table 3).

The interaction of transition with team rotation resulted in significant changes in spike performance and effectiveness: with greater effectiveness when there was no transition in RT1 and RT5; and with greater spike performance in actions performed without transition in RT1, RT2 and RT5, and with transition in RT2 and RT4 in relation to actions performed with transition in RT6.

The higher frequency of directing sets to zone 4 has been associated with both excellent receptions that generate quick sets (Barzouka, 2018) and poor receptions or difficult sets made outside the ideal set zone (Barzouka, 2018; Grgantov et al., 2018); and allowing the opponent to form more frequent, well-structured two- or three-player blocks (Araújo et al., 2011). With a front setter, the attacking system has one less setter on the front line, which increases the percentage of sets directed to the front receivers (FSP: 38%; BSP: 32%). Therefore, the fact that a greater spike effectiveness with transition and front setters was obtained, as in RT2 and RT4, may be related to the fact that a higher percentage of sets started from better quality receptions. However, the improved performance of the transition with front setters is partly contradictory to the findings of Araújo

et al. (2011), who report a better block structuring with a higher number of triple blocks against the front receiver, when the setter is a front setter.

With a back setter, the front receiver shares the front line of attack with the centre and the opposing attacker, and with the latter being a spiking specialist, setters may tend to direct more sets to opposing players once they have received the front receivers, which prevents the transition. And they may also direct more sets to the front receivers creating more transitions from more difficult situations, especially when reception is close to their spike zone and it is difficult to send a set to other players.

In relation to the greater effectiveness of the front receiver-spiker in RT1 and RT5 without transition compared to with transition, in addition to re-considering the argument already set out in the previous paragraph, the fact that RT1 is the only rotation in which the front receiver normally receives in zone 1 and strikes throughout zone 2 must also be taken into consideration. Therefore, it is not their usual striking zone, and the transition could be less practised than the one executed in zone 4, which is their usual attacking zone. In addition, zone 2 is closer to the ideal set zone (zone 2-3) than zone 4, which decreases the ball's time in the air and may further limit the time available for transition for the back receiver. López et al. (2022), using a high-level male sample, found a higher than expected serving frequency in RT1 in zone 1 and in RT5 in zone 5, with the possible aim of making the transition more difficult for the front receiving attacker. Furthermore, in the same study it was found that in RT6 significantly more serves occurred in zone 1 and in the areas close to the setter than in the left half of the court (zone 6-5). Nonetheless, reception performance in zone 5 was lower. According to the authors, this could be related to a possible imbalance of the receiving structure in RT6 by overloading the line of receivers towards zone 1, which forces the front receiver to move away from the spike zone (zone 4), which would result in the lower spike performance when the transition occurs in RT6.

Conclusions

The spike performance of the front receiver is affected by the interaction between transition and team rotation in K1; either when studying the rotations individually, or according to the position of the front or back setter. In particular, it appears that the spiker's performance decreases when transition occurs and the setter is at the back.

As practical considerations, the results suggest the need to expand the libero's zone of intervention in receiving systems, in order to free the front receivers from that responsibility as much as possible. This solution is considered to be more applicable to women's volleyball, as it can be used especially in the case of serves executed at a slower speed. This release would allow the attacking receivers to make a quicker transition without prior contact with the ball during the reception. This increase in the spatial responsibility of the libero may lead to the need for faster and broader liberos. Furthermore, although volleyball can be approached and analysed as a set of isolated actions, due to the dynamics of the game itself, it is essential that chained actions, where the player maintains effectiveness in each one, are part of training. And taking into account the influence of the rotation and the position of the setter found in this study, it is considered relevant that the reception-attack transition is also integrated into training in the different rotations, understood as differentiated initial situations.

It would be interesting in future research to carry out the same study in women's volleyball, and in training stages.

As a limitation of this study, it is possible that the tendencies of some teams may have masked those of others, which is why it is considered relevant to study the opponents individually, assessing how the transition affects the spike performance in each of the rotations.

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Tendencies in Action, Type of Sport and Training Style in Sportswomen

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Abstract

The main objective of the study was to analyse whether there are differences in the action tendencies (assertive, aggressive and submissive) of female athletes depending on the type of sport they play (contact, non-contact). Research suggests that participants in non-contact sports show more mature reasoning regarding moral dilemmas of action tendencies in sport than participants in medium-high contact sports. 272 female athletes (149 from non-contact sports; 123 from contact sports) aged 11-16 years (M = 13.48, SD = 1.93) responded to three questionnaires. Different generalised linear models were tested and in all of them the type of sport (contact, non-contact) predicted assertive and aggressive action tendencies in sport in the presence of assertive and aggressive action tendencies in other contexts (trait) and the coach's interpersonal style. The results suggest that the type of sport played shapes action tendencies related to moral dilemmas in female athletes.

Keywords: aggressiveness, gender, interpersonal style, moral reasoning, sport.

Introduction

In recent years, a growing body of theoretical and empirical literature has emerged, addressing the study of the relationships between moral thinking, tendencies and action and the practice of sport (Nascimento Junior et al., 2020). In order to examine these relationships, researchers have employed different strategies, which are presented below together with the results obtained:

a) Comparative analysis:

a1) Between athletes and non-athletes (e.g. university students who play sport versus university students who do not play sport). College basketball players reasoned at a less mature level than their non-athlete counterparts (Bredemeier & Shields, 1984), both as regards reasoning of moral dilemmas in sport and in other contexts (Bredemeier & Shields, 1986).

a2) Between different types of sport (e.g. high-contact versus low-contact sports). Participants in different types of sports showed no significant differences in the development of moral reasoning (Proios et al., 2004). College students who participate in individual sports showed higher levels of moral reasoning than college students who participate in team sports (Priest et al., 1999). Team sports players showed lower levels of concern for the opponent than individual sports players (Vallerand et al., 1997).

a3) Between different levels of sport practice (e.g. elite versus trainee athletes). Elite athletes showed poorer moral reasoning than trainee athletes (Shrout et al., 2017). A similar trend was observed among professional and amateur handball players (Fruchart & Rulence-Paques, 2014).

b) Correlational studies between the degree of sport involvement and moral thinking, tendencies and action in sporting contexts (e.g. relationships between levels of sport practice and fair play). Boys' levels of participation in high-contact sports and girls' levels of participation in medium-contact sports correlated positively with less mature moral reasoning and greater aggressive tendencies (Bredemeier et al., 1986). In university athletes, participation in medium-high contact sports was associated with lower levels of fair play in the sport (Cecchini et al., 2007).

c) Explanatory studies that provide a sense of understanding regarding the phenomenon to which the results obtained in descriptive and correlational studies refer (e.g. the role of goal orientations in moral functioning). To explain these results, researchers analysed the influences of personal and contextual variables from different theoretical contexts. Among the former, they observed, for example, how goal orientations and sportsmanship orientations play a critical role in moral reasoning (Shrout, 2017). Furthermore, it was observed that participation in contact sports positively predicts ego-orientation, which in turn predicts low levels of moral functioning (Kavussanu & Ntoumanis, 2003), and low levels of fair play (Cecchini et al., 2007). Additionally, the manner in which self-determined motivation positively predicts sportsmanship orientations, subsequently predicting aggression in sport was observed (Chantal et al., 2005). Competition orientation was also a powerful predictor of sportsmanship (Shields et al., 2016).

Among the contextual variables, the climate created by parents, peers and coaches was analysed. For example, the performance climate in training sessions significantly predicted low levels of morality in sport, whereas the perceived mastery climate predicted more mature moral reasoning (Miller et al., 2004). The relationship between the mother and father-initiated learning climate/enjoyment was also found to be moderately and positively associated with prosocial attitude (Wagnsson et al., 2016). Other studies addressed controlling behaviours by the coach and found that these predict frustration of the athlete's basic psychological needs, which in turn predicts low moral functioning and doping intentions/doping use (Ntoumanis et al., 2017). An indirect relationship has also been found between the meta-perception of competence of multiple significant others and different orientations towards sportsmanship (Cecchini et al., 2014). Delrue et al. (2017) demonstrated how variation in coaches' frustration of athletes' basic psychological needs was related from one football match to the next to variation in antisocial behaviour towards the opponent. Another variable that has been taken into account is the moral atmosphere of the team. For example, athletes' perceptions of their team's moral atmosphere were found to have a significant effect on moral functioning (Kavussanu et al., 2002), and a favourable moral atmosphere was positively associated with more prosocial behaviour in sport (Rutten et al., 2011).

Based on this background and, considering the fact that sport-related moral thinking, tendency and action also depend on the gender of the participants (Martin et al., 2017), the main aim of the present study was to analyse whether there are differences in young female athletes' action tendencies (assertive, aggressive and submissive)

in sport and in other contexts of everyday life depending on the type of sport they play (contact, non-contact). This is the first study to address this issue, so it is considered premature to establish a hypothesis. However, differences between types of sports in the more general context of moral reasoning have not been conclusive because, while some studies showed no significant differences in the development of moral reasoning between participants in different types of sports (Proios et al., 2004), others did (Priest et al., 1999). The second objective was to determine whether assertiveness, aggressiveness and submissiveness in sport are related to the type of sport played (contact, non-contact) once the respective effects of assertiveness, aggressiveness and submissiveness in everyday life have been accounted for. Finally, perceptions of interpersonal styles were added to the model (satisfaction/frustration of athletes' basic psychological needs by the coach). For the latter two objectives, no hypotheses were made as they are being studied for the first time.

Methodology

Participants

Convenience sampling was used. The sample consisted of 272 female athletes, 149 of whom were involved in non-contact sports (badminton: n = 43, inline skating, n = 19, synchronised swimming: n = 51, and triathlon: n = 36), and 123 participants involved in sports where there is physical contact with the opponent (basketball: n = 105, rugby: n = 18), aged between 11 and 16 (M = 13.48, SD = 1.93) from a city in northern Spain. There was no sample mortality.

Materials and methods

Assertive, aggressive and submissive action tendencies. The version of CATS (*Children's Action Tendency Scale*) translated into Spanish by Cecchini et al. (2009) was used, which raises moral dilemmas about assertive, aggressive and submissive attitudes and behaviour in children (Deluty, 1979). The participant must answer questions that involve situations of frustration, provocation and conflict (e.g. "You have just left school. A child smaller than you throws a stone at you and it hits you on the head. What would you do?"). Each of the situations is followed by three alternatives (aggression: "Give him a good 'beating' so that he 'knows' how much it hurts"; assertiveness: "Scold him by telling him that throwing stones at people's heads is very dangerous", and submission: "Ignore him"), presented in contrast (assertiveness versus aggression, assertiveness versus submission, and submission versus aggression), so that they are forced to compare and choose the best alternative. In this study, the reduced version of six questions has been used, resulting in eighteen responses. The total scores for each subscale (assertiveness, aggressiveness and submissiveness) range from 0 to 12 points. In the present research the internal consistency of each subscale has been examined by the Kuder-Richardson formula (K-R 20) for dichotomous responses. The values were as follows [in brackets are the values obtained by Bredemeier (1994); also with a shortened version of the questionnaire]: assertiveness = .60 (.54), aggressiveness = .82 (.80) and submission = .63 (.58).

Assertive, aggressive and submissive action tendencies in sport. The version of SCATS (*Sport Children's Action Tendency Scale*) translated into Spanish by Cecchini et al. (2009) was used, which poses moral dilemmas about attitudes and behaviours of these same variables in sport-specific situations (Bredemeier, 1994). The structure is the same as the Child Action Tendencies Scale (CATS). The participant must answer questions that also involve conflict situations ("You are the fastest runner in your school. A new boy comes to school and boasts that he can beat you without difficulty. You decide to compete with him. Near the end of the race you're in the lead, but then you twist your ankle. What would you do?) Each of the scenarios is followed by three alternatives (aggression: "I would use my elbows to keep him behind me so I could beat him"; assertiveness: "I would stop and challenge him to a new race when my ankle gets better", and submission: "I would finish the race as best I could and not tell anyone about my ankle"), presented in contrast (assertiveness vs. aggression, assertiveness vs. submission, and submission vs. aggression). The total scores for each subscale range from 0 to 20 points. The Kuder-Richardson values for dichotomous responses were as follows (original scale values in brackets): assertiveness = .72 (.68), aggressiveness = .89 (.85) and submission = .69 (.66).

Coach's interpersonal style. In order to assess the athletes' perceptions of their coaches' instructional style, the *Coaches' Interpersonal Style Questionnaire* (Pulido et al., 2017) was used. This instrument consists of 24 items

designed to assess athletes' perceptions of their coaches' supportive and frustrating behaviours as regards athletes' psychological needs. The questions are preceded by the statement "During practice, our coach...". The scale consists of six factors (four items per factor): Autonomy support (e.g. "... often asks us about our preferences regarding the activities/tasks to be performed"), Competence support ("… proposes exercises adjusted to our level so that we can do them well"), Relationship support ("... always encourages good relationships between teammates"), Autonomy frustration ("... prevents me from making decisions about how I play"), Competence frustration ("... proposes situations that make me feel incapable"), and Relationship frustration ("... sometimes I have felt rejected by him/her"). All responses were rated on a 5-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). In the present study, Cronbach's alpha values were respectively .72, .82, .80, .72, .87, and .75.

Procedure

Informed consent was obtained from parents, coaches and presidents of the sports clubs. The questionnaires were anonymous and the athletes were assured that their answers would not be read by their coaches or parents. All questionnaires were completed under the supervision of an experienced researcher. Data were collected immediately after a training session. Respondents took approximately 30 minutes to complete the questionnaires. Permission was granted by the Ethics Committee of the University of Oviedo.

Data analysis

All data were analysed using SPSS 24.0. The Kolmogorov-Smirnov test (with Lilliefors correction) was used to test whether or not the data set fit a normal distribution. Using a significance level of 5% it was concluded that none of the variables used in this study had a normal distribution. The Kruskal-Wallis test was used to determine the differences between the groups (contact versus non-contact sports) for the variables under study. Bivariate correlations were established using Spearman's Rho test. To determine whether the sport (contact, non-contact) was related to moral reasoning in sport, independently of moral reasoning in general, different generalised linear models (GLM) were constructed, taking as the dependent variable the athletes' moral reasoning about (a) assertive, (b) aggressive, and (c) submissive behaviours in sport, and as predictor variables the type of sport (contact, non-contact), and the athletes' reasoning about (a1) assertive, (b1) aggressive and (c1) submissive behaviours in other contexts of everyday life. Furthermore, in order to uncover the relationship between moral reasoning and the coach's satisfaction/frustration of basic psychological needs, the six dimensions of the questionnaire and all their possible outcomes were included in the model. Age was also included as a contrast variable. The GLM establishes how the dependent variable was related to the factors and covariates through a certain link function. In addition, the model allows the dependent variable to display a non-normal distribution. In the construction of the GLM, different factors and covariates were incorporated until no significant improvement in the model was obtained. Non-significant variables were excluded from the model to avoid over-parametrisation that would dilute other effects (Punsly & Deriso, 1991). The most appropriate model was the one that minimised the residual deviation. In the case of heteroscedasticity in the residuals of the model the robust estimator option is used. For the interpretation of the results, the omnibus test was used (if not significant, the analysis is terminated). Goodness-of-fit measures, based on deviation and AIC values, were then assessed.

Results

Differences between groups

Participants showed statistically significant differences on six variables according to the type of sport played. Women in contact sports scored higher on aggressive action tendencies in sport and in other contexts, and lower on assertive action tendencies and submissive action tendencies in sport than women in non-contact sports (Table 1). As reasoning of action tendencies was quantified on the basis of dichotomous questions, it could be concluded that the group of athletes who play contact sports had lower levels of moral reasoning than athletes who play sports in which there is no physical contact between participants. It was also observed that players of non-contact sports perceived a higher degree of satisfaction regarding basic psychological needs of competence and relationship from their coach. Figures 1 and 2 show a clear trend towards more adaptive behaviour in the non-contact group, both in moral reasoning and in satisfaction/frustration of basic psychological needs by the coach, except for frustration of autonomy.

Table 1
Descriptive analyses and differences between groups (contact versus non-contact sports) of the variables under study.

	Non-contact sport		Contact sport		Total	
	M	SD	M	SD	M	SD
General Assertiveness	9.27	1.37	9.07	1.54	9.18	1.45
General Aggressiveness	3.28	2.00	3.86*	2.13	3.54	2.08
General Submission	5.46	2.23	5.06	2.21	5.28	2.23
Sport Assertiveness	15.66*	2.67	14.74	3.15	15.24	2.93
Sport Aggressiveness	5.97	4.10	7.62**	4.14	6.72	4.19
Sport Submission	8.37*	3.08	7.63	2.95	8.04	3.04
Autonomy Satisfaction	3.19	.99	2.98	1.03	3.09	1.02
Competence Satisfaction	4.19**	1.03	3.87	1.11	4.05	1.08
Relationship Satisfaction	5.66**	1.01	5.28	1.22	5.49	1.12
Autonomy Frustration	3.04	1.02	3.03	.97	3.03	.99
Competence Frustration	2.17	1.28	2.38	1.30	2.27	1.29
Relationship Frustration	1.83	.96	2.02	.96	1.92	.96

Note: * $p < .05$; ** $p < .01$.

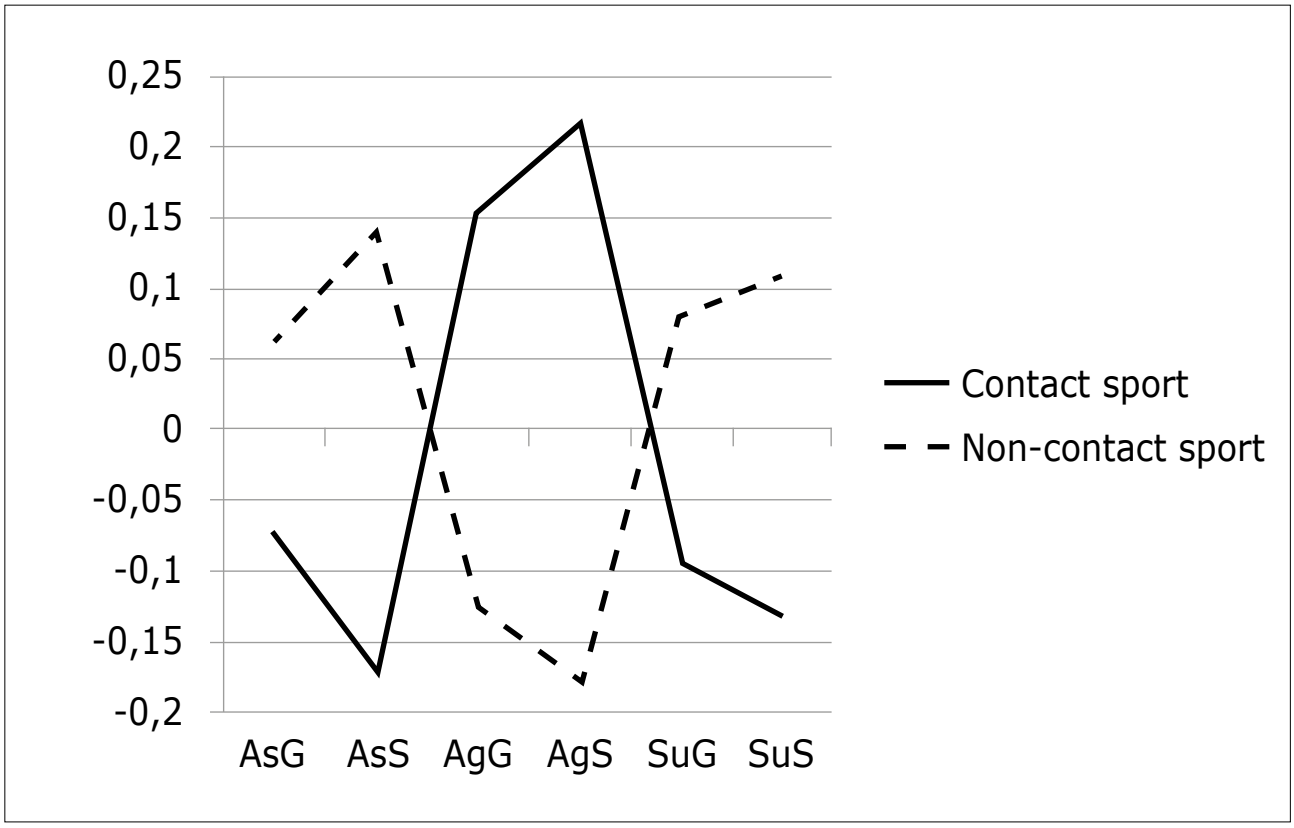

Figure 1
Z Scores of the moral reasoning variables in each of the groups.
Note: AsG = General Assertiveness, AsS = Assertiveness in sport, AgG = General Aggressiveness, AgS = Aggressiveness in sport, SuG = General Submission, SuS = Submission in sport.

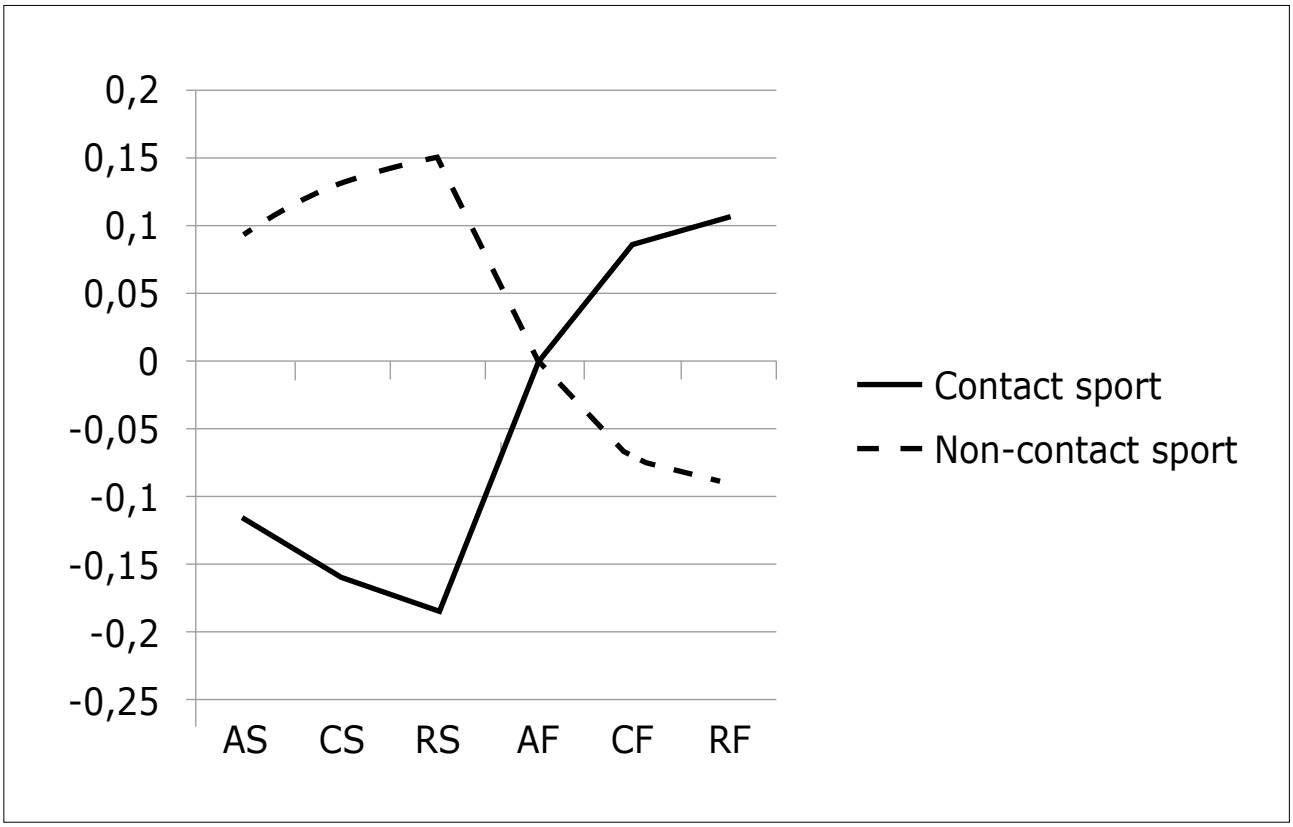

Figure 2
Z scores of satisfaction/frustration of the basic psychological needs of the athletes by the coach, in each of the groups.
Note: AS = Autonomy Satisfaction, CS = Competence Satisfaction, RS = Relationship Satisfaction, AF = Autonomy Frustration, CF = Competence Frustration, RF = Relationship Frustration.

Table 2
Bivariate correlations.

	1	2	3	4	5	6	7	8	9	10	11
1. General Assertiveness	1.00										
2. General Aggressiveness	-.22***	1.00									
3. General Submission	-.45***	-.73***	1.00								
4. Sport Assertiveness	.17**	-.38***	.25***	1.00							
5. Sport Aggressiveness	-.04	.54***	-.47***	-.69***	1.00						
6. Sport Submission	-.06	-.37***	.38***	.04	-.73***	1.00					
7. Autonomy Satisfaction	-.17**	.02	.09	.03	-.01	-.01	1.00				
8. Competence Satisfaction	.00	-.06	.06	.17**	-.12	-.03	.49***	1.00			
9. Relationship Satisfaction	.05	-.14*	.10	.18**	-.13*	.00	.43***	.60***	1.00		
10. Autonomy Frustr.	.03	.10	-.13*	-.25***	.13*	.10	-.23***	-.36***	-.22***	1.00	
11. Competence Frustr.	-.04	.10	-.07	-.32***	.19**	.07	-.23***	-.50***	-.39***	.60**	1.00
12. Relationship Frustration	-.13*	.15*	-.06	-.33***	.19**	.05	-.11	-.41***	-.42***	.43***	.70***

Table 3
Generalised linear models with assertiveness in sport as the dependent variable.

Parameter	B	SD	Wald	Sig.	Exp(B)	95% CI		R^2
						Lower	Higher	
Model 1								
Sport	-.918	.358	6.576	.010	.399	.198	.805	.02
Model 2								
Sport	-.838	.351	5.701	.017	.433	0.217	0.861	.07
General Assertiveness	.409	0.119	11.914	0.001	1.505	1.193	1.899	
Model 3								
Sport	-0.699	0.340	4.231	0.040	0.497	0.256	0.968	0.15
General Assertiveness	0.408	0.112	13.236	0.000	1.504	1.207	1.875	
Competence Frustration	-0.872	0.179	23.796	0.000	0.418	0.295	0.594	
Model 4								
Sport	-0.664	0.337	3.880	0.049	0.515	0.266	0.997	0.17
General Assertiveness	0.366	0.114	10.218	0.001	1.442	1.152	1.804	
Competence Frustration	-0.495	0.206	5.766	0.016	0.610	0.407	0.913	
Relationship Frustration	-0.529	0.239	4.918	0.027	0.589	0.369	0.940	

Bivariate correlations

Both in the sporting context and in life in general, the highest correlations between the three variables measuring action tendencies were between submissiveness and aggressiveness. All three action tendencies in everyday life correlated positively with the corresponding variable in sport, although aggressiveness showed the highest correlation. In sport, these same dimensions showed a higher degree of correlation with the variables measuring satisfaction/frustration of basic psychological needs by the coach, except for the submission variable, which showed no relationship in the sporting context. A higher correlation was also observed in the sporting context for assertiveness and aggressiveness (negative and positive, respectively) with variables measuring frustration of basic psychological needs.

Generalised linear models

Table 3 presents the results of the GLMs with assertiveness in sport as a response variable. The omnibus test was significant ($x^2 = 50.146$ (4), $p < .001$). Overall, the model explains 17% of the variance. Model 2 shows that in the presence of assertiveness in sport, the type of sport remains a significant variable, although it explains a very low percentage of the variance. In model 3 the frustration of competition variable is included, which increases the explained variance by 8%. Finally, model 4 incorporates relationship frustration, which explains a further 2% of the variance. Consequently, moral reasoning of assertiveness in sport is explained by assertiveness in general, the type of sport played (less assertiveness in contact sports), and the coach's frustration of basic psychological needs regarding competence and relationship.

The results of the GLMs with aggression in sport as a response variable are shown in Table 4. The omnibus test was significant ($x^2 = 111.45$ (3), $p < .001$). Overall, the model explains 34% of the variance. In model 2 it is observed that, in the presence of general aggressiveness, sport type remains a significant variable, although it explains a low percentage of the variance. In model 3, the competence frustration variable is incorporated. Ultimately, moral reasoning of aggressiveness in sport

Table 4
Generalised linear models with aggressiveness in sport as the dependent variable.

Parameter	B	SD	Wald	Sig.	Exp(B)	95% CI		R^2
						Lower	Higher	
Model 1								
Sport	1.653	0.501	10.723	0.001	5.222	2.957	13.936	0.04
Model 2								
Sport	1.016	0.420	5.838	0.016	2.761	1.211	6.295	0.32
G Aggressiveness	2.256	0.199	128.94	0.000	9.621	6.509	14.221	
Model 3								
Sport	0.948	0.421	5.070	0.024	2.581	1.131	5.892	0.34
G Aggressiveness	2.237	0.202	122.331	0.000	9.362	6.298	13.915	
Competence F.	0.470	0.203	5.387	0.020	1.601	1.076	2.381	

Table 5
Generalised linear models taking submission in sport as the dependent variable.

Parameter	B	SD	Wald	Sig.	Exp(B)	95% CI		R^2
						Lower	Higher	
Model 1								
Sport	-0.735	0.366	4.031	0.045	0.480	0.234	0.938	0.01
Model 2								
Sport	-0.528	0.336	2.470	0.116	0.590	0.305	1.139	0.16
G Submission	1.178	0.171	47.259	0.000	3.248	2.322	4.545	

is determined by aggressiveness in general, the type of sport played (higher aggressiveness in contact sports), and the coach's frustration of basic psychological needs regarding competence.

In the omnibus test, the GLM results using sport submission as a response variable were significant ($x^2 = 48.390$ (2), $p < .001$). Model 2 explains 16% of the variance. In this model it is observed that, in the presence of general submission, the type of sport is no longer a significant variable.

Discussion

The results of the study allow us to conclude that, in young female athletes, there are differences in assertive, aggressive and submissive action tendencies in sport depending on the type of sporting activity they practice (contact, non-contact). Participants in medium-high contact sports scored significantly higher on aggressive action tendencies than participants in non-contact sports, while participants in medium-high contact sports scored significantly higher on assertive and submissive tendencies. As these variables were measured in the present research, it can be affirmed that participants in non-contact sports show more mature reasoning regarding moral dilemmas of action tendencies in sport than participants in medium-high contact sports. This result is consistent with what has been observed in children (Bredemeier et al., 1986) and in university athletes (Cecchini et al., 2007; Priest et al., 1999), and contradicts what has been observed by Proios et al. (2004) in a much more heterogeneous population.

The results were less conclusive when action tendencies in other contexts of everyday life were analysed. While differences are observed in levels of aggressiveness (higher scores for contact sports participants, $p < .05$), they do

not appear in assertiveness or submissiveness. In order to try to understand how these variables relate to each other (action tendencies in sporting and other contexts) and to address the second objective of the study, bivariate correlations were performed and different models (GLM) were tested. The bivariate correlations between the three action tendencies in everyday life with the corresponding variable in sport were found to be low (assertiveness) to moderate (aggressiveness), which determines that they are relatively independent. This is confirmed when the first GLMs are designed with the three dimensions of action tendencies in sport as outcome variables and the type of sport and the corresponding action tendency in everyday life as independent variables (models 2). In both assertive and aggressive action tendencies, the type of sport remains a significant predictor. In other words, the type of sport (contact, non-contact), predicts assertive and aggressive action tendencies in sport in the presence of assertive and aggressive action tendencies in other contexts (trait). These results are not observed in submission, this is believed to be because of the way these variables have been measured.

When satisfaction/frustration of basic psychological needs by the coach is included in the models, the variable with the greatest explanatory power for both assertive and aggressive action tendencies is competence frustration. This is consistent with the observations of Shields et al. (2016) on the relationship between competence orientation and sportsmanship. The relationship between frustration and aggression is also well documented. The results are also consistent with those observed for the relationship of satisfaction-frustration of basic psychological needs with victimisation (Menéndez-Santurio et al., 2020), and antisocial behaviour with adversarial behaviour (Delrue et al., 2017).

Finally, model 4 in the prediction of assertive tendency in sport also includes the relationship frustration variable in negative. Considering that assertiveness is an interpersonal and social communication skill, it seems logical to think that it is also linked to social relationship processes. Steps 3 and 4 decrease the explanatory power of sport type on the outcome variables, but do not cancel it out, so they cannot fully explain the relationship.

The present study has some limitations. The first is that it is based on a cross-sectional approach that cannot account for cause-effect relationships. The second is that the variables used do not fully explain the relationship between sport type and action tendencies in sport. Moreover, a third limitation is the fact that a dichotomous measurement has been carried out. For all these reasons, it is believed that new longitudinal and experimental studies should be carried out to explain this relationship by incorporating new variables such as respect, personal responsibility, sportsmanship and companionship.

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SCIENTIFIC NOTES

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Women Representation among Editors-in-Chief in Physical Education Journals

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Abstract

This study examined women representation in editor-in-chief (EiC) position at physical education (PE) journals. A total of twenty-five PE journals were selected from *Web of Science* (*Social Science Citation Index* and *Emerging Sources Citation Index*) and *Scopus*. Each journal was classified based on indexation [*Journal Impact Factor-Journal Citation Reports* (JIF-JCR)/*Journal Citation Indicator-Journal Citation Reports* (JCI-JCR)/*Scimago Journal & Country Rank* (SJR)], subject category, quartile (ranking year 2020), region, language(s) and EiCs' gender. Only five journals (20%) listed women as EiCs: *Apunts Educación Física y Deportes* (JCI-JCR-Q2, SJR-Q1, Spain), *Educación Física y Ciencia* (JCI-JCR-Q4, Argentina), *Motriz. Revista de Educação Física* (SJR-Q4, Brazil), *Retos. Nuevas Tendencias en Educación Física, Deportes y Recreación* (JCI-JCR-Q4, SJR-Q3, Spain), and *South African Journal for Research in Sport, Physical Education and Recreation* (SJR-Q4, South Africa). Gender disparities are evident in EiC position at the PE discipline. Gathering and reporting data on male-female representation in EiC position is a necessary first step to move towards a more equitable scientific community. A joint effort from editorial boards in PE journals must be done to address this gender gap. A more gender diversity in leading journals might create a publishing environment that can reduce bias in how papers are selected and approved in the PE discipline.

Keywords: female, gender bias, gender gap, gender imbalance, physical education.

Introduction

Scholarly recognition and impact are necessary for promotion in academia, and women face additional obstacles to obtain high-ranking positions (Larivière et al., 2013). Research productivity is a key factor (Chatterjee & Werner, 2021) and previous literature highlighted a gender imbalance (< 50% ♀) in authorship of papers in fields such as neuroscience (Dworkin et al., 2020), psychology (Huang et al., 2020) or sport sciences (Martínez-Rosales et al., 2021). In addition, a lower h-index has been observed in females compared to males in disciplines such as psychology (Geraci et al., 2015), surgery (Myers et al., 2019) or medicine (Ha et al., 2021). Research on this matter has not focused on physical education (PE). In education sciences, the academic discipline closer to the PE field, three old studies found a lower representation of women authorship (Lockheed & Stein, 1980; White, 1997; Zawacki-Richter & von Prümmer, 2010). More recently, more positive scores (62% ♀) were found (Holman et al., 2018).

The editor-in-chief (EiC) in scientific journals is usually a highly experienced researcher in an academic discipline and plays a major role in all the journal's operations and policies (James et al., 2019). For this reason, holding the EiC position is reserved for senior scientists with a large and productive career (Holman et al., 2018). Evidence supports that women still remain underrepresented among the EiC position of scientific journals in disciplines such as medicine (21% ♀, Pinho-Gomes et al., 2021), dermatology (18% ♀, Lobl et al., 2020), surgery (4.8% ♀, Ehrlich et al., 2021) or sport sciences (0% ♀, Martínez-Rosales et al., 2021; 9% ♀, Ortega et al., 2015). No previous research has been conducted in PE field. Based on the aforementioned, the purpose of this study was to investigate the gender distribution of the EiCs of PE journals indexed in the *Social Science Citation Index* (SSCI), *Emerging Sources Citation Index* (ESCI) and *Scopus*, attending to journals' performance: *Journal Impact Factor-Journal Citation Reports* (JIF-JCR), and/or *Journal Citation Indicator-Journal Citation Reports* (JCI-JCR), and/or *Scimago Journal & Country Rank* (SJR).

Method

A cross-sectional study was designed to examine the proportion of women as EiCs in PE journals. Data were extracted from two databases: *Web of Science* and *Scopus*. As there is no specific science category for the PE discipline, the search process for the journals followed some steps (Figure 1). First, we used the search term '*physical education*' in title, abstract or keywords in published articles from *SSCI*, *ESCI* and *Scopus*. Second, results were filtered by the last 5 years (2017-2021) and 3 languages: English, Spanish and Portuguese. Third, we accessed the name of the journals where the articles had been published. The inclusion criteria were: (1) journal name including PE, and/or (2) explicit reference to PE in the aims and scope of the journal. Fourth, two independent researchers selected the PE journals, resolving discrepancies through discussion and consensus. Finally, 25 PE journals were identified for further analysis.

Data collection took place in January 2022. EiCs were determined based on information available in the journals' website. EiCs' gender was tabulated in binary form (woman or man) via personal and institutional web pages, photograph, Google Scholar or ResearchGate. Each journal was classified based on indexation (JIF-JCR/JCI-JCR/SJR), subject category, quartile (ranking year 2020), region, language(s) and EiCs' gender.

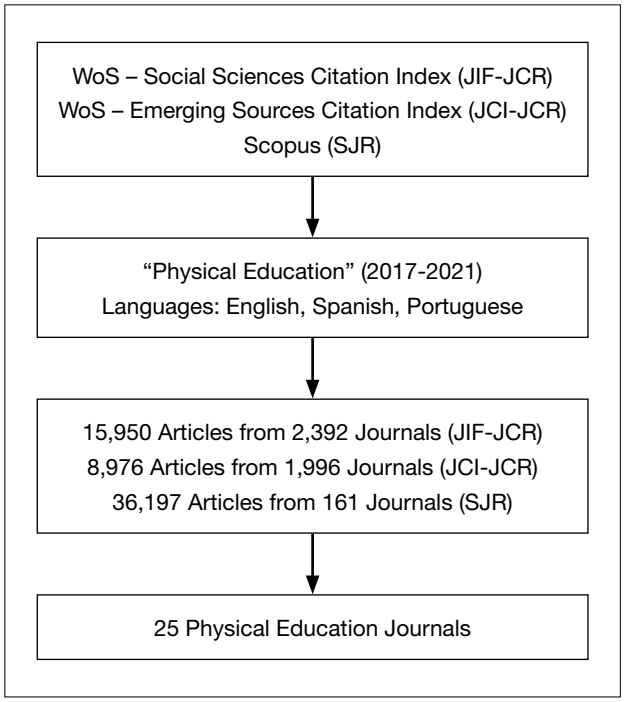

Figure 1
Search strategy.

Results

A total of 25 PE journals were identified (Table 1), indexing in JIF-JCR and SJR (7 journals), JCI-JCR (7 journals), SJR (8 journals), and JCI-JCR and SJR (3 journals). There were a total of 30 EiCs across these journals. In three journals (*Educación Física y Ciencia, Journal of Physical Education*, and V*iref-Revista de Educación Física*) 2 or more EiCs were listed. Only five journals (20%) listed women as EiCs: *Apunts Educación Física y Deportes* (JCI-JCR-Q2, SJR-Q1, Spain), *Educación Física y Ciencia* (JCI-JCR-Q4, Argentina), *Motriz. Revista de Educação Física* (SJR-Q4, Brazil), *Retos. Nuevas Tendencias en Educación Física, Deportes y Recreación* (JCI-JCR-Q4, SJR-Q3, Spain), and *South African Journal for Research in Sport, Physical Education and Recreation* (SJR-Q4, South Africa). Therefore, women representation occurred in three JCI-JCR journals and two SJR journals.

Table 1
Gender of editors-in-chief and main features of physical education journals.

Journal	Indexation (category)	Region	Language(s)	Editor(s)-in-Chief
Ágora para la Educación Física y el Deporte	JCI-JCR-Q4 (Education & Educational Research)	Spain	Spanish, English	Man
Apunts Educación Física y Deportes	JCI-JCR-Q2 (Education & Educational Research) SJR-Q1 (Cultural Studies)	Spain	Spanish, English, Catalan	Woman
Cultura, Ciencia y Deporte	JCI-JCR-Q4 (Hospitality, Leisure, Sport & Tourism) SJR-Q3 (Health - Social Science)	Spain	Spanish, English	Man
Curriculum Studies in Health and Physical Education	SJR-Q1 (Education)	United States	English	Man
Educación Física y Ciencia	JCI-JCR-Q4 (Education & Educational Research)	Argentina	Spanish, English, Portuguese	1 Woman 2 Men
European Journal of Physical and Health Education	SJR-Q4 (Education)	Poland	English, Spanish, Portuguese	Man
European Physical Education Review	JIF-JCR-Q1 (Education & Educational Research) SJR-Q1 (Education)	United Kingdom	English	Man
Facta Universitatis Series Physical Education and Sport	SJR-Q3 (Orthopedics and Sports Medicine)	Serbia	English	Man
Journal of Physical Education	SJR-Q4 (Education)	Brazil	English, Portuguese	2 Men
Journal of Physical Education, Recreation and Dance	SJR-Q3 (Education)	United Kingdom	English	Man
Journal of Teaching in Physical Education	JIF-JCR-Q1 (Education & Educational Research) SJR-Q1 (Education)	United States	English	Man
Journal of Physical Education and Sport	SJR-Q3 (Sports Science)	Romania	English	Man
Measurement in Physical Education and Excercise Science	JIF-JCR-Q2 (Education & Educational Research) SJR-Q2 (Sports Science)	United States	English	Man

Table 1 (Continuation)
Gender of editors-in-chief and main features of physical education journals.

Journal	Indexation (category)	Region	Language(s)	Editor(s)-in-Chief
Motriz. Revista de Educação Física	SJR-Q4 (Social Sciences)	Brazil	English, Portuguese	Woman
Movimento. Revista de Educação Física	JCI-JCR-Q4 (Education & Educational Research) SJR-Q3 (Education)	Brazil	Portuguese, Spanish, English	Man
Pedagogy of Physical Culture and Sports	JCI-JCR (quartile not available) (Hospitality, Leisure, Sport & Tourism)	Ukraine	English	Man
Physical Education and Sport Pedagogy	JIF-JCR-Q1 (Education & Educational Research) SJR-Q1 (Education)	United Kingdom	English	Man
Physical Education of Students	JCI-JCR-Q2 (Education & Educational Research)	Ukraine	English	Man
Quest	JIF-JCR-Q2 (Education & Educational Research) SJR-Q1 (Education)	United States	English	Man
Retos. Nuevas Tendencias en Educación Física, Deportes y Recreación	JCI-JCR-Q4 (Hospitality, Leisure, Sport & Tourism) SJR-Q3 (Education)	Spain	Spanish, English, Portuguese	Woman
South African Journal for Research in Sport, Physical Education and Recreation	SJR-Q4 (Education)	South Africa	English	Woman
Sport, Education and Society	JIF-JCR-Q1 (Education & Educational Research) SJR-Q1 (Education)	United States	English	Man
Sportis. Revista Técnico-Científica del Deporte Escolar, Educación Física y Psicomotricidad	JCI-JCR-Q3 (Education & Educational Research)	Spain	Spanish, English	Man
The Physical Educator	JCI-JCR-Q3 (Education & Educational Research)	United States	English	Man
Viref-Revista de Educación Física	JCI-JCR-Q4 (Education & Educational Research)	Colombia	Spanish, English	4 Men

Discussion

This study aimed to evaluate female representation in the EiC position at PE journals. Findings showed that women comprised a minority of EiCs across the 25 PE journals examined. Only 5 PE journals (20%) listed women as their EiCs. These results supported women underrepresentation in EiC position in the same line with others recent studies in fields such as medicine (Pinho-Gomes et al., 2021), dermatology (Lobl et al., 2020), surgery (Ehrlich et al., 2021) or sport sciences (Martínez-Rosales et al., 2021; Ortega et al., 2015).

Gender disparities in authorship and h-index could be spreading to the appointment of EiC position (Ehrlich et al., 2021). In this context, science and gender equality is one of the major themes included in the 2030 Agenda for Sustainable Development (Goal 5: 'Achieve gender equality and empower all women and girls'). Key targets include ensuring equal opportunities for women's participation and leadership. Despite a lower number of females enrolled in PE university programs (Abt et al., 2021; Serra et al., 2021), gender-equity policies should be promoted in PE research.

Some potential areas for intervention have been identified to facilitate the growth of women in scientific research. For example, improve women's professional networks or implement female mentorship pipeline programs to avoid the gradual decrease in the presence of women in the academic career (Ehrlich et al., 2021). On the other hand, the journals should also implement proactive strategies, eliminating unconscious barriers and advocating for transparency in the selection processes of the EiCs (Haffez et al., 2019). A joint effort from editorial boards in PE journals must be done to address this gender gap. Hegemonic masculinity remains an enduring challenge.

Finally, these descriptive findings limit inferences related to causality, so they should be interpreted with caution. Future studies could adopt a more qualitative or mixed methods in order to explain gender inequalities.

Conclusion

Gender disparities are evident in the EiC position at the PE discipline. Gathering and reporting data on male-female representation in the EiC position is a necessary first step to move towards a more equitable scientific community. Actions are recommended to promote equitable gender representation in the EiC roles in PE journals. Proactive strategies should be designed to achieve a greater representation of women and more egalitarian scenarios (gender parity). A more gender diversity in editorial boards might create a publishing environment that could reduce the bias in how papers are selected and approved in the PE discipline.

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LITERATURE REVIEW

OPEN ACCESS

Book review: *El entrenamiento en los deportes de equipo ("Training in team sports")*

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Sports practice in childhood favours the growth and emotional health of children.
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The coordinator of this book review, Francisco Seirul·lo, a graduate in Physical Education and Human Motricity, has many years of experience in physical training and coaching in high performance sports (athletics, handball, judo, tennis and football), and also as a teacher at the INEFC in Barcelona. He is currently working as director of training methodology at the F. C. Barcelona.

Seirul·lo designed and built the foundations of Structured Training in team sports. The text shows the principles of the methodological approach developed by the Barcelona School, which has influenced (and continues to influence) a large number of coaches, trainers and physical therapists all over the world.

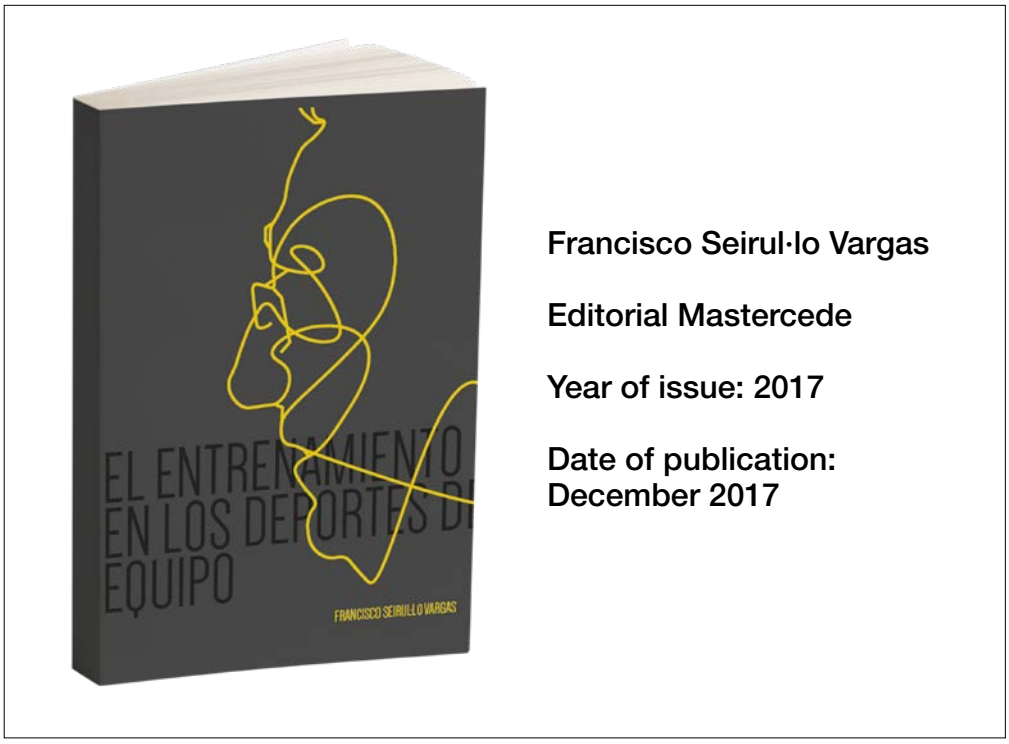

Figure 1
From Seirul·lo Vargas (2017).

The book encompasses a process initiated in the late 1980s by a group of professionals who worked for the INEFC in Barcelona, led by Seirul·lo and comprised of the authors of the chapters in the book under review: Tous, Moras, Vizuete, Fortó, Serrés, Massafret, Espar, Romero and Padullés. These members worked on the development of a renewed theory of training for team sports. Influenced by the concepts and ideas of the Complexity paradigm (coming from the sciences of Gestalt, Cognitivism and Structuralism), from a systemic and multifunctional view of the human athlete, they focused on the optimisation of their structures and movement as the focus of their proposal. This methodology began to be put into practice in high performance sports and was subsequently developed in the Professional Master's Degree in High Performance in Team Sports of Barcelona (2003). Since then, this innovative way of understanding training, focusing on the universality of sports and the particularity of athletes, has been constantly evolving and reinventing itself, supported by technological advances, to improve the practice of design, control and assessment of players.

The book presents Structured Training (the theory of training for team sports), its methodology, planning and control processes, in a generic and specific way for each sport speciality, with the purpose of preparing the athlete to train and compete.

The first chapter contains an overview of the general theory of sports training, from which closed, universal and multidisciplinary models applied to athletes and successfully applied to individual sports were presented. Seirul·lo states that this movement originating from Mechanicism and Behaviourism (Simplification paradigm) has numerous limitations for team sports. Whereas the complexity paradigm, which supports Structured Training, according to the author, is more adequate for conceiving team sports as intuitive, synthetic, holistic, non-linear, cooperative and qualitative.

Throughout the extensive chapter two, the training of conditional structure as a support in the prevention of injuries and optimisation of performance is established. This is what the authors call "preparing for training'' and involves the inclusion of oriented, general and targeted exercises, proposing training strategies based on three-dimensional and four-dimensional strength development.

In chapter three, the explanation of "prepare for competition'' begins, with the predominance of the coordinative structure. It develops the methodology for the design of training tasks through preferential simulated situations.

In chapter four the authors address the cognitive structure, explaining the importance of strengthening and developing these capacities of shared space athletes, emphasising decision-making in the game and its implication in the design of exercises.

In the next chapter, Seirul·lo develops socio-affective structure as an inexorable element that enables knowledge on how and why a team wins, since sporting success and failure are group-based. The author stresses that high levels of interpersonal relationships are necessary for the fulfilment of each team's objectives.

In chapter six, the authors address planning in structured training, describing it as a systematic and continuous process, which requires rigorous timing of theoretical and practical tasks of periodisation, cyclisation, programming, assessment and control. They characterise planning as unique and specific to each sport speciality and personalised to the athlete.

In the last two chapters, they work on the transversal contents of the proposal: the methodology of preventive intervention within the optimising training of the athlete and control of the internal and external load of team sports.

As physical education and physical preparation professionals, we now have access to a great book that brings them closer to the world of high performance sports with the possibility to compare, complement and continue to study their actions in the sports field. This book contains many articles that help to better understand how to coach based on this ideology, which has greatly influenced many of the world's best clubs. The enjoyable reading and rereading of this compilation has been a decisive before and after moment in our profession. Reading it is highly recommended.

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