ISOKINETIC STRENGTH PERFORMANCE PROFILE OF YOUNG NATIONAL SOCCER PLAYERS

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Abstract
The aim of the study was to determine the profile of muscular strength and strength asymmetries of national male soccer players (n = 25, age = 15.6 ± 0.2 years, body height = 177.4 ± 6.8 cm, body mass = 67.0 ± 7.7 kg).The muscular strength of the lower limbs was assessed using a CybexHumac Norm isokinetic dynamometer (Cybex NORM ®, Humac, CA, USA). The maximum peak muscle torque of the knee extensors (PT_E) and flexors (PT_F) of the dominant (D) and non-dominant leg (N) during concentric contraction were measured at several angular velocities of movement (60, 120, 180, 240 and 300 °/s). The muscular strength of knee extensors and flexors were significantly reduced with increasing movement velocity in both extremities ($p<0.05$). Significant differences were found between muscle strength of extensors at 240 and 300 °/s, and flexors at the lowest velocity ($p<0.05$). Hamstring to quadriceps ratio (H:Q) between legs at 240 °/s was significantly different ($p<0.05$).Our study indicated that almost 60 % of young male players have at least one strength asymmetry (bilateral knee flexor or quadriceps) regardless of their limb's preferences. Screening examination of muscle strength asymmetries is a useful tool for prevention of muscle injuries in young soccer players. The strength asymmetries represent a potential risk of a player's injury; therefore the detected asymmetries should be systematically monitored and compensated using specific exercises.

Key words: *testing, training, isokinetic strength, strength imbalances, injury prevention*

Introduction

Since the game of soccer frequently involves one-sided activities such as kicking, tackling and passing, asymmetries in muscle strength between both legs are possible. Muscle strength is an important component of player's physical fitness. Its level and balance determines player's physical performance and eliminates the risk of injury (Lehance, Binet, Bury & Croiser, 2009). Combination of cyclic and acyclic movements in irregular (intermittent) intervals and preferring one of the extremities may lead to strength asymmetries. These asymmetries may results in large changes in myodynamic characteristics of the muscle, particularly in the dominant leg (Fousekis, Tsepis & Vagenas, 2010). Knapik, Bauman, Jones, Harris and Vaughan (1991) reported, that the athletes with muscle strength imbalances higher than 15% at bilateral comparison of extremities had 2.6-times higher frequency of injuries when compared to athletes who had this difference lower than 15%. Testing lower limbs strength is very important in soccer when muscle groups must generate and absorb high forces during acceleration, deceleration, jumping, kicking, turning, tackling, changes of direction. Comparing muscle strength from bilateral limbs or from agonist and antagonist may find a potential weakness that can predispose the player to injury. Testing of isokinetic strength provides an objective approach in diagnostics and simpler quantification of muscular strength. Croisier, Roisier, Ganteaume & Ferret (2005) reported that the isokinetic strength assessment before the start of the season enables identification of strength indicators as predictors of possible muscle injury. Lehance et al. (2009) present a higher proportion of muscle strength imbalances in young soccer players in comparison to senior players. Muscular strength tested on an isokinetic dynamometer belongs to the most widely used methods of the identification of knee extensors and flexors strength and its parameters in soccer players in terms of both identification of player's physical fitness – strength abilities and prevention of injury. Identified outputs of peak muscle torque (PT) of particular muscle groups near to the knee joint determine the measure of integrity and stability of the joint. Several studies (Lehnert, Xaverova & De Ste Croix, 2014; Maly, Zahalka, Mala & 2010; 2011; 2014; Rahnama, Lees, & Bambaecichi, 2005) dealt with examining differences in PT from the viewpoint of age, limb dominancy, performance level or seasonal variation. However, the some of them used absolute values, or in other words, they did not further analyse factors determining strength differences (determinants, strength imbalances, strength asymmetries etc.) in young national level soccer players. The strength and functional asymmetries are often caused by unilateral and uncompensated load of the body and result in maladaptive effects (Maly, Zahalka, & Mala, 2010). However, they were not found in very young soccer players (Maly, Zahalka, Mala, & Teplan, 2013). The aim of the study was to determine the profile of muscular strength and strength asymmetries of national male soccer players.

Methods

Study sample
The screened sample consisted of twenty five national male soccer players (age = 15.6 ± 0.2

years, body height = 177.4 ± 6.8 cm, body mass = 67.0 ± 7.7 kg). Concerning the playing positions, the following players were assessed: 3 goalkeepers, 5 fullbacks, 5 central midfielders, 8 wide midfielders and 4 attackers. Testing took place in the national soccer training camp during the competitive period. Participants recruited were not injured or rehabilitating from injury at time of testing.

Assessment of strength indicators

Assessment was performed on the isokinetic dynamometer CybexHumac Norm(Cybex NORM ®, Humac, CA, USA). Following parameters were obtained in concentric contraction during five velocities (60,120,180, 240 and 300°/s) for dominant (D) and non-dominant leg (N): Peak torque (PT), quadriceps (Q_D:Q_N) and hamstring (H_D:H_N) ratio, ipsilateral ratio between H and Q for both legs (H_D:Q_D; H_N:Q_N).The testing protocol consisted of three attempts at knee flexion and extension at the monitored velocities (from the lowest to the highest velocity). Before testing at each velocity, the participants completed 4 training trials at submaximal intensity.The research was approved by the Ethical Committee of the Faculty of Physical Education and Sports at Charles University in Prague. Measurements were carried out in accordance with the ethical standards of Declaration of Helsinki and ethical standards in sport and exercise science research (Harriss& Atkinson, 2011).

Statistical analysis

We used the methods of descriptive statistics (arithmetic mean - as a measure of central tendency and standard deviation and standard error of the mean - as measures of variability). The statistical significance between limbs or muscle groups was determined using the Student's *t*-test for dependent samples which was preceded by analysis of variance identity based on an *F*-test.

Significant differences in the monitored strength indicators depending on the performed angular velocity were evaluated by the analysis of variance for repeated measurements (RM ANOVA 1x5), which compares the variance of within-groups effects. Determination of strength parameters significance between the individual velocities was then conducted using the multiple comparison of means (Bonferonni's*post-hoc* test). Statistical analysis was performed using IBM® SPSS® v21 (Statistical Package for Social Science, Inc., Chicago, IL, 2012).

Results

The muscular strength of knee extensors and flexors were significantly reduced with increasing movement velocity in knee extensors (Dominant leg: $F_{4,96}$ = 425.2; p = 0.00, η^2 = 0.95, Non-dominant leg: $F_{4,96}$ = 456.8; p = 0.00, η^2 = 0.95) and knee flexors (Dominant leg: $F_{4,96}$ = 175.4; p = 0.00, η^2 = 0.88, Non-dominant leg: $F_{4,96}$ = 411.7; p = 0.00, η^2 = 0.82), (Figure 1, Figure 2).

With increasing angular velocity the bilateral differences were not significant (Q:Q ratio: $F_{4,96}$ = 0.31; p = 0.87, η^2 = 0.01, H:H ratio: $F_{4,96}$ = 0.13; p = 0.97, η^2 = 0.01) (Figure 3). However, we find the significant difference between Q:Q difference (5.92 %) compare to H:H difference (9.04 %) at 180 °/s. The ipsilateral ratio (H_D:Q_D or H_N:Q_N) respectively, significantly changed during increasing velocity (dominant limb: $F_{4,96}$ = 7.59; p = 0.00, η^2 = 0.24, Non-dominant leg: $F_{4,96}$ = 4.99; p = 0.00, η^2 = 0.17) (Figure 4). H_D:H_Q at the lowest velocity was significant when compared to each other velocity (p<0.05). H_N:Q_N at 60°/s was different in comparison to H_N:H_Q at 120 or 300°/s, respectively.

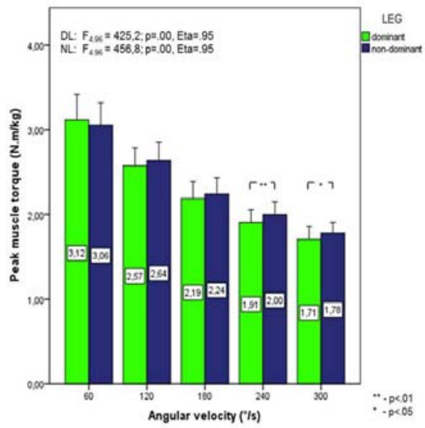

Figure 1.Peak muscle torque of knee extensors in relative values (N·m·kg^{-1}).

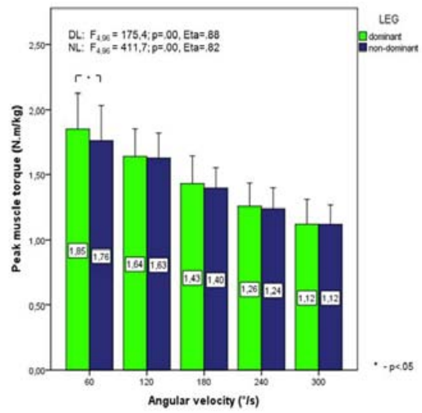

Figure 2. Peak muscle torque of knee flexors in relative values (N·m·kg^{-1}).

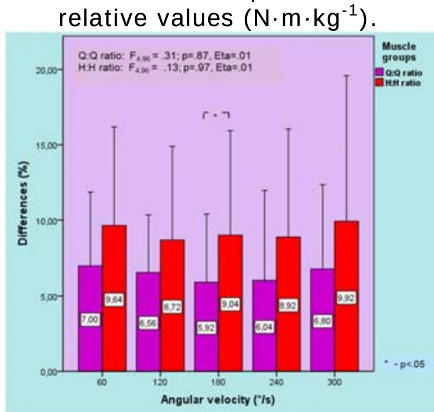

Figure 3.Bilateral ratio between peak muscle torque of extensors (Q:Q) and flexors (H:H)

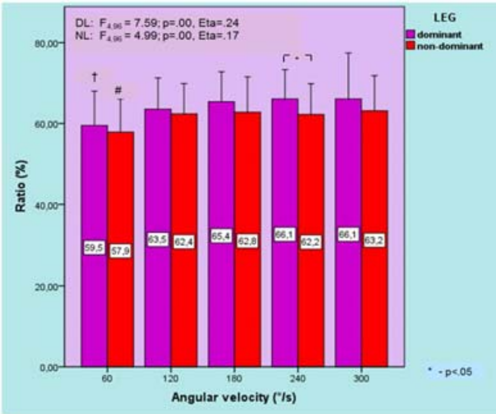

Figure 4. Unilateral ratio between peak muscle torque of knee flexors and extensors (H:Q)

Discussion

The level of muscle strength declined with increasing velocity in both preferred and non-preferred lower extremities. Generally, muscle strength, which the muscle is able to exert, decreases with increasing velocity of the movement in the concentric contraction. This relationship between muscle strength and speed of contraction is known as the Hill's curve (Hill, 1938). One of the explanations of this relationship is that the maximum time available for the contact between actin and myosin filaments reduces with increasing velocity of concentric activity (Huxley model), thus duration of the contact phase reduces in the overall cycle. Cross-bridges have to be re-released shortly after their connection without sufficient time to produce power, so the share of combined bridges in the muscle declines and the produced strength is lower (Wirth & Schmidtbleicher, 2007). The knee extensor strength in the dominant leg, exerted on the isokinetic dynamometer by our participants, was PT_{E60}=3.12 ±0.31 N·m·kg^{-1} at the lowest velocity and PT_{E300} = 1.71 ± 0.17 N·m·kg^{-1} at highest velocity. Differences between them is 1.41 N·m·kg^{-1}(45.2 %). The results of our study are in line with other research. Kellis, Gerodimos, Kellis & Manou (2001) indicate values of 2.92±0.29 N·m·kg^{-1} in young Greek players and atthe lower performance level. Newman et al. (2004) reported values.Our players exerted more muscle strength in knee extensors in the nondominant leg compared to the dominant leg at higher velocities (240 and 300°.s^{-1}). It could be due to adaptation effect of jumping leg (non-dominant) compare to kicking leg (dominant leg). Lehance et al. (2009) and Kelliset all. (2001) also reported the results when soccer players reached higher values in the non-preferred leg at least at one of the measured velocities. Rahnama et al. (2005) did not find any significant differences in knee extensor strength between the preferred and non-preferred legs at three different velocities (60, 120, 300 °/s) in elite soccer players.In our study, we found out statistically significant difference between the muscle strength of flexors in both legs exerted at the lowest velocity (60°/s) in favour of dominant leg ($p<0.05$).

The difference between muscle strength at the highest and lowest velocity is 39.5% in the preferred leg and 36.4% in the non-preferred leg. Our results are in line with Maly et al. (2010) when author reported in junior players differences 36.4% in the dominant leg and 34.9% in the non-dominant leg. The bilateral ratio was not significantly different from the angular velocity. The same result in professional players has been published by other researchers (Maly et al. 2010; Rahnama et al. (2005)). Croisier et al. (2003) indicate a risk bilateral difference between concentric muscle strength in professional players higher than 15%. In our case, 15 players (60 %) reached this value minimum at one velocity. It is in line with Lehance et al. (2009) who reported that up to 56% of the players are at risk of muscle strength imbalances of knee flexors or extensors. Rahnama et al. (2005) reported that 68% of players had bilateral strength muscle imbalance between the extremities higher than 10% in at least one of the measurements of muscle strength. The higher strength asymmetries were in flexors compare to extensors, particularly at higher velocities, but the key soccer specific activities (shooting, acceleration, deceleration of movement, changes of direction, etc.) are performed especially at high velocity.

The H:Q ratio raised with increasing angular velocity in both preferred and non-preferred extremities. We found out that H:Q ratio was higher on dominant limb compare to non-dominant. It means that non-dominant leg has higher potential to injury and this should be take into account in terms of set-up of strength specific training regimes. The H:Q ratio at lowest velocity revealed the lowest value of H:Q in both legs. The finally, four players reached lower values of H:Q ratio than critical value for professional players (0.47) at velocity of 60°·s^{-1},which means a risk muscle imbalance (Croisier et al. 2003).

Conclussion

The results of this study indicate that the assessment of strength asymmetries in laboratory conditions for young elite soccer players should be useful tool for measurement both strength performance as well as strength asymmetries. Strength imbalances may affect motor performance, potentially leading to stronger limbs in human motor movement.From a practical point of view, we believe that results will be beneficial for fitness coaches, physiotherapists, doctors and other clinical staff in professional soccer.Monitoring of isokinetic muscle strength indicators at the beginning of the preparatory period enables identification of possible muscle strength imbalances, which should be further reduced during the preparatory period. The results are standardised per kilogram of body weight and therefore may serve for comparative purposes for other researchers as well as a base (criterion) of assessment of elite professional soccer players.

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PROFIL IZVEDBE IZOKINETIČKE SNAGE MLADIH NACIONALNIH NOGOMETAŠA

Sažetak

Cilj istraživanja bio je utvrditi profil mišićne snage i čvrstoće asimetrije nacionalnih muških nogometaša (n = 25, dob = 15.6 ± 0.2 godina, tjelesne visine ht = 177,4 ± 6,8 cm, tjelesne mase = 67,0 ± 7,7 kg). Mišićna snaga donjih ekstremiteta procijenjena je pomoću CybexHumac Norm izokinetičkog dinamometra (Cybex NORM ®, Humac, CA, USA). Maksimalni okretni moment vrha mišića ekstenzora koljena (PTE) i fleksora (PTF) dominantne (d) i nedominantne noge (N) tijekom koncentrične kontrakcije mjereni su na više kutnih brzina kretanja (60, 120, 180, 240 i 300 °/s). Mišićna snaga ekstenzora koljena i fleksora su značajno smanjene s povećanjem brzine kretanja u oba ekstremiteta (p <0,05). Dobivene su značajne razlike između mišićne snage ekstenzora na 240 i 300 °/s, a fleksora na najnižoj brzini (p <0,05). Omjer (H:P) tetiva koljena kvadricepsa između nogu na 240 °/s bio je značajno različit (p <0,05). Naša studija pokazuje da je gotovo 60% mladih muških igrača ima barem jednu asimetriju snage (bilaterale koljena istezača ili kvadricepsa), bez obzira na njihovu dominantnu nogu. Praćenje ispitivanja čvrstoće asimetrije mišića je koristan alat za sprečavanje ozljeda mišića u mladih nogometaša. Asimetrija predstavlja potencijalni rizik od ozljeda igrača; Stoga, otkrivene asimetrije treba sustavno pratiti i kompenzirati uporabom posebnih vježbi.

Ključne riječi: *testiranje, trening, izokinetička snaga, snaga disbalansa, prevencija povreda*

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