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ORIGINAL RESEARCH PAPER

DOES KNEE EXTENSORS AND FLEXORS MUSCLE STRENGTH AND STRENGTH BALANCE DIFFER BY PLAYING POSITION OF SOCCER PLAYERS?

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Abstract

The purpose of this study is to compare the strength and muscle balance of peak torque of knee extensors and flexors of soccer players according to playing positions. The strength parameters consist of absolute and relative strength, and muscle balance parameters of bilateral strength balance and H/Q ratio of dominant and non-dominant leg. The participants of this study are 102 male soccer players of Estonian Premium League teams: 41 defenders, 40 midfielders and 21 forwards. Muscle strength is measured in the isokinetic concentric mode at angular velocities of 60 and 300°/s and in the eccentric mode at 60°/s (Humac Norms). The one-way ANOVA and Bonferroni methods are used to compare strength parameters between positions. The Student t-test is used to compare dominant and non-dominant leg within the playing position groups. We find that absolute peak torque values of midfielders are statistically significantly smaller than defenders and forwards at angular velocity 60°/s on concentric and eccentric mode. No statistically significant differences are found between soccer players' positions at angular speed 300°/s. We find that relative peak torque does not differ statistically significantly between players position. Defenders have statistically significantly stronger dominant leg compared to non-dominant leg in the concentric and eccentric mode at angular velocity 60°/s. No statistically significant differences are found between playing positions in bilateral strength balance and H/Q ratio. Players in *different playing position have different knee extensors and flexors strength values, but no differences are observed between playing position and knee extensors and flexors strength balance.*

Keywords: *soccer, isokinetic, strength, bilateral, H/Q ratio, asymmetry.*

Introduction

Playing in different positions demands different anthropometrics and physical abilities (Tourny-Chollet et al., 2000, Bloomfield et al., 2007). Defenders cover a shorter distance in high-intensity running (Mohr et al., 2003) and their bilateral deficit of muscle strength is the lowest compared to players in other positions (Tourny-Chollet et al., 2000). Defenders are taller and heavier than midfielders and forwards, taller players are most suitable for playing in central defensive position. (Tourny-Chollet et al., 2000; Reily et al., 2000). Midfield players have the lightest weight (Tourny-Chollet et al., 2000), cover the longest distance during the match (Bangsbo et al., 1991, Mohr et al., 2003, Di Salvo et al., 2007), their VO2 max is the highest (Reilly et al. 2000), they have lower muscle strength (Thourny-Collet et al., 2000; Reilly et al. 2000) and their jumping height is lower compared to players in other positions (Haugen et al., 2013). Forwards are taller and heavier than defenders and midfielders (Nikolaidis et al., 2014), fastest and jump higher (Gil et al., 2007, Haugen et al., 2013), they have greater muscular strength (Tourny-Chollet et al., 2000) and they cover longer distance in high intensity, than players in other positions (Gil et al., 2007).

Muscle strength of the lower extremities is the key factor in many sports disciplines, including soccer (Lehance et al., 2009). The quadriceps muscle is important in kicking, jumping and running (Kary, 2010). Hamstring muscles is important in soccer players for stabilizing joints (Aagard 1998, Cometti, 2001). Very often there are muscular asymmetries of lower extremities observed in soccer players (Dauty et. al., 2003, Fousekis et al., 2010, Lehance et al., 2009, Rahnama et al., 2005, Daneshjoo et al., 2013). Problems in the muscular bilateral strength of knee extensors and flexors appear in 56-97% of soccer players (Lehance et al., 2009, Rahnama et al., 2005, Daneshjoo et al., 2013). Functional asymmetry may cause performance reduction and may increase the risk of injury (Fousekis et al., 2010, Jones et al., 2010). Playing position is one out of five factors that affect functional asymmetry (Fousekis et al., 2010). There are many previous studies about isokinetic strength parameters of soccer players at top level (Eniseler et al., 2012, Fousekis et al., 2010, Dauty et al., 2003, Fonseca et al., 2007, Croisier et al., 2008, Geofitsidou et al., 2008, Cotte et al., 2011), differences between various performance levels (Papaevangelou et al., 2012, Cometti et al., 2001) and differences between age (Andrade et al., 2012; Lehance et al., 2009, Kellis et al., 2001, Gür et al., 1999). But there are only a few studies on differences between playing positions (Tourny-Chollet et al., 2000; Ruas et al., 2015). Tourny-Chollet et al. (2000) find that midfielders' knee muscles relative peak torque was statistically significantly lower in concentric mode, but there are no differences in eccentric mode. Ruas and co-authors (2015) find that forwards and goalkeepers have hamstrings' concentric and eccentric peak torque asymmetry significantly greater than 10%.

The purpose of this study is to compare knee extensors and flexors absolute and relative peak torque; and bilateral strength balance and H/Q ratio of soccer players according to playing positions.

Material and methods

All procedures described in the study were approved by the National Institute for Health Development of Estonia.

*Participants.*The participants of this study are 102 male soccer players of professional Estonian Premium League teams: 41 defenders, 40 midfielders and 21 forwards. All athletes were physically healthy and were ready to perform maximum performance. All athletes participated in the study voluntarily.

Instrumentation and procedures. The athletes were measured and weighed at the beginning of the study. After that, athletes made a warm up program: 5 minutes riding the veloergometer and 5 minutes individual stretching exercises. This was followed by the knee extensor and flexor muscles strength testing by isokinetic dynamometer (Humac Norms). The dynamometer set according to the manufacturers' instructions, was used at a sitting position where back angle was 85°. Muscle strength was measured in the isokinetic concentric mode at angular velocities of 60 and 300°/s and in the eccentric mode at 60°/s. Athletes completed three different types of tests. Before each type of test there was a trial testing, in which the athletes could exercise in performing the movement. There was a two minute pause after the trial and a three minute pause between the tests. There was a five minute pause between the tests of different body side. Testing order of body sides was randomized. During the trial testing and control testing they made five concentric repetitions at 300°/s, three concentric repetitions at 60°/s and three eccentric repetitions at 60°/s. The best result of all repetitions is taken for the statistical analysis of this paper.

Measures. The following parameters are measured in this study:

- Absolute peak torque (Nm)
- Relative peak torque (Nm/kg)

-The strength difference (bilateral symmetry) between dominant and non-dominant leg is quantified with absolute symmetry index (ASI) – (ASI=|D-ND|/max[D;ND])

-Unilateral strength balance is measured as hamstring and quadriceps strength ratio in %.

Analysis. Absolute and relative peak torque of dominant and non-dominant leg, muscle groups' bilateral muscle strength values and H/Q ratios are compared between defenders, midfielders and forwards using ANOVA. The differences between the dominant and non-dominant leg by position groups are tested with the Student t-test for paired data. These tests estimate the existence of systematic body side differences in different playing positions. The statistically significant difference criterion is determined as p value smaller than 0.05 and Cohen d value at least 0.20. The size of the effect is interpreted as follows: 0.20, 0.60, 1.2, 2.0 and 4.0 for respectively small, moderate, large, very large and extremely large (Hopkins, 2010).

Results

The anthropometry of soccer players according to their playing position is statistically significantly different (Table 1).

Table 1

Comparison of age and anthropometry of soccer players according to playing position

	Total	Defenders	Midfielders	Forwards	ANOVA probability of significance
Age	22.9±4.4	23.4±4.6	22.2±4.0	23.2±4.5	0.432
Height	181.1±6.7	182.7±7.2[b]	178.1±5.7[a,c]	183.7±5.4[b]	0.001
Body mass	76.6±8.2	78.5±8.1[b]	72.7±6.5[a,c]	80.1±8.6[b]	0.000

a-statistical difference from defenders; b-statistical difference from midfielders; c-statistical difference from forwards.

No differences are found between the ages of soccer players according their playing position. Midfielders are shorter and lighter than defenders and forwards with moderate effect size.

Table 2 presents the results of absolute peak torque of soccer players according to their playing positions.

Table 2

Comparisons of knee extensors and flexors absolute peak torque of the dominant (D) and non-dominant (ND) leg of soccer players according to playing position

Action	Defenders (n=40)	Midfielders (n=41)	Forwards (n=21)	ANOVA probability of significance
Extensors con 300°/s D	127.1±18.8	124.2±19.7	130.2±17.8	0.489
Extensors con 300°/s ND	128.2±20.2	124.0±16.0	130.4±18.8	0.370
Flexors con 300°/s D	82.0±14.4	81.3±13.4	87.3±14.8	0.258
Flexors con 300°/s ND	79.1±15.5	79.7±13.1	86.5±13.9	0.134
Extensors con 60°/s D	246.4± 37.0[b]	220.1±41.5[ac]	248.1±36.6[b]	0.004
Extensors con 60°/s ND	240.0± 33.8[b]	218.6±36.7[ac]	253.5±35.3[b]	0.001
Flexors con 60°/s D	156.6±27.4[b#]	137.9±24.7[ac]	162.3±30.4[b]	0.001
Flexors con 60°/s ND	149.4±25.4	137.0±23.5[c]	155.4±24.0[b]	0.011
Extensors ecc 60°/s D	309.7±50.8[b]	265.4±61.5[ac]	316.2±55.6[b]	0.001
Extensors ecc 60°/s ND	300.6±47.1[b]	267.7±56.5[ac]	309.6±57.8[b]	0.005
Flexors ecc 60°/s D	185.5±37.0 [#]	164.4±40.7	184.3±38.7	0.042
Flexors ecc 60°/s ND	173.7±32.9	160.4±33.8	177.2±41.1	0.133

a-statistically significant difference from defenders; b-statistically significant difference from midfielders; c-statistically significant difference from forwards; # statistically significant difference from non-dominant leg.

Midfielders absolute peak torque of extensors are smaller than defenders (p=0.009; d=0.67) and forwards (p=0.026; d=0.72) at angular velocity 60°/s in concentric mode of dominant leg. Similar results are revealed on non-dominant leg, where midfielders' absolute peak torque of extensors is smaller than defenders (p=0.023; d=0.61) and forwards (p=0.001; d=0.97) at angular velocity 60°/s in concentric mode. Midfielders absolute peak torque of flexors is smaller than defenders (p=0,007; d=0.72) and forwards (p=0,003; d= 0.89) at angular velocity 60°/s in concentric mode of dominant leg. Midfielders' absolute peak torque of flexors is smaller than forwards (p=0,018; d=0.77) for non-dominant leg.

The tests in eccentric mode revealed similar results as in concentric mode for extensors. Midfielders absolute peak torque of extensors are smaller than defenders (p=0.003; d= 0.79) and forwards (p= 0.004; d= 0.84) for dominant leg. There is the same differences between positions for non-dominant leg, midfielders' absolute peak torque of extensors is smaller than defenders (p=0.025; d=0.64) and forwards (p=0.014; d=0.73). No statistically significant differences are found between playing positions of soccer players at angular velocity 300°/s.

There are no statistically significant differences between dominant and non-dominant leg in most cases. Only defenders have stronger flexors of dominant leg compared to non-dominant leg at angular velocity 60°/s concentrically (p=0.013; d=0.27) and eccentrically (p=0.011; d=0.34).

Table 3 presents the results of relative peak torque of soccer players according to their playing positions.

Table 3

Comparisons of knee extensors and flexors relative peak torque of the dominant and non-dominant leg of soccer players according to playing position

Action	Defenders (n=37)	Midfielders (n=39)	Forwards (n=21)	ANOVA probability of significance
Extensors con 300°/s D	1.62±0.18	1.71±0.23	1.62±0.12	0.078
Extensors con 300°/s ND	1.63±0.19	1.71±0.17	1.63±0.16	0.119
Flexors con 300°/s D	1.04±0.15	1.12±0.15	1.09±0.15	0.094
Flexors con 300°/s ND	1.02±0.15	1.10±0.14	1.09±0.14	0.055
Extensors con 60°/s D	3.14±0.39	3.02±0.43	3.09±0.30	0.348
Extensors con 60°/s ND	3.06±0.34	3.00±0.40	3.16±0.23	0.262
Flexors con 60°/s D	1.99±0.27 #	1.90±0.29	2.03±0.34	0.169
Flexors con 60°/s ND	1.90±0.25	1.88±0.25	1.95±0.28	0.634
Extensors ecc 60°/s D	3.96±0.59	3.63±0.74	3.82±0.66	0.064
Extensors ecc 60°/s ND	3.84±0.57	3.66±0.64	3.77±0.59	0.324
Flexors ecc 60° D	2.36±0.41 #	2.25±0.50	2.31±0.46	0.584
Flexors ecc 60° ND	2.21±0.37	2.20±0.40	2.21±0.40	0.972

statistically significant difference from non-dominant leg.

No statistically significant differences are found in relative peak torque of knee extensors and flexors by playing position of soccer players. Differences were found only between dominant and non-dominant leg in flexors of defenders, where dominant leg has higher peak torque than non-dominant leg in concentric mode (p=0.012; d=0.35) and in eccentric mode (p=0.010; d=0.38)

Table 4 shows soccer players knee extensors and flexors peak torque deficit between legs by playing position.

Table 4

Comparisons of soccer players knee extensors and flexors peak torque deficit between legs by playing position

Action	Defenders (n=37)	Midfielders (n=39)	Forwards (n=21)	ANOVA probability of significance
Extensors con 300° DEF	6.4±6.0	5.8±4.8	5.5±3.8	0.783
Flexors con 300° DEF	5.6±18.4	2.4±9.4	1.7±14.7	0.506
Extensors con 60° DEF	8.6±5.9	9.5±6.9	7.7±6.9	0.569
Flexors con 60° DEF	10.6±7.7	8.9±7.7	8.6±6.8	0.496
Extensors ecc 60° DEF	8.6±7.2	11.1±9.4	11.6±7.9	0.302
Flexors ecc 60° DEF	12.6±9.1	10.8±10.1	11.5±6.7	0.718

No statistically significant differences are found in bilateral deficit of soccer players according to their playing position. No statistically significant differences are found also between knee extensors and flexors deficit by playing position. It is observed that the standard deviations of these indicators are large, especially for knee flexors.

Table 5 is showing the results of H/Q ratios of the dominant and non-dominant leg of soccer players by playing position.

Table 5

Comparisons of H/Q ratio of the dominant and non-dominant leg of soccer players according playing position

Action	Defenders (n=37)	Midfielders (n=39)	Forwards (n=21)	ANOVA probability of significance
Hcon/Qcon 300 ratio D	0.65±0.08	0.66±0.08	0.67±0.08	0.523
Hcon/Qcon 300 ratio ND	0.63±0.09	0.64±0.08	0.67±0.09	0.197
Hcon/Qcon 60 ratio D	0.64±0.09	0.63±0.09	0.66±0.10 #	0.639
Hcon/Qcon 60 ratio ND	0.64±0.08	0.63±0.08	0.62±0.09	0.849
Hecc/Qecc 60 ratio D	0.60±0.09	0.64±0.1	0.61±0.1	0.173
Hecc/Qecc 60 ratio ND	0.58±0.10	0.60±0.08	0.60±0.08	0.536
Hecc/Qcon 60 ratio D	0.76±0.12	0.76±0.16	0.77±0.13	0.947
Hecc/Qcon 60 ratio ND	0.73±0.13	0.76±0.14	0.72±0.12	0.529

statistically significant difference from non-dominant leg

No statistically significant differences are found between soccer players and playing positions in H/Q ratio. Statistically significant differences are found between dominant and non-dominant leg in H/Q ratio of forwards, where H/Q ratio of dominant leg was higher.

Discussion

The purpose of this study is to compare knee muscle strength and muscle strength balance of soccer players playing in different positions. The following strength parameters are compared: knee extensors and flexors absolute and relative peak torque, bilateral strength balance and H/Q ratio. There are specific demands for players in different positions during the soccer matches (Bangsbo et al., 1991, Mohr et al., 2003, Di Salvo et al., 2007) and depending on this players with different specialities may have different morpho-functional properties (Bloomfield et al., 2007). We find differences between soccer players of different playing position in anthropometrical characteristics such as body height and mass. Findings of this study are well in line with the previous study where the midfield players were lighter and defenders were heavier and taller than other players

(Tourny-Chollet et al., 2000; Hencken & White, 2006; Haugen, 2013, Nikolaidis et al., 2014).

We find also some differences between player positions in absolute strength level (measured as peak torque), but no differences in strength values normalized with body mass. The findings of our study are partly in line with the previous study by Tourny-Chollet et al. (2010) that finds that midfielders' relative peak torque values in low angular speed (60°/s) are statistically significantly lower than the values of defenders and attackers. Our study does not find any differences between playing positions in relative peak torque, but we find that midfielders have statistically significantly lower absolute peak torque values than players at other positions. Like in previous study we find the same result in high angular velocities (240° and 300°), there are no statistically significant differences between relative peak torque values for players from different position.

The skill of two-footed play and asymmetrical musculoskeletal loading is causing functional asymmetry which is related to larger injury risk (Brady et al., 2001, Fousekis et al., 2010). Study by Tourny-Chollet et al. (2000) finds that hamstring muscles of midfielder and forward dominant leg are statistically significantly stronger than the non-dominant leg in concentric mode. No statistically significant differences between playing positions are found for extensors in eccentric mode. These findings are partly in line with findings of our study. We find also that the extensors of the dominant leg are statistically significantly stronger than the extensors of the non-dominant leg at low angular speed (60°). Like in previous study we do not find any differences in extensors.

The main difference between previous study and this one is that we find differences for the group of defenders. Results of our study are supported by previous study (Fonseca et al., 2007) where no statistically significant differences are found between dominant and non-dominant leg extensors, but statistically significant differences are revealed between knee flexors. Knee flexors of the dominant leg are stronger than those of the non-dominant leg. The probable reason why the dominant leg is stronger than the non-dominant leg is that soccer players are using their dominant leg more for shooting and passing. Knee flexors have to slow the limb down at the end of the shooting and passing movement, where they are working in eccentric mode. We find more differences between the dominant and the non-dominant leg eccentric mode, Cohen d values are higher in the eccentric mode compared to the concentric mode. There are some reasons why the differences between dominant and non-dominant leg revealed only among defenders. They play soccer using their dominant leg most of the time; they are holding a ball on a side where they are playing. The second reason can be that defenders have to often do long passes and crosses, and they are using the dominant leg for these activities.

The results described above show that only defenders had some direction specific differences between the dominant and the non-dominant leg, but the results of absolute and non-directional symmetry between body sides have not been discussed. Results of this study are not in line with the previous study by Ruas et al. (2015) where they find statistically significant differences between muscular asymmetry and playing position. This previous study finds that forwards have statistically significantly higher hamstring muscles asymmetry than defenders and midfielders. Our study does not reveal any differences between playing positions in bilateral symmetry. There are many authors who find that if the bilateral asymmetry is more than 10% (Fonseca et al., 2010, Rahnama et al., 2005, Daneshjoo et al., 2013) or 15% (Croisier et al., 2003; Geofitsidou et al., 2003) it reduces performance and increases the risk of injury. Soccer players with untreated strength imbalances before the season had significantly higher rate of muscle injury than players with no imbalances (Croisier et al., 2008). We do not find statistically significant differences between playing positions in bilateral strength deficit. We find that the average bilateral deficit value is around 10%, which is in the same magnitude as in the previous study (Ruas et al., 2015). We observe the smallest differences between the dominant and the non-dominant leg at 300°/s (1.7-6.4 %), while the largest differences between the dominant and the non-dominant leg are at angular velocity 60 °/s, ranging between 7.7% and 12.6%. One reason why soccer players bilateral deficit is not statistically significantly different between playing positions is that the nowadays soccer is a very dynamic game, more or less all players are dealing with attacking and defending. For example, side backs are defence players, but they turn on to attacks more often.

It is well known that the balance between hamstring and quadriceps, like bilateral asymmetry discussed above, is important for preventing non-contact injuries. Most common H/Q ratio value is 0.6 at angular velocity 60°, which is a "normal" value (Coombs & Garbutt, 2002; Fonseca et al., 2007). Previous studies find that mixed H/Q ratio (eccentric flexors and concentric quadriceps) less than 0.8 refers to muscular abnormalities; and mixed ratio lower than 0.6 is the best predictor of previous hamstring injuries (Croisier et al., 2003, Dauty et al., 2003). The average value of H/Q ratios is more than 0.6 in this study in both concentric and eccentric mode, but mixed ratio is lower than 0.8. We find no statistically significant differences between playing position in H/Q ratio. Statistically significant differences are revealed only between the dominant and the non-dominant leg H/Q ratio for forwards, where the ratio was higher in dominant leg. The reason why forwards dominant leg H/Q ratio is higher than the non-dominant leg H/Q ratio can be that soccer players are using their dominant leg for most cases like set piece and shot to the goal in training and in competitions (Carey, et al. 2001) and this is more common for forwards. The mechanism is the same as we describe above, the hamstring muscles have to decelerate the leg at the end of movements; and that is why the hamstring muscles get the load that makes these stronger and the H/Q ratio higher.

In sum, we can say that midfielders have lower absolute strength level that at least partly is related with their lower body mass. We find no players' position specific differences in muscle balance parameters, while defenders have stronger dominant side and have direction-specific differences in knee flexors strength at lower testing speeds in concentric and eccentric mode. We find also that forwards demonstrated higher unilateral strength balance of the dominant leg in low concentric speed.

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