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External and internal load during the effort tests in different ages in young futsal players: association between leg power, shot speed and fatigue levels

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RESEARCH ARTICLE

Abstract

Futsal is a sports game that features high intensity movements with change of speed or direction, present in several actions during the game. With this study is intended to analyse, compare and evaluate the predictive factor of leg power on shooting speed and fatigue levels in young futsal athletes in order to establish effort patterns in these ages, to prescribe training sessions adequately in terms of external/internal load. The study had 32 participants, male, aged between 12 and 17 years (Mean = 14.56±1.66). Participants were evaluated in relation to their lower limb power through the Chronojump system, the speed was measured through a radar placed on the goal line, and in relation to their fatigue levels through the Running Anaerobic Sprint Test (RAST). To identify the differences between groups, the tests of Kruskal Wallis and Mann Whitney were used, and also a simple linear regression tests for predictive values between variables. In relation to the shots speed, higher values were found in the older groups ($P \leq 0.001$), which is directly and significantly related to the higher values of lower limb power, also verified in the older athletes ($P \leq 0.001$). In relation to the fatigue levels, it increases as the age of the athletes is higher, verifying that the power of the lower limbs is a predictor variable of the fatigue index ($P \leq 0.001$). The analysis conducted indicate that there are significant differences in the association between shooting speed, lower limb power and fatigue indices according to the players levels studied.

Keywords: futsal, leg power, shot speed, fatigue index, young athletes

1. Introduction

Team sports, such as futsal, demand from their players a considerable and high aerobic capacity, despite a great ability to perform sub-maximal and maximal efforts repetitively (Girard *et al.*, 2011) also called anaerobic power/capacity. Reilly *et al.* (2000) state that movements without the ball comprise more activity during a game and are considered mainly aerobic, given that the movements directly involved in the game itself are effective and highly anaerobic. It is an excellent way to analyse and enhance the level of muscle capacity of the lower limbs in athletes, to identify levels of anaerobic power and fatigue levels, where, among others, the RAST test can be used. Anaerobic power is a component present in the stimulus produced in this sport. 'Anaerobic power is understood as the greatest effort performed during a given action for the smallest unit of time available' (Barth, 2018).

The physiological requirement of futsal is extremely complex and reflects on players the need to develop several physical qualities, as already mentioned, aerobic and anaerobic capacity, muscle strength, speed and agility (Kalva-Filho *et al.*, 2013; Karaloc *et al.*, 2012). This diversity of physical qualities, since they act simultaneously, promote an athletic preparation of these players in a multifactorial and multifaceted context, as this will certainly be a requirement in competition contexts. The contexts of physical preparation within this type of sports that require reaction speed and explosive strength have, and should, be applied in jumping training practices (Bompa, 2005) performed through impulsion or vertical jump. According

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to Boone *et al.* (2012) and Buchheit *et al.* (2010) it is a sport in which athletes perform high-intensity and short-duration efforts, with periods of intense effort but with different duration. Coelho *et al.* (2011a) refers that in intermittent or continuous sports such as futsal, it is important to have reliable performance in terms of income.

These fast and intense movements, with a constant change of speed and/or direction in response to a certain stimulus, present in numerous actions during the game, are closely related to the concept of agility (Sheppard and Young, 2006). However, its definition of strength, referred to as the ability of the muscles to produce an acceleration, to keep it immobile or to stop its displacement, present in these periods of high intensity, are also observable in about 30% of the game total time (Dogramaci and Watsford, 2006). Futsal is currently one of the most practiced sports in the world, characterised above all, as already mentioned, for being an intermittent sport with high-intensity movements (Barbero-Alvarez *et al.,* 2009; Dogramaci and Watsford, 2006).

This study is intended to analyse, compare and evaluate the predictive factor of leg power on shooting speed and fatigue levels in young futsal athletes in order to establish effort patterns in these ages, to prescribe training sessions adequately in terms of external/internal load.

Physiological demands in futsal

Futsal is characterised as a team sport of invasion, according to its intermittent nature, it requires players to perform several high-intensity requests during the game, making it a requirement for the contribution of different energy systems (Barth, 2018). The great physiological demands imposed on these players and the fact that the game has a time limit can exponentially increase the pressure on these same physical and psychological demands. Castagna *et al.* (2009) also mention that the unlimited number of substitutions and the possibility of the goalkeeper's participation in the field of play, will allow the team to play in numerical superiority, thus contributing to a high intensity game. During futsal games both metabolic systems contribute to the maintenance of these intense actions, with the aerobic system being predominant in energy supply, in about 90% of the total energy supplied. It promotes the recovery of energy reserves during the game, with main emphasis on the interval between high-intensity efforts (Barbero- Alvarez, 2009).

Lower limb power

Strength is a decisive parameter, but there are lots of definitions and applications in several contexts. Muscle strength is identified (Osterning, 1986) as an individual's ability to obtain the greatest possible muscle power in a static and dynamic situation. In this line of thought Knuttgen and Kraemer (1987) identify strength as the maximum tension manifested at a given speed. Later, Jones *et al.* (2000) defined strength as the maximum tension that the muscle or muscle group can develop during a voluntary action to perform specific tasks at a given time. In the specific case of futsal and according to the context in which it is currently practiced, it requires players to be able to perform several high-intensity efforts, considering the stimuli elapsed during it, with very short recovery periods (Soares-Caldeira *et al.,* 2014). According to the same author, there is an identified average where each player performs about fifteen jumps in both defensive and/or offensive actions. According to this, the specific stimuli that are provided by the game are considered insufficient for this skill to be further developed. Cometi *et al.* (2001) recommended that specific strength training for jumping be included in the physical preparation of players in this sport. However, Coelho *et al.* (2011b) also mentioned that vertical jumps varied between athletes, without this explosive capacity being a determining factor, whether in futsal or other sports, namely those that require speed, agility, speed and strength. explosive. Lees *et al.* (2004) found that ground instant velocity mainly depends on muscle power, as a decisive factor for jump height. However, even though this specificity of training is extremely important, it may not be enough to change jumping performance. Following this context, it is important to point out (Carvalho, 2008) that the performance of the vertical jump is a way of evaluating the strength and potency of the player, where the success of the player in his actions in the game can be determined by this skill. Many athletes use this motor action to perform headers and in the case of goalkeepers in their defensive tasks (Cronin *et al.*, 2004). The use and evaluation of vertical jumps to analyse the power of the lower limbs has been recurrent in futsal and soccer players, according to the dynamics it provides in the context of a game. Thus, the use of jumping platforms is referred to be one of the most used for this purpose, considering its approximation of the specificity of jumps during a game (Braz *et al.*, 2014; Silva and Marins, 2014).

Shooting ball speed

A player (Garel, 1976) who has good levels of strength capacity in his lower limbs will present greater stability and body balance, which in turn will result in superior shooting power and better shock resistance in terms of body contact against his opponents. The shot is a technical gesture of high motor complexity, seen as a finishing action that will be adjusted to the different variables of the game. It takes place in a certain place and time suited to these same variables, so it requires high levels of explosive strength (Soares and Tourinho, 2006). The shot in football will involve your main objective, that is, the goal. It will be according to the context of these situations that the shot will be defined in the different variants of its technical gesture (Garganta and Cunha e Silva, 2000). As part of the notion of shooting effectiveness, the variables of ball speed and placement are also present. The players (Cabri *et al.,* 1988) in addition to their superior technical quality, have higher strength values than other individuals who are not players, as well as in relation to their level of performance for the execution of the shot, praising the influence of specific training on this ability. Specific training of these technical skills also promotes more efficient use of the muscular system. Cabri *et al.* (1988) studied that were significant correlations between kicking performance and the stretch/shortening cycle of the quadriceps muscles. There were significant correlations between shooting performance and concentric strength of knee extensors and eccentric strength of flexors (De Proft *et al.*, 1988). An elite-level player (Bosco, 1991) is able to show high speed on the ball, given the leg's ability to give muscle elasticity, when the foot makes contact with the ball, with different muscle groups being requested, which depends and varies on the ability of each player, the decision-making capacity, personal technique and that in this way distinguishes the quality among the players. It is also mentioned that to achieve the highest speed of shooting, there must also be great speed of the foot by contacting the ball at the highest point of the movement, that is, at the fastest moment of this movement (Busko and Nowak, 2008).

Fatigue levels

As already mentioned, futsal is a team sport where, very fast and short runs are observed, constant offensive and defensive transitions, shots and displacements in different directions, usually associated with the movement of the ball (Kokubun and Daniel, 1992; Santos *et al.,* 2004). This type of sports is characterized as a continuous activity since there is an alternation of high-intensity efforts and recovery periods. Eleno *et al.* (2002) refer that high-intensity efforts occur less frequently, as they manifest in some game-determining actions. Thus, the type of training that is conducted in this sport, as well as in other team sports, requires a mixed supply of energy. Anaerobic power is present in the stimulus generated by the physiological requirements of the sport (Hernadez and Gomes, 2002) and anaerobic power is identified as the greatest effort performed during a given action for the smallest unit of time available. In addition to anthropometric characteristics and abilities such as flexibility, speed and agility, a high performance of the maximum power of the lower limbs, contributes positively and effectively to the accuracy of the main gestures of the sport throughout the game. Anaerobic power, defined as the maximum energy released per unit of time by the anaerobic system, becomes a fundamental characteristic of futsal, since it involves situations in the game of high energy expenditure and short durations of movement, classified with relative values less than 10.19 W/kg. All these actions performed during a highly intense game, require from the players, in addition to a high anaerobic power, a low value of fatigue indexes (FI). It was demonstrated by Zagatto *et al.* (2009) that the RAST has good validity and reproducibility in the assessment of anaerobic capacity in practitioners of intermittent activities, in addition to being a good predictor in short-distance activities. Another crucial factor is that it is a simple and accessible method, which can be easily incorporated into training routines. The RAST test is identified as extremely useful because it has been used to evaluate individuals who practice different sports, such as football, basketball and handball, as well as in other studies developed (Álvares *et al.*, 2017; Castagna *et al.* 2014; Júnior *et al*, 2014; Macedo *et al.,* 2020; Silva and Marins, 2014).

2. Material and methods

This is an observational, descriptive and cross-sectional study. With this study is intended to analyse, compare and evaluate the predictive factor of leg power on shooting speed and fatigue levels in young futsal athletes in order to establish effort patterns in these ages, to prescribe training sessions adequately in terms of external/internal load for different players levels.

Hypothesis 1: U17 athletes present greater leg power and, in turn, more speed in shots performed compared to U15 and U13 athletes.

Hypothesis 2: The leg power variable is a predictor of higher shooting speed and lower fatigue rates.

Participants

The number of participants evaluated were 32 male athletes, aged between 12 and 17 years old (Mean = 14.56±1.66), divided into the categories of Under-13 (10), Under-15 (10) and Under-17 (12). The Under-13 team trained 2 times a week, for 90 min at each training and the Under-15 and Under-17 teams trained 3 times a week for 90 min too, when these evaluations took place. They were conducted roughly in the middle of the season, for 3 weeks, and the respective variables were evaluated in each of these weeks (in the 1st week the fatigue levels were evaluated, in the 2nd week the power of the lower limbs, and in the 3rd week the shooting speed). The study was approved by the School Ethics Committee under the number 412/2022.

Procedures

Firstly, an authorisation request was made to the club for the use of the facilities and respective access to training and players and later the parents were contacted to request authorisation to observe their child and consequent informed consent. After these steps, each player was asked if they would like to participate in the study, the objectives of the study and the tasks they would have to perform. All players participated of their own free will, however, any one of them was free to refuse. Each of the evaluations took place in different weeks, to interfere as little as possible with the training dynamics. Before starting the evaluations, the athletes performed a warm-up between 15 and 20 min for general functional activation and were individually requested to perform the respective tests, namely:

Explosive strength test in ChronoJump

For the evaluation of the strength of the lower limbs, the ChronoJump platform was used according to the proposed and validated protocol (Blas *et al.*, 2012), where we were allowed to collect the values of the power of lower limbs through the vertical jumps of each athlete, in which we obtained the maximum strength produced in each jump by performing the countermovement jump (CMJ) method. According to the protocol, the participants performed 3 repetitions of the respective jump on the Chronojump Mat. The vertical jump was performed as follows: Starting from the standing position and with hands on the waist, the individual made a quick movement of knee flexion (up to an angle of 90 degrees) and, consecutively and without pause, performs a countermovement (knee extension) projecting the body vertically (vertical jump; explosive strength). Jump performance records were used to calculate the maximum power in the CMJ.

Shot speed

According to the rules of the sport, two penalty marks are defined on the field where ball shots are performed: one of those, 6 meters from the central point between the goalposts and equidistant from these and the other 10 meters from the central point between the goalposts and equidistant from these also. Not knowing any specific protocol for this type of procedure, the players made 6 consecutive shots, 3 for each of the distances with an interval of 1 min between each shot. We chose to record the best of the three shots for each distance for statistical analysis, thus adopting the same methodology in other studies (Marques, 2017; Marques *et al.*, 2013).

A Pro-Sport Smart Radar brand was placed above the goal line to measure the speed of the ball (km/h) when entering the goal and athletes were asked to shoot at the maximum speed possible. If the ball did not reach the target, that is, did not enter the goal, the shot was annulled and repeated. For this purpose, an official Mikasa FL555-P-W-WOR futsal ball (Mikasa Sports, Hiroshima, Japan) was used, with a circumference of 63 cm and a weight of 430 g.

RAST test

Within the group of tests that can be used to evaluate the anaerobic power of each athlete, the Running Anaerobic Sprint Test (RAST) was implemented. It has been used in several studies (Zagatto *et al.* 2009; Álvarez *et al.*, 2017) and presenting a crucial factor that it is a simple method and affordable, which can be easily incorporated into training routines. The RAST anaerobic running test was developed at the University of Wolverhampton (UK) to evaluate the anaerobic performance of athletes. The RAST is similar to the Wingate test (30 s cycle ergometer anaerobic test). The test provides coaches with measures of power and fatigue levels. Test results should be compared with the athlete's previous results to determine if the training program is having effectiveness. The results should also serve to adjust the training program. The RAST test can be used regularly (3 to 6 weeks) throughout the season. The period between tests will be determined by the training phase and the amount of training to be performed. The test consists of covering a certain distance in the shortest possible time, with an interval of 10 s between each repetition. Each of the running times was measured using the photocell device of the Chronojump system. The anaerobic parameters determined were: maximum power, mean power, minimum power and fatigue levels. The calculation for the fatigue level is determined as follows:

FI: (maximum – minimum power) / total time for the 6 running sets.

The RAST Test assessment consists of:

1. Choose a flat and demarcated place, beginning and end, of 35 m (conducted inside the pavilion with dimensions of 42×20 m).
2. Position the photocell equipment on the respective brands; weigh the athlete before the test.
3. Conduct a specific pre-warm-up for 10 min.
4. After the warm-up, there is a brief explanation of what is intended, and we position the athletes.
5. Perform six times 35 m at maximum speed (with 10 s of recovery between each run.
7. The time of each race is recorded in seconds and hundredths.
8. After the 6 runs, an active recovery takes place.

Statistical procedures

Statistical procedures were based on the calculation of the mean and standard deviation of the groups described. To identify the differences between groups, according to lower limbs strength, shot performance fatigue levels the Kruskal Wallis test was used. To identify paired differences, we applied the Mann Whitney test. To assess the predictive influence of leg power on shooting speed and fatigue, we performed simple a linear regression test.

3. Results

Table 1 shows the values related to shooting speed at distances of 6 and 10 m, as well as the values obtained in terms of power of the lower limbs in the player's age levels. In all the variables analysed, the values of shooting speed and lower limb power significantly increase as the player level increases. The under-17 level has the highest shooting speed, a factor that can be explained by the higher muscular power index.

Table 2 shows that the fatigue levels increases from the youngest to the oldest level, that is, the greater the age, the greater the fatigue level. Although the power values are higher in the older levels, this factor, in relation to the fatigue levels, could be explained by the fact that the older levels train longer periods and play longer games. Table 3 shows the correlation between these variables.

4. Discussion

In an evaluation conducted with soccer players (Silva *et al.* 2103), where the power of the lower limbs was analysed in the pre-season, during competition and at the end of the season, between levels, no significant differences were observed between the values in the CMJ, disagreeing with these significant results analysed between tiers. Regarding fatigue indexes, our study reported mean values in the respective levels (Under 13=3.08; Under 15=5.18; Under 17=7.62), that is, these values increase according to the age of the player echelon. Values referring to the fatigue index (Spigolon *et al.*, 2007) did not show significant differences between the Under 15 and Under 17 groups and are also

Table 1. Mean, standard deviation (SD) and statistical significance of the performance of futsal athletes in relation to shooting speeds in distances of 6 and 10 meters and lower limb power levels analysed on the Chronojump platform.

Player's level	Max. shooting speed on 6 m distance (km/h) Mean ± SD	Max. shooting speed on 10 m distance (km/h) Mean ± SD	Maximum leg power (Watt) Mean ± SD	Differences between athletes' level[1] Significance
Under 13	63.2±6.84	60.3±5.06	267.88±48.43	Under 13 – Under 15
Under 15	65.44±12.8	62.33±12.67	320.79±78.38	Under 13 – Under 17**
Under 17	81.92±9.57	77.92±10.71	490.70±165.23	Under 15 – Under 17**
Significance	0.001	0.001	0.001	0.001**

[1] Significant difference: ** $P \leq 0.01$.

Table 2. Mean, standard deviation (SD) and statistical significance of futsal athletes' performance in relation to lower limb power and fatigue indexes.

Player's level	Maximum leg power (Watt) Mean ± SD	Fatigue levels (Watt/s) Mean ± SD	Differences between athletes' level[1] Significance
Under 13	267.88±48.43	3.08±1.3	Under 13 – Under 15*
Under 15	320.79±78.38	5.18±1.26	Under 13 – Under 17**
Under 17	490.70±165.23	7.62±2.85	Under 15 – Under 17**
Significance	0.001	0.001	**0.001

[1] Significant difference: * $P \leq 0.05$; ** $P \leq 0.01$.

Table 3. Linear regression for the maximum leg power variable as a predictor of shooting speed and fatigue index.

Variables		Beta	Significance	R^2
Maximum leg power (Watt)	Max. shooting speed on 6 m distance (km/h)	0.491	0.004	0.22
	Max. shooting speed on 10 m distance (km/h)	0.490	0.004	0.22
	Fatigue levels (Watt/s)	0.961	0.001	0.92

similar to the values found in the study by Zagatto *et al.* (2009) where no significant differences were found either. In the study of Cruz (2014) fatigue indexes with values=9.8 were found in older practitioner's levels that had higher values of fatigue indexes. It is evident that with advancing age and practice levels, the anaerobic capacity is lower and must be increased in order to succeed in a professional context. Álvares *et al.* (2007) found that, according to their positions on the field, the IF values ranged between 4.8 and 8.4 for athletes with a mean age of 21.8 years; values that match the current study population according to the ages of the players (Under 13=3.08; Under 15=5.18; Under 17=7.62).

Macedo *et al.* (2020) analysed fatigue values in handball athletes aged between 18 and 34 years. The athletes had higher fatigue rates ranging from 5.59 (in the youngest) to 11.27 (in the oldest), which is in line with the previous mentioned literature and the data from our study. Regarding the other variable analysed, i.e. the shooting speed, it appears that this has a direct relationship with the power of the lower limbs: the greater the power produced, the greater the induced shooting speed in the body ball. Bona (2016) found slightly higher values, mainly in the under 17 age group, where speeds were higher than those acquired in this age group in our study. On the other hand, Isokawa and Lees (1988) found in players with ages identical to our study group mean ball speed values of 65 km/h, values that fit as good indicators in these age groups. Rodano and Tavana (1993) obtained ball speed values in under 17 level elite athletes that varied between 22.3 and 30 m/s (80 and 108 km/h). These values are much higher than this study, however the training times were also higher than that practiced by our athletes. Marques (2017) verified that after 6 weeks of training, the group that performed strength training combined with plyometric training resulted in a significant improvement in shooting ability with a respective increase in the speed of exit of the ball. Ramos-Campo *et al.* (2016) evaluated elite and amateur futsal athletes, and found that elite athletes with higher indices of leg speed and power reached higher shooting speed, although there were no significant differences between the two levels. Barbero-Alvarez *et al.* (2009), Ayala *et al.* (2015) and Le Gall *et al.* (2010) also showed that there was always a direct relationship between leg power and shooting speed and fatigue indexes.

5. Conclusions

The study aimed to analyse, compare and evaluate the predictive factor of leg power on shooting speed and fatigue in young futsal athletes. According to the analyses we verified that any of the variables increases its values whenever the age of the athletes increases. They present significant differences between ranks for these same variables and the power of the lower limbs has a direct relationship with the shooting speed since higher power values allow greater shooting speed. However, higher power values in the lower limbs also revealed higher levels of fatigue. In view of the above, and considering the results obtained, it seems that the practice of futsal requires that athletes have a similar development in the explosive strength of the lower limbs, so that the results of the athletes' performance can serve as a reference in future evaluations of elite futsal athletes, as well as developing training skills closer to the anaerobic threshold that result in a greater tolerance to high levels of fatigue.

Conflict of interest

The authors declare no conflict of interests.

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