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COMPARATIVE ANALYSIS OF ISOKINETIC LEG STRENGTH IN PROFESSIONAL SOCCER AND BASKETBALL PLAYERS

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ABSTRACT

This study aimed to compare and analyse flexion and extension peak torques and hamstring to quadriceps peak torque muscle ratio of the knee joints by measuring isokinetic knee strength in professional soccer and basketball players. Twenty-two players were recruited, which included 12 soccer players (age: 15.8±1.0 years) and 10 basketball players (age: 15.7±0.9 years). After recording the stature, body mass, body mass index, body fat percentage, body fat mass and vertical jump measurement of each participant, lower extremity knee-joint measurements were conducted using an isokinetic dynamometer at angular velocities of $60°\cdot s^{-1}$ and $240°\cdot s^{-1}$. Peak torques of the hamstring and quadriceps muscles at $60°\cdot s^{-1}$ and $240°\cdot s^{-1}$ were significantly higher in basketball than soccer players ($p<0.05$ to $p<0.01$). When the hamstring to quadriceps peak torque muscle ratios were compared between soccer and basketball players, the only significant difference was found in the left knee of basketball players at $60°\cdot s^{-1}$. However, the relative strength of the hamstring and quadriceps muscles did not differ between soccer and basketball players at $60°\cdot s^{-1}$ and $240°\cdot s^{-1}$. In conclusion, body mass has a decisive effect on the production of peak torque values of quadriceps and hamstring muscles in soccer and basketball players.

Key words: Hamstring; Quadriceps ratio; Peak torque; Knee flexion; Knee extension; Isokinetic strength.

INTRODUCTION

Muscle strength is one of the key factors in successful sport performance and is an important indicator of the effectiveness of injury rehabilitation in athletes (Croisier *et al.*, 2002). To monitor the performance of athletes, as well as the rehabilitation progress of injured players, various lower limb strength indices have been investigated. Among these, hamstring-to-quadriceps muscle peak torque muscle ratio (H:Q muscle ratio) is one of the most commonly evaluated. This ratio of strength of agonist to antagonist leg muscles has been used to examine functional ability, knee joint stability and muscle balance between hamstring (H) and quadriceps (Q) muscles during velocity-dependent movements (Aagaard *et al.*, 1995; Zakas *et al.*, 1995; Li *et al.*, 1996; Orchard *et al.*, 1997; Clanton & Coupe, 1998; Hewett *et al.*, 1999). An injury may occur during rapid leg extension if the hamstrings fail to generate effective eccentric counteraction to decelerate the movement (Croisier *et al.*, 2008). Further, when the hamstrings act to extend the hip, muscle strains may occur during rapid alterations between flexion and extension (Petersen & Holmich, 2005). The anterior cruciate ligament, assisted by the hamstring muscles, stabilises the knee by preventing anterior translation of the tibia on the femur (Kannus, 1988; Moore & Wade, 1989; Pettitt & Bryson, 2002), which can occur during pivoting movements, such as landing from a jump and sudden changes in direction in field (soccer) and court (volleyball and basketball) athletes (Griffin *et al.,* 2000).

One of the most important motor skills in sport is referred to as the vertical jump (Barnett *et al.,* 2008). Thissen-Milder and Mayhew (1990) hypothesise that the jump is an important factor for most athletes in sport, because jumping is a major part of attack and defence movements in all sport games. The vertical jump is described as a ballistic movement and consists of rapid eccentric muscle activity followed by maximal concentric actions. Performing the motor movements requires the ability to strengthen the muscles and dynamic stabilisers of the knee. The extensors, dynamic knee stabiliser muscles based on the requirements of the sport, function mainly in the impulsive phase of the jump and the landing phase (Panni *et al.,* 2002).

The demands of certain sport on the knee joint may be related to the high incidence of injury in that joint (Richards *et al.*, 1996), and may cause imbalances in muscle strength between antagonistic dynamic knee stabiliser muscles. These muscle imbalances in muscle force production may increase the risk of injury because of the resultant high levels of stress in tissues (Oberg *et al.*, 1986). The isokinetic dynamometer provides fast and reliable quantification of variables related to muscle performance at different angular velocities, including the maximum torque, total work, reciprocity between agonist and antagonist muscles and fatigue index (Perrin *et al.*, 1987). Isokinetic assessment allows the identification of muscle strength deficit between bilateral muscle groups and between reciprocal muscle groups (agonist and antagonist) (Siqueira *et al.*, 2002).

There are several studies that used isokinetic dynamometer measurements in different populations (Kazazovic *et al*., 2008). However, there is little information about the measurements used for athletes in team sport, especially in research of the lower extremities (Kazazovic *et al*., 2009). Basketball and soccer are among the most popular sports. Both sports use the lower extremities and consist of some complex movements which require strenuous efforts, such as sudden feints, stops, starts, duels, sprints and jumps (Reilly & Thomas, 1976). These efforts depend on the strength of the neuromuscular system, especially in the lower limbs (Cometti *et al.*, 2001).

The aim of this study, therefore, was to compare and analyse the maximal voluntary peak torques of the quadriceps and hamstring muscles, and the torque ratio between these muscle groups of the right and left legs in professional basketball and soccer players by using isokinetic tests.

MATERIALS AND METHODS

Participants

The study included 12 male professional (division III) soccer players (age: 15.83±1.03 years; body mass: 59.25±6.43kg; stature: 171.50±4.89cm) and 10 male professional basketball players (division III) (age: 15.67±0.87 years; body mass: 75.68±13.27kg; stature: 185.67±8.93cm). All of the participants were fully informed of the goals and methodology of the test and provided signed consent. The participants agreed with the testing process and the use of the data for further research. The day before testing, the players were not subjected to any intense training.

Prior to participation in the study, the players were interviewed about their medical records and completed an injury questionnaire. Participants were excluded from participation in the study if they had any current hip, knee, or ankle injury or any other leg injury. The participants were all right-leg dominant.

Physical measurements

Stature and body mass were measured with an electronic scale (708 Seca, Hamburg, Germany). Body mass index (BMI), body fat percentage and body fat mass were measured with a Tanita Body Composition Analyser BC-418, using the bioelectrical impedance analysis method. The vertical jump test was also performed using a specialised apparatus called the Vertec. Before the testing session started, the participants were allowed a 15-minute warm-up at a light intensity on the leg curl and leg extension machine.

Isokinetic measurements

Participants were tested in the sitting position on IsoMed 2000 isokinetic dynamometer. Participants were seated for testing in the chair of the dynamometer with the backrest angle at 90°. The axis of rotation of the right knee was aligned with the axis of rotation of the dynamometer's armature, and the ankle cuff was attached approximately 3cm above the dorsal surface of the foot. Gravity correction was performed before the test. Stabilisation straps were placed over the pelvis and chest, and participants positioned their arms across their chests during familiarisation and testing. To synchronise themselves with the testing device, participants were instructed to perform 3 active repetitions of knee movement ranging from maximal flexion to maximal extension.

To adapt to the test conditions, participants were allowed 3 sub-maximal contractions of the quadriceps and hamstring muscle groups at the beginning of the tests. Standardised verbal motivation techniques were used to encourage maximal work from the test participants. All participants performed 10 maximal (the first and the last of the 10 were dismissed) concentric contractions (knee flexion and extension) of both legs at velocities of $60°\cdot s^{-1}$ and $240°\cdot s^{-1}$ (Brockett *et al.*, 1999). A rest period of 3 minutes was allowed between test speeds, and 5 minutes were allowed between test limbs.

Statistical analysis

The data were processed with SPSS 15.0 for Windows (SPSS Inc., USA). Statistical parameters were calculated for all of the variables, and one-way analysis of variance (ANOVA) was applied to determine the statistically significant differences between basketball and soccer players. Statistical significance was set at the level of $p<0.05$.

RESULTS

Age and physical characteristics of the participants are presented in Table 1. No significant between-group differences in age, BMI and vertical jump were noted. However, the mean of stature, body mass and body fat mass were significantly ($p<0.01$) lower in soccer players than basketball players. Further, body fat percentage was also significantly ($p<0.05$) lower in soccer players than basketball players (Table 1).

***TABLE 1*: MEAN ± SD FOR AGE AND PHYSICAL CHARACTERISTICS OF PARTICIPANTS**

Parameter	Soccer (n = 12)	Basketball (n = 10)
Age (years)	15.8±1.03	15.7±0.9
Stature (cm)	171.5±4.9	185.7±8.9**
Body mass (kg)	59.3±6.4	75.7±13.3**
Body mass index (kg/m^2)	20.1±1.8	22.1±4.3
Body fat (%)	11.0±4.5	15.5±5.1*
Body fat mass (kg)	6.6±2.8	12.1±5.9**
Vertical jump (cm)	42.8±3.2	48.4±7.9

Significant differences: * p <0.05; ** p <0.01

***TABLE 2*: MEAN VALUES (±SD) OF HAMSTRING AND QUADRICEPS PEAK TORQUES AT VELOCITIES OF 60°·S^{-1} AND 240°·S^{-1}**

Variable	Angular Velocity LEFT Soccer (n=12)	Angular Velocity LEFT Basketball (n=10)	Angular Velocity RIGHT Soccer (n=12)	Angular Velocity RIGHT Basketball (n=10)
PT Hamstring (Nm)				
60°·s^{-1}	96.8±16.5	138.0±24.8**	103.8±10.0	138.8±27.1**
240°·s^{-1}	82.4±21.2	115.1±27.8*	85.7±12.0	118.7±28.9**
PT Quadriceps (Nm)				
60°·s^{-1}	203.3±33.4	244.0±37.2*	199.2±33.0	252.8±40.5**
240°·s^{-1}	125.3±17.0	168.6±40.3*	123.6±24.7	168.7±31.2**
PT Hamstring: Quadriceps (%)				
60°·s^{-1}	48.4±7.7	56.7±4.8*	53.2±7.0	55.1±6.0
240°·s^{-1}	66.3±16.5	69.0±9.9	70.8±10.3	70.9±7.2
PT Hamstring/Body Mass				
60°·s^{-1}	1.6±0.2	1.8±0.3	1.8±0.2	1.9±0.3
240°·s^{-1}	1.4±0.4	1.5±0.4	1.45±0.2	1.6±0.3
PT Quadriceps/Body Mass				
60°·s^{-1}	3.4±0.4	3.3±0.5	3.4±0.5	3.4±0.5
240°·s^{-1}	2.1±0.2	2.2±0.4	2.1±0.3	2.2±0.3

Significant differences: * p<0.05; ** p<0.01 Nm: Newton meter PT: Peak Torque

Mean peak torque of the hamstring muscle of the left and right knees was significantly lower in soccer players compared with basketball players at 60°·s^{-1} ($p<0.01$). Furthermore, mean peak torque was significantly lower in soccer players than basketball players at 240°·s^{-1} in the right knee ($p<0.01$) and in the left knee ($p<0.05$) (Table 2). Mean peak torque of the quadriceps muscle of the right knee was significantly higher in basketball players compared to soccer players at 60°·s^{-1} and 240°·s^{-1} in the right ($p<0.01$) and the left knee ($p<0.05$) (Table 2).

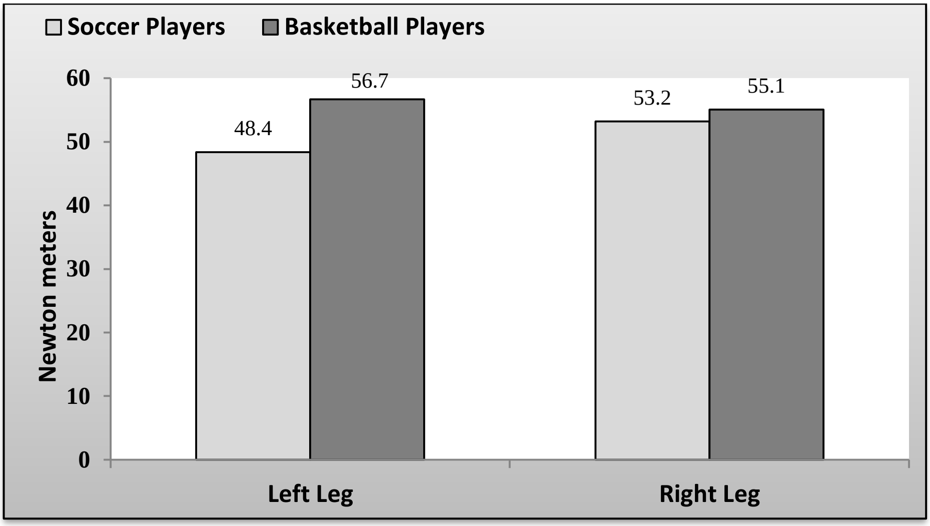

***FIGURE 1*: HAMSTRING AND QUADRICEPS MUSCLE RATIO (%) AT PEAK TORQUE AT A VELOCITY OF 60°·S^{-1}**

There was only 1 significant between-group difference in peak torque H:Q muscle ratio. The left knee ratio at 60°·s^{-1} (Figure 1) was significantly higher in the basketball players ($p<0.05$). There were no significant differences between soccer and basketball players in peak torque flexion/body mass ratio and in peak torque extension/body mass ratio (Table 2).

DISCUSSION

The study was conducted to determine and compare the maximal voluntary peak torques of the quadriceps and hamstring muscles, as well as on the reciprocal relationship between agonist and antagonist muscles of the right and left legs in professional soccer and basketball players. There were observed differences between soccer and basketball players. When these results were compared with those of other studies regarding peak torque of H and Q muscles, both similarities and differences in isokinetic peak torque H:Q muscle ratio and peak torque extension and flexion/body mass ratios were observed.

Regarding left and right knee extension and flexion, hamstring and quadriceps muscle peak torques were higher in basketball players than soccer players. Similar results have been found in previous studies (Zakas *et al.*, 1995; Metaxas *et al.*, 2009; Kazazovic *et al*., 2010; Ozkan & Isler Kin, 2010; Alemdaroglu, 2012), that investigated maximal voluntary peak torques of the Q and H muscles and the torque ratio between these muscle groups in basketball and soccer players participating in teams of different divisions. Zakas *et al.* (1995) and Metaxas *et al*. (2009) found that peak torque expressed in absolute terms was significantly higher in basketball than soccer players at velocities of 60°·s^{-1} and 180°·s^{-1}.

Kazazovic *et al.* (2010) used isokinetic dynamometer measurements to evaluate maximum torque, total work and agonist–antagonist reciprocity of the knee joint in professional and amateur athletes at angular velocities of $60°·s^{-1}$ and $180°·s^{-1}$. Their results revealed that professional athletes presented significantly higher values for total work and maximum torque of the knee flexors at an angular velocity of $60°·s^{-1}$. Moreover, peak torque H:Q muscle ratio was much higher in the basketball players' left leg than the soccer players' left leg at $60°·s^{-1}$ (Dauty *et al.*, 2007). Metaxas *et al.* (2009) examined and compared cardio-respiratory performance and isokinetic muscle strength at angular velocities of $60°·s^{-1}$, $180°·s^{-1}$, and $300°·s^{-1}$ between Greek soccer and basketball players of different divisions before starting the training season. Regarding peak torque, only basketball players in the III^rd^ and IV^th^ divisions showed significantly higher values at $60°\ s^{-1}$ in the hamstrings.

When the average peak torque H:Q muscle ratios were compared between basketball and soccer players, no significant differences were found between the groups except for the left leg at a velocity of $60°·s^{-1}$ (Table 2). Peak torque H:Q muscle in the left limb at $60°·s^{-1}$ was significantly greater in basketball than soccer players. Similar studies (Zakas *et al.*, 1995; Masuda *et al.*, 2003; Patricia & Vassilios, 2003; Ergun *et al.*, 2004; Magalhaes *et al.*, 2004; Egan *et al.*, 2006; Zakas, 2006; Tabakovic *et al.*, 2009; Brughelli *et al.*, 2010), yielded the same results. Brughelli *et al.* (2010) researched the effects of eccentric exercise on optimum length of the knee flexors and extensors during the preseason in professional soccer players. They reported that peak torque levels and H/Q ratios were not significantly altered throughout their study and that eccentric exercise could also increase the optimum lengths of both knee extensors and flexors during the preseason in professional soccer.

Ergun *et al.* (2004) conducted a cross-sectional analysis of sagittal knee laxity and isokinetic muscle strength in soccer players. Their results showed that the dominant extremity in soccer players had significantly higher knee flexor peak torque and H:Q muscle ratio at $180°·s^{-1}$ and that those soccer players had significantly higher extensor and flexor peak torque values and H:Q muscle ratios than sedentary participants for both extremities.

However, Magalhaes *et al.* (2004) studied the concentric quadriceps and hamstring isokinetic strengths in volleyball and soccer players and reported that the H:Q muscle ratio was significantly lower in volleyball players at $90°·s^{-1}$ and that no significant differences were found for H:Q muscle ratio in soccer players of different positional roles.

Additionally, Masuda *et al.* (2003) examined the relationships between muscle cross-sectional area (CSA) and muscular strength in terms of knee extension and flexion, hip extension and flexion and hip abduction and adduction among 14 well-trained university soccer players, who were divided into two groups based on ability (Group A: above-average ability; Group B: average ability). They observed no significant differences between the two groups in muscle CSA and isokinetic strength. Rahnama *et al.* (2003) studied how exercise that simulates the work rate of competitive soccer players affects the strength of the knee extensors and knee flexors and showed that significant changes were found ($p<0.05$) for both legs in the hamstring to quadriceps muscle ratio.

No significant differences were found for average peak torque H/body mass ratio and Q/body mass ratio between the soccer and basketball players in this study. This indicates that soccer and basketball players have the same relative strength. However, some researchers (Williams & Singh, 1997; Pincivero *et al*., 2002; Buchanan & Vardaxis, 2003), found significant relationships between peak torque Q/body mass ratio and H/body mass ratio. Pincivero *et al*. (1997) studied the relationship between open and closed kinematic chain assessment of knee strength and functional performance. They noted that correlation coefficients were statistically greater for peak torque/body mass at a velocity of $180°·s^{-1}$.

Additionally, Williams and Singh (1997) studied dynamic trunk strength of Canadian football players, soccer players, and middle- to long-distance runners. According to their results, eccentric flexor peak torque relative to body mass was significantly greater in soccer players than runners and recreationally active participants. Buchanan and Vardaxis (2003; 2009) explored the differences in Q and H strength among the genders and different age groups and found that, with body mass-stature normalisation, most age and gender differences were small. Pincivero *et al.* (2002) assessed isokinetic torque, work and power among non-injured, ACL (anterior cruciate ligament)-deficient and ACL-reconstructed individuals. The H peak torque corrected for body mass was significantly higher in the non-involved than in the involved limb only at $60°·s^{-1}$.

CONCLUSION

This study revealed significant differences between professional basketball and soccer players for peak torques of H and Q muscles. However, when peak torque H:Q muscles ratio was compared between soccer and basketball players, there was only a significant difference for the left knee of basketball players at $60°·s^{-1}$.The difference was due to bilateral left- and right-leg strength differences in soccer players, which were not found in basketball players. Therefore, the isokinetic strength of the left knee might be lower than that of the right knee in soccer players. Strength training, especially for the left leg, may be necessary to reduce injury risk in soccer players. However, there were no significant differences in average peak torque Q/body mass and H/body mass ratios between basketball and soccer players.

Therefore, relative strength is comparable in soccer and basketball players, but absolute strength is greater in basketball than soccer players. According to the study data, body mass has a decisive effect on Q and H muscle peak torque values in soccer and basketball players and relationships also exist between mass and peak power.

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