

Relationship between explosive strength, linear speed and final speed in the 30–15 IFT among Chilean female university soccer players

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Abstract

Introduction: Modern soccer demands high levels of physical performance, including strength, speed, and endurance, which are key determinants of success. However, the physical profiles of female soccer players have been less studied than those of male players, particularly regarding the associations between various physical attributes. **Purpose:** This study aims to explore the relationship between lower limb explosive strength, linear speed, and final speed in the 30:15 intermittent fitness test (IFT) among Chilean female university soccer players. **Materials & Methods:** The sample was composed of 22 university soccer players (Ages: 21.32 ± 2.15 ; Mass: 60.39 ± 9.36 ; Size: 1.62 ± 0.07). Jump height (JH), normalized peak force (PF), normalized peak power (PP), and peak yank (PY) were evaluated through a countermovement jump with two force platforms. The linear speed in 10 meters (T10) and 30 meters (T30) were assessed with three photocells. The final speed of the intermittent fitness test (VIFT) was recorded. The relationship between variables was analyzed using the Spearman correlation coefficient. **Results:** Significant correlations were found between PP and JH ($r = 0.886$ $p > 0.001$), T10 and T30 ($r = 0.775$ $p < 0.001$), VIFT and T30 ($r = -0.513$ $p < 0.05$), JH and T30 ($r = -0.678$ $p < 0.001$), JH and VIFT ($r = 0.594$ $p < 0.001$), PP and T30 ($r = -0.631$ $p < 0.001$), PP and VIFT ($r = 0.655$ $p < 0.001$), PF and PY ($r = 0.517$ $p < 0.001$), JH and T10 ($r = -0.480$ $p < 0.05$). **Conclusion:** Significant correlations were identified between the jumping capacity, linear speed, and the final speed of the 30:15 IFT. The normalized peak power was the kinetic variable of the CMJ best related to the linear speed and the final test speed of 30:15 IFT.

Key words: Athletic performance, 30:15 intermittent fitness test, Football, Vertical jump.

Introduction

Contemporary soccer has become more physically demanding, with the physical profile becoming an increasingly important determinant of athletic performance (Barnes et al., 2014). Intermittent efforts and explosive actions, such as jumps and sprints, have become crucial during the competition (Bradley et al., 2009; Faude et al., 2012). The physical profile of male soccer players at various levels of competition is well established, with strength, speed, and endurance proving crucial in sports performance (M. C. Marques et al., 2016; Sporis et al., 2009; Vigne et al., 2010), however, the physical profile of female soccer players has been less studied.

Despite the rapid growth of women's soccer in recent years, there is a significant gap in the production of scientific knowledge compared to men's soccer. Specifically, the literature on women's soccer represents only about 20% of all research in the field of soccer (Kirkendall & Krstrup, 2022). Understanding the physical demands and interactions between the physical qualities of female soccer players is fundamental, since the main differences in performance are found in the physical section, influenced by anthropometric and physiological differences (Bradley et al., 2014; Pedersen et al., 2019). Adequate knowledge of the requirements of female soccer players contributes to orient physical and sport specific training for this population, thus promoting sport performance.

Assessing the physical performance of the lower body is essential in soccer, and the countermovement jump (CMJ) is a widely used test, providing metrics to optimize sports performance, monitor neuromuscular fatigue, and guide sports reintegration (Bishop et al., 2023). To date, significant associations have been found between the height of a CMJ and linear sprint performance in female soccer players (Kobal et al., 2021; Križaj, 2020; Merino-Muñoz et al., 2021), which helps to improve the understanding of the physical profile of female

soccer players. However, jump height is not a direct indicator of explosive strength, as is the rate of force development, also known as Yank (Lin et al., 2019; Merino-Muñoz et al., 2020). Therefore, it is essential to analyze the kinetic variables of countermovement jumping (CMJ) and its relationship with speed or other physical capacities. This will allow a more efficient structuring of physical conditioning programs, optimizing sports performance.

Another highly used assessment in soccer is the 30-15 Intermittent Fitness Test (30-15 IFT), which measures both aerobic and anaerobic performance due to the repeated changes of direction and sprints during its execution (Buchheit, 2009). The final velocity achieved during the test (VIFT) is used as a key indicator to prescribe intermittent training and has shown a significant correlation with linear sprinting, providing a valuable reference to optimize the physical conditioning of soccer players (González Vargas & Gallardo Pérez, 2023). Given that the 30-15 IFT has become an increasingly popular assessment in soccer due to its high ecological value, it is particularly interesting to explore how this test can be associated with variables such as strength, power or speed in high-intensity actions. However, these associations have not currently been investigated in depth, which opens an important area of study to optimize the performance of soccer players.

Therefore, this study aims to determine the relationship between lower body explosive strength, linear speed and VIFT in Chilean female university soccer players. The findings could help coaches 'valuable information for training prescription and programming, as well as in the selection of tests for the evaluation and follow-up of players. This would contribute to a better understanding of the physical profile of female soccer players and their specific requirements in the context of sports performance.

Materials & methods

Design

The present research presents a quantitative approach of correlational scope and cross-sectional design (Sampieri, 2018).

Participants

The sample for this research corresponds to 22 female university soccer players, whose characteristics are described in Table 1. The players compete regularly in the Chilean metropolitan and national leagues, and they are declared to be without lower body injuries that could prevent them from participating. The selection of the sample was non-probabilistic by convenience. All the participants were informed of the study's objectives and the voluntary nature of their participation through informed consent, respecting the Declaration of Helsinki. These consents were reviewed and signed by each one of them after authorization from the entities responsible for the club to conduct the research.

Table 1. Characterization of the sample.	
Variables	Mean $\pm$ standard deviation
Age (years)	21.32 $\pm$ 2.15
Mass (kg)	60.39 $\pm$ 9.36
Height (m)	1.62 $\pm$ 0.07

Instruments

To assess jumping ability and lower body strength, the CMJ test (Bosco et al., 1983) and two PASCO PD-2142 force platforms were used, which have proven to be valid for the measurement of CMJ mechanical variables in the field (Peterson Silveira et al., 2017). To evaluate linear speed, distances of 10 meters (T10) and 30 meters (T30) were considered due to their relevance in competitive actions (Andrzejewski et al., 2013). To measure the performance in T10 and T30, three photocells (Microgate-Witty Systems, Italy) were used, and the distances were determined with a large wheel digital odometer (18 millimeters in diameter) with an accuracy of 0.1 meters. The distances of the 30-15 IFT were determined as described by (Buchheit, 2008) using the same digital odometer to demarcate the zones with 20-centimeter-high cones and with lentil cones. A Sony MHC-V02 mini-component with Bluetooth system and the 30-15 IFT application in the Spanish version for soccer were used to reproduce the auditory signal.

Procedures

Before the measurements, a two-block warm-up of 15 minutes was performed, including mobility exercises, dynamic stretching, jumps over hurdles, and accelerations of 5 and 10 meters. The first measurement was the CMJ, in which each player made two attempts with a 1-minute pause between attempts; the indication was to jump as high and fast as possible. Subsequently, the players completed the linear speed tests T10 and T30. One photocell was placed at the beginning of the track; the second one we set up at ten meters, and the last one at the end gate of the track (thirty meters); each player had to place herself half a meter before the first photocell and perform two attempts with a complete pause (> 3 minutes) between one attempt and the other. The 30-15 IFT the players performed following the guidelines set out by Buchheit (2008), ending the test when the

subject fails to reach the established zones during the auditory signal on three consecutive occasions, as well as the subject can withdraw her own free will.

The tests were conducted on a surface of artificial grass, and the players used shoes suitable for this type of terrain. The tests were held in March, before the start of the competitive season.

The variables analyzed for the CMJ were jump height (JH), normalized peak force (PF), normalized peak power (PP), and peak yank (PY). For the linear speed T10 and T30, the time required to complete these distances was considered. For the 30-15 IFT, the VIFT was considered.

Statistical analysis

The normality of the data was verified through the Shapiro-Wilk test and visualization of histograms where the assumption of normality was fulfilled ($p < 0.05$), so the descriptive statistics were performed through median and percentile statistics (25th and 75th percentiles). The relationship between variables was analyzed through Spearman's correlation coefficient, considering the following magnitudes: 0 to 0.09, very small; 0.1 to 0.29, small; 0.30 to 0.49, moderate; 0.50 to 0.69 large; 0.70 to 0.89 very large; and 0.90 to 1.0 almost perfect to perfect, applying the same ranges for negative values (Hopkins, 2002). An alpha of 0.05 was established. All statistics were performed using the IBM SPSS statistics version 24.0® program.

Results

The results of the evaluations and correlations between variables are detailed in Table 2. Very large correlations were found between PP and JH ($r = 0.886$ $p > 0.001$), T10 and T30 ($r = 0.775$ $p < 0.001$). Large correlations between VIFT and T30 ($r = -0.513$ $p < 0.05$), JH and T30 ($r = -0.678$ $p < 0.001$), JH and VIFT ($r = 0.594$ $p < 0.001$), PP and T30 ($r = -0.631$ $p < 0.001$), PP and VIFT ($r = 0.655$ $p < 0.001$), PF and PY ($r = 0.517$ $p < 0.001$). A moderate correlation between JH and T10 ($r = -0.480$ $p < 0.05$).

Table 2. Descriptive statistics and correlation coefficient between physical tests.

Variables	Sperman's correlation coefficient						Descriptive		
	T30	VIFT	JH	PF	PP	PY	M	P25	P75
T10 (s)	0.775**	-0.237	-0.480*	0.226	-0.369	0.383	1.89	1,88	1,95
T30 (s)		-0.513*	-0.678**	-0.017	-0.631**	0.311	4.82	4,77	5,02
VIFT (km/h)			0.594**	0.416	0.655**	-0.119	16.25	15	17,5
JH (cm)				0.214	0.889**	-0.241	24	23	27
PF (N/kg)					0.231	0.517*	23.4	22.5	24
PP (W/kg)						-0.31	37.25	37	43
PY (N/s)							11565	8731	14114

*: significant correlation at the 0.05 level; **:significant correlation at the 0.001 level; T10: time over 10 meters; T30: time over 30 meters; VIFT: final velocity of the 30:15 fitness test; JH: jump height; PF: normalized peak force; PP: normalized peak power; PY: peak yank; M: median; P25: 25th percentile; P75: 75th percentile.

Discussion

Our findings are in agreement with previous research regarding the relationship between JH and T10 ($r = -0.48$) and T30 ($r = -0.678$), Vescovi & McGuigan (2008) evidenced large ($r = -0.658$) and very large ($r = -0.75$ to -0.78) correlations between CMJ height and times required to run various distances (9.1 to 36.6 meters). More recently, a substantial correlation of JH with T10 ($r = -0.72$) and T30 ($r = -0.77$) was determined (Merino-Muñoz et al., 2021), as well as a large correlation ($r = -0.59$) between JH and T30 (Gonzalez Vargas & Gallardo Pérez, 2023). Although the relationship between JH and linear speed varies between investigations, these discrepancies could be explained by the characteristics of the samples evaluated and the differences in the distances used in linear speed tests. Despite the above, all these results indicate a clear positive relationship between vertical jumping ability and linear speed. Although the above, explosive strength represented by PY does not demonstrate significant correlations with T10 ($r = 0.383$), T30 ($r = 0.311$), and VIFT ($r = -0.119$), which is consistent with the findings of M. Marques et al., (2011) ($r = 0.354$) and (M. C. Marques & Izquierdo, 2014) ($r = 0.435$) when associating RFDmax of vertical jump with 5 and 10 meter sprints respectively. It would appear that explosive strength measured in a CMJ has not been shown to have a high correlation with linear speed test performance or VIFT in female soccer players.

Mechanical power has a close relationship with jump height (Gonzalez-Badillo & Marques, 2010), which is in agreement with our results ($r = 0.886$ $p < 0.001$), explaining the relationship between PP and T30 ($r = -0.63$ $p < 0.001$). However, the moderate non-significant relationship between PP and T10 could be partly

explained by the need to produce higher force levels at a lower velocity during the acceleration phase of sprinting over short distances (Samozino et al., 2022). Therefore, PP could be a better indicator to monitor at distances over 30 meters because the acceleration phase of a sprint varies between 30 to 50 meters depending on the level of the athlete (Mero et al., 1992). For VIFT, we found a large and moderate significant correlation with JH and T30, respectively, which differs from the findings of Gonzalez Vargas (2023), who found no non-significant relationship between VIFT and JH ($r=0.287$) and a positive relationship with large T30 ($r=0.621$ $p<0.05$). Despite the above, Silva et al. (2022) identified significant correlations ($r=0.650$ to 0.631) between JH and VIFT in male youth soccer players. These contradictory results highlight the need for further research to elucidate the relationship between these variables. Based on those mentioned above, the importance of the multifaceted development of physical abilities in women's soccer can be corroborated, just as in men's soccer (Pérez-Contreras, 2022). This is mainly due to the interconnection of strength, speed, and endurance in soccer development (Boone et al., 2012).

Limitations in this study, such as sample size, are recognized due to the impossibility of accessing other university women's soccer teams. Also, only 10 and 30 meters were considered in the speed test, considering that a soccer player can cover a greater variety of distances. Finally, it was a limiting factor not to be able to directly measure the speed-strength profile in a linear sprint, this being a specific measurement for soccer due to the force vector that is applied when running (Jiménez-Reyes et al., 2022).

The results obtained in this study provide a basis for future research that will address the interrelationships between different physical abilities in female soccer players, especially in university contexts, considering this as a competitive reality. Especially the relationship between VIFT and linear speed at various distances. It is also recommended to analyze the relationship that biomechanical variables of a sprint may have with linear speed and VIFT, which is a much more specific evaluation for soccer.

This data guides the design of specific and compelling training programs focused on improving both jumping ability and linear speed and endurance in women's soccer. As a practical application, it is essential to implement workouts that combine explosive strength exercises with sprinting at different distances and with variations in action and recovery times. This will thus optimize performance not only in speed and endurance tests but also in actual competition. Furthermore, these findings underscore the importance of customizing training routines to maximize the physical abilities that best correlate with on-field performance, which may be particularly beneficial for talent recruitment and development in college soccer teams.

Conclusions

In relation to the results, this research highlights a significant relationship between jumping ability, linear speed and VIFT in Chilean female university soccer players. However, explosive strength measured through the jumping action does not seem to have a direct correlation with linear velocity and VIFT. In contrast, jump height and normalized peak power emerge as the most relevant variables for predicting performance in VIFT and in 15- and 30-meter sprints. These findings provide crucial information about the physical profile of female soccer players, facilitating a deeper understanding of the physical characteristics that influence their performance. This allows coaches and sports specialists to program and prescribe training that maximizes the interaction between the different physical capacities, in addition to guiding the selection of physical tests for a more comprehensive evaluation of female soccer players.

An additional contribution of this research is that it highlights the importance of further exploring the relationship between physical variables, particularly those related to the horizontal force-velocity profile. This approach has greater ecological value in the context of soccer performance and could provide a more accurate perspective for assessing and improving players' abilities in real game situations.

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Conflict of interest The authors declare that they have no conflicts of interest.

Authors' contribution All authors have actively participated in writing the paper and analyzing the documents.

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