Effect of limb dominance on peak torque and angle of peak torque of hamstrings in recreational female football players

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Abstract

Purpose: To investigate whether there is a significant difference between the peak torque and angle of peak torque of the hamstrings in a group of recreational female football players.

Methods: A convenience sample of 17 females aged 18-22 years from a university ladies football team. Peak torque and angle of peak torque of both hamstrings were measured using a Biodex system 2 isokinetic dynamometer in concentric and eccentric mode at an angular velocity of 60°/sec. The related t-test was used to test for significant differences between limbs.

Results: Muscle strength differences ranging between 0.9% - 38.3% (Concentric: 9.7±7.7; Eccentric: 15.4±9.3) were noted. However, no significant differences were found between the dominant and non dominant limb (peak torque concentric p=0.068, eccentric p= 0.063; angle of peak torque concentric p= 0.449, eccentric p=0.246).

Conclusions: In a group of recreational football players, limb dominance did not significantly affect peak torque or angle of peak torque at 60°/secs. However, noteworthy strength imbalances were observed in a number of participants, indicating that clinicians need to be cautious when using the uninjured limb as a baseline measure.

Implications: The findings highlight that caution may be exercised when using the peak torque and angle of peak torque of the contralateral limb as a target for rehabilitation.

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Key words:
Isokinetic dynamometry; Peak torque; Hamstrings; Limb dominance.

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Introduction

Hamstring strains are one of the most common injuries in sport (Walden et al. 2005; Rolls and George 2004; Dadebo et al. 2004; Clanton and Coupe 1998; Orchard et al. 1997) particularly in those which involve kicking, jumping and sprinting (Peterson and Holmich 2005; Proske et al. 2004). They are the most prevalent injury in professional football, accounting for 15 missed games per club per season (Walden et al. 2005; Woods et al. 2004). The risk factors for hamstring strains include recent history of the same injury, older age, strength deficits or muscular imbalance and a reduced angle of peak toque (Woods et al. 2004; Orchard 2001; Crossier et al. 2002; Orchard et al. 1997; Proske et al. 2004; Brockett et al. 2004). Weak knee flexors are also associated with increased injury rates in the knee complex (Ross et al. 2004). Participation in sports such as football which involve repetitive one sided activity may lead to bilateral strength imbalances or asymmetry resulting from increased muscular development of the preferred limb (Rahnama et al. 2005; Brady et al. 1993). Strength imbalance between the dominant and non-dominant leg is an important predictor of risk of injury (Ross et al. 2004; Rahnama et al. 2005). During rehabilitation, peak torque of the uninjured limb is frequently used as a goal for return to participation (Clanton and Coupe 1998; Rahnama et al. 2005). However, it is accepted that this is not always appropriate due to potential baseline differences (Holder-Powell and Rutherford 1999).

Previous research investigating differences between the peak torque of the dominant and non-dominant hamstrings failed to reach a consensus and there is limited high quality research using football players. Various studies have found the peak torque of the dominant leg to be significantly higher than the non-dominant leg in football players (Kellis et al. 2001; Tourny-Chollet et al. 2000; Gür et al. 1999). However, observations of significant statistical difference were frequently limited to one out of many contraction speeds (Tourny-Chollet et al. 2000; Gür et al. 1999). Some studies have found no significant difference at any speed (Brady et al. 1993; Magalhaes et al. 2004; Ostenberg et al. 2000; Reilly and Drust 1997), whilst one study found a significant difference in favour of the non-dominant leg (Rahnama et al. 2005).

It is difficult to draw firm conclusions from these studies due to omissions in methodological description i.e. gravity correction (Kellis et al. 2001), testing protocol (Reilly and Drust 1997), randomisation of limb testing order (Rahnama et al. 2005; Gür et al. 1999) and use of average rather than peak torque (Tourny-Chollet et al. 2000). Furthermore, much of the research involves only elite players or male participants (Rahnama et al. 2005; Brady et al. 1993; Kellis et al. 2001; Tourny-Chollet et al. 2000; Gür et al. 1999). Important differences have been found between patterns of injury and strength profiles between male and female players (Ostenberg et al. 2000; Mercer et al. 2003; Lindenfeld et al 1994) and elite and lower level players (Tourny-Chollet et al. 2000; Ostenberg and Roos 2000; Soderman et al. 2001). Furthermore, some studies failed to include eccentric isokinetic testing, limiting their clinical relevance (Ross et al. 2004; Magalhaes et al. 2004; Reilly and Drust 1997).

The hamstrings undergo eccentric contraction during the swing phase of kicking and sprinting (Proske et al. 2004; Woods et al. 2004). Hamstring strains are thought to occur during this eccentric muscle action due to microscopic damage to the muscle fibres (Brockett et al. 2004; Garrett 1990). It has been proposed that the amount of damage that occurs in the muscle is associated with its optimum length for active tension and it has been found that the lower the angle of peak toque, the higher the risk of damage (Brockett et al. 2004; Proske et al. 2004). Therefore, angle of peak torque is suggested as a measure of susceptibility for hamstring strains. There is a paucity of research in this area. However, one study found that the angle of peak torque in the dominant hamstring was significantly higher than in the non dominant limb (Clark et al. 2005). Furthermore, the same study found that angle of peak torque was significantly lower in injured muscles than in uninjured muscles. In accordance with previous literature, this suggests that a lower angle of peak torque may predispose a muscle towards injury. The present study aims to add to existing research in investigating whether a bilateral difference in angle of peak torque exists.

The purpose of this study was to investigate if limb dominance has a significant effect on hamstring peak torque and angle of peak torque in a group of recreational female football players.

Methods

Participants

A convenience sample consisting of 17 recreational female football players was recruited from a university ladies' football club. At the time of the study, it was required that all subjects had a minimum of 2 years experience of playing regular football and currently participated at least once a week. Prospective participants with current pain or who had suffered injury to the knee, calf or thigh in the past 6 months were excluded. Ethical approval was granted from the Faculty of Health Sciences Ethics Committee. All subjects gave their informed consent and were provided with information sheets.

Equipment and measurements

Concentric and eccentric peak torque and angle of peak torque of the hamstrings were measured at an angular velocity of 60°/sec using a Biodex System 2 isokinetic dynamometer (Biodex Medical Systems, New York, USA). This method of testing the muscles surrounding the knee joint has been shown to be both valid (Drouin et al. 2004) and reliable (Pincivero et al. 1996; Brown et al. 1993; Feiring et al. 1990; Kramer 1990). 60°/sec was chosen as results at this velocity are highly reproducible (Pincivero et al. 1996). The highest recorded value of peak torque and the angle at which this was achieved were used for further analysis. Three pilot testing sessions were completed with 2-3 volunteers, which identified no problems with the equipment or protocol. Gravity correction was set at 45° and the equipment was calibrated prior to each testing session. Testing took place in a research laboratory at the Faculty of Health Sciences, University of Southampton.

Procedure

Testing was preceded by a five minute cardiovascular warm up on a stationary cycle ergometer set at minimal resistance and a series of lower extremity stretches, in accordance with previous protocol (Le Chevlier et al. 2000; Thompson et al. 1993). In view of previous research into dominance, the preferred kicking leg was considered as the dominant limb (Beling et al. 1998). The dominant and non-dominant limbs were tested in a pre-determined randomised order. Participants were seated on the isokinetic dynamometer in 90˚ hip flexion. The upper body was secured with straps across the waist and over the shoulders and participants were instructed to cross their arms over the chest. The rotational axis was aligned with the lateral femoral epicondyle of the knee to be tested and a strap was secured over the thigh to limit excess movement of the limb. The lever arm was secured around the distal tibia. Comfortable range of movement of the knee was recorded against minimal resistance and outer limits of range were set for safety purposes. Testing range was set at 0-90˚ knee flexion (Kellis et al. 2001; Pincivero et al. 1996).

The participants completed 3 sub-maximal (50% perceived effort) and 1 maximal contraction as a warm up and to familiarise themselves with the procedure. During testing, 3 maximal concentric contractions and 3 maximal eccentric contractions were performed individually in a predetermined randomised order separated by a 2 minute rest period. Previous research has shown that a between set rest of at least 1 min is appropriate (Parcell et al. 2002). The participants were advised to 'give maximal effort' but no further verbal instructions were provided during the test (Perrin 1993).

Data processing and analysis

Data were analysed using SPSS 14.0. Histograms of the data demonstrated normal distribution and hence a related t-test was used to test for a significant difference between the dominant and non-dominant limbs for peak torque and angle of peak torque. The level of significance was set at $p<0.05$.

Results

Seventeen participants (Age: 19.8±1.1 years) who met the inclusion criteria took part in the study. Fifteen participants considered their right leg to be their dominant kicking leg and 2 considered their left as dominant. Participant characteristics are presented in table 1.

Peak torque

The mean concentric peak torque was 83.98 ± 17.88 Nm for dominant and 79.97± 17.8 Nm for non-dominant limbs. The mean eccentric peak torque was 107.17± 27.51 Nm for the

Table 1. Participant Characteristics

	Mean	Standard deviation	Range
Age (years)	19.8	1.1	18-22
Height (cm)	166.3	6.8	153-178
Weight (kg)	65.2	10.4	40-85
Years playing football	7.6	3.3	2-14
Sessions of football played per week	2.4	1.3	1-6

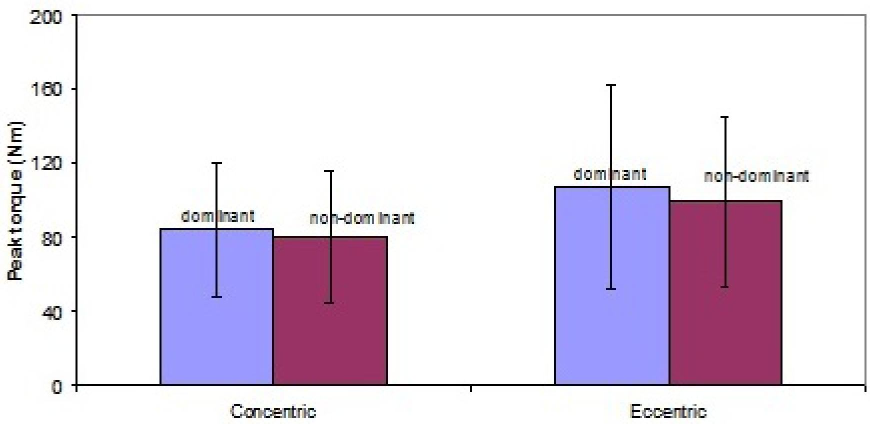

Figure 1. Mean values of peak concentric and eccentric torque

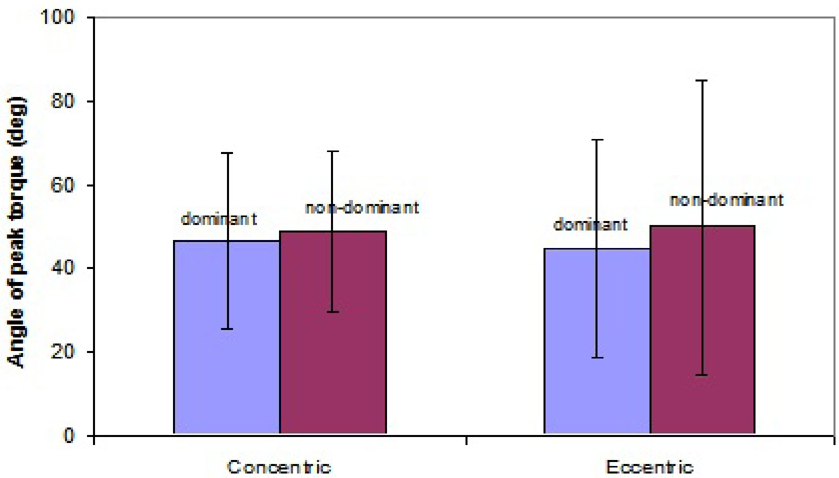

Figure 2. Mean values of angle of peak torque for concentric and eccentric muscle action

dominant limb and 99.29± 23.2 Nm for the non-dominant limb. No statistical difference was found between the peak torque of the dominant and non dominant limb during either concentric ($p=0.068$) or eccentric contraction testing ($p=0.063$). However, the peak torque of the dominant limb was generally higher than the non-dominant (fig.1).

The mean percentage difference between limbs was 9.7% for concentric contraction and 15.4% for eccentric contraction.

Angle of peak torque

No significant differences in angle of peak torque were found between the dominant and non-dominant limb (concentric $p=0.449$, eccentric $p=0.246$). The mean angle of peak torque for each leg is presented in fig.2.

The summary of the data including the mean, standard deviation, range and p value for each of the testing conditions are presented in table 2.

Discussion

The present study highlighted that limb dominance did not significantly affect peak torque and angle of peak torque of hamstrings at an angular velocity of 60°/secs, in a group of recreational female football players.

Peak torque

The results of this study have shown no significant effect of limb dominance on the peak torque created by the hamstrings at an angular velocity of 60°/sec. These results concur with previous studies investigating peak torque at low contraction speeds (Rahnama et al. 2005; Brady et al. 1993; Tourny-Chollet et al. 2000; Gür et al. 1999; Magalhaes et al. 2004; Ostenberg et al. 2000; Reilly and Drust 1997). Various explanations for these findings are proposed. Firstly, it is possible that football training and match-play involves sufficient bilateral activities i.e. running and dribbling to minimise the influence of leg preference. Additionally, it is possible that the sample group's training regime may involve sufficient focus on developing the non-dominant limb to avoid strength imbalances or that some players may not elicit a pronounced dominance on one limb. This is particularly pertinent considering the participants had a high level of playing experience (Mean 7.6, SD 3.3 years) and may potentially be more comfortable with the use of the non-dominant limb. Alternatively, the average of 2.4 (±1.3) sessions of football completed per week may be insufficient in duration and intensity to bring about significant strength related unilateral changes. Finally, the complex demands required of the hamstring muscles during playing activities may compound unilateral strength changes which would be expected if the muscles were responsible for an isolated action. For example whilst kicking, the hamstrings may play a stabilising role in the slightly bent stance limb (Rahnama et al. 2005) whilst they simultaneously play a decelerating role in the kicking limb (Gür et al. 1999). These findings conflict with one study which found the peak torque of the dominant leg to be significantly higher at all testing speeds in young soccer players (mean age: 13.2 ± 2.1 years) (Kellis et al. 2001). However, this involved young male participants and proposes that strength profiles in young athletes are unique due to changes in body mass,

Table 2. Peak torque (Nm), angle of peak torque (degree) and between-side differences for concentric and eccentric muscle action

Variable	Limb	Mean	Standard deviation	Range	t	p-value
Concentric peak torque (Nm)	Dominant	83.98	17.88	44.6 - 116.3	-1.96	0.068
	Non-dominant	79.97	17.80	40.5 - 112.4		
Eccentric peak torque (Nm)	Dominant	107.17	27.51	56.1-157.7	-2.00	0.063
	Non-dominant	99.29	23.20	48.7 -134.5		
Concentric angle of peak torque (degree)	Dominant	46.50	10.55	30 - 67	0.78	0.449
	Non-dominant	48.75	9.73	30 - 69		
Eccentric angle of peak torque (degree)	Dominant	44.88	12.90	29 - 74	1.20	0.246
	Non-dominant	49.82	17.74	25 - 93		
Between side difference - Concentric peak torque		9.7	7.7	0.9 – 25.8		
Between side difference – Eccentric peak torque		15.4	9.3	1.3 – 38.3		

body fat, neuromuscular responses and leg musculature. Therefore, bilateral strength differences may be attributable to the sample group undergoing a stage of rapid development.

Despite the results of this study failing to show statistical significance, large differences in peak torque were observed in a number of participants, most notably during eccentric contraction. This greater difference in eccentric peak torque may be explained by gains in eccentric hamstring strength in the dominant leg as a result of specific muscular loading patterns during the open chain kicking technique (Gür et al. 1999). It has been suggested that players with a strength difference of 15% or more are 2.6 times more likely to suffer an injury in the weaker leg (Knapik et al. 1991). In the present study, a between side difference of 15% or more was observed in 3 participants for concentric and 10 participants for eccentric torque. A bilateral difference in peak torque of 10% or more has been considered to be clinically significant (Keating and Matyas 1996) and rehabilitation aims to restore peak torque to within 10% of the uninjured limb (Clanton and Coupe 1998). The high number of participants (58%) displaying a notable difference during eccentric contraction in the current study may have clinically significant implications for using the 10% target in rehabilitation.

Angle of peak torque

No significant difference was found when comparing the angle of peak torque of the dominant to the non-dominant limb. These findings conflict with a previous study which found the angle of peak torque in the dominant leg to be significantly greater than in the non-dominant limb at the same velocity in male amateur football players (Clark et al. 2005). The angle of peak torque has been shown to be significantly lower in previously damaged hamstrings than in uninjured hamstrings (Proske et al. 2004) which are subsequently at an increased risk of future injury (Brockett et al. 2004). The results of the study by Clarke et al (2005) suggest the non-dominant limb may be at a higher risk of injury due to a lower angle of peak torque. However, various high quality studies have found no significant difference in the incidence of hamstring injury between the dominant and non-dominant limbs (Woods et al. 2004; Orchard 2001). In accordance with the findings of the present study, this suggests that a change in angle of peak torque is likely to be a result of injury or tissue healing and not due to limb dominance.

Limitations

This study is limited to a relatively small sample size which restricts the clinical application of the findings. Additionally, testing was limited to a single angular velocity. Previous studies have found noteworthy differences between results at different angular velocities (Rahnama et al. 2005; Tourny-Chollet et al. 2000; Gür et al. 1999). Interestingly, significant strength imbalances were frequently found at the higher velocities and this may better reflect the neuromuscular demands of football. Furthermore, the playing position on the pitch may influence the ratio between muscles, and hence a large study is needed to examine the effect of different positions on muscle characteristics. The present findings almost reached significance at the 0.05 level, so a type II error may have occurred and a fully powered study with larger numbers may reveal significant differences. Finally, the study did not consider the other activities and conditioning undertaken by the participants. However, whilst other sporting activities are liable to influence a player's muscular profile, the results remain representative of recreational level players who are likely to participate in other activities. Therefore, future research should involve a large sample size, using a wide range of testing velocities and may undertake more detailed analysis of the factors that influence the degree of strength dominance developed at an individual participant level.

Conclusion

The findings of this study suggest that in a group of recreational female football players, limb dominance does not significantly affect peak torque or angle of peak torque at 60°/sec. The results agree with previous research into peak torque using slow angular velocities. However, large strength imbalances were observed at an individual participant level, particularly during eccentric contraction. Therefore, clinicians may exercise caution when using the uninjured limb as a baseline for peak torque or angle of peak torque.

Key points

1. The findings of this study indicate that caution is needed when using the peak torque of the contralateral limb as a target for rehabilitation.
2. The clinician may need to be aware of the potential for pre-existing strength imbalances in athletes who participate in predominately unilateral activities.
3. Angle of peak torque does not appear to differ between dominant and non- dominant limbs.
4. It would be desirable for clinicians to determine pre-season imbalances to provide baseline measurements for return to sport following rehabilitation where possible.

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