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Bilateral and reciprocal relation
between extensor and flexor knee strength in football and basketball players

Key words: **Isocinetic strength, balance of muscles, extensor of lower leg, flexor of lower leg, football players, basketball players**
Ključne riječi: **Izokinetička snaga, mišićna ravnoteža, ekstenzor potkoljenice, fleksor potkoljenice, nogometaši, košarkaši**
Original scientific paper

Abstract
The purpose of this study was to examine the peak torque, total work as well as bilateral and reciprocal relation between extensor and flexor muscles of dynamic knee stabilizers. The examinees who took part in this study were students of Faculty of Sport and Physical Education from Sarajevo. 30 of them were active football players and 27 of them were active basketball players. All players had right leg dominant and systematic football as well as basketball activities for about 8 years. The maximal strength of dynamic knee stabilizers was tested at isocinetic equipment (Biodex 3) at angle velocities 60°·s^{-1} and 180 °·s^{-1}. Taking muscles of dynamic knee stabilizers into consideration, this study proves that there are no significant differences among peak torque and total work as well as there are no significant differences in reciprocal relation between agonist and antagonist muscles of right and left leg. These results indicate that trainings and matches of these football and basketball players during the period of training process influenced equal development of these muscles (bilateral and reciprocal relation).

Sažetak
Svrha ovog istraživanja je da ispita maksimalni moment sile, ukupni rad, kao i bilateralni i recipročni odnos ekstenzora i fleksora mišića dinamičkih stabilizatora koljena. Ispitanici koji su sudjelovali u ovom istraživanju su studenti Fakulteta sporta i tjelesnog odgoja u Sarajevu (30 studenata koji se aktivno bave nogometom i 27 studenata koji se aktivno bave košarkom). Svi ispitanici su imali dominantnost desne noge i igrali su aktivno nogomet i košarku 8 godina. Maksimalna jačina dinamičkih stabilizatora koljena testirana je na izokinetičkom instrumentariju (aparata Biodex 3) na ugaonim brzinama veličine 60°/s i 180 °/s. Rezultati ovog istraživanja su pokazali da nema značajnih razlika u maksimalnom momentu, ukupnom radu kod mišića dinamičkih stabilizatora koljena, također nema značajnih razlika koje su evidentirani u recipročnom odnosu mišića agonista i antagonista desne i lijeve noge. Ovi rezultati ukazuju na to da su treninzi i utakmice nogometaša i košarkaša u periodu trenažnog procesa kod obje grupe ispitanika uticale na podjednak razvoj jačine ovih mišićnih grupa, tj. njihovog međumišićnog omjera (bilateralnog i recipročnog).

Introduction

Football and basketball are top sports. Both sports consist of some complex movements which require strenuous efforts such as sudden feints, stops, starts, duels, sprints, jumps etc. (Reilly & Thomas, 1976). These efforts depend at the strength of neuromuscular system, especially on ones of lower limbs (Cometti et al., 2001). Muscles of dynamic knee stabilizers are important in injury prevention as well as in improvement of knee function. Muscles of knee stabilizers are most often injured during football and basketball matches causing prolonged absence from training (Muckle, 1981). There are several factors which contribute to these injures. Some of them relate to imbalance between left and right leg muscles as well as reciprocal relation between muscle groups. Putting stress on one side, like one-legged take off, can cause asymmetry and dominance in one leg, which, as a result, may cause huge differences in strength (Brady et al., 1993). It is proved that weakness of one leg contributes to greater chance of injury (Reilly, 1996). The difference between reciprocal muscle groups (agonist and antagonist muscles of dynamic knee stabilizers) leaves the weaker muscle groups at disadvantage. Hypertrophy of extensor muscles of lower leg comparing to flexors of lower leg can cause flexor injures (Reilly, 1996). High level of capability to use both legs improves skills of football and basketball players.

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There are many contradictory reports concerning comparison of dominant and non-dominant leg. Some researches have reported symmetry between dominant and non-dominant legs (Brady et al., 1993; Rosene et al., 2001; Siqueira, 2002), whereas others suggest the existence of a significant asymmetry (Molnar and Aleksandar, 1974; Goslin and Charteris, 1979; Wyatt and Edwards, 1981).
The aim of the current study was therefore to evaluate, through isokinetic tests, the influence of football and basketball practice and playing matches on the peak torque of the knee flexor and extensor muscles as well as reciprocal relation between agonist and antagonist muscles of right and left leg in professional football and basketball players.

Methods

Subjects

57 students from the first year of Faculty of Sport and Physical Education volunteered to participate in this study. 30 of them were active football players who were 20, 8 ±3,5 years old, height 177, 4± 5,1 cm, body mass 78,1 ± 4,3 kg and 8,1 ± 3,3 years of training respectively. 27 of them were active basketball players who were 20,6 ± 2,9 years old, height 182,7 ± 5,5 cm, body mass79,9 ± 5,6 kg and 8,8 ± 2,1 years of training respectively.

The frequency of the training programme was almost the same for both groups. They had training 3 to 5 times a week. Duration of their trainings was also similar (approximately 2 hours per day). During the competition season the participants refrained from participating in muscle strength programmes using free weights or other resistance training machines. However, in pre-season, all participants underwent specific strength training programmes.

Isocinetic testing of the strength of dynamic knee stabilizer was performed 15 days before the end of the competition half-season in both groups.

All participants had no history of knee surgery, hip or ankle lesions, or any known pathology that interfered with their motor function. Furthermore, none were taking any medications at the time of the study with known musculoskeletal side effects. Thus, the participants did not show any conditions that could be aggravated by the testing protocol or confound the test results. The participants signed an informed consent form in accordance to the University guidelines for research involving human subjects. They were asked to refrain from any unusual activities or vigorous exercise 24 hours before each testing session.

Maximal peak torque and total work of flexor and extensor knee muscles were measured on both legs using isocinetic dynamometer (Biodex 3 system) at angular velocities $60°\cdot s^{-1}$ and $180°\cdot s^{-1}$. These angular velocities were used by many researchers in order to measure the strength of dynamic knee stabilizers (Kazazović et al., 2007; Kazazović and Tabaković, 2008; Kazazović et al., 2008). All tests were performed from a seated position. They were given instructions on exactly what to do. Verbal encouragement was given during every trial. Furthermore, participants were instructed to work as hard as possible in both directions of the movement (flexion and extension). In addition, participants were instructed to hold their arms comfortably across their chest to further isolate knee joint flexion and extension movement.

Every test was preceded by warm up exercises (3 sub maximal and 1 maximal repetition). Testing consisted of maximum test at angular velocity of $60°\cdot s^{-1}$ 5 repetitions), that was followed by a pause (30 seconds), and then maximum test at angular speed of $180°\cdot s^{-1}$ (5 repetitions) Following the testing of one leg, there was a 3 minute rest, and then the testing of the other leg began with the same conditions.

Statistical analysis

Paired - Samples T-tests were used to compare the peak torque values of dependent variables of football and basketball players in both legs. The significance level of $p<0.05$ was set for all analyses.

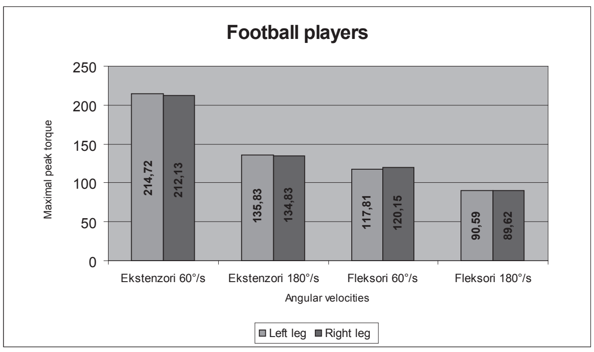
Results

The analysis of the main effect revealed no significant differences for the legs or for the groups, except for angular velocities $60°\cdot s^{-1}$ and $180°\cdot s^{-1}$. Torque values torque as well as total work were higher in lower angular velocities and lower in higher angular velocities. There was no important connection between dominant and non-dominant side which proves that there is no influence of maximal peak torque of dynamic knee stabilizer on the legal dominance between groups (Table1).

Table 1.
- Peak torque (Nm) and total work of extensor and flexor knee muscles 60 °·s⁻¹and 180 °·s⁻¹and comparisons between right and left legs in football and basketball players (students of Faculty of Sport and Physical education in Sarajevo).

Angular velocities		Football players					Basketball players				
		Left leg	Right leg	r	t	p	Left leg	Right leg	r	t	p
Extensors 60 °·s⁻¹	Maximal peak torque	214,72 ± 41	212,13 ± 40	0,878	,712	,482	225,09 ± 34	221,68 ± 34	0,828	,879	,387
	Total work	876,58 ± 163	863,26 ± 164	0,898	,984	,333	941,21 ± 139	900,67 ± 177	0,723	1,712	,099
Extensors 180 °·s⁻¹	Maximal peak torque	135,83 ± 25	134,83 ± 23	0,852	,412	,683	144,87 ± 23	143,24 ± 24	0,861	,685	,499
	Total work	618,46 ± 114	625,98 ± 119	0,787	-,541	,593	669,83 ± 103	638,56 ± 104	0,620	1,807	,082
Flexors 60 °·s⁻¹	Maximal peak torque	117,81 ± 22	120,15 ± 24	0,787	-,851	,402	128,03 ± 21	129,06 ± 22	0,774	-,367	,716
	Total work	578,2 ± 132	595,16 ± 140	0,863	-1,297	,205	615,80 ± 115	637,56 ± 133	0,796	-1,392	,176
Flexors 180 °·s⁻¹	Maximal peak torque	90,59 ± 23	89,62 ± 21	0,829	,413	,682	96,46 ± 23	95,16 ± 23	0,848	,536	,597
	Total work	433,33 ± 127	444,63 ± 134	0.878	-,951	,350	458,53 ± 102	466,33 ± 112	0,790	-,579	,568

Figure 1.
Extensors and flexors peak torques (Nm) at velocities 60 °·s⁻¹ an 180 °·s⁻¹ in both legs in football and basketball players



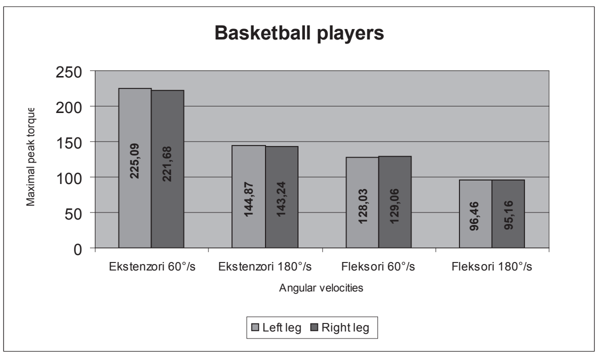
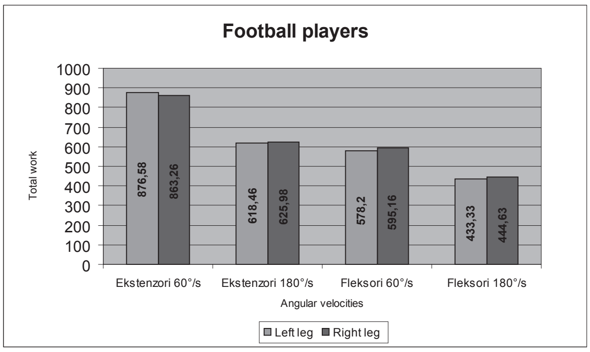
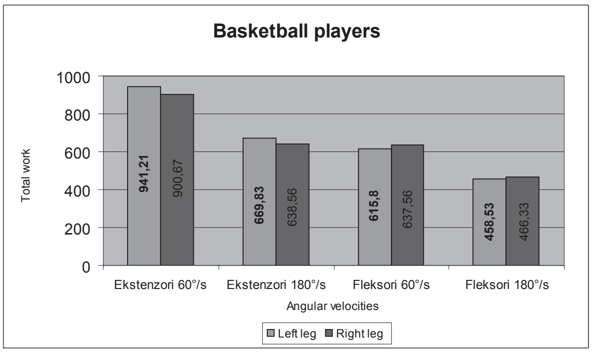


Figure 2.
Extensors and flexors Total work *(J) at velocities 60 °·*s^{-1} *and 180 °·*s^{-1} *in both legs in football and basketball players*





Reciprocal relationship between agonist and antagonist muscles of dynamic knee stabilizers and both legs in football and basketball players is presented in Table 2. Statistically important differences were not found out for this intermuscular ratio between these two participant groups.

Discussion

Results of this study revealed similar results of dynamic knee stabilizers of both legs. This result suggests that strength is connected with sport demands, and in this case it is football and basketball (Zakas et al.,1995). In this study Thomsen et al., (1997) found the differences in muscle strength among alpine skiers, jumpers and sprinters. Zakas et al., (1995) claimed that dynamic knee stabilizers were stronger in basketball players than in football players at angular speed of 60 °·s^{-1} and 180°·s^{-1}.
Result of the studies support the lack of asymmetry between right and left leg of every tested group of muscles, and that is proved on the following (Brady et al.,1993; Holmes and Alderink 1984; Gur et al., 1999; Rosene et al., 2001; Siqueira et al., 2002). However, this research as well as the previous ones disputes those earlier studies which supported the existence of asymmetry (Molnar and Aleksandar, 1974; Goslin and Charteris, 1979; Wyatt et al., 1981). Asymmetry of muscles that was spotted for knee flexors and extensors could be the consequence of balanced load on lower limbs. It therefore seems that training and playing games for many years can contribute to improve muscular strength of both the flexor and extensor muscles of the lower limbs. During football and basketball trainings and matches, players perform various explosive-type efforts, such as starts, sprint, and jump, duels and feints. For these types of actions both parts of lower limbs are active. In addition, when shooting, the non-dominant limb has a support function, while the dominant leg has a propulsion function.
The muscular symmetry that was registered in this work both in the flexor and extensor muscles of the knee might be due to the power training which took place during the preparation of the players in the pre-competition period. Bangsbo (1994) suggested that one of the most important aims of the training programmes during the pre-competitive period is specific training of strength.
Recent studies of reciprocal relation between muscle groups of dynamic knee stabilizers are shown in studies (Holmes and Alderink,1984; Rosene et al.,2001; Siqueira et al.,2002). In these studies, reciprocal relation is on the same level but only different at different angular velocities. There are higher values at angular velocity of 180°·s^{-1}. There are many studies that are full of opposite results concerning reciprocal relation of muscle groups. Some studies suggest That angular velocity does not influence the results of intermuscular ratio and that results are similar at lower as well as higher angular velocity, taking the correction of gravitation into account (Zakas et al., 2002; Fillyaw et al., 1986). On the contrary, the reciprocal relation is significantly higher in the higher angular velocities, when gravity is not taken into consideration (Zakas et al., 2002, Fillyaw et al., 1986).
According to Moffroid and his associates (1969), the peak torque of the extensor muscles is approximately twice that of the flexors, due to a greater muscular mass and irrespective of the angular velocity. Similar findings accrue from the present study. Zakas et al., (2002) reported similar ratios on the same angular velocities of elite Greek basketball, volleyball and football players.
The findings regarding the relationship between reciprocal muscle groups and lesions are contradictory. The inequality or the asymmetry of reciprocal relation of muscle groups between the right and the left limb can predispose individuals to lesions of the weaker muscular group (Brady et al., 1993). Previous research indicates that a lack in the symmetry in both directions that is more than 10% was predictive of flexor injury (Burkett, 1970). On the contrary, Bennell and his associates (1998) considered strength imbalances greater than 10% or reciprocal relation between agonist and antagonist muscle groups less than 60% on either leg did not place the player at greater risk for subsequent flexor injury. Stafford and Grana (1984) reported that bilateral H/Q ratios need to be compared to each speed in addition to the bilat-

Table 2.
Comparisons of intermuscular ratio on both legs for both angular velocities in football and basketball players

	Football players					**Basketball players**				
Angular velocities	Left leg	Right leg	r	t	p	Left leg	Right leg	r	t	p
60 °·s^{-1}	54,85 ± 8,0	56,69 ± 7,0	0,540	-1,385	,176	56,02 ± 6,6	56,97 ± 6,6	0,498	-,748	,461
180 °·s^{-1}	65,96 ± 12,3	66,81 ± 9,5	0,763	-,585	,563	64,75 ± 12,7	66,35 ± 11,4	0,739	-,947	,352

eral comparison of strength, for when bilateral torques are within the normal comparison limits of 90%, the ratio of the two muscle groups is not necessarily within the normal boundaries for the two limbs.
When asymmetry exists in the muscular power between the two limbs or in reciprocal relation between agonist and antagonist muscles, it is suggested to consider rehabilitation and muscle invigoration for the balance of muscular strength between the two limbs.

Conclusion

If we take into consideration the result of this study we will see that there is no significant difference between extensor and flexor muscles of dynamic knee stabilizers as well as no significant difference between agonist and antagonist muscles in both legs in football and basketball players. Reciprocal relation between agonist and antagonist muscles do not show any difference between these two groups of participants. However, coaches were warned to make individually designed programmes for the players with asymmetry off bilateral and reciprocal muscle groups of dynamic knee stabilizers. In the case of asymmetry, an appropriate treating of its removal must be obligatory part of exercises.

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