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Semi-supervised aerobic interval training improves cardiorespiratory fitness in sedentary adults with cardiometabolic risk factors

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An athlete doing parkour. ©Image Source. Adobe Stock.

Abstract

The aim of this study was to evaluate the effects of a high-intensity semi-supervised exercise programme alongside lifestyle counselling on cardiorespiratory adaptation to exertion in sedentary adults with cardiometabolic risk factors. Forty-week three-arm randomized controlled clinical trial (16-week intervention and 24-week follow-up). Sedentary adults (23 men, 38 women) aged 34-to-52 years (M = 44.6, SD = 4.6), with at least one cardiometabolic risk factor were randomized into one of the following arms: (1) aerobic interval training plus lifestyle counselling (AIT); (2) low-to-moderate-intensity continuous training plus lifestyle counselling (TCT); or (3) lifestyle counselling alone (COU). Cardiorespiratory fitness, in terms of peak oxygen uptake (VO_{2peak}) and oxygen uptake at the respiratory compensation point (VO_{2RCP}), ventilatory efficiency index (VE-VCO_2 slope), oxygen uptake efficiency slope (OUES), were assessed at baseline, after the intervention and at follow-up. All intervention programmes induced comparable significant changes in cardiorespiratory fitness, but changes in VO_{2peak} differed according to whether participants could reach maximal criteria at baseline or not. Intervention was more effective for participants that were unable to reach maximal criteria at baseline than for those that reached maximal criteria. In participants that did not reach maximal criteria at baseline, VO_{2peak} increased significantly. All intervention programmes induced comparable significant but non-persistent increases in VO_{2VT}, no changes in VE-VCO_2 slope and persistent improvements of OUES. Semi-supervised AIT intervention had positive effects on physiological adaptation to exertion and cardiorespiratory fitness but did not differ substantially from TCT or COU.

Keywords: cardiopulmonary exercise testing, graded exercise test, metabolic syndrome, oxygen consumption, oxygen uptake efficiency slope, ventilatory efficiency index.

Introduction

Metabolic syndrome (MetS), a cluster of cardiometabolic risk factors, has a strong negative impact on cardiovascular health and premature death (Gami et al., 2007). Epidemiological evidence indicates that unhealthy lifestyles are closely linked to the increasing prevalence of MetS and other non-communicable diseases worldwide (WHO, 2018). Lifestyle modifications have shown positive results in preventing and managing cardiometabolic risk (Pattyn et al., 2013).

Physical activity is considered a keystone of a healthy lifestyle and the health benefits of moderate-intensity exercise are well established (Pedersen & Saltin, 2015). However, for some years now, there has been growing interest in high-intensity interval training (HIIT), particularly aerobic interval training (AIT), in real-healthcare settings (Pattyn et al., 2013). Current evidence has revealed the potential of AIT as a valuable strategy to reduce the prevalence of cardiometabolic risk factors (Tjønna et al., 2018).

The level of cardiorespiratory fitness (CRF) has also been identified as an independent and strong predictor of mortality (Lee et al., 2010; Myers et al., 2015). In a recent systematic review, Lee (2020) reports that regardless of obesity status, low CRF was associated with 3.59 times higher metabolic syndrome risk, while high CRF decreased it by 77%. According to Knaeps et al. (2018), a combination of decreasing sedentary behaviour (SB) and increasing moderate-to-vigorous physical activity (MVPA), resulting in positive change in CRF, is likely to be most beneficial for cardiac and metabolic health.

CRF is commonly assessed by means of peak oxygen uptake (VO_{2peak}) measured during cardiopulmonary exercise testing (CPET). An increase in VO_{2peak} of 3.5 mL/kg/min (1-MET: metabolic equivalent) results in an improvement in survival of between 10% and 25% in both genders (Myers et al., 2015). It has been reported that the reduction in mortality may be even higher (30% per 1-MET increase) in low-fit individuals (<5 MET of functional capacity) with cardiovascular disease that participate in cardiac rehabilitation programmes (Myers et al., 2015).

AIT has consistently shown better results than traditional continuous training (TCT) when it comes to improving VO_{2peak} (Pattyn et al., 2014; Wisløff et al., 2007). Given that low VO_{2peak} is associated with premature mortality and cardiovascular risk (Lee, 2020; Myers et al., 2015), the potential ability of AIT to improve this parameter is, from the health perspective, a promising finding.

Besides VO_{2peak}, CPET allows to assess several indices that are relatively independent of maximal effort, including the ventilatory efficiency index (ventilation vs. carbon dioxide output slope (VE-VCO_2 slope)) and the oxygen uptake efficiency slope (OUES) (Baba et al., 1996). These indices are integrated measurements of physiological adaptation to exercise. They have prognostic value, are sensitive to change and relevant to evaluate the progression of the exercise capacity in patients with cardiac disease or mitochondrial myopathy (Akkerman et al., 2010). To our knowledge, there are few studies that evaluate the effects of HIIT interventions on these indices in individuals with metabolic syndrome (Guio de Prada et al., 2019a).

As a final point, although the efficacy of AIT to induce physiological improvements in a well-controlled research environment is no longer in doubt, questions remain regarding the extent to which its benefits are transferable to a less-controlled clinical environment (effectiveness). The evidence regarding the effectiveness of interventions promoting physical activity is inconsistent, because frequently exercise programmes have large dropout rates after a few weeks or months. Moreover, most studies have focussed on the short-term efficacy, but have not reported the persistence of effects. However, to achieve long-lasting and successful outcomes, these programmes need to include actions to help individuals enhance their self-efficacy, improving literacy and providing self-control tools (WHO, 2018). In this regard, our study analyses the short and medium-term effects and includes a lifestyle counselling intervention that incorporates strategies for promoting regular physical activity, minimizing sedentary behaviour, improving dietary habits, and enhancing participants' self-efficacy.

The primary aim of this study was to evaluate the effectiveness of a semi-supervised aerobic interval training programme alongside lifestyle counselling (AIT) on cardiorespiratory fitness in terms of VO_{2peak}, oxygen uptake at the respiratory compensation point (VO_{2RCP}), VE-VCO_2 slope and OUES in sedentary adults with cardiometabolic risk factors. This intervention was compared to low-to-moderate-intensity continuous training plus lifestyle counselling (TCT) and to lifestyle counselling (COU) alone. It was hypothesized that AIT would exhibit better results in terms of improving CRF than TCT or COU.

Materials and Methods

Design

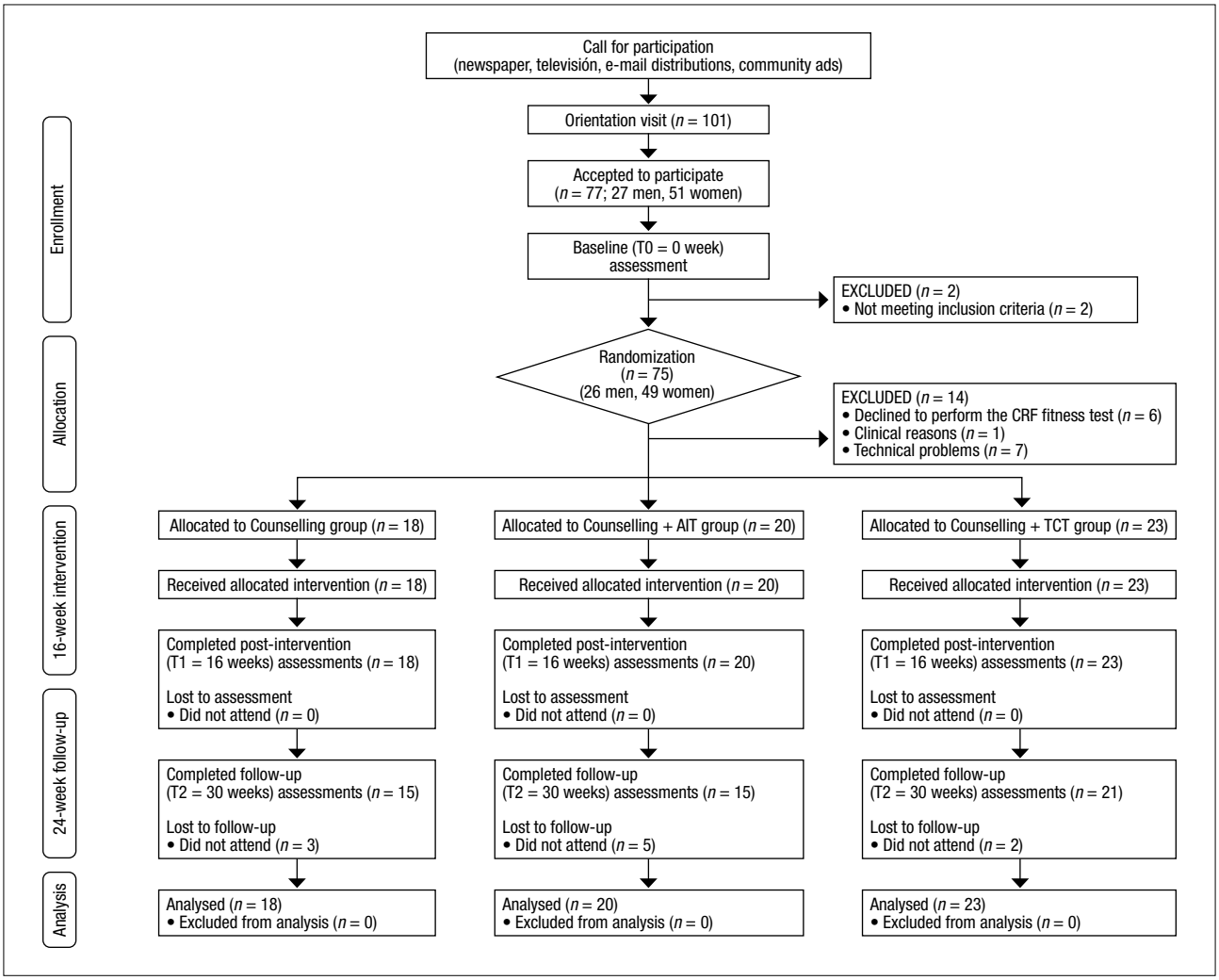
A three-arm randomized controlled clinical trial (NCT02832453) was implemented in a primary care setting over a period of 16 weeks, with a 24-week follow-up. It included two semi-supervised exercise groups with different levels of exercise intensity (AIT and TCT), and a non-exercise control group (COU) (Ensenyat et al., 2017, 2020).

Participants

Initially, the study comprised 75 (26 men, 49 women) sedentary volunteers, 34 to 55 years old. To be eligible, participants should be between 30 and 55 years old, spent most of their awaken time in sedentary behaviour (sitting, lying down) and have at least one cardiometabolic risk factor (waist circumference >94.5 cm for men, and >89.5 cm for women; blood pressure ≥130/ 85 mmHg; triglycerides in plasma ≥150 mg/dL; HDLc in plasma <40 mg/dL for men and <50 mg/dL for women; fasting glucose ≥100 mg/dL). Individuals with severe health problems (morbid obesity, significant cardiopulmonary diseases, neuromuscular or psychiatric disorders) or diseases that may contraindicate performing physical exercise were excluded (Ensenyat et al., 2017, 2020).

Participants were recruited from primary healthcare centres and advertisements in the media. All participants were fully informed of the experimental procedures and provided written informed consent prior to enrollment. Then they were randomly assigned to one of the study groups (AIT, TCT, or COU) (Figure 1).

Figure 1
Participant's flow chart.



Note: Participants included in the Bellugat trial [Ensenyat, 2020 3078 /id] but that did not successfully perform the cardiorespiratory fitness test are excluded from the participant's flow chart.
CRF: cardiorespiratory fitness test; AIT: aerobic interval training study group; COU: counselling study group. TCT: traditional continuous training study group.
T0: baseline assessment; T1: 16-week intervention assessment; T2: 24-week follow-up assessment

Study procedures were approved by the Clinical Research Ethics Committee of the Institute for Primary Health Care Research Jordi Gol (IDIAP) (registration number: P15/122) and conformed to the Declaration of Helsinki (Cook et al., 2003). The study methods were consistent with the CONSORT guidelines (Schulz et al., 2011).

Intervention

The trial comprised a 16-week intervention and a 24-week follow-up. During the intervention phase, all groups were offered lifestyle counselling, which consisted of six 50-minute group sessions and four individual sessions lasting 40-50 minutes each (Ensenyat et al., 2017). The two exercise groups (AIT and TCT) also joined a semi-supervised physical exercise programme. This programme consisted of 16 supervised group training sessions lasting 50 minutes each and 32 self-administered sessions. The frequency of supervised sessions decreased throughout the intervention, while the frequency of the pre-scheduled self-administered sessions increased. All the training sessions comprised five parts: introduction, warm-up, main part (see below), cool-down, and conclusion. The main part differed between the AIT and TCT groups. AIT sessions consisted of four 4-minute repetitions at 80% of VO_{2peak}, alternating with 2-minute active pauses at 60% of VO_{2peak} and lasted a total of 24 minutes of effective exercise time while TCT sessions consisted of 40 minutes of moderate-intensity (60% of VO_{2peak}) activities.

No discomfort or incidences were reported. Mean attendance of supervised exercise sessions, group and individual counselling sessions was 71.9% (SD = 20.2), 83.1% (SD = 17.1) and 98.8% (SD = 5.4) of the offered sessions, respectively. There were no differences between the study groups or genders.

Outcome measurements

Outcome measurements were recorded at baseline (T0 = week 0), after the intervention (T1 = week 16) and after the 24-week follow-up (T2 = week 40).

Cardiorespiratory graded exercise test

Participants completed a voluntary maximal graded exercise test on a cycle ergometer (Monark 828E, Monark, Sweden). After a two-minute warm-up stage at 10 W, the workload increased 20 W every two minutes until participants were unable to maintain the pre-established cadence (60 rpm) or if abnormal responses were observed (Balady et al., 2010).

During the test, ergoespirometric variables were measured using the Oxycon Mobile metabolic system (Oxycon Mobile, Carefusion, Germany). Gas calibrations were conducted before each test. Heart rate was measured using a Polar 610s chest heart rate monitor (Polar Electro YO, Kempele, Finland). Blood pressure was taken at 30s left within each stage using an automatic upper arm blood pressure monitor (Omron M, Omron Healthcare Europe B.V. Hoofddorp, the Netherlands). Before the end of the stage, participants reported their subjective perception of exercise using the Borg CR-10 scale (Borg & Kaijser, 2006). Chronotropy greater than 85% (Balady et al., 2010) and respiratory exchange ratio (RER) > 1.1 were used as criteria for having reached maximum exertion.

Data collection was undertaken in a well-ventilated laboratory room. Participants were instructed to fast and restrain from caffeine for 2 h prior the test and were asked to avoid any strenuous exercise the day before the test.

Maximal measures

Maximal (peak) ergoespirometric data for workload (W), oxygen uptake (VO_2), dioxide production (VCO_2), ventilation (VE), heart rate (HR), blood pressure (systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean blood pressure (MBP)) were reported.

Effort-independent measures

To assess submaximal exercise capacity, the respiratory compensation point (RCP) was obtained by means of a concomitant increase in both ventilatory equivalents (VE/VO_2 and VE/VCO_2) and a decrease in partial pressure of CO_2 ($P_{ET}CO_2$) after a plateau (Beaver et al., 1986). Two observers independently calculated this point, and later corroborated it.

Ventilatory efficiency slope was obtained by linear regression analysis of the relationship between ventilation (VE) and carbon dioxide output (VCO_2) with all exercise data (Arena et al., 2003). Oxygen uptake efficiency slope (OUES) was calculated with all exercise data according to Baba et al. (1996) by performing a linear regression analysis of the relationship between VO_2 and the logarithm of VE ($VO_2 = a\log_{10}VE + b$).

Cardiometabolic risk and lifestyle measures

A continuous metabolic syndrome severity score (MetSSS) was calculated, as described by Wiley and Carrington (2016). The score contains six risk factors: waist circumference (WC), triglyceride (TG) levels, high-density lipoprotein cholesterol (HDLc) levels, glycemia, systolic blood pressure (SBP) and diastolic blood pressure (DBP). WC was measured in triplicate following WHO guidelines (2011). Blood samples for determining plasma TG, HDLc and glucose levels were obtained after an overnight fast and analysed with automated methods at the university hospital. Blood pressure (BP) was measured at the level of the brachial artery of the dominant arm using an automated device (Omron M, Omron Healthcare Europe B.V. Hoofddorp, the Netherlands), with the participant in a relaxed sitting position.

Active and sedentary behaviour were assessed objectively using the ActiGraph GT3X+ accelerometer (ActiGraph LLC, Pensacola, FL, USA) over seven consecutive days. The data from the accelerometers were downloaded and analysed with the ActiLife 6.0 software (ActiGraph, Pensacola, FL, USA). Sleeping hours were excluded from the analysis. The data were analysed to yield an overall physical activity index (number of steps per day and as a vector magnitude (VM) in mean counts per minute (CPM)) and the percentage of time spent undertaking different levels of physical activity (Troiano et al., 2008).

A three-day 24-h dietary record (two weekdays and one weekend-day) was completed to monitor the dietary habits of each participant. The software PCN-CSNIS 1.0 was used to analyse the dietary records. The healthy eating index (HEI) was calculated to assess the participant's dietary status (Basiotis et al., 2002).

Statistical methods

To determine the sample size for this study a power analysis was conducted using G*Power 3.1. (Faul et al., 2007) and the results obtained by Tjonna et al. (2008) in a supervised physical exercise intervention aimed at people with metabolic syndrome. To detect the expected changes with a bilateral hypothesis, an expected effect size of d = 0.46, a risk α of .05, a power of 80%, and repeated measures on 3 occasions and 3 study groups; the estimated number of participants was 48; 16 individuals per study group. The current sample of 62 people was considered sufficient to evaluate the hypotheses raised in relation to the CRF.

Data were checked for normality; then Chi-square (χ^2) and Kruskal-Wallis (K-W) tests were used to compare the study arms at baseline (T0). Intention-to-treat analysis was performed for all the participants who completed the graded exercise test at baseline. Two-time frameworks were established: effectiveness (at the end of the intervention; T1) and persistence (at 24-week follow-up; T2). Wilcoxon and Kruskal-Wallis tests were used to analyse the differences between the study groups and changes over time. Continuous variables are expressed as the mean and standard deviation (SD). Categorical variables are expressed as counts (*n*) and percentages (%), unless otherwise specified.

Pearson (*r*) correlation was used to assess associations between the quantitative variables.

Significance was set at $p < .05$. For all analyses, SPSS 17.0 (SPSS, Chicago, IL, USA) was used.

Results

Participants

The baseline graded exercise test was completed successfully by 61 (23 men, 38 women) participants (aged 34 to 52 (M = 44.6, SD = 4.6) years) (Figure 1). There were no differences between the study groups regarding physical activity and dietary habits or any cardiometabolic risk factor at baseline.

Cardiometabolic risk and lifestyle outcomes

A significant time-effect was observed for MetSSS without group effect (Table 1). A significant small decrease in the MetSSS score was observed after the intervention. Changes persisted at follow-up, with 34.4% and 35.7% of the participants decreasing their MetSSS score by at least 0.5 points at T1 and T2. The effects were similar in all study groups.

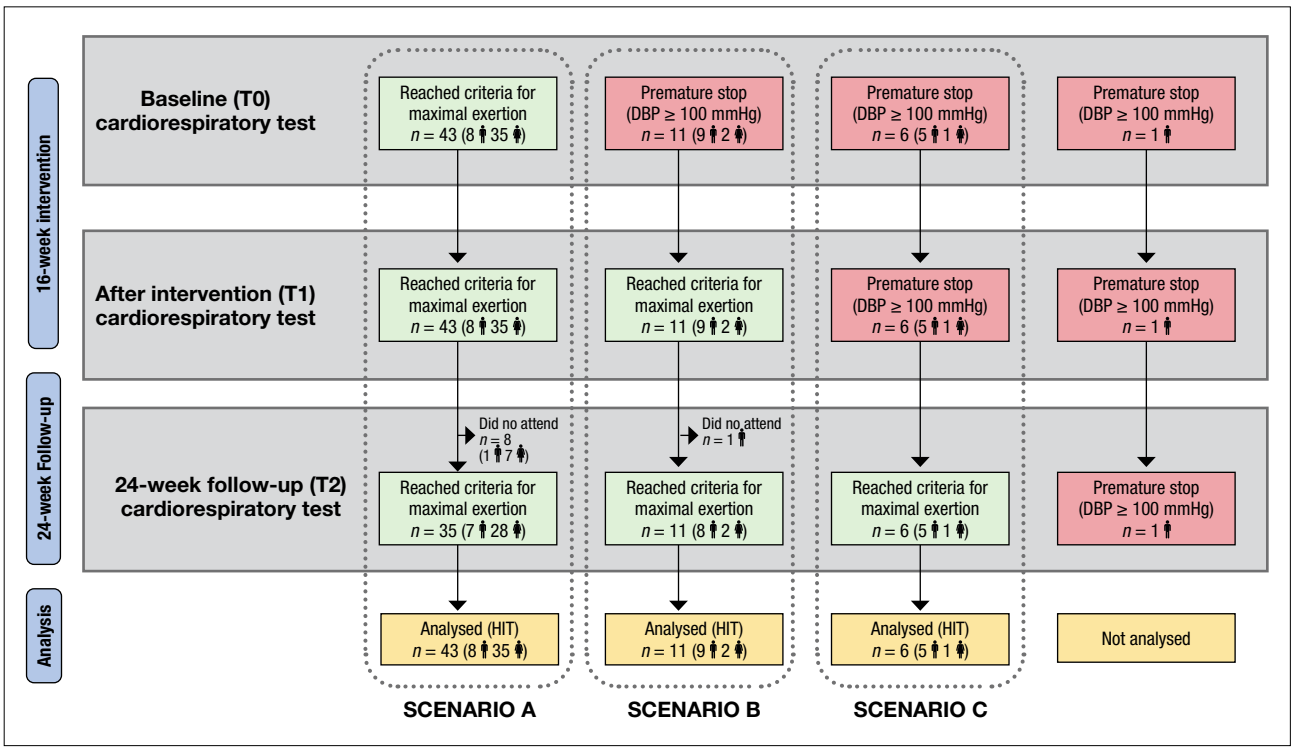
Participants wore the accelerometer for 6.98 (SD = 0.6) days and 820.9 (SD = 77) minutes per day. A significant time-effect was observed for steps/day, overall activity, sedentary time, MVPA and HEI without group-effect (Table 1).

Table 1
Metabolic syndrome risk score and lifestyle measures at baseline (T0), after the intervention (T1) and at 24-weeks follow-up period (T2) (n = 61).

		T0		T1		T2		T0 vs. T1		T0 vs. T2	
	N	M	SD	M	SD	M	SD	Time effect P_W	Group effect P_{KW}	Time effect P_W	Group effect P_{KW}
METABOLIC SYNDROME SEVERITY SCORE											
MetSSS (Wiley 2016)	61	1.5	1.5	0.9	1.1	0.9	1.1	.000	.874	.000	.325
PHYSICAL ACTIVITY/SEDENTARY BEHAVIOUR/DIETARY HABITS											
Steps/day (number)	61	8318.6	2350.5	9586.3	3633.3	9235.7	3086.6	.000	.488	.004	.938
VM (CPM)	61	649.8	144.8	697.2	195.6	694.6	170.1	.029	.155	.023	.985
Sedentary time (%[a])	61	62.5	6.1	61.0	7.7	61.1	6.3	.054	.109	.037	.755
LPA (%[a])	61	33.2	6.0	33.8	7.2	33.7	5.9	.264	.227	.399	.925
MVPA (%[a])	61	4.4	2.0	5.2	2.7	5.2	2.5	.001	.227	.003	.936
AFMV (min/día)	61	35.8	17.1	44.6	24.9	43.3	23.0	.000	.379	.003	.903
IAS (Bassiotis, 2002)	61	45.5	17.2	51.0	15.0	55.3	16.0	.030	.195	.003	.330

Note: AIT: aerobic interval training study group; COU: counselling study group; CPM: counts per minute; HEI: Healthy eating index (Bassiotis, 2002); LPA: light intensity physical activity; MetSSS: metabolic syndrome severity score; MVPA: moderate-to-vigorous intensity physical activity; TCT: traditional continuous training study group; VM: vector magnitude.
T0: baseline assessment; T1: after the 16-week intervention assessment; T2 at 24-week follow-up assessment.
[a] Percentage relative to awaken time.
Data shown as mean (M) and standard deviation (SD).
P_W, according to Wilcoxon test; P_{KW}, according to Kruskall-Wallis test.

Figure 2
Distribution of participants in scenarios according to reasons for ending the cardiorespiratory test in each assessment time-point (scenarios).



Note: **Scenario A** corresponds to participants who achieved maximal criteria for CRF test at T0, T1 and T2; **Scenario B** corresponds to participants who ended the CRF test due to high blood pressure response at T0 but achieved maximal criteria for CRF at T1 and T2; **Scenario C** corresponds to participants who ended the CRF test due to high blood pressure response at T0 and T1 but who achieved maximal criteria for CRF test at T2.
CRF: cardiorespiratory fitness; DBP: diastolic blood pressure; T0: baseline assessment; T1: after the 16-week intervention assessment; T2 at 24-week follow-up assessment.

Table 2
Cardiorespiratory fitness test data at baseline (T0), after the intervention (T1) and at 24-weeks follow-up period (T2).

			T0		T1		T2		T0 vs. T1		T0 vs. T2	
		N	M	SD	M	SD	M	SD	Time effect P_W	Group effect P_{KW}	Time effect P_W	Group effect P_{KW}
PEAK WORKLOAD												
W_{peak} (W)	All	61	118.39	36.58	138	40	138.9	42.0	.000	.757	.000	.739
	A	43	119.3	37.3	129.3	40.1	127.5	41.4	.000	.757	.002	.739
	B	11	120	38.7	164.5	35.9	170	29.7	.003	.772	.003	.727
	C	6	103.3	30.11	146.7	23.38	156.7	32.7	.066	.519	.057	.454
VO_{2peak} (mL/kg/min)	All	61	23.8	6.0	26.2	6.8	25.3	6.9	.001	.206	.101	.005
	A	43	24.5	5.9	25.4	7.0	23.9	6.8	.299	.206	.356	.005
	B	11	23.5	6.3	29.1	6.3	28.1	6.9	.003	.824	.021	.591
	C	6	19.5	6.1	25.1	4.5	28.0	3.2	.046	.888	.028	.213
VENTILATORY THRESHOLD WORKLOAD												
W_{VT} (W)		61	98.5	29.5	112.0	30.5	105.4	32.1	.001	.579	.172	.590
VO_{2VT} (mL/kg/min)		61	16.1	4.2	18.2	4.4	16.7	4.4	.000	.930	.528	.216
pVO_{2VT} (% VO_{2peak})		61	68.7	10.6	70.2	10.3	67.2	14.1	.423	.419	.132	.397
INDICES												
VE/VCO_2 slope (whole test)		61	28.7	3.8	28.3	3.7	29.6	4.0	.318	.079	.017	.872
OUES (whole test)		61	1.8	0.6	2.0	0.6	1.9	0.6	.000	.281	.191	.158

Note: OUES: oxygen uptake efficiency slope; pVO_2: percentage related to VO_{2peak}; T0: Baseline; T1: after 16-week intervention; T2: at 24-week follow up; VCO_2: carbon dioxide production; VE: ventilation; VO_2: oxygen uptake; VT: Ventilatory threshold; W: power output.
Data shown as mean (M) and standard deviation (SD).
P_W, according to Wilcoxon test; P_{KW}, according to Kruskall-Wallis test.

Cardiorespiratory graded exercise test

Sixty-one participants completed the baseline cardiorespiratory test assessment. Forty-three (70.5%) participants accomplished it satisfactorily and reached criteria for maximal exertion. As Figure 2 shows, these participants also reached maximal effort levels at T1 and T2 (Scenario A). The other 18 participants (29.5%) had to end the baseline test prematurely due to abnormal blood pressure response. (Scenario B and Scenario C). There were no differences between study groups regarding reasons to end the cardiorespiratory test (χ^2 = 1.431, p = .489).

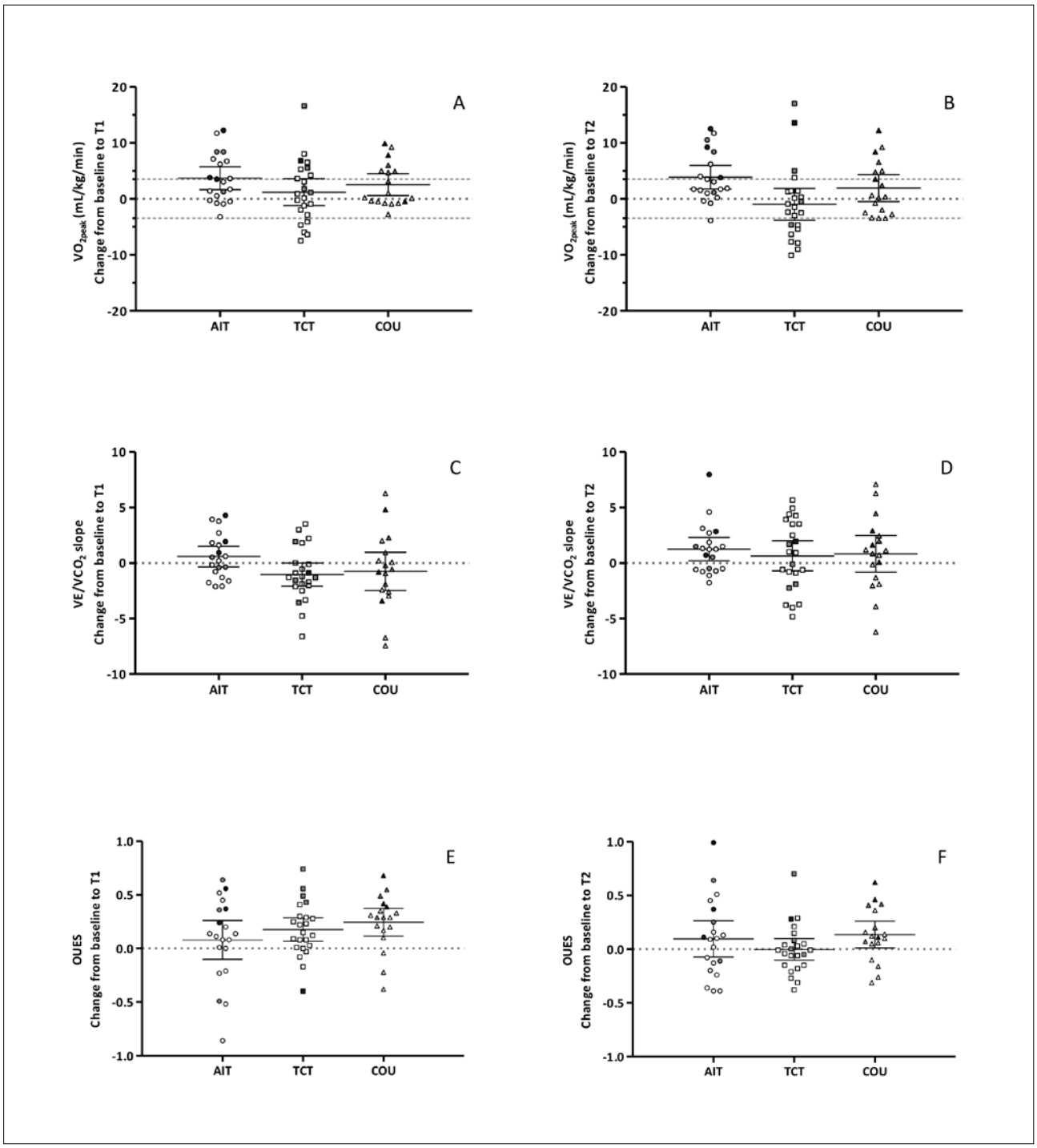
We feel that maximal data cannot be analysed with all participants/scenarios pooled together. For that reason, we have split the analysis of VO_{2peak} into three scenarios (Table 2). Effort-independent data have been analysed with all participants pooled together.

VO_{2peak}

Scenario A: At baseline (T0), there were no significant differences between study groups in relation to peak values. Peak respiratory exchange ratio (RER_{peak}) (M = 1.19, SD = 0.07), chronotropy (M = 85.5%, SD = 17.7) and Borg CR-10 values (M = 7.8, SD = 1.8) suggest a high level of effort during the test.

A significant time-effect was observed for peak workload (W_{peak}) without group effect (Table 3a). Despite this improvement, VO_{2peak} did not change after intervention or at follow-up. Mean VO_{2peak} increases tended to be better in the AIT group, but changes were lower than the clinical threshold of 3.5 mL/kg/min (Figure 3). However, the percentage of participants who improved their VO_{2peak} above this threshold was higher in the AIT group (36%) than in the other groups (TCT = 28%; COU = 18%). At follow-up, the improvement persisted in 28% of AIT participants, but only in 5% and 18% of participants for TCT and COU.

Figure 3
Individual changes from baseline to the end of the 16-week intervention (left panel) and from baseline to 24-week follow-up (right panel) for VO_{2peak}, VE/VCO_2 slope and OUES.



Note: T1: after the 16-week intervention assessment; T2 at 24-week follow-up assessment.
AIT: aerobic interval training study group; COU: counselling study group; TCT: traditional continuous training study group.
OUES: oxygen uptake efficiency slope; VCO_2: carbon dioxide production; VE: ventilation; VO_2: oxygen uptake;
VT: Ventilatory threshold; W: power output.
Each point indicates an individual participant
O Light symbols indicate Scenario A; Grey symbols indicate Scenario B, and ● Black grey symbols indicate Scenario C

Table 3a
Cardiorespiratory fitness test data at baseline (T0), after the intervention (T1) and at 24-weeks follow-up period (T2) for Scenario A (n = 43).

		T0		T1		T2		T0 vs. T1		T0 vs. T2	
	N	M	SD	M	SD	M	SD	Time effect P_W	Group effect P_{KW}	Time effect P_W	Group effect P_{KW}
PEAK WORKLOAD											
W_{peak} (W)	43	119.3	37.3	129.3	40.1	127.5	41.4	.000	.757	.002	.739
VO_{2peak} (mL/kg/min)	43	24.5	5.9	25.4	7.0	23.9	6.8	.299	.206	.356	.005
VE_{peak} (L/min)	43	66.1	15.8	69.2	18.9	67.7	17.7	.303	.036	.552	.016
$_{Peak}$HR (bpm)	43	160.1	16.1	158.0	13.6	160.8	15.3	.091	.906	.945	.318
$_{Peak}$HR pulse (mL/b)	43	11.5	4.3	11.9	4.8	11.0	4.2	.218	.069	.065	.003
SBP_{peak} (mmHg)	43	178.7	22.1	170.8	17.3	166.9	19.0	.004	.374	.000	.610
DBP_{peak} (mmHg)	43	87.8	7.0	83.6	7.1	82.6	7.4	.004	.059	.002	.056
MBP_{peak} (mmHg)	43	118.1	10.6	112.7	9.4	110.7	10.5	.001	.140	.000	.695
VENTILATORY THRESHOLD WORKLOAD											
W_{VT} (W)	43	99.8	30.4	104.9	28.3	99.3	28.4	.085	.794	.847	.975
VO_{2VT} (mL/kg/min)	43	16.6	4.1	17.7	4.1	16.2	4.3	.013	.820	.294	.329
pVO_{2VT} (% VO_{2peak})	43	68.6	9.5	70.5	8.8	68.9	14.6	.398	.188	.612	.325
INDICES											
VE/VCO_2 slope (whole test)	43	29.5	3.9	29.1	4.3	30.1	4.2	.223	.155	.159	.456
OUES (whole test)	43	1.7	0.7	1.8	0.6	1.7	0.7	.007	.419	.269	.901

Note: DBP: diastolic blood pressure; HR: heart rate; MBP: mean blood pressure; OUES: oxygen uptake efficiency slope; pVO_2: percentage related to VO_{2peak}; SBP: systolic blood pressure; T0: Baseline; T1: after 16-week intervention; T2: at 24-week follow up; VCO_2: carbon dioxide production; VE: ventilation; VO_2: oxygen uptake; VT: Ventilatory threshold; W: power output.
Data shown as mean (M) and standard deviation (SD).
P_W, according to Wilcoxon test; P_{KW}, according to Kruskall-Wallis test.

Scenario B: As Figure 2 shows, eleven participants had to end the baseline test prematurely (RER_{peak} (M = 1.02, SD = 0.11), chronotropy (M = 60.8%, SD = 21.4), Borg CR-10 values (M = 5.3, SD = 2.0)). No statistically significant differences between the study groups were observed. At the end of the intervention these participants improved their adaptation to effort and reached maximal exertion as well as at follow-up. A moderate positive time-effect was observed for VO_{2peak} without study group effects (Table 3b). Seven participants (63.6%) improved their VO_{2peak} by at least 3.5 mL/kg/min at the end of the intervention and this remained elevated in six of them at follow-up.

Scenario C: Six participants had to end the cardiorespiratory exercise test prematurely at baseline and at the end of the intervention but were able to reach maximal criteria at follow-up (RERpeak (M = 1.2, SD = 0.09), chronotropy (M = 94.6%, SD = 12.1), Borg CR-10 values (M = 7.3, SD = 1.7)).

Although at the end of the intervention (T1) these participants had to end the cardiorespiratory test prematurely, VO_{2peak} showed a large significant increase. At follow-up, VO_{2peak} improved further, with all 6 participants increasing VO_{2peak} by more than 3.5 mL/kg/min (Table 3c).

Table 3b
Cardiorespiratory fitness test data at baseline (T0), after the intervention (T1) and at 24-weeks follow-up period (T2) for Scenario B (n = 11).

		T0		T1		T2		T0 vs. T1		T0 vs. T2	
	N	M	SD	M	SD	M	SD	Time effect P_W	Group effect P_{KW}	Time effect P_W	Group effect P_{KW}
PEAK WORKLOAD											
W_{peak} (W)	11	120	38.7	164.5	35.9	170	29.7	.003	.772	.003	.727
VO_{2peak} (mL/kg/min)	11	23.5	6.3	29.1	6.3	28.1	6.9	.003	.824	.021	.591
VE_{peak} (L/min)	11	63.2	20.0	84.7	20.5	87.4	24.2	.006	.839	.008	.232
$_{Peak}$HR (bpm)	11	139.4	17.4	154.5	12.2	160.2	11.9	.033	.876	.004	.414
$_{Peak}$HR pulse (mL/b)	11	15.3	3.2	16.7	2.4	15.7	3.2	.110	.564	.722	.515
SBP_{peak} (mmHg)	11	202.6	21.8	192.5	11.0	195.3	11.9	.168	.190	.247	.048
DBP_{peak} (mmHg)	11	97.7	8.9	92.7	4.1	92.5	5.9	.060	.311	.099	.155
MBP_{peak} (mmHg)	11	132.7	8.6	126.0	4.2	126.8	7.0	.022	.750	.093	.181
VENTILATORY THRESHOLD WORKLOAD											
W_{VT} (W)	11	97.3	31.3	140.9	30.2	133.6	32.0	.005	.411	.011	.741
VO_{2VT} (mL/kg/min)	11	15.1	4.5	20.7	5.3	18.4	4.4	.004	.417	.083	.931
pVO_{2VT} (% VO_{2peak})	11	66.0	14.4	71.7	12.0	66.6	11.6	.424	.273	.790	.824
INDICES											
VE/VCO_2 slope (whole test)	11	26.9	3.4	26.6	3.5	27.7	3.8	.594	.317	.230	.068
OUES (whole test)	11	2.2	0.4	2.6	0.4	2.4	0.4	.021	.364	.026	.815

Note: DBP: diastolic blood pressure; HR: heart rate; MBP: mean blood pressure; OUES: oxygen uptake efficiency slope; pVO_2: percentage related to VO_{2peak}; SBP: systolic blood pressure; T0: Baseline; T1: after 16-week intervention; T2: at 24-week follow up; VCO_2: carbon dioxide production; VE: ventilation; VO_2: oxygen uptake; VT: Ventilatory threshold; W: power output.
Data shown as mean (M) and standard deviation (SD).
P_W, according to Wilcoxon test; P_{KW}, according to Kruskall-Wallis test.

Table 3c
Cardiorespiratory fitness test data at baseline (T0), after the intervention (T1) and at 24-weeks follow-up period (T2) for Scenario C (n = 6).

		T0		T1		T2		T0 vs. T1		T0 vs. T2	
	N	M	SD	M	SD	M	SD	Time effect P_W	Group effect P_{KW}	Time effect P_W	Group effect P_{KW}
PEAK WORKLOAD											
W_{peak} (W)	6	103.3	30.11	146.7	23.38	156.7	32.7	.066	.519	.057	.454
VO_{2peak} (mL/kg/min)	6	19.5	6.1	25.1	4.5	28.0	3.2	.046	.888	.028	.213
VE_{peak} (L/min)	6	56.5	13.2	74.3	14.8	93.3	15.8	.075	.888	.028	.667
$_{Peak}$HR (bpm)	6	139.5	33.22	158.5	22.42	170.2	17.20	.116	.651	.046	.807
$_{Peak}$HR pulse (mL/b)	6	12.4	2.5	13.5	2.1	14.1	2.0	.116	.888	.046	.213
SBP_{peak} (mmHg)	6	190.3	13.88	198.0	18.89	185.0	16.91	.078	.643	.500	.304
DBP_{peak} (mmHg)	6	97.8	6.34	95.0	8.17	89.7	8.89	.496	.304	.042	.294
MBP_{peak} (mmHg)	6	128.7	7.50	129.3	10.67	121.4	11.37	.917	.304	.093	.304
VENTILATORY THRESHOLD WORKLOAD											
W_{VT} (W)	6	93.3	26.6	113.3	15.1	96.7	37.2	.276	.609	.916	.635
VO_{2VT} (mL/kg/min)	6	13.9	3.9	17.7	4.6	16.1	4.6	.046	.304	.344	.529
pVO_{2VT} (% VO_{2peak})	6	72.5	11.9	70.3	13.1	57.4	14.2	.753	.304	.028	.213
INDICES											
VE/VCO_2 slope (whole test)	6	27.6	2.3	27.9	2.8	30.1	2.7	.600	.145	.028	.377
OUES (whole test)	6	1.9	0.3	2.2	0.3	2.3	0.4	.173	.304	.028	.953

Note: DBP: diastolic blood pressure; HR: heart rate; MBP: mean blood pressure; OUES: oxygen uptake efficiency slope; pVO_2: percentage related to VO_{2peak}; SBP: systolic blood pressure; T0: Baseline; T1: after 16-week intervention; T2: at 24-week follow up; VCO_2: carbon dioxide production; VE: ventilation; VO_2: oxygen uptake; VT: Ventilatory threshold; W: power output. Data shown as mean (M) and standard deviation (SD).
P_W, according to Wilcoxon test; P_{KW}, according to Kruskall-Wallis test.

Effort independent data

Small but significant improvements were observed in the W_{RCP}, VO_{2RCP} and OUES at the end of the intervention without group effect. These increases did not persist at follow-up. However, considering only scenario B and C; W_{RCP}, VO_{2RCP} and OUES show large and persistent increases. No differences between study groups were appreciated. No time-effect was observed for VE-VCO_2 slope.

Discussion and Conclusion

The present study evaluates the effectiveness of a 16-week intervention of semi-supervised interval training exercise programme alongside lifestyle counselling (AIT) on CRF in terms of VO_{2peak}, VO_{2RCP}, VE-VCO_2 slope and OUES, in sedentary adults with cardiometabolic risk factors. The intervention was implemented in a real-world setting and compared to low-to-moderate-intensity continuous training plus lifestyle counselling (TCT) and to lifestyle counselling alone (COU).

AIT was well accepted by the participants with rather high levels of adherence to the exercise sessions. All study groups exhibited comparable modest decreases in MetSSS and positive lifestyle changes that persisted in the medium term.

All intervention programmes induced significant changes in CRF variables. Although the effects of the AIT intervention on CRF and physiological adaptation to exertion did not differ substantially from TCT or COU, the number of participants increasing their VO_{2peak} was

slightly higher. Changes in VO_{2peak} differed according to whether or not the physiological adaptation to maximal graded exercise testing was satisfactory at baseline. Intervention was more effective for individuals with a poorer physiological adaptation to the graded exercise. All intervention programmes induced comparable significant non-persistent increases in VO_{2VT}, no changes in VE-VCO_2 slope and persistent improvements in OUES.

Several recent studies have shown that HIIT is effective in producing modest-to-moderate improvements in VO_{2peak}/VO_{2max} after 16-week (48 sessions) to 4-week (12 sessions) periods (Blackwell et al., 2017). Two previous meta-analyses reported greater effects of HIT compared to moderate-continuous training (Milanović et al., 2015; Pattyn et al., 2014).

These studies were mainly supervised and reported only the data from individuals who reached symptom-limited exercise at the CRF test. They reported increases in VO_{2peak} ranging from 9-to-27% (Blackwell et al., 2017; Guio de Prada et al., 2019b). These values are greater than ours. However, the present study differs from the others in its semi-supervised nature and in the descending weekly frequency of supervised sessions. Moreover, as most studies include only individuals who completed at least 85% of the training sessions, it cannot be discarded that high values were due to the exclusion of non-responders from the analysis. Our data are consistent with Blackwell et al. (2017) who observed a lower improvement in VO_{2peak} in the group that trained at home (≈ 10%) than in the group that received supervised exercise training (≈ 20%).

Although exercise intensity appears to be a critical factor for improving CRF, the baseline CRF level determines the individual exercise intensity needed to generate clinically significant increases. Low-fit individuals (CRF < 10 metabolic equivalent (METs)) will need a training intensity of 50% heart rate reserve (HRR) or VO_2 reserve (VO_{2R}), while a high-fit individual (CRF > 14 METs) will need a higher intensity (> 85% HRR or VO_{2R}) (Ross et al., 2016). This could explain why participants who at baseline reached criteria for maximal effort did not improve their VO_{2peak}. In these participants, the overall training load may have been too low to induce large changes in VO_{2peak} in any study group. Nonetheless, the fact that the number of participants in AIT who improved their VO_{2peak} was higher than in TCT and COU seems to support the hypothesis that even a semi-supervised AIT may be more effective than TCT and COU.

In contrast, for participants who presented a maladaptation to graded exertion at baseline, it is possible that the training load or even the lifestyle change were enough to induce a better response to exertion. Thus, in that case, large improvements in VO_{2peak} were recorded in all study groups. This is consistent with findings in Milanović's meta-analysis (Milanović et al., 2015) that revealed a likely moderate greater beneficial improvement in VO_{2max} for participants with lower baseline CRF (for both HIT and endurance training).

Low cardiorespiratory fitness (VO_{2peak}) is an independent and strong predictor of premature mortality (Lee et al., 2010) that has been associated with a greater risk of metabolic syndrome (Lee, 2020) thus, even small improvements of CRF can have positive effects on health.

Most daily life activities do not require maximal effort; thus, it has been proposed that indicators of submaximal exercise capacity may be of interest from a health point of view (Balady et al., 2010). Ventilatory thresholds (VT and RCP) are widely used indices of submaximal exercise capacity. In the field of exercise-and-health, several studies report increases in the workload and the VO_2 achieved at the first ventilatory threshold (VT) in sedentary individuals (Blackwell et al., 2017) or in patients with metabolic syndrome (Guio de Prada et al., 2019a) or with CHF (Kemps et al., 2010). To our knowledge, few studies have analysed the effects of training on the second ventilatory threshold (RCP). Guio de Prada et al. (2019b) reported an increase in VT and in RCP after HIIT in 76 sedentary individuals with obesity. Our results confirm that RCP is also sensitive to the effects of semi-supervised training but changes are not persistent.

VE-VCO_2 slope reflects the ventilation for a given VCO_2 production (Akkerman et al., 2010) and has been considered as an indicator of CRF and a predictor of mortality in patients with chronic heart failure (CHF). In the current study, none of the three intervention programmes had an impact on VE-VCO_2 slope. Our data agree with other studies that have observed no changes in VE-VCO_2 slope after exercise training in patients with cardiovascular diseases (Kemps et al., 2010; Nilsson et al., 2019; Pattyn et al., 2014) but contrast with others that reported decreases of VE-VCO_2 slope in individuals with high values (>35) at baseline (Van Laethem et al., 2007). Thus, the possible training-induced changes might be more limited in participants with slope values within the normal range of 20–30. Still, Anaya (Anaya et al., 2009) has reported a significant dose-dependent trend for changes of VE-VCO_2 slope in post-menopausal women.

In the current study, the lack of changes in VE-VCO_2 slope could be attributed to a training load too low to induce

changes in the VE-VCO_2 slope or alternatively, it could be because the VE-VCO_2 slope is not sensitive enough to the effects of exercise training in sedentary individuals with slope values lower that 30.

OUES is considered an integrated measurement that reflects the coordination of pulmonary and cardiovascular systems and the extraction of O_2 during exercise (Balady et al., 2010). Our data show that all intervention programmes induced comparable significant improvement in OUES. It seems that OUES may be more sensitive to change than VE-VCO_2 slope. Data are consistent with other studies that have reported similar improvements in OUES after exercise training interventions in patients with cardiometabolic diseases (Kemps et al., 2010; Nilsson et al., 2019). However, in another study (Mourot et al., 2004), where participants were healthy, physically active young women, 18 sessions of intermittent endurance training had no effects on OUES or on VE-VCO_2 slope, despite significant increases in VO_{2peak} and VO2VT.

The semi-supervised nature of the exercise training could be considered a limitation. In this study, the participants were closely supervised by a physical activity professional at the beginning of the programme but should became more self-governing with time. This may explain the lack of greater effects of the exercise training programmes on cardiorespiratory fitness (VO_{2peak}, VO_{2RCP}, VE-VCO_2 slope, OUES) compared with the COU group or other studies. We are aware that we did not adequately track the participants during the self-administered sessions. Non-compliance with the expected training load could result in lower training stimuli and hence with lower adaptations. For future research, we recommend increasing the number of supervised training sessions and strengthening the monitoring of self-administered sessions with strategies, such as e-based communication platforms.

A major strength of this study was that the 16-week intervention combined the semi-supervised exercise training programme with lifestyle counselling to promote behavioural change. This study is unique as, unlike other AIT studies, it not only considers physical exercise, but also links it to strategies that promote behavioural change and empowerment, and assesses the medium-term persistence of the effects. Most AIT interventions have been performed in a highly controlled experimental setting for a limited time period and report only immediate effects of the interventions. In the current study diverse beneficial changes (CRF and lifestyle), in particular in less fit individuals (VO_{2peak}, OUES), persisted at 24-week follow-up.

In conclusion the study demonstrates that a 16-week intervention of semi-supervised AIT alongside lifestyle counselling could be (1) a feasible strategy to be translated into the real-word exercise programme aimed at sedentary individuals with cardiometabolic risk factors; and was (2) equally effective to TCT or COU programmes in increasing VO_{2peak} in low-fit individuals, although the number of responders was higher in AIT than in TCT or COU study groups; and (3) as effective as TCT or COU in improving effort-independent variables such as VO_{2RCP}, and OUES. However, (4) none of the three intervention programmes had an impact on VE-VCO_2 slope.

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Glossary

AIT- Aerobic Interval Training

CPM- Counts per minute

CPET- Cardiopulmonary Exercise Testing

CRF- Cardiorespiratory Fitness

DBP- Diastolic blood pressure

HEI- Healthy eating index

HIIT- High Intensity Interval Training

HR- Heart rate

MBP- Mean blood pressure

MET- Metabolic Equivalent

MetS- Metabolic Syndrome

MetSSS- Metabolic syndrome severity score

MVPA- Moderate to Vigorous Physical Activity

OUES- Oxygen Uptake Efficiency Slope

$P_{ET}CO_2$- Partial pressure of CO_2

RCP- Respiratory compensation point

RER- Respiratory Exchange Ratio

SB- Sedentary Behaviour

SBP- Systolic blood pressure

TCT- Traditional Continuous Training

VCO_2- Carbon dioxide output

VCO_2- Dioxide production

VE- Ventilation

VE/VCO_2- Ventilatory equivalent of CO_2

VE/VO_2- Ventilatory equivalent of oxygen uptake

$VE\text{-}VCO_{2\ slope}$- Ventilatory Efficiency Index

VM- Vector magnitude

VO_2- Oxygen uptake

VO_{2peak}- Peak Oxygen Uptake

VO_{2RCP}- Oxygen Uptake at the Respiratory Compensation Point

W- Workload

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Dual Careers in Women's Sports: A Scoping Review

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Abstract

Previous reviews on dual careers (DC) provide findings on athletes in general, without reference to gender and perpetuating the under-representation of women. Therefore, this scoping review focuses only on sportswomen in order to get an overview of the current landscape of DC studies in women's sport. The methodology is based on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis statement and recommendations for scoping reviews. The bibliographic search was carried out in the databases: Web of Science, PsycINFO, Scopus, Pro-Quest and SPORTDiscus. Studies on DC with female participants and publications in scientific journals from 2012 onwards were included, and 19 articles were obtained for the analysis and synthesis of current research on women's sport and DC. The results reveal a progressive increase in publications on sportswomen and DC, a predominance of combining sport and studies, and a gap in studies on work-life balance and critical transitions in women's sport. This review makes visible and highlights the research carried out on DC and sportswomen, as well as the effect of androcentrism, gender roles and the lack of points of reference in the sporting context. Although it is evident that DC is inherent to women's sport, it has traditionally been studied and conceptualised based on male models. Therefore, research on this topic should be carried out in a holistic way, using models adapted to the realities of women's sport and consciously including the different modes of being a woman.

Keywords: feminism, mixed studies review, sport and studies, sport and work, sportswomen.

Introduction

The field of sports social sciences has studied the incorporation, evolution and status of women within this sector for years, as well as the use and perception of the spaces they occupy (Vilanova & Soler, 2008). Research evidence in this area demonstrates how, as they have gained access to the world of sport, far from reproducing masculine behaviours, they have modelled a sporting culture of their own (Martin et al., 2017). This is possibly due to the fact that women project the values acquired through their socialisation (Puig & Soler, 2004). Thus, the progressive increase in women's sport has been accompanied by "new ways of doing, understanding and relating to sport" (Martin et al., 2017, p. 101).

In the current context, despite this rise in women's sport, there is a structural inequality of opportunities that limits women's social agency in the development of a professional sports career (Ronkainen et al., 2020). This means that few women have the privilege of building a career exclusively centred on sport and that, therefore, dual career discourses that promote the compatibility of sport with a parallel work or academic commitment are particularly relevant for young women (Ronkainen et al., 2020).

Dual career (DC) is "a career focused on both sport and study or work" (Stambulova & Wylleman, 2015, p. 1). Depending on the degree of prioritisation, four possible sporting trajectories are described: (a) linear, where the person focuses almost exclusively on their sporting career; (b) convergent, where sport is still prioritised, but is partially compatible with studies or a job; (c) parallel, where sport and studies or work are equally prioritised; and (d) divergent, which occurs when sport and studies or work demand so much from the athlete to the point of being forced to abandon one or the other (Torregrossa et al., 2020). Different works on disengagement and other transitions (e.g. Perez-Rivases et al., 2017a; Torregrossa et al., 2015) indicate that linear and divergent trajectories have negative consequences for the person who pursues them (e.g. dropping out). Moreover, evidence suggests that those individuals - in some cases referred to as "strategists" (Vilanova & Puig, 2016) - who pursue convergent and parallel trajectories are often associated with certain positive benefits: good levels of resilience and mental health (e.g., increased wellbeing, improved life balance; Tekavc et al., 2015; Torregrossa et al., 2015) and DC competences (e.g. emotional awareness, career planning, DC management and social intelligence and adaptability), leading to healthier and more balanced personal development (De Brandt et al., 2018). Moreover, in the long term, they get better jobs and are happier with their lives beyond sport (López de Subijana et al., 2015).

In order to better develop DC, career assistance programmes (CAPs) have been developed around the world with the aim of providing assistance to athletes with career-related aspects of their lives, both in and out of sport, and some even after retirement (Henry, 2013; López de Subijana et al., 2015; Torregrossa et al., 2020). These are based on the holistic sport career model (Wylleman, 2019), which considers the athlete holistically and addresses the development of the individual in different interacting domains (i.e., sport, psychological, psychosocial, academic/vocational, financial and legal; Wylleman, 2019), and provides accompaniment during the transitions that the athlete will experience throughout his/her sporting life.

Research on DC is now a core topic in sport science (Torregrossa et al., 2020), having increased significantly in recent decades (e.g., Stambulova & Wylleman, 2019). This has led to different models of career development that are generally valid and effective in determining transitions that occur in different domains throughout a sporting career. In both European and Spanish contexts, most studies focus on athletes in general, without taking into account the peculiarities of specific contexts and realities (e.g., López de Subijana et al., 2015), although the sport career experience involves both athlete-specific (e.g., gender, age, type of sport) and environmental (i.e., culture and sport context; Stambulova & Alfermann, 2009) characteristics. Some researchers suggest that personal characteristics, including gender, may influence an athlete's perception and experience of transitions and decision-making (Samuel & Tenenbaum, 2011; Tekavc, 2017). In fact, it has been found that while men and women perceive some challenges and demands in a similar way, there are others, such as the transition to university (Perez-Rivases, et al. 2017a), which are perceived markedly differently (Tekavc, 2017).

Systematic reviews synthesise all available research in a transparent, rigorous and reproducible way, providing a clear and up-to-date understanding of what is already known, what is unknown, and what next steps research should take (Tod et al., 2021). While there are systematic reviews on DC (e.g. Guidotti et al., 2015; Stambulova & Wylleman, 2019), they deal with athletes in general and there are none specific to sportswomen. In the systematic review by Guidotti et al. (2015), no special mention is made of gender, nor is there any mention of sportswomen; in contrast, there is a reference to the state of the art by Stambulova and Wylleman (2019), in which two comparative sentences can be found in the results section with respect to men. Furthermore, in the critical reflections section, major research gaps and future challenges encourage "research and further investigation of individual career pathways, including minority athletes

(e.g. women) and transnational athletes" (Stambulova & Wylleman, 2019, p. 85). Both cases exemplify that women are often significantly underrepresented in science in general and specifically in sport psychology (Gledhill et al., 2017), and are considered a minority. Although social change is underway in the European and North American context, sport remains one of the most accentuated pillars of androcentric domination (Rovira-Font & Vilanova-Soler, 2022). The androcentric view that predominates in science means that, according to Kavoura et al. (2012), male athletes are the norm, while female athletes are studied later, on the basis of similarities or differences in relation to them (Cooky, 2016). Along these lines, and according to Ronkainen et al. (2016) and Andersson and Barker-Ruchti (2018), research on DC and women is still limited and needs to be strengthened by further investigation in this field. For this reason, this study aims to conduct a scoping review of the literature on the DC of sportswomen. While previous reviews focus on literature on athlete DC in general, this one focuses on sportswomen and studies that place them at the centre of knowledge construction.

This scoping review aims to provide an overview of the current landscape of research done on women's DC in sport. After identifying studies on DC and sportswomen and synthetically summarising the characteristics and results, the following question was asked: how has research evolved and what is there in the existing literature on dual careers in sportswomen? It thereby contributes to research by providing the first integrated synthesis of studies on the DC of sportswomen.

Method

The methodology selected was the scoping review which allows for the identification and categorisation of what is known and unknown about a topic, and identifies gaps in the literature, as a starting point for the development of new work and lines of research (Grant & Booth, 2009).

For the development of this review the authors relied on the Preferred Reporting Items for Systematic Reviews and Meta-Analysis (PRISMA; Page et al., 2021) statement and specifically on the PRISMA-ScR extension by Tricco et al. (2018) following the specific criteria for developing this type of review.

Eligibility criteria and search strategy

In order to carry out the review, the following inclusion criteria were taken into account: (a) the studies had to be studies on DC (i.e., sportswomen-students or sportswomen-workers), (b) the participants had to be exclusively sportswomen, (c) the studies had to have been published in scientific journals from 2012 (i.e., the year in which the European Commission established the working guidelines on DC), and (d) they had to have an abstract in English. Finally, as exclusion criteria (a) studies with a mixed or male sample and (b) studies related to the COVID-19 pandemic were not considered.

For the identification of potentially relevant documents, articles published between 2012 and 6 June 2022 were retrieved from the following bibliographic databases: Web of Science (Core collection), PsycINFO, Scopus, Pro-Quest and SPORTDiscus. The search strategy, organisation and combination of terms were determined using the CHIP tool (i.e., Context, How, Issues, Population; Shaw, 2010), grouping keywords and terms related to DC and (female) athletes, designed in English, in order to identify abstracts of studies conducted in any language (see Table 1). The relationship between search terms, databases and articles found is shown in Table A in the annexes. The electronic database search was supplemented by hand searching for documents in reference lists and key journals in the field (Williams & Shaw, 2016).

Table 1
Key words organised with the CHIP tool.

CONTEXT	Research in Psychology/Sociology of Women's Sport and Dual Career.
HOW	**Method:** "qualitative" OR "quantitative" OR "mixed" OR "interviews" OR "focus groups" OR "questionnaires" OR "surveys" **AND**
ISSUES	**Dual Career:** "Dual Career*" OR "Dual-career*" OR "Dual Career athlete*" OR "Dual Career experiences" OR "Dual Career Balance" OR "Dual Career* competenc*" OR "Dual Career Develop*" OR "Dual Career Transition*" OR "Transition" OR "Dual Career Support" OR "Dual Career Assistance" OR "Career Development Gender Inequity"**AND** **Education:** "Student-athlete*" OR "College-athlete*" OR "pupil-athlete" OR "Elite Sport and Education" OR "Sport and Education" OR "Sport and university" OR "Sport and school" OR "Sport and Studies" OR "university students" **OR** **Work:** "Employee-athlete*" OR "Sport and Work" OR "Elite sport and Employment" OR "Sport and Labor market" OR "Academic and vocational levels" **AND**
POPULATION	**Woman:** "Wom* student-athlete" OR "wom* athlete" OR "elite sport wom*" OR "Female" OR "women" OR "female soccer players" OR "Sportswomen" OR "women's dual-careers" OR "female athletes" **NOT**
NOT	"men" OR "mal*" OR "man" **OR** "covid" OR "COVID-19" OR "pandemic" OR "coronavirus" OR "lockdown"

Identification and selection of relevant studies

To ensure that the search method was systematic, robust and valid, the three steps proposed by PRISMA were followed: identification, selection and inclusion (Figure 1; Page et al., 2021). Once the potentially relevant studies were identified (i.e., studies derived from the search and pending evaluation), the references and abstracts of each of these were downloaded and stored and organised using the bibliographic management tool Mendeley. After excluding duplicates, the study evaluation was conducted in two phases: first, studies were screened by titles and abstracts, and then full texts were analysed by assessing eligibility and rejecting articles that did not meet the inclusion criteria. This process of identification, screening and selection of articles was carried out by the first author of the article, under the supervision of the other authors. To ensure transparency in this process, it is important to record the decisions that have been made using the PRISMA flowchart (see Figure 1; Page et al., 2021).

Figure 1
Systematic search, inclusion and exclusion of articles (Page et al., 2021)

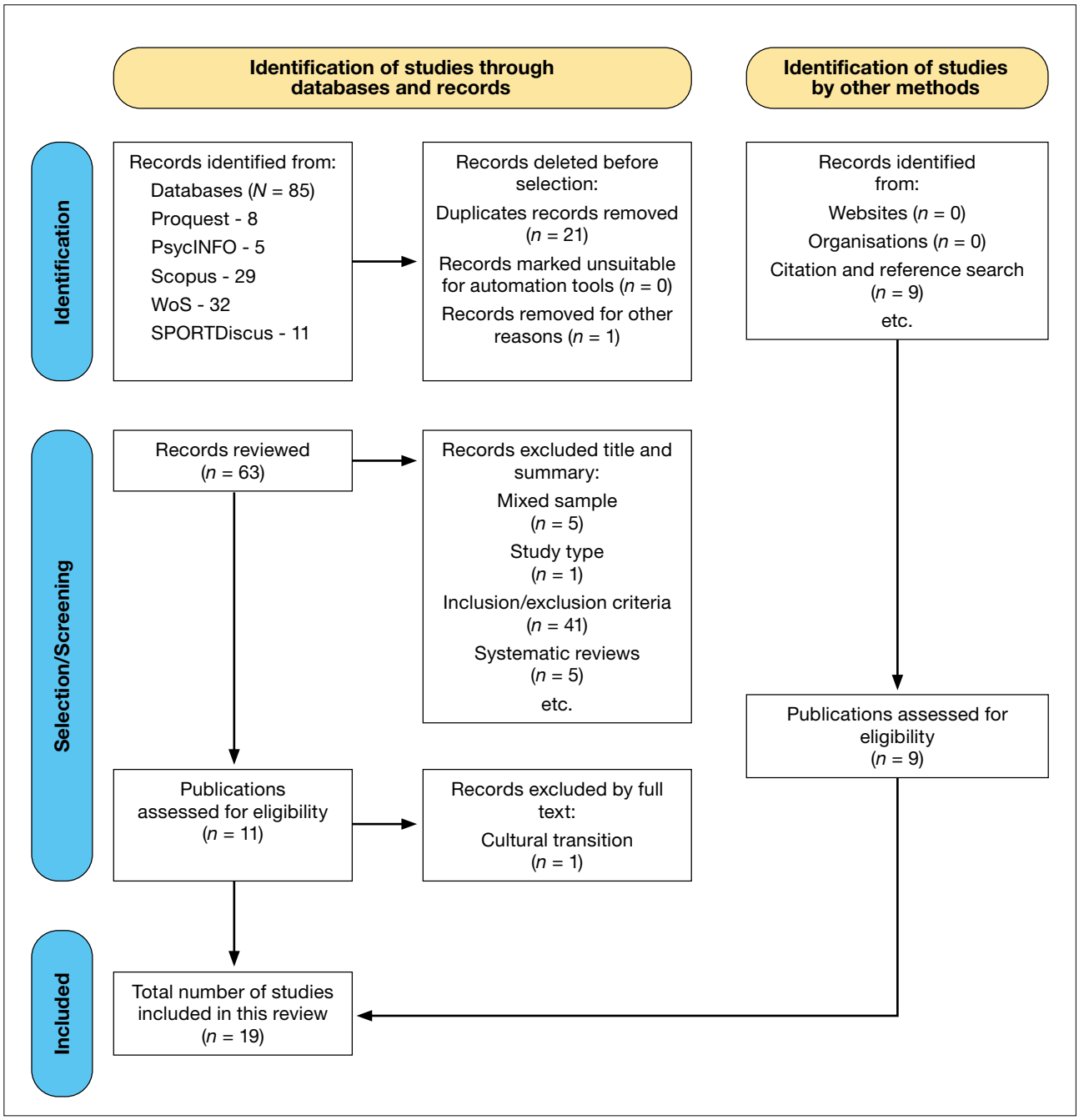


Table 2
*Results and characteristics of the identified articles on dual careers and women in sport (*N=*19).*

Bibliographic Code and Reference	Participants	DC (studies/ work)	Context	Type of study	Method of data collection	Theme
1. Bergström et al. (2022)	1 retired skier Age: NA	Studies	Norway	Mixed	- Semi-structured interview - Training diaries - Rankings - Syllabus data	- DC management - Sporting and non-sporting transitions - Barriers and Resources - Parallel trajectory
2. Frederickson (2022)	13 athletes; Football, basketball, lacrosse, volleyball, softball, hockey, gymnastics and athletics Ages: 22-34	Studies	United States	Qualitative	- Semi-structured interview	- DC Management and DC Perception - Transition to university - Barriers and Resources - Parallel trajectory
3. McGreary et al. (2021)	6 football players Age: 18-26	Studies	United Kingdom	Qualitative	- Semi-structured interview	- DC Management and DC Perception - Transition from junior to senior - Transition to university - Barriers - Coping strategies - Convergent trajectory
4. Pankow et al. (2021)	6 athletes; Cross-country, rugby and athletics Ages: 18-22	Studies	Canada	Qualitative longitudinal	- Semi-structured interview - Diaries	- Mental Health - DC management - Convergent trajectory
5. Harrison et al. (2020)	11 football players Age: 16-22	Studies and Work	United Kingdom	Qualitative	- Semi-structured interview	- Future planning - Transition to university - DC Perception - CAPs - Barriers - Parallel and divergent trajectory
6. Kavoura & Ryba (2020)	6 judokas Age: 20-27	Studies	Finland	Qualitative	- Semi-structured interview	- DC management - Future planning - Identity - Parallel and convergent trajectory

Note: abbreviations used Table 2
DC: Dual Career; CAPs: Career Assistance Programmes; DCCQ-A: Dual Career Competency Questionnaire for Athletes; NA: Not Available

Table 2 (Continued)
*Results and characteristics of the identified articles on dual careers and women in sport (*N=*19).*

Bibliographic Code and Reference	Participants	DC (studies/ work)	Context	Type of study	Method of data collection	Theme
7. Perez-Rivases et al. (2020)	72 athletes; Sports: NA Age: mean 17	Studies	Spain	Quantitative	- DCCQ-A29	- DC Competences and Management - CAPs - Parallel trajectory
8. Ronkainen et al. (2020)	10 athletes Sports: NA Age: 19-22	Studies	Finland	Qualitative	- In-depth interviews	- DC Management and DC Perception - Perfectionism - Parallel and divergent trajectory
9. Slaten et al. (2020)	14 athletes Football and Hockey Age: 18-23	Studies	United States	Qualitative	- Semi-structured interview	- DC Management and DC Perception - CAPs - Transition to university - Sports identity - Parallel trajectory
10. Cooper & Jackson (2019)	4 athletes Sports: Olympians Age: NA	Studies	United States	Qualitative	- Individual interviews - Focus Group Interview - Demographic questionnaire	- DC Management and DC Perception - Identity and roles - Resources and Careers - Convergent and parallel trajectory
11. Andersson & Barker-Ruchti (2018)	7 football players Age: Over 22	Studies and Work	Sweden	Qualitative	- Semi-structured interview - Bibliographic mapping	- DC management - Career paths - Transition from junior to senior - Convergent trajectory
12. Kristiansen & Stensrud (2017)	6 female handball players Age: 13-14	Studies	Norway	Qualitative	- Semi-structured interview - Physical tests	- DC management - Sporting and non-sporting transitions - Puberty - Parallel trajectory
13. Perez-Rivases et al. (2017a)	3 athletes Waterpolo and Swimming Age: 18	Studies	Spain	Qualitative	- Semi-structured interview	- Transition to university - Parallel trajectory

Note: abbreviations used Table 2
DC: Dual Career; CAPs: Career Assistance Programmes; DCCQ-A: Dual Career Competency Questionnaire for Athletes; NA: Not Available

Table 2 (Continued)
*Results and characteristics of the identified articles on dual careers and women in sport (*N=*19).*

Bibliographic Code and Reference	Participants	DC (studies/ work)	Context	Type of study	Method of data collection	Theme
14. Madsen & McGarry (2016)	13 athletes Football, basketball, volleyball, rowing, lacrosse, field and ice hockey, athletics and tennis Age: NA	Studies	United States	Qualitative	- Focus Group - Semi-structured interview	- DC Perception - Future planning - Gender roles - Parallel trajectory
15. Gledhill & Harwood (2015)	13 retired football players Age: mean 19	Studies	United Kingdom	Qualitative	- Semi-structured interview	- DC Perception - Holistic perspective - DC management - Parallel and divergent trajectory
16. Han et al. (2015)	13 athletes Age: 15-17	Studies	South Korea	Qualitative	- Semi-structured interview	- DC Identity - Gender roles - Barriers - DC management - Parallel trajectory
17. Falls & Wilson (2013)	12 football players Age: 23-30	Studies	United States	Qualitative	- Oral History Interview	- Sporting and non-sporting transitions - Transition to university - Identity - Parallel trajectory
18. Selva et al. (2013)	23 active and retired sportswomen Sports: Olympians and non-Olympians. Age: 18-39	Studies and Work	Spain	Qualitative	- Semi-structured interview	- DC management - Barriers and Resources - Linear, parallel and convergent trajectories - Retired
19. Debois et al. (2012)	1 retired fencer Age: NA	Studies and Work	France	Qualitative	- In-depth interview - Notes from advisory and follow-up interviews	- Sporting and non-sporting transitions - Transition from junior to senior - Retired - Convergent and parallel trajectory

Note: abbreviations used Table 2
DC: Dual Career; CAPs: Career Assistance Programmes; DCCQ-A: Dual Career Competency Questionnaire for Athletes; NA: Not Available

Coding and data extraction

For data cleaning, a data extraction tool was developed in the form of a table containing the articles included in this review (see Table 2). The table provides information on the key characteristics of the study and details the authorship, year of publication, participants and sport modality, the focus of the study, the design and methodology, and finally the main themes. The first author was responsible for this cleaning, under the supervision of the other authors.

The included studies were organised in reverse chronological order, so that the most recent studies (i.e., from 2022 to 2012) were listed first. Within each year, they were arranged alphabetically according to the authors' surnames. In addition, each article has a bibliographic code (see Table 2), which is used in the text (in square brackets) to help with reading the following sections and to distinguish the articles included from other references.

Assessment of the quality of included studies

The quality of the research methodology for the articles ultimately included was assessed by means of the Mixed Methods Appraisal Tool (MMAT: Hong et al., 2018). In making this assessment, it is important to use criteria and tools appropriate for the type of evidence being examined (Tod, 2019; Tod et al., 2021). The MMAT is a suitable assessment tool for this work as it is designed for the evaluation of mixed studies (i.e., reviews including qualitative, quantitative and mixed methods studies). In the MMAT checklist, there are two general questions and five questions for each type of study, to which one must answer "yes", "no" or "don't know". The quality assessment was carried out by the first author, under the supervision of the other authors. Most of the studies were considered to be of high quality, two of medium quality and one of low quality. The quality assessment of all studies can be found in Table B of the Annexes.

Results

As shown in Figure 1, 85 publications were returned from the search of the aforementioned databases. Subsequent to the elimination of duplicates, 63 relevant studies were identified. Based on the title and abstract, 53 were excluded, resulting in 11 articles for full text review, one of which was excluded. In parallel, nine relevant papers were included in the manual search. Eventually, relevant papers were included according to titles, abstracts and full texts, which resulted in a total of 19 studies. The main results and characteristics of interest for each study are presented in Table 2.

The following is a description of the characteristics of DC studies on women (i.e., trend, situation), followed by a narrative synthesis of the extent of knowledge produced in these studies.

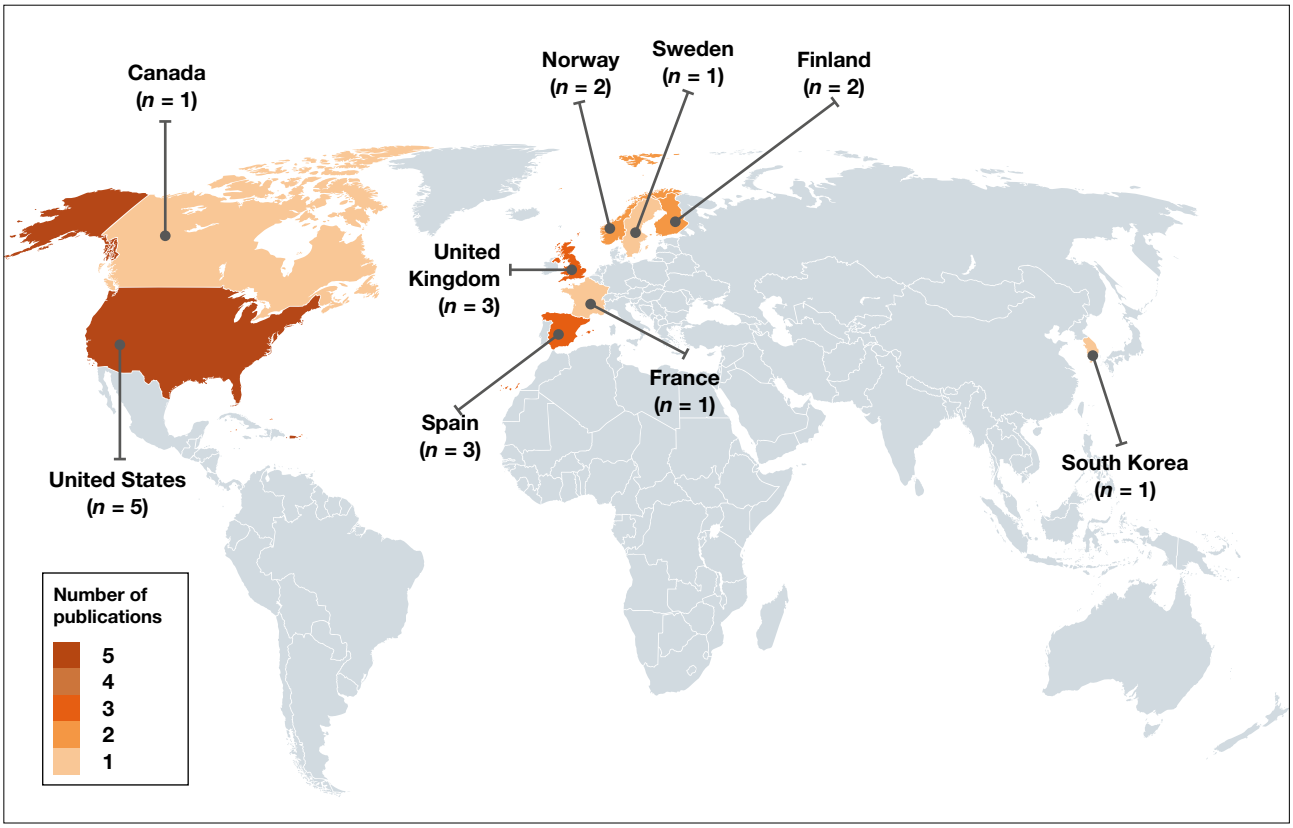
Description of study characteristics

As for the publication trend, although it is generally stable, the last three years have seen an upward trend. From 2012, the date of the first article included, to 2019, ten articles have been published with a focus on the DC of sportswomen. This number is almost the same (i.e., nine publications) as the publications made in the last three years (i.e., from 2020 to 2022).

Figure 2 shows an overview of the perspective from which women's DC has been studied. The 19 studies included were carried out in nine countries on three different continents, countries in the northern hemisphere, mostly in North America and Europe. The country in which women's DC has been most researched is the United States, with five studies carried out, followed by the United Kingdom and Spain with three and Norway and Finland with two each. In last place, South Korea, France, Sweden and Canada with one study in each country. In terms of language, of the 19 entries, 17 were in English and two in Spanish. Regarding the study participants, most of them are active sportswomen, while only four studies include former sportswomen in their sample [1, 15, 18, 19]. The predominant study design is qualitative and the most commonly used technique for data collection is the semi-structured interview. Exceptionally, there is one study [7] which uses quantitative methodology utilising the Dual Career Competency Questionnaire for Athletes (DCCQ-A; De Brandt et al., 2018), and one study with mixed methodology [1], which combines data collection through an individual interview and a training diary with data on rankings and data from a syllabus.

Depending on the focus of the DC, four studies assess the compatibility of sport and alternative work and focus exclusively on job placement and non-sport career (e.g. barriers and resources to combine sport and work), while the rest (n = 15) assess compatibility with studies and explore more general topics (e.g. management and perception of DC, identity, transitions, CAPs).

Figure 2
Geographical location of the included studies.



With regard to transitions, the transition to university ($n = 6$) is the one most frequently considered in the studies, followed by the transition from junior to senior ($n = 3$), followed by the transition from retirement ($n = 2$) and, finally, the transition from puberty ($n = 1$).

Finally, it can be inferred from the studies that the majority of sportswomen followed a parallel trajectory (i.e., similar importance placed on sport and studies/work), followed by those sportswomen with a convergent trajectory (i.e., more importance placed on sport than studies/work). Some studies also refer to moments of diverging trajectories (i.e., where sporting and vocational demands conflict and they drop out of sport). Lastly, there is only one study that addresses the possibility of following a linear trajectory as a sportswoman.

Having outlined the evolution of the research and the general characteristics of the studies, it can be seen that the most predominant study profile is that of football players ($n = 5$), who combine sport with studies ($n = 15$) and follow a parallel career ($n = 16$), using a qualitative methodology based on a semi-structured interview ($n = 14$), where aspects of the management and perception of the DC are dealt with (i.e., barriers and resources, transitions and future planning; $n = 17$).

Scope of DC studies on women

In this section, a narrative synthesis of the scope of contributions and knowledge on the management and perception of sportswomen's DC (i.e., barriers and resources, identities and trajectories) is presented.

DC management is often perceived as problematic [3, 5, 8, 11], as in many cases it is difficult to find a balance and a period of adaptation is often necessary to adjust and cope with the different demands [3, 5, 13]. On the one hand, the main perceived barriers are lack of, or poor time management [2, 5, 6, 10, 19], poor time flexibility [1, 2, 5, 11, 18], having to leave home [3, 7, 19], environments with excessive competitiveness or perfectionism [1, 8, 16, 19] and increased sporting and academic demands [3, 5, 11, 12], which, ultimately, they try to compensate for by reducing their social life [7, 12]. On the other hand, the main perceived resources are social support (e.g. colleagues, coaching staff, family and friends) [2, 3, 4, 12, 15, 17, 18], acquired skills (e.g. planning, organisation, ability to sacrifice) [1, 8, 18], motivation and commitment to continue studying [1, 2, 5, 10, 17] and access to institutional resources [2, 5, 7, 9, 10, 18]. In relation to institutional resources, women are often regular users of CAPs and they play an important role in the development of DC [5, 7].

The lack of female role models means that some sportswomen are not able to envisage a path to a professional future in elite sport [6, 16] and, therefore, link their identity as professional sportswomen [5, 6, 14, 16]. However, some studies [3, 10, 11] show that this sport identity is more prevalent, especially in sports that have reached professional status (e.g., women's football) or high competitive levels (e.g., Division I college sports in the United States). Therefore, in general, women do not tend to develop a single sport identity, but develop multiple alternative identities besides sport (e.g., student identity) [1, 6, 9, 15, 17]. In this sense, when academic demands start to increase, sportswomen start to develop these non-sporting identities [1, 5, 8] and may even decrease their focus on sport and see it as just another hobby [5]. For example, the transition to university is perceived by some as an opportunity to consider and investigate other career options, with the aim of personal and individual development [17]. At this point some begin to follow divergent trajectories, triggering possible abandonment of sport and premature withdrawals [5, 15, 16, 17]. In post-retirement career planning, many women choose to follow traditionally "female" careers because of the pressure to conform to social gender roles and few consider a career path linked to sport [14].

Discussion

This study enables sportswomen to be placed at the centre of the construction of knowledge about DC and to explore a reality that has traditionally been silenced or sidelined. In this way the existing literature has been categorised and trends and gaps in knowledge in this field have been identified.

19 primary studies published in scientific journals between 2012 and 2022 have been identified, the quality of most of which is considered to be high. The growing number of publications on women's DC is noteworthy. This is in line with the findings of Stambulova and Wylleman's (2019) state of the art, which suggest a trend of intensifying research within DC discourse. However, it should be noted that most articles are published in European countries or the United States, which only builds knowledge from a Western and Northern perspective. These results are in line with those found in the review by Guidotti et al. (2015), which suggest that states that facilitate the education of talented elite athletes also promote scientific interest in this field of research, but it should be borne in mind that knowledge of women's DC is being constructed based on hegemonic culture (e.g. white, cisgender, middle-class women) and, for the moment, invisibilising the experiences and knowledge of other women in the world and other modes of being a woman.

The main barriers to DC for sportswomen are associated with poor time management, poor time flexibility, leaving home, environments with excessive competitiveness or perfectionism, and increased sporting and academic demands. These findings reinforce other research on DC more generally, for example, in the study by López de Subijana et al. (2015) or the study by Miró et al. (2018), in which poor time management and little time flexibility are recognised as the main obstacle when undertaking a DC. Complementarily, social support and CAPs stand out as key resources for the development of a DC (López de Subijana et al., 2015).

On a general level, the need to study DC from a broad perspective (i.e., holistic sport career model; Wylleman, 2019), which takes into account the specificity of sportswomen (i.e., predominant transitions and trajectories, role conflicts, lack of professional sport structures, multiple identities crossed by gender roles), has become evident. This implies that it is important to conduct studies that consciously investigate critical transitions in the development and overall experience of sportswomen (e.g. puberty, motherhood, retirement; Debois et al., 2012). The transition to university has been studied both prospectively and retrospectively (Perez-Rivases et al., 2017a), as has occurred in the literature generally (Brown et al., 2015; Defruyt et al., 2020). In both cases, the importance of planning ahead in order to successfully meet the challenge of increased academic and sporting demands is highlighted (Brown et al., 2015; Perez-Rivases et al., 2017a). This transition is particularly critical for women, as there is a high drop-out rate from sport during this period. In contrast, transitions which, generally speaking, in previous literature are highly studied (i.e., transition from junior to senior and retirement; Park et al., 2012; Torregrossa et al., 2016) do not feature prominently in the literature review. According to Ronkainen et al. (2016) there is a gap in the literature on women's sport careers and few studies have focused on understanding the impact of gender on the career development and retirement processes of sportswomen. As for the critical pubertal transition, there is only one study that considers it. Because of the changes it entails and the perception of the body and physical abilities of sportswomen (Kristiansen & Stensrud, 2017; Tekavc et al., 2015), this is one of the critical transitions that should be strengthened in the research, along with motherhood (Ferrer et al. (2022). All these transitions can be addressed in CAPs so that they occur and are experienced in the healthiest possible way.

Currently, these CAPs are created and designed based on a general model of the athlete (e.g. male, white, middle class), and therefore constructed under the androcentric bias. In fact, from some articles included in the review (Harrison et al., 2020; Perez-Rivases et al., 2020), there is a concern and a call for an improvement in the quality of care afforded to CAPs, specifically that they should be more gender-sensitive and designed to maximise the personal resources of sportswomen, so as to better adapt to the specific demands of their DC (Skrubbeltrang et al., 2020). Many CAPs continue to provide advice beyond their sporting careers, even after retirement (Henry, 2013). In fact, one of their functions is to advise the athlete on how to combine sport with a job and how to find a job during and/or after retirement. This review highlights the scarcity of research focusing on the reconciliation of sport with work or employment after retirement. As noted by Stambulova and Wylleman (2019), there is a lack of data on work-sport balance, and there is a need to put this issue on the research agenda in women's DC research. This need is also reflected in the recent Position Stand of the International Society of Sport Psychology (ISSP) which sets the challenge of research beyond the sport career in order to study also the employability competences of the athlete, as well as DC combining sport and work (Stambulova et al., 2021). The lack of studies in this area has important repercussions on the development of the sporting career, as it entails overlooking one of the main areas of the athlete's life.

This vocational area is particularly relevant for women as women's sport generally has fewer resources and structures (Ronkainen et al., 2020), and many competitions do not have professional status. Although high-level sportswomen can be found competing at national or international level and are paid for their performance (Gladden & Sutton, 2014), most of them have to combine sport and work or retire prematurely from sport because salaries at the professional level alone are not sufficient (Sherry & Taylor, 2019; Skrubbeltrang et al., 2020).

The study and concept of DC emerges as a preventive resource from the withdrawal process based on the logic of professional sport with a linear trajectory. In other words, the DC phenomenon is constructed on the basis of the male athlete with real professional options and, therefore, from an androcentric logic. In contrast, in the results of the study, the majority of sportswomen follow parallel or converging trajectories and this collation is rarely a voluntary decision, but an essential and idiosyncratic fact of women's sport (Ronkainen et al., 2020). So much so that the possibility of following a linear trajectory as a sportswoman is only mentioned in one study. Sportswomen are aware that, as women, they need education in order to provide them with something to fall back on as an alternative to sport (Harrison et al., 2020). Given this reality, it is important that women's careers are studied from perspectives adapted to their realities by focusing on the specific stressors, experiences and motivations that women have for pursuing this DC.

As seen in the results of this review, multidimensional identity and sport are highly studied topics. Considering the sportswoman developing DC holistically implies understanding that she is traversed by multiple roles (e.g., gender, student, athlete) and identities, and while these are ultimately a protective factor against withdrawal (Douglas & Carless, 2009; Jordana et al., 2017), what conflicts prioritising multiple domains simultaneously over the course of DC has not been sufficiently explored. Of the articles reviewed, only one attempts to explicitly explain why. Han et al. (2015) suggest that this conflict may arise because they are expected to play a triple role: women, students/workers and sportswomen. On the one hand, and in line with other research (Tekavc, 2017), being an athlete today is still associated with a conventional masculine role that conflicts with the role of being a woman. Furthermore, because of the dual athlete-student identity, in which most women feel more sporty, given that most of their schedule is occupied by training and most of their social relations are within the sporting context (Han et al., 2015). Along these lines, Lee (2012) reports that student-athletes are more distanced from classmates because attendance is less regular and they may spend less time outside school hours. In this sense, the results of some studies included (Falls & Wilson, 2013) are in line with previous studies (Tekavc et al., 2015), which point out that teammates are a crucial source of support for their development and suggest that sport identity is closely linked to the team.

The results of the studies included suggest that the perceived lack of career opportunities, multidimensional identity, the exploration of other interests, the attempt to combine sport and work and the transition to higher education result in the adoption of divergent trajectories (Torregrossa et al., 2020) that lead to a higher probability of dropout and early withdrawal. Specifically, Han et al. (2015) suggest that in the face of a social system with limited opportunity for career choices, when faced with an alternative to sport, sportswomen may consider withdrawal. Previous research follows the same line and warns of the high risk of women retiring prematurely (Skrubbeltrang, 2019) with the main reasons being entering the world of work (Tekavc et al., 2015), receiving a good job opportunity (Stambulova et al., 2007), the low probability of succeeding in a professional sports career (Skrubbeltrang et al., 2020) and motherhood (Tekavc et al., 2020).

When the time comes to retire, the results show that it is difficult for women to continue with a job linked to the world of sport (e.g. coaches, referees, physical trainers). On the one hand, the lack of female role models in these jobs plays an important role in this situation, which may explain why women are not so attracted to this career path (Borrueco et al., 2022). On the other hand, according to Ryba et al. (2015) and seconded by Ronkainen et al. (2016), by socialising as women, sportswomen often feel pressure to adhere to the life path set for them or have to choose between that or sport. This life path dictates that graduation should lead to a full-time job and family (Ronkainen et al., 2016). Therefore, it is common for women to opt to follow traditionally "feminine" careers once they have finished their sporting careers, and their professional aspirations are congruent with the academic training they have obtained (Navarro, 2015). This would exacerbate the shortage of women managers and women in positions of power and leadership in the world of sport (Perez-Rivases et al., 2017b).

In order to provide guidance on how to manage gender-specific aspects of a sporting career (e.g. conflict between sporting agenda and female role, conflict between sporting and academic/vocational agenda, balancing motherhood and sport, critical transitions), so that women's participation and aspirations in the world of sport can be increased and women's sport can continue to grow, different female sporting role models need to be made visible as points of reference. Women who act as role models and points of reference are of great importance for the construction of identity because they provide examples that can be reflected upon. For example, Han et al. (2015) report athletes lamenting the lack of female role models for women with DC trajectories and career paths in sport. Along the same lines, there is also a lack of women in different leadership positions in the world of sport (Borrueco et al., 2022; Perez-Rivases et al., 2017b). For this reason, it is essential that academia constructs and makes visible narratives that are close to their identities and needs and that allow them to be guided towards action (Ronkainen et al., 2019). Only in this way will it be possible that in the future the different ways of doing, understanding and relating to sport that women bring to the table will form part of and nourish the socialisation of future generations of sportsmen and women.

Limitations and future lines of research

This study is not without limitations, among which it is worth highlighting that approximately half of the articles included in the review come from manual searches in other sources, when usually the majority of the articles included come from systematic searches in databases. One possible reason for this anomaly is that the subject of study is not currently mainstream. This often means that even if there are studies on the topic of interest, they are difficult to find through systematic database searches with the search engines used. This is knowledge that must be explored, and which is invisible due to the lack of relevance given to both the results and the conclusions drawn, as a result of the androcentrism that predominates in science. For this reason, while the scoping reviews are comprehensive, it is possible that some relevant studies may have been omitted. Finally, a potential limitation is that the scope of the results only allows for the description of the development of DC for women in general. Given the characteristics of the samples of the included studies, there is a lack of specific articles that explore and incorporate the experiences of all types of women, specifying the different axes of oppression that affect them (e.g. race, culture, sexual orientation, abilities -intersectionality-; Collins, 2015).

Therefore, it is recommended that beyond increasing the amount of research that explores the identified gaps in women's DC (e.g. sport-work balance, the concept and status of professionals in women's sport, the lack of role models, women's motivation towards DC), future research should also include and take into account diversity among women. In this way, future research designs should be sensitive to intersectionality which is understood as the "web of intersecting relations" considering various forms of oppression (e.g. race, sexuality, nationality) that intertwine with each other and co-construct people's lived realities (Collins, 2015). This will make it possible to visualise different realities and experiences of women undertaking a DC and to broaden the diversity of points of reference. Finally, this review provides an overview of the state of the literature in this area. At the same time, it allows for the detection of the studied population's needs in order to develop future actions that raise awareness in society and enable the implementation of egalitarian practices. This implementation is necessary at different levels: in the management of sport by institutions and sports federations (i.e., equal opportunities, resources and visibility); in the work of professionals linked to clubs and sports centres, in order to make the experience of sportswomen as healthy as possible (e.g. advice in CAPs). This is why it is necessary that research and application move in the same direction.

Conclusions

This scoping review has provided an overview of the current research landscape on DC and sportswomen. In this way, a new door is opened to women's sport with the aim of enriching and increasing research and the representation of women in this field. The results reveal that most of the perceived barriers and resources are the same as those in

research in general, but due to socialising as a woman, the way of experiencing, understanding and relating to sport is different. The multiple identities developed (e.g. athlete, woman, student/worker), combined with the male-dominated context in which sportswomen find themselves and strong gender roles in society, trigger role conflicts that often lead to discomfort and premature withdrawal. The main mechanism that accounts for many of the gaps identified in the literature and the need to study the careers of sportswomen from points of view adapted to the everyday life of women's sport is androcentrism. In this sense, this pioneering review becomes a seed from which to grow knowledge that attempts to carefully describe the realities of women's sport from a holistic perspective. This will open up new branches of research to generate knowledge from which women leave the margins and become the centre, overcoming their under-representation and the current androcentrism of sport psychology.

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ANNEXES

Table A
Database search strategies.

Database	Boolean/Phrase:	Results	Search date
SPORTDiscus	("Dual Career*" OR "Dual-career*" OR "Dual Career athlete*" OR "Dual Career experiences" OR "Dual Career Balance" OR "Dual Career Develop*" OR "Dual Career Transition*" OR "Transition" OR "Dual Career Support" OR "Dual Career Assistance" OR "Career Development Gender Inequity") AND ("Student-athlete*" OR "College-athlete*" OR "pupil-athlete" OR "Elite Sport and Education" OR "Sport and Education" OR "university students" OR "Sport and university" OR "Sport and school" OR "Sport and Studies" OR "Employee-athlete*" OR "Sport and Work" OR "Elite sport and Employment" OR "Sport and Labo$r market" OR "Academic and vocational levels") AND ("Wom* student-athlete" OR "wom* athlete" OR "elite sport wom*" OR "Female" OR "women" OR "female soccer players" OR "Sportswomen" OR "women's dual-careers" OR "female athletes") AND ("qualitative research" OR "quantitative research" OR "mixed" OR "interviews" OR "focus groups" OR "questionnaires" OR "surveys") NOT (men OR males OR man OR male) NOT (covid OR covid-19 OR pandemic OR coronavirus OR lockdown)	11	6 June, 2022
Scopus	(TITLE-ABS-KEY ("Dual Career*" OR "Dual-career*" OR "Dual Career athlete*" OR "Dual Career experiences" OR "Dual Career Balance" OR "Dual Career Develop*" OR "Dual Career Transition*" OR "Transition" OR "Dual Career Support" OR "Dual Career Assistance" OR "Career Development Gender Inequity") AND TITLE-ABS-KEY ("Student-athlete*" OR "College-athlete*" OR "pupil-athlete" OR "Elite Sport and Education" OR "Sport and Education" OR "Sport and university" OR "Sport and school" OR "Sport and Studies" OR "university students" OR "Employee-athlete*" OR "Sport and Work" OR "Elite sport and Employment" OR "Sport and Labo$r market" OR "Academic and vocational levels") AND TITLE-ABS-KEY ("Wom* student-athlete" OR "wom* athlete" OR "elite sport wom*" OR "Female" OR "women" OR "female soccer players" OR "sportswoman" OR "women's dual-careers" OR "female athletes") AND TITLE-ABS-KEY ("qualitative research" OR "quantitative research" OR "mixed" OR "interviews" OR "focus groups" OR "questionnaires" OR "surveys") AND NOT TITLE-ABS-KEY ("men" OR "mal*" OR "man") AND NOT TITLE-ABS-KEY ("covid" OR "COVID-19" OR "pandemic" OR "coronavirus" OR "lockdown"))	29	6 June, 2022
PsycINFO	("Dual Career*" OR "Dual-career*" OR "Dual Career athlete*" OR "Dual Career experiences" OR "Dual Career Balance" OR "Dual Career Develop*" OR "Dual Career Transition*" OR "Transition" OR "Dual Career Support" OR "Dual Career Assistance" OR "Career Development Gender Inequity") AND ("Student-athlete*" OR "College-athlete*" OR "pupil-athlete" OR "Elite Sport and Education" OR "Sport and Education" OR "Sport and university" OR "Sport and school" OR "Sport and Studies" OR "university students" OR "Employee-athlete*" OR "Sport and Work" OR "Elite sport and Employment" OR "Sport and labor$r market" OR "Academic and vocational levels") AND ("Wom* student-athlete" OR "wom* athlete" OR "elite sport wom*" OR "Female" OR "women" OR "female soccer players" OR "Sportswomen" OR "women's dual-careers" OR "female athletes") AND ("qualitative research" OR "quantitative research" OR "mixed" OR "interviews" OR "focus groups" OR "questionnaires" OR "surveys") NOT ("men" OR "mal*" OR "man") NOT ("covid" OR "COVID-19" OR "pandemic" OR "coronavirus" OR "lockdown")	5	6 June, 2022
Proquest	("dual career" OR "Dual-career*" OR "dual careers" OR "Dual Career athlete*" OR "Dual Career experiences" OR "Dual Career Balance" OR "Dual Career Develop*" OR "Dual Career Transition*" OR "Dual Career Support" OR "Dual Career Assistance" OR "Career Development Gender Inequity") AND ("student-athlete*" OR "College-athlete*" OR "pupil-athlete" OR "Elite Sport and Education" OR "Sport and Education" OR "Sport and university" OR "Sport and school" OR "Sport and Studies" OR "university students" OR "Employee-athlete*" OR "Sport and Work" OR "Elite sport and Employment" OR "Sport and labor$r market" OR "Academic and vocational levels") AND ("Wom* student-athlete" OR "wom* athlete" OR "elite sport wom*" OR "Female" OR "women" OR "female soccer players" OR "Sportswomen" OR "women's dual-careers" OR "female athletes") AND ("qualitative research" OR "quantitative research" OR "mixed" OR "interviews" OR "focus groups" OR "questionnaires" OR "surveys") NOT ("men" OR "mal*" OR "man")	8	6 June, 2022
WoS (Core Collection)	("Dual Career*" OR "Dual-career*" OR "Dual Career athlete*" OR "Dual Career experiences" OR "Dual Career Balance" OR "Dual Career Develop*" OR "Dual Career Transition*" OR "Transition" OR "Dual Career Support" OR "Dual Career Assistance" OR "Career Development Gender Inequity") AND ("Student-athlete*" OR "College-athlete*" OR "pupil-athlete" OR "Elite Sport and Education" OR "Sport and Education" OR "Sport and university" OR "Sport and school" OR "Sport and Studies" OR "university students" OR "Employee-athlete*" OR "Sport and Work" OR "Elite sport and Employment" OR "Sport and Labo$r market" OR "Academic and vocational levels") AND ("Wom* student-athlete" OR "wom* athlete" OR "elite sport wom*" OR "Female" OR "women" OR "female soccer players" OR "Sportswomen" OR "women's dual-careers" OR "female athletes") AND ("qualitative research" OR "quantitative research" OR "mixed" OR "interviews" OR "focus groups" OR "questionnaires" OR "surveys") NOT ("men" OR "mal*" OR "man") NOT ("covid" OR "COVID-19" OR "pandemic" OR "coronavirus" OR "lockdown"))	32	6 June, 2022

Table B
MMAT quality assessment profile.

Code Bibliographic	Reference	Screening Questions		1. Qualitative Studies					Total
		S1. Are the objectives and/or research questions clear?	S2. Does the data collected address the research objectives and/or research questions?	1.1. Is the qualitative approach appropriate for answering the research objective and/or research question?	1.2. Are the qualitative data collection methods appropriate for addressing the research objective and/or research question?	1.3. Are the conclusions adequately derived from the data?	1.4. Is the interpretation of the results sufficiently supported by the data?	1.5. Is there consistency between qualitative data sources, collection, analysis and interpretation?	
2	Frederickson (2022)	Yes	Yes	Yes	Yes	Unknown	Yes	Yes	80%
3	McGreary et al. (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
4	Pankow et al. (2021)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
5	Harrison et al. (2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
6	Kavoura & Ryba (2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
8	Ronkainen et al. (2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
9	Slaten et al. (2020)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
10	Cooper & Jackson (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
11	Andersson & Barker-Ruchti (2018)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
12	Kristiansen & Stensrud (2017)	Yes	Yes	Yes	Yes	No	No	No	40%
13	Perez-Rivases et al. (2017)	Yes	Yes	Yes	Yes	Yes	No	Yes	80%
14	Madsen & McGarry (2016)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
15	Gledhill & Harwood (2015)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
16	Han et al. (2015)	Yes	Yes	Yes	Yes	Unknown	Yes	Yes	80%
17	Falls & Wilson (2013)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
18	Selva et al. (2013)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	100 %
19	Debois et al. (2012)	Yes	Yes	Yes	Yes	Yes	Unknown	Yes	80%

N.B. 1 'yes' corresponds to 20% of the MMAT criterion; 2 'yes' corresponds to 40% of the MMAT criterion; 3 'yes' corresponds to 60% of the MMAT criterion; 4 'yes' corresponds to 80% of the MMAT criterion; 5 'yes' corresponds to 100% of the MMAT criterion. 20-40 % = low quality; 60–80 % = moderate quality; 80–100 % = high quality

Table B (Continued)
MMAT quality assessment profile.

Code Bibliographic	Reference	Screening Questions		2. Quantitative Descriptive Studies					Total
		S1. Are the objectives and/or research questions clear?	S2. Does the data collected address the research objective and/or research question?	2.1. Is the sampling strategy appropriate for addressing the research objective and/or research question?	2.2. Is the sample representative of the target population?	2.3. Are the measures appropriate?	2.4. Is the risk of non-response bias low?	2.5. Is the statistical analysis appropriate for answering the objective and/or the research question?	
7	Perez-Rivases et al. (2020)	Yes	Yes	No	Yes	Yes	Unknown	Yes	60%
Code Bibliographic	Reference	Screening Questions		3. Mixed methods studies					Total
		S1. Are the objectives and/or research questions clear?	S2. Does the data collected address the research objective and/or research question?	3.1. Is there adequate justification for using a mixed methods design to address the research objective and/or research question?	3.2. Are the different components of the study effectively integrated in order to answer the research objective and/or research question?	3.3. Are the results of the integration of qualitative and quantitative components adequately interpreted?	3.4. Are divergences and inconsistencies between quantitative and qualitative results adequately addressed?	3.5. Do the different components of the study adhere to the quality criteria of each tradition of the methods involved?	
21	Bergström et al. (2022)	Yes	Yes	Yes	Unknown	Yes	No	Yes	60%

N.B. 1 'yes' corresponds to 20% of the MMAT criterion; 2 'yes' corresponds to 40% of the MMAT criterion; 3 'yes' corresponds to 60% of the MMAT criterion; 4 'yes' corresponds to 80% of the MMAT criterion; 5 'yes' corresponds to 100% of the MMAT criterion. 20-40 % = low quality; 60–80 % = moderate quality; 80–100 % = high quality

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Balancing Sport Coaching with Personal Life. Is That Possible?

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An athlete doing parkour.
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Abstract

The sport coaching profession is characterized by demanding environments that affect work-life balance. Accordingly, there is a need to examine the challenges coaches face in balancing their professional duties with their family and/or personal interests. This study aimed to gain a better understanding of the different experiences of work-life conflict that Spanish coaches face and how they perceive the support provided by their sport organizations in terms of work-life balance. The study was based on semi-structured interviews with a sample of seven male and eight female coaches in Spain. The results showed that the coaching profession had a negative impact on their personal and social lives, and coaches often prioritized their work. Family and friends' support (mainly wives for men and friends and grandparents for women) allowed coaches to continue in the profession. Organizations also implement actions to balance work and family/personal spheres, such as offering personal and financial support, adjusting schedules, and condensing training sessions. These results can help professionals better identify strategies to reduce work-life conflict among sport coaches.

Keywords: coaches' career, gender, organizations, work-life conflict.

Introduction

Sport coaches are a key component of the sports system and play a significant role in emotional and informative support provided to athletes (Porto et al., 2021). Nevertheless, how sport organizations may assist on coaches' career development has not been widely studied (Dawson & Phillips, 2013).

The coaching profession is often characterized for long and unorthodox hours and specific working conditions of the profession, such as fulfilling multiple roles and coping with a range of stressors (e.g., overload, job insecurity, expectation of others) (Fletcher & Scott, 2010; Norris et al., 2017). Furthermore, coaches often have a blended professional identity (combined with other [paid] jobs) and the opportunity for remuneration is low (Duffy et al., 2011; Viñas & Pérez, 2014). To support coaches' career pathways, there is a need to explore the challenges that coaches face when attempting to *balance* their professional role with their family duties or personal interests.

Accordingly, there has been an interest in examining the work-family conflict of coaches (Bruening et al., 2016; Dixon & Bruening, 2005; Dixon & Sagas, 2007; Graham & Dixon, 2017; Joncheray et al., 2019; Sisjord et al., 2022). Work-Family Conflict (WFC) has been defined as a type of inter-role conflict where some work and family responsibilities are not easily compatible and consequently, it can have a negative effect on the conflicting domains (Greenhaus & Beutell, 1985). WFC has been considered to have consequences for both work-related outcomes (e.g., job satisfaction, job performance, intention to turnover) and non-work-related outcomes (e.g., life satisfaction, family satisfaction) (Allen et al., 2000). For instance, previous research has highlighted the negative impact of WFC on coaches' intention to leave the profession (Kamphoff, 2010), and for those coaches who have children, the impact on their relationship with them (Dixon & Bruening, 2007).

Previous researchers have suggested the analysis of the complexity of the work–family interface through a multisystem model which include individual, organizational and sociocultural levels (Dixon & Bruening, 2007; Sisjord et al., 2022). According to this model, the individual level considers how coaches differ in their experiences of WFC, depending on personal factors such as personality, work values, family structure, coping strategies and gender. The organizational level focuses upon workplace characteristics (e.g., job pressure, working hours and scheduling, organizational culture) and how these characteristics interact with individual behaviour. Thirdly, the sociocultural level focuses on social meanings, norms, and values associated with, and the larger social interpretations of, work and family. This level assumes that the work, life and family interface is embedded into a larger system of social meaning that impacts on coaches' life (Dabbs et al., 2016).

For instance, traditional gender ideologies that attribute housework and childcare as women's responsibilities can influence in coaching (Hinojosa et al., 2018, 2020; Knoppers, 1992; LaVoi & Dutove, 2012; OECD, 2020). Academics have examined barriers and supports that female coaches perceive (Hinojosa et al., 2018, 2020; LaVoi & Dutove, 2012; Stirling et al., 2017). The "two-person, one career" model (Knoppers, 1992) makes the claim that the coach (usually a man) has their own time and energy to dedicate to the profession and also the time and energy of the female partner, who will attend games and take care of the children and the domestic duties (Dixon & Bruening, 2005; Knoppers, 1992).

In this context, while most of the previous research has focused on the difficulties that father or mother coaches encounter, there is a gap of knowledge on the work and personal life adaptations faced by the coaching workforce without children (Taylor et al., 2019). In the Spanish context, a recent study found that 61.8 % of men coaches and 84.6 % of women coaches had no children (Hinojosa et al., 2018, 2020). Consequently, in the present study, the experiences of both men and women coaches with and without children in the family structure where taken into consideration. Accordingly, the term Work-Life Conflict (WLC) was used with the intention to incorporate a broader conceptual meaning of the conflict between work, personal life and family life (Hill et al., 2010).

Therefore, the aim of the present study was to gain a more comprehensive understanding of the different experiences of WLC that Spanish coaches encounter, and how they perceive the organizational support that the sport organization offers in terms of work-life balance. In doing so, the present study also sought to contribute to the understanding of coaches with children and without children in the family structure.

Method

This study made up one stage of a large research project in Spain regarding the work environment of sport coaches. A qualitative approach was used in the design of this particular stage of the research project.

Participants

We adopted a purposive sampling approach in order to ensure the representation of men and women coaches with different family structures, years of experience and sports context. The initial criteria were people with at least three years of experience in coaching and who were actively coaching. Fifteen participants were interviewed (7 men and 8 women aged between 26 and 60) from a larger group of coaches who, in a previous study, had completed a quantitative questionnaire about their psychosocial work environment (N = 1,420), and who subsequently agreed to participate.

The result was a sample with coaches who had been coaching in a diversity of sports, for an average of 17 years, and in different coaching positions (ranging from head coach to assistant coach) in different levels. The sample was also diverse in terms of family structures and contractual conditions (see Table 1).

Procedures

Following the approval from the Ethics Committee of the Sport Administration of Catalonia (05/2016/CEICEGC), active sport coaches that previously agreed to participate were sent an e-mail that contained a full description of the present study and were given the opportunity to volunteer to participate in face-to-face interviews. Informed consent was obtained from the participants before the study began. The interviews were conducted using a semi-structured interview guide based on the dimensions proposed in Dixon and Bruening's multilevel framework (2005) (individual, organizational, and sociocultural). The interview guide covered biographies and pathways to coaching, details about the coaching career, recruitment/employment, barriers and supports to become a coach (e.g., "Could you describe your daily life as a coach and what does it involve?" and "How do you plan and manage your work?"). Interviews were conducted with each of the coaches at a time and location convenient to the participant, ranged from 35 to 90 minutes, and were tape recorded and transcribed verbatim. We provided a pseudonym for each participant to protect their identity.

Data Analysis

The thematic analysis followed the analytical guidance recommended by Sparkes and Smith (2014) identifying and categorising the themes following six steps: (1) familiarisation with the data, which included transcribing and reading the interviews; (2) generating the initial codes based on previous research and, subsequently, some of the codes were identified as the data was analysed through an inductive approach; (3) grouping the codes in main themes, the data was grouped into a more inclusive and meaningful whole (not segregating each level, but looking for the coherence of the narratives of coaches); (4) reviewing the themes; (5) defining and naming the themes, and (6) producing the report. Software Atlas.ti 7 was used to organize data codification and interview analyses. According to these steps, for this article, the authors selected the data set that had some relevance to WLC. Moving back and forward between the entire data set, the initial related codes were "family structure", "work and life values", "organizational culture", and "supportive mechanisms". Then, the different codes were sorted into potential themes that were refined into the final ones. For each individual theme a detailed analysis was conducted, and also each theme was considered in relation to others. The most significant statements from participants were identified to exemplify the themes in the results section.

After data saturation was reached, trustworthiness and credibility were established through the following three verification strategies (Creswell & Miller, 2000): (1) rich and thick descriptions using quotations from the participants (to be presented in the results and discussion); (2) peer review or debriefing (the research team discussed the initial list of codes and the codes that arose from the interviews); and (3) external audits (two external researchers verified the process of identifying and finalising the themes).

Table 1
Characteristics of the sample.

Pseudonym	Sex	Age	Co-habiting or married	Number of children	Age of children (years)	Sport	Years of experience	Current role	Weekly workload	Job besides coaching
Andrés	Man	26	no	0	-	Swimming	9	head coach	25	student
Ana	Woman	34	yes	2	6, 9	Gymnastics	8	head coach	10	yes
Jaume	Man	60	no	3	adults	Football	34	technical director	40	no
Josep	Man	54	yes	5	3, 8, 13, 13, 21	Football	11	head coach	6	yes
Irene	Woman	30	yes	0	-	Volleyball	6	technical director	35	no
Ferran	Man	46	yes	1	adult	Basketball	20	head coach	11	yes
Sonia	Woman	56	no	2	adults	Basketball	40	technical director	25	yes
Albert	Man	36	yes	1	5	Basketball	15	head coach	8	yes
Jesús	Man	58	yes	1	adult	Volleyball	43	technical director	6	yes
Jordi	Man	31	yes	0	-	Swimming	3	head coach	15	yes
Mar	Woman	26	no	0	-	Basketball	12	technical director	30	student
Manuela	Woman	33	no	0	-	Football	12	head coach	6	yes
Cristina	Woman	34	no	0	-	Gymnastics	16	assistant coach	24	yes
Mercè	Woman	32	yes	0	-	Football	7	head coach	10	yes
Ainhoa	Woman	49	yes	1	15	Swimming	29	technical director	40	no

Results and discussion

An examination of the coaches' experiences of attempting to balance work and life roles provided an understanding of the variable and complex situations that coaches encounter. Three main themes were identified: "Coaching or family and friends?", "Family and friends' support" and "Organizational support".

Coaching or family and friends?

This theme described the situation that 5 women and 3 men coaches experienced when they felt that they had to choose between their personal or professional life. The participants in this study highlighted that they often prioritised their work over other aspects of their life. Thus, many of the coaches decided to increase the time they spend on coaching, choosing this over their social time, such as spending time with their families and friends. Sonia recognised that she prioritised her work as a coach and, as a consequence, she had no free time and could not enjoy other life interests:

> *"The truth is that I have left my personal life and my home life behind (...). I have no time for anything. I have an apartment in the countryside and I don't go there anymore, because I have competitions."* (Sonia, 2 children, basketball)

Cristina, an international assistant coach in gymnastics with over 16 years' experience, also stated:

> *"At present, officially I work 24 hours per week. Unofficially, I arrive every day at 9 am and leave at 8 pm, every day. I'm trying to adapt to the schedule, but when you're with a group that do double training sessions and you are preparing for important competitions, you have to be there. If you're not there, you'll lose too much..."* (Cristina, no children, gymnastics)

In the case of Cristina, an organizational factor such as the results-oriented culture of her organization influenced her individual decision to focus primarily on coaching. Although she had a part-time contract, she was present full-time at the sports club. This decision was also influenced by her high occupational commitment as previous research has described (Cunningham et al., 2001). As a result of this, many of the coaches felt that there was no room for other activities other than coaching. They described spending a disproportionate time training and attending competitions (their own competitions, and also other colleagues and opponents' competitions), which directly and negatively impacted their personal time. This overwhelming and time-consuming routine, which is very common in the Spanish context, had consequences on coaches' work-life interface.

In addition, four participants admitted that they had broken up with their partner because of their involvement and commitment to coaching. Jaume, a full-time international head coach, explained that being a football coach was the main reason for his divorce:

> *"Well, in football and especially when you are a coach, it's complicated to manage your family life. I separated from my wife because of football... Yes, maybe some of the problems and fights with my ex-wife were because she didn't understand this way of life, which was normal for me because I was born in and grew up in this environment."* (Jaume, 3 children, football)

Cristina had similarly experienced the time constraints when trying to balance her role as a coach and her role as a partner:

> *"I was living with a stable partner 5 or 6 years ago. And one of the reasons why I left the relationship was that I could not manage it with the demands of coaching. Coaching invaded my personal time and he was not willing to accept it and it was one of the reasons why we broke up."* (Cristina, no children, gymnastics)

Jesús, a technical director and regional part-time coach in volleyball, gave another example of how relationships were affected by a heavy-time commitment towards coaching:

> *"For me it was hard because it also affected my social or family life. At that time I wasn't married, but I already had a partner and we broke up for this reason, because I spent many hours at the club."* (Jesús, 1 child, volleyball)

The circumstances of coaches may be different, but the main reason for relationship breakdown was due to the way of life expected of coaches, which pushed them to prioritise coaching over their personal life.

When the schedule was not accommodated to coaches, they suffered from an overwhelming and heavy workload

and felt that there were no boundaries between their personal and professional life. As Irene, a full-time national volleyball coach, states:

> *"Well, there is one thing that I consider unfair and I would like it to be changed in the future. It's about the working hours, because people leave their work and this means that work has finished, but the coach has to take the work home. A match does not last only as long as the score is in progress, it lasts the hours before, the injured player that you take to the doctor... All these things are not valued. For me this is the unfair part of the profession."* (Irene, no children, volleyball)

In this sense, the demands of coaching are high and sometimes coaches struggle to balance personal, social and professional commitments. The individual outcomes such as job dissatisfaction resulted from working long hours and their difficulties to separate their working time from their free time. The concept of workaholism arose from coaches' voices who were putting more effort than expected in coaching while they disregarded their life outside coaching. As previous research has evidenced, sport careers, such as coaching, are more susceptible to workaholism (Taylor et al., 2019).

Nevertheless, the WLC can also lead to quitting the job. Jesús, the volleyball coach, after his first experience, chose to quit a coaching job and looked for another one in order to prioritise his current family life:

> *"There was a time in my life that I was coaching with full dedication. In the previous club I worked from Monday to Sunday, but I was single and I spent many hours there. Being married, and coaching in another club I was expected to do too much and I decided not to continue in that club."* (Jesús, 1 child, volleyball)

This finding highlights how WLC is relevant for, and influential on, coaches' intention to leave the club or the profession. As described by Fletcher and Scott (2010), this study also shows that coaching is characterised for demanding long and unorthodox hours, high commitment (coaches feel the need to be connected 24/7), and a results-oriented culture. And these organizational factors affected the coach's personal life until he confronted the choice between family/life and coaching. Then, coaches feel the need to constantly choose between two spheres (e.g., work and family). Regardless of coaches' age, gender, competitive level and working hours, coaches described the work and life/family interface as independent elements that comprise a dichotomy.

The findings illustrate that the individual outcomes that coaches experienced such as emotional toll, relationship breakdowns or coaching turnover were influenced by the organizational and sociocultural factors that characterise the coaching profession. According to Dixon and Bruening (2007), when individuals make choices about work and family, they do not have an unlimited set of options, since the structural conditions interact with the individual choices. In the Spanish sociocultural context, which is characterised by minimal measures and policies on work-family reconciliation (OECD, 2020, Valiente, 2000), WLC has an important influence on coaches' career development, especially for women. Accordingly, the family and friends' support, as well as sport organisations, play a key role in determining how coaches manage their WLC. We develop this in the following themes.

Family and friends' support

While trying to balance life and work, most of the coaches highlighted the importance of family support in order to pursue a career in coaching. Coaches described how their family was a key source of support. Unlike the experiences described in the previous theme, there are coaches who were not forced to choose between spheres (work or life/family), as Jordi, a local water polo head coach, explained:

> *"My wife met me as an athlete, so she already knew that sport was very important for me. And somehow, she understood it and accepted it."* (Jordi, no children, water polo)

In most cases, for those male coaches who were married or co-habiting with a partner, the partner played an important role in supporting them. The support of the wife was a key factor for Albert to continue his career as a coach, especially when there were children in the family structure:

> *"My support is basically my wife. If she had not supported me, I couldn't have continued coaching."* (Albert, 1 child, basketball)

Consequently, family support at the individual level was an important factor in leading coaches to a positive outcome such as job satisfaction or life satisfaction. The findings highlight that these coaches expected their family to get involved with coaching, and to be supportive within their family and coaching roles:

> *"When my wife was pregnant, I was already coaching teams and they (wife and child) already followed me. And when my daughter was born, they continued following me with the baby in the buggy. Of course, the problem of a coach who doesn't leave the profession is that the family must follow him. And I'm lucky that my wife has understood that coaching is part of my life."* (Jesús, 1 child, volleyball)

In all these cases, men coaches were basically supported by their spouses or stable partner. Furthermore, these findings illustrated the structure of the "two-person, one career" model that has been previously described in the coaching profession (Dixon & Bruening, 2005; Hinojosa-Alcalde et al., 2020; Knoppers, 1992; LaVoi & Dutove, 2012). This connects to mostly the male participants' experiences but not to female coaches.

In contrast, women coaches more often described other types of supportive mechanisms than their spouse or stable partner. For instance, Sonia, a basketball regional part-time head coach, explained:

> *"While I was coaching, the mother of my daughter's friend would keep them to do the homework and when I finished the trainings, I would pick my daughters up and go home."* (Sonia, 2 children, basketball)

Ana, a part-time gymnastics coach, also highlighted the role of her children's grandparents in terms of balancing coaching with their personal life:

> *"My father and mother help me with the children a lot while I am coaching, but it is difficult to manage. Sometimes I have to find other options or hire a babysitter."* (Ana, 2 children, gymnastics)

This situation showed that the supportive mechanisms from the partner facilitated the male career development as coaches and reduced the feelings of work-life conflict, but not for women.

Accordingly, the results of this study highlight how gender ideology at the sociocultural level also influence coaches' career development, as previous research has revealed (Hinojosa et al., 2018, 2020; Knoppers, 1992; LaVoi & Dutove, 2012; OECD, 2020; LaVoi & Dutove, 2012; Stirling et al., 2017).

Furthermore, it implies that the sustainability of coaching has a high dependency on and is determined by supportive family and friends' mechanisms. Cristina, who has no children, stated:

> *"If I had children, then I would need help to continue coaching, but now I am not aware of having help, but I think I do not need it either."* (Cristina, no children, gymnastics)

The participants' experiences showed that the supportive mechanisms (family or friends) allowed coaches to continue in the profession and reduced the feeling of WLC, as described by Sisjord et al. (2022). Then, the concern arising from these particular findings is the dependence on this support and its impact on coaches' life/family interface, which suggests that any change on these individual supportive mechanisms would lead to greater WLC. Accordingly, measures to lower the dependency on external supportive mechanisms in sport organizations are relevant for coaches to access and progress in the profession and also to retain those coaches' who may not have this dedication from the family environment, especially women.

Organizational support

The sociocultural factors such as the cultural norms and expectations of the multiple tasks that involve coaching contributed to the low perception of organizational support in most cases. Nevertheless, there are several experiences where coaches perceived organizational support within their sport organization as a way to balance their work-life interface.

Thus, coaches perceived different supportive mechanisms developed by the organizations. For example, the fact that coaches' children could train at the same time and space of work of the coach without an economic cost was perceived as a way to balance work and family spheres.

> *"When my daughters were little it was the worst time for me to manage the coaching profession with the family. My daughters were like 'balls', because they went from one side to the other and were always with me. (...) My youngest daughter was also training here, because she could come with me and so she was training with my team."* (Sonia, 2 children, basketball)

Thus, organizational factors such as a family-friendly culture of the organization led coaches to experience lower levels of WLC.

Moreover, the sport organization can become a supportive mechanism for the coaches when there are personal difficulties. For example, Sonia described how the sport organization supported her when she was considering quitting the profession. In this case, the sport organization offered personal and financial support to the coach:

> *"When I got divorced it was a hard time for me and I was about to quit coaching. I was lucky with the old organizational board, because they all supported me and they told me not to quit the profession. They told me that if I couldn't afford the bills, they would pay the bills for me, but that I was not going to quit sport."* (Sonia, 2 children, basketball)

The gesture of support of the sport organization board at that critical moment enabled Sonia to continue in the profession. According to Dixon and Sagas (2007), higher levels of organizational support are strongly associated with individual outcomes as job satisfaction and low levels of work-life conflict. Thus, coaches with these supportive mechanisms at an organizational level can then avoid having to choose between the coaching profession or family.

Furthermore, another perception of organizational support was having social support from colleagues in the sport organization. Participants highlighted the importance of the professional relationships and organizational culture. The comparisons between members of the organization and family were recurrent. For instance, Ainhoa, a full-time international head coach, remarked the supportive relations that she experienced in the club:

> *"With this day-to-day fatigue, sometimes you wish everything would go to hell. But I can also tell you that I have had the support of the club, of all the people at the club, the family, you know? That has been the bedrock of support, which has told me: 'No, no, don't give up and don't move on'."* (Ainhoa, 1 child, swimming)

Cristina, a gymnastics part-time assistant coach, highlighted her good relation with the head coach and explained:

> *"The relationship with him (head coach) is…we seem to be married! We have a lot of confidence. Sometimes sparks fly, but we solve it easily and we understand each other very well. We have a lot of complicity."* (Cristina, no children, gymnastics)

Another way in which coaches perceived the support of the organisation was when they had the opportunity to have an open communication between line managers and coaches in order to be able to adapt to the coaches' personal needs. For instance, having the opportunity to adapt the schedule to the coach personal life before the start of the season. Albert, a basketball part-time head coach, was able to compact the training sessions into a fewer number of sessions and having flexible scheduling so that the workload was not consistently heavy. He highlighted that the club needed to adjust his work schedule in order to continue as a coach:

> *"I have tight schedules and the club knows that if they want me to coach, they must meet some of my requirements. For example, the training sessions of both teams have to be on the same day. Because I need two free days to be at home. So they have to plan it like this. And I also asked the club to train after 7 pm. At the end if they want me to coach, they have to adapt to this situation. If they didn't want me to coach, they would say no. But that's also a sign that they recognise and value your work."* (Albert, 1 child, basketball)

Coaches such as Albert, who are able to demand and negotiate job conditions, were able to better reconcile their personal life with their coaching role. Nevertheless, not all the coaches perceived the support from the organization in terms of work-life balance. More usually women coaches did not perceive they had a power position to demand and negotiate their working conditions (Greenhill et al., 2009; Knoppers, 1992).

Actions implemented by organizations can help coaches to integrate the coaching profession within their life/family duties. According to Carlson and Grzywacz (2008), the integrative perspective is focused on work-family balance. These findings highlight how a variety of aspects of the work and non-work spheres of coaches were integrated and formed one coherent whole (Mainiero & Sullivan, 2005). In pursuing this integration, balance is a key element. Previous studies have defined integration as an effective way to create a balanced lifestyle (Carlson & Grzywacz, 2008; Mazerolle et al., 2008). Moreover, this supportive environment provides social integration and social acceptance to these coaches which is relevant for their social well-being (Norman & Rankin-Wright, 2016).

These findings reflect the key role that sport organizations play in balancing WLC and the need to facilitate the work-life balance for retaining sport coaches. As previous literature has suggested (Dixon & Sagas, 2007), the organizational support is relevant for coaches in order to balance their work and family spheres and decrease WLC. Dabbs et al. (2016) described that when coaches have a supportive organizational culture, they are more likely to succeed in balancing the work and life interface, which results in a more favorable work environment, better performance and well-being among coaches.

To summarise, the participants perceived that the organizational support in terms of work-life balance that they perceived was relevant for pursuing a career as coaches. The different ways in which coaches perceived organizational support in terms of work-life balance ranged from family-friendly environment, board support in personal difficult moments, social support from colleagues, schedule flexibility and open communication, which were important for coaches to continue in the profession.

Concluding comments

The present study provides evidence of the different ways in which the experiences of work-life conflict and perceived organizational support impacted the coaching career and coaches' personal life. As the findings show, from the holistic and multilevel view from Dixon and Bruening's theoretical framework (2005), it is important to highlight that the coaches' experiences are varied, complex and dynamic.

Within this study, the participants spoke about the difficulties they encountered balancing work and life issues, since they felt that coaching invaded their personal time and pushed them to choose between either their personal or their professional life. Personal lives, relationships, social and family commitments were influenced by their role as coaches. The family, and especially the spouse for men coaches, became the coaches' primary support mechanism which, in the long-term, is an unsustainable strategy as evidence shows that this can lead to relationship breakdown and negative impacts on the family structure, or coaching turnover. According to gender, the results also show how men and women coaches differ in their experiences. Furthermore, the perception of coaches' organizational support was also relevant for them to continue in the profession, since the organization may be a key support making adjustments to coaches' personal situations.

The present study provides new evidence that work-life interface remains a crucial area of examination for sport organizations and for the sports system. By understanding the different experiences that surround coaches, sport organizations can better identify strategies to reduce WLC among sport coaches in order to optimise their experience of the profession, enhance outcomes such as their productivity and performance, and retain coaches, especially women.

The diverse sample of the present study, which included men and women with different family structures, is a strength that offers a broader insight to the existing literature mostly focused on mother and father coaches. WLC is not only experienced by fathers or mothers. The study also highlights that WLC is observed in full-time and part-time coaches, and among coaches with and without a job besides coaching. Moreover, by using a qualitative approach, we can privilege the personal stories and account of coaches' experiences to better understand the impact of WLC on their lives.

Despite the strengths and contributions of this research, there are some limitations that could be addressed in future research. Future research should examine the experiences of coaches that decided not to continue in the coaching profession because of the challenge of managing coaching, family and personal life.

In terms of practical implications of the present study, the participants spoke about the actions that organizations were implementing in their workplace to promote their integration of the work and life interface. These actions were perceived as key elements for remaining in the sport organization and in the coaching profession. The most relevant actions suggested by the participants in the present study as ways that sport organizations could sustain their work included: (a) promoting family friendly culture in the sport organization, which means that the family can be integrated in the sport organization in different roles as participants or other roles in the organization, (b) promoting networks between colleagues and superiors that provide a climate of confidence and social support, (c) schedule flexibility and autonomy, in terms of weekly and season schedule that provides balance between the dedication to coaching and personal life, (d) open communication between technical directors and coaches in order to be able to come to an agreement about their personal needs.

The present study showed that there is a need to improve the work-life balance among coaches that enhances their career development from a holistic perspective. Rather than understanding these findings as coaches' personal inability to cope with work-life conflict, sport organizations need to be more proactive and responsible promoting family conciliation policies in the coaching workforce.

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PHYSICAL EDUCATION

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Kinematics, arm coordination, and oxygen uptake in swimmers with amputations in all-out front crawl test

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Abstract

The aim of this study was to describe the kinematics, inter-arm coordination, and oxygen uptake of swimmers with amputations, and to verify how these parameters behave in two laps (75-100 m and 175-200 m) of an all-out 200 m front crawl test (T200). Six swimmers (four males and two females) with amputations participated (age: 30 ± 9.8 years). Anthropometric measurements were obtained, and 19 markers were placed on predetermined regions of the body for later scanning of the T200. The swimmers warmed-up and then performed the T200. The test was recorded on digital video. The images were processed (APAS software) and the videos analyzed in three dimensions (3D). Kinematic (mean stroke rate and length, swimming speed, and stroke index) and coordinative (coordination index) data were obtained from the images. During T200, oxygen uptake (VO_2) was measured breath-by-breath (portable gas analyzer) and its peak value (VO_{2peak}) was identified. Descriptive statistics and Student's t-test for paired data were used for comparison between the laps. The performance of the swimmers assessed was 197.8 ± 24.7 s. The stroke rate, length, speed, and stroke index were, respectively, 41.0 ± 5.1 cycles/min, 1.5 ± 0.3 m, 0.98 ± 0.02 m/s, and 1.67 ± 0.59 m^2/s. In general, the coordination was in capture with peak oxygen uptake of 43.6 ± 8.0 $ml.kg^{-1}.min^{-1}$. The kinematic variables and coordination did not vary between the analyzed laps.

Keywords: adaptive sport, amputees, biomechanics, physiology, swimming.

Introduction

To be successful in competitive swimming, the athlete needs to cover a certain distance in the shortest time, under set rules. Swimming technique and energy supply must make it possible to reach and maintain the intended swimming speed. For a correct swimmers' assessment, it is essential to obtain data related to swimming performance indicators, such as kinematic, coordinative, and physiological (Pelarigo et al., 2017; Pelarigo et al., 2018). Moreover, these factors play an important role in athlete performance as they are interconnected (Figueiredo et al., 2013).

In swimming, kinematic parameters such as the mean stroke rate (SR) and the mean stroke length (SL) are often investigated. The product between SR and SL determines the average pure swimming speed (*s*), without the effect of starts and turns (Craig & Pendergast, 1979). The interaction between SR and SL, according to Hay and Guimarães (1983), allows an increase in *s* and, consequently, in performance. However, these parameters are inversely related. To increase *s* acutely, the observed strategy is to increase SR. On the other hand, in response to training, the chronic effect generates an increase in *s* as a result of an increase in SL due to physiological and technical adaptations (Yanai, 2003). Theoretically, as a swimmer trains and improves physiological and technical skills, the SL increases, leading to greater *s* in more technical swimming (Castro et al., 2021). The same behavior is also expected in swimmers with amputations (Figueiredo et al., 2014).

Although swimming is recognized as a symmetrical sport, balance between each side of the body cannot be assured. Swimmers with physical and motor impairments may present even more pronounced asymmetries (Santos et al., 2020). Swimmers with upper limb amputation need to compensate for the lack of propulsive segment (Prins & Murata, 2008) and consequently use more SR to increase *s* (Prins & Murata, 2008; Hogarth et al., 2018). Regarding the behavior over 200 m front crawl, Castro et al. (2021) found that there was a decrease in *s* until the third 25 m bout and then it stabilized.

In front crawl swimming, the upper limb movements (alternating) are responsible for about 85-90% of the propulsion, generated mainly by hands and forearms, in swimmers with typical anatomy (Toussaint & Beek, 1992). However, there are phases that are not propulsive, such as recovery and entry until the hand "catches" the water (Chollet et al., 2000). Each swimmer adapts the beginning and the end of each phase for both upper limbs according to the restrictions imposed on them (*s*, for example). Therefore, it is important to understand the coordination of the upper limbs by the temporal identification of the beginning and end of propulsive and non-propulsive phases. In this context, swimmers with physical impairments in the upper limb (amputation in the elbow region) have a loss in propulsion compared to swimmers with typical anatomy. If this occurs, the swimmer needs to use the existing surface area of the limb to generate propulsion (Prins & Murata, 2008).

To assess the inter-arm coordination, Chollet et al. (2000) proposed the quantification of coordination (the Index of Coordination – IdC) based on the division of the stroke into four phases for each of the upper limbs, two of which are highlighted as propulsive (pull and push - submerged) and the other two as non-propulsive (recovery and entry to support). Thus, the inter-arm coordination can be described from three models: (i) opposition model, when one of the upper limbs starts the pull exactly when the other ends the push phase, resulting in a continuous series of propulsion actions; (ii) capture model, which has a time delay between the propulsion phases of the upper limbs, and (iii) superposition model, characterized by the start of the pull phase before the end of the push phase (Chollet et al., 2000).

The IdC makes it possible to identify quantitatively the coordination model adopted by the swimmer (Chollet et al., 2000). The IdC is the time between the beginning of the propulsion phase of an upper limb and the end of the propulsion phase of the other upper limb and it is calculated by means of the time delay (difference) between the start of the propulsive action of one stroke and the end of the propulsive action of the other stroke. For swimmers with upper limb amputation the IdC is adapted (IdCAdapt), which is obtained from a common point in both upper limbs (Osborough et al., 2010).

In swimming 200 m events, it is known that there are difficulties in keeping the SL constant over the distance and thus there is an increase in SR in the last laps to maintain or increase the *s* (Figueiredo et al., 2013). Furthermore, Ramos Junior (2017) suggests that swimmers with physical impairment have difficulty in maintaining maximal aerobic effort. Thus, checking the behavior of the kinematic and coordinative variables throughout the 200 m race allows coaches, swimmers, and researchers to clearly understand the conditions of the athlete's swimming technique, to identify possible solutions for strategies to be adopted throughout the race, and to have more objectivity and transparency in determining the athlete's eligibility (Payton et al., 2020; Santos et al., 2021).

It is noteworthy that there are few studies regarding the performance of swimmers with physical impairments (Feitosa et al., 2019). Therefore, the objective of this study was to analyze the performance of swimmers with amputations in the T200, through kinematic and coordination variables in two moments (75-100 m and 175-200 m) of the test, and through peak oxygen uptake.

Methods

Participants

Six volunteer swimmers (four males and two females) with upper and lower limb amputation participated in this study (mean age 30.0 ± 9.8 years; mean height 174 ± 0.07 cm; mean upper-arm span 162.3 ± 26.1 cm; mean total body mass 70.4 ± 8.6 kg), with previous experience in the sport of 5.1 ± 3.5 years. All of them trained five times a week with an average of approximately 2,800 m per training session with competitive objectives at national or international level. All of them were from sport classes S8 to S10 of the International Paralympic Committee (IPC, 2015). Participants were in the following sport classes: S8 (n = 1; male with unilateral amputation near the right shoulder); S9 (n = 4; one male with forearm amputation and three with transfemoral amputation - two males and one female) and S10 (n = 1; female with transtibial amputation). All participants had been classified in their respective sport classes in the last two months before data collection by the Brazilian Paralympic Committee. The study was approved by the Research Ethics Committee of the University where it was carried out (Comitê de Ética em Pesquisa da Universidade Federal do Rio Grande do Sul – UFRGS, number 2.274.037) and complied with national and international guidelines regarding research with human beings. All participants received and signed an Informed Consent Form to participate in the research and received verbal explanations about methods and objectives.

Anthropometric Assessment

Anthropometric measurements were collected before the T200: (i) body mass (kg), wearing swimming clothes and barefoot; (ii) height (cm), standing upright, with feet together and close to the stadiometer and upper limbs beside the trunk in a relaxed manner, the head adjusted after a deep breath, according to the Frankfurt plane (Eston & Really, 2009); and (iii) upper arm span (cm): lying on the ground, in dorsal decubitus, shoulders abducted at 90°, and elbows, wrists, and fingers in extension. The maximum distance between the extremities of the upper limbs was obtained. After the anthropometric measurements, 19 references were marked with non-toxic black ink on the swimmer's skin to be later digitized: vertices of the shoulder, elbow, wrist, femoral trochanters, meta phalangeal joints of the fingers, and toes, knee, ankle; both on the right and left sagittal planes. These markings, approximately 2 cm in diameter, were necessary for subsequent digitization of landmarks for three-dimensional (3D) kinematic analysis (Sanders et al., 2015).

Experimental design

To familiarize participants with the test equipment, they used, for six to ten usual training sessions before the test, a conventional snorkel together with a nose clip. Along these sessions, participants performed open turns. The test protocol was an all-out 200 m front crawl (T200). Participants were instructed not to perform any physical activity and to abstain from caffeine and alcohol 24 h before the test. Before T200, the athletes performed a standardized warm-up of 600 m in front crawl stroke: 200 m at light to moderate intensity, 200 m with a conventional snorkel and the use of a nose clip, and 200 m with a snorkel (Aquatrainer, Cosmed, Italy) connected to a gas analyzer (K5, Cosmed, Italy) and a nose clip.

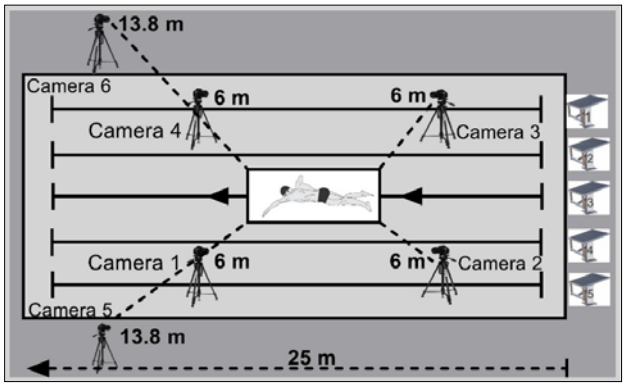
The swimmers performed the T200 individually and performed (i) starting from the pool edge, (ii) with open turns, always to the same side, without underwater gliding, and (iii) swimming without cervical rotational movements during breathing, due to the use of the snorkel. During the T200, a manual chronometer (CASIO HS-30W, Japan) recorded the time in seconds from the beginning to the end of the test (performance). The T200 was performed by all athletes under the same environmental conditions, in a 25 m indoor heated pool—water temperature approximately 28 °C.

Kinematic data acquisition

The kinematic parameters were acquired using three-dimensional (3D) videogrammetry with six fixed cameras (operating at 60 Hz), four of which were positioned underwater (0.5 m) inside watertight box, and two above water (1.52 m high from the ground) (De Jesus et al., 2015).

The course swum by the athletes was recorded by the cameras within a calibrated space located in lane 3 of the pool, oriented longitudinally (x-axis as the swimmer's direction), equidistant from both heads of the pool (Figure 1) with dimensions of the calibrated space structure of x = 4.5 m (horizontal axis); y = 1 m (medial-lateral axis); z = 1.5 m (vertical axis). A light signal, recorded simultaneously by the six cameras, was used to synchronize the images from the video cameras on the same time base as a reference in the reconstruction of the coordinates in the analysis software.

Figure 1
Positioning of the cameras for 3D analysis and the calibrated space.



In two laps of T200 (M1, from 75 to 100 m, and M2, from 175 to 200 m), a stroke cycle was analyzed, starting with the entry and re-entry of the same hand into the water (Barbosa et al., 2008). One cycle was used for all swimmers. The chosen cycle was the one in which the swimmers were more centered in the calibration volume space, with the beginning and end of the cycle within the previously calibrated space. The distance traveled by the swimmers within the calibrated space was used for the 3D image analyses. For the swimmers with upper limb amputation, the cycle was adapted to the entry and re-entry from the distal part of the limb into the water. The calibration frame was recorded by the cameras for three seconds before the swimmers started the T200, to provide the spatial parameters for the conversions of the images from two dimensions into three dimensions, with Direct Linear Transformation (DLT) by calculations performed in the Ariel Performance Analysis System (APAS) software. The images were cropped (stretches of swimming in the calibrated space) and converted (AVCHD 1080p to AVI 1,080 × 720 p, uncompressed format) by means of Sony Vegas Pro 15 Software (MAGIX GmbH & Co. KGaA, Germany).

Then, the images were uploaded to the APAS software through trimming, in which were processed to obtain the kinematic and coordinative parameters. The digitalization was manual, at each frame, of the 18 markers on the swimmer's body (vertex of the head, middle finger, wrist, elbow, shoulder, hip, knee, heel, and first metatarsal phalanx) and a fixed marker in the same place in all frames. At the end of the digitization of each moment—a stroke cycle—24 calibration volume control markers were digitized and used for the transformation from two to three dimensions DLT. Finally, the display was used to identify the displacement results of all the scanned markers for the calculations of the kinematic variables. The frame location of the center of body mass was identified. The data were smoothed by a Butterworth filter with a cut-off frequency of 4 Hz passed low second order. The results were saved in Microsoft Excel spreadsheets and saved in txt format files for the variable calculations.

To evaluate the coordination model and the duration of the stroke phases, the horizontal and vertical coordinates of the hands and shoulders were identified, frame by frame, the beginning and the end of each stroke phase, total propulsive and total non-propulsive, as described below (Chollet et al., 2000):

- Entry and support: time between the entry of the hand into the water until the beginning of the backward movement of the hand or the distal part of the upper limb in the case of swimmers with amputation (phase onset: first frame in which the entry of the hand into the water was identified).
- Pull: time between the beginning of the backward movement of the hand or the amputated arm until it is below the swimmer's shoulder (beginning of the phase: first frame in which the horizontal coordinate of the hand decreased, after the hand entered the water).
- Push: elapsed time between the time the hand is below the shoulder line to the side of the thigh breaking the surface of the water (phase start: frame in which the vertical coordinates of the shoulder and hand markers were the same).
- Recovery: elapsed time between the hand out of the water and the same hand entering the water in front of the swimmer's body (phase start: frame that the hand marker appears out of the water).

Kinematic data collection

The *s* was obtained by the quotient between the horizontal displacement of the center of mass (x-axis) over the stroke cycle and the time to complete the same cycle. The SR was calculated by the inverse of the stroke cycle duration multiplied by 60. The SL was identified by the horizontal displacement of the swimmer's center of mass during the stroke cycle.

Identification of the coordination model

The coordination model was identified by calculating IdC (for swimmers without upper limb amputation) and IdCAdapt (for the swimmer with upper limb amputation) (Chollet et al., 2000; Osborough et al., 2010). The average duration of each stroke phase was determined after scanning the first two consecutive movements (one of the right arm and one of the left arm) (Chollet et al., 2000). At the time the swimmers entered the calibrated space, such as by the left upper limb, the IdC was defined as the time interval between the end of the push phase of the left upper limb and the beginning of the pull phase of the right (LT1) and the time interval between the end of the push phase of the right upper limb and the beginning of the second phase of the left (LT2) (Chollet et al., 2000). Regardless of which hand enters the pre-calibrated space first, the average delay between the push phases of the two was presented as a percentage of the average time of a complete stroke cycle (T) (Chollet et al., 2000), using Equation 1, to calculate IdC or IdCAdapt:

Equation 1

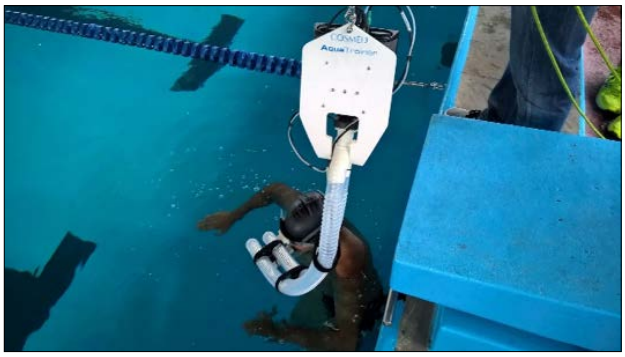
$$IdC = \frac{(LT1 + LT2)}{2} * \frac{100}{T}$$

Thus, when IdC or IdCAdapt were < 0, the coordination model was capture; when IdC or IdCAdapt were = 0, the model was opposition and when IdC or IdCAdapt were > 0, the model was overlapping (Chollet et al., 2000).

Peak oxygen uptake (VO_{2peak})

T200 only started when the respiratory exchange rate (RER), identified by the ergospirometer, was close to 0.8. During T200, VO_2 and RER were collected in a continuous breath-by-breath mode. Before the beginning of all collections, the ergospirometer was calibrated according to the manufacturer's instructions. After calibration, it was connected to the athlete by a snorkel for respiratory gas uptake (Figure 2). All this apparatus was suspended at a height of 2 m from the water surface by means of carabiners and steel cable with pulleys, thus making it possible to follow the swimmer along the pool, minimizing the disturbances created to the swimmer's movements (Sousa et al., 2013). After the test, the oxygen uptake values were manually filtered using the mean ± 4*standard-deviation reference value (De Jesus et al., 2014) to minimize artifacts from gas uptake that does not represent physiological data. The moving average of five breaths was used in the analyses (Fernandes et al., 2011). The VO_{2peak} was considered the highest value identified during the test (Ribeiro et al., 2016).

Figure 2
Swimmer breathing into the tube for respiratory gas uptake.



Statistical analysis

The Shapiro-Wilk normality test was applied. Means, standard deviations, and limits of confidence intervals of the mean (CI 95%) of all variables in this study were calculated. For comparison between the two analyzed 200 m laps, Student's t-test for paired data was applied. Statistical significance was set at $p < .05$. The effect size used was Hedge's g, with the following categorization: 0 to 0.19 trivial; 0.2 to 0.59 small; 0.6 to 1.19 moderate; 1.2 to 1.99 large; 2.0 to 3.99 very large, and > 4 nearly perfect (Hopkins, 2002).

Results

The mean performance on the T200 was 197.8 ± 24.7 s (CI 95%: 171.9 to 223.7 s). By sport class, performance on the T200 was 195 s (S8, *n* = 1), 192 ± 28.3 s (S9, *n* = 4), and 221 (S10, *n* = 1). The VO_{2peak} mean and standard deviation were 44.1 ± 8.4 $ml \cdot kg^{-1} \cdot min^{-1}$ (CI 95%: 35.2 to 53.1 $ml \cdot kg^{-1} \cdot min^{-1}$). Table 1 shows the mean values, standard deviations, and CI 95%, results of the comparisons, and the stretch's effect sizes in the T200.

Table 1
Mean ± standard deviations, limits of confidence intervals of the mean (95%) and statistical data for s, SR, SL (n = 6), IdC (n = 5) and stroke length phases of stretch 1 and 2 (S1: 75-100; S2: 175-200 m) respectively of T200.

	S1 (75 - 100 m) Mean ± sd; (CI 95%)	S2 (175 - 200 m) Mean ± sd; (CI 95%)	t-student; *p*-value Hedge's g'
Swimming speed ($m \cdot s^{-1}$)	0.99 ± 0.15 [0.83 to 1.16]	0.96 ± 0.19 [0.76 to 1.16]	0.65;.61 0.17
Stroke rate ($cycles \cdot min^{-1}$)	40.5 ± 6.8 [33.4 to 47.6]	41.5 ± 3.2 [38.1 to 44.9]	–0.46; .60 0.18
Stroke Length (m)	1.51 ± 0.38 [1.10 to 1.91]	1.39 ± 0.38 [1.07 to 1.70]	1.36; .23 0.31
IdC/IdCadapt (%)	-4.4 ± 9.2 [-15.9 to 7.0]	-3.5 ± 8.9 [-14.6 to 7.5]	–0.46; .61 0.09
Entry and support phase (%)	30.7 ± 12.0 [15.7 to 45.8]	30.2 ± 6.4 [22.1 to 38.2]	–0.25; .81 0.05
Pull phase (%)	13.4 ± 8.5 [2.8 to 24.0]	15.7 ± 2.7 [12.3 to 19.1]	–0.53; .61 0.36
Push phase (%)	23.0 ± 6.2 [15.2 to 30.8]	24.7 ± 7.3 [15.7 to 33.8]	0.64;.55 0.25
Recovery phase (%)	32.7 ± 11.0 [18.9 to 46.5]	29.3 ± 4.6 [23.6 to 35.0]	–0.73; .50 0.40
Propulsive phases (%)	39.4 ± 13.2 [25.4 to 53.2]	42.3 ± 6.0 [35.9 to 48.6]	-0.65; .54 0.28
Non-propulsive phases (%)	60.6 ± 13.2 [46.7 to 74.5]	57.7 ± 6.0 [51.3 to 64.0]	0.65; .54 0.28

IdC = Index of coordination.

Effect sizes (stretch effects in T200) were (i) trivial for swimming speed, stroke rate, IdC/IdCAdapt, duration of entry and support, and pull phases; and (ii) small for stroke length, duration of pull, push, recovery, propulsive and non-propulsive phases.

Discussion

The present study aimed at describing the performance of swimmers with amputations in the T200, through kinematic and coordination parameters in two stretches of the test and by the peak oxygen uptake. The main findings of this study were that the kinematic variables did not present statistical variations regarding the two stretches analyzed, the coordination was classified as capture and peak oxygen uptake was lower than that found with swimmers without impairment in the same test, by direct method gas exchange system by telemetry (Figueiredo et al., 2013). The effect sizes of the analysis times on the variables were trivial or small.

According to Prins and Murata (2008) and Osborough et al. (2009), swimmers with physical impairments in general, and with upper limb amputation, in particular, to achieve and maintain the desired s, compensate for the lack of the propulsive segment with higher SR values when compared to swimmers without physical impairment. That is, SR plays a more important role in relation to performance than SL. In the present study over 200 m, s and SR statistically remained constant (trivial effect size implied in reduction of s and increase of SR), whereas the SL showed a greater decrease (small effect size). This result supports the importance of SR for swimmers with amputations. It is noteworthy that this behavior was the same for all swimmers in the present study: four with lower limb amputations and two with upper limb amputations. That is, the reduced propulsive capacity of the lower limbs also led to increased SR for the maintenance of s.

Compared to swimmers with typical anatomy, a similar behavior of SR and SL for the 200 m front crawl (increase in SR and decrease in SL throughout the 200 m) was identified in 11 of the 17 swimmers (Huot-Marchand et al., 2005). However, a higher *s* ($1.45\ m \cdot s^{-1}$) reached by a higher SL (2.1 m) and similar SR ($41.4\ cycles \cdot min^{-1}$) in relation to the swimmers of the present study in the same test. At least for swimmers with physical impairments at the national level (100 m freestyle events), SL seems to be more directly related to the *s* and sport class for the male and female genders (Pérez-Tejero et al., 2018).

Also, in T200 with typical swimmers, Franken et al. (2016) analyzed four 25 m splits before the 50, 100, 150 and 200 m of T200 m, and found an increase only between 50 and 200 m in SR. On the other hand, SL values decreased from 50 m to 200 m. Thus, it can be verified that both, swimmers with impairments and swimmers with typical anatomy, throughout T200, tend to increase SR, while SL decreases, modifying the way the s is reached and maintained over the distance assessed.

Regarding the inter-arm coordination, the effect sizes of the analyzed laps of T200 were trivial for IdC or IdCAdapt and all swimmers, in both stretches of the test, performed the front crawl swimming in capture model. In a T200, among swimmers without impairments, a capture model was observed in the study by Figueiredo et al. (2010), assessing the coordination of six conventional athletes who presented capture coordination during the entire 200 m test. An increase in IdC was also observed in the 4th 50 m partial and this, according to the authors, was attributed to an attempt to maintain s when there is a decrease in SL. Increasing SR is at the expense of reducing the duration of the non-propulsive phases of the strokes, which also leads to a reduction in the time without propulsion. Whereas in the study of Franken et al. (2016) the values of IdC did not change during the analyzed T200 partials. For Franken et al. (2016), only at high s, when SR is high, is there a change from capture model to opposition/overlap.

The behavior of the phases' duration along the T200 in this study was similar to that found in the literature (Franken et al., 2016). In the same study, no statistical differences were found in the duration of the entry and support, pull, and recovery phases at T200, but an increase in the duration of the pull phase was observed. This increase may be related to the maintenance of body balance and because it is the beginning of the movement that would be more propulsive in front crawl stroke due to the absence of other typical limbs (Santos et al., 2020). The reasons for this imbalance may be a preference for unilateral breathing, strength imbalance between homologous muscle pairs, and motor control deficit. Improving hand speed, and optimizing the pull phase, seems to be a crucial point to be improved among amputee swimmers (Santos et al., 2021).

In relation to VO_{2peak}, it can be verified, for the same T200, reduced values of the present study swimmers (44.1 ± 8.4 ml·kg^{-1}·min^{-1}) in comparison to high level swimmers of typical anatomy (68.5 ± 5.7 ml·kg^{-1}·min^{-1}) (Sousa et al., 2011), and master swimmers of typical anatomy (52.5 ± 6.3 ml·kg^{-1}·min^{-1}) (Trindade et al., 2018). By the amputations, reduced muscle mass causes decreased muscle perfusion, which in turn reduces the VO_2 values (Saltin et al., 1998). In this way swimmers with limb amputation have lower VO_{2peak} than those with typical anatomy, even master swimmers. Along with the already lower VO_2, the difficulty of swimmers with a deficiency in maintaining maximal aerobic effort is highlighted (Ramos Junior, 2017).

As the main limitation of this study, the sample size can be highlighted. This limitation does not allow extrapolation of the data to all populations of swimmers with physical impairment. However, the results allow for approximations within the context of swimmers with amputations. Future investigations may be carried out with this population for a better understanding of the data with the purpose of helping professionals involved with sports for people with impairment.

Conclusion

The findings of this study indicate that at T200 amputee swimmers tended to modify kinematic variables over times M1 and M2 with an increase in SR and decrease in SL, as well as a decrease in *s*. The athletes adopted coordination in capture and spent most of it in non-propulsion phase. The peak oxygen uptake was lower than that found with swimmers without impairment in the same test.

Disclosure statement

No funding. The study was approved by the local ethics committee (Comitê de Ética em Pesquisa da Universidade Federal do Rio Grande do Sul – UFRGS, number 2.274.037) and was performed in accordance with the Declaration of Helsinki.

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Lessons from COVID's social distancing in the Physical Education class

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Abstract

The present study aimed to analyze the impact of maintaining or not social distancing on the satisfaction of basic psychological needs and the intention to be physically active of Primary Education students in Physical Education. A quasi-experimental design with pre-test-post-test measures was used. A total of 149 students (72 boys, 77 girls; 9-12 years old) from eight classes of a school in northern Spain (75 in 5th grade, 74 in 6th grade) participated. The data obtained are the result of the comparison between two eight-session educational interventions: one in the experimental group (n = 74), in which social distancing was maintained at all times, and another one in the control group (n = 75), where the same proposals were developed, but social distancing was not maintained. It was found that no variable was affected by the maintenance of social distancing and, in addition, the students' competence-satisfaction increased significantly only in the group that experienced it. Thus, this study found that, contrary to expectations, due to the "social" nature of the subject, the imposed distancing had no negative effects in the short term.

Keywords: autonomy, competence, primary education, relatedness, students.

Introduction

In 2019, COVID-19 appeared abruptly in our lives changing, among many other things, the educational system as we knew it. Most countries ordered mandatory home isolation, forcing teachers to go online teaching with hardly any training. Unfortunately, a systematic review (Viner et al., 2021) reported the association between school closures and harm to the health and well-being of children and youths.

To avoid the negative impact of the lockdown, in the 2020-21 academic year, the educational administrations moved back to face-to-face teaching, providing a plethora of changes, including rules and recommendations to guarantee a safe back-to-school (Filiz & Konukman, 2020). National and international organizations (CDC, 2020; European Physical Education Association, 2020; UNICEF, 2020) published basic principles and guidelines for COVID-19 prevention when reopening educational facilities. Wearing face masks in the school setting, constant disinfection of materials and facilities, and maintaining a physical distance of at least 3 feet (1 meter) were common key takeaways from these administrations. This last rule was seen as a true challenge in physical education, especially difficult to follow because of its social character, with frequent contact among students. As a consequence of the difficulties faced, individual teachers, as well as professional organizations (James [@kjamespe], 2020; Professional Development Service for Teachers, 2020), developed sets of activities following the international guidelines for COVID-19 prevention, which included avoiding team sports to elude contact among players (Filiz & Konukman, 2020), and the promotion of students' autonomy and self-regulated learning (Fernández-Río, 2020). Additionally, professional organizations such as the Physical Education Association of Ireland (2020) offered their expertise to the teachers designing a traffic light system to evaluate the risk involved in the physical education activities to be used in class. In the United Kingdom, the Association for Physical Education (2020) analyzed the government guidance for the context of physical education and developed suggestions based on it. In Spain and Canada, the General Council of Physical Education and Sports (2020) and the Physical and Health Education Canada (2020) developed documents with pedagogical recommendations for a safe return to in-person physical education after the online schooling period. Despite the difficulties for teachers and students, they all highlighted how important it was to maintain social distancing in the physical education class.

The scarce previous research conducted on the impact of the COVID-19 pandemic on physical education has focused on teachers. Varea and Gonzalez-Calvo (2021) assessed the effects of the social distancing imposed on a group of pre-service physical education teachers during their practicum, which was conducted online. The authors concluded that the future teachers believed that the subject was losing its identity because of the lack of direct contact and that the teacher education programs should prepare better their students to teach physical education online. On his part, Howley (2022) conducted a study across different countries which faced the same online remote teaching in physical education. Although inequity hindered the analysis of a uniform experience, Howley (2022) uncovered issues such as flexibility in implementation and assessment, narrow (traditional) pedagogical approaches with an emphasis on physical activity and exercise, and lack of social and emotional support for students and equitable access. He concluded that traditional approaches to teaching and learning fell short facing the new situation and that there is a need for continuous professional development on remote and/or blended learning. In Sweden, where schools did not close at any time throughout the pandemic, physical education teachers also decreased physical contact with their students (Kamoga & Varea, 2022). They reported experiencing a challenge while teaching due to the significant changes in the context confronted, the content implemented, the roles experienced and the responsibilities faced, which included avoiding physical contact and enforcing social distancing. Along the same line, Hortigüela-Alcala et al. (2021) found that primary, secondary and future physical education teachers highlighted the negative impact of social distancing, which limited the content to be taught. Therefore, the "new reality" brought by the COVID-19 pandemic has imposed changes in the way physical education is taught in schools worldwide, where physical contact among the students and with the teachers was part of the class (Varea et al., 2022). Research showed that social distancing was an issue for many physical education teachers. Some even admit in private that they cannot maintain it in many classes because they lack enough resources and materials for

all the students or because they do not believe in "this new" physical education, and they focused on wearing masks at all times and reinforcing hygiene. The question is: what about the students? What do they think of the "new context"?

Self-Determination Theory (Deci & Ryan, 1985) is one of the leading theoretical frameworks used to study and understand individuals' behavior, including motivation. It includes five mini-theories, one of them being the Basic Needs Theory (Ryan & Deci, 2002). Used in the context of physical education (Diloy-Peña et al., 2021; Vasconcellos et al., 2020), it describes the existence of three basic psychological needs in any individual: a) Autonomy: which is the desire of being responsible for one's behaviors; b) Competence: it is the personal perception of being effective when performing a task; and c) Relatedness: it is the sense of belonging to a group. Research has shown that each one of these needs can be promoted or thwarted depending on the teacher's decisions (Deci & Ryan, 2000). Basic psychological needs' thwarting promotes less self-determined types of motivation: extrinsic (to perform an activity to please others) or even amotivation (not to have the desire to perform an activity) and negative consequences such as anxiety or lack of effort (Vasconcellos et al., 2020). On the other hand, promoting the individuals' basic psychological triggered the most self-determined types of motivation: intrinsic motivation (to perform an activity for pleasure), and positive consequences, such as better interpersonal relations, learning, or enjoyment (Deci & Ryan 2016). Moreover, it has also been linked to an increase in students' moderate-to-vigorous physical activity (Grasten et al., 2021). This is extremely important in a world where physical inactivity is high and is linked to negative health consequences (Sallis et al., 2021).

In this trend, research has shown that school contexts can become perfect scenarios to promote students' regular physical activity practice and help them avoid sedentary behaviors (Tremblay et al., 2016). Therefore, "the goal of physical education is to develop physically literate individuals who have the knowledge, skills, and confidence to enjoy a lifetime of healthy physical activity" (Shape America, 2021). One of them is adherence to a physically active lifestyle (Silva et al., 2018). Physical education teachers can promote their students' basic psychological needs by avoiding controlling teaching styles, which can also damage their self-determined motivation (Trigueros et al., 2019). This type of motivation has also been found to positively predict the students' intention to be physically active in their free time (Hagger & Chatzisarantis, 2016).

Based on the aforementioned, two questions arise: what has been the impact of COVID-19 on the students in the physical education class? How did it affect their behaviors, values, or intentions? Most of the existing published research has focused mainly on the impact of the COVID-19 pandemic on teachers (Hortigüela-Alcala et al., 2021; Howley, 2022; Kamoga & Varea, 2022; Varea et al., 2022; Varea & Gonzalez-Calvo, 2021). One previous study focused on physical education students revealed that students retrospectively reported that COVID-19 safety measures generated emotional changes in students (Hortigüela-Alcala et al., 2022). Thus, it seems vital to assess the effects of one of the most widely mentioned consequences of the pandemic, in-class social distancing, on students from inside the physical education class to understand it and be able to adjust. Therefore, the main goal of the present study was to analyze the impact of maintaining, or not, in-class social distancing on students' basic psychological needs and their intentions to be physically active. The first hypothesis was that the students' basic psychological needs would be negatively affected. The second hypothesis was that their intentions to be physically active would be negatively affected too.

Methods

Participants

A quasi-experimental research design with experimental and control groups and pre-test-post-test measures was conducted (Dimitrov & Rumrill, 2003). A total of 149 students agreed to participate in the study, selected through non-probabilistic purposive sampling. They were enrolled in eight primary education classes in a school located in northern Spain (75 students in 5th grade and 74 students in 6th grade). The sample consisted of 72 boys (48%) and 77 girls (52%) aged between 9 and 12 years (M = 10.43, SD = 0.61). Of the 149 participants, 74 (two classes of 5th grade and two classes of 6th grade) constituted the experimental group (which experienced

activities with 1.5 meters of social distancing during the whole session) and 75 (two classes of 5th grade and two classes of 6th grade) constituted the control group (which did not experience social distancing during the classes). All the sessions were coordinated by one of the authors of this work, and a teacher at the school, and implemented by a total of four teachers (one for each of the two class groups). The teachers (like all others everywhere) had no previous experience in such extraordinary circumstances like the ones caused by COVID-19 and they were forced to adapt their teaching and their classes to this new and changing context.

Instruments

Sociodemographic variables. Information was collected on three individual variables: gender, age, and grade level.

Basic psychological needs. To assess the satisfaction (or not) of these needs, the subconstruct *Satisfaction* of the Spanish-validated version (Longo et al., 2018) of the Basic Psychological Needs Satisfaction and Frustration Scale (Longo et al., 2016) was used. Through this Likert-type scale with seven response options (from one: "totally disagree" to seven: "totally agree"), students' feelings of satisfaction with their autonomy, competence, and relatedness were assessed. There are seven response options to sentences headed by: "I feel that...". Three dimensions can be obtained in this scale: Autonomy-satisfaction (e.g., "...I have the freedom to decide how to do things"), competence-satisfaction (e.g., "...I am pretty good at the things I do"), relatedness-satisfaction (e.g., "...I matter to the people around me"). In the present study, Cronbach's alphas were: autonomy: .82 and .90, competence: .80 and .78, and relatedness: .83 and .89 on the pre-test and post-test, respectively.

Intention to be physically active. To evaluate the intention of the participating students to be physically active, the Spanish-validated version (Moreno et al., 2007) of the Intention to be Physically Active Scale of Hein et al. (2004) was used. It is a Likert-type scale composed of five items (e.g., "Apart from physical education classes, I like to practice sports") preceded by the stem: "Regarding your intention to practice physical-sports activity...". It presents 5 response options, where one corresponds to "totally disagree" and five to "totally agree". In the present study, Cronbach's alphas were: .65 and .69 in the pre-test and post-test, respectively.

Procedure

First, permission was obtained from the Ethics Committee of the researchers' university (023/2022). Secondly, prior to the implementation of the program, the research team contacted the target school and the teachers involved to fully explain the study. Permission to conduct the study was obtained and all signed written consent. Then, the families involved were contacted to explain the project. Those willing to let their children participate signed a written consent explaining the purpose of the project, the option of completing the questionnaires or quitting the study at any time, the anonymity of the data processing, and that the project will not affect their grades. All participants were treated according to the ethical guidelines provided by the American Psychological Association (2019). Data collection was carried out before and after the intervention. The teachers offered the questionnaire to the students, who completed it in the class before the first session of the intervention program and after the last one.

Intervention program

The data obtained in this study were the result of the comparison between two educational interventions (learning units), eight sessions long, conducted in physical education: one in the experimental group, where an in-class social distance of 1.5 m was maintained at all times (including breaks, teacher's explanations, and students' performance) and another one in the control group, where the same activities were used, but in-class social distance between students was not enforced by the teachers. All participating students had previous experience with in-class social distancing (prior to the intervention, COVID-19 measures had been withdrawn, and physical education classes were conducted without social distancing and face masks). The research team carefully designed all activities and sessions based on proposals from different organizations and individuals to maintain in-class social distancing (Fernández-Río, 2020; Filiz & Konukman, 2020; James [@kjamespe],

2020; Professional Development Service for Teachers, 2020). These included non-contact, open-ended (multiple valid solutions), self-regulated tasks to work on basic locomotor (e.g., running, jumping, sliding, skipping) and non-locomotor skills (e.g., throwing, catching, turning). The structure of the sessions was the same for the experimental and the control groups: (1) warm-up and activation, (2) main part, and (3) return to calm. Four different teachers, including one of the authors, implemented the proposal designed during the same weeks (at this point in the pandemic, some authorities recommended social distancing during the school period, but there was no rule requiring it). All students wore facemasks during the sessions. Two of the teachers, long before the beginning of the study, had been conducting their physical education classes without enforcing the 1.5 m in-class social distancing recommendation, and they agreed to participate in the study, to include their classes in the control group and to follow the same learning unit than the experimental group (with minimal adaptations of the activities), but no social distancing was enforced. Students in the experimental group did not share any material, while those in the control group did. The research team supervised that each study group was taught, at all times, according to the teacher's decision: with or without enforcing in-class social distancing. For this purpose, a researcher was present during the sessions. Furthermore, all sessions were recorded and 40% were randomly selected to evaluate the correct implementation of the program. Results showed that 100% of lessons complied with the selected framework.

Data analysis

Analyses were performed using IBM SPSS Statistics v.24.0 software (SPSS Inc., Chicago, IL, USA). First, normality tests were conducted. The results of the Kolmogorov-Smirnov test revealed that data was not normally distributed. However, F-statistics are still considered a valid statistical procedure when there is no normality, but the skewness and the kurtosis are between –1 and 1 (Blanca et al., 2017). For this study, all values before and after the intervention were in this range, except for the relatedness-satisfaction and autonomy-satisfaction variables after the intervention, which obtained a skewness value of –1.17 and a kurtosis value of –1.17, respectively. So, it was possible to perform parametric tests. Descriptive statistics (means and standard deviations) were calculated for each group and gender before and after the intervention. To compare between-groups and within-group differences, a 2 × 2 × 2 group (experimental/control) × test time (pre- and post-intervention) × gender (boys and girls) multivariate analysis of variance was performed. Effect sizes (Cohen, 1988) were calculated using the partial eta-squared statistic (η^2_p), considering small (> .01), medium (> .06), and large (> .14). Statistical significance was established at $p \leq .05$ (95% CI).

Results

Between-group pre-post-intervention analysis

For boys, no significant multivariate effect was found (Wilks' lambda = .99, F = 0.23, p = .92, η^2_p = .02) in the experimental group in contrast with those students who did not maintain social distancing during the intervention (control group). The pairwise analysis showed no significant differences between the boys who maintained social distancing and those who did not. For girls, a significant multivariate effect with a large effect size was found (Wilks' lambda = .80, F = 4.24, p = .004, η^2_p = .20). Pairwise analysis in girls showed significant differences between groups for autonomy-satisfaction both before ($p < .001$) and after the intervention ($p < .001$), being higher for the experimental group at all times.

Within-group pre-post-intervention analysis

No significant multivariate effect was found for any of the variables under study for boys (Wilks' lambda = .96, F = 0.66, p = 0.63, η^2_p = .04) or girls (Wilks' lambda = .98, F = .27, p = .89, η^2_p = .02) maintaining social distancing at all times. Additionally, no significant differences were again found for boys and girls in the pairwise comparisons between the pre-intervention and post-intervention scores, except for a significant improvement in the competence-satisfaction of boys in the experimental group (see Table 1).

Table 1
Descriptive statistics, between-group post-intervention and within-group pre-post-intervention analysis of each dependent variable.

		Pre-intervention (experimental group)	Post-intervention (experimental group)			Pre-intervention (control group)	Post-intervention (control group)		
Variables	Gender	*M (SD)*	*M (SD)*	*p*	*95% CI*	M (SD)	M (SD)	*p*	95% CI
Autonomy-satisfaction	Boys	3.96 (1.58)	4.04 (1.84)	.72	[–0.53, 0.36]	3.85 (1.76)	*3.92 (2.05)*	.76	[–0.53, 0.39]
	Girls	5.09 (1.50)*	5.18 (1.47)*	.70	[–0.51, 0.34]	3.79 (1.31)*	3.76 (1.64)*	.92	[–0.40, 0.45]
Competence-satisfaction	Boys	5.35 (1.30)	5.76 (1.23)	.03**	[–0.78, 0.03]	5.47 (1.06)	5.45 (1.10)	.89	[–0.36, 0.42]
	Girls	5.26 (1.46)	5.50 (1.32)	.19	[–0.6, 0.12]	4.86 (1.18)	5.16 (1.09)	.10	[–0.66, 0.06]
Relatedness-satisfaction	Boys	5.44 (1.14)	5.56 (1.54)	.60	[–0.55, 0.31]	5.31 (1.33)	5.22 (1.60)	.68	[–0.35, 0.53]
	Girls	5.51 (1.63)	5.80 (1.37)	.18	[–0.69, 0.13]	5.25 (1.62)	5.48 (1.60)	.59	[–0.64, 0.18]
Intention to be physically active	Boys	4.24 (0.76)	4.38 (0.70)	.14	[–0.34, 0.05]	4.20 (0.68)	4.17 (0.70)	.80	[–0.17, 0.22]
	Girls	4.28 (0.74)	4.25 (0.69)	.74	[–0.15, 0.22]	4.15 (0.73)	4.24 (0.73)	.31	[–0.28, 0.09]

Note: Between-group pre- and post-intervention analyses are reported with an asterisk (*) when $p < 0.05$; within-group pre-post-intervention analyses are reported with two asterisks (**) when $p < 0.05$.
M: mean; SD: standard deviation; CI: confidence interval.

Discussion

The present study aimed to assess the impact of maintaining, or not, in-class social distancing on students' basic psychological needs and their intentions to be physically active. The results showed that no variable was affected by the enforcement of social distancing. Furthermore, competence-satisfaction increased for boys who experienced social distancing after the intervention compared to before the intervention.

The first hypothesis was that the satisfaction of the psychological needs of the participating students would be negatively affected, and the results showed that it was not supported, since two needs experienced no changes (the values were maintained) and the third one, competence-satisfaction, significantly improved for boys in the group where social distancing was implemented in class after the intervention compared to before the intervention. These results indicate that students did not negatively experience social distancing in class. Consequently, it did not damage the satisfaction of their basic psychological needs and even increased their feelings of competence at the end of the intervention. Unfortunately, to our knowledge, there are no published studies that specifically assessed the effects of physical distancing on students to compare the results obtained in the present study. Previous studies on the impact of schools' physical education context resulting from the COVID-19 pandemic mainly focused on teachers and reported difficulties and concerns due to the lack of direct contact with pupils, changes in the context confronted, the content implemented, the roles experienced and the responsibilities faced (Howley, 2022; Kamoga & Varea, 2022; Varea & Gonzalez-Calvo, 2021). Perhaps the fact that students in the experimental condition were asked to regulate their performance, to work independently, in their own space, and at their own pace was positive to improve their competence-satisfaction. Moreover, in this group, where social distancing was constantly reinforced, students were able to work without the pressure exerted by their peers, which sometimes can pose a negative influence on their performance (Ruiz Pérez et al., 2018). Previous research found that students' peer influence appears to guide adolescents' emotional, cognitive, and behavioral engagement (Wang et al., 2018). The enforced in-class social distancing may have prevented this constant comparison and avoided outcomes such as negative peer pressure. In contrast, in the groups where social distancing was not maintained, students, although they had the same individual tasks, could interact with each other, and perhaps even exert the aforementioned negative peer pressure. Of course, this is speculative at this time and more research is needed to confirm or reject these ideas.

Despite reducing the possibilities of movement and socialization in the experimental group, students' autonomy-satisfaction and relationship-satisfaction were not affected and, even, competence-satisfaction increased for boys in the experimental group after the intervention compared to before the intervention. Several reasons could be argued to try to explain these positive trends found: (a) despite the enforced in-class social distancing, there continued to be rapport (relatedness) among the students (e.g. they could talk, laugh, encourage each other or ask each other questions during the completion of the tasks), and b) students had to perform all the tasks independently (they could not expect other classmates to do the tasks for them) and, therefore, they could rely only on themselves (autonomy). In other words, teachers supported the development of the student's basic needs (competence, autonomy, and relatedness), and the enforced in-class social distancing not only did not frustrate their development but in some cases (competence) promoted it. A recent systematic review of self-determination theory applied to physical education raised the possibility that peer support could lead to the satisfaction of all students' needs (Vasconcellos et al., 2020). The present study indicates that, at certain times, the absence of social interaction might also be beneficial to the satisfaction of students' needs. Perhaps, not only peer support could favor the satisfaction of the basic psychological needs, but the hypothetical absence of negative interrelationships could also have a positive impact on these needs. These ideas have a certain speculative character at this time, and more research is needed to confirm or refute them.

The second hypothesis was that the students' intention to engage in future physical activity would be negatively affected by social distancing. The results showed that it was not supported, as there were no significant differences after the intervention. Unfortunately, to our knowledge, there are no similar published studies to compare the results obtained in the present one. Nevertheless, previous research (Trigueros et al., 2019) found that there is a direct connection between the satisfaction of individuals' basic psychological needs and the most self-determined types of motivation, which, in turn, can predict students' intention to participate in physical activities in their free time (Hagger & Chatzisarantis, 2016). Therefore, considering that in the present study the satisfaction of the students' basic psychological needs was not negatively affected by the enforced in-class social distancing, their intentions to perform physical activity in the future were not negatively affected either. These results are in line with those obtained by Jang et al. (2021) in a

sample of adults during the COVID-19 pandemic in South Korea, where the satisfaction of the participants' basic psychological needs remained significantly related to their physical activity intentions. The results obtained in the present study could be considered noteworthy because they showed that the imposed social distancing did not negatively affect the students' healthy behavioral intentions such as future physical activity practice. Again, these ideas may be considered speculative at this time, and more research is needed to confirm or refute them.

Finally, the present study is not without several limitations. Firstly, it was based on an eight-session intervention program, which could be considered too short. Future studies should use a larger number of sessions to test the medium- and long-term effects of in-class social distancing. Secondly, the proposal was carried out in a single school. Future research should include different schools to encompass different populations and socioeconomic contexts. Thirdly, the particular characteristics of the students analysed, as well as the nature/type of the activities carried out during the intervention, establish a particular educational situation and therefore there is a limitation when attempting to generalize the data. Further, the teachers could have influenced the results, since they were not the same for the experimental and the control groups. Finally, a fifth limitation may be the quantitative nature of the research. Future studies should be based on qualitative or mixed research designs to achieve a global and more in-depth view of the problem under investigation.

Conclusion

In the short-run, the in-class social distancing recommended in the physical education classes did not hurt the satisfaction of the basic psychological needs of primary school students, nor their intention to engage in physical activity. On the contrary, the satisfaction of their competence was significantly increased for boys only in the group that experienced social distancing after the intervention compared to before the intervention. To our knowledge, this is the first study conducted on the impact of COVID-19 and specifically on one of the measures proposed to address it, social distancing, on the students in the physical education class. Contrary to the expectations, due to the "social" nature of the subject, the imposed distancing had no negative effects in the short-term and even increased the students' competence-satisfaction for boys in the experimental group after the intervention compared to before the intervention. More studies are needed to better understand the effects of the pandemic, but some decisions (measures) do not seem to have negatively affected students.

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Analysing self-concept, emotional intelligence and violence according to sport modality in Higher Education

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An athlete doing parkour.
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Abstract

Violence in the university context presents a serious concern for higher education, due to the increasing number of violent episodes among young people. The sport modality played together with psychosocial factors such as self-concept or emotional intelligence effectively counteract these disruptive behaviours. The aim of this study is to test the relationship between the type of sport played, self-concept and emotional intelligence with violence in university students. The study was conducted with a sample of 1,057 Spanish university students among whom 43.8% (n = 463) were female and 56.2% (n = 594) were male. The TMMS-24 test was used to measure emotional intelligence and the SC-5 scale to measure self-concept. Those who do not play sport were found to have higher rates of direct and indirect violence. Likewise, young people involved in contact sports have the highest rates of direct violence. It is necessary to promote the practice of physical activity related to the development of emotional intelligence in order to reduce violent behaviour.

Keywords: emotional intelligence, multigroup structural equation model, self-concept, sport, violent behaviour.

Introduction

Aggressiveness is a construct that has been widely examined in the field of psychology, and is defined as the performance of an action ranging from threatening gestures to actual attacks against another (Giammanco et al., 2005). Its manifestation into aggressive behaviour depends on multiple factors internal and external to the person (Haller, 2020). In this line, violence arises as a consequence of the individual's inability to control and manage his or her own impulses, turning him or her into a hostile and socially maladjusted subject in various environments. From a narrow perspective, violence implies the use of force with the intention of harming another person, but reducing violence to the physical act is a reductionist attempt to focus only on what can be measured (Martínez-Pacheco, 2016).

On the contrary, it is appropriate to consider violence from a relational perspective, where it appears as a consequence of the mechanisms of power that are produced in the interplay of social relations, in any context. There are many triggers that can lead to violent behaviour, such as the need for social recognition, anger or the need to maintain a certain status regardless of the consequences, among others. To mitigate this situation, it is important that the individual learns a repertoire of coping strategies that help to regulate and alleviate such impulses (García-Martínez et al., 2021).

Psychosocial factors have traditionally been related to people's overall well-being. Among them, emotional intelligence (EI), together with self-concept, have been identified as two reliable factors in determining the physical and psychological health of university students. In this respect, EI has been conceptualised using various models, most notably the ability model (Salovey & Mayer, 1990) and mixed models (Pérez-González et al., 2020). In this sense, EI can be defined as a person's ability to identify, express and regulate his or her emotions and those of others, with a view to building stable bonds with the environment around him or her.

On the other hand, self-concept is associated with the person's perception of him/herself in different environments, ranging from emotional and physical aspects to performance in academic, social and family environments. The study of both constructs contributes to the development and construction of a profile of the individual that enables one to predict the individual's behaviours to a certain extent. When examined from the field of physical activity and sport, it is observed that sport practice has also been identified as a factor that influences health, as a practice that is effective for channelling emotions and adverse feelings that a person may feel and maintaining balance.

Accordingly, distinctions are made depending on the type of sport played, with a distinction being made between individual and group sports. Another common criterion usually applied is the existence or non-existence of contact between athletes, with a distinction being made between contact and non-contact modalities. From the above criteria, the four categories to be considered in this study are: individual non-contact, individual contact, group non-contact and group contact.

In view of the above, the aim of this study is to examine the levels of aggressiveness, self-concept and emotional intelligence of university students according to the type of sport they play by means of an explanatory structural equation model.

Materials and methods

Design and sample

With regard to the study design, a cross-sectional, descriptive and non-experimental analysis was performed. It was carried out with a sample of 1,057 university students from Andalusian public universities selected using convenience sampling. Regarding the gender distribution of the sample, 43.8% ($n = 463$) were female and 56.2% ($n = 594$) were male, aged between 18 and 23 years (20.78 ± 2.85).

Resources

Four tools were used to collect data for this research. The *ad-hoc* questionnaire collected the socio-demographic data of the sample, such as gender, age and type of sport played.

The Trait Meta-Mood Scale (TMMS-24) developed by Salovey et al. (1995) was used to measure EI, but in this study the version translated into Spanish by Fernández-Berrocal et al. (2004) was used. This questionnaire assesses emotional intelligence as a trifactorial construct using 24 items, where the dimensions emotional attention, emotional clarity and emotional repair are scored through a summation. In this study, a Cronbach's alpha of $\alpha = .910$ was obtained for the overall scale.

With regard to the measurement of self-concept, the *Self-Concept Form 5*- SC5 (García & Musitu, 2014) was used. This scale is composed of 30 items and is divided into five categories: academic, social, emotional, family and physical. The questionnaire is completed on a 5-choice Likert-type scale, where 1 is "never" and 5 is "always". The internal consistency of the scale was $\alpha = .820$ in this research.

The *Scale of Violent Behaviour at School*, originally developed by Little et al. (2003) and adapted to Spanish by Estévez (2005), was used to measure violent behaviour. This questionnaire is divided into two categories: direct aggression is generated in a personal encounter between the aggressor and the victim; and indirect aggression, which occurs when the aggressor remains anonymous. The Likert-type scale is completed by responding to 25 items ranging from 1 "never" to 4 "always". In this research, an internal consistency of $\alpha = .880$ was obtained. The scale has been used in studies on adolescents, such as that of San-Román-Mata et al. (2019) or Zurita-Ortega et al. (2018) and in primary school students (Rojas-Jiménez & Castro-Sánchez, 2020; Sánchez-Zafra et al., 2018).

Procedure

The research process was divided into three phases. In the first, permission was requested from the University of Granada (Spain), and was granted by the corresponding ethics committee (2342/CEIH/2021). In the second phase, an informative letter was drafted explaining the objectives of the study and requesting informed consent from the participants. Following the agreed participation of 1,234 students, the questionnaire was sent to the students by email.

During the third phase, the 1,085 student responses were reviewed and 28 questionnaires were discarded because they were not properly completed. The data analysis was carried out between November and December 2021, ensuring the confidentiality of the participants. Data analysis was carried out following the human research guidelines of the Ethics Committee of the University of Granada and the ethical principles established by the Declaration of Helsinki in 1975 and its revision in Brazil in 2013.

Data analysis

SEM analysis was used to test the fit of the proposed theoretical model with the data obtained due to its suitability for testing the mediation hypotheses, as opposed to other techniques such as linear regression analysis (Gunzler et al., 2013). Furthermore, this analysis also enables the estimation of measurement error (Garson, 2012). IBM Statistical Package for Social Sciences version 25.0 (IBM Corp., Armonk, NY, USA) was used for descriptive and exploratory analysis while IBM Statistical Package for Social Sciences Amos version 26.0 (IBM Corp., Armonk, NY, USA) was used for SEM analysis.

Little's test (1988) was used and produced values for total and random absence (MCAR). Because such data were available in the database and did not exceed 3% of the total number of cases (28 participants had missing values), the Garson (2012) approach was used and those cases with missing values were removed. This procedure was carried out in order to avoid compromising the reliability of the data. Thus, the sample was slightly reduced to 1,057 participants.

Following this process, the multivariate normality assumptions were checked. The Mardia coefficient test obtained 12.33, indicating that the data were not normal (Ullman, 2006). This requires the use of robust adjustment statistics, such as the Satorra-Bentler, which allows for the reduction of biases such as those caused by non-normal data distributions (Kline, 2015). Moreover, it is important to treat ordinal variables with 5 or more categories as continuous variables and to use the maximum likelihood method with a robust statistic (Rhemtulla et al., 2012).

Convergent validity and reliability or internal consistency were assessed according to the average variance extracted (AVE) and composite reliability (CR). AVE .50 and CR .70 were considered adequate (Fornell & Larcker, 1981).

Goodness-of-fit for both the measurement model and SEM was assessed by: a) S-B x^2, degrees of freedom (df) and p-values; b) comparative fit index (CFI) as incremental fit index; c) normalised fit index (NFI) analysis; d) incremental fit index (IFI); e) Tucker-Lewis index (TLI); and f) root mean square error of approximation (RMSEA) with 90% confidence interval (CI). Taking into account the sample size and the number of indicator variables, an adequate model fit was defined as S-B x^2 value of $p \geq .05$, CFI .92 and RMSEA .07 (Hair et al., 2014).

Finally, Harman's one-factor test was used to check the variance problem of the common method, as this could compromise the validity of the results (Podsakoff et al., 2003).

Results

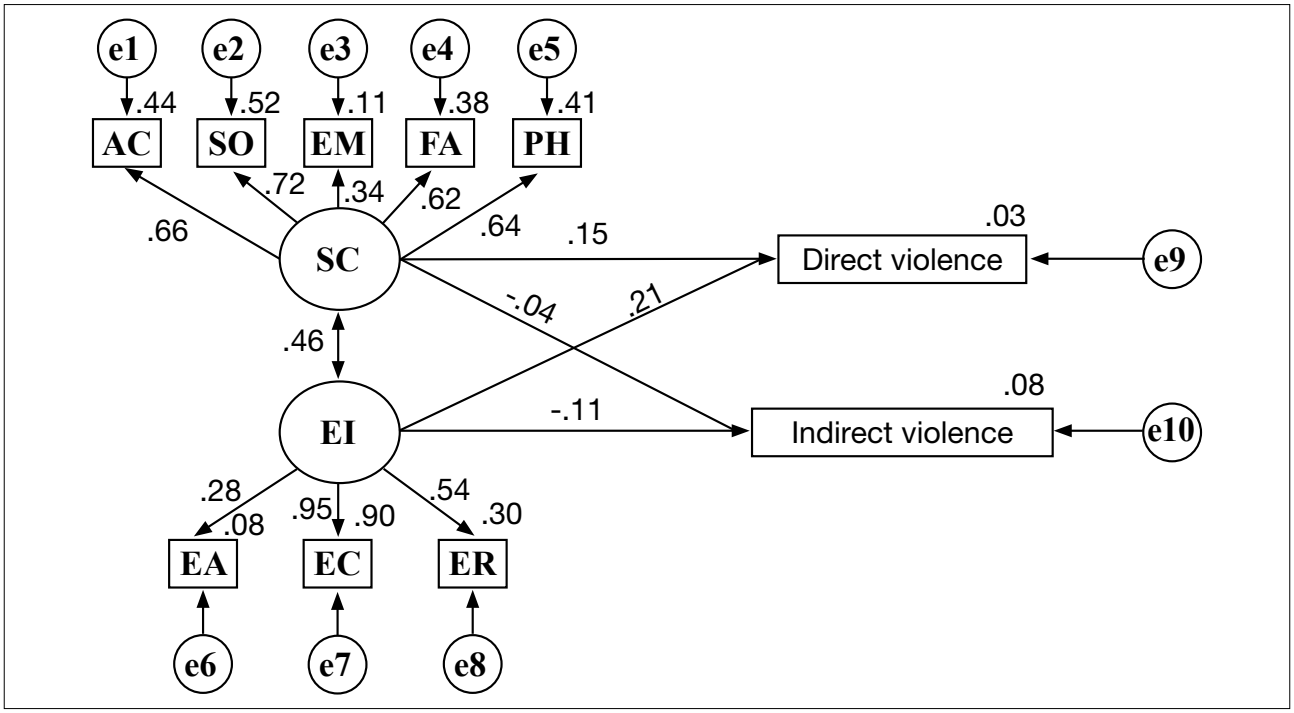
First, the model developed for students who play contact group sport. The model analysis shows a good fit (S-B $x^2 = 210.416$; df = 32; $p < .000$; NFI = .943; IFI = .958; TLI = .986; CFI = .971; RMSEA = .062).

Table 1
SEM for contact team sports players.

Variable relationship	RW				SRW
	Estimate	SE	CR	*p*	Estimate
AC ← SC	1.000				.663
SO ← SC	0.704	.105	6.697	***	.719
EM ← SC	0.584	.163	3.594	***	.337
FA ← SC	0.592	.097	6.088	***	.619
PH ← SC	0.915	.147	6.242	***	.641
ER ← EI	1.000				.543
EC ← EI	1.964	.499	3.939	***	.950
EA ← EI	0.515	.165	3.118	***	.277
DIRECT VIOLENCE ← SC	–0.074	.053	–1.403	.161	.150
INDIRECT VIOLENCE ← SC	–0.024	.054	–0.449	.654	–.044
DIRECT VIOLENCE ← EI	–0.122	.061	–1.980	***	.211
INDIRECT VIOLENCE ← EI	–0.069	.062	–1.112	.266	–.108

Note: Regression Weight (RW); Standard Regression Weight (SRW); Standard Error (SE); Critical Ratio (CR); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (ES); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Repair (ER); Emotional Clarity (EC); Emotional Attention (EA); Self-Concept (SC); Emotional Intelligence (EI);
*** Statistically significant relationship at the *p*level < .001

Figure 1
Final model for contact team sports players.



Note: Self-Concept (SC); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (EM); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Intelligence (EI); Emotional Attention (EA); Emotional Clarity (EC); Emotional Repair (ER).

Table 1 and figure 1 show the regression weights of the theoretical model, with statistically significant differences at $p < .001$. In terms of self-concept, positive relationships are observed with the social (SO) (β = .719), family (FA) (β = .619), physical (PH) (β = .641), emotional (EM) (β = .337) areas. Similarly, EI is found to be positively related to emotional clarity (EC) (β = .950) and emotional attention (EA) (β = .277). Regarding direct violence, a negative relationship with self-concept (β = -.150) and a positive relationship with EI (β = -.211) is observed. Finally, for indirect violence, negative relationships with self-concept (β = .044) and negative relationships with EI (β = -.108) are observed.

Examining the model developed for students who play non-contact group sport, it can be seen that the model fit is good (S-B x^2 = 210.853; df = 32; p < .018; NFI = .924; IFI = .976; TLI = .909; CFI = .965; RMSEA = .057).

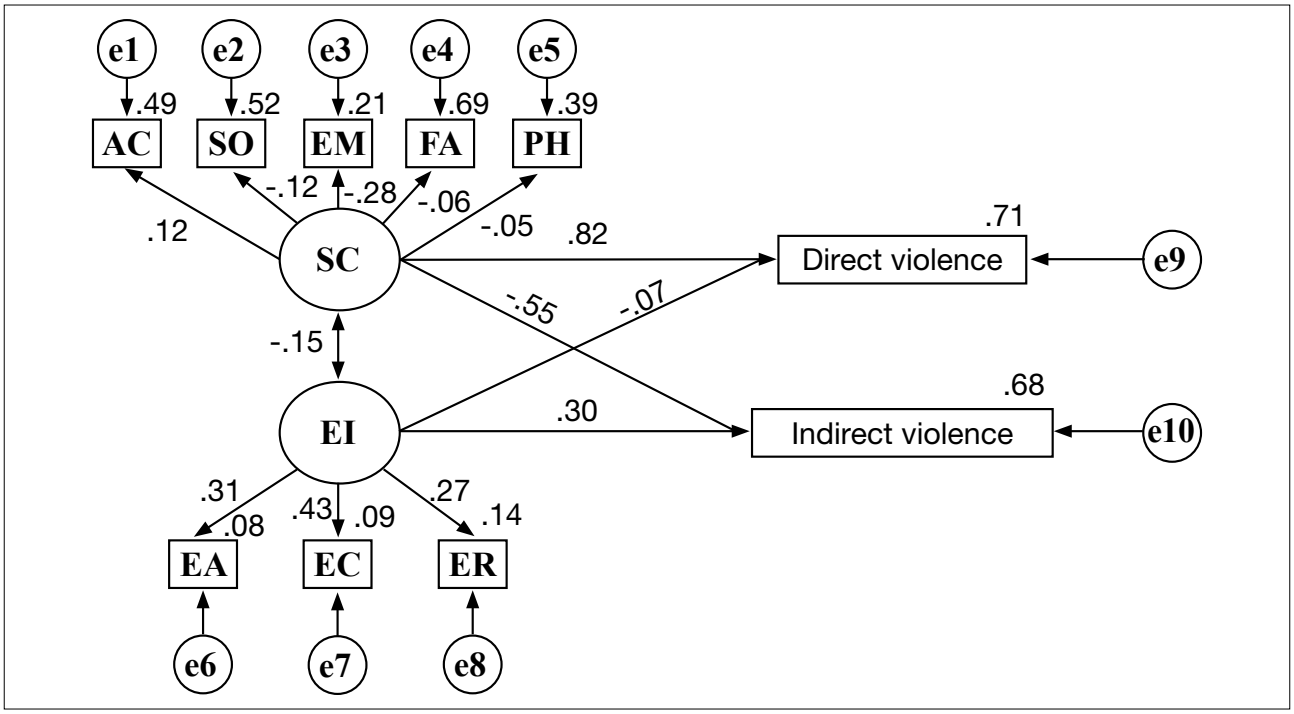
Table 2 and figure 2 show the regression weights of the theoretical model, with statistically significant differences at p < .001. Direct violence is negatively correlated with EI (β = –.071) while indirect violence is positively associated with EI (β = .301).

Table 2
SEM for non-contact team sports players.

Variable relationship	RW				SRW
	Estimate	SE	CR	*p*	Estimate
AC ← SC	1.000				.121
SO ← SC	–0.828	0.708	–1.169	.243	–.127
EM ← SC	–2.754	1.872	–1.479	.141	–.283
FA ← SC	–0.251	0.342	–0.734	.463	–.061
PH ← SC	–0.377	0.589	–0.640	.522	–.052
ER ← EI	1.000				.277
EC ← EI	4.724	3.203	1.475	.140	.435
EA ← EI	1.030	0.396	2.604	.009	.319
DIRECT VIOLENCE ← SC	31.344	78.864	0.397	.691	.823
INDIRECT VIOLENCE ← SC	–9.882	24.474	–0.404	.686	–.550
DIRECT VIOLENCE ← EI	–4.055	4.413	–0.919	***	–.071
INDIRECT VIOLENCE ← EI	13.620	15.298	0.890	***	.301

Note: Regression Weight (RW); Standard Regression Weight (SRW); Standard Error (SE); Critical Ratio (CR); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (ES); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Repair (ER); Emotional Clarity (EC); Emotional Attention (EA); Self-Concept (SC); Emotional Intelligence (EI);
*** Statistically significant relationship at the *p*level < .001

Figure 2
Final model for non-contact team sports players.



Note: Self-Concept (SC); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (EM); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Intelligence (EI); Emotional Attention (EA); Emotional Clarity (EC); Emotional Repair (ER).

The proposed SEM for students who play individual non-contact sport shows a good fit (S-B x^2 = 326.986; df = 32; p < .000; NFI = .955; IFI = .981; TLI = .953; CFI = .969; RMSEA = .053).

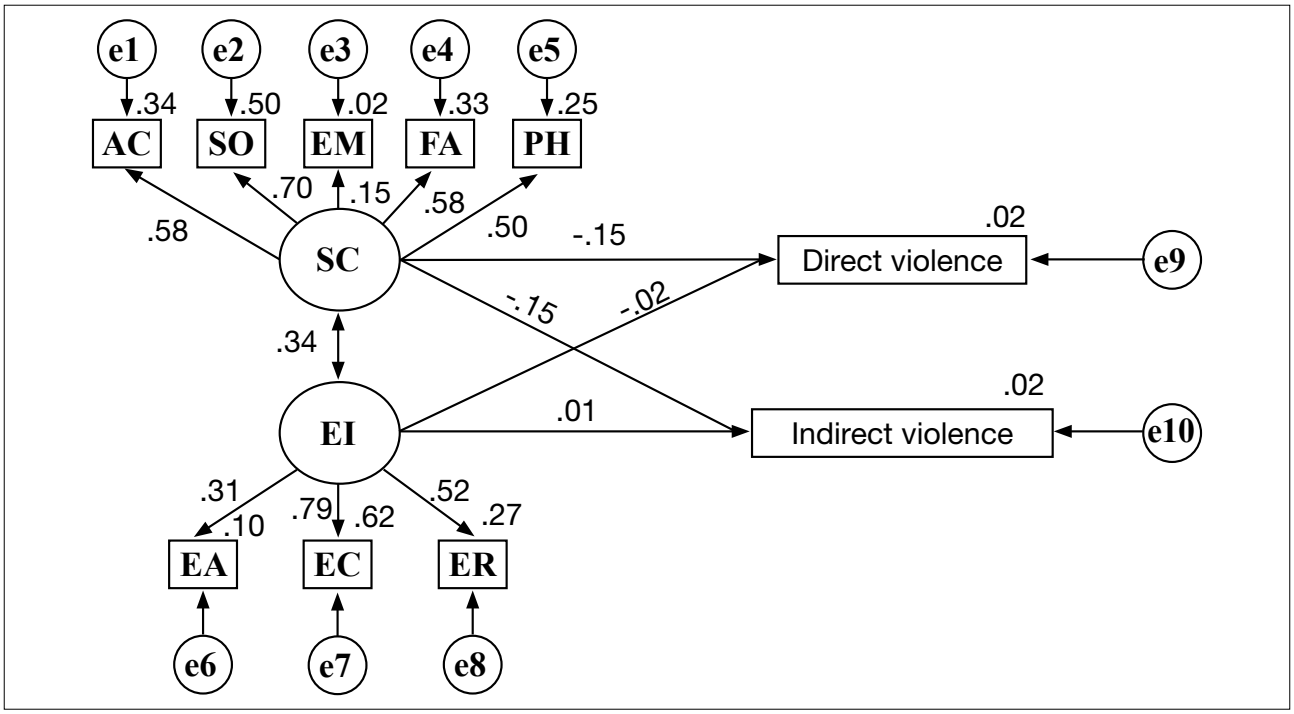
Table 3 and figure 3 show the regression weights of the theoretical model, with statistically significant differences at p < .001. The self-concept values reveal positive relationships with the categories AC (β = .580); SO (β = .704); FA (β = .578); and PH (β = .498). On the other hand, EI is positively related to ER (β = .521); EC (β = .789); and EA (β = .310). Observing both times of violence (direct and indirect), they reveal negative associations with EI (β = –.022; β = –.004) and with self-concept (β = –.310; β = –.156).

Tabla 3
SEM for individual non-contact sports players.

Variable relationship	RW				SRW
	Estimate	SE	CR	*p*	Estimate
AC ← SC	1.000				.580
SO ← SC	0.830	0.119	6.999	***	.704
EM ← SC	0.300	0.143	2.093	.036	.148
FA ← SC	0.721	0.110	6.586	***	.578
PH ← SC	0.880	0.147	6.008	***	.498
ER ← EI	1.000				.521
EC ← EI	1.371	0.352	3.894	***	.789
EA ← EI	0.506	0.129	3.925	***	.310
DIRECT VIOLENCE ← SC	–0.091	0.048	–1.899	.058	–.149
INDIRECT VIOLENCE ← SC	–0.119	0.060	–1.958	.047	–.156
DIRECT VIOLENCE ← EI	–0.011	0.041	–0.275	.784	–.022
INDIRECT VIOLENCE ← EI	–0.003	0.051	–0.050	.960	–.004

Note: Regression Weight (RW); Standard Regression Weight (SRW); Standard Error (SE); Critical Ratio (CR); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (ES); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Repair (ER); Emotional Clarity (EC); Emotional Attention (EA); Self-Concept (SC); Emotional Intelligence (EI);
*** Statistically significant relationship at the *p*level < .001

Figure 3
Final model for individual non-contact sports players.



Note: Self-Concept (SC); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (EM); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Intelligence (EI); Emotional Attention (EA); Emotional Clarity (EC); Emotional Repair (ER).

Finally, the SEM associated with university students who play individual contact sport shows a good fit (S-B x^2 = 124.229; df = 32; p < .000; NFI = .925; IFI = .992; TLI = .947; CFI = .978; RMSEA = .049).

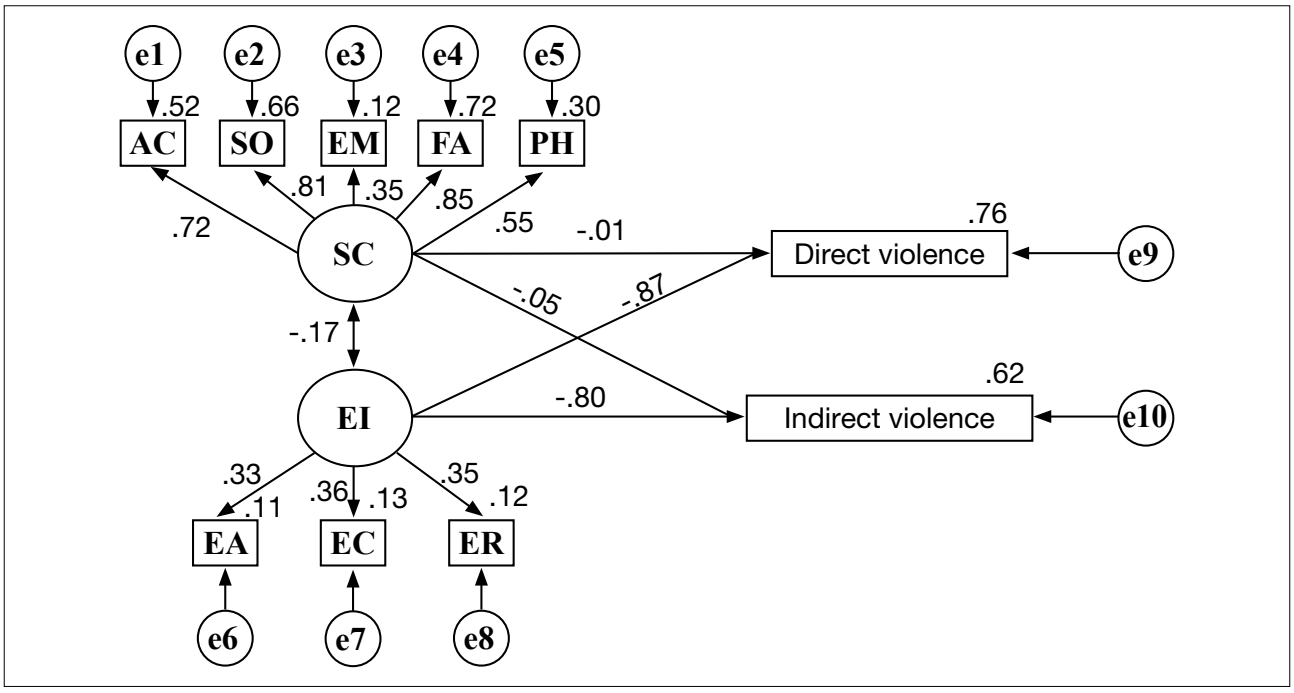
As can be seen in the table, the regression weights of the theoretical model are shown, with statistically significant differences at p < .001. The self-concept values reveal positive relationships with the categories AC (β = .724); SO (.813); EM (β = .347) FA (β = .849); and PH (β = .551). On the other hand, EI is positively related to ER (β = .350); EC (β = .356); and EA (β = .327). Focusing on direct violence, negative associations are found with EI (β = –.873) and with self-concept (β = –.003). Finally, indirect violence is negatively associated with EI (β = –.797) and with self-concept (β = –.053) (figure 4).

Table 4
SEM for individual contact sports players.

Variable relationship	RW				SRW
	Estimate	SE	CR	*p*	Estimate
AC ← SC	1.000				.724
SO ← SC	0.909	0.138	6.564	***	.813
EM ← SC	0.545	0.189	2.882	.004	.347
FA ← SC	0.906	0.135	6.709	***	.849
PH ← SC	0.692	0.152	4.556	***	.551
ER ← EI	1.000				.350
EC ← EI	1.138	0.522	2.179	.029	.356
EA ← EI	0.923	0.445	2.075	.038	.327
DIRECT VIOLENCE ← SC	0.001	0.072	0.016	.987	.003
INDIRECT VIOLENCE ← SC	–0.028	0.090	–0.309	.758	–.053
DIRECT VIOLENCE ← EI	–0.812	0.289	–2.812	***	–.873
INDIRECT VIOLENCE ← EI	–0.975	0.341	–2.861	.004	–.797

Note: Regression Weight (RW); Standard Regression Weight (SRW); Standard Error (SE); Critical Ratio (CR); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (ES); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Repair (ER); Emotional Clarity (EC); Emotional Attention (EA); Self-Concept (SC); Emotional Intelligence (EI);
*** Statistically significant relationship at the *p*level < .001

Figure 4
Final model for individual contact sports players.



Note: Self-Concept (SC); Academic Self-Concept (AC); Social Self-Concept (SO); Emotional Self-Concept (EM); Family Self-Concept (FA); Physical Self-Concept (PH); Emotional Intelligence (EI); Emotional Attention (EA); Emotional Clarity (EC); Emotional Repair (ER).

Discussion

This study examined the levels of emotional intelligence, self-concept and violence according to the sport modality practised, while establishing relationships between the variables considered. Thus, EI and self-concept have been found to have a positive relationship, in line with previous studies (Martínez-Monteagudo et al., 2021; Sánchez-Zafra et al., 2022).

A negative relationship between EI and self-concept has also been identified with both types of violence. In this regard, the study by (Díaz-López et al., 2019) with adolescents found a negative relationship between EI and aggressive behaviour. In turn, previous studies have also identified a negative relationship between self-concept and violent behaviour (Castro-Sánchez et al., 2019; Sánchez-Zafra et al., 2019). In this sense, EI has been shown to improve emotional expression (Castillo-Viera et al., 2021).

Focusing on the forms of violence, self-concept is found to be negatively associated with direct and indirect violence, in line with previous literature (Blakely-McClure & Ostrov, 2016; Jenkins & Demaray, 2012; Malhi et al., 2014).

Similarly, EI was also found to be strongly and negatively related to both types of violence. This relationship has also been observed in the literature, and there is research in which EI programmes have been implemented to prevent violence in adolescents, an approach that supports the importance of fostering emotional skills among students with a view to reducing this type of behaviour (Garaigordobil & Peña-Sarrionandia, 2015). In addition, EI is also related to the practice of physical activity, with a direct relationship between the two factors as reported in the systematic review by Puertas-Molero et al. (2017).

EI is negatively associated with direct violence and positively associated with indirect violence. In this regard, Porche (2016) states that EI should be understood as a cognitive-behavioural strategy for overcoming violence, as it enables the determination of the person's potential to perform violent actions, self-awareness about the emotions they feel and that motivate them to react violently or the role that past and present experiences of violence have on their behaviour.

Regarding the relationship between sport and violence, this study found that people who do not play sport tend to develop both types of violence. Along these lines, the study by Medina-Cascales and Reverte-Prieto (2019) concluded that high level of sport participation in less competitive environments is associated with lower rates of violence. In contrast, the research by Martínez-Martínez et al. (2017) did not report significant relationships between the sport modality played and violent behaviour, despite the benefits that physical activity brings to the management and control of aggression according to other studies (Magnan et al., 2013; Sánchez-Alcaraz et al., 2020).

At the same time, it is important to highlight the limitations and prospects of this study. Firstly, the cross-sectional methodological design does not allow for the identification of the evolution of these variables, as well as causal relationships between them. In this line, longitudinal research, with pre-post methodological designs, will contribute to a better understanding of the behaviour of these variables, which will allow for the examination of the effectiveness of certain psychological constructs on student behaviour, as well as for testing educational programmes aimed at providing students with the strategies they need to cope with situations that challenge their psychosocial well-being.

Conclusions

From the findings obtained, it can be concluded that there is a pressing need to develop educational programmes based on physical activity and the promotion of psychosocial factors among university students. In particular, EI-based programmes will lead to a reduction in violent behaviour. This initiative could equip students with the necessary strategies to cope adequately in different contexts in diverse areas of their lives.

Likewise, from the findings it has been observed that promoting group contact sports requires this type of programme to a greater extent in order to mitigate the predisposition towards direct violence. To a certain extent, it is a matter of promoting educational programmes aimed at replacing violent behaviour with more adaptive behaviour from an integral education perspective. In contrast, the finding of higher emotional control and lower propensity towards violence among university students who play individual contact sports (wrestling, karate, etc.) calls for reflection on the type of sports promoted among students. Although it is true that the results obtained should be interpreted with caution, the findings obtained encourage reflection on the sports that need to be promoted in educational programmes in higher education and, considering that this study involves future teachers, it is possible to transfer these good practices to lower levels of education. One area to consider is the development of physical activity programmes or active breaks within the different subjects taught in university degrees in order to release stress and anxiety produced by academic performance.

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Influence of quality of opposition in the creation of goal scoring opportunities in women's football

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An athlete doing parkour.
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Abstract

The aim of this study was twofold: i) firstly, to determine the influence of the criterion opponent quality on the offensive tactical behaviour of teams participating in the FIFA Women's World Cup France 2019 and, ii) on the other hand, to determine whether there were differences in criteria related to the start and development of ball possessions and their influence on the creation of scoring opportunities based on opponent quality. Using observational methodology, 2,045 ball possessions from 14 matches of the final phase of this championship were analysed. First, a bivariate analysis was carried out on the basis of opponent quality, and then three predictive decision tree models were run for the weak, normal and strong categories of the opponent quality criterion. Statistically significant differences were found based on opponent quality for the criteria match result, depth start area, defensive positioning, spatial context of the interaction, possession time in opponent's half, total time of possession, possession area and possession outcome. On the other hand, a similar pattern was found to exist in obtaining goal scoring opportunities regardless of opponent quality, which was characterised by maintaining possession in the opponent's half, starting possession in areas close to the opponent's goal and an initial attacking intention to advance towards the opponent's goal quickly.

Keywords: decision tree, FIFA Women's World Cup, observational methodology, women's football.

Introduction

Women's football is a phenomenon that has recently started to grow in a significant manner. Among the women's leagues that still exist, the earliest was founded in 1968 in Italy. This represents a difference of 80 years compared to men's football (Lago et al., 2022). During these decades, women's football has had to face, among other difficulties, the ban imposed on playing matches on English Football Association (FA) club grounds (Jenkel, 2021). Today, however, football has benefited from a remarkable increase in social and media interest, but despite this, there are still obvious disparities between men's and women's football (Lago et al., 2022).

One such gap is in the area of research. Only 20% of studies published on the sport are carried out on women's football (Kirkendall & Krustup, 2020). This highlights the large gender knowledge gap in sport and its scientific development (Lago et al., 2022; Nassis et al., 2022). These factors may account for some of the differences in team performance across the sexes (Casal et al., 2021; Garnica-Caparrós & Memmert, 2021; Pappalardo et al., 2021).

Performance in football should be understood from a polyhedral perspective (Preciado et al., 2021) in which possession-related performance indicators play an important role (Wang et al., 2022). In recent years, some studies on women's football have been published in this area (Iván-Baragaño et al., 2021, 2022; Maneiro et al., 2021; Mitrotasios et al., 2022). Despite this, expertise on these indicators in men's football (Wang et al., 2022) has been the only reliable and objective source of information for several decades for women's football professionals. In this sense, this work agrees with Lago et al. (2022) in stating that performance in football should not be approached from a unisex perspective (applying knowledge from men's football to women's football), and consideration should be given to the need to increase scientific work on women's football (Nassis et al., 2022) in order to equip professionals with specific knowledge.

In relation to team performance in competition, there are some contextual criteria that have been proven to influence the offensive and defensive behaviour of football teams. Among these criteria, opponent quality has been rigorously studied in men's football (Almeida et al., 2014; Castellano et al., 2013; Fernández-Hermógenes et al., 2021; García-Rubio et al., 2015; Lago, 2009; Sánchez et al., 2019) and to a lesser extent in women's football (Lee & Mills, 2021). One of the first studies that analysed the influence of opponent quality criteria on offensive play in men's football revealed a reduction in possession time of 0.2% for each unit of difference in the final classification of the 2005-2006 Spanish League (Lago, 2009). In turn, Castellano et al. (2013) observed how offensive and defensive positioning changed depending on the quality of the opponent: teams showed greater depth and width in the offensive phase against weak teams and, surprisingly, teams facing strong teams showed greater depth and width in the defensive phase (Castellano et al., 2013). Almeida et al. (2014) demonstrated that the top-ranked teams in the 2011/2012 UEFA Champions League were able to recover the ball in more forward areas of the pitch, an indicator related to offensive success in women's football (Iván-Baragaño et al., 2021). In the same competition, a longitudinal study carried out during the 2009 to 2013 seasons revealed a significant positive association between opponent quality (i. e. difference in UEFA ranking) and goal difference in the match (García-Rubio et al., 2015). On the other hand, research on the influence of opponent quality on match performance in women's football is scarce. In this regard, the only study published to date is that of Lee & Mills (2021). This study sought to determine the influence of the criteria opponent quality and time score on the execution of corners in the Women's World Cup France 2019, revealing statistically significant differences based on opponent quality for the criteria passing the ball, type of pass, number of attackers and attacking organisation, among others (Lee & Mills, 2021). In contrast, opponent quality was not found to be a criterion that significantly influenced the outcome of the set-pieces analysed.

For all of the above reasons, and due to the need to increase the degree of understanding about the offensive process in women's football, as well as to determine which criteria can influence this process, this study was carried out. The objectives of this study were: i) to determine the influence of the criterion opponent quality on the offensive tactical behaviour of teams participating in the FIFA Women's World Cup France 2019 and ii) to determine whether there were differences in criteria related to the start and development of ball possessions and their influence on the creation of scoring opportunities based on opponent quality.

Materials and method

Design

To carry out this study, the observational methodology (Anguera, 1979) was used. This methodology is ideal for the analysis of collective behaviour in natural events such as football matches (Anguera et al., 2011).

It was a nomothetic design —several study units—, isolated (intra-session follow-up) —a single championship analysed—, and multidimensional —several levels of response reflected in the observation instrument (Anguera et al., 2011).

Participants

All incidents of ball possession (n = 2,045) with a duration of four seconds or more during the FIFA Women's World Cup France 2019 finals matches were analysed. Ball possession starts from the moment the observed team gains control of the ball, through a ball interception or a restart of play, until possession is transferred to the opposing team, or there is a break in the game (Almeida et al., 2014).

Two matches were excluded from the analysis because of the large difference in quality level of the teams involved: (i) Germany 3-0 Nigeria (Round of 16: No 2 and 38 FIFA ranking, respectively) and (ii) England 3-0 Cameroon (Round of 16: No 3 and 46 FIFA ranking, respectively).

The analysed games were ranked based on opponent quality using the latest FIFA rankings pre-tournament [https://www.fifa.com/fifa-world-ranking/women?dateId=ranking_20190329]. This ranking is calculated on the basis of the sum of points obtained in the matches played by each team taking into account: (i) the result of the matches played, (ii) the location of the match, (iii) the importance of the match, and (iv) the difference between the FIFA ranking positions at that time [https://www.fifa.com/fifa-world-ranking/procedure-women]. The criterion opponent quality was calculated based on the difference between the FIFA ranking positions of the competing teams for each of the ball possessions (i. e. in the final between the USA (No 1 FIFA ranking) and the Netherlands (No 8 FIFA ranking) the USA's ball possessions were recorded as -7 and vice versa). The actions were classified based on an analysis of k means into three groups according to the value of the criterion opponent quality: i) weak (n = 700): [-12, -4], ii) similar (n = 765); [-3, +3] and iii) strong (n = 580): [+4, +12].

Observation and recording instrument

The observation instrument was adapted from Iván-Baragaño et al. (2022) and is presented in Table 1. It was a combination of field format and exhaustive and mutually exclusive category systems, which was necessary due to the high complexity of the situation under study (Anguera et al., 2018).

The recording instrument used was free *Lince Plus* software [https://observesport.github.io/lince-plus] (Soto et al., 2019).

Table 1
Observation instrument.

Dimensions	Criteria	Categories	Definition
Dimension 1. Identification of possession	Opponent quality	Weak	Opponent's quality in the range [-12, -4]
		Similar	Opponent's quality in the range [–3, +3]
		Strong	Opponent's quality in the range [+4, +12]
Dimension 2. Initial possession	Match result	Winner	The team observed won the match
		Loser	The team observed lost the match
		Draw	The match ended in a draw
	Temporality of the action	1Q	The action starts between the start of the game and minute 15
		2Q	The action starts between minute 16 and minute 30
		3Q	The action begins between minute 31 and the end of the first half
		4Q	The action starts between the start of the second half and minute 60
		5Q	The action starts between minute 61 and minute 75
		6Q	The action starts between minute 76 and the end of the match

Table 1 (Continued)
Observation instrument.

Dimensions	Criteria	Categories	Definition
Dimension 2. Initial possession	Match status	Winning	The team observed is winning when the action starts
		Drawing	The teams are level when the action starts
		Losing	The team observed is losing when the action starts
	Type of start	Static	The action starts after a break in play
		Dynamic	The action begins with a ball being stolen or intercepted
	Depth start area	Defensive	The action begins in the defensive area of the pitch
		Pre-defensive	The action begins in the pre-defensive area of the pitch
		Midfield	The action begins in the midfield area of the pitch
		Pre-offensive	The action begins in the pre-offensive area of the pitch
		Attack	The action begins in the offensive area of the pitch
	Width start area	Left Defense	The action starts from the left wing
		Centre-Back	The action starts from the centre
		Right Defense	The action starts from the right wing
	Defensive organisation	Organised	The opposing team is defensively organised
		Circumstantial	The opposing team is defensively disorganised
	Defensive positioning	Back	Opponents positioning is forward at the start of the action
		Midfield	Opponents positioning is midfield at the start of the action
		Forward	Opponents positioning is at the back at the start of the action
	Spatial context of the interaction	FF	Forward area vs. forward area
		FM	Forward area vs. midfield area
		FB	Forward area vs. back area
		MF	Midfield area vs. forward area
		MM	Midfield area vs. midfield area
		MB	Midfield area vs. back area
		BF	Back area vs. forward area
		BM	Back area vs. midfield area
		BB	Back area vs. Back area
		GF	Goal area vs. forward area
Dimension 3. Development of possession	Offensive intention	Advance	The team observed advances towards the rival goal
		Maintain	The team observed maintains possession of the ball
	Defensive Intention	Recover	The opposing team shows a pressing intention to recover the ball
		Defend	The opposing team shows an intention to defend their goal
	Own half P		Time of possession in own half
	Opponent half P		Possession time in opponent's half
	TTotal		Total time of possession
	Passes		Number of passes
	Possession area	MD	Most possession in own half
		MO	Most possession in opponent's half
Dimension 4. Result of the action	Result of the action	Goal	The offensive action ends with a goal
		Shot	The offensive action ends with a shot
		Ball into penalty area	The offensive action ends with a ball into the penalty area
		No success	The offensive action ends with failure

Procedure

This study was approved by the Ethics Committee of the University of A Coruña (approval code): EIUDC-2019-0024). All matches were recorded from public television, stored on an external hard drive and analysed post-event (Casal et al., 2019).

Three observers were trained in the observation, recording and coding of the offensive actions analysed (Losada & Manolov, 2015). All three observers were authors of this work, held the UEFA PRO football coaching qualification and two of them hold PhDs in Sport Science and have more than 30 years of experience in observational methodology between them. The third observer was a pre-doctoral researcher in their research group.

The data quality control was achieved by calculating the Cohen's (1960) inter-observer kappa coefficient, calculated from the average between the three pairs of observers, who independently recorded 258 ball possessions in two randomly selected entire matches (Arana et al., 2016). The average value of this coefficient was .869 (range = .746 - .979), considered excellent (Landis & Koch, 1977).

Statistical Analysis

To achieve the first objective, a bivariate analysis was carried out using contingency tables of the criteria included in the instrument and observation and the criterion opponent quality. The degree of association was analysed using the contingency coefficient. The effect size was classified as mild (ES = .10), moderate (ES = .30) or large (ES ≥ .50) (Gravetter & Wallnau, 2007). For the four quantitative categories, which evidences the fact that observational methodology is mixed methods in itself (Anguera et al., 2018), normality and homoscedasticity among the three groups were tested and rejected using the KS test and Levéne test, respectively, with a significance level $p < .05$. The Kruskall-Wallis test was applied to these criteria. The *post-hoc* differences were calculated using the Bonferroni correction.

Secondly, in order to test whether there were differences in scoring opportunities based on opponent quality, three multivariate predictive analyses were performed using the decision tree technique (for the *weak*, *similar* and *strong* categories of the *opponent quality* criterion). This technique, recently applied within the field of sport (Giménez et al., 2020; Iván-Baragaño et al., 2021; Maneiro et al., 2019) enabled an optimal interpretation of the results obtained. For the construction of these models, a recoding of the criterion *result of the action* was used as the dependent variable (*Success* = goal, shot and delivery into the penalty area; *No success* = remaining possessions). The remaining criteria were entered as independent or predictors in all three models. The tree growth method was CHAID. The model was validated using the cross-validation method, the minimum number of observations at the nodes was 80 (parent nodes) and 40 (terminal nodes) and the maximum depth of the tree was set at 4 levels. Misclassification costs were assumed to be equal for the two categories of the dependent variable. The proposed models demonstrated a high predictive ability, with a risk estimate value of .277, .208 and .217 for the *weak*, *similar* and *strong* categories, respectively. Statistical analyses were performed with SPSS 25.0 software (IBM Corp. Released 2017. IBM SPSS Statistics for Windows, Version 25, IBM Corp., Armonk, NY, USA).

Results

The results obtained from the bivariate analysis are presented in Table 2. Statistically significant differences were found based on opponent quality for the criteria match result, depth start area, defensive positioning, spatial context of the interaction, possession time in opponent's half, total time of possession, possession area and possession outcome.

Table 2
Bivariate analysis based on the criterion opponent quality.

Criterion	Categories	Weak *n* = 700	Similar *n* = 765	Strong *n* = 580	*p* [ES]
Match result	Winner	309 (44.1 %)*	269 (35.2 %)	158 (27.2 %)**	<.001 [.151]
	Loser	237 (33.9 %)**	345 (45.1 %)	287 (49.5 %)*	
	Draw	145 (22.0 %)	151 (19.7 %)	135 (23.3 %)	

NB. ES = Effect size; *More observed values than expected at Z, **Fewer observed values than expected based on Z (adjusted residual typed) a. Differences were found for Strong-Weak ($p < .001$) and Similar-Weak ($p < .001$) b. Differences found for Strong-Weak ($p < .001$) c. Differences found for the Strong-Weak ($p < .001$) and Strong-Similar pairs ($p < .001$).

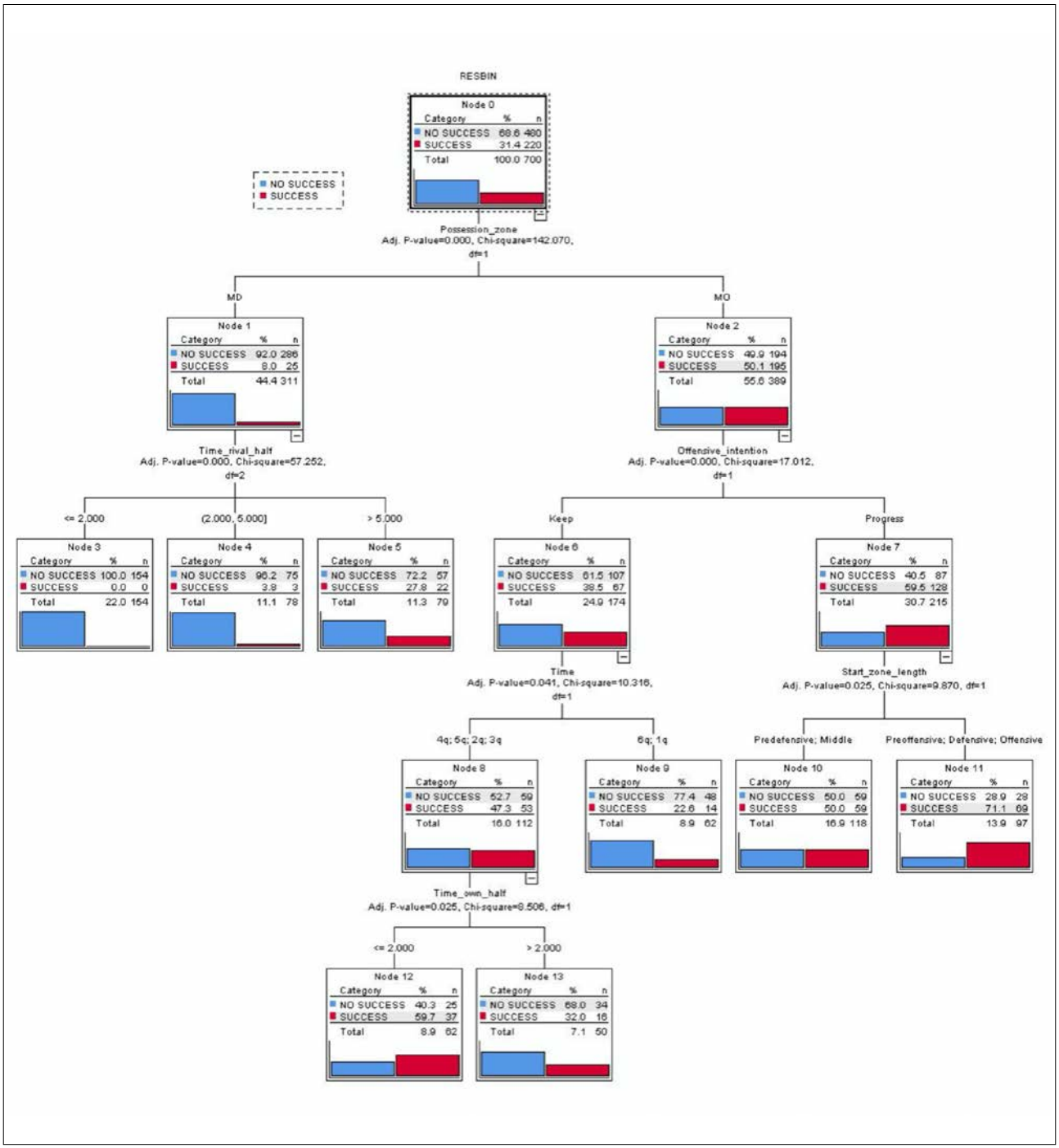
Table 2 (Continued)
Bivariate results based on opponent quality criterion.

Criterion	Categories	Weak *n* = 700	Similar *n* = 765	Strong *n* = 580	*p* [ES]
Temporality of the action	1Q	118 (16.9 %)	137 (17.9 %)	111 (19.1 %)	.288
	2Q	132 (18.9 %)	121 (15.8 %)	99 (17.1 %)	
	3Q	108 (15.4 %)	144 (18.8 %)	91 (15.7 %)	
	4Q	108 (15.4 %)	136 (17.8 %)	83 (14.3 %)	
	5Q	113 (16.1 %)	118 (15.4 %)	93 (16.0 %)	
	6Q	121 (17.3 %)	109 (14.2 %)	103 (17.8 %)	
Match status	Winning	126 (18.0 %)	165 (21.6 %)	120 (20.7 %)	.210
	Drawing	345 (49.3 %)	340 (44.4 %)	283 (48.8 %)	
	Losing	229 (32.7 %)	260 (34.0 %)	177 (30.5 %)	
Type of start	Static	233 (33.3 %)	238 (31.1 %)	173 (29.8 %)	.388
	Dynamic	466 (66.7 %)	527 (68.9 %)	407 (70.2 %)	
Depth start area	Defensive	206 (29.4 %)**	269 (35.2 %)	198 (34.1 %)	<.05 [.100]
	Pre-defensive	108 (15.4 %)	104 (13.6 %)**	119 (20.5 %)*	
	Midfield	199 (28.4 %)	206 (26.9 %)	141 (24.3 %)	
	Pre-offensive	160 (22.9 %)	159 (20.8 %)	105 (18.1 %)	
	Attack	27 (3.9 %)	27 (3.5 %)	17 (2.9 %)	
Width start area	Left Defense	173 (24.7 %)	178 (23.3 %)	107 (18.4 %)**	<.05 [.070]
	Centre-Back	361 (51.6 %)	392 (51.2 %)	337 (58.1 %)*	
	Right Defense	166 (23.7 %)	195 (25.5 %)	136 (23.4 %)	
Defensive organisation	Organised	678 (97.3 %)	749 (98.0 %)	558 (96.2 %)	.126
	Circumstantial	19 (2.7 %)	15 (2.0 %)	22 (3.8 %)	
Defensive positioning	Back	356 (50.9 %)*	337 (44.2 %)	231 (39.8 %)**	<.001 [.104]
	Midfield	130 (18.6 %)	131 (17.2 %)	102 (17.6 %)	
	Forward	214 (30.6 %)**	294 (38.6 %)	247 (42.6 %)*	
Spatial context of the interaction	FF	255 (36.5 %)**	324 (42.4 %)*	228 (39.3 %)	<.005 [.134]
	FM	1 (0.1 %)	3 (0.4 %)	4 (0.7 %)	
	FB	10 (1.4 %)	11 (1.4 %)	11 (1.9 %)	
	MF	5 (0.7 %)	5 (0.7 %)	5 (0.9 %)	
	MM	69 (9.9 %)	61 (8.0 %)	47 (8.1 %)	
	MB	5 (0.7 %)	16 (2.1 %)	8 (1.4 %)	
	BF	12 (1.7 %)	12 (1.6 %)	9 (1.6 %)	
	BM	243 (34.8 %)*	244 (31.9 %)	162 (27.9 %)**	
	BB	28 (4.0 %)	29 (3.8 %)	17 (2.9 %)	
	GF	71 (10.2 %)	59 (7.7 %)**	89 (15.3 %)*	
Offensive intention	Advance	415 (59.3 %)	458 (59.9 %)	321 (55.3 %)	.209
	Maintain	285 (40.7 %)	307 (40.1 %)	259 (44.7 %)	
Defensive Intention	Recover	468 (67.0 %)	474 (62.1 %)	354 (61.0 %)	.057
	Defend	231 (33.0 %)	289 (37.9 %)	226 (39.0 %)	
Own half P		5 [0-12]	6 [0-11]	6 [0-10]	.715
Opponent half P		7 [3-11]	5 [1-9]	5 [1-9]	<.001a
TTotal		12 [8-20]	12 [7-18]	11 [7-16]	<.005b
Passes		3 [2-5]	3 [2-5]	3 [1-4]	<.001c
Possession area	MD	311 (44.4 %)**	390 (51.0 %)	293 (50.7 %)	<.05 [.06]
	MO	389 (55.6 %)*	375 (49.0 %)	285 (49.3 %)	
Result of the action	Goal	8 (1.1 %)	7 (0.9 %)	8 (1.4 %)	<.001 [.106]
	Shot	84 (12.0 %)*	61 (8.0 %)	47 (8.1 %)	
	Ball into penalty area	128 (18.3 %)*	94 (12.3 %)**	81 (14.0 %)	
	No success	480 (68.6 %)**	603 (78.8 %)*	444 (76.6 %)	

NB. ES = Effect size; *More observed values than expected at Z, **Fewer observed values than expected based on Z (adjusted residual typed) a. Differences were found for Strong-Weak ($p < .001$) and Similar-Weak ($p < .001$) b. Differences found for Strong-Weak ($p < .001$) c. Differences found for the Strong-Weak ($p < .001$) and Strong-Similar pairs ($p < .001$).

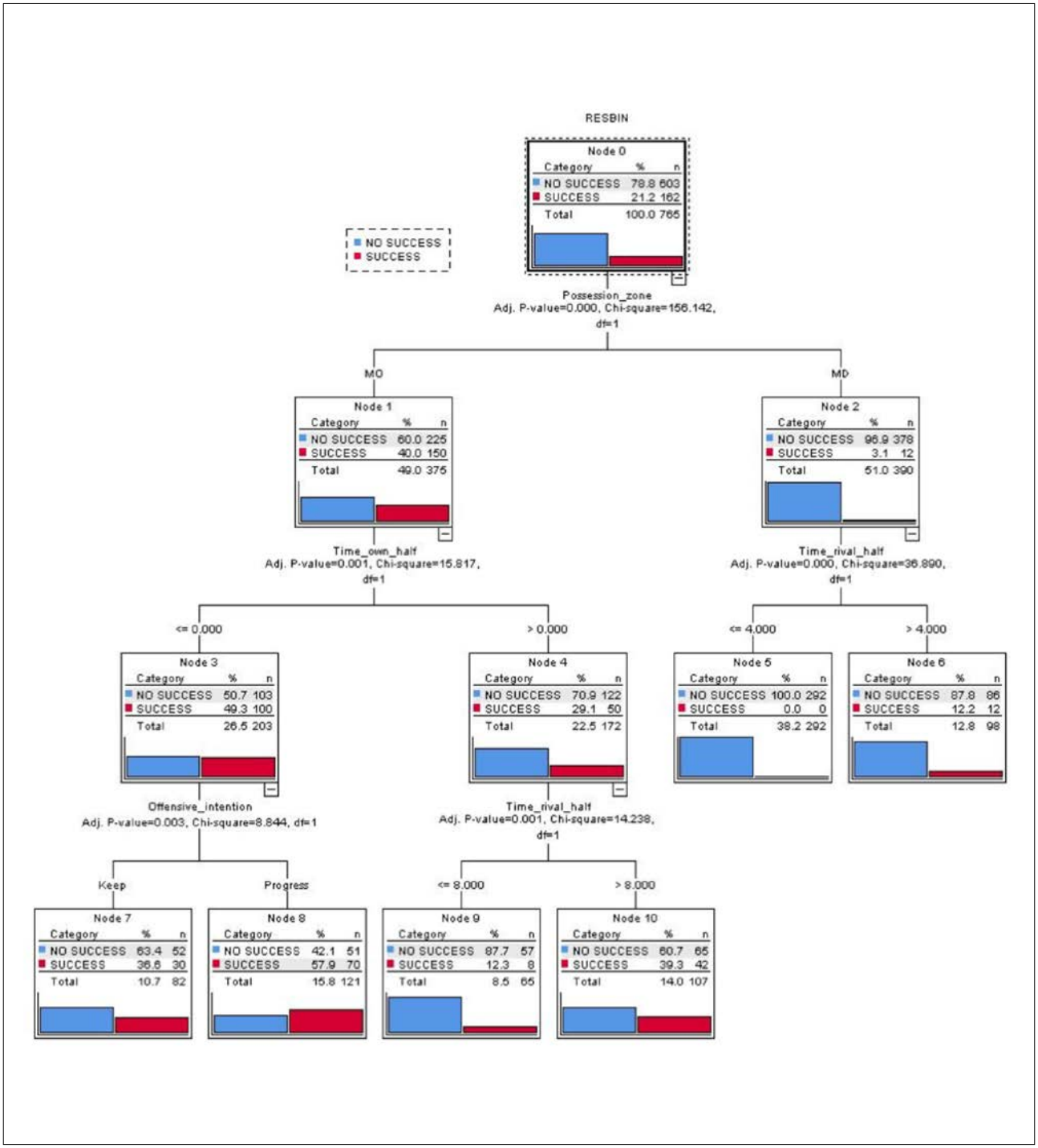
The results obtained from the predictive decision tree analysis for the possessions made in the *weak* category are shown in Figure 1. The final model had a reliability of 76.1% (48.2% sensitivity; 89.0% specificity). The criteria that were significant for scoring opportunities were possession area ($\chi^2 = 142.07$; $p < .001$), possession time in opponent's half ($\chi^2 = 57.252$; $p < .001$), initial offensive intention ($\chi^2 = 17.012$; $p < .001$), possession time ($\chi^2 = 10.316$; $p < .05$), depth start area ($\chi^2 = 9.870$; $p < .05$), time of possession in own half ($\chi^2 = 8.506$; $p < .05$). Furthermore, the criteria interaction which produced a higher probability of scoring opportunities was observed at node 11 ($n = 97$; 71.1 % Success – 28.9 No success), involving the interaction of the criteria possession area (attacking half), initial offensive intention (advance), and depth start area (pre-defensive, pre-offensive, offensive).

Figure 1
Decision tree: level of weak opponent.



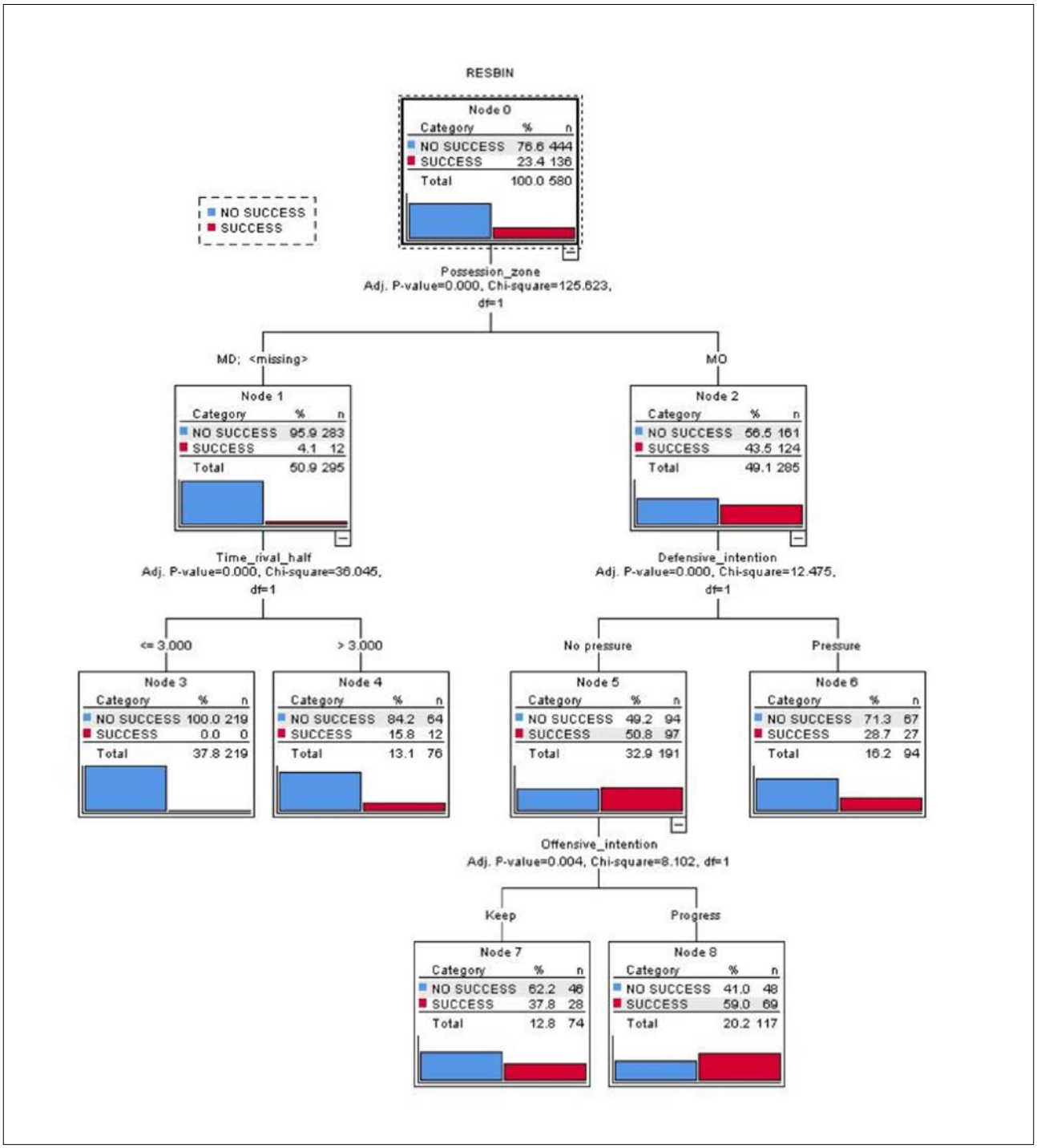
For possessions made when facing an opponent of similar quality (Figure 2) the criteria entered by the decision tree algorithm were possession area ($\chi^2 = 156.142$; $p < .001$), time of possession in own half ($\chi^2 = 15.817$; $p < .001$), possession time in opponent's half ($\chi^2 = 36.89$; $p < .001$), and initial offensive intention ($\chi^2 = 8.844$;$p < .005$). The model had a reliability of 81.31% (43.2% sensitivity; 91.5% specificity). For this type of action, the highest probability of attaining a scoring opportunity was observed in node 8 ($n = 121$; 57.9 % Success), involving the interaction of the criteria possession area (attacking half), time of possession in own half (≤ 0 seconds), and initial offensive intention (advance).

Figure 2
Decision tree: level of similar opponent.



Finally, the results obtained from this technique for the *strong* category of the opponent quality criterion (Figure 3) revealed the influence of the criteria possession area (χ^2 = 125.623; p < .001), possession time in opponent's half (χ^2 = 36.045; p < .001), initial defensive intention (χ^2 = 12.475; p < .001), and initial offensive intention (χ^2 = 8.102; p < .005). For this type of action, the highest probability of scoring opportunities was observed in node 8, involving the interaction of the criteria possession area (mid-offensive), initial defensive intention (defend) and initial offensive intention (advance). When these criteria and categories interacted with each other, the probability of gaining opportunities was 59% (n = 69) compared to a 41% probability of no success (n = 48). The proposed model had a specificity of 89.2% and a sensitivity of 50.7% (80.2% reliability).

Figure 3
Decision tree: level of strong opponent.



Discussion

This study was carried out with a twofold objective. Firstly, the aim was to determine how the criterion *opponent quality* influenced the tactical behaviour of teams participating in the final phase of the FIFA Women's World Cup France 2019 and, on the other hand, to determine whether there were differences in criteria related to the start and development of ball possessions and their influence on the creation of scoring opportunities based on opponent quality.

The results obtained from the bivariate analysis revealed differences in 10 of the 17 criteria analysed in this study. In this line, differences have been found in the match result criteria. This is a logical finding, which confirms the accuracy of the FIFA ranking prepared prior to the championship under analysis in predicting the performance of teams in international championships. In addition, differences have been observed in the criterion *depth start area*. Possessions made against an opponent of strong quality began in the defensive zone more frequently, in line with the findings of Almeida et al. (2014). The criterion *spatial context of the interaction* also revealed differences based on opponent quality. Possessions made against an opponent of similar quality began mainly through MM interaction contexts (middle zone vs. middle zone). This finding may be justified by a higher concentration of female players in the central areas of the effective playing space, as observed in men's football (Castellano et al., 2013). In relation to the spatial context of interaction, it is significant that when possessions were made facing an opponent of weak quality, there was an increase in defensive contexts of interaction, such as BF (back zone versus forward zone). This finding may indicate that better teams are able to advance and overcome opposing lines of pressure more easily (Almeida et al., 2014), reaching contexts of offensively valuable interaction more frequently during their ball possessions.

In relation to the duration of the ball possessions analysed, differences were observed for the criteria *possession time in opponent's half*, *total time of possession* and *number of passes*. This demonstrates that opponent quality was a criterion that influenced the duration of ball possessions, in the same way as in men's football (Lago, 2009). Possessions made against an opponent of weak quality had a longer duration overall and in the opponent's half. This is an important finding due to the importance of maintaining possession in the opponent's half (Casal et al., 2017; Casal et al., 2019) and highlights the greater ability of better teams to execute combinative actions in tight spaces and close to the opponent's goal. In addition, keeping the opposing team away from their own goal (Camerino et al., 2012) makes it impossible for the opposing team to create goal-scoring opportunities, due to the added difficulty of creating such opportunities from back areas of the pitch in women's football (Iván-Baragaño et al., 2021; Scanlan et al., 2020). In this sense, this work agrees with Almeida et al. (2014) in stating that the best teams are more effective at pressing after losses in forward areas of the pitch, as the simple act of maintaining possession in these areas may enable them to press more aggressively and efficiently once they have lost possession of the ball.

The results obtained in relation to the criterion *result of the action* based on the criterion *opponent quality* revealed statistically significant differences. The probability of scoring opportunities (i. e. goal, shot or delivery into the penalty area) against a weak opponent was 10 and 8 percentage points higher compared to possessions made against similar and strong opposition, respectively.

Furthermore, from the multivariate results obtained from the decision tree technique, it is possible to observe common factors in the way goal scoring opportunities are attained regardless of the opponent quality. From these results, it can be confirmed that possession area was the most influential criterion in obtaining this type of action, just as in other studies carried out in men's football (Casal et al., 2017, 2019) and women's football (Iván-Baragaño et al., 2021, 2022; Maneiro et al., 2021). Similarly, initial offensive intention significantly influenced the likelihood of scoring opportunities in the championship analysed. Specifically, ball possessions that started with an initial offensive intention to advance significantly increased the probability of success, consistent with existing literature (Mitrotasios et al., 2022; Maneiro et al., 2019). In this sense, this work agrees with Sarmento et al. (2014) in stating that, once ball possession is regained, a quick pass or drive to areas far away from the opposing team must take place, quickly disabling several players from the opposing team and taking advantage of this situation of defensive disorganisation.

Finally, a differentiating element was observed between the three multivariate models considered: the influence of

the initial defensive intention criterion in obtaining scoring opportunities in possessions made against an opponent of strong quality. This factor, which may be important when considering pressure after a turnover, highlights the need for the best teams to quickly press the player who regains possession (Vogelbein et al., 2014) in order to reduce the time and space for action, thereby reducing the likelihood of scoring opportunities in that play action.

Conclusions

Based on the results of this study, it has been demonstrated that opponent quality was a criterion that significantly affected tactical criteria such as the starting area of ball possessions, the opponent's defensive positioning or the spatial context of interaction. In addition, higher total possession times and possession times in the opponent's half were found when ball possessions were made against teams of a weaker quality, a factor that has been proven to influence the success of ball possessions in elite football. Furthermore, the fact that only matches from the final phase of the FIFA Women's World Cup France 2019 were analysed (the 14 teams analysed were among the top 16 in the FIFA 2019 ranking) is an important factor, as it reveals that opponent quality not only influences the behaviour and outcome of ball possessions between teams of very unequal levels, but also influences these actions among the elite of world women's football. In contrast, from the results obtained from the three decision tree models, it has been possible to verify a trend present in elite women's football, regardless of the quality of the opponent: the greatest probability of obtaining successful ball possessions is produced by the interaction of criteria associated with ball recoveries in forward areas, with the intention of advancing towards the opponent's goal and the development of ball possessions in the opponent's half. These results can help these teams to design match strategies aimed at reproducing these tactical behaviours.

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Validation of an instrument to qualify Football Competence via WyScout

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Abstract

The aim of this work was to design and validate an instrument (TOPSTATS) to rate, classify and compare the performance of professional players based on the Wyscout data provider. Content validity through consultation with three experts showed considerable agreement using Fleiss' kappa index (k = .691). Extracting data on players' play in the 2019-2020 season in La Liga and the English Premier League, criterion validity was calculated by relating the total player scores obtained in TOPSTATS to those in SofaScore. Pearson's correlation showed a significant association in all playing positions (r = 0.3-0.88, $p < .05$). The same procedure was used to ensure construct validity, relating the players' total scores to their market value. In this case, Pearson's correlation showed a significant association in 17 of the 24 playing positions (r = 0.36-0.80; $p < .05$). It was concluded that TOPSTATS showed optimal validity values. It is an instrument capable of comparing the football competence shown by players in their play during the same competition, according to their playing position. To this end, the tool allows for the agile and semi-automatic calculation of an overall performance index obtained from the interaction and weighting of variables containing data provided by Wyscout, which, being a subscription platform, has coverage in more than 200 competitions.

Keywords: data analysis assessment, football, La Liga, Premier League, sporting performance.

Introduction

Sports data analysis has long been of interest (Anderson & Sally, 2014; Bornn et al., 2018), but it is only in recent years that football statistics have been developed, thanks to technologies that provide large streams of highly reliable data extracted on a match-by-match basis (Pappalardo et al., 2019b). Unfortunately, the use and manipulation of this data is not an easy endeavour if the aim is to assess the football competence (Parlebas, 2018) exhibited by players during their play, as there is no consolidated and widely accepted metric to measure the quality of performance in all its facets (Pappalardo et al., 2019a). This is because football is a highly complex sport, which requires a multidimensional approach, as players' motor responses are dynamic and non-linear (Garganta & Gréhaigne, 1999; Gréhaigne et al., 1997; Ric et al., 2016).

Players' motor responses are shaped by the behaviours they exhibit in accordance with their socio-motor role. The role of each player is a specific socio-motor status (Parlebas, 2001), which changes during the game. Each player develops his or her behaviours based on the particular approach he or she takes to his or her role (Lasierra, 1993). In other words, from the actions of the socio-motor subroles, which result in each of the possible behaviours that the player can develop during the game (Hernández Moreno, 1995), with each behaviour representing a particular modality of the generic concept of "motor action" (Parlebas, 2023). The efficacy of the behaviours displayed by each player during his or her play in a given event or set of events determines his or her performance. Whilst performance is concrete and temporary, competence is an overarching concept that deals with lasting and stable performance over time as a result of learning.

Providers essentially provide two types of data: "tracking" and "eventing". Tracking data provides data on the exact position of the player on the field (Otero-Saborido et al., 2021), allowing for the assessment of emergent behaviours through the player's position and movement tendencies that result from interaction with teammates and opponents. Based on these positional data, scientific studies have been carried out on football training (Coutinho et al., 2022; Errekagorri et al., 2020) and elite football (Castellano & Echeazarra, 2019). Eventing data consists of recording and labelling the actions carried out by the player, as well as their effectiveness, usually in relation to the ball (Otero-Saborido et al., 2021). Using the Wyscout provider, several recently published papers can be retrieved (Díez et al., 2021; Izzo et al., 2020; Zeng & Pan, 2021).

The performance of players with respect to a variable can be compared within the eventing platforms offered by data providers. It is also possible to use scatter plots to compare variables in pairs, or even to agglomerate several metrics into one graph, which is usually presented in the form of a radar. However, none of these options tend to answer questions such as: which player is performing best in the league, which player should be signed; and player selection is a key factor in the success of any competition (Partovi & Corredoira, 2002). In other words, if a striker scores a lot of goals, perhaps his/her overall performance could be considered high, because scoring is a very important variable, but it is not the only factor to consider. Similarly, if a winger is a highly effective dribbler, or a centre-back an interceptor, it cannot be assumed that their overall performance will be high, since performance in football, as has been noted, is a multifactorial construct. In this sense, it is evident that within a playing position there are some actions that are more important than others, either because they occur more frequently or because they are particularly relevant.

Currently, large amounts of data are collected, although in many cases the validity of the metrics, i.e. how they are linked to success or whether they allow different levels of performance to be defined, is unknown (Castellano & Clemente, 2020). It is clear that there is a progressive shift from the classic metrics offered by suppliers to more advanced and contextualised metrics. In this way, game play, traditionally identified from the player's relationship with the ball, is progressively being understood as the result of the functional interaction between the player and his or her environment with a certain purpose (Araújo, 2005). Through sufficiently large databases, in which play according to different variables has been recorded, analysts can obtain overall rankings and ratings of players through the evaluation of all these actions (Berrar et al., 2019). Therefore, it is important to assess the validity of performance ratings and indices quantitatively and comprehensively, through datasets created with the help of experts (Pappalardo et al., 2019a).

In short, given the need for calculating a global performance indicator, a product of the volume and effectiveness of the most representative actions that players perform according to their playing position, the aim of this work was to design and validate an instrument that would allow the performance of professional players to be rated, classified and compared, understood as the footballing competence they show in their play, based on the Wyscout data provider.

Method

Design

The present work responded to an instrumental study (León & Montero, 2007), aimed at the design and validation of a tool for the qualification, classification and comparison of football competence in professional football players. It should be noted that this study did not address the process of obtaining evidence of reliability on the data extracted from the Wyscout platform, as the results found in a previous study (Pappalardo et al., 2019a), which replicated the protocol used to ensure the reliability of Opta data (Liu et al., 2013), were used to confirm the reliability of the data.

Participants

For the design and validation of the TOPSTATS instrument, two football experts, together with a researcher, contributed their knowledge in four consultation and discussion sessions. The two football experts had more than 10 years of experience in analysing the Spanish Primera División and the English Premier League, respectively.

Instrument Design

The TOPSTATS instrument was designed using Excel 2013 software, factoring in the 111 variables provided by the supplier Wyscout at the time of validation of the tool. Ultimately, it consists of a set of Excel files designed *ad hoc* that separately represent those playing positions that, in the opinion of the experts involved in the validation process of the instrument, are most commonly encountered in the teams. There are nine of these: goalkeeper, central defender, full-back (right and left), defensive midfield, box-to-box, creative midfield, wide midfield (right and left), winger (right and left) and striker. For each position, the overall performance of the players who play in that position is analysed, based on the interaction of the 12 most representative variables, as judged by the experts.

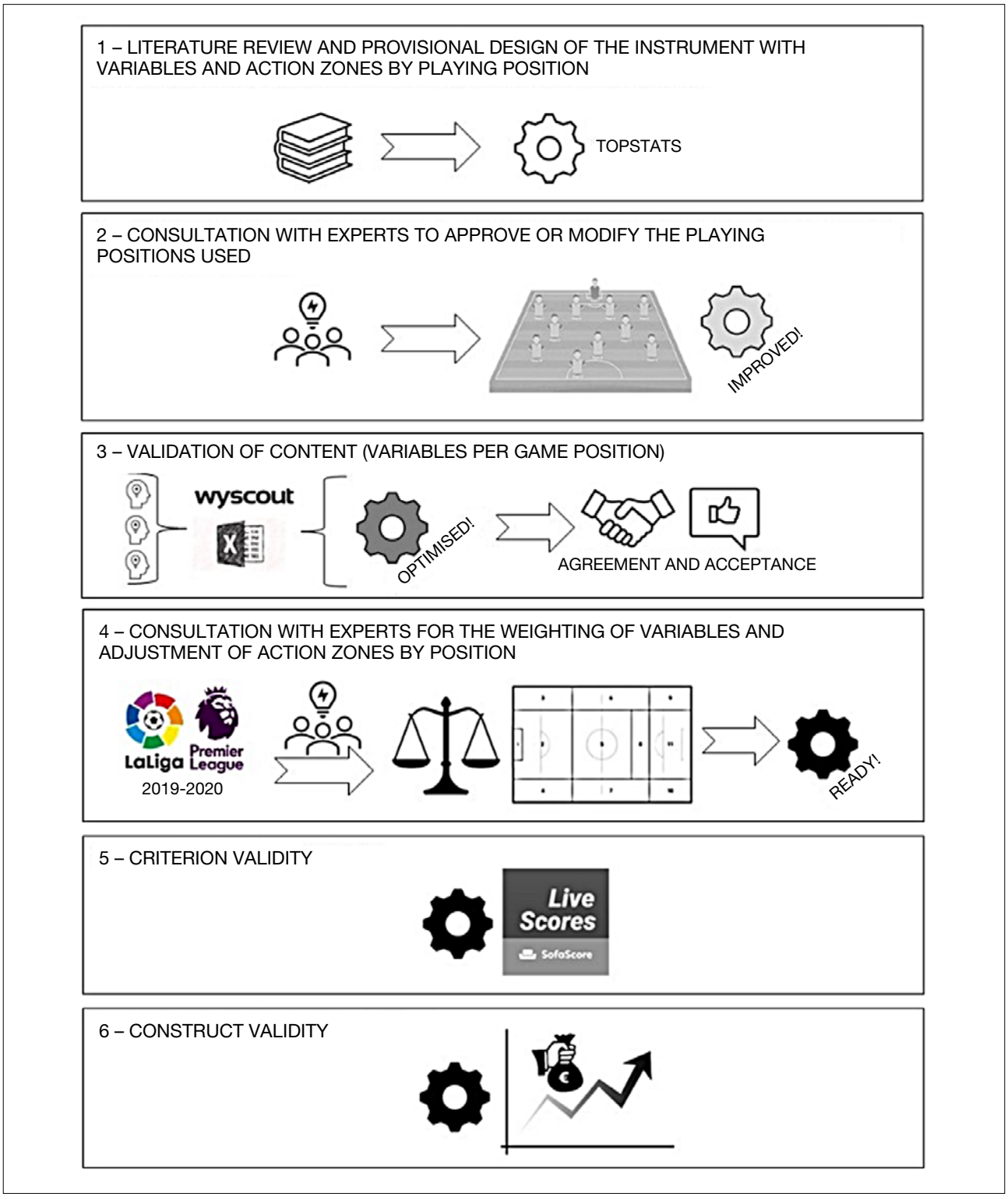
Validity of Instrument

Any instrument that claims to be scientific, regardless of its type and objective, must undergo a process of validation. Traditionally, three types of validity are recognised: content, construct and criterion validity (Cronbach & Meehl, 1955). Content validity qualitatively assesses whether the instrument measures what it is intended to measure. In this case, in order to assess the football competence of a player, the most representative variables must be selected according to the position played. In order to do so, it appears necessary to rely on expert judgement. Another of the keys to validating this type of instrument is criterion validity, i.e. comparing the results obtained in the instrument to be validated with an external criterion that aims to measure the same thing (Hernández et al., 2010), in order to ensure that there are no significant differences between the two measurement criteria. Finally, construct validity can be expressed in different ways, using the perspective of discriminant validity in this kind of instrument, as it allows for validating whether the instrument is able to distinguish between individuals who are expected to be different (Carvajal et al., 2011). As for the reliability of the data, it is directly dependent on the suppliers, unless ad hoc tools designed for this purpose are used. This may be common in analytical departments that aim to collect data in a certain way from observation. If so, it is necessary to ensure that the tool is used homogeneously by all analysts involved in the process, so that it is always measured in the same way.

Procedure

The instrument design and validation process was carried out in six stages (see Figure 1), following the procedure established in other studies that have validated tools recently (Sánchez-López et al., 2021, 2023c, 2023b): (a) literature review and provisional design of the instrument identifying seven possible playing positions, with their respective action zones and associated metrics, (b) consultation and discussion with experts to approve or modify the most commonly played positions in the teams, (c) content validation of the instrument based on the agreement among experts of the 12 most representative variables in each position studied, (d) consultation and discussion with experts to adjust the weighting of the variables, taking the data extracted from La Liga and the Premier League as a reference, as well as the action zones to be filtered for each playing position, (e) criterion validation, and (f) construct validation of the instrument.

Figure 1
Stages in the design and validation of "TOPSTATS".



In the first stage, a literature review was carried out on studies that analysed the most significant technical-tactical variables in each playing position (Dellal et al., 2010, 2011; Firiteanu Vasile, 2013; Hughes et al., 2012; Van Lingen, 1997; Wiemeyer, 2003; Yi et al, 2018) and their spatio-temporal data (Konefał et al., 2019; Pappalardo et al., 2019b), as well as studies aimed at designing tools that assess sport performance from supplier data (Brooks et al., 2016; Duch et al., 2010; Pappalardo et al., 2019a).

Based on this review, the provisional tool was designed, initially with seven playing positions (goalkeeper, centre-back, right/left full-back, defensive midfield, attacking

midfield, right/left wing, striker). Later, two new playing positions were to be included. For each playing position, the 12 most decisive variables in the opinion of the researcher were selected. This selection of variables was determined by the metrics offered by the subscription provider Wyscout. In this case, Wyscout was able to provide a total of 111 variables on the player at the time of validation of the tool. Data for which can be downloaded from the "advanced search" option, filtering by league, period, position, as well as by any variable that is intended to drive the search.

The provisional selection of variables for each playing position was not shared with the experts until the third stage, and these data were used for comparison with the data extracted from the experts' criteria to validate the tool. In this phase, the action zones of each playing position were also provisionally determined according to the positional filter offered by Wyscout. This selection was to be fine-tuned in the fourth stage through discussion with experts.

Based on the aforementioned prior selection of variables for each position, files were designed in Excel for the analysis and processing of the data obtained. These would be adapted during the process until the final version was obtained, in accordance with each game position. The software focuses on the data of the 12 variables selected for each position, establishing 7 intervals according to the minimum and maximum data for each variable studied. Subsequently, those players who meet the positional filtering are ranked on the corresponding interval for each variable using a Likert scale 1-7, with 1 being not competent at all and 7 being very competent. In this way, the variables are standardised so that they all "speak the same language". Finally, a report displaying the performance index of the entire sample of players analysed is obtained from the sum of the 12 ratings obtained, which are weighted according to their level of relevance in the playing position.

In the second stage, in a first discussion session, the researcher presented the provisional playing positions to the experts, resulting in a consensus on including new playing positions to better reflect the most common positions in a football team. Accordingly, nine playing positions were considered (goalkeeper, centre-back, right/left full-back, defensive midfield, box-to-box, creative midfield, right/left wing, right/left winger, striker). Once this was done, and to conclude the first discussion session, the researcher agreed to send a list of 108 variables to the experts so that they could independently select the most relevant variables by playing position, before scheduling a new discussion session.

In the third stage, the experts had to independently indicate the 12 variables they considered most relevant for each of the playing positions when assessing the football competence of the players playing in those positions. A selection of 102 of the 111 variables offered by Wyscout was allowed, as player name was discarded because it is the representative variable of the player, the specific position, as this variable was used for filtering, the market value that would be used later to carry out the construct validity process of the tool, as well as other variables that did not offer quantitative or relevant data in the opinion of the researcher (current team, contract expiration, country of birth, passport, foot, on loan). It was agreed that other variables which, although not directly related to game assessment, might be important in determining player performance, should not be ruled out. For example, in reference to the variable minutes played, those players with the highest level of participation in their teams tend to be the most competent players. The variable age could also influence medium to long-term performance in younger players. The height variable can be a determining factor in the position of goalkeeper. They were also provided with the Wyscout event glossary describing each of the variables (https://dataglossary.wyscout.com/).

Excel software was used to carry out this process. The researcher also had to perform this task with the new game positions validated during the first discussion session. Once this was done, and the researcher had received the files, content validity was calculated. In this way, the concordance of the two experts' selections was used, as well as the provisional selection made by the researcher, comparing the data jointly through Fleiss' kappa coefficient, as well as in pairs, using Cohen's kappa coefficient. Once sufficiently high agreement was obtained, a second discussion was held with the two experts, and they were shown the researcher's provisional selection of variables for each position, as well as the two selections made by the experts themselves. Once this was done, all variables that had been selected by the three experts for each position were approved, while those variables that had been selected by one or two experts were discussed until consensus was reached on their inclusion/exclusion, and the 12 most representative variables for each game position were determined. For the position of striker it was decided that a metric resulting from the number of goals divided by the number of shots would be included.

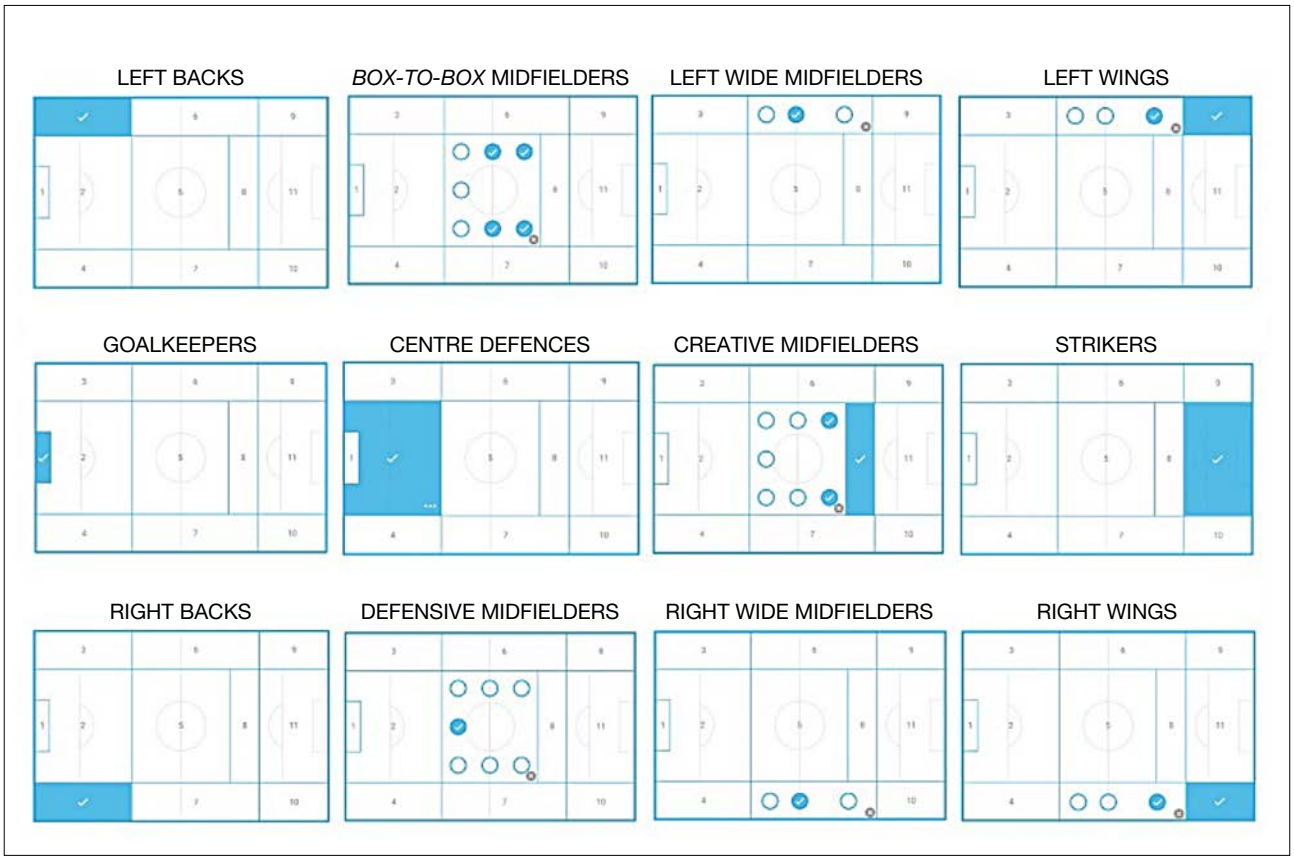
In the fourth stage, a third and fourth discussion session were held with the two experts to weight the 12 variables selected for each position. For this purpose, data from the 2019-2020 Spanish Primera División season (matchdays 1 to 27) and the English Premier League (matchdays 1 to 29) were used, and the discussion began with the variables unweighted, i.e. they all had the same weight when it came to assessing player performance. It was decided that this process should be carried out jointly, rather than independently, as both the experts and the researcher could contribute their ideas and knowledge on how each of the variables could influence one another, taking into account the direct dependence that they would always have on the desired player profile and the game style in which they are being assessed.

Table 1 shows the list of selected variables and their weights. In parallel to this process, and as mentioned in stage 1, the action zones of each playing position were adjusted through the analysis of the players that appeared or disappeared when any of the zones were selected or not in the filter offered by Wyscout. In this way, the most relevant zones for each playing position were determined. Figure 2 shows the filtered zones for each playing position after the above mentioned process.

Table 1
Variables selected for each position and their weighting based on expert consensus.

	Variable \ Position	Goalkeeper	Centre	Full-back	Defensive midfield	Midfield *box-to-box*	Creative midfield	Wide midfield	Winger	Striker
4	Age	5%	5%	5%	5%	5%	5%	5%	5%	5%
8	Minutes played	10%	10%	10%	10%	10%	10%	10%	10%	10%
16	Height	10%	5%							
20	Defensive clashes in the 90 min				10%	10%				
21	Defensive clashes won %		14%	15%	10%	15%	7.50%	12.50%		
23	Air clashs won %		12%	10%	12%	12.50%				5%
25	Entries/30opponent possession		12%	10%	12%	7.50%				
29	Interceptions/30 opponent possession	2.50%	12%	10%	12%	10%		10%		5%
30	Fouls in the 90 min				4%					5%
39	xG in the 90 min		10%	5%	5%	5%	7.50%	5%	15%	15%
47	Centres in the 90 min			7.50%				7.50%		
48	Centres %			7.50%				7.50%		
54	Shots in the 90 min								5%	
55	Shots taken %						5%	10%	5%	
56	Offensive clashes in the 90 min					10%				
57	Offensive clashes won %					10%	10%	12.50%		10%
58	Touches in the penalty area/90 min					2.50%			5%	10%
59	Advancing runs over 90 min			5%				5%	5%	
60	Passes in the 90 min	7.50%	7%		7.50%		7.50%			
61	Passing accuracy %	5%	4%		10%		7.50%			
71	Long Passing Accuracy %	5%	4%							
72	Average pass length, m	5%	5%							
74	xA in the 90 min			7.50%	2.50%	2.50%	15%	7.50%	15%	10%
77	Clearances/90 min								7.50%	5%
78	Accuracy of clearances %								7.50%	5%
79	Key plays/90 min			7.50%			15%	7.50%	10%	
81	Passing accuracy in last third %								10%	
84	Deep passes/90 min						5%			
85	Accuracy of deep passes %						5%			
94	Unbeaten goals in the 90 min	12.50%								
95	Stops %	20%								
103	Ball calls/fist deflections	10%								
105	Air clashs won %	7.50%								
-	Goals/Shots (Resulting metric)									15%
		100%	100%	100%	100%	100%	100%	100%	100%	100%

Figure 2
Positional filter of players according to playing position.



In the fifth stage, the criterion validity of the instrument was calculated. This estimates the degree of agreement with some external criterion that purports to measure the same thing. For this purpose, player performance indices obtained in TOPSTATS from the weighted total score in each playing position were compared with player scores in SofaScore. The player scores on SofaScore are calculated objectively using data from the provider Opta.

In the sixth stage, to estimate construct validity, the discriminant validity perspective was used (Carvajal et al., 2011), which measures the degree to which the instrument is able to distinguish between groups of individuals who are expected to be different (McDowell & Newell, 1996), due to their characteristics or performance (Thomas et al., 2011). In this particular case, the market value of the players was used to determine if this related to the overall TOPSTATS score.

Statistical Analysis

In order to calculate content validity, expert consultation was needed, as described in the third step of the procedure. Through this process, the Fleiss kappa index from the Excel "Real Statistics" add-in was used to calculate the degree of agreement between the 3 experts when selecting the 12 most relevant variables in each of the game positions. This procedure allows the degree of agreement between two or more observers to be obtained. Although it is usually used as a measure of reliability, given the uniqueness of this study, it was considered the best way to undertake this step for the content validity of the tool, as it was intended to verify whether each position was measuring what it was intended to measure, according to the variables selected by the experts, given that in most sports it is found that important performance indicators vary from one coach to another (Hughes et al., 2012). Similarly, as a supplementary procedure, SPSS v.19 software was used, using Cohen's (1988) kappa agreement index by pairs of observers, allowing the same final result to be arrived at in a different way.

In the fifth and sixth stages of the procedure, the Pearson correlation was used to determine the criterion and construct validity of the tool by relating the total scores of the players obtained in TOPSTATS to the SofaScore and to their market value, respectively.

Results

For content validity, a Fleiss kappa index (k = .691) was obtained, indicating considerable agreement between the three observers according to the interpretation scale proposed by Landis & Koch (1977). For observer-pair agreement, a similar average (k = .691) was obtained from Cohen's kappa index. The pairwise concordance can be seen in table 2.

For criterion validity, the total player scores obtained in TOPSTATS were related to those of Sofascore through Pearson's correlation index (see table 3), with significant evidence of association ($r = 0.3–0.88$; $p < .05$) in all playing positions.

Finally, to estimate the construct validity of the tool, the total player scores obtained in TOPSTATS were correlated with their market value extracted from Wyscout at the time of the analysis. In this case, there was significant evidence of association in 17 of the 24 playing positions ($r = 36$-80; $p < .05$), excluding the positions of left-back and box-to-box midfield in the Spanish La Liga, and right and left wings in both competitions (see table 4).

Table 2
Concordance according to Cohen's kappa pairs.

Kappa measure of agreement	Value	Typical error asint.[a]	Approximate T[b]	Approximate sig.
Expert1 * Expert2	.672	.039	21.229	.000
Expert1 * Expert3	.745	.035	23.535	.000
Expert2 * Expert3	.657	.039	20.779	.000

a Assuming the alternative hypothesis / b Using the asymptotic standard error based on the null hypothesis

Table 3
Pearsoncorrelation between Overall Performance Index (total weighted) in TOPSTATS and SofaScore ratings of players with more than 800 minutes played in the 2019-20 League and Premiership.

	Spanish La Liga 2019-20 Matchdays 1-27	English Premier League 2019-20 Matchdays 1-29
Goalkeepers	(r = .63; p = .001; n = 23)	(r = .63; p = .001; n = 23)
Centre defences	(r = .38; p = .000; n = 62)	(r = .55; p = .000; n = 70)
Right backs	(r = .72; p = .000; n = 32)	(r = .78; p = .000; n = 34)
Left backs	(r = .61; p = .000; n = 36)	(r = .71; p = .000; n = 35)
Defensive centre midfielders	(r = .85; p = .000; n = 20)	(r = .49; p = .019; n = 26)
Box-to-box midfielders	(r = .36; p = .002; n = 71)	(r = .30; p = .016; n = 65)
Creative midfielders	(r = .71; p = .000; n = 78)	(r = .79; p = .000; n = 51)
Right wide midfielders	(r = .53; p = .003; n = 30)	(r = .50; p = .008; n = 27)
Left wide midfielders	(r = .56; p = .000; n = 43)	(r = .71; p = .000; n = 21)
Right wings	(r = .82; p = .000; n = 24)	(r = .71; p = .000; n = 25)
Left wings	(r = .58; p = .004; n = 23)	(r = .57; p = .004; n = 24)
Strikers	(r = .87; p = .000; n = 51)	(r = .88; p = .000; n = 47)

Table 4
Pearson Correlation between Overall Performance Index (total weighted) in TOPSTATS and market value of players with more than 800 minutes played in La Liga and Premier League 2019-20.

	Spanish La Liga 2019-20 Matchdays 1-27	English Premier League 2019-20 Matchdays 1-29
Goalkeepers	(r = .60; p = .002; n = 23)	(r = .52; p = .012; n = 23)
Centre defences	(r = .36; p = .004; n = 62)	(r = .43; p = .000; n = 70)
Right backs	(r = .36; p = .043; n = 32)	(r = .58; p = .000; n = 34)
Left backs	(r = .17; p = .323; n = 36)	(r = .50; p = .002; n = 35)
Defensive centre midfielders	(r = .67; p = .001; n = 20)	(r = .43; p = .027; n = 26)
Box-to-box midfielders	(r = .17; p = .168; n = 71)	(r = .06; p = .628; n = 65)
Creative midfielders	(r = .41; p = .000; n = 78)	(r = .48; p = .000; n = 51)
Right wide midfielders	(r = -.11; p = .577; n = 30)	(r = .21; p = .300; n = 27)
Left wide midfielders	(r = -.04; p = .803; n = 43)	(r = .18; p = .425; n = 21)
Right wings	(r = .80; p = .000; n = 24)	(r = .63; p = .001; n = 25)
Left wings	(r = .64; p = .001; n = 23)	(r = .68; p = .000; n = 24)
Strikers	(r = .54; p = .000; n = 51)	(r = .67; p = .000; n = 47)

Discussion

The aim of the present study was to design and validate an instrument to rate, classify and compare the overall performance of professional players, understood as the football competence they show throughout their play, based on the Wyscout data provider. The developed instrument analyses data extracted from the Wyscout provider in a semi-automatic way, and provides a player rating, in the form of an overall performance index, according to their position and in relation to players playing in the same position and in the same league. In this way, comparisons between players can be made quickly, which is crucial when working in sports clubs where time is of the essence and analysis processes are carried out at a dizzying pace. In addition, this process can be carried out in more than 200 competitions that are included in Wyscout data coverage.

Football competence has been studied in recent works using an observational system (Sánchez-López et al., 2021), or by describing collective behaviours according to the level of football competence shown by the participants (Nieto et al., 2022). As a central concept of this work, in the face of very different teams, it is revealed by the player's ability to adapt to the behaviour of the other players, to participate in a collective strategy, to show empathy and anticipation in the position, and to be successful in the behaviours developed during the match (Parlebas, 2018). This is why play and competition are two inseparable terms, as play is the product of competition, and performance during play is the best indicator of the players' competence.

Ensuring the validity of any instrument that aims to assess the performance of players is a necessary step in order to guarantee the quality of the assessment. One of the problems that often arises when trying to obtain evidence of content validity through expert knowledge is that a list of the correct content of the phenomenon to be measured is often not available and therefore has to be established (Carvajal et al., 2011). In the case of this study, the principal researcher provided a detailed list of all the metrics that can be extracted from Wyscout, and the experts had to establish which metrics were the most relevant for each playing position. This part of the research was carried out with great care and patience, in order to ensure expert consensus on the selection of the variables that define each positional profile, as well as the weights associated with each variable. The experts' knowledge of the performance of players in both La Liga and the Premier League allowed them to adjust these weights in order to obtain total scores in line with reality.

In order to obtain evidence of criterion validity, scores from the SofaScore platform were used as external criteria that purported to measure the same thing. These scores are the result of the data processing provided by the Opta provider, which was found to be reliable in a previous study (Liu et al., 2013). Sofascore, at the time of publication of this paper, continues to increase its data coverage, but falls short of Wyscout's data coverage, so a tool such as TOPSTATS could be used to obtain global performance indices across a larger volume of countries and divisions. For example, in the case of Spain, performance indices could be obtained in divisions such as the 1st RFEF or 2nd Spanish RFEF which, at the date of submission of this paper, are not supported by Sofascore.

With respect to construct validity, it could be seen that in 7 of the 24 positions analysed, there was no relationship between the rating of the players and market value. This was because market value is not only determined by the performance of the players but also by their potential and future possibilities. Age is therefore a variable that can skew results in certain positions, as experienced players approaching the final years of their careers had very low market values. For example, Joaquín and Cazorla in La Liga, both performing at a very high level in midfield positions. It is also the case, specifically in midfiled positions, that the experts tried to identify a more multifunctional player profile as opposed to the positions occupied by wingers, which have particularly offensive characteristics. Another drawback encountered, in order to ensure the construct validity of the tool, was that the positions of creative and box-to-box midfield share spatial filtering, i.e. many players were rated in both positions, as they performed in the central area of the field. This resulted in many players who scored high as creative midfielders obtaining low scores as box-to-box midfielders, due to the variables of analysis being different. Their market value also skewed the results, since the best creative midfielders (De Bruyne, Maddison, David Silva, Tony Kroos, Odegaard...) had higher market values than the best box-to-box midfielders (Mikel Merino, Saúl Ñíguez, Fred, Ward-Prowse...). In the case of left-backs in La Liga, no significant relationship was found between rating and

market value. This was surely due to the fact that several players with low market values performed at a high level during the season (Estupiñán, José Ángel, Fran Gámez, Lucas Olaza, Toño...) and, at the same time, that several players with high market value did not perform at the level expected (Gayà, Jordi Alba, Mendy...).

As for the limitations of the study, on the one hand, the main limitation of the tool revolves around its dependence on the data provider, since the files were coded taking the database that can be downloaded through Wyscout as a reference. This is a minor shortcoming, as the provider could change the way data is exported at any time, which would require modifications to the tool's code. On the other hand, it is interesting to mention that variables focused on relationship with the ball, which are widely used to assess performance in team sports, should be judged with care when comparing players from different divisions and categories (Sánchez-López et al., 2023a). Although the leagues may have a similar level of play, the contexts of confrontation may be different due to the cultural system. With regard to this idea, it also seems important to point out that it is necessary to consider the selection variables by position and the weighting of these variables when determining which player in the team may be suitable to play as a starter in a match, or which players on the market may be suitable to bring into the club. Regarding this point, the team's style of play plays a key role in winning (Kong et al., 2022), as well as in the type of actions that are more relevant to good collective performance. In this sense, the selection of variables and weightings presented in this work have been thoroughly validated, attempting to respond to any style of play. For this reason, it is not recommended that very drastic modifications be made, as some validity could be lost in this process.

Sport sciences are continuously working on the application of new methodologies and training systems to improve and maintain the performance of athletes (Pons Alcalá et al., 2020). Consequently, the instrument validated in this study has innumerable possibilities of applicability in the sporting and academic field, among which the following could be highlighted: (1) within the team itself, it is possible to analyse and compare the performance of players occupying the same position, in order to identify which player may be more suitable for a given match, or which player is performing better in that position according to his play; (2) it is also possible to analyse the performance of players from the team itself and players from teams in the league, establishing comparisons and rankings by playing position; (3) another alternative revolves around the assessment of possible recruits on the basis of the performance of the players; (4) it is also possible to assess the evolution of players by comparing their performance longitudinally, e.g. from one season to another, or in two different periods of a league.

As for future prospects for the tool, they depend directly on the future of the supplier, in the knowledge that the scenario that lies ahead is very exciting, as suppliers are increasingly offering a greater quantity of data, of much higher quality.

Conclusions

As conclusions of the study, TOPSTATS shows optimal validity values. It is an instrument capable of rating, classifying and comparing the football competence shown by professional players in their play during the same competition, according to their playing position. To this end, the tool allows for the agile and semi-automatic calculation of an overall performance index obtained from the interaction and weighting of variables contained in the data obtained from the Wyscout provider, which has data coverage in more than 200 competitions.

Therefore, the instrument could be used by professional clubs, sports performance analysis departments and coaches to analyse and compare players, allowing for further optimisation of training and evaluation processes. Similarly, in the scientific field, the instrument could be useful in research that requires the creation of study groups around the competitive performance of players.

Declaration of conflict of interest

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Comparative of the goals scored by set pieces during the Eurocup and Copa America 2021

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Abstract

This study aimed to establish a comparison between the goals scored from set pieces (corners, direct and indirect free kicks) in the European and South American (EURO 2021 - COPA 2021) competitions, coinciding within the same time frame. For this purpose, all goals (22 and 17, respectively) were analysed and variables related to the following different action phases were collected: beginning (kicker's foot, minute, starting area), development (marking, ball trajectory, number of attackers or defenders) and the end (height of the previous pass, number of passes or contacts before the goal). A Cohen's kappa and the Intra-class Correlation Coefficient were per-formed between two observers, and an analysis using Chi-square and Mann Whitney U was carried out. The results showed no significant differences, except for the height of the pass (with a higher-than-expected number in the medium pass and COPA) and the confederation of the club to which the scoring player belonged (a higher percentage of players scored from UEFA in EURO, and CONCACAF in COPA). These findings could suggest a European influence in set-pieces due to recent success in international competitions and could be useful for coaches and analysts to expand the information about rivals.

Keywords: corners, free kicks, international championship, outcome, performance analysis.

Introduction

Set pieces have clear importance in football development in recent years as one of the trends accounted for in team performance analysts (Sarmento et al., 2018). The technical-tactical behaviours associated with some of the categories belonging to this variable have evolved through differences in the importance of each variable in different editions played, such as the type of offensive organisation, the transcendence, or the number of attackers involved in the play (Maneiro et al., 2021). In the existing literature, studies have focused on analysing different competitions to clarify different questions, such as which type of defence presented more favourable results or whether the effectiveness of the actions increased by getting more players in the team in contact with the ball, or through the trajectory of the ball (Casal et al., 2015; Kubayi & Larkin, 2019).

Set-pieces are a fairly common occurrence on the field, consuming around 38% of the total match time (Siegle & Lames, 2012). Several studies estimate that between 30 and 40% of goals scored by teams come from set pieces (Casal et al., 2015; Kubayi, 2020). González-Rodenas et al. (2020) point out that 24.1% of UEFA Champions League goals in the 2016-2017 season were scored from set pieces, highlighting that the technical-tactical actions that achieve a goal and their spatial characteristics are related to the type of defence used by the opposing team, which is why authors such as Rumpf et al. (2017) extol its relevance. The average number of corners per game is between 10 and 11 (Sainz de Baranda et al., 2011) and, despite their low effectiveness (2.2% following Casal et al. [2015]; 3.6% in Lee & Mills [2021]), this type of action can be decisive for the outcome of the match (Casal et al., 2015; Maneiro Dios et al., 2019).

Regarding free kicks, López-García et al. (2018) found an average of 31.42 free kicks per game. Although free kicks had a similar low effectiveness as corner kicks (3.1%), highlighting these actions, the number of attackers involved, the delivery and the offensive organization could be important indicators to consider improving the scoring ratio. Link et al. (2016) valued density, type of barrier, distance and the number of players as important variables highly dependent on space, while also highlighting centrality and proximity to the goal as factors that increased these variables. About the defensive organisation in these actions, it was found that those teams defending corners using zonal marking conceded more goals compared to a combined model, and that, by placing a defender at each of the posts, no goals were conceded by the defending teams.

Due to its importance, different research has been carried out in both national and international competitions. This type of action has not only been studied in men's football but also in women's football, showing that it is key to winning or drawing matches and that the executions are similar (Maneiro Dios et al., 2019).

Although a widely studied field, it is rare to find comparisons between international competitions in the published literature. The research focused on this comparison finds that the passing networks before scoring a goal are similar in both continents (McLean et al., 2017).

For this reason, and to establish a comparative line of research between these two competitions, we have taken advantage of the simultaneity of tournament development to analyse whether there are different patterns or associations in the goals scored from set pieces between a European international competition (EURO 2021) and a South American competition (COPA 2021), thus proposing a new line of research.

Materials and Methods

Sample

For the analysis of these actions, all goals scored from direct free kicks, indirect free kicks and corner kicks in the final phases of the EURO 2021 and COPA competitions were collected, with a total of 22 and 17 goals scored respectively. A total of 51 EURO 2021 matches, and 39 COPA matches were watched. Both tournaments took place between 11 June and 11 and 10 July 2021, respectively. Penalty kicks, centre kicks and throw-ins were excluded from this study because the structure is similar for direct, indirect and corner kicks; in penalty kicks there is no defence and the percentage of goals from goal kicks and throw-ins is low, although they occur frequently (Siegle & Lames, 2012; Stone et al., 2018).

Procedure

Set pieces were analysed by systematic observation according to Lames (1994) and Singer and Willimczik (2002). Two professionals in sport sciences with more than 10 years of experience in the area oversaw the recording, visualised all the actions, and were trained to provide an accurate and reliable data recording.

Although the analysis of these actions was carried out independently, a total of four meetings were held to define the variables and understand each situation. To achieve this, less than 15% of the sample was used in the meetings.

Variables

To set the variables, several studies were considered (Sainz de Baranda et al., 2005; Di Salvo et al., 2007; Sainz de Baranda et al., 2011; Casal et al., 2015; Link et al., 2016; Fernández-Hermógenes et al., 2017; Beare & Stone, 2019; Kubayi & Larkin, 2019; Wang & Qin, 2020; Lee & Mills, 2021; Maneiro et al., 2021). Those previously used in different studies of set pieces had been taken and adapted, adding other indicators used for patterns of play and scoring research in both international and national competitions. The categorical variables are shown in Table 1.

Table 1.
Description and categorisation of the nominal variables used for the study.

Variable	Description
Type of set piece	Action leading to the goal
	Direct free kicks: free kicks that are taken without the need for contact with the ball by a team-mate before attempting to score a goal.
	Indirect free kicks: free kicks that are taken with the need to have contact with the ball from a teammate before attempting to score a goal.
	Corner kick: kick from the corner of the field after the ball has cleared the end line after being touched by a defender.
Position	Position of the player who scored the goal
(Di Salvo et al., 2007)	Central defender
	External defender
	Central midfielder
	External midfielder
	Forward
Confederation	Confederation of the club to which the player scoring the goal belonged at the end of the season 2020/2021
	UEFA - Union of European Football Associations
	CONMEBOL - Confederación Sudamericana de Fútbol
	CONCACAF - Confederation of North, Central America and Caribbean Association Football
	AFC - Asian Football Confederation
Time	Time frame in which the goal was scored
	1-15
	16-30
	31-45
	46-60
	61-75
	76-90
	Extra-Time
Relevance	Incidence of the goal action on the outcome of the match
	Unimportant: the goal has no bearing on the outcome of the match.
	Tie: the achievement of the goal implies a draw in the match.
	Victory: scoring the goal leads to a victory in the match.

Table 1. (Continuation)
Description and categorisation of the nominal variables used for the study.

Variable	Description
Starting zone, Finishing zone, Goalkeeper position	Area in which the play is initiated, depending on the laterality of the set- piece action
	Space from which finalisation takes place
	Area in which the goalkeeper is at the time of the shot
(Adaptaded from Fernández-Hermógenes et al., 2017; Beare & Stone, 2019; Lee & Mills, 2021; Wang & Qin, 2020; Figure 1)	Short Corner Zone (SCZ)
	Front Zone (FZ)
	Goal Area 1 (GA1)
	Goal Area 2 (GA2)
	Goal Area 3 (GA3)
	Critical Area 1 (CA1)
	Critical Area 2 (CA2)
	Critical Area 3 (CA3)
	Edge (E)
	Back Zone (BZ)
	Opposite Corner Zone (OCZ)
	Medium Lateral Zone (MLZ)
	Central Close Zone (CCZ)
	Central Away Zone (CAZ)
	Opposite Medium Lateral Zone (OMLZ)
	Large Lateral Zone (LLZ)
	Midfield Close Zone (MCZ)
	Midfield Away Zone (MAZ)
	Opposite Large Lateral Zone (OLLZ)
	Own Half (OH)
Kicker's foot	Leg with which the thrower executes the set-piece action
	Right
	Left
Fault trajectory	The direction the ball takes once it has been put into play for direct and indirect free kicks
(Adaptaded from Kubayi & Larkin, 2019; Maneiro et al., 2021)	Open; Ball trajectory away from the goal.
	Closed; The trajectory of the ball approaches the goal.
	Short; The ball is put into play looking for a close teammate.
	Direct; The trajectory of the ball is direct to the goal.
Corner trajectory	The direction the ball takes after it has been put into play at corner kicks.
(Adaptaded from Kubayi & Larkin, 2019; Maneiro et al., 2021)	Open; Ball trajectory away from the goal.
	Closed; The trajectory of the ball approaches the goal.
	Short; The ball is put into play looking for a close teammate.
Defence style	Player positioning to defend the action
(Adaptaded from Casal et al., 2015; Maneiro et al., 2021)	Zone; Each player is responsible for a certain zone of the field or area.
	Man-to-man; Every attacker is marked by a defender.
	Combined; Mix of Zone marking and Man-to-Man marking.
	Mixed; Each player is responsible for a zone, and for the opposing player who stands in that zone.

Table 1. (Continuation)
Description and categorisation of the nominal variables used for the study.

Variable	Description
Opposition	The situation of the player finishing the action about the defenders
(Adaptaded from Casal et al., 2015)	9.15 m
	High; Active defender in front of the player who is going to finish the action and within his range of action is at a distance of interposing a body part to intercept the ball.
	Medium; Active defender in the radius of action, but is laterally or behind the finishing player and allows for some ease of shooting.
	Low; There are no defenders within range of the passer and he performs unopposed.
Type of completion	Technical completion action
(Adaptaded from Casal et al., 2015)	Shooting
	Control and shooting
	Driving
	Dribble
	Own goal
Striking surface	Part of the body with which the player shoots at goal
(Adapted from Sainz de Baranda et al., 2011)	Inside of the foot
	Outside of the foot
	Foot sole
	Instep
	Heel
	Toe
	Head
	Trunk
Height of the previous pass	The altitude of the pass received by the finisher
	High - Parabolic; The player receives a ball that has a flight higher than his neck height.
	Medium; The player receives a ball with a mid-flight (lower neck to knees).
	Low; Player receives a ball low or below knee height.
Finishing leg	Distinguishing between right and left, and whether it is the player's dominant leg or not, as long as the goal is scored with the foot.
(Adaptaded from Casal et al., 2015)	Dominant right
	Non-dominant right
	Dominant left
	Non-dominant left
Goal zone	The sector of the goal through which the ball enters the net
(Sainz de Baranda et al., 2005, Figure 2)	1 – Lower - right
	2 – Lower - centre
	3 – Lower - left
	4 – Middle - left
	5 – Middle-centre
	6 – Middle - right
	7 – Upper - right
	8 – Upper - centre
	9 – Upper - left

Table 2 presents the definition of the numerical variables that have been collected for this study.

Table 2
Description of the numerical variables used in the research.

Variable	Description
Seconds	Time taken for the goal to be scored from the start of the action
Number of attackers (Adapted from Maneiro et al., 2021)	Number of offensive players seeking to participate in the action, not counting the pitcher
Number of defenders (Adapted from Maneiro et al., 2021)	Number of defensive players involved in the action
Numbers of offensive contacts	Number of offensive players touching the ball before a goal is scored
Numbers of defensive contacts	Number of defensive players touching the ball before a goal is scored
Number of passes (Adapted from Maneiro et al., 2021)	Number of passes made in the course of action
Contacts	Number of contacts the player makes to score the goal
Barrier (Link et al., 2016)	Number of players within 9.15 m at set pieces

Figure 1
Observation templates of the starting zone, finishing zone and goalkeeper's position when the free kick or corner kick is taken from the left and right zone. Adapted from Beare & Stone, 2019; Lee & Mills, 2021; Wang & Qin, 2020.

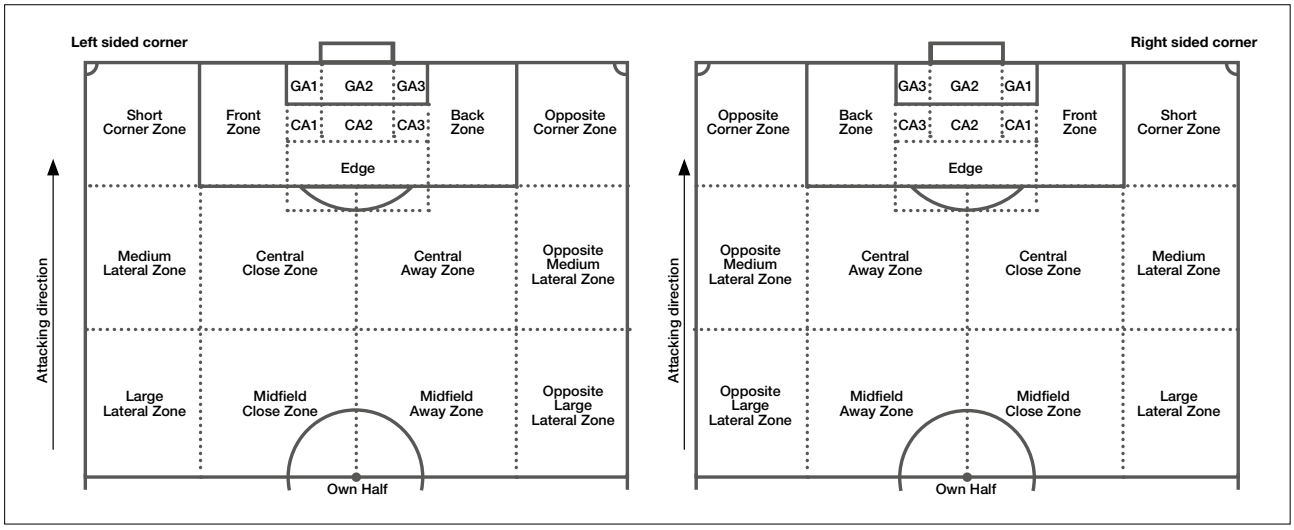
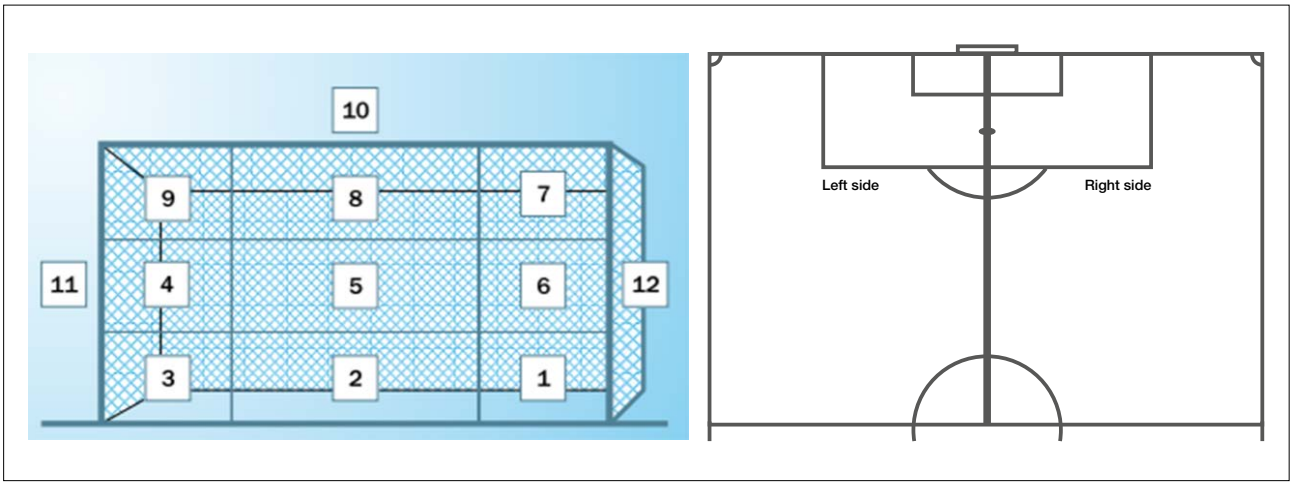


Figure 2 (left) and 3 (right)
Figure 2, taken from Sainz de Baranda et al. (2005), illustrates the different zones for the registration of a shot on goal. Figure 3, based on Fernandez-Hermógenes et al. (2017), corresponds to the criteria for the use of zones according to the laterality of action and goal zones.



To establish common criteria for the zones, a modified categorisation from previous studies was used (Beare & Stone, 2019; Lee & Mills, 2021; Wang & Qin, 2020). The register was used for the right or left zone according to the scenario of the kick around the central zone, and the penalty spot and the central point of the field were used as references (Ardá et al., 2014), as shown in Figure 3.

Statistical analysis

As with the analysis, the methodology applied in this study was similar to González-García et al. (2016). Cohen's kappa coefficient (k) was used to determine the degree of agreement between observers on nominal or categorical variables, and the following criteria was used to determine interpretation: 0 - .2 Poor agreement; .21 - .40 Fair agreement; .41 - .60 Moderate agreement; .61 - .80 Good agreement; .81 - 1 Very good agreement (Altman, 1991). These variables are expressed using the frequency of observation.

For those continuous variables, expressed as mean and standard deviation (M ± SD), the standardised typical error, the intra-class correlation coefficient (ICC), and Pearson's r were calculated using the Hopkins' spreadsheet (2015). To classify ICC, criteria established by Koo and Li (2016) was followed; <.5 Poor reliability; .5 - .75 Moderate reliability; .75 - .9 Good reliability; >.9 Excellent reliability.

Cohen's kappa and ICC values are shown in Table 3.

Table 3
Cohen's kappa and ICC for all variables.

Variable	*k*	CCI		
		Value	*r*	Typical error
Type of set piece	1			
Position	1			
Confederation	1			
Time	1			
Relevance	1			
Starting zone	.951			
Kicker's foot	1			
Fault trajectory	1			
Corner trajectory	.964			
Defence style	.875			
Opposition	.873			
Type of completion	1			
Striking surface	.890			
Finishing zone	.906			
Height of the previous pass	1			
Finishing leg	.924			
Goal zone	.887			
Goalkeeper position	1			
Seconds		.96	.95	.22
Number of attackers		.84	.82	.42
Number of defenders		.91	.70	.31
Numbers of offensive contacts		.98	.99	.13
Numbers of defensive contacts		.92	.92	.32
Number of passes		.98	.98	.16
Contacts		.91	.92	.32
Barrier		.97	.97	.24

The normal distribution of the variables was checked using the Shapiro-Wilk test. The Mann-Whitney U test was used to compare numerical variables, such as seconds, number of players involved, touches, barrier, and number of passes by the tournament. In parallel, the relationship between the different nominal variables and tournament was observed using Pearson's Chi-square test, with Fisher's Exact Test.

To calculate the size effect, Cramer's V was the measure used for Pearson's Chi – square, following Rea and Parker (1992), with the following interpretation: <0.1 = Negligible association; ≥ .1 to < .2 = Weak association; ≥ .2 to < .4 = Moderate association; ≥ .4 to < .6 = Relatively strong association; ≥ .6 to < .8 = Strong association; ≥ .8 to 1 = Very strong association.

The level of significance was set at .05. The collected data were studied using the software Statistical Package for the Social Science (SPSS, IBM Corporation; Armonk, New York, USA), in version 25.0.

Results

In most cases, no significant differences were observed between the qualitative variables. A relatively strong association was found between the height of the previous pass and the tournament, with the number of passes at an average height higher than expected by chance in COPA 2021; in EURO 2021 the same figure was lower than expected (Table 4).

Table 4.
Comparison of nominal variables between EURO 2021 and COPA 2021.

		EURO 2021	COPA 2021	χ^2	*p*	ES
Type of set piece				0.09	.759	
	Corner kick	14	10			
	Direct free kicks	8	7			
Position				3.64	.505	
	Central defender	4	5			
	External defender	2	0			
	Central midfielder	5	2			
	External midfielder	4	6			
	Forward	7	4			
Confederation						
	UEFA	21	10	8.86	.007	.491
	CONMEBOL	0	2			
	CONCACAF	0	4			
	AFC	1	1			
Time				9.71	.108	
	0-15	2	2			
	16-30	3	1			
	31-45	1	6			
	46-60	2	3			
	61-75	9	2			
	76-90	4	3			
	Extra-time	1	0			
Relevance				1.57	.486	
	Victory	3	5			
	Tie	4	3			
	Unimportant	15	9			

Table 4. (Continuation)
Comparison of nominal variables between EURO 2021 and COPA 2021.

		EURO 2021	COPA 2021	χ^2	*p*	ES
Starting zone				5.01	.622	
	Central Close Zone (CCZ)	2	3			
	Edge (E)	0	1			
	Large Lateral Zone (LLZ)	1	0			
	Midfield Close Zone (MCZ)	0	1			
	Medium Lateral Zone (MLZ)	3	1			
	Own Half (OH)	1	0			
	Short Corner Zone (SCZ)	15	11			
Kicker's foot				0.41	.522	
	Right	12	11			
	Left	10	6			
Fault trajectory				3.92	.282	
	Open	5	3			
	Closed	2	0			
	Direct	1	3			
	Short	0	1			
Corner trajectory				0.74	.864	
	Open	7	5			
	Closed	4	4			
	Short	3	1			
Defence style				0.07	1	
	Combined	20	15			
	Zone	2	2			
Opposition				4.87	.176	
	9.15 m	1	3			
	Low	8	4			
	Medium	6	6			
	High	8	8			
Type of completion				1.45	.761	
	Shooting	20	15			
	Control and shooting	2	1			
	Own goal	0	1			
Striking surface				4.85	.392	
	Head	11	5			
	Trunk	0	1			
	Instep	4	4			
	Inside of the foot	5	7			
	Foot sole	1	0			
	Heel	1	0			

Table 4. (Continuation)
Comparison of nominal variables between EURO 2021 and COPA 2021.

		EURO 2021	COPA 2021	χ^2	*p*	ES
Finishing zone				13.04	.070	
	Back Zone (BZ)	1	0			
	Critical Area 1 (CA1)	2	0			
	Critical Area 2 (CA2)	7	1			
	Critical Area 3 (CA3)	0	2			
	Central Away Zone (CAZ)	1	0			
	Central Close Zone (CCZ)	1	2			
	Edge (E)	1	1			
	Goal Area 1 (GA1)	4	1			
	Goal Area 2 (GA2)	4	8			
	Goal Area 3 (GA3)	1	2			
Height of the previous pass				5.21	.044	.412
	High - Parabolic	14	7			
	Medium	3	6			
	Low	4	0			
Finishing leg				4.23	.248	
	Dominant right	6	7			
	Non-dominant right	2	0			
	Dominant left	1	3			
	Non-dominant left	2	0			
Goal zone				10.24	.154	
	1 – Lower - right	2	2			
	2 – Lower - centre	6	1			
	3 – Lower - left	5	2			
	4 – Middle - left	4	3			
	5 – Middle-centre	1	1			
	6 – Middle - right	3	1			
	7 – Upper - right	0	4			
	9 – Upper - left	1	3			
Goalkeeper position				0.925	1	
	Critical Area 3 (CA3)	1	0			
	Goal Area 2 (GA2)	19	15			
	Goal Area 3 (GA3)	2	2			

In addition, a relatively strong relationship was also observed between the confederation of the scoring player and the tournament. The percentage of scoring players belonging to a UEFA club was higher than expected in EURO 2021 when compared to COPA 2021, while COPA 2021 recorded a higher-than-expected number of scoring players belonging to CONCACAF when compared to EURO 2021. No differences were found for players belonging to AFC or CONMEBOL clubs in the tournaments.

Regarding the numerical variables, no significant differences were found depending on the competition analysed ($p > .05$) (Table 5).

Table 5
Comparison of quantitative variables between EURO 2021 and COPA 2021.

	EURO 2021	COPA 2021	*Z*	*p*
Seconds	3.77 ± 1.65	3.11 ± 1.96	1.48	.073
Number of attackers	6.59 ± 1.01	7.06 ± 1.14	1.35	.100
Number of defenders	10.64 ± 0.73	10.70 ± 0.47	0.05	.478
Numbers of offensive contacts	2.45 ± 0.80	2.29 ± 1.05	0.58	.302
Numbers of defensive contacts	.09 ± 0.29	.58 ± 0.87	0.33	.069
Number of passes	1.45 ± 0.86	1.35 ± 1.22	0.44	.246
Contacts	1.14 ± 0.47	1.12 ± 0.33	0.21	.461
Barrier	1.87 ± 1.46	3.28 ± 2.50	0.95	.198

Discussion

After an analysis of the variables collected in this study that accounted for the development of these set pieces, no significant differences were found in the comparison between the Copa America and the European Championship, except for the height of the pass received by the player and the confederation to which the scoring player's club belongs. These findings could align with Wilwock and Furtado (2019), where no substantial differences were found between Euro 2016, Copa America Centenario 2016 and the 2017 Confederation Cup; however, this analysis takes into account all goals scored by teams, not only those scored from set pieces.

It is worth noting that although a higher-than-expected number of players with clubs belonging to the UEFA confederation were randomly registered for EURO 2021, which would be logical given that they belong to the continent, the same was not observed for CONMEBOL players. This could be related to the influence or impact of the European style of play, which has dominated international competitions for much of the last decade. For example, European teams have won the FIFA World Cup uninterruptedly from 2006 to 2018 (FIFA, 2021). Regarding the FIFA Club World Cup, Europe has also been the tournament leader since its inception, and the UEFA confederation has won 13 titles, compared to CONMEBOL's four (FIFA, 2021). This fact could be a determining factor in the teams' execution of similar models or actions of play. However, a more in-depth study should be carried out on the historical development of Latin American and European teams over time to confirm this hypothetical influence, given that research focused on this comparison determines that there are similar styles between the football passing network before scoring goals on the American and European continents (McLean et al., 2017).

Another possible explanation for these results, and one of the limitations of the study, could be the lack of a larger sample. With only successful set-pieces, and in competitions of short durations, the number of actions counted was small. One of the alternatives to alleviate this deficit could be to limit the time frame and acquire a larger sample with a collection of data from different championships.

Regarding the contrast of the data from our research with other studies, it is difficult to establish similarities due to the scarcity of similar scenarios occurring in the same year and period. A comparison could be drawn with the study of Prieto-Lage et al. (2021), which analyses corner kick behaviour in different European leagues. Although there are differences in the conceptualisation of the variables (for example, only attackers or defenders inside the area in the first contact are counted), can also be found in the same study that European teams usually attack with more than four players, and it is frequent in leagues such as the English, Italian and German leagues that attack with more than six players. Further, there are more than six players in the defence area; we found an average of 10.64 players in Europe, accounting for those players located close to the area.

It is also worth noting the contrast between previous studies that indicates that the second half is key to the achievement of these actions in the competitions of both confederations. While the European competition does register these standards, similar to the Spanish and German leagues, in the South American competition could be found a similardistribution between the first and second half (Prieto-Lage et al., 2021), unlike in regular club competitions in this region. This differs from what is reported in the

Spanish and German leagues (Carelli et al., 2016). The distribution of the first and second halves differs from that reported by the authors in the study of other national and international competitions (Casal et al., 2015; Junior, 2015; Njororai, 2014; Prieto-Lage et al., 2021).

Regarding the completion and initiation of these actions, it is difficult to establish comparisons with other studies (Beare & Stone, 2019; Link et al., 2016; Prieto-Lage et al., 2021) by modifying and adapting the observation graph that has been used in this research from Lee and Mills (2021), according to the side on which the stationary ball was located. Finally, emphasising the relevance of these actions, it could be determined that a low number of set-piece goals presented a direct impact on the final result, although this could be due to the conceptualisation of the variable (Ardá et al., 2014; Casal et al., 2014, 2015; Maneiro Dios et al., 2017).

Among the future lines of research that could be added to the study of these types of actions in competitions, it could be analysed whether the time differences suffered by the teams when competing in different locations, within the same competition, could influence these behaviours and their effectiveness.

Another possible line of research could be the study of the influence of playing as a "host" of the competition or as an away team, similar to studies that analyse the relevance of playing as a home team in this type of tournaments.

Conclusions

The goals scored from set pieces (direct kicks and corners) in the European Championship and the Copa America did not show any differences, except for the height of the pass received by the player and the conference of the club to which the player scoring the goal belonged. These findings are in line with the few studies previously conducted on this comparison. The small sample size and the European dominance in international competitions could affect these results, so the line of research must be continued in order to assess potential reasons for these results.

The use of this information for coaches and performance analysts can help explore similarities between teams from different confederations, broadening the information at hand regarding the development of these actions, and establishing key points for operational strategy in matches or championships.

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Bilateral comparison of shoulder range of motion and peak isometric strength in amateur tennis players

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Abstract

Lower values of shoulder internal rotation range of motion (ROM-IR) and external/internal rotation strength ratio (S-ER/S-IR) of the dominant arm (racket grip) compared to the non-dominant arm have been observed in professional tennis players. It is considered that these adaptations could increase the risk of shoulder injury. Little is known about these adaptations in amateur tennis players. The aim of this study was to bilaterally compare the range of motion (ROM) and peak isometric strength (S) of shoulder rotation movements in amateur tennis players (dominant arm [DA] versus non-dominant arm [NDA]). In thirteen amateur tennis players (18-45 years old) the passive ROM and the S of internal rotation (IR) and external rotation (ER) were measured from the supine position, 90° of shoulder abduction and 90° of elbow flexion. DA and NDA values were compared by paired samples T-test. DA had lower ROM-IR (t = –9.053; $p < .001$; d = –2.551) and total ROM-(t = –4.429; $p < .001$; d = –1.228) compared to NDA (ΔROM-IR = 23.73 %; ΔROM-total = 8.32 %). Greater DA S-IR was also detected compared to NDA (t = 2.344, $p = .037$, d = .650, ΔS-IR = 9.67 %). These results indicate the existence of unilateral adaptations of the shoulder, which have been identified in other publications as risk factors for injury. In contrast to observations in professional tennis players in other studies, no S-related injury risk indicators were found.

Keywords: adults, external rotation, functional assessment, internal rotation, scapulohumeral joint, tennis.

Introduction

Tennis is a sport that involves a large number of overhead arm movements. These movements occur mainly when serving and smashing. For example, all points in a match are initiated by a serve, which makes this action one of the main game actions and accounts for 45-60% of all hitting actions in the match (Johnson & McHugh, 2006). These tennis hitting actions are performed in a highly explosive manner with the aim of delivering the ball at high speeds, with records of up to 210 km/h top speed on serves at professional levels (Kovacs, 2007). In these tennis hitting actions, the shoulder is at the central point of the sequence that generates, aggregates and transmits kinetic energy from the lower limbs to the racket (Van Der Hoeven & Kibler, 2006). The highly complex and mobile anatomical characteristics of the shoulder mean that it has poorly congruent articular surfaces, thereby conferring a critical role on the adjacent ligaments and musculature for joint stability (Felstead & Ricketts, 2017). Both factors, the high number of repetitions of the hitting actions combined with the explosiveness of the movements, expose the player to a high risk of injury, especially overuse or chronic injuries (Pluim et al., 2006; Renstrom & Johnson, 1985). In fact, previous studies have shown that most chronic injuries in professional tennis occur in the upper arm and that a large proportion of these injuries occur in the shoulder joint complex (Pluim et al., 2006; Van Der Hoeven & Kibler, 2006). Moreover, the review by Abrams et al. (2012) revealed that in tennis players at all levels, not just professionals, shoulder injuries accounted for between 4 and 17% of all injuries and that the number of players reporting shoulder pain increased to 50% in middle-aged adult players. Thus, understanding the risk factors associated with shoulder injuries in tennis players is a relevant issue that can help in the design of interventions and training plans aimed at improving the performance and health of the athlete (Prieto-González & Brahim, 2018; Prieto-González & Larumbe-Zabala, 2021).

This situation of risk can be highly aggravated when there are functional deficits of the shoulder joint. Previous studies have shown how impaired range of motion and/or strength of the shoulder joint can be an important factor linked to shoulder injuries. In fact, some studies (Ellenbecker, 1992; Kibler et al., 1996) have observed that in high-level tennis players there are several alterations related to the range of motion and strength of the internal rotation (IR) and external rotation (ER) movements of the racquet grip arm or dominant arm (DA). In the review by Pluim et al. (2006), 6 out of 7 studies reported a decrease in both the range of motion in IR (ROM-IR) and total range of motion (ROM-T) of DA shoulder rotation compared to the non-dominant arm (NDA). Furthermore, Kibler et al. (1996) demonstrated how the differences between DA and NDA in range of motion worsened with years of experience in high-level players. This same trend has been observed in other sports involving overhead hitting and throwing actions, which show a high prevalence of decreased ROM-IR and ROM-T of DA versus NDA (Hams et al., 2019). Furthermore, these reductions in ROM have been used as a predictor of shoulder injuries (Corbi & Baiget, 2015; Hams et al., 2019). In relation to strength, the review by Pluim et al. (2006) showed that in 5 studies (out of 7) the IR strength (S-IR) was higher in the DA than in the NDA. This increase in S-IR also implied a lower strength ratio between the ER and IR (S-ER/S-IR ratio) of the DA compared to the NDA. It has been proposed that an increase in S-IR that is not in balance with S-IR may be a risk factor for injury, as the external rotational musculature may not be able to decelerate and stabilise the shoulder joint at the end of ball smashing actions (Ellenbecker, 1992). It has also been estimated that a difference in rotational strength between limbs of 10-15% may increase the risk of injury (Corbi & Baiget, 2015). Thus, the presence of these alterations related to range of motion or strength in shoulder rotational movements may increase susceptibility to injury during tennis strokes. In particular, a significant risk situation could arise when both factors are present simultaneously. For example, athletes who are capable of generating large IR strength would not be able to stop the accelerations generated during smashing actions because of low levels of strength in the ER. This could mean that during the post-smash deceleration phase in the arm, the joint position could dangerously approach or exceed the maximum ROM-IR of the joint.

As a result of the above issues and the differences between DA and NDA found in the case of high level tennis players, there is a growing awareness of the importance of monitoring the range of motion and strength of both arms in order to control and reduce the risk of injury. However, the extent of this problem is not well documented outside the field of top-level tennis. More than 33,500 adult women and men play tennis at amateur level under a federation licence

in Spain alone (Real Federación Española de Tenis, 2021) and invest a large number of hours per week in training and competitions. The number of amateur players is greater than the number of high-level players and, in addition, tennis is a sport played by adults of various ages. Therefore, it is necessary to study whether in adult amateur players there are alterations in terms of range of motion and strength of the dominant arm movements of IR and ER that could predispose this population to a risk of shoulder injury. Thus, the objectives of this study were as follows: (1) to evaluate the differences in IR (ROM-IR), ER (ROM-ER) and total (ROM-T) range of motion between the DA and NDA shoulder in adult amateur tennis players; and (2) to compare the IR (S-IR), ER (S-ER) strength and S-ER/S-IR ratio of the DA and NDA shoulder in adult amateur level tennis players.

Method

Participants

A total of 13 tennis players participated in the study (biological sex): 12 male, 1 female; age: 32 ± 10.8 years old; height: 1.81 ± 0.1 m; weight: 77.9 ± 10.1 kg; dominant arm: 11 right-handed, 2 left-handed; age when starting tennis: 6.8 ± 2.5 years old; hours per week: 7.6 ± 2.5 h/set). The requirements for participation in the study were: (1) being 18 years of age or older, (2) having started playing and training for tennis almost every day since childhood (5-12 years old), (3) playing tennis between 3 and 15 hours per week, and (4) being free of injury and/or discomfort in the shoulder joint for the last 6 months. The study was conducted in accordance with the Declaration of Helsinki. All participants gave written consent for participation in this study after receiving a detailed explanation of the procedures. The study was approved by the Clinical Research Ethics Committee of the Catalan Sports Administration (031-CEICGC-2022).

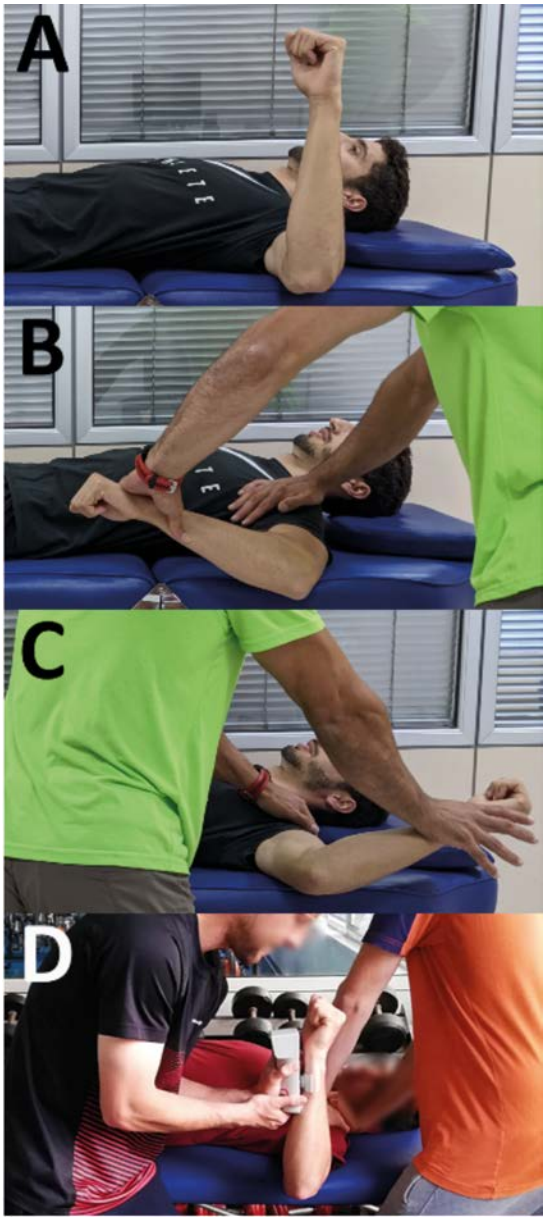
Procedure

At the beginning of the assessment session, participants completed a questionnaire with information regarding personal data, tennis history and shoulder health history. This questionnaire was used to assess the inclusion criteria for the study. The participants then performed two different tests: firstly, a passive range of motion (ROM) assessment test and, secondly, a peak isometric strength (S) assessment test, both applied to the internal rotation (IR) and external rotation (ER) movements of the shoulder. Prior to initiation of the two tests, all participants did a warm-up consisting of: (1) two sets of 12 repetitions of shoulder IR and ER with medium resistance rubber bands, with the shoulder positioned in 90° abduction and the elbow flexed to 90°; and (2) submaximal passive stretching of the IR and ER movements, following the same execution protocol as that used for the range of motion test. This second part of the warm-up also serves as preparation for the passive range of motion test.

Passive range of motion assessment test

The aim of this test was to measure the shoulder joint ROM-IR and ROM-ER. For the execution of the test, participants were stretched out on a stretcher in the supine decubitus position, with the shoulder positioned at 90° of abduction, the elbow at 90° of flexion and in a neutral position of rotation (forearm perpendicular to the stretcher) (Moreno-Pérez et al., 2015) (Figure 1-A). The forearm was required to protrude laterally from the stretcher to allow maximum ROM-IR and ROM-ER of the scapulohumeral joint to be performed. This position was used as it is the position that bears the most similarities to the service movement for the execution of the ROM tests (Kibler et al., 1996). During the execution of the test, an investigator slowly pushed the distal part of the participant's forearm until reaching the maximum ROM of IR or ER (Figure 1-B, Figure 1-C). With the other hand, the same researcher held the participant's shoulder to avoid possible compensatory movements of the scapulothoracic region. The point of maximum rotation was considered to be the point at which the participant verbally expressed that he/she could not endure the passive movement any longer. Two attempts of the test were carried out for each arm and direction of rotation (IR and ER). Each attempt was recorded using a digital video camera (Casio Exilim High Speed EX-FH25) placed at stretcher height, perpendicular to the plane of movement, 5 metres away from the participant. The filming frequency of the camera was set to 60 Hz.

Figure 1
Graphical example of the initial position (A), internal rotation position (B) and external rotation position (C) for performing the range of motion test. The initial position was also the position used for the peak isometric strength assessment test, in which one experimenter manipulated the hand-held dynamometer while another fixed the participant's shoulder (D).



Peak isometric strength assessment test

The aim of this test was to assess the peak voluntary isometric strength (S) in the IR and ER movements of the scapulohumeral joint. A hand-held dynamometer (Nicholas Manual Muscle Tester by Lafayette Instrument Company, Model 01160) was used to obtain shoulder S-IR and S-ER, which provided strength values in kilograms (kg). For this test, participants were placed on a stretcher in the same starting position as described above for the ROM assessment test (Figure 1-D). The starting position ensured that the effects of gravity were removed and the muscles tested were placed in the middle of their range of motion (Amundsen, 1990). Two researchers were required to carry out this test. One researcher held the participant's shoulder to avoid possible offsets. The other investigator positioned the hand-held dynamometer 2cm medial to the ulnar styloid process on the dorsal side of the participant's forearm to measure S-ER and in the same location on the ventral side to measure S-IR. The dynamometer was held to prevent any movement of the participant's arm (i. e., preventing IR or ER movement) (Cools et al., 2014, 2016; Riemann et al., 2010). Two attempts of the test were carried out for each arm and direction of rotation (IR and ER). For each attempt, the participant was encouraged to exert peak voluntary isometric IR or ER strength against the dynamometer for a time of 5 seconds (Amundsen, 1990). Participants were asked to progressively perform peak voluntary isometric strength and were allowed a 30-second rest between attempts. At the end of each attempt, the peak isometric strength value (kg) reached was recorded.

Data processing

ROM-IR and ROM-ER angles were obtained from footage processing during the ROM assessment test using Kinovea v0.8.15 (Puig-Diví et al., 2019). The ROM of each attempt was considered to be the absolute angle formed between the linear vector perpendicular to the stretcher and the vector between the anatomical points of the styloid process (mobile point) and the olecranon (fixed point). The ROM-T was calculated as the sum of the ROM-IR and ROM-ER angles (Gillet et al., 2017). For each arm, the average value of each variable was calculated with the values obtained from the two attempts (Couppé et al., 2012; Gillet et al., 2017; Moreno-Pérez et al., 2015).

In relation to the data from the peak isometric strength assessment test, the peak strength values recorded in each

attempt were defined as S-IR and S-ER. All strength values were converted to newtons (N). For each arm, the average value of each variable was then calculated from the values obtained in the two test attempts (Couppé et al., 2012). Finally, from these mean values, the S-ER/S-IR ratio was calculated for each arm (Cools et al., 2016; Riemann et al., 2010).

Statistical Analysis

The data was tested for normal distribution using the Shapiro-Wilk normality test. Range of motion values (ROM-IR, ROM-ER and ROM-T) of the dominant arm (DA) and non-dominant arm (NDA) were compared using a paired samples Student's t-test. In addition, the peak isometric strength variables (S-IR, S-ER and S-ER/S-IR) of both arms were also compared through a paired samples T-test. Statistical significance was set at $p \leq .050$ for all analyses. The effect size of the different tests was expressed with Cohen's *d* (1988) and with the following interpretation: 0.2 to 0.5, small effect; 0.5 to 0.8, medium effect; and more than 0.8, large effect.

Results

In relation to the first objective of the study, a comparison of the range of motion (ROM) of internal rotation (IR) and external rotation (ER) of the two arms (dominant: DA and non-dominant: NDA) was carried out (Table 1). The results of the paired samples T-test revealed significant differences between the DA and the NDA in terms of ROM-IR, with the NDA exhibiting a greater range of motion compared to the DA (23.73%) (Figure 2). Significantly higher ROM-T values were also observed in the case of the NDA (8.32%). No significant differences were observed in the ROM-ER comparison, indicating similar ROM between the two arms.

Table 1.
Descriptive statistics of range of motion and peak isometric strength and results of bilateral comparison by paired samples T-test.

Variable	DA	NDA	t	*p*	d
ROM-IR (°)	70.46 ± 10.36	92.38 ± 10.15	–9.053	<.001	2.551
ROM-ER (°)	120 ± 10.55	115.35 ± 9.07	1.566	0.143	.434
ROM-T (°)	190.46 ± 13.11	207.73 ± 12.66	–4.429	<.001	1.228
S-IR (N)	177.19 ± 32.43	160.04 ± 29.40	2.344	.037	0.65
S-ER (N)	166.49 ± 33.10	159.55 ± 34.23	1.037	0.32	0.288
S-ER/S-IR	0.94 ± 0.10	1.01 ± 0.21	–1.638	0.127	0.454

Abbreviations: DA = dominant arm, NDA= non-dominant arm, ROM = range of movement, IR = internal rotation, ER = external rotation, T = total, S = peak isometric strength.

Figure 2
*Bilateral comparison of the range of motion of internal rotation, external rotation and total range of motion. DA = dominant arm, NDA= non-dominant arm, ROM = range of movement, IR = internal rotation, ER = external rotation, T = total; * indicates significant differences.*

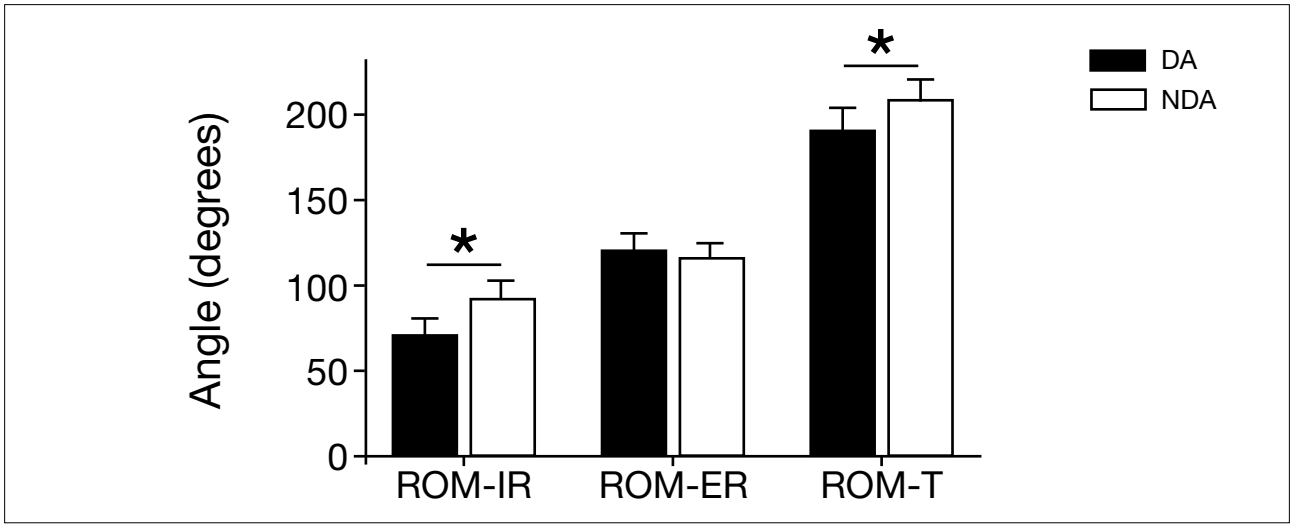
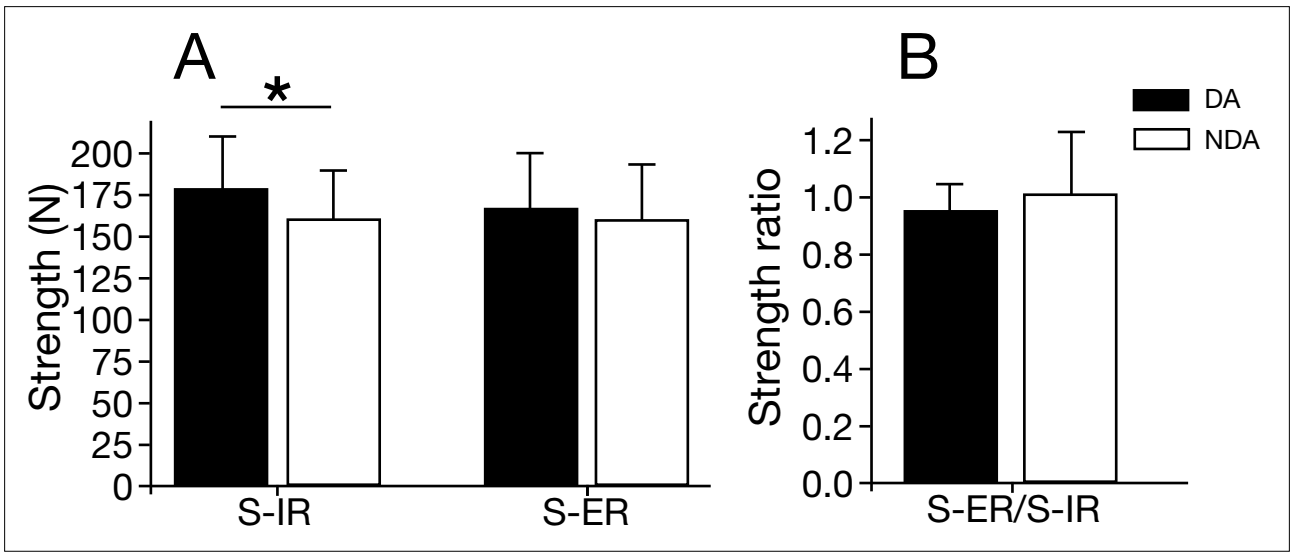


Figure 3
*Bilateral comparison of peak isometric strength of internal rotation, external rotation and S-ER/S-IR ratio. DA = dominant arm, NDA= non-dominant arm, S = peak isometric strength, IR = internal rotation, ER = external rotation; * indicates significant differences.*



With regard to the second objective, a comparison of the peak isometric strength of both arms was carried out (Table 1). T-test results revealed a significantly higher S-IR of DA compared to NDA (9.67%) (Figure 3). No significant differences were found for the other variables of peak isometric strength.

Discussion

In tennis, the shoulder is one of the areas with the highest incidence of overuse injury. These injuries could be related to alterations in the range of motion and strength of the internal (IR) and external (ER) rotator muscles of the joint (Renstrom & Johnson, 1985). The aim of this study was to evaluate possible alterations in range of motion (ROM) and peak isometric strength (S) in the IR and ER movements of the shoulders in adult amateur tennis players. In order to achieve these objectives, a comparison of the racket grip arm or dominant arm (DA) and the non-dominant arm (NDA) was carried out.

In relation to ROM, DA was found to have a lower ROM-IR and ROM-T compared to NDA. In contrast, no differences were observed in ROM-ER, which could indicate that the differences found in ROM-T derive mainly from a reduction in ROM-IR. This is in line with other studies that also reported reductions in ROM-IR and ROM-T (Ellenbecker, 1992; Ellenbecker et al., 1996; Pluim et al., 2006). The lower ROM-IR found in the present study could be a reflection of the relatively advanced age and years of sport practice of the participants (Kibler et al., 1996; Moreno-Pérez et al., 2015). In contrast, in the present study a similar ROM-ER was observed between the two limbs. This result contrasts with previous studies, which revealed a higher ROM-ER in the DA of high-level players of different ages (Ellenbecker et al., 1996; Kibler et al., 1996; Moreno-Pérez et al., 2015). It is believed that increasing ROM-ER may enhance performance in overhead smashing or throwing actions by increasing the angular travel of these skills, thereby extending the acceleration time of the limb and thus facilitating the achievement of higher velocities at the end of the smash or throw (Hams et al., 2019). The fact that it is an adaption linked to the performance of the hitting gesture and the lack of differences in adult amateur athletes could imply that adaptations in ROM-ER are specific to high-level players.

These findings concerning the ROM could be relevant for the prevention of injuries in amateur tennis players. Range of motion differences between DA and NDA are often characterised as possible indicators of risk for shoulder joint injury (Pluim et al., 2006). Although there is no consensus on normative values for ROM in tennis players, an asymmetry between DA and NDA of less than 18° for ROM-IR and no more than 5° for ROM-T seems desirable (Cools et al., 2015; Wilk et al., 2011). Taking these values as a reference, the profile of the amateur player characterised in the present study could present a certain

risk of shoulder injury given that bilateral differences in the ROM-IR (23.74%) and ROM-T (8.32%) are higher than the thresholds considered safe. In spite of this situation, the fact that a prerequisite for participation in this study was the absence of discomfort or injury to the shoulder joint limits the possibility of establishing a relationship between ROM disturbances and injury. Furthermore, the lack of agreed normative values for ROM in both healthy and injured tennis players limits the interpretation of the results of the present study. More studies are needed to explore the relationship between ROM disorders and shoulder joint injury in tennis, especially in amateur tennis players.

In the comparison of peak isometric strength values, higher S-IR values were observed for the DA compared to the NDA. These results are consistent with the results presented in the review by Pluim et al. (2006) where, in most of the studies analysed, tennis players had higher S-IR in the DA versus the NDA. On the other hand, in the present study, no differences were observed in either the S-ER or the S-ER/S-IR ratio between the DA and the NDA. Although the results indicated that there was a difference between arms in terms of S-IR, all other strength parameters exhibited similar values between limbs. Pluim et al. (2006) reported that higher S-IR values in the DA also contributed to a reduction in the S-ER/S-IR ratio values. Furthermore, this situation has been linked to the occurrence of shoulder joint pain and has been associated with the likelihood of injury (Gillet et al., 2018; Hams et al., 2019). Thus, despite the increase in S-IR in the DA, the absence of differences in S-ER and in the S-ER/S-IR ratio suggests that the participants in the present study may be relatively safe from potential shoulder injury with respect to strength-related risk factors. For example, the tennis players in this study would fall within the recommended range of the S-ER/S-IR ratio (between 0.75 and 1) proposed in previous publications (Cools et al., 2016). The absence of differences in the S-ER/S-IR ratio in the present study compared to previous publications (Pluim et al., 2006) could be explained by the absence of differences in S-ER and a lower difference in S-IR between arms. Therefore, it could be suggested that, similar to what has happened in the case of ROM-ER, the differences in S-ER and S-ER/S-IR ratio could be specific to high-level players, with training regimes of higher load (volume and intensity of play/training) than amateur players. Further studies are needed to determine the vulnerability of the amateur tennis player profile in relation to shoulder joint strength. The use of larger sample sizes, other peak strength assessment conditions (e.g., eccentric or concentric), and the inclusion of participants with a history of joint injury and/or discomfort may help to deepen understanding of this population.

Conclusions

In the present study of adult and amateur tennis players, less range of motion in internal rotation and total range of motion was observed in the dominant arm compared to the non-dominant arm. Also, greater peak isometric internal rotational strength was observed in the dominant arm compared to the non-dominant arm. These results, especially in relation to range of motion, suggest that adult amateur tennis players may be predisposed to shoulder injury in the dominant arm.

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