DIFFERENCES IN PERFORMANCE AND INJURY PROFILE IN SOCCER PLAYERS: A COMPARISON ACROSS AGE CATEGORIES AND POSITIONS

Luis Torres-Martín[1], Javier Sánchez-Sánchez[1], Rodrigo Ramirez-Campillo[2], and Javier Raya-González[3]

[1]Research Group Planning and Assessment of Training and Athletic Performance, Pontifical University of Salamanca, Salamanca, Spain
[2]Department of Physical Activity Sciences, Universidad de Los Lagos, Santiago, Chile
[3]Research Group on Sport and Physical Education for Personal and Social Development (GIDEPSO), Faculty of Education Sciences and Psychology, University of Córdoba, Córdoba (Spain)

Original scientific paper
DOI 10.26582/k.57.2.8

Abstract:

The aims of this study were to compare physical performance and injury profiles across different age categories and playing positions of soccer players, and to establish relationships between physical performance tests and positions. Soccer players of different age categories, senior (n=34), under-19 years (U19; n=53) and under-16 years (U16; n=54), performed countermovement jump (CMJ), change of direction (COD, 10+10-m with 90° turn), and linear sprint over 30-m tests. Change-of-direction loss was calculated. Injuries (i.e., incidence and burden) during the first phase of the season were recorded. Senior players showed the best performance in COD (effect size [ES] = 1.23-1.42), the U19 players were the best in sprint over 30-m (ES = 0.64-1.44) and the worst in COD loss (ES = 1.18-1.68). The U16 players showed the lowest values in countermovement jump (ES = 0.90-1.00) and linear sprint tests (ES = 0.64-1.46). No differences in physical performance were reported for the playing positions analysis. Senior players showed the highest total injury incidence and the greatest burden values, while wide midfield players presented the highest burden values. These results indicate that individualized training programmes must be applied based on age and playing positions.

Keywords: *physical fitness, team sports, physical conditioning, incidence, football, muscle strength, exercise therapy*

Introduction

Soccer is a team sport demanding high-performance actions like sprints, accelerations and decelerations, changes of direction (COD), and jumps (DiSalvo, et al., 2007; Söhnlein, Müller, & Stöggl, 2014). For example, during a soccer match, each player performs ~30 sprints, 90 accelerations and 700-1,400 changes of direction (Bloomfield, Polman, & O'Donoghue, 2007a; Ingebrigtsen, Dalen, Hjelde, Drust, & Wisløff, 2015; Suarez-Arrones, et al., 2015). Additionally, most sprints are performed following linear and curvilinear trajectories, which are under the influence of the opponents, teammates, or the trajectory of the ball (Beato, Drust, & Dello Iacono, 2021a). Therefore, the improvement of these actions is one of the main objectives of the technical staff in soccer and knowing the physical performance evolution of the players in each age category seems to be a key factor to optimize the training process (Borghi, et al., 2021; Taylor, Wright, Dischiavi, Townsend, & Marmon, 2017).

Studies conducted in elite soccer clubs noted that senior professional players performed better compared to their young counterparts (i.e., under 15 years [U15], under 17 years [U17] and under 20 years [U20]) in squat jump and counter movement jump (Kobal, et al., 2016; Loturco, et al., 2018, 2019a) and manifested better results in mean power and one repetition maximum during half-squat and squat jump exercises (Kobal, et al., 2016; Loturco, et al., 2018). However, change of direction ability and sprint performance (0-5 m) were better in young players (U15) than in senior players (Loturco, et al., 2019a; Loturco, et al., 2018). Controversial findings were also observed for 20-m sprint, since Loturco et al. (2019a) observed better performance in older players compared to their younger counterparts, while no differences across age categories (i.e., senior, U-20 and U-17) were reported by Kobal et al. (2016). Moreover, Castillo et al. (2020) analyzed the differences in physical performance in several age categories of the same semi-professional soccer academy. These authors reported better performances in under 18 years (U18) compared to under 16 years (U16) and under 14 years (U14) age categories in 20-m sprint or 505 tests. Further, studies comparing the soccer players' physical performance according to playing position (e.g., defenders; forwards) are scarce (Bujnovsky, et al., 2019; Lockie, et al., 2018). Therefore, it seems necessary to continue research on this topic to increase knowledge about physical performance of players of different age categories and playing positions.

To improve sprinting, jumping, change of direction speed, and related physical performance measures, players are exposed to great training demands, added to the very high demands of the competition (Nonnato, Hulton, Brownlee, & Beato, 2022). Consequently, injury incidence in soccer is extremely high (Ekstrand, Hägglund, & Waldén, 2011b). A recent meta-analysis (López-Valenciano, et al., 2019) established that injury incidence in professional male soccer players was 8.1 injuries/1,000 hours of exposure, whereas the match injury incidence rate (i.e., 36 injuries/1,000 hours of exposure) was almost 10 times higher than the training injury incidence rate (i.e., 3.7 injuries/1,000 hours of exposure). Although previous studies have been conducted with senior players (Bianchi, Veneziani, Cantalice, Notarnicola, & Tafuri, 2019; Ekstrand, Hägglund, & Fuller, 2011a; Mallo, González, Veiga, & Navarro, 2011), injuries are a growing problem for young soccer players as well since they are facing ever bigger training volumes and intensities to achieve excellence (Brink, et al., 2010). In male young players (i.e., from U14 to under 23 years), total injury incidence was 2.9 injuries/1,000 hours of exposure (Raya-González, Suárez-Arrones, Navandar, Balsalobre-Fernández, & de Villarreal, 2020c), most commonly at the hamstring. Injuries negatively impact sport performance and impose an important economic burden (Raya-González, de Ste Croix, Read, & Castillo, 2020b). Epidemiological analysis is the first step to develop an adequate programme to prevent injuries in soccer players (O'Brien, Finch, Pruna, & McCall, 2019). Knowing injury incidence and the specific burden suffered by each age category and each playing position will allow a more specific approach to the injury problem, which is necessary to establish comprehensive preventive programmes (Beato, Maroto-Izquierdo, Turner, & Bishop, 2021b).

Therefore, the aims of this study were to compare physical performance and the injury profile across different age categories and playing positions of soccer players and to establish relationships between physical tests for each age category and playing position. Based on previous studies (Bujnovsky, et al., 2019; Castillo, et al., 2020; Raya-González, et al., 2020c), we hypothesized that there would be differences in physical performance and injury incidence and burden regarding age categories and playing positions, while a negative association was expected between sprint performance and time loss during change of direction.

Methods

Participants

One hundred and forty-one soccer players (age: 18.1 ± 3.2 years, height: 173.5 ± 6.5 cm, body mass: 67.1 ± 8.2 kg, body mass index: 22.2 ± 1.9 kg·m^{-2}), belonging to the same club, participated in the study. According to their age, players were divided in senior (n = 34); under 19 years (U19; n = 53) and under 16 years (U16; n = 54), while attending to playing positions, players were classified in goalkeepers (n = 14), central backs (n = 30), full backs (n = 23), central midfields (n = 33), wide midfields (n = 24) and forwards (n = 17) (Raya-González, et al., 2020b). Participants had 1-2 official matches and 3-4 training sessions per week (i.e., 50% technical-tactical drills, 40% small-sided and simulated games, 10% injury-prevention drills). Although goalkeepers were considered for the injuries analyses, they were excluded from the statistical analysis related to physical tests due to their special role in soccer practice. All soccer players were informed of the procedures, potential risks and benefits of the study and the participants or their parents or tutors (< 18 years) signed a written informed consent. The study was conducted according to the Declaration of Helsinki (2013) and the protocol was fully approved by Ethics Committee of the Isabel I University (Code: Ui1-PI008) before recruitment.

Procedures

A comparative and correlational design was used to describe and compare physical performance and injury profile among age groups and playing positions and to examine the associations among physical tests. In a single testing session (September), soccer players' physical performance was evaluated in the following order: jump performance (i.e., countermovement jump [CMJ]), and sprinting (i.e., over 10, 20 and 30-m distances), and change of direction ability ([COD]; i.e., 10+10-m with 90° turn). For COD assessments, the dominant leg was considered as the one in which each player obtained the best result (Raya-González, et al., 2020a). Additionally, injuries suffered by the soccer players during the first competitive phase (from September to December, both included) were registered. Prior to the physical assessment, players undertook a 17-min standardized warm-up, consisting of 3-min of slow jogging, followed by 7-min of strolling locomotion and finishing with 7-min of progressive sprints and accelerations. Players were familiarized with physical tests due to their assessment routines previously carried out in the club during the preseason. Likewise, the testing sessions were performed in the afternoon (6-8 p.m.) on an artificial grass field where the team performed their usual training sessions (17-22º C, 60-70% humidity) and were supervised by the same strength and conditioning specialist (Raya-González, Castillo, de Keijzer, & Beato, 2021a). Additionally, players were advised not to perform any type of physical exercise during 48 h preceding the testing sessions, to take their last meal 3-h before the beginning of the tests and not to drink any caffeinated beverages.

Countermovement jump

Players performed three bilateral CMJs separated by 45 s of a passive recovery (Raya-González, et al., 2020a). Players were instructed to perform a downward movement followed by a complete, explosive extension of the lower limbs, maintaining their hands on the hip (Sáez de Villarreal, Suarez-Arrones, Requena, Haff, & Ferrete, 2015). The application MyJump 2.0 was used to assess jump height in CMJ. The MyJump presented a strong validity ($r = 0.995$, $p<.001$) and reliability (intraclass correlation coefficient = 0.997, $p<.001$) for assessing CMJ height (Balsalobre-Fernández, Glaister, & Lockey, 2015). Every jump was recorded at 240 Hz with an iPhone 8 Plus mobile device (Apple Inc, Cupertino, CA) (Raya-González, Scanlan, Soto-Célix, Rodríguez-Fernández, & Castillo, 2021b). For the subsequent analysis, the highest jump (in cm) was selected.

30-m sprint test (SPR30)

Soccer players completed two maximal 30-m sprints, with split times on 10-m (SPR10), 20-m (SPR20) and 30-m (SPR30), interspersed with a 120-s passive standing rest. Performance time were assessed using four pairs of photoelectric cells (Polifermo Light Radio, Microgate™, Bolzano, Italy) at 0, 10, 20 and 30-m. Players started each sprint 0.5 m before the first timing gate upon their own volition. The fastest time was considered for the subsequent analysis. Additionally, the sprint momentum (SM [$kg·m·s^{-1}$]) was obtained for each distance by multiplying the athlete's body mass by the respective velocity during the linear sprint at 10-m (SM10), 20-m (SM20) and 30-m (SM30) (Freitas, et al., 2021).

Change of direction (COD) sprint test

Participants were evaluated over a 20-m COD sprint test using two pairs of photoelectric cells (Polifermo Light Radio, Microgate™, Bolzano, Italy). Four maximum 10 + 10-m sprints with a COD turn of 90º (i.e., two trials with the dominant leg [CODdom] on the outside during the turn and two trials with the non-dominant leg [CODndom] on the outside) were performed allowing two minutes of a passive recovery between trials. Players were instructed to adopt the position described in SPR30 test. The best time obtained with each leg was identified and was selected for the subsequent analysis, which was compared with the SPR20 to estimate the percentage mean of speed loss due to executing the COD(DEC-COD) through the formula:

$$[(\text{DEC-COD} = \text{COD} - \text{SPR20})/\ \text{SPR20}) \times 100]$$

(Núñez, et al., 2018).

Injuries: definitions and data collection

According to the guidelines from the Union of European Football Associations (UEFA) for epidemiological research (Hägglund, Waldén, Bahr, & Ekstrand, 2005), injury was defined as "an injury that occurred during a scheduled training session or match that caused absence from the next training session or match" (Hägglund, et al., 2005), while burden was defined as "the numbers of days lost per 1,000 hours of exposure" (Bahr, Clarsen, & Ekstrand, 2018). On the other hand, the criteria used to consider the exposure was the following: "the time (in hours), both in training and match play, during which the player is in a position to suffer an injury, and incidence refers to the number of injuries sustained during practice, both in training and competition, for every 1,000 hours of exposure" (van Mechelen, Hlobil, & Kemper, 1992). Match play exposure was calculated when playing against teams from different clubs, and training sessions were considered those in which a coach directed physical activity carried out with the team. A player was considered fully recovered after an injury when he was given clearance by the medical staff to participate fully in team training and match play (Raya-González, et al., 2020c).

Information related to injuries was recorded by the strength and conditioning specialist of each team and supervised by the head fitness coach of the club. The club's medical staff diagnosed all injuries and followed the evolution during the rehabilitation process (Raya-González, et al., 2020b). Injuries were registered on a computerized standard report based on the instruction manuals created for the UEFA studies (Hägglund, et al., 2005) and information about absence days, type of injury, or moment of injury (i.e., training or match) were recorded. Regarding exposure, this time was registered daily individually, in hours, in training and matches (friendly and official alike) (Raya-González, et al., 2020b).

Statistical analysis

Data are presented as mean ± standard deviations (SD). To evaluate the normality of data distribution and the homogeneity of variances, the Kolmogorov-Smirnov and Levene tests were conducted, respectively. Since all analyzed variables reported a normal distribution, parametric analyses were applied. A one-way analysis of variance (ANOVA) with the least significant difference *post-hoc* comparison (Bonferroni correction) was used to analyze differences in physical performance among age categories (i.e., senior, U19, and U16) and playing positions (i.e., central backs, full backs, central midfields and forwards). The statistical significance was set at $p<.05$. To examine practical significance, Cohen's effect size (ES) was calculated (Cohen, 1988), and the obtained results were interpreted as follows: trivial (lower than 0.2), small (between 0.2 and 0.5), moderate (between 0.5 and 0.8), and large (above 0.8). Paired comparisons among age categories and playing positions for each variable were expressed using mean differences, calculated as:

$$\text{Mean difference (\%)} = [(\text{mean 1} - \text{mean 2})/\text{mean 2}] \times 100.$$

Pearson *r* correlations were conducted to establish the relationship between tests for each age category and playing position. The following scale of magnitudes was used to interpret the correlation coefficients: <0.1, trivial; 0.1-0.3, small; 0.3-0.5, moderate; 0.5-0.7, large; 0.7-0.9, very large; and >0.9, nearly perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). These data were analyzed using the Statistical Package for Social Sciences (SPSS 25.0, SPSS Inc., Chicago, IL, USA).

Injury incidence and burden are presented as the number of injuries/1,000 hours (van Mechelen, et al., 1992) and the number of absence days/1,000 hours (Bahr, et al., 2018), respectively, each with 95% confidence intervals (CI), and the level of significance was set at $p<.05$. The incidence and burden of injuries were compared for each age category (i.e., senior, U19, and U16) and playing position (i.e., central backs, full backs, central midfields and forwards) by calculating rate ratios (RR) with a 95% CI and using the Z-test (Kirkwood & Sterne, 2003). These data were analyzed using Microsoft Excel 2011 software (Microsoft, Redmond, WA, USA) and GraphPad Prism v.6.0c (GraphPad Software, La Jolla, CA, USA).

Results

Descriptive data regarding anthropometric measures and exposure time for each age group is presented in Table 1.

Table 2 shows the players' physical performance and the differences among age categories. Senior players performed better than their counterparts in CODdom ($p<.01$; ES = 1.02-1.55) and CODndom ($p<.01$; ES = 1.23-1.42), whereas U19 players presented the best result in SPR30 ($p<.05$-0.01; ES = 0.64-0.78). In addition, U19 showed worse results in DEC-CODdom ($p<.01$; ES = 1.40-1.68) and DEC-CODndom ($p<.01$; ES = 1.18-1.36) compared to the U16 and senior players. U16 players manifested the worst performances in the CMJ ($p<.01$; ES = 0.90-1.00) and for the linear sprint-related tests ($p<.05$-0.01; ES = 0.64-1.62) compared to the senior and U19 groups.

Table 1. Characteristics and exposure time of soccer players according to chronological age-groups

	Senior	U19	U16	Total
*Anthropometric measures**				
Players included (n)	34	53	54	141
Age (y)*	22.3 ± 3.8	17.9 ± 0.8	15.6 ± 0.5	18.1 ± 3.2
Height (cm)*	176.7 ± 7.3	174.1 ± 5.5	171.1 ± 6.1	173.5 ± 6.5
Body mass (kg)*	72.3 ± 9.0	67.8 ± 7.7	63.2 ± 6.1	67.1 ±8.2
Body mass index (kg/m²)*	23.1 ± 1.9	22.4 ± 1.9	21.6 ± 1.7	22.2 ± 1.9
Exposure time				
Total exposure (h)	3416.3	4862.2	4639.9	12853.5
Training exposure (h)	2890.2	4102.1	3904.8	10842.3
Match exposure (h)	526.1	760.1	735.1	2011.2
Mean total exposure/player (h)*	93.1 ± 30.1	81.1 ± 14.4	80.1 ± 10.6	83.5 ± 18.9
Mean training exposure/player (h)*	78.8 ± 25.4	68.4 ± 11.3	67.3 ± 7.9	70.4 ± 15.6
Mean match exposure/player (h)*	14.3 ± 7.1	12.7 ± 6.6	12.9 ± 4.22	13.2 ± 5.9

Note. *Values are mean ± SD.

Table 2. Soccer players' physical performance according to age categories

Physical test	Senior	U19	U16	Pair comparisons (mean differences; ES, interpretation)		
				Senior vs. U19	Senior vs. U16	U19 vs. U16
CMJ (cm)	37.85 ± 4.58	37.35 ± 4.20	33.68 ± 3.94	0.50; 0.11, trivial	4.17; 1.00, large**	3.67; 0.90, large**
CODdom (s)	3.91 ± 0.19	4.15 ± 0.14	4.10 ± 0.16	0.27; 1.55, large**	0.18; 1.02, large**	0.09; 0.58, moderate
CODndom (s)	4.01 ± 0.19	4.27 ± 0.15	4.22 ± 0.17	0.24; 1.42, large**	0.23; 1.23, large**	0.01; 0.07, trivial
DEC-CODdom (%)	18.52 ± 6.86	27.39 ± 5.66	18.78 ± 5.57	9.63; 1.40, large**	0.38; 0.06, trivial	10.01; 1.68, large**
DEC-CODndom (%)	21.50 ± 7.06	31.14 ± 6.27	22.17 ± 5.81	8.88; 1.36, large**	1.30; 0.20, small	7.57; 1.18, large**
SPR10 (s)	1.97 ± 0.08	1.96 ± 0.13	2.09 ± 0.13	0.04; 0.04, trivial	0.12; 1.06, large**	0.12; 0.95, large**
SPR20 (s)	3.30 ± 0.11	3.26 ± 0.13	3.46 ± 0.14	0.04; 0.32, small	0.16; 1.23, large**	0.20; 1.46, large**
SPR30 (s)	4.59 ± 0.18	4.46 ± 0.16	4.70 ± 0.18	0.13; 0.78, large**	0.12; 0.64, moderate*	0.24; 1.44, large**
SM10 ($kg \cdot m \cdot s^{-1}$)	358.80 ± 42.93	341.70 ± 45.13	302.01 ± 29.51	17.12; 0.39, small	56.84; 1.62, large**	39.72; 1.04, large**
SM20 ($kg \cdot m \cdot s^{-1}$)	427.70 ± 53.37	410.01 ± 49.75	363.9 ± 34.10	17.71; 0.35, small	63.88; 1.51, large**	46.17; 1.09, large**
SM30 ($kg \cdot m \cdot s^{-1}$)	462.20 ± 59.07	450.10 ± 53.20	401.60 ± 39.18	12.07; 0.22, small	60.61; 1.27, large**	48.53; 1.04, large**

Note. Data are presented as mean ± standard deviation; ES: effect size; CMJ: countermovement jump; CODdom and CODndom: time in 10+10 m sprint change of direction of 90º with dominant and non-dominant legs; DEC-CODdom and DEC-CODndom: percentage time loss due to CODs execution compared to 20 m sprint time; SPR10: time to cover a distance of 10 m; SPR20: time to cover a distance of 20 m; SPR30: time to cover a distance of 30 m; SM10, 20 and 30: sprint momentum calculated in distances of 10, 20 and 30 m; * Significance level set at p<.05; ** Significance level set at p<.01.

Relationships among physical fitness tests for each age group are presented in Table 3. For the senior players, significant relationships were observed among COD variables (r = 0.61-0.85; large to very large, p<.01), among SPR distances (r = 0.65-0.90; large to very large, p<.01), and among SM measures (r = 0.97-0.99; nearly perfect, p<.01). In addition, faster senior players in SPR10 and SPR20 presented higher DEC-COD values in the dominant and non-dominant leg (r = -0.41/-0.50; moderate to large, p<.05-0.01, respectively). For the U19 age category, CODdom was related to all other COD variables (r = 0.30-0.60; moderate to large, p<.05-0.01), while CODndom was related with the DEC-COD only in the non-dominant leg (r = 0.56; large, p<.01). Additionally, faster players over all distances (i.e., SPR10, SPR20, and SPR30) presented higher values of DEC-COD in both legs (r = -0.57/-0.73; large to very large, p<.01), while significant relationships were observed among SPR distances (r = 0.63-0.86; large to very large, p<.01) and among SM measures (r = 0.93-0.98; nearly perfect, p<.01). For the U16 players, significant relationships were observed among COD variables (r = 0.49-0.67; moderate to large, p<.05-.01), with the exception of CODdom and DEC-CODndom, among SPR distances (r = 0.64-0.90; large to very large, p<.01), and among SM measures (r = 0.88-0.98; very large to nearly perfect, p<.01). In addition, faster players over all distances performed better in CODdom (r = 0.31-0.43; moderate, p<.01), but only those faster in SP30 performed better in CODndom (r = 0.28; small, p<.05). On the other hand, faster players over all distances (i.e., SPR10, SPR20, and SPR30) presented higher values of DEC-COD in both legs (r = -0.49/-0.61; moderate to very large, p<.01). Finally, faster players in SPR10 and SPR20 showed higher SM10 (r = -0.28/-0.37; small to moderate, p<.05-0.01), while faster players in SPR30 performed better in all SM distances (r = -0.29/-0.30; small to moderate, p<.05).

Table 4 shows the injury incidence and burden by age groups. The only significant difference regarding injury incidence was observed in senior players, which presented a higher total incidence compared to their U19 counterparts (9.37 vs 5.14 injuries/1,000 hours exposure, RR = 1.82, 95% CI 1.08-3.07, p<.001). The senior players presented the highest burden in all categories (i.e., total, training and match exposure) (RR = 1.41-2.25, p<.001), while the U16 players showed greater burden in match exposure compared to the U19 players (266.63 vs 213.13 absence days/1000 hours exposure, RR = 0.80, 95% CI 0.65-0.98, p<.01).

No significant differences (p>.05) were observed in any physical test when performance was compared by playing positions (i.e., central back, full back, central midfield, wide midfield and forward) or when analyzing all the players together or separated by age categories.

Differences in injury incidence and burden according to playing positions are presented in Figure 1. No significant differences in injury incidence were observed between playing positions (p>.05). Wide midfield players presented the highest burden values (RR = 0.09-2.79, p<.01), while goalkeepers showed the lowest burden (RR = 0.09-0.82, p<.05-.001). Additionally, greater burden values were observed in the central midfield group compared to the central backs, full backs, and forwards (RR = 0.58-1.83, p<.01).

Table 3. Relationships (r) between physical tests in each age category

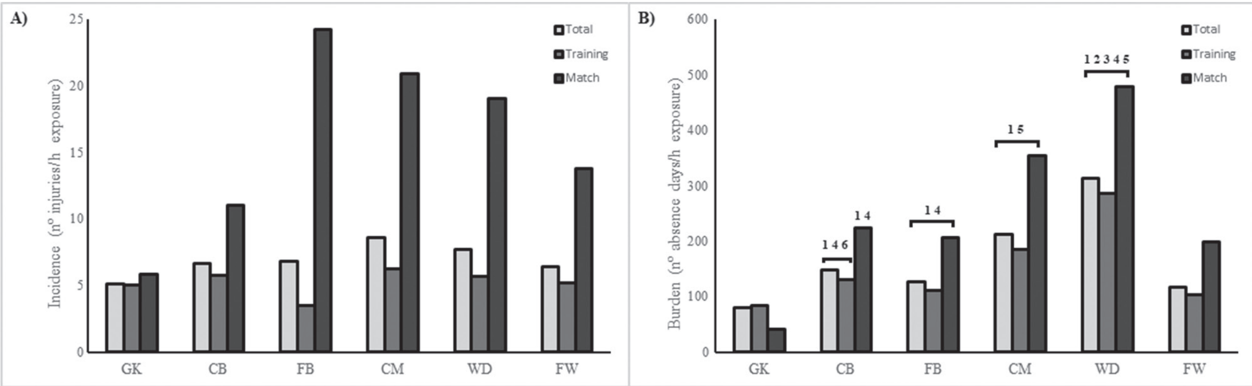
Age-category	Test	CMJ	CODdom	CODndom	DEC-CODdom	DEC-CODndom	SPR10	SPR20	SPR30	SM10	SM20	SM30
Senior (n = 30)	CMJ	-	-	-	-	-	-	-	-	-	-	-
	CODdom	-0.13; S	-	-	-	-	-	-	-	-	-	-
	CODndom	-0.31; M	0.77; VL**	-	-	-	-	-	-	-	-	-
	DEC-CODdom	-0.06; T	0.85; VL**	0.61; L**	-	-	-	-	-	-	-	-
	DEC-CODndom	0.22; S	0.68; L**	0.84; VL**	0.82; VL**	-	-	-	-	-	-	-
	SPR10	-0.09; T	-0.07; T	-0.01; T	-0.44; M**	-0.41; M*	-	-	-	-	-	-
	SPR20	-0.09; T	0.03; T	0.10; S	-0.50; L**	-0.50; L**	0.74; VL**	-	-	-	-	-
	SPR30	-0.19; S	0.15; S	0.23; S	-0.33; M	-0.28; S	0.65; L**	0.90; VL**	-	-	-	-
	SM10	0.36; M	0.10; S	0.24; S	0.21; S	0.34; M	-0.18; S	-0.23; S	-0.26; S	-	-	-
	SM20	0.35; M	0.07; T	0.20; S	0.19; S	0.31; M	-0.04; T	-0.24; S	-0.12; S	0.98; NP**	-	-
	SM30	0.37; M	0.03; T	0.15; S	0.16; S	0.28; M	-0.05; T	-0.25; S	-0.34; M	0.97; NP**	0.99; NP**	-
U19 (n = 48)	CMJ	-	-	-	-	-	-	-	-	-	-	-
	CODdom	-0.19; S	-	-	-	-	-	-	-	-	-	-
	CODndom	0.12; S	0.51; L**	-	-	-	-	-	-	-	-	-
	DEC-CODdom	-0.16; S	0.60; L**	0.14; S	-	-	-	-	-	-	-	-
	DEC-CODndom	0.04; T	0.30; M*	0.56; L**	0.73; VL**	-	-	-	-	-	-	-
	SPR10	-0.01; T	0.09; T	0.13; S	-0.58; L**	-0.58; L**	-	-	-	-	-	-
	SPR20	0.07; T	0.11; S	0.27; S	-0.73; VL**	-0.65; L**	0.80; VL**	-	-	-	-	-
	SPR30	0.12; S	0.10; T	0.22; S	-0.62; L**	-0.57; L**	0.63; L**	0.86; VL**	-	-	-	-
	SM10	0.14; S	-0.12; S	-0.26; S	0.14; S	0.02; T	-0.34; M	-0.27; S	-0.15; S	-	-	-
	SM20	0.11; T	-0.11; S	-0.31; M	0.10; S	-0.06; T	-0.23; S	-0.22; S	-0.13; S	0.95; NP**	-	-
	SM30	0.10; T	-0.11; S	-0.29; S	0.06; T	-0.09; T	-0.17; S	-0.16; S	-0.16; S	0.93; NP**	0.98; NP**	-
U16 (n = 49)	CMJ	-	-	-	-	-	-	-	-	-	-	-
	CODdom	0.03; T	-	-	-	-	-	-	-	-	-	-
	CODndom	-0.15; S	0.67; L**	-	-	-	-	-	-	-	-	-
	DEC-CODdom	0.04; T	0.49; M**	0.37; M**	-	-	-	-	-	-	-	-
	DEC-CODndom	-0.12; S	0.19; S	0.61; L**	0.77; VL**	-	-	-	-	-	-	-
	SPR10	0.09; T	0.31; M*	0.09; T	-0.52; L**	-0.60; L**	-	-	-	-	-	-
	SPR20	-0.02; T	0.44; M**	0.25; S	-0.58; L**	-0.61; L**	0.82; VL**	-	-	-	-	-
	SPR30	-0.09; T	0.43; M**	0.28; S*	-0.49; M**	-0.51; L**	0.64; L**	0.90; VL**	-	-	-	-
	SM10	-0.05; T	-0.14; S	0.05; T	0.14; S	0.26; S	-0.37; M**	-0.28; S*	-0.30; M*	-	-	-
	SM20	0.02; T	-0.14; S	-0.01; T	0.07; T	0.16; S	-0.10; S	-0.21; S	-0.30; M*	0.93; NP**	-	-
	SM30	0.05; T	-0.11; S	0.01; T	0.02; T	0.09; T	0.01; T	-0.12; S	-0.29; S*	0.88; VL**	0.98; NP**	-

Note. CMJ: countermovement jump; CODdom and CODndom: time in 10+10 m sprint change of direction of 90° with dominant and non-dominant legs; DEC-CODdom and DEC-CODndom: percentage time loss due to execute CODs compared to 20 m sprint time; SPR10: time to cover a distance of 10 m; SPR20: time to cover a distance of 20 m; SPR30: time to cover a distance of 30 m; SM10, 20 and 30: sprint momentum calculated in distances of 10, 20 and 30 m; T: trivial; S: small: M: moderate; L: large; VL: very large; NP: nearly perfect; * Significance level set at p<.05; ** Significance level set at p<.01.

Table 4. Male soccer player's injury incidence and burden by age groups

Variable	Senior	U19	U16	Pair comparisons (RR with 95% CI)		
				Senior vs. U19	Senior vs. U16	U19 vs. U16
Total incidence (95% CI)	9.37 (6.62-13.25)	5.14 (3.47-7.61)	7.76 (5.60-10.76)	1.82 (1.08-3.07)**	1.21 (0.75-1.94)	0.66 (0.40-1.10)
Training incidence (95% CI)	6.57 (4.19-10.31)	3.66 (2.20-6.07)	6.41 (4.33-9.48)	1.80 (0.91-3.54)	1.03 (0.57-1.86)	0.57 (0.30-1.08)
Match incidence (95% CI)	24.71 (14.35-42.56)	1.16 (7.08-24.45)	14.96 (8.29-27.02)	1.88 (0.82-4.28)	1.65 (0.74-3.69)	0.88 (0.37-2.07)
Total burden (95% CI)	279.25 (262.08-297.54)	144.18 (133.89-155.26)	140.73 (130.34-151.95)	1.94 (1.76-2.14)**	1.98 (1.80-2.19)**	1.02 (0.92-1.14)
Training burden (95% CI)	263.30 (245.24-282.69)	131.40 (120.76-142.97)	117.03 (106.78-128.27)	2.00 (1.79-2.24)**	2.25 (2.00-2.53)**	1.12 (0.99-1.27)
Match burden (95% CI)	376.37(327.43-432.62)	213.13 (182.71-248.61)	266.63 (231.80-306.70)	1.77 (1.43-2.17)**	1.41 (1.16-1.72)**	0.80 (0.65-0.98)**

Note. CI = confidence intervals; RR = rate ratio; incidence = number of injuries / hours of exposure; burden = number of absence days / hours of exposure.
* Significance level set at p<.05; ** Significance level set at p<.01.



Note. GK = goalkeepers; CB = central backs; FB = full backs; CM = central midfields; WD = wide midfields; FW = forwards. [1] Significant difference (p<.05) compared to goalkeepers. [2] Significant difference (p<.05) compared to central backs. [3] Significant difference (p<.05) compared to full backs. [4] Significant difference (p<.05) compared to central midfields. [5] Significant difference (p<.05) compared to forwards.

Figure 1. Differences in A) incidence and B) burden by playing position.

Discussion and conclusions

The aims of this study were to compare physical performance and the injury profile across the different age categories and playing positions in soccer players of the same club and to establish relationships between the physical tests for each age category and playing position. This is the first study that compares both physical performance and injury profile as per age categories and playing positions in senior and youth soccer players, which provides further understanding in this specific research field (Castillo, et al., 2020; Loturco, et al., 2019a; Raya-González, et al., 2020c). Senior players showed the best performance in CODdom and CODndom, while U19 players showed the best results in SPR30 as well as the worst performance in DEC-CODdom and DEC-CODndom, while U16 players showed the worst values in CMJ and linear sprint tests. A higher number of specific relationships were observed in each age category. However, no differences in physical performance were reported for the playing positions analysis. Senior players showed the highest total injury incidence and the greatest burden values, while wide midfield players presented the highest burden values.

Previous research has shown the importance of players' physical performance in early development stages since it allows to determine the specific competence for top soccer players (Los Arcos, Martínez-Santos, & Castillo, 2020; Martinez-Santos, Castillo, & Los Arcos, 2016). Therefore, to know the physical fitness' evolution across age categories seems to be a key factor to improve the training process (Loturco, et al., 2019a) and match performance (Reynolds, Connor, Jamil, & Beato, 2021), focusing on specific variables for each playing position. Our results revealed better CMJ performance in older players (i.e., senior and U19) compared to the U16 age group, but without differences between the U19 and seniors. These results confirmed those showed by Loturco et al. (2019a), who observed that U15 players performed the worst in CMJ compared to their older counterparts. Similarly, Loturco et al. (2018) observed a significant evolution in CMJ performance in early ages, but a possible hampered evolution in the older players (i.e., U15 vs. U17, U20 and senior). Attending to COD, the best results were observed in senior players, conversely to what was reported by Loturco et al. (2019a), who affirmed that the COD ability remained fairly stable throughout the younger categories (i.e., U15, U17, and U20) but decreased in older players (i.e., senior). On the other hand, U19 players presented the worst performance in DEC-CODdom and DEC-CODndom, maybe related to their fastest sprint tests since the fastest players needed more time to perform the COD test than their slower counterparts (Loturco, et al., 2019b). In this regard, U16 players showed the worst performance in sprint test, similar to previously reported by Castillo et al. (2020), Loturco et al. (2019a) or Loturco et al. (2018). U19 are the players with the best results in SPR30. It is possible that the increase in soccer-specific aerobic training and the lack of specific speed training contributed to the hampering of muscular power, and consequently of the ability to sprint (Loturco, et al., 2015). Although some neuromechanical variables might improve during the transition from the end of adolescence to the mature phase (Loturco, et al., 2018), due to the evolution in muscle power (i.e., CMJ) and sprint capacity (i.e., SPR30) between U19 and senior players, it is recommended to increase both the frequency and volume of strength-power training (Beato, et al., 2021b), and to introduce specific speed training during adulthood (Beato, et al., 2021a).

Several specific relationships have been observed in each age category regarding the different tests applied. No significant relationships between CMJ and the other tests were observed in any age category, contrary to the results observed in previous studies (Köklü, Alemdaroğlu, Özkan, Koz, & Ersöz, 2015; Yanci, Los Arcos, Mendiguchia, & Brughelli, 2014), in which CMJ was correlated with linear sprint over several distances. Similarly, McFarland, Dawes, Elder, and Lockie (2016) observed significant relationships between CMJ and sprint over 10 and 30-m. These differences could be due to the samples used, since the aforementioned studies were conducted with a single team, while our study was performed in an academy fashion. Attending to COD ability, significant relationships among COD variables were obtained in all age categories, although in young groups (i.e., U19 and U16) CODndom was related only with DEC-CODndom, possibly due to the structural changes that take place in soccer players of these ages (van der Sluis, et al., 2014). On the other hand, significant relationships were observed among SPR variables and among SM variables in all age categories. A relevant finding was that faster players performed worse in COD tests in terms of DEC-COD, possibly due to a greater difficulty in braking during the COD maneuver when reaching higher speeds in the linear sprint phase (Loturco, et al., 2019b). In this sense, the application of specific strategies with faster players to improve their COD performance seems to be necessary, such as flywheel exercises, which could improve braking capacity consequently improving COD performance (Raya-González, et al., 2021a). Finally, no relationship between SPR and SM (only some specific ones in U16) was observed. This indicates that SPR and SM are two independent variables, one of them being influenced by body mass, which must be considered to obtain a complete picture of physical performance of soccer players and apply the most appropriate strategies for improving performance.

Injury incidence is considered as the key factor in knowing the impact of injuries (Mallo, et al., 2011), so the analysis of this factor attending to age categories seems to be a relevant strategy to optimize preventive programmes individualizing them for each age (Raya-González, et al., 2020a). Conversely to what was observed in previous similar studies where the senior group presented the highest values of injury incidence (Raya-González et al., 2020b, 2020c), in the current study only significant differences were observed in the total injury incidence between the senior group and the U19 players, with no differences between the younger groups (i.e., U19 and U16). Nevertheless, this absence of differences between the young groups does coincide with those reported in the aforementioned studies. On the other hand, some authors have highlighted the problem of considering only the injury incidence to describe the injury profile of professional athletes, so the burden must be considered to better understand the real impact of injuries (Bahr, et al., 2018). Regarding this, senior players showed the highest burden values in all categories (i.e., total, training and match). Additionally, greater burden values were reported related to the U19 age group compared to their U16 counterparts, possibly due to the higher competitive demands that U19 players must satisfy (Read, Oliver, de Ste Croix, Myer, & Lloyd, 2018; Zhou, Lorenzo, Gómez, & Palao, 2020). This information shows the importance of applying effective preventive programmes mainly for older players, since although the number of injuries does not vary excessively with respect to young players, the consequences of these are higher in this age group.

Since each playing position presents specific demands during competition (Bloomfield, Polman, McNaughton, & O'Donoghue, 2007), it seems pertinent to study physical performance and injury profile attending to each playing position. In this regard, no significant differences were observed for any tests among playing positions. These results support partially those reported by Bujnovsky et al. (2019), who observed a few differences (i.e., SPR20 between wide midfields and central backs) when compared the physical fitness among playing positions with young soccer players. In the same line, Lockie et al. (2018) only observed differences in 5-m sprint between midfielders and defenders, with no other significant between-position differences. These results show that these physical tests do not seem useful in discriminating among the playing positions since they are also influenced by other types of factors (i.e., technical, tactical, and psychological). Therefore, although during the game, playing positions have different demands, it seems that from a certain conditioning level players are able to perform on the field, which should be key to maintain physical performance throughout the competitive season (Castillo, et al., 2020). Regarding injuries, no differences were observed in incidence values according to the specific positions. These results coincide with those reported by Della Villa, Mandelbaum, and Lemak (2018), who conducted a systematic review to assess the risk of specific injury for each specific position, concluding that there were no significant differences between them. However, in our study, the differences in burden have been observed, with wing midfielders having the highest values and goalkeepers the lowest. These results allow us to delve into the injury profile of soccer players to facilitate the application of preventive strategies to reduce the injury risk, both in senior and young players.

Aside from its novelty and strengths (e.g., great sample size), this study is not exempt from limitations. The study was applied in one club, therefore the data from different contexts (other clubs) may provide confirmation of current results. Further, we did not address players' endurance performance, so comparisons about this variable are not clarified. Also, tests that include perception-reaction components must be used, and the relationship between fitness tests and injuries could be analyzed in future studies. Finally, this study enrolled a sample of male players only, therefore our findings cannot be applied to female players and therefore further research is needed to verify the applicability of our findings to this specific population.

Senior players showed the best performance in COD, U19 players manifested the best results in SPR30 but the worst performance in DEC-COD, while U16 showed the lowest values in CMJ and linear sprint tests. No differences in physical performance were reported for the playing positions analysis, therefore playing position does not seem to be a variable that differentiates players' physical level. Senior players showed the highest total injury incidence and the greatest burden values, while wide midfield players presented the highest burden values. These findings provide valuable information to optimize the training process aimed at improving physical performance and reducing the injury risk in soccer players of different age categories through specific and individualized physical and preventive training for each age.

References

Bahr, R., Clarsen, B., & Ekstrand, J. (2018). Why we should focus on the burden of injuries and illnesses, not just their incidence. *British Journal of Sports Medicine*, *52*(16), 1018-1021. https://doi.org/10.1136/bjsports-2017-098160

Balsalobre-Fernández, C., Glaister, M., & Lockey, R.A. (2015). The validity and reliability of an iPhone app for measuring vertical jump performance. *Journal of Sports Sciences*, *33*(15), 1574-1579. https://doi.org/10.1080/02640414.2014.996184

Beato, M., Drust, B., & Dello Iacono, A. (2021a). Implementing high-speed running and sprinting training in professional soccer. *International Journal of Sports Medicine*, *42*(4), 295-299. https://doi.org/10.1055/a-1302-7968

Beato, M., Maroto-Izquierdo, S., Turner, A.N., & Bishop, C. (2021b). Implementing strength training strategies for injury prevention in soccer: Scientific rationale and methodological recommendations. *International Journal of Sports Physiology and Performance*, *16*(3), 456-461. https://doi.org/10.1123/ijspp.2020-0862

Bianchi, F.P., Veneziani, V., Cantalice, M.A., Notarnicola, A., & Tafuri, S. (2019). Epidemiology of injuries among Italian footballers: The role of the playing field. *Injury Prevention*, *25*(6), 501-506. https://doi.org/10.1136/injuryprev-2018-042968

Bloomfield, J., Polman, R., & O'Donoghue, P. (2007a). Physical demands of different positions in FA Premier League soccer. *Journal of Sports Science and Medicine*, *6*(1), 63-70.

Bloomfield, J., Polman, R., O'Donoghue, P., & McNaughton, L. (2007b). Effective speed and agility conditioning methodology for random intermittent dynamic type sports. *Journal of Strength and Conditioning Research*, *21*(4), 1093-1100. https://doi.org/10.1519/R-20015.1

Borghi, S., Colombo, D., La Torre, A., Banfi, G., Bonato, M., & Vitale, J.A. (2021). Differences in GPS variables according to playing formations and playing positions in U19 male soccer players. *Research in Sports Medicine (Print)*, *29*(3), 225-239. https://doi.org/10.1080/15438627.2020.1815201

Brink, M.S., Visscher, C., Arends, S., Zwerver, J., Post, W.J., & Lemmink, K.A. (2010). Monitoring stress and recovery: New insights for the prevention of injuries and illnesses in elite youth soccer players. *British Journal of Sports Medicine*, *44*(11), 809-815. https://doi.org/10.1136/bjsm.2009.069476

Bujnovsky, D., Maly, T., Ford, K., Sugimoto, D., Kunzmann, E., Hank, M., & Zahalka, F. (2019). Physical fitness characteristics of high-level youth football players: Influence of playing position. *Sports*, *7*(2), 46. https://doi.org/10.3390/sports7020046

Castillo, D., Lago-Rodríguez, A., Domínguez-Díez, M., Sánchez-Díaz, S., Rendo-Urteaga, T., Soto-Célix, M., & Raya-González, J. (2020). Relationships between players' physical performance and small-sided game external responses in a youth soccer training context. *Sustainability (Switzerland)*, *12*(11), 4482. https://doi.org/10.3390/su12114482

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillside, NJ: Lawrence Earlbaum Associates.

Della Villa, F., Mandelbaum, B.R., & Lemak, L.J. (2018). The effect of playing position on injury risk in male soccer players: Systematic review of the literature and risk considerations for each playing position. *American Journal of Orthopedics (Belle Mead, N.J.)*, *47*(10). https://doi.org/10.12788/ajo.2018.0092

DiSalvo, V., Baron, R., Tschan, H., Calderon Montero, F., Bachl, N., & Pigozzi, F. (2007). Performance characteristics according to playing position in elite soccer. *International Journal of Sports Medicine*, *28*(3), 222-227. https://doi.org/10.1055/s-2006-924294

Ekstrand, J., Hägglund, M., & Fuller, C.W. (2011a). Comparison of injuries sustained on artificial turf and grass by male and female elite football players. *Scandinavian Journal of Medicine and Science in Sports*, *21*(6), 824-832. https://doi.org/10.1111/j.1600-0838.2010.01118.x

Ekstrand, J., Hägglund, M., & Waldén, M. (2011b). Injury incidence and injury patterns in professional football: The UEFA injury study. *British Journal of Sports Medicine*, *45*(7), 553-558. https://doi.org/10.1136/bjsm.2009.060582

Freitas, T.T., Alcaraz, P.E., Calleja-González, J., Arruda, A.F.S., Guerriero, A., Kobal, R., …, & Loturco, I. (2021). Differences in change of direction speed and deficit between male and female National Rugby Sevens players. *Journal of Strength and Conditioning Research*, *35*(11), 3170-3176. https://doi.org/10.1519/JSC.0000000000003195

Hägglund, M., Waldén, M., Bahr, R., & Ekstrand, J. (2005). Methods for epidemiological study of injuries to professional football players: Developing the UEFA model. *British Journal of Sports Medicine*, *39*(6), 340-346. https://doi.org/10.1136/bjsm.2005.018267

Hopkins, W.G., Marshall, S.W., Batterham, A.M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise*, *41*(1), 3-13. https://doi.org/10.1249/MSS.0b013e31818cb278

Ingebrigtsen, J., Dalen, T., Hjelde, G.H., Drust, B., & Wisløff, U. (2015). Acceleration and sprint profiles of a professional elite football team in match play. *European Journal of Sport Science*, *15*(2), 101-110. https://doi.org/10.1080/17461391.2014.933879

Kirkwood, B., & Sterne, J. (2003). *Essential medical statistics* (2nd ed.). Blackwell Science.

Kobal, R., Loturco, I., Gil, S., Cal Abad, C.C., Cuniyochi, R., Barroso, R., & Tricoli, V. (2016). Comparison of physical performance among Brazilian elite soccer players of different age-categories. *Journal of Sports Medicine and Physical Fitness*, *56*(4), 376-382.

Köklü, Y., Alemdaroğlu, U., Özkan, A., Koz, M., & Ersöz, G. (2015). The relationship between sprint ability, agility and vertical jump performance in young soccer players. *Science and Sports*, *30*(1), e1-e5. https://doi.org/10.1016/J.SCISPO.2013.04.006

Lockie, R.G., Moreno, M.R., Lazar, A., Orjalo, A.J., Giuliano, D.V., Risso, F.G., …, & Jalilvand, F. (2018). The physical and athletic performance characteristics of division I collegiate female soccer players by position. *Journal of Strength and Conditioning Research*, *32*(2), 334-343. https://doi.org/10.1519/jsc.0000000000001561

López-Valenciano, A., Ruiz-Pérez, I., Garcia-Gómez, A., Vera-Garcia, F.J., De Ste Croix, M., Myer, G.D., & Ayala, F. (2019). Epidemiology of injuries in professional football: A systematic review and meta-analysis. *British Journal of Sports Medicine*, *54*(12), 711-718. https://doi.org/10.1136/bjsports-2018-099577

Los Arcos, A.L., Martínez-Santos, R., & Castillo, D. (2020). Spanish elite soccer reserve team configuration and the impact of physical fitness performance. *Journal of Human Kinetics*, *71*(1), 211-218. https://doi.org/10.2478/hukin-2019-0085

Loturco, I., Jeffreys, I., Abad, C.C.C., Kobal, R., Zanetti, V., Pereira, L.A., & Nimphius, S. (2019a). Change-of-direction, speed and jump performance in soccer players: A comparison across different age-categories. *Journal of Sports Sciences*, *38*(11-12), 1279-1285. https://doi.org/10.1080/02640414.2019.1574276

Loturco, I., Jeffreys, I., Kobal, R., Abad, C.C.C., Ramirez-Campillo, R., Zanetti, V., …, & Nakamura, F.Y. (2018). Acceleration and speed performance of Brazilian elite soccer players of different age-categories. *Journal of Human Kinetics*, *64*(1), 205-218. https://doi.org/10.1515/hukin-2017-0195

Loturco, I., Pereira, L.A., Freitas, T.T., Alcaraz, P.E., Zanetti, V., Bishop, C., & Jeffreys, I. (2019b). Maximum acceleration performance of professional soccer players in linear sprints: Is there a direct connection with change-of-direction ability? *PLoS One*, *14*(5), e0216806. https://doi.org/10.1371/journal.pone.0216806

Loturco, I., Pereira, L.A., Kobal, R., Zanetti, V., Gil, S., Kitamura, K., …, & Nakamura, F.Y. (2015). Half-squat or jump squat training under optimum power load conditions to counteract power and speed decrements in Brazilian elite soccer players during the preseason. *Journal of Sports Sciences*, *33*(12), 1283-1292. https://doi.org/10.1080/02640414.2015.1022574

Mallo, J., González, P., Veiga, S., & Navarro, E. (2011). Injury incidence in a Spanish sub-elite professional football team: A prospective study during four consecutive seasons. *Journal of Sports Science and Medicine*, *10*(4), 731-736.

Martinez-Santos, R., Castillo, D., & Los Arcos, A. (2016). Sprint and jump performances do not determine the promotion to professional elite soccer in Spain, 1994-2012. *Journal of Sports Science*, *34*(24), 2279-2285. https://doi.org/10.1080/02640414.2016.1190460

McFarland, I., Dawes, J.J., Elder, C., & Lockie, R. (2016). Relationship of two vertical jumping tests to sprint and change of direction speed among male and female collegiate soccer players. *Sports*, *4*(11), 11. https://doi.org/10.3390/sports4010011

Nonnato, A., Hulton, A.T., Brownlee, T.E., & Beato, M. (2022). The effect of a single session of plyometric training per week on fitness parameters in professional female soccer players. *Journal of Strength and Conditioning Research*, 36(4), 1046-1052. https://doi.org/10.1519/jsc.0000000000003591

Núñez, F.J., Santalla, A., Carrasquila, I., Asian, J.A., Reina, J.I., & Suarez-Arrones, L.J. (2018). The effects of unilateral and bilateral eccentric overload training on hypertrophy, muscle power and COD performance, and its determinants, in team sport players. *PLoS One*, *13*(3), e0193841. https://doi.org/10.1371/journal.pone.0193841

O'Brien, J., Finch, C.F., Pruna, R., & McCall, A. (2019). A new model for injury prevention in team sports: The Team-sport Injury Prevention (TIP) cycle. *Science and Medicine in Football*, *3*(1), 77-80. https://doi.org/10.1080/24733938.2018.1512752

Raya-González, J., Bishop, C., Gómez-Piqueras, P., Veiga, S., Viejo-Romero, D., & Navandar, A. (2020a). Strength, jumping, and change of direction speed asymmetries are not associated with athletic performance in elite academy soccer players. *Frontiers in Psychology*, *11*, 175. https://doi.org/10.3389/fpsyg.2020.00175

Raya-González, J., Castillo, D., de Keijzer, K.L., & Beato, M. (2021a). The effect of a weekly flywheel resistance training session on elite U-16 soccer players' physical performance during the competitive season. A randomized controlled trial. *Research in Sports Medicine*, 29(6), 571-585. https://doi.org/10.1080/15438627.2020.1870978

Raya-González, J., de Ste Croix, M., Read, P., & Castillo, D. (2020b). A longitudinal investigation of muscle injuries in an elite Spanish male academy soccer club: A hamstring injuries approach. *Applied Sciences*, *10*(5), 1610. https://doi.org/10.3390/app10051610

Raya-González, J., Nakamura, F.Y., Castillo, D., Yanci, J., & Fanchini, M. (2019). Determining the relationship between internal load markers and noncontact injuries in young elite soccer players. *International Journal of Sports Physiology and Performance*, *14*(4), 421-425. https://doi.org/10.1123/ijspp.2018-0466

Raya-González, J., Scanlan, A. T., Soto-Célix, M., Rodríguez-Fernández, A., & Castillo, D. (2021b). Caffeine ingestion improves performance during fitness tests but does not alter activity during simulated games in professional basketball players. *International Journal of Sports Physiology and Performance*, *16*(3), 387-394. https://doi.org/10.1123/ijspp.2020-0144

Raya-González, J., Suárez-Arrones, L., Navandar, A., Balsalobre-Fernández, C., & de Villarreal, E.S. (2020c). Injury profile of elite male young soccer players in a Spanish professional soccer club: A prospective study during 4 consecutive seasons. *Journal of Sport Rehabilitation*, *29*(6), 801-807. https://doi.org/10.1123/JSR.2019-0113

Read, P.J., Oliver, J.L., de Ste Croix, M.B.A., Myer, G.D., & Lloyd, R.S. (2018). An audit of injuries in six English professional soccer academies. *Journal of Sports Sciences*, *36*(13), 1542-1548. https://doi.org/10.1080/02640414.2017.1402535

Reynolds, J., Connor, M., Jamil, M., & Beato, M. (2021). Quantifying and comparing the match demands of U18, U23, and 1ST team english professional soccer players. *Frontiers in Physiology*, *12*, 706451. https://doi.org/10.3389/fphys.2021.706451

Sáez de Villarreal, E., Suarez-Arrones, L., Requena, B., Haff, G.G., & Ferrete, C. (2015). Effects of plyometric and sprint training on physical and technical skill performance in adolescent soccer players. *Journal of Strength and Conditioning Research*, *29*(7), 1894-1903. https://doi.org/10.1519/JSC.0000000000000838

Söhnlein, Q., Müller, E., & Stöggl, T.L. (2014). The effect of 16-week plyometric training on explosive actions in early to mid-puberty elite soccer players. *Journal of Strength and Conditioning Research*, *28*(8), 2105-2114. https://doi.org/10.1519/JSC.0000000000000387

Suarez-Arrones, L., Torreño, N., Requena, B., Sáez De Villarreal, E., Casamichana, D., Barbero-Alvarez, J.C., & Munguía-Izquierdo, D. (2015). Match-play activity profile in professional soccer players during official games and the relationship between external and internal load. *Journal of Sports Medicine and Physical Fitness*, *55*(12), 1417-1422.

Taylor, J.B., Wright, A.A., Dischiavi, S.L., Townsend, M.A., & Marmon, A.R. (2017). Activity demands during multi-directional team sports: A systematic review. *Sports Medicine*, *47*(12), 2533-2551. https://doi.org/10.1007/s40279-017-0772-5

van der Sluis, A., Elferink-Gemser, M.T., Coelho-e-Silva, M.J., Nijboer, J.A., Brink, M.S., & Visscher, C. (2014). Sport injuries aligned to peak height velocity in talented pubertal soccer players. *International Journal of Sports Medicine*, *35*(4), 351-355. https://doi.org/10.1055/s-0033-1349874

van Mechelen, W., Hlobil, H., & Kemper, H.C. (1992). Incidence, severity, aetiology and prevention of sports injuries. A review of concepts. *Sports Medicine*, *14*(2), 82-99. https://doi.org/10.2165/00007256-199214020-00002

Yanci, J., Los Arcos, A., Mendiguchia, J., & Brughelli, M. (2014). Relationships between sprinting, agility, one- and two-leg vertical and horizontal jump in soccer players. *Kinesiology*, *46*(2014), 194-201.

Zhou, C., Lorenzo, A., Gómez, M.Á., & Palao, J.M. (2020). Players' match demands according to age and playing position in professional male soccer players. *International Journal of Performance Analysis in Sport*, *20*(3), 389-405. https://doi.org/10.1080/24748668.2020.1753979

Submitted: December 21, 2021
Accepted: October 10, 2025
Published Online First: December 18, 2025

Correspondence to:
Javier Raya-González, Ph.D.
Research Group on Sport and Physical Education for Personal and Social Development (GIDEPSO), Faculty of Education Sciences and Psychology,
University of Córdoba
San Alberto Magno s/N, Córdoba, Spain
Phone: +34 957218948
Email: rayagonzalezjavier@gmail.com