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Section III – Sports Training

The Influence of Sprint Mechanical Properties on Change of Direction in Female Futsal Players

by
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The aim of the present study was to analyze the association of the sprint force-velocity profile [Hzt FV profile] variables with change of direction [COD] performance in female futsal players. Twelve female futsal players (age: 19.83 ± 4.2 years; body height: 160.75 ± 8.37 cm; body mass: 57.64 ± 8.3 kg) volunteered to be evaluated in the following assessments: Hzt FV profile, 505 test, modified 505 test [M505test] and V-cut test. The Spearman's correlation coefficient [r_s] ($p < 0.05$) was used to determine the relationship of the mechanical variables of the sprint (maximum power output [P_{max}], maximum horizontal force production [F_0] and maximum velocity [V_0]) with COD performance. V_0 showed a very large significant association with the 505 test (r_s = -0.767; 90% CI: (-0.92 to -0.43); $p < 0.01$) and a large association with the V-cut test (r_s = -0.641; 90% CI: (-0.86 to -0.21); $p < 0.05$), whereas P_{max} was strongly associated with results of the 505 test (r_s = -0.821; 90% CI: (-0.94 to -0.55); $p < 0.01$) and largely associated with the V-cut test results (r_s = -0.596; 90% CI: (-0.84 to -0.14); $p < 0.05$). In conclusion, maximal power and velocity output during sprinting are determinant factors to successful COD in 180º and 45º cuts, thus, the Hzt FV profile should be assessed in female futsal players to better understand the influence of sprint mechanical properties on COD performance and prescribe individualized training programs.

***Key words**: team sports, strength, acceleration, power, velocity.*

Introduction

Futsal is the indoor version of soccer characterized by intermittent and high intensity actions (13.7% of the total distance is covered at speed ≥ 15 km·h^{-1} and 8.9% ≥ 25 km·h^{-1}) that require physical, tactical and technical efforts (Naser et al., 2017). Futsal players are required to continually accelerate, decelerate and perform quick changes in speed and direction in very short periods of time, in particular during decisive moments, such as goal-scoring opportunities (Sweeting et al., 2017; Taylor et al., 2017). Ramos-Campo et al. (2016) suggested that one factor where semi-professional female futsal players differed from professionals was in terms of agility performance, showing lower velocities during COD tests. Therefore, identifying physical capacities that determine COD may be relevant when optimizing training program interventions in futsal.

Throughout the duration of a game female futsal players are required to perform around 31 accelerations (acc) and 40 decelerations (dcc) and cover approximately 50 m of high-speed running (Beato et al., 2017), which are demands similar to those of male futsal (Barbero-Álvarez et al., 2004). Therefore, it is important to consider "stop & go" actions, requiring a high capacity for acceleration and deceleration. In this regard, it is known that the time available for performing COD decreases as the level of performance increases (Condello et al., 2013; Hader et al., 2015;

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Nimphius et al., 2010) so that the COD speed (i.e. the athletes' ability to decelerate during a running motion and immediately accelerate in another direction) is considered a performance-selective factor in futsal (Spiteri et al., 2013). Previous studies observed that faster female basketball players in COD tests showed greater eccentric, isometric and propulsive force values (Spiteri et al., 2015) which might enable them to absorb and apply force during cutting or pivoting maneuvers. Similarly, Nimphius et al. (2010) observed significant association of peak power assessed with loaded squat jumps with directional changes of 180º in female softball players. However, an inconsistent relationship has been also reported between other strength measures and COD performance which can be attributed to gender, sports level and strength assessment methods (Nimphius et al., 2010). Although the female category has been getting more popular over the last years, previous studies have specially attempted to analyze the physical qualities that influence COD performance in male players, showing that athletes with higher sprint velocities or greater maximum acceleration rates from zero to 5 m performed better in COD tests (Loturco et al., 2019). However, the use of this split time values does not bring sufficient information about the underlying muscular variables and mechanical effectiveness of horizontal ground force application (Morin and Samozino, 2016) which might determine COD performance in female futsal players.

The FV relationship during sprinting (Hzt FV profile) has recently been proposed to describe the capacity of the entire neuromuscular system to generate force at maximum speed in particular movement directions (Samozino et al., 2016) and it is summarized through the theoretical maximal force (F_0), theoretical maximal velocity (V_0) and maximal power output (P_{max}) variables (Samozino et al., 2016). Sprint and COD tasks present similar mechanical demands during the propulsive phase of the movement, which is mainly determined by the athlete's acceleration capacities. Assessing the Hzt FV profile may provide valuable information of the individual mechanical properties underpinning sprint acceleration, which might also determine COD performance. Therefore, this information could help coaches optimize training programs in female futsal players.

However, to the best of our knowledge, this is the first study analyzing the association of the mechanical variables derived from the Hzt FV profile with COD performance in female futsal players, which can optimize specific training programs. For this reason, the aim of the present study was to analyze the association of the mechanical variables of the Hzt FV profile with COD performance through different COD tests in female futsal players.

Methods

Participants

Twelve female futsal players (age: 19.83 ± 4.2 years; body height: 160.75 ± 8.37 cm; body mass: 57.64 ± 8.3 kg) playing for the same team in the Spanish second division voluntarily participated in this study. Participants were informed of the risks and benefits of the study and gave their written consent before the initiation of the study. This study was approved by an Ethics Committee in accordance with the Declaration of Helsinki.

Design and Procedures

The present study used a cross-sectional design to determine the association of the different variables of the Hzt FV profile (i.e. F_0, V_0, P_{max}) with COD performance. The study consisted of one experimental session which was preceded by a familiarization session (48 h before). Both sessions took place during the competitive period, in which the team trained three times per week in addition to an official game every weekend. The Hzt FV profile and the the three different COD testing procedures were determined in the same experimental session. Both sessions were held between 8-10 pm in their daily indoor court to avoid any influence of the surface.

Testing procedures

All participants performed a standardized warm-up protocol including 5 min jogging and 5 min of lower limb dynamic stretching. Moreover, a specific warm-up was performed before each specific test (i.e. 3 progressive sprints of 30 m at 50%, 70%, 90% of the athletes' self-perceived maximal velocity before Hzt FV profile assessment and one trial at 70% of maximum effort before both COD tests). Players recovered for 3 minutes from the end of the specific warm-up to the beginning of every test and 5-7 minutes between tests.

Horizontal Force-Velocity Profile: After the specific warm-up participants performed two maximal sprints of 30 m separated by 4 min of recovery to determine the individual FV profile in sprinting. Mechanical sprint variables were collected via a Stalker Acceleration Testing System (ATS) II radar device (Model: Stalker ATS II Version 5.0.2.1; Applied Concepts, Dallas, TX, USA). The radar device was attached to a tripod 10 m from the starting line at a height of 1 m corresponding approximately to the height of the participants' centre of mass; the sprint was initiated from a crouching position (staggered-stance). Velocity-time data were recorded at 46.9 Hz and used to calculate the individual Hzt FV profile mechanical variables (i.e. F_0, V_0 or P_{max}, and the decrease in the ratio of horizontal force application (DRF), referring to the FV imbalance in sprinting) according to Samozino's validated method (Samozino et al., 2016). F_0 and P_{max} were normalized to body mass.

505 Test: Athletes began the test 10 m from the pair of photocells (Microgate, Bolzano, Italy) placed 5 m from a designated turning point. Athletes were instructed to accelerate as quickly as possible through the photocells, pivot at the 15 m line and sprint through the photocells (Draper and Lancaster, 1985). Two trials were completed for each pivot foot. The fastest time was used for statistical analysis.

Modified 505 Test (M505test): Athletes began the test 0.3 m behind the pair of photocells placed at the starting line. The set of cones were set at 5 m from the start position. Athletes were instructed to accelerate as fast as possible along the 5 m distance, placing either their right or left foot on the line, pivot and sprint through the finish (photocells placed at starting position) (Gabbett et al., 2008; Taylor et al., 2019). Two trials were completed for each pivot foot, using the fastest time for statistical analysis.

V-cut Test: Athletes began the test 0.3 m behind a pair of photocells placed at the starting line. Athletes performed a 25 m sprint with 4 COD of 45º each 5 m. Two trials were completed using the fastest trial for statistical analysis. Players had to pass the line (drawn on the floor) completely with one foot at every turn. A new trial was allowed when the previous one was considered not valid. Each pair of cones was separated by 0.7 m. Another pair of photocells was placed at the finish line (Gonzalo-Skok et al., 2015).

Statistical Analysis

Data are presented as mean and standard deviation [SD]. Spearman's correlation coefficients (r_s) were used to assess the relationship between the Hzt FV profile mechanical variables and COD tests (i.e. 505 test, M505 test and V-cut test). Qualitative interpretations of r_s coefficients were provided as defined by Hopkins et al. (2009): trivial (0.00 - 0.09), small (0.10 - 0.29), moderate (0.30 - 0.49), large (0.50 - 0.69), very large (0.70 - 0.89), nearly perfect (0.90 - 0.99), and perfect (1.00). The level of significance was set at $p < 0.05$. Statistical analyses were performed using SPSS software version 25.0 (SPSS, Chicago, Illinois, USA).

Results

Table 1 contains the descriptive data of the mechanical variables of the Hzt FV profile and COD performance tests expressed as mean [SD].

Table 2 shows the correlations between the mechanical variables of the Hzt FV profile and different COD performance tests (505 test, M505 test and V-Cut test). A significant association was found between V_0 and the 505 test (r_s = -0.767; 90% CI: (-0.92 to -0.43); $p < 0.01$) and the V-cut test (r_s = -0.641; 90% CI: (-0.86 to -0.21); $p < 0.05$), respectively. P_{max} showed a significant association with the 505 test (r_s = -0.821; 90% CI: (-0.94 to -0.55); $p < 0.01$) and the V-cut test (r_s = -0.596; 90% CI: (-0.84 to -0.14) $p < 0.05$), respectively.

Figure 1 presents the largest correlations reported between mechanical variables of the Hzt FV profile and COD performance tests.

Discussion

This study was designed to analyze the association of mechanical variables obtained from the Hzt FV profile with performance in different COD tests in female futsal players. The primary findings indicate that P_{max} is the mechanical variable most strongly associated with performance in the 505 test in which players are required to sprint over 15 m before pivoting in a 180º COD. V_0 was the mechanical variable most strongly associated with the V-cut test indicating the influence of maximal velocity during the COD maneuver with less accentuated turning angles.

Table 1

Descriptive data of the horizontal FV profile mechanical variables as well as COD and sprint times

Female futsal players (n = 12)		
	Mean	SD
F_0 (N·kg^{-1})	6.39	0.65
V_0 (m·s^{-1})	7.34	0.59
P_{max} (W·kg^{-1})	11.64	1.72
M505test (s)	2.82	0.19
505test (s)	4.45	0.31
V-Cut test (s)	7.25	0.58
20m (s)	3.89	0.21

Data are mean [SD]. F0 = maximum horizontal force production; Pmax = maximum power output; V0 = maximum velocity application; M505test = modified 505 test; 20m = time in 20 meters sprint

Table 2

Spearman correlation between the Hzt FV profile variables and performance in the different COD tests

Test	F_0 (N·kg^{-1})	V_0 (m·s^{-1})	P_{max} (W·kg^{-1})
M505 test	-0.063 (-0.55 to 0.45)	-0.434 (-0.77 to 0.08)	-0.266 (-0.68 to 0.27)
505 test	-0.518 (-0.81 to -0.03)	-0.767** (-0.92 to -0.43)	-0.821** (-0.94 to -0.55)
V-Cut test	-0.315 (-0.7 to 0.22)	-0.641* (-0.86 to -0.21)	-0.596* (-0.84 to -0.14)

**Correlation is significant ($p < 0.05$). **Correlation is significant ($p < 0.01$). Confidence interval at 90%. F_0 = maximum horizontal force production; P_{max} = maximum power output; V_0 = maximum velocity application; M505test = modified 505 test*

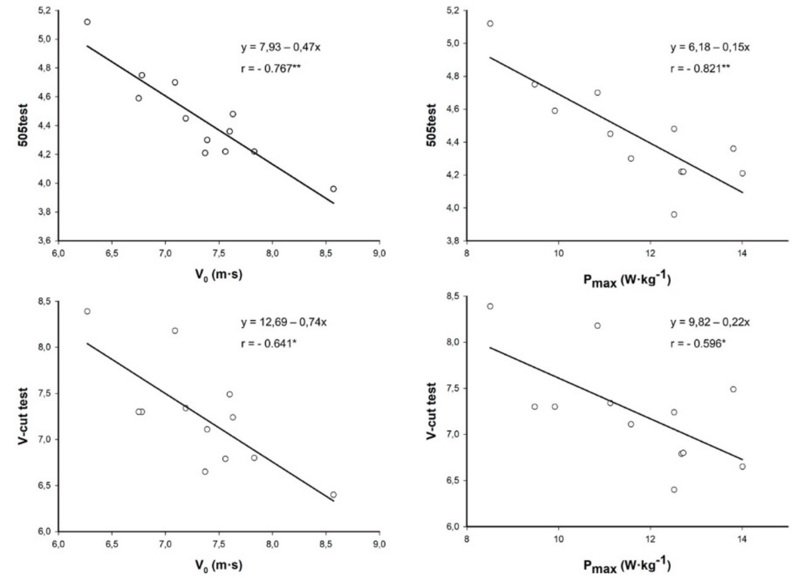

Figure 1

*Strongest association between Hzt FV profile variables and COD performance. r_s, Spearman's correlation coefficient. *Correlation is significant ($p < 0.05$). **Correlation is significant ($p < 0.01$).*

Although women's futsal competitions have been getting increasingly popular over the years, little research has been conducted to date regarding the physical qualities that determine COD performance in futsal which is of great practical interest, especially in such a physical demanding sport in which acceleration and maximal velocity capacities are of paramount importance for success (Jiménez-Reyes et al., 2019; Mohammed et al., 2014). Jiménez-Reyes et al. (2019) recently obtained reference values of the sprint mechanical properties of both male and female elite futsal players showing that males displayed higher values of F_0, P_{max} and V_0 and mechanical effectiveness of force application during sprinting compared to females. These results highlight the higher ability of male players to apply high amounts of force at low velocity (i.e. beginning of the sprint) and to apply that horizontal force at high velocity contractions (i.e. high speed). Interestingly, the descriptive characteristics in Jiménez-Reyes et al. (2019) were similar to those in this study. Specifically, F_0 was higher for elite female futsal players (6.63 [0.46] N·kg^{-1} vs. 6.39 [0.65] N·kg^{-1}) as well as P_{max} (12.6 [1.2] W·kg^{-1} vs. 11.74 [1.72] W·kg^{-1}) and V_0 (7.64 [0.40] m·s^{-1} vs. 7.34 [0.59] m·s^{-1}) compared to the second division female futsal players recruited in this study. Although these findings suggest that second division female futsal players might have lower maximum force, power and velocity characteristics when compared to elite players, taken together, these results support that the Hzt FV profile is a sensitive tool useful to distinguish between levels of practice (Jiménez-Reyes et al., 2019) as well as to provide an integrative view of the sprint mechanical properties and mechanical effectiveness during sprinting in second division female futsal players.

To note, the Hzt FV profile individually describes changes in external horizontal force application with increasing running velocity as well as determines mechanical effectiveness on ground force application (i.e., the maximal ratio of the effective horizontal resultant component) during the acceleration phase (Morin et al., 2012; Samozino et al., 2016). This information is relevant for the training process since the same mechanical demands are required to successful COD in maneuvers with sharper cuts such as directional changes of 180º where players need to apply a substantial amount of horizontal forces onto the ground to accelerate their body forward and shift their momentum during the braking phase (Dos'Santos et al., 2017; Spiteri et al., 2015). In this regard, our results did not show significant associations of F_0 and 180º COD performance. This may be directly related to the inexperience of the players in resistance training, which makes it difficult to apply high amounts of horizontal force at low velocity. Although previous studies assessed the association of acceleration and linear sprint velocity (both determined by split times) with COD performance (Loturco et al., 2019; Pereira et al., 2018; Suarez-Arrones et al., 2020), the present findings support the importance of the Hzt FV profile evaluation to obtain a more comprehensive description of the role of sprinting mechanical properties in COD performance than just split times since it is known that two players could have the same split time in a distance, but different F_0 and mechanical effectiveness values (Morin and Samozino, 2016). Therefore, obtaining individual specific deficits in maximal horizontal force production and the ability to transfer it forward at the first steps of the acceleration phase (Morin and Samozino, 2016) might help coaches implement individualized training programs to maximize athlete's acceleration capabilities which, in turn, may translate into improved COD performance in female futsal players.

Sprint running acceleration mainly depends on athlete's mechanical power output which is determined by both maximal force and velocity output (Samozino et al., 2016). Interestingly, moderate to very large associations observed between P_{max} and all COD tests (Table 2) may be explained by the futsal-specific need to produce high levels of power and velocity rather than high levels of maximal horizontal force during sprinting. Thus, it may be assumed that both the small dimensions of futsal fields and the predominance of short accelerations during futsal games (Mohammed et al., 2014; Taylor et al., 2017) have presumably predisposed these female futsal players to display their maximal power and velocity values earlier in the sprint running since they are not required to sprint over long distances (i.e. close to maximal velocity) (Jiménez-Reyes et al., 2019). When it comes to COD performance, the present findings showed that horizontal V_0 and P_{max} were strongly associated with the 505 test and V-cut test results. In that sense, Loturco et al. (2018) and Freitas et al. (2019) previously observed that more powerful athletes in loaded squat jumps (i.e., vertical measurements) were faster in the Zig-Zag test than their weaker counterparts whereas Spiteri et al. (2014) did not observe significant contribution of vertical power to 505 test performance. Since horizontal force application is predominant during COD maneuvers (Dos'Santos et al., 2017), specific force, power and velocity assessment are needed to be conducted when aiming to examine the influence of these mechanical variables on COD performance.

Additionally, V_0 was the mechanical variable most strongly associated with 505 test results which supports previous studies indicating that faster athletes in 180º COD tests tended to display greater approach velocity (Dos'Santos et al., 2017, 2018). This may be especially relevant in this COD test in which players have to sprint over 15 m before performing the COD maneuver. Similarly, the strong association of V_0 with the V-cut test strengthens the theory that COD demands are angle dependent since players do not need to decelerate their body as much as during sharper cuts, which enables them to maintain a superior velocity during the task (Dos'Santos et al., 2017, 2018). Together with technical skills, this higher V_0 may lead to a superior COD speed which becomes a determinant as the level of practice increases (Hader et al., 2015).

This study has some limitations. First, the sample size was rather small and studies with larger samples are needed. Thus, these results are not necessarily generalizable to elite players who display greater performance in agility so that mechanical determinants might differ. Second, the relationships obtained in the present study must be contrasted in future longitudinal research. Moreover, assessing whether optimizing sprint mechanical properties directly improves performance in these COD tests is needed. Finally, there are other factors involved in COD performance such as technical skills, tactical attributes and cognitive factors that should also be considered when aiming to maximize performance in these multidimensional maneuvers.

The results of the present study indicate that the Hzt FV profile should be considered as an evaluation method to provide an integrative view of the sprint mechanical properties and a better understanding of the underpinning muscular variables that influence COD performance in female futsal players in order to individually implement training programs based on player's FV profile deficits. For instance, in these velocity-oriented female futsal players it could be recommendable to implement exercises (e.g., heavy resisted sprints) to improve F_0 and the ratio of the horizontal-to-resultant force component which are fundamental in acceleration performance (Lahti et al., 2020). Taken together, this improvement may enable them to better horizontally apply high amounts of force therefore resulting in better COD performance.

In conclusion, P_{max} was the sprint mechanical variable most strongly associated with the 505 test results which highlights the importance of developing maximal power output during previous linear sprint running. V_0 was largely associated with the V-cut test showing the influence of maintaining maximal velocity during directional changes of 45º. These results display that training prescription based on the sprint FV profile should be performed for a better performance of COD maneuvers.

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