

Isokinetic Evaluation of Knee Extensor and Flexor Muscles in Professional Soccer Players



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ABSTRACT

Introduction and objective: Studies that relate parameters of muscular performance in different sports, and especially in soccer, have been frequently reported in the literature. However, the methodological variations among studies, the type of dynamometer used in each search and placement of each subject during the evaluations results in the divergence of the data collected. Therefore, the objective of this study was to perform a data collection to provide figures on the muscular profile and establish normative parameters for the professional soccer players' muscular performance, supporting scientific research and future studies. **Methods:** The sample consisted of 39 athletes from a professional soccer club in Porto Alegre. In order to evaluate muscular performance, an isokinetic dynamometer was used and the tests consisted of maximal concentric contractions, being knee flexors and extensors muscles tested at 60°/s and 240°/s velocities. Analysis of means by t test (independent samples) was used to investigate significant differences between legs considering the parameters evaluated in this study. For all statistical procedures the confidence interval was 95% ($p < 0.05$). **Results:** The results of this study characterized the muscular profile of professional soccer players on the capacity of torque, work and maximum power, normalized by body weight. Moreover, significant differences were observed between legs considering some of the study's variables. **Conclusion:** The normative data set can be used as reference values for prevention, training and rehabilitation of athletes, and serve as reference for future studies with the aim to relate parameters of muscular performance and incidence of injuries in soccer.

Keywords: isokinetic dynamometer, muscle injury, muscle balance, knee, soccer.

INTRODUCTION

Soccer is the most practiced sport in the world and its popularity increases year after year making the number of practitioners increase as well. In 2001, the number of players affiliated with FIFA (International Federation of Football Association) would surpass 240 million, with 200,000 of these players being professional^(1,2). This sport is characterized by high intensity movements, with accelerations, disaccelerations, change of direction, jumps, spins, kicks and sudden starts and stops. Thus, the high number of practitioners and the high physical demand make soccer a great source of lesion incidence^(3,4), presenting many elements not possible to be controlled, such as surface (field) and physical contact between players.

The muscular lesions are responsible for a third of the soccer maladies^(1,5), and can be classified as direct or indirect depending on the trauma mechanism. The direct lesions are lacerations and sprains, while the indirect ones are the muscle strains⁽⁶⁾. It is estimated that the incidence of lesions is of approximately of 10-15 lesions at every 1,000 played/trained hours, and between 68% and 88% of these lesions occur in the lower limbs^(3,7). Previous studies show that the lesions are responsible for the loss of physical capacity of the athletes as well as for their time out from games/training, besides the high costs with medication⁽⁸⁾.

The evaluation of muscular strength allows determining the

profile of the muscular condition of an athlete, specifically identifying muscular imbalances, reflecting an important parameter in suitable performance of sports practice⁽⁹⁾. Thus, the isokinetic evaluation has been widely used in the last decades as a method to evaluate muscular strength and balance, since the isokinetic dynamometer provides reliable and reproducible data⁽⁶⁾. Alterations in the muscular torque, work and power parameters are closely related to sports lesions and consequently, to decrease in functional performance of the athlete. The main risk factors for the onset of lesions in soccer are asymmetry in comparison of one limb with its contraateral. Muscular evaluation by the isokinetic dynamometry allows describing normative data useful in the prevention, training and rehabilitation of athletes⁽⁷⁾.

Isokinetic data evidence the probability of an athlete to develop a muscular lesion by strains, allowing the designing of specific training and physiotherapeutic procedures concerning prevention. Therefore, the bilateral and unilateral comparisons are extremely important to the determination of the risk of lesion by muscle strain. In the bilateral relations, differences above 15% are already considered predisposition to muscle lesion. Regarding unilateral relations, the hamstrings should have about 60% of the quadriceps strength (H:Q ratio) in low velocities (60°/s-180°/s), increasing to 80% to 100% in higher velocities (300°/s-450°/s)^(6,10,11).

The isokinetic evaluation becomes increasingly necessary in the high performance sports scenario, since it allows identifying

and quantifying muscular performance and balance of athletes. Such evaluation makes it possible to plan specific and functional training of the lower limbs, besides elucidating specific deficiencies of the muscular function so that they can be eliminated or minimized, allowing the designing of prevention programs to decrease incidence of muscle lesions.

The present study has as aim to evaluate the muscular peak torque, work, power and balance (conventional ratio) of extensor muscles (quadriceps) and flexor muscles (hamstrings) of the knee joint in professional athletes from a Brazilian soccer club. An isokinetic test was performed for this purpose, aiming to perform data collection which provides values on the muscular profile and establishes normative parameters concerning muscular performance of professional soccer players, supporting the scientific research and future investigations.

METHODS

Sample

The sample was composed of 39 professional soccer players from an elite soccer club of Rio Grande do Sul state capital, regardless of nationality or race, aged between 23.8 ± 4.5 years, stature of 1.82 ± 0.07 m and weight of 78.1 ± 7.8 kg. The athletes included in the study should be participating in the training during the 2009 season at the moment of the evaluation, regardless of their position on the field (goalkeeper, defender, forward and so forth) and of their participation in the games or not. All players submitted to the evaluation were able to fully perform the test. Athletes with acute inflammatory process due to any kind of lesion and/or immediate post-surgery period were excluded from the research.

The participants received information on the aims of the research and the procedures they would be submitted to and subsequently signed the Free and Clarified Consent Form. This study was approved by the Ethics in research Committee of the University which originated the study, following the ethical procedures of decree 196/96 from the National Health Board of the Brazilian Ministry of Health.

Research Instrument

In order to evaluate muscular performance and balance in the knee joint, an isokinetic dynamometer Biodex System 4® (Biodex Medical Systems, Shirley, NY, USA) which belonged to the Grêmio Foot-Ball Porto Alegrense club (Porto Alegre, RS) was used.

Data Collection

Prior to the evaluation, the participants performed warm-up exercise on ergometric bicycle with 10 minutes of duration, using low resistance and pedaling cadence of approximately 85-90rpm; and stretching of the musculature to be tested (quadriceps and hamstrings), in a single set of 30 seconds for each muscle group, bilaterally performed.

The athletes were sat on the dynamometer chair according to the manufacturer's recommendations and were suitably stabilized with belts around their thorax, hip and thigh of the limb to be tested to avoid compensations.

The knee joint range of motion was 100° of flexion from knee

total active extension. The rotation axis of the dynamometer was aligned with the rotation axis of the tested knee joint (lateral femoral condyle), to avoid that the torque measurements were invalidated. The equipment used in this study allows that the limb is weighed and decomposed for more reliable data production, compensating the gravity action. The athletes were assessed by the same evaluator, who encouraged the athlete during the entire test with verbal commands to perform his maximal strength.

At the moment of the isokinetic evaluation and as complement to the warm-up, the subjects performed a familiarization session on the dynamometer at the same velocities used in the test in order to reduce the learning effects and guarantee the reproducibility of the collected data.

The angle velocities used in the test were of $60^\circ/s$ (one set of four repetitions for each lower limb) and $240^\circ/s$ (one set of six repetitions for each lower limb), with rest interval of one minute between sets. In both velocities the following parameters were evaluated: peak torque, work and power (normalized by the body weight of each athlete), bilateral comparisons and conventional ratio (hamstrings/quadriceps). In addition to the weight normalization procedure, the parameters assessed in the study were calculated by the software of the isokinetic dynamometer itself.

Statistical Analysis

Descriptive analysis was used, characterizing the mean and standard deviation among the athletes in the parameters: peak torque, total work, mean power and conventional ratio. Means were analysed through the t test (independent samples) to investigate bilateral differences in the evaluated parameters. In all the statistical procedures, the confidence interval was of 95% ($p < 0.05$). The Excel program, version 2003 was used in all analyses.

RESULTS

The values of peak torque (PT), work (W) and maximal power (MP) of the flexor and extensor muscles of the knee joint were normalized by the body weight of the athletes and are described in table 1.

Table 1. Mean and standard deviation of the peak torque (PT), work (W) and maximal Power (MP) in relation to body weight, expressed in %.

	60°/s					
	Extension			Flexion		
	Right	Left	p	Right	Left	p
PT	336.6 ± 33.1	343.4 ± 38.7	0.40	193.6 ± 25.3	197.3 ± 18.6	0.46
W	371.2 ± 35.9	391.3 ± 38.8	0.02*	250.6 ± 31.7	256.9 ± 34.7	0.41
MP	171.9 ± 25.8	170.4 ± 23.5	0.79	105.0 ± 23.4	103.8 ± 14.1	0.79
	240°/s					
	Extension			Flexion		
	Right	Left	p	Right	Left	p
PT	201.6 ± 23.1	210.4 ± 34.1	0.10	138.3 ± 16.4	140.8 ± 14.5	0.48
W	227.0 ± 24.6	239.3 ± 24.8	0.03*	163.8 ± 23.0	163.0 ± 21.6	0.86
MP	319.3 ± 48.8	327.3 ± 45.7	0.46	209.4 ± 36.2	201.5 ± 36.4	0.34

* t test for paired samples.

The mean of the conventional ratios (hamstrings/quadriceps – H:Q), in the angle velocities of 60°/s and 240°/s, is described in table 2.

Table 2. Mean and standard deviation of the conventional ratio (H:Q), expressed in %.

	60°/s			240°/s		
	Right	Left	p	Right	Left	p
H:Q	57.8 ± 8.4	57.7 ± 7.4	0.95	69.5 ± 8.9	67.1 ± 8.9	0.23

* t test for paired samples.

DISCUSSION

The muscular performance of the athletes assessed by the isokinetic test is represented by means and standard deviation of the following parameters: peak torque, work, mean power and bilateral comparisons in these variables and also the agonist/antagonist ratio (H:Q).

Peak Torque (%)

According to the practical application of the isokinetic evaluation and ratification by the literature^(9,12-15), the peak torque presents an inverse relation to the angle velocity applied in the test. More specifically speaking, the lower the dynamometer velocity, the higher the peak torque will be.

In the present investigation, the results of peak torque (normalized by the body weight of each individual and expressed in %) were, in mean, of 340 ± 35.9 for extension and 195.5 ± 22.1 for flexion, evaluated in the 60°/s velocity. At 240°/s, the means were of 206 ± 23.9 for extension and 139.5 ± 15.4 for flexion. In both velocities, significant differences between the lower right and left limbs have not been observed for the quadriceps or hamstrings.

The present research when compared with studies which evaluated athletes of different modalities, presents divergence concerning the torque values, sometimes being higher when compared to long-distance runners⁽¹⁶⁾, other times being lower when compared to jiu-jitsu fighters⁽¹⁷⁾. These differences in muscular performance probably reflect the physical demand imposed by the modality and the specificity of each sport. Additionally, Rosene et al.⁽¹⁸⁾ reported to have not found significant differences in the isokinetic evaluation between athletes of different sports. However, these differences become evident when athletes are compared with a population of non-athletes.

Moreover, it is worth highlighting that the differences observed concerning peak torque are mentioned in the literature by methodological variations between studies, type of dynamometer used in each research and subjects' positioning during the evaluations⁽¹⁹⁾.

Work (%)

While peak torque shows the highest strength production in a specific point of the range of motion (ROM), work represents the torque generated during the entire ROM, being inversely proportional to the angle velocity^(5,6,15,16). The ROM used for the evaluations of this research was of 100° of flexion from the total active extension, not allowing that the athletes performed hyperextension (ROM already mentioned in the methodology).

In the present study, the work performed at 60°/s was in mean of 381.2 ± 38.5 for the extensors and of 253.8 ± 33.1 for the flexors (normalized by the body weight of each individual and expressed in %). In the 240°/s velocity, the values are reduced, 233.2 ± 25.3 and 163.4 ± 22.2, for extension and flexion, respectively. In the bilateral comparisons, in both tested velocities there was significant difference between the left and right quadriceps (p = 0.02 at 60°/s and p = 0.03 at 240°/s). Regarding the flexor muscles, there was not significant difference. These results for the muscular work are close to the values found by Goulart et al.⁽²⁰⁾, who in their study found around 258,5% for work of flexors and 374.2% for the extensors, at the angle velocity of 60/s.

Confronting these results, Fonseca et al.⁽⁷⁾ found mean muscular work values of 520% for the quadriceps and 288% for the hamstrings, at 60°/s. These superestimated values may reflect differences in the methodology, in the research scenario as well as in the dynamometer used or the study. It is necessary to stress that differences in range of motion alter the muscular work data, being it the torque representation in the entire ROM. Nevertheless, at higher velocities, the results found by Fonseca et al.⁽⁷⁾ are within the expectation, with approximate work value of 367.2% for extension and 214.8% for flexion, at 180°/s. In the 300°/s velocity, the authors present in mean 255.8% and 153.7%, for quadriceps and hamstrings, respectively.

Maximal Power (%)

Power considers torque, distance to be completed (ROM) and time. Thus, Power represents the ratio between total work and the needed time to perform it^(5,6,12,15,16).

Regarding the evaluated group, maximal power was of 323.3 ± 47.2 for quadriceps and of 205.4 ± 36.3 for hamstrings, at 240°/s (normalized by the body weight of each individual and expressed in %). Power was reduced at 60°/s, since power is overestimated in the extremes of the velocity spectrum, demonstrating hence a parabolic ratio and having its highest point at approximately 240°/s. At the angle velocity of 60°/s, power was 171.2 ± 24.5 for extension and 104.4 ± 19.2 for flexion. When a limb is compared with its contralateral, neither extensors nor flexors presented significant differences. The results found in this study are different from the ones found by Goulart et al.⁽²⁰⁾, Who tested and assessed 78 soccer players with the use of the Cybex® dynamometer, model Norm 6000, considering the position of each player. Nevertheless, the data concerning muscular power were obtained only in the 300°/s velocity, being 329.7% for flexion and 457.9% for extension. However, Fonseca et al.⁽⁷⁾ assessed power only at 60°/s. Thus, the authors found for the flexors power of 130.5% and for extensors, 235.2%. Maximal power despite representing functional values of muscular condition, does not present reference values^(5,6,12,15,16). This variable is hence specific for each population, and especially for each sports modality.

Conventional Ratio (H:Q)

Widely discussed in the literature^(10,13,14,16,18,19,21-24), the conventional ratio represents the proportionality between the quadriceps and the hamstrings, being applied for each joint. This ratio

is useful in athletes with a lesion episode, since it will show the muscular imbalance derived from such lesion. In lower velocities (60-180°/s), the agonist/antagonist ratio should appear as around 60%. Values below 50% indicate severe level of muscular imbalance^(13,14). At higher velocities (240-300°/s), this ratio increases and should be around 70 to 80%.

In the present study, at 60°/s a mean of the conventional ratio of $57.8 \pm 7.9\%$ was established. At the 240°/s velocity, the mean was of $68.3 \pm 8.9\%$. There was not significant difference between the right and left lower limbs in any of the tested velocities. These values for the conventional ratios are in agreement with the results obtained by Carvalho and Cabri⁽²⁵⁾. In their study, the authors found ratio of around 58% in the 60°/s velocity, increasing to approximately 66% at 180°/s. In their findings, Magalhães et al.⁽²³⁾ presented a ratio of 56.7% to the 90°/s velocity and 81.3% at 360°/s.

Previous history of muscular lesion may affect the balance between knee extensors and flexors. In previous studies^(13,14,22,24), muscular lesions altered the agonist/antagonist ratio and make the players prone to new lesions. Thus, the conventional ratio may serve as parameter to a specific and objective intervention from the physiotherapeutic point of view.

CONCLUSION

The results obtained in this study provide reference values of the isokinetic muscular performance related to the capacity in generating torque, work and maximal power of professional soccer athletes. In addition to the muscular profile characterization, the present study established a comparison between lower limbs in the evaluated parameters, besides the conventional ratio. Asymmetry between the flexor and extensor muscles of the knee joint has been observed in this comparison. Thus, normative data make it possible to compare the results of the test of an athlete with the reference values of his group and establish a level of muscular performance to be reached with training or rehabilitation. Moreover, these data can ground new studies which aim to correlate the muscular profile parameters with incidence of lesions in soccer. These studies would make the development of specific therapeutic interventions possible with the aim to prevent and/or treat lesions and their recurrence.

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

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