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Hamstring/Quadriceps Strength Ratios in Professional Football Players

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Abstract

It is widely known in the medical field of football, that knee injury is one of the most important problems professional schools of soccer. One of the most widely used neuromuscular assessments to determine knee joint injury risk has been the Hamstring/Quadriceps (H/Q) force ratio. Although Maximum Voluntary Contraction (MVC) has often been used to evaluate the H/Q ratio, the ability to rapidly develop force (Rate of Force Development-RFD) is more relevant in relation to fast dynamic movements. The objective of this study was to evaluate the RFD in the hamstrings and quadriceps to determine the (H/Q) ratio and compare it with the H/Q ratio of the MVC, a test traditionally used in soccer. Thirty professional soccer players participated in the study (15 women: Age 20.9 ± 1.9 years; body weight 69 ± 1.9 kg; height 169 ± 27 cm), (15 men Age 25.8 ± 2 years; body weight 73 ± 3.1 kg; size 172 ± 3.9 cm), belonging to the Fortaleza CEIF professional team from the city of Bogotá Colombia. The maximum isometric force was evaluated in knee flexion at 70° and in the same way it was performed in knee extension at 70° for 5s, to determine the MVC and RFD of the hamstrings and quadriceps at the evaluated angle. The reliability of the test for RFD I/C was high (intraclass correlation coefficient = (0.664-0.933). The initial contraction phases up to 50 ms from the start of contraction showed a low RFD I/C ratio compared to the MVC ratio. I/C (p=0.001). These results demonstrate a potential risk for stabilization of the knee joint during the initial phase of muscle contraction.

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Introduction

There is high scientific evidence on the high incidence of knee injuries in sports activities such as soccer, handball, basketball and other ball games [1]. It is for this reason that there is a need to evaluate potential indicators of neuromuscular and mechanical risk, to prevent or reduce the appearance of serious knee injuries in athletes who participate in high-risk sports such as ball sports.

The force of contraction of the quadriceps muscle during knee extension produces a shearing force directing anteriorly to the tibia relative to the femur at extended joint angles [2]. This shear can be counteracted not only by the Action of the Cruciate Ligament (ACL), but also by coactivation of the hamstrings, which act as synergists [3]. Therefore, decreased muscle strength of the hamstrings relative to the quadriceps at the same joint angle has been proposed to increase the risk of non-contact knee joint injuries [4].

A force ratio of H/Q, based on maximum force values during a voluntary static or dynamic contraction, has traditionally been used to describe the stabilization potential of the knee joint [5].

Although an MCV is reached in approximately 500 ms from the start of the contraction [6], the first 50 ms may be more important to stabilize the knee joint during situations of rapid contact with the ground, since the time Estimated ACL injury ranges from 17 ms to 50 ms after initial ground contact [7]. Therefore, the MVC of H/Q ratio may not reflect the potential for dynamic stabilization of the knee joint during match situations. For this reason, identifying the ability to rapidly activate the hamstrings relative to the quadriceps is important.

The ability to rapidly activate the muscle can be assessed in a standardized manner with the RFD during a maximum voluntary static contraction [6]. In this study, we present the ratio of RFD H/Q to demonstrate the rapid activation capacity of the antagonist *vs.* agonist muscles in the knee joint during explosive actions, since it is not possible to investigate the ratio of RFD H/Q during closed

kinetic chain movements such as the side cut and landing. The RFD H/Q ratio provides the best standardized estimate of the dynamic knee stabilization potential. Furthermore, it has been shown that isometric RFD has a high correlation with the dynamic functional performance of the knee [8].

One of the most serious knee injuries in sport is an ACL tear. The relative incidence of this non-contact injury has been reported to be higher in female compared to male athletes [9]. Therefore, the possible gender difference in the capacity for dynamic stabilization of the knee joint is an aspect to be considered in this study. In fact, in athletes it has been found that they depend more on their quadriceps muscles in situations of anterior translation of the tibia, while male athletes depend more on the hamstring muscles for stabilization of the knee [10].

The objective of this study was to determine the RFD H/Q and compare it with the relation of the MVC H/Q in men and women professional soccer players belonging to the Club Fortaleza CEIF of the city of Bogotá Colombia.

Methodology

Thirty professional soccer players participated in the study (15 women: Age 20.9 ± 1.9 years; body weight 69 ± 1.9 kg; height 169 ± 27 cm), (15 men Age 25.8 ± 2 years; body weight 73 ± 3.1 kg; size 172 ± 3.9 cm), belonging to the Fortaleza CEIF professional team from the city of Bogotá, Colombia. The inclusion criteria for the sample were: having competed in the last professional tournament and not having any type of joint and muscle injury involving the lower limb by the date of application of the evaluation. This study tested the hypothesis that when examining the initial phase of muscle contraction, the ability to produce force per unit time of the hamstrings relative to the quadriceps is reduced. Therefore, it is assumed that the RFD H/Q ratio is lower in the initial phase of muscle contraction compared to the MVC H/Q ratio. Furthermore, this study tested the hypothesis that female compared to male soccer players have a lower RFD H/Q ratio. The ability to rapidly activate the hamstrings relative to the quadriceps during explosive movements was determined in a standardized manner whit the RFD during the maximum voluntary static contraction in 5s.

Instruments and Procedure

The isometric MVC assessment was performed for both hamstrings and quadriceps, using a 500 kg WinLaborat type S load cell; the sampling signal was 1000 Hz and was stored in its software on an HP Laptop.

For evaluation, it was locked in the knee joint at an angle of 70°, both for extension and flexion. The subjects were evaluated sitting on a rigid chair with 90° hip flexion and crossed arms. The hip and lower limbs were fixed by straps attached to the chair and the lever arm of the dynamometer, respectively. The axis of rotation of the dynamometer was aligned with the lateral femoral epicondyle and the lower leg was attached to the lever of the dynamometer above the medial malleolus. The evaluations were preceded by a 15 min warm-up on a stationary bike, followed by a series of submaximal contraction tests on the evaluation chair.

To ensure an accurate assessment of isometric force, subjects were given visual feedback on a computer screen; subjects were instructed to perform all contractions as fast and hard as possible to obtain both MVC and RFD. Initial trials were excluded and an additional test was performed for each type of contraction, i.e. isometric knee flexion and extension. Three maximal trials were performed, separated by a 45s rest period. The MVC was defined as the highest peak force value of the 3 maximum attempts; the RFD was defined as the slope of the force-time curve in increments of periods from 0 to 10, 0 to 20, 0 to 30.0 up to 250 ms of the start of contraction. The onset was defined as the moment where the force exceeded the baseline of 2 kg/N. The contractile RFD for any of the time periods examined was determined as the highest value obtained in any of the 3 trials.

Determination of hamstring/quadriceps strength ratio was based on RFD and MVC. The force ratio was calculated by dividing the RFD of the hamstrings with RFD of the quadriceps in the time periods examined, that is, 0 to 10, 0 to 20, 0 to 30 and 0 to 250 ms, the unit of measurement for MVC was N · M · kg and for RFD it was N · ms · kg.

To calculate the MVC H/Q ratio, the division between the hamstring MVC and quadriceps MVC values was performed. In the same way, for the calculation of the RFD H/Q ratio, the division between the values of RFD of the hamstrings and RFD of the quadriceps was performed, as shown below:

RFD H/Q=RFD Hamstrings/RFD Quadriceps

MVC H/Q=MVC Hamstrings/MVC Quadriceps

Statistic Analysis

The bidirectional analysis of variance was performed using the mixed method procedure in SAS version 9.1 for Windows (SAS Institute, Cary, NC, USA). The Factors included in the RFD H/Q model was, the proportion of force by gender (male, female), time (0 to 10, 0 to 20, 0 to 50 ms from the start). When a significant main effect was found, post tests were performed to locate relevant differences. Test-retest reliability was assessed using Intraclass Correlation Coefficients (ICC 3.1). An alpha level of 5% was chosen as statistically significant. All values are expressed as mean ± SD.

Ethical Considerations

The participants were informed verbally and in writing about the objectives of the study, the benefits and possible risks of their participation, as well as the procedure related to data collection; in this way, the respective signature of the informed consent was carried out. This study was prepared following the scientific, technical, and administrative standards for research in the Republic of Colombia set forth in Resolution No. 8430 of 1993 [11], as well as the ethical recommendations for scientific research in sports and sports. Physical exercise and the ethical principles for research in human beings of the Declaration of Helsinki [12,13].

Results

The RFD and MVC expressed per kilogram of body weight were generally lower for women compared to men (Table 1).

There was no difference in the MVC H/Q ratio between male and female soccer players. The average MVC H/Q for the evaluated group was 0.44 ± 0.07. High reliability was found in the test for RFD H/Q in most of the time intervals (Table 2). Therefore, the RFD H/Q was generally as reliable as the traditional MVC H/Q. The RFD H/Q tests evaluated during the first contraction phase (up to 50 ms from the start) differs compared to the MVC H/Q force ratio (p=0.001).

Discussion

This study shows reduced muscle activation of the hamstring

Table 1: Data for Women and Men, number of evaluated by gender MCV and TDF of 50 and 200 ms.

	Woman (n=15)		Men (n=15)	
Age (years)	20.9 ± 1.9		25.8 ± 2	
Weight (kg)	69 ± 1.9		73 ± 3.1	
height (cm)	169 ± 27		172 ± 3.9	
	H	Q	H	Q
TDF (N·m·s·kg) 0 to 50 ms	20.9 ± 1.9	27.6 ± 7.9	14.0 ± 6.0	36.0 ± 4.3
0 to 200 ms	7.2 ± 2.2	15.5 ± 3.9	8.0 ± 1.0	17.6 ± 1.7
MCV (N·m·kg)	2.6 ± 0.3	4.7 ± 1.7	2.8 ± 0.2	5.0 ± 0.5

MVC: Maximum Voluntary Contraction; Q: Quadriceps; RFD: Rate of Force Development; H: Hamstrings

Table 2: The test - retest reliability for RFD H/Q and MVC H/Q.

The test-retest reliability for RFD H/Q and MVC H/Q.		
	ICC 3.1	Valor p
Relation MVC H/Q	0.751 to 0.856	0.043
Relation RFD H/Q	0.664 to 0.933	0.001

MVC: Maximum Voluntary Contraction; Q: Quadriceps; RFD: Rate of Force Development; H: Hamstrings

muscles, hence poor stabilization of the knee joint during the initial phase of muscle contraction in both genders. The RFD H/Q compared to the MVC H/Q was reduced in the initial 50 ms in both groups evaluated, which shows a poor synergistic protection for the ACL. This could have important clinical consequences, since the estimated time of ACL injury is 17 ms to 50 ms after initial contact with the ground, this based on video analysis of 39 cases [14]. In contrast, ACL injuries rarely occur during heavy, controlled lifting, for example during weightlifting, where the period of time is sufficient for the hamstrings to develop adequate levels of force to protect the ACL.

Furthermore, studies have shown that during a lateral cut maneuver or change of direction, where the majority of non-contact ACL injuries are found [14], hamstring activation is only 30% to 50% of the MVC [16,17], based on the evidence found, it would be more important to determine the RFD H/Q rather than the MVC H/Q as a knee stabilization parameter in explosive actions. It has been proposed that evaluation of knee joint function using isokinetic dynamometry should comprise data on dynamic or static MVC H/Q ratios combined with data on absolute muscle strength [18]. None of these take into account the capacity for rapid force in the initial phase of contraction. The high test-retest reliability of the introduced RFD H/Q force ratio indicates that changes with time of force production, for example, during specific preventive periodic evaluations in hamstrings, can be followed with a high level of accuracy.

This could make the method a tool in the standardized clinical evaluation as a parameter of stabilization of the knee joint, evaluating the agonist-antagonist RFD. It is important to emphasize that the presence of low MVC H/Q is associated with an increased risk of knee injuries and hamstring injury [15,19], for this reason the assessment of RFD H/Q could be established as an indicator of joint ACL and muscle risk in ball sports.

Conclusion

During the initial phase of muscle contraction, the ability to produce force per unit time of the hamstrings relative to the quadriceps is reduced. This means that the RFD H/Q ratio is lower in the initial phase of muscle contraction compared to the MVC H/Q ratio. In women compared to men soccer players, the RFD H/Q ratio is lower. High test reliability was found for RFD H/Q in most time intervals; therefore, RFD H/Q is generally as reliable as traditional MVC H/Q.

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