RELATIONSHIP BETWEEN EXTENSOR TORQUE AND H:Q RATIO WITH TRIPLE HOP DISTANCE IN PROFESSIONAL SOCCER PLAYERS

ORIGINAL ARTICLE

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ABSTRACT

Objective: The aims of this study were: 1) to determine and compare the extensor torque, H:Q ratio and triple hop distance in functional test between lower extremities; 2) to identify the relationship between extensor torque and H:Q ratio with the performance in triple hop distance in professional soccer players. Materials and methods: Twenty-one healthy male professional soccer players, average 23.2 (± 3.6) years old, without history of injury were selected. The athletes were assessed in an isokinetic dynamometer at three angular velocities: 60, 180 and 300°/s, and from this assessment the peak of torque and calculated H:Q ratio at the three velocities were obtained. The triple hop distance was also used to calculate the hopped distance in meters. Results: No significant difference was found between the lower extremities (dominant and non-dominant) ($p = 0.23$). Also, a weak relationship between extensor torque and functional test at the three velocities was observed (Dominant: 60°/s_r = 0.38; 180°/s_r = 0.43*; 300°/s_r = 0.26. Non dominant: 60°/s_r = 0.36; 180°/s_r = 0.30; 300°/s_r = 0.48*) (*$p \leq 0.05$). Similar results were found for H:Q ratio (Dominant: 60_r = 0.01; 180_r = 0.11; 300_r = –0.02. Non-dominant: 60_r = –0.20; 180_r = –0.15; 300_r = –0.18). Conclusion: Due to a weak relationship, the isokinetic test cannot be replaced by the triple hop distance (functional test) for muscular function assessment.

Keywords: isokinetic dynamometer, athletes, hop test, correlation, functional test.

INTRODUCTION

Isokinetic dynamometry is considered one of the most specific methods for evaluation of muscular function[1,2]. The equipment provides many parameters which enable identifying muscular deficit otherwise identified with difficulty in the ordinary clinical evaluation[1,3]. Among these parameters we find the peak torque (PT), characterized by the maximal torque moment generated during a movement and specific velocity[4]. The hamstrings/quadriceps ratio (H:Q) can be calculated from the PT, a parameter which is used to evaluate the agonist/antagonist relationship of a joint[5-7]. These parameters allow identifying muscular imbalance, either between the dominant and non-dominant limb or between agonist and antagonist musculature[8-11].

It is of great importance for professional athletes to know and identify this imbalance, since many studies demonstrate that muscular imbalance is related to muscular injuries and decrease in performance[11-15]. However, the isokinetic dynamometer is a high cost equipment and therefore, unviable in the clinical practice of great part of the professionals of the sports field. In an attempt to fulfill this demand, many methods have been created and developed with the aim to provide information about muscular function[16]. Among these methods, we can mention the hop test, created by Daniel *et al.*, 1982, for evaluation of the strength, power and stability components of an injured segment. As time has passed, other functional tests based on the hop test were developed[17-19], among which, the triple hop distance (THD). The THD, as other functional tests, presents well-established advantages, such as low cost, easy application, good validation and reliability[16,20,21]. However, few studies have aimed to identify the relationship between isokinetic validation and functional tests in soccer athletes[21-24].

The identification of a good correlation between these evaluation methods for muscular function could aid in the evaluation in the clinical practice, making them faster and more efficient, as the isokinetic evaluations, but with no high cost and time consumption. Therefore, this study had the aim to: 1) determine and compare the knee extensor torque, the H:Q ratio and performance in the functional test between the dominant and non-dominant limb; 2) identify the relationship between extensor torque and the H:Q ratio with performance in the THD in professional filed soccer athletes.

MATERIALS AND METHODS

Sample

The sample was composed of 21 male individuals, mean age of 23.2 years (± 3.6), mean height of 1.80m (± 0.09), mean weight of 76.4kg (± 8.4) and mean time of practice in the modality of 10.2 years (± 5.1). The individuals were selected from a team from the second league of the São Paulo state championship. Inclusion criteria in the study were: absence of injury in the lower limbs (LL), absence of severe injury in the LL history (fractures, total ligament rupture) and time of practice longer than two years, so that the adaptations caused by the practice of the modality were present in these athletes. The athletes received information and clarification about the procedures for the evaluations, as well as the risks and benefits. After having received the clarifications, the individuals signed a free and clarified consent form. This research was approved by the Ethics in Human Research Committee of the Federal University of São Carlos (CEP/UFSCar) – legal opinion number 420/2009.

Isokinetic evaluation

Muscular capacity was evaluated with an isokinetic dynamometer 2 Multi-Joint System (Biodex Medical System, New York, NY, USA). The athletes arrived at the evaluation premises (School Health Unit (USE) – UFSCar) in a previously set day wearing suitable and standardized outfit (T-shirt, shorts, socks and sneakers given by the team itself). The isokinetic evaluation was performed by a professional with practice in these evaluations, using standard evaluation procedures such as positioning, verbal commands, explanation about the evaluation an interval time between velocities. Initially, warm-up in cycle ergometer of electromagnetic braking was performed (ERGO-FIT® brand, model 167 CYCLE) during 10 minutes, with intensity of 60 watts and rotation between 60 and 70rpm. Subsequently, the evaluator drew the member who would start the test (dominant or non-dominant), considering the limb used to kick the ball as dominant. After the draw, the individual was positioned in the equipment using two diagonal straps on the thorax, one around the waist and another around the thigh of the limb under evaluation, to avoid compensation movements during the test. The lateral epicondyle of the femur was aligned with the center of the axis of the equipment, keeping knee 90° angulation, besides hip 90° flexion kept by the support position for trunk at 90°. The lever arm was positioned parallelly to the leg of the individual and placed at mean height of 5cm above the lateral malleolus. Range of motion was set at 80°, initiating the movement in 90° of flexion for extension of 10°; full extension was not used to avoid discomfort during the test by muscular shortening. After concluding the positioning of the individual, the evaluator explained again all the steps of the evaluation, especially instructing the individuals to perform the movements (knee flexor-extension) using maximum strength and as fast as possible, besides other instructions, such as: used verbal command, the interval times, the quantity of repetitions and the previous repetitions for familiarization. The pre-test repetitions were used so that the individual could be familiarized with each velocity of the test, identifying even possible discomfort which would be observed only during the test. This adaptation was composed of three knee flexion-extension submaximal repetitions and another repetition using maximal capacity, being the latter used as performance example of the individual for the test. Subsequently, two-minute-interval was respected and the test was initiated in that velocity previously familiarized. The same procedure was performed in each velocity in the two limbs. The test started with the verbal command "on your marks, get set and go" and only after the "go" they should start making effort. The individuals also received verbal stimulation "keep it strong" and "stronger" during the test, to stimulate maximal dedication during the procedure; however, the individuals received visual feedback of the equipment in any moment of the evaluation. The isokinetic evaluation was performed for the concentric movements of knee flexion and extension and three angular velocities were used, namely: 60, 180 and 300°/s, being five, 10 and 10 repetitions in each velocity, respectively. The first velocity (60°/s) was chosen for being close to the maximal strength of the athlete; the third (300°/s), for being close to the sports gesture velocity; and the second (180°/s), for evaluating the muscular torque behavior in an intermediate velocity. The variables of extensor and flexor peak torque (Nm) of each velocity in the dominant and non-dominant limb were acquired from this evaluation, and the H:Q ratio was then calculated. The gravitational factor of the dynamometer was calculated by the equipment and automatically compensated in the results calculation.

Triple hop distance (THD)

The hops evaluation occurred on different days of the isokinetic evaluation (24 hours after) when the athletes once again arrived at the evaluation premises wearing standard garments as in the isokinetic evaluation. Previously to the test, the athletes performed warm-up on a cycle ergometer (ERGO-FIT® model 167 CYCLE) using the same parameters adopted in the isokinetic evaluation. The athletes performed three submaximal THD units with a two-minute interval between them for specific warm-up and test familiarization. The athletes were told to hop the longest distance possible through three hops and were encouraged to use the upper limbs (UL) to help in the movement similarly to the one used in the modality. In a trial to become even closer to the modality, the individuals performed the hops on smooth and with no irregularities turf ground to avoid any adversity; however, they started from the cement floor not to harm the hops measurement. The players were positioned with foot posterior extremity on a tape placed on the ground which was used as reference for the measurements, and, from that tape, the hopped distance was calculated with a tape measure (anthropometric, steel, 2m, Sanny). Before the test started, a draw was performed to determine which limb would be initially evaluated; after this draw, the participants performed three THD units using the same limb, with two-minute intervals between them and only after that the evaluation of the other limb was performed. The mean of the hopped distance (in meters), of three hops considered valid was obtained for the analyses. In order to consider the test valid, the athlete should: correctly position himself, the three hops should occur in a continuous manner, the contralateral limb could not touch the ground and, at the end of the third hop, the athlete should remain on the same lower limb evaluated for marking performance. In case these criteria were not respected, the hop should be repeated; moreover, if the athlete performed three invalid tests, he was excluded from the study. After performance of the first HOLTH, the distance was marked and measured and the tape on the ground was removed to avoid any visual stimulus to the athlete.

Statistical analysis

After the normality test application, the Pearson correlation test was used to identify the correlation between the horizontal one--legged triple hop and the isokinetic evaluation. The variables peak torque, H:Q ratio and hopped distance were used for the analyses, through the *Estatistica* 7 program for *Microsoft Windows*.

RESULTS

The hops distance, extensor PT and H:Q ratio values found are presented in table 1. There was no significant difference between the dominant and non-dominant limbs of the sample for the evaluated parameters.

The Pearson correlation test showed weak correlation between performance in the triple hop distance and extensor PT and H:Q ratio; moreover, there was no significant correlation between variables, as evidenced in table 2.

Table 1. Values of mean of hopped distance, extensor PT, H:Q ratio and p value of the variables when the dominant and non-dominant limbs are compared.

			Dominant	Non-dominant	p
Hopped distance (m)			**6.65**	**6.74**	**0.23**
Extensor PT	**Anglular velocity (°/s)**	60	264.9 (± 43.3)	272.6 (± 42.1)	0.15
		180	181.2 (± 25.3)	180.4 (± 24.4)	0.80
		300	146.4 (± 25.5)	151.3 (± 21.8)	0.20
HI:Q ratio		60	0.55 (± 0.05)	0.54 (± 0.04)	0.40
		180	0.65 (± 0.08)	0.63 (± 0.06)	0.46
			0.67 (± 0.12)	0.66 (± 0.12)	0.68

PT: peak torque; H:Q: hamstrings/quadriceps; p: significance level ($p \leq 0.05$).

Table 2. Correlation values between triple hop distance and extensor PT and H:Q ratio in the 60, 180 and 300°/s velocities.

	Dominant – r (p)	Non-dominant – r (p)
Ext_60°/s	0.38 (0.08)	0.36 (0.11)
Ext_180°/s	0.43 (0.05)*	0.30 (0.19)
Ext_300°/s	0.26 (0.26)	0.48 (0.02)*
H:Q_60°/s	0.01 (0.97)	–0.20 (0.38)
H:Q_180°/s	0.11 (0.63)	–0.15 (0.52)
H:Q_300°/s	–0.02 (0.92)	–0.18 (0.42)

Ext: extensors; Flx: flexors; H:Q: hamstrings and quadriceps ratio.*Significant value ($p \leq 0.05$).

DISCUSSION

It is currently well-known that the isokinetic evaluation presents high quality for determination of muscular capacity [2,25]; on the other hand, the difficult access to this equipment has intensified the search for other evaluation methods of the same variables. Therefore some functional tests have been designed and developed, presenting advantages such as low cost, good reliability, practicality and easy application. Had a good association between these evaluation methods been identified, it would be an enormous contribution to the clinical practice, avoiding longer time consumption and high cost needed to the isokinetic evaluation[26,27]. However, the correlation between these functional tests and the isokinetic evaluation is not well-established yet.

According to Lehance *et al.*[22], two elements are crucial in the care of the soccer athlete's musculature: absence of asymmetry between dominant and non-dominant limbs, besides a good relation between knee flexors and extensors. This importance is justified due to the role these muscular groups play in the practice of this modality. An example is the knee extensors, which play an important role during kicks and jumps, activities which many times are trained and developed in only one limb[28]. Therefore, Zakas[10] analyzed the extensor PT and the H:Q ratio in professional soccer players with dominance of the right, left or both lower extremities, but did not find difference in any of the velocities evaluated (12, 60, 180 and 300°/s). These velocities were similar to the ones used in the present study, (60, 180 and 300°/s) where differences between extremities has not been identified either. These results demonstrate that, despite the massive soccer activities and training being unilateral, these adaptations do not seem to be identified in the isokinetic evaluation, even when different velocities are used. The same results were observed in the functional test, since when the dominant and non-dominant extremities were compared, there was not difference in performance between limbs. This test was chosen due to its applicability in the clinical practice, good validation and reliability for strength and muscular power assessment in soccer athletes[21]. Despite the good validation of this functional test, studies which compared performance in the THD between limbs have not been found.

The extensor PT did not demonstrate difference between limbs. Additionally, as in the work by Zakas[10], comparing the extensor PT and the H:Q ratio in professional soccer players of the first league with right, left and bilateral dominance, using the 12, 60, 180 and 300°/s velocities, the results did not demonstrate difference among the individuals in any velocity. Despite the difference in the league of the players, it seems to be a factor of little importance in production of torque, regardless of the dominant limb of the soccer players. Similar results have also been found by Lehance *et al.*[22], who assessed 19 professional players of the first Belgium league, using the 60 and 240°/s velocities, through the extensor and flexor PT variables, besides the H:Q ratio; however, they did not find difference between limbs in any of the analyses. These results demonstrate that Hamilton *et al.*[21] used 40 soccer players (20 men and 20 women) from the first national league, to determine the correlation between THD with isokinetic evaluation (60 and 180°/s velocities, concentric model for knee flexors and extensor); the results demonstrate good correlation between THD and extensor torque at 60°/s ($r = 0.49$, $p \leq 0.01$) and 180°/s ($r = 0.59$, $p \leq 0.01$). However, the present study demonstrated good correlation only in the dominant limb at 180°/s ($r = 0.43$, $p \leq 0.05$) and non-dominant at300°/s ($r = 0.48$, $p \leq 0.05$), results which can be explained by the independent analysis of the limbs performed in the present study. Another important factor is sex, since in the mentioned study; the sample is composed of men and women. An example of this is the study by Östenberg *et al.*[12], who assessed the THD correlation with the extensor peak torque in healthy women soccer players and found good correlation at 60°/s ($r = 0.43$) and 180°/s ($r = 0.52$), obtaining results similar to the study by Hamilton *et al.*[21].

The weak correlation between the THD and extensor PT can also be explained by the isokinetic evaluation factor performance only in the concentric movement and in open kinetic chain (OKC), while the THD is initiated with an eccentric contraction of quadriceps, followed by its concentric contraction, besides being a movement in closed kinetic chain (CKC), a factor which has also been pointed in other studies[12,29]. Another important factor are the compensation movements, allowed in the functional test and minimized in the isokinetic test, which contributed to adaptations in the neuromuscular control system and directly influences on the performance of a functional task of the athlete. The present study used the THD, allowing the athletes use the UL to help during the hops. Greenberger and Paterno[29] gave instruction to the subjects to keep the UL steady behind the trunk, and when analyzing the correlation between the single hop distance and the extensor torque at the 240°/s velocity, found moderate correlation for the dominant limb ($r = 0.78$, $p \leq 0.05$) and non-dominant ($r = 0.65$, $p \leq 0.05$).

Finally, the H:Q ratio seemed to be an important factor for the correlation with the THD, since it is clear in the literature that good

balance between agonist and antagonist contributes not only to prevention of injuries, but also to better performance of the segment[30]. Nevertheless, the results demonstrated weak correlation between these variables (H:Q ratio and isokinetic evaluation), which may be explained by the evaluation methods used, since while the THD requires variation of eccentric and concentric contractions of the knee flexor and extensor musculatures, the isokinetic evaluation evaluates only the concentric activity of these musculatures, besides evaluating them separately.

The main limitation of this study was the absence of eccentric evaluation of knee flexors and extensors; moreover, the analysis of other variables of the isokinetic, the use of different sexes and the correlation with other functional tests seem to be good guidelines for future investigations. Thus, it is not possible to substitute the isokinetic evaluation by the use of THD; however, it is a fact that the two methods help in the strength and muscular power evaluation of soccer athletes, besides contributing to the sports professionals understanding and enable specific activity in these athletes for prevention of injuries.

All authors have declared there is not any potential conflict of interests concerning this article.

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