Journal of Physical Education and Sport ® (JPES), 11(3), Art 47, pp.306 - 312, 2011
online ISSN: 2247 - 806X; p-ISSN: 2247 – 8051; ISSN - L = 2247 - 8051 © JPES

Original Article

Differences between isokinetic strength characteristics of more and less successful professional soccer teams

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Acknowledgements: This study was supported by GACR P407/11/P784 and MSM 0021620864

Published online:: September 25, 2011
(Accepted for publication September 05 2011)

Abstract

Purpose

The aim of the study was to compare the level of isokinetic strength of knee extensors (KE) and flexors (KF) and ratio of knee flexors (H) vs. extensors (Q) muscle strength of the dominant lower limb in two professional soccer teams of differing performance level.

Material and method

The tested groups consisted of professional soccer players of the highest league in the Czech Republic (n = 40 players). The players were divided into two groups according to the score in the overall table. The first group was composed of players who were placed in the second place in overall table (n = 22) and the second team consisted of players whose team were third bottom (n = 18). Maximum peak muscle torque of KE and KF and their mutual ratio (H:Q) were assessed during concentric contraction at different velocities by means of an isokinetic dynamometer.

Results

The results of the study did not show any significant differences between the tested groups in the level of KE and KF strength ($p>0.05$). Contraction velocity indicated significant influence on the level of KE and KF strength ($p>0.05$). Contraction velocity did not significantly effect ipsilateral ratio between H and Q thigh muscles ($p>0.05$). Similarly, no significant difference was found in this ratio between both tested groups ($p>0.05$). Values of H:Q ratio that indicate an increased predisposition to injury were found in four players.

Discussions and conclusions

The results of the study suggest that, in the case of professional players of the same league level (regardless of score in the table), the level of indicators of thigh muscle isokinetic strength is comparable.

Key words: knee extensor, knee flexor, strength asymmetries, elite sport

Introduction

Testing of strength abilities in elite athletes by means of isokinetic dynamometry has been used since approximately 1960 (Wrigley & Strauss, 2000). Testing of muscle strength in the area of knee joint belongs to the most commonly measured areas in the population (Hoffman, 2006). Maximum peak muscle torque is a reliable indicator of muscle activity both in the intact (healthy, undamaged) knee and after injury.

Identified outputs of peak muscle torque of particular muscle groups near to the knee joint determine the measure of integrity and stability of the joint (Hoffman, 2006).

Bilateral (right vs. left) or unilateral (agonist – antagonist) comparison of muscle group strength may reveal potentially weak points, which increase the risk of injury of the athlete (Baratta et al., 1988; Knapik, Bauman, Jones, Harris, & Vaughan, 1991; Lin et al., 2010).

Isokinetic testing may be used for the assessment of front and back thigh muscle strength; it provides information on the determination of the size of generated muscle peak torque and also their mutual ratio H (hamstring) : Q (quadriceps) (Rosene, Fogarty, & Mahaffey, 2001). H:Q ratio is used to determine similarities between the compared muscle groups in terms of speed-strength protocol and to assess the knee functionality and muscle balance of particular muscle groups (Holmes & Alderink, 1984; Li, Maffulli, Hsu, & Chan, 1996).

However, it is difficult to generalize this ratio but some studies indicate its size in the range of 50-80% depending on angular velocity (Kong & Burns, 2010; Rosene et al., 2001). Aagaard, Simonsen, Magnusson, Larsson, & Dyhre-Poulsen (1998) state that H:Q ratio lower than 60% assessed at lower velocities may increase susceptibility to injury for an athlete.

The pressure on players in professional soccer is enormous. Croisier, Ganteaume, Genty, Binet, & Ferret (2006) monitored 617 professional soccer players in the long term. The authors suggest that up to 65% of players return to soccer after muscle injury despite continuous muscle problems. Lehance, Binet, Bury, & Croisier (2009) state

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that 56% of elite and professional players suffer from risk of muscle asymmetry in the area of the knee joint.
Isokinetic strength testing at low velocity of 60°.s^{-1} is used to determine a player's muscle characteristics indicating the possible risk of injury; or, on the basis of particular characteristics, it is possible to detect previous injury to the back thigh muscles (Houweling, Head, & Hamzeh, 2009). Croisier, Ganteaume, & Ferret (2005) mention a four times higher risk of injury in professional players who undertook the measurement of isokinetic strength before the season and did not work on removal of muscle imbalances compared to players who tried to compensate these imbalances.
Some studies declare higher strength in professional players in comparison to players of lower performance level (Cometti, Maffiuletti, Pousson, Chatard, & Maffiulli, 2001; Gissis et al., 2006). On the contrary, Metaxas, Koutlianos, Sendelides, & Mandroukas (2009) did not find any significant differences in isokinetic strength during concentric contraction in players of different performance levels of the Greek league (1st to 4th league) at three different velocities (60, 180 and 300°.s^{-1}).
Isokinetic strength testing should become a part of a player's diagnostics before a preparatory period aimed at determining both the level of strength predispositions and strength asymmetries of knee extensors and flexors (Croisier et al., 2005; Fousekis, Tsepis, & Vagenas, 2010).
The aim of our study was to compare the level of extensors and flexors isokinetic strength and H:Q ratio in two professional soccer teams of different performance level in one competition.

Material and method

Study sample

The monitored groups were composed of professional soccer players of the highest league in the Czech Republic (n = 40 players). The players were divided into two groups according to their score in the overall table. The first group consisted of a team which was in second position in the overall table and plays regularly in European competitions (Champions league or UEFA – *Union of European Football Associations* cup) (n = 22, age = 24.8±4.7 years, body height = 185.5±5.0 cm, body weight = 80.9±6.4 kg). The second groups consisted of players whose team were third bottom (n = 18, age = 23.9±4.4 years, body height = 182.0±5.6 cm, body weight = 76.9±6.2 kg).

Assessment of strength parameters

Isokinetic strength parameters were measured by means of isokinetic dynamometer Cybex Humac Norm (Cybex NORM ®, Humac, CA, USA). We detected maximum peak muscle torque (PT) of knee extensors and flexors in the dominant extremity during the concentric contraction at five different angular velocities of the movement (60, 120, 180, 240 and 330°.s^{-1}). We also monitored the ipsilateral ratio between knee flexors (H) and extensors (Q) (H:Q ratio). The testing procedure from the lowest to the highest velocity was standardized and recommended by the authors Wilhite, Cohen, & Wilhite (1992). Reliability of PT and total work was higher than 0.90 at three tested velocities - 60,120 and 180°.s^{-1} (Impellizzeri, Bizzini, Rampinini, Cereda, & Maffiuletti, 2008).
The participant sat on the seat of an isokinetic dynamometer with the trunk and thigh of the tested extremity fixed by means of fixing straps because of the isolation of the examined movement. For each participant we adjusted 90° range of motion (the maximum extension was set as the „anatomic zero - 0°"). The motor axis of dynamometer was visually aligned (by means of laser point) with the axis of the knee joint of the leg. Torque was corrected for gravity at each velocity for determination of maximum PT which is part of testing software. Before the testing, participants completed a short warm-up (jogging 3 min, individual stretching, 3 series / 3 repetitions of vertical jumps and 2 series / 10 repetitions of dynamic half-squats). The participant's task was to generate maximum strength in concentric muscle contraction during 5 tested repetitions. Between the tested velocities there was a break with passive rest of 1 minute (Rahnama, Lees, & Bambaecichi, 2005).
Prior to each velocity, participants had 4 untested attempts. The participant held the side handles of the device during the test. Visual feedback and verbal stimulation were given to all participants during the measurement.
Study was approved by ethical committee of Faculty of Physical Education and Sport, Charles University in Prague and measurement were performed according to the ethical standards of the Helsinki Declaration.

Statistical analysis

Results of isokinetic strength are presented in relative values (a ratio of absolute value and player's body weight). Two–Way analysis of variance ANOVA 2x5 (performance level * movement velocity) was performed to examine significance of differences in the monitored parameters. The dependent variable was maximum peak muscle torque of knee extensors and flexors and their mutual ratio (H:Q ratio). A null hypothesis was rejected with a risk of $p<0.05$. Effect size was assessed using the „Eta square" coefficient (η^2), which explains the proportion of variance of the monitored factor. Effect size was examined as follows: $\eta^2=0.20$ – a small effect, $\eta^2=0.50$ – medium effect and $\eta^2=0.80$ – large effect (Cohen, 1992).

The statistical software IBM® SPSS® 19.0 version was used for processing the results. Results are expressed as arithmetic mean ± standard deviation.

Results

Isokinetic strength of knee extensors was not significantly different between the tested groups ($F_{1, 190} = 0.01$, $p>0.05$, $\eta^2 = 0.00$). The produced strength of knee extensors significantly reduced with increasing velocity (Figure 1) ($F_{4, 190} = 263.88$, $p<0.001$, $\eta^2 = 0.85$). Post hoc tests indicated significant differences in strength produced at each of the tested velocities. The effect of examined factors interaction (performance level * movement velocity) was not significant ($F_{4, 190} = 0.52$, $p>0.05$, $\eta^2 = 0.00$).

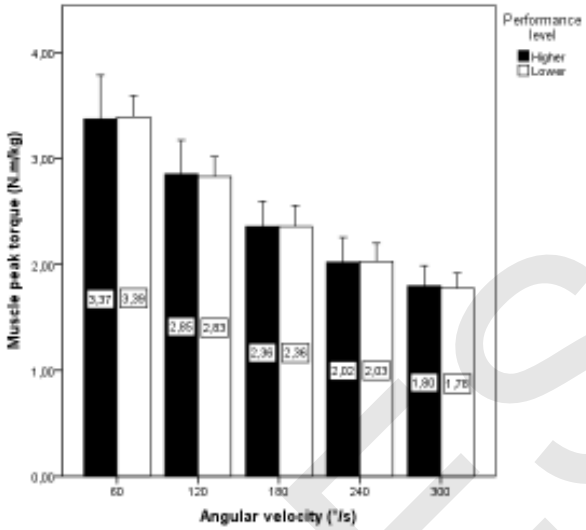

Figure 1 Comparison of knee extensor isokinetic strength in the tested groups

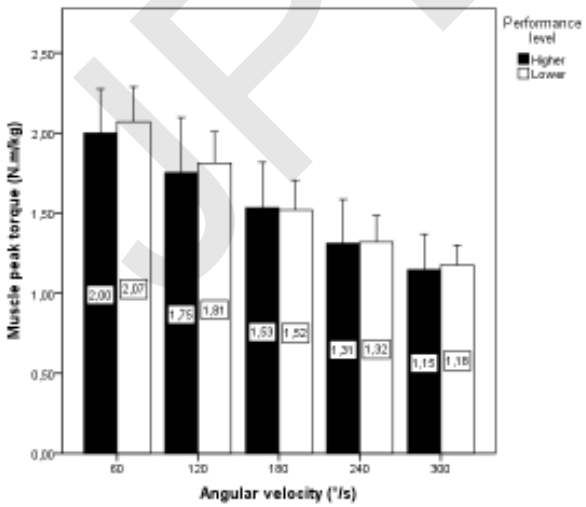

Figure 2 Comparison of knee flexors isokinetic strength in the tested groups

The criterion of performance level did not show significant differences in knee flexors strength ($F_{1., 190} = 0.803$, $p>0.05$, $\eta^2 = 0.00$). Significant differences were found in the examined depended variable at various velocities ($F_{4, 190} = 83.00$, $p<0.001$, $\eta^2 = 0.64$). With increasing velocity, we registered gradual decrease in knee flexors strength production (Figure 2). The effect of interaction of the examined factors was not proved ($F_{4, 190} = 0.200$, $p>0.05$, $\eta^2 = 0.00$).

Ipsilateral ratio (H:Q ratio) between knee flexors and extensors was 0.60 for the higher-performance group and 0.61 for the lower-performance group at the lowest velocity (Figure 3). On the other hand, at the highest velocity, it was 0.64 and 0.66. Analysis of variance did not indicate any significant differences between the monitored groups ($F_{1, 190} = 0.725$, $p>0.05$, $\eta^2 = 0.00$). No significant changes in H:Q ratio, depending on the

velocity of the monitored factors, were found ($F_{4, 190} = 1.713$, $p>0.05$, $\eta^2 = 0.04$). Similarly, we did not find any effect of interaction of the examined factors ($F_{4, 190} = 0.130$, $p>0.05$, $\eta^2 = 0.00$).

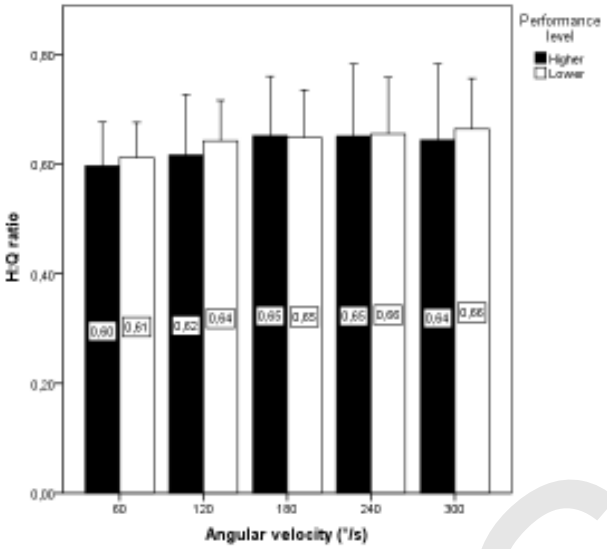

Figure 3 Ipsilateral ratio (H:Q) in the tested groups

Discussion

Players of both monitored groups reached significantly higher values of isokinetic strength at lower velocities compared to higher velocities. These results are in accordance with other studies (Dauty & Potiron-Josse, 2004; Gür, Akova, Pündük, & Kücükoglu, 1999; Malý, Zahálka, & Malá, 2010). This fact is logically explained by means of the relationship between speed of muscle contraction and size of load, which is known as Hill's equation (Hill, 1938). The maximum time available for the contact between actin and myosin filaments reduces with increasing velocity of concentric activity, thus duration of the contact phase reduces in the overall cycle. PT_{E60} in the higher-performance group was 3.37±0.41 $N.m.s^{-1}$ and in the lower-performance group it was 3.39±0.20 $N.m.s^{-1}$. Similar values between the groups were recorded at the highest tested velocity ($PT_{E300} = 1.80$ $N.m.s^{-1}$ resp. $PT_{E300} = 1.78$ $N.m.s^{-1}$).

Rahnama, Reilly, Lees, & Graham-Smith (2003) provide the value $PT_{E60} = 3.10±0.50$ $N.m.s^{-1}$ for amateur players (n = 13). Lower value $PT_{E60} = 3.06±0.44$ $N.m.kg^{-1}$ is mentioned only by Lehance et al. (2009) in elite junior players (1st Belgian league) or $PT_{E60} = 2.98±0.35$ $N.m.kg^{-1}$ in professional players.

Tourny-Chollet, Leroy, Léger, & Beuret-Blanquart (2000) state an even lower value $PT_{E60} = 2.06±0.08$ $N.m.kg^{-1}$ in French amateur players (n=21).

In our study, we did not find any significant differences in the results of knee extensors and flexors isokinetic strength between the tested groups.

Cometti et al. (2001) suggest significantly higher values in knee flexors strength in higher-performance players at velocities from 60° to 240°.s^{-1} in comparison to lower-performance players. The authors did not reveal significant differences in knee extensors strength during concentric activity between groups of different performance level. However, during eccentric contraction of knee extensors, the authors state significantly higher values of muscle peak torque in favour of amateur players.

In the higher-performance group we registered strength decrease caused by velocity (60 vs. 300°.s^{-1}) by 46.9% in extensor muscles strength and by 42.5% in knee flexor muscles strength. Strength reduction in the second group was similar, when extensors strength decreased by 47.5% and flexors by 43.0%. Comparable values are observed in the study by Wong and Wong (2009), who present a decrease in PT_E on the dominant lower extremity by 47% and PT_F by 42% in young Chinese national U17 team players.

Muscular preparedness of the player must be provided not only from the performance, but also from the preventive perspective. Results of a number of studies suggest that significant changes are observed in back thigh muscle groups during eccentric contraction and functional ipsilateral ratio between hamstring and quadriceps (Small, McNaughton, Greig, & Lovell, 2010). This fact may be associated with increased risk of injury in players since approximately half of all injuries (47%) of hamstrings occurred in the last 15 minutes of each half (Woods et al., 2004).

The ratio between knee extensors and flexors muscle strength produced (H:Q ratio) is one of the indicators of player's predisposition to injury.
Kong and Burns (2010) present significantly different H:Q ratio at velocities 60°.s^{-1} vs. 180°.s^{-1}; but insignificant when comparing velocities 180°.s^{-1} vs. 300°.s^{-1}. Players of higher performance level, in our study, achieved H:Q ratio 0.60±0.08 at the lowest velocity and 0.64±0.14 at the highest velocity. The second group reached comparable values (0.61±0.06 and 0.66±0.09). No significant differences were found between the two examined groups.
Gür et al., (1999) state H:Q ratio in elite players (n=13) at velocity of 180°.s^{-1} = 0.61±0.07, H:Q_{240} = 0.61±0.08 and H:Q_{300} = 0.63±0.08. Zakas, Mandroukas, Vamvakoudis, Christoulas, & Aggelopoulou (1995) did not find significant differences in H:Q ratio of Greek teams of four league levels. However, the authors carried out the measurements only at two angular velocities 60 and 180°.s^{-1}.
Cometti et al., (2001) indicate significantly higher H:Q ratio in higher-performance players (1st league) in comparison to 2nd league players only at the lowest movement velocity of 60°.s^{-1} ($p<0.05$).
The results of the studies mentioned above are difficult to compare with our study, since in our research, differences in performance level are lower (1st league teams) than those in the studies published by other authors (different leagues).
(Croisier et al., 2003) present the critical value of H:Q ratio for professional soccer players 0.47, which represents a risky strength asymmetry between the compared groups. In our study, four players (all from higher performance group) reached H:Q value lower than the mentioned critical value, at least at one of the tested velocities. This result indicates the necessity to improve knee flexors muscle strength in these players.
Results of study by Fousekis et al. (2010) suggest that long-term training in soccer causes strength asymmetries of different characters and degrees. Out of 100 professional players tested, only 11% did not show strength asymmetry in 14 examined parameters. In contrast, up to 20% showed 4-7 strength asymmetries. Increase of knee flexors strength in players is published by De Proft, Cabri, Dufour, & Clarys (1988), who present up to 77% increase in maximum peak muscle torque by including two strength training units per week. It is considered, that knee flexors strength is not sufficiently stimulated by the game (Cometti et al., 2001) or traditional model of soccer players' preparation (Botek et al., 2010). Mjølsnes, Arnason, Østhagen, Raastad, & Bahr (2004) present better results in knee flexors strength increase during eccentric contraction than during concentric contraction.
Based on the literature sourced, our knowledge and experience, the following main objectives in diagnostics of strength predispositions appear: conditionality of strength abilities in relation to performance in sport discipline or another parameter, monitoring of strength indicators in players and its comparison with the relevant standards, monitoring of the training process in the field of strength preparation, identification of strength imbalances and determination of potential risk for injury, monitoring of the rehabilitation process after injury.
Some results of our study are in accordance with results of other studies; however some of them are in contrast. One of the possible reasons could be the label „elite soccer players" for different types of players' performance level (players of international level, 1st division players, professional players of the third league, etc.). Another possible cause of divergent results could be differences in methods used for obtaining research data (warm-up methods, testing on the isokinetic dynamometer with arms crossed on the chest or holding the handles, verbal motivation and visual feed-back provided etc.).

Conclusions

The results of the study did not indicate significant differences between the tested groups in the level of muscle strength of knee flexors and extensors during concentric contraction at five different angular velocities of the movement. Speed of contraction showed a significant influence on the level of knee extensors and flexors strength produced. Speed of contraction did not significantly effect the change in ipsilateral ratio between the front and back thigh muscle groups. Similarly, no significant difference was found in this ratio between the examined groups.
Four players reached H:Q values indicating higher predisposition to injury. Our results suggest that, in the case of professional players of the same league level, the level of isokinetic strength indicators is comparable. For this reason, it is essential to deal with other issues of strength abilities in terms of their influence on players' performance with the aim of explaining a more and less successful team (the question of strength abilities transfer into speed, strength-speed and specific locomotion actions).

This project was supported by GACR P407/11/P784 and MSM 0021620864

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