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Original scientific paper

Bilateral Concentric and Eccentric Isokinetic Strength Evaluation of Quadriceps and Hamstrings in Basketball Players

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A B S T R A C T

The aim of the study was to investigate the existence of bilateral asymmetry in healthy basketball players of different age, as evidence suggest that it may be an age related phenomenon which develops over the years of training. Fifty healthy basketball players (26 males and 24 females) participated in the study. The quadriceps (Q) and the hamstring (H) were tested concentrically and eccentrically at 60°/s. The main outcome measure was body weight normalized peak torque (PT/BW). We have also calculated different strength ratios as well as the bilateral strength differences. The main findings indicate that (1) bilateral strength asymmetry is noticeable in senior basketball players relating predominantly to the Q (2) some gender related strength differences were mainly associated with the concentric strength of Q and H (3) when corrected for weight and height, age related strength differences were relatively small and observed only with respect to H strength in males (4) superiority of eccentric over concentric strength values of Q and H was more pronounced in females than in males. Strength asymmetry in senior basketball players may be more attributable to the better neuromuscular control during vertical jumping than to the strength itself, as there were no age related differences between cadets and senior players.

***Key words**: knee, muscle, strength, isokinetic, basketball*

Introduction

The strength and strength ratios of the major knee muscles – quadriceps (Q) and hamstrings (H) – may constitute an important role in the proficiency of basketball players, as some studies have shown that compared to average-level players, elite-level players achieve significantly higher peak extension torque[1]. Moreover, there were important strength differences among different playing positions in basketball indicating that specific conditioning regimen of the quadriceps, according to the playing position, may be beneficial[2]. Apart from sports success, Q and H strength and strength evaluation in basketball players has an important role in injury prevention in basketball, where knee injuries represent the majority during practice and game[3] and during physical education classes[4]. It has been shown that data obtained from isokinetic strength testing in basketball players could predict ACL injury subsequent to strength testing[5]. Furthermore, isokinetic evaluation of knee extensors at 60°/s may indicate knee extensors torque asymmetry which in turn may play a role in jumper's knee pathology which is one of the most common overuse injuries in basketball players[6].

Evaluation of Q and H strength and H/Q ratios in basketball players of different age and sex has been reported. Bamac[7] compared concentric Q and H strength and conventional hamstring quadriceps ratio between basketball and volleyball players at 60, 180 and 300°/sec, but found significant differences only at the high velocity. Buchanan[8,9] explored the differences in Q and H strength among the sexes and different age groups finding that with body mass-height normalization, most age and gender differences were small. Gerodimos[10] looked into Q and H concentric and eccentric strength profile in 180

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young (12–17y) male basketball players applying tests at 60 and 180°/s. The normalized strength (in Nm/kg) of the H and Q ranged 0.98–2.29 and 1.53–3.69 Nm/kg, across all age, velocity, and muscle action levels. The main purpose of those studies was to give coaches and medical professionals some baseline strength values to be used in training and/or rehabilitation.

In one of the most recent studies to examine Q and H strength in basketball players' player's injury history was registered[11]. The study was performed on 15 professional and 10 junior basketball players and 20 healthy controls. The relative isokinetic and functional performances of professional basketball players were similar to those of junior players, with no dominant-side effect, while a history of knee injury in the professional athlete was reflected in bilateral isokinetic asymmetries. Strength asymmetry of Q and H plays an important risk factor for lower leg injuries and preseason detection of strength imbalances followed by proper intervention program may decrease the injury incidence[12,13]. Based on these findings, the main purpose of our study was to investigate the existence of bilateral asymmetry in healthy basketball players of different age, as we believe that strength asymmetry may be an age related phenomenon which develops over the years of basketball training. In basketball Q strength is enhanced as a result of the player's preferred use of single leg push off during vertical jump. This selective enhancement may lead to strength asymmetry in favor of the dominant (preferred) leg and such asymmetry than could play an important risk factor for injury. Apart from that we have also investigated the gender and age related differences, as well as the relationship between the eccentric and concentric strength of the same muscle group, in order to illuminate the force-velocity relationship of Q and H in basketball players.

Material and Methods

Subjects

Twenty six male (11 cadets and 15 seniors) and 24 female (14 cadets and 10 seniors) basketball players participated in this study. Cadet players were randomly selected from Slovenian national cadet team, while senior players were randomly selected from the clubs from Slovenian 1st and 2nd Division. All players had at least three basketball practice sessions per week. Prior to testing all players answered a questionnaire regarding injuries in the previous season. Injuries acquired during practice or competitive play that caused a player to miss the following match or/and training sessions were reported. Testing was performed only in players without previous knee injury as this factor must be considered in studies of explosive strength in basketball players[11]. The basic anthropometric characteristics of the players are depicted in Table 1. The study was approved by Ethics Committee of the Faculty of Sport, University of Ljubljana, and all players signed an informed consent form.

TABLE 1
DESCRIPTIVE ANTHROPOMETRIC DATA

Sex	Factor	Mean (Std. Dev.)	
		Cadets	Seniors
Male	Age (yrs)	15.73 (0.47)	22.87 (3.93)
	Body mass (kg)	83.86 (11.33)	95.2 (14.33)
	Body height (cm)	192.64 (6.93)	198.40 (6.93)
	Body mass index (kg/m^2)	22.52 (1.90)	24.11 (2.67)
Female	Age (yrs)	14.93 (0.83)	20.70 (2.00)
	Body mass (kg)	63.29 (9.55)	70.20 (8.90)
	Body height (cm)	175.39 (6.71)	179.40 (10.28)
	Body mass index (kg/m^2)	20.51 (2.46)	21.82 (2.27)

Testing procedure

Testing was performed by the same experienced examiner in the Laboratory for isokinetic testing at the Faculty of Sport in Ljubljana, Slovenia. The laboratory was air-conditioned and room temperature was held between 22–24 °C. Testing was performed between 10 AM and 4 PM over a period of two weeks. A day prior to testing no practice was allowed. Each testing session started with a warm-up consisting of cycling for 6 minutes at moderate pace (50–100 W), followed by a 15 second stretch of Q and H. All participants were given a detailed explanation about the testing procedure which was also demonstrated on an independent subject not participating in the study prior to testing[1].

Testing of Q and H was performed using a TechnoGym REV 9000 isokinetic dynamometer (TehnoGym, SpA, Via G. Perticari 20, 47035 Gambet-Tola, Forlí, Italy). Players were tested in the sitting position. Forward sliding on the seat was prevented using proper belts that pushed the pelvis downward and backward, but were not uncomfortable. Trunk movement was also prevented using comfortable strapping over the chest region. The thigh of the tested leg was secured using a special attachment. The subjects were instructed not to hold the handles and to keep hands folded across the chest during testing. We used the lateral femoral condyle as the average axis of rotation of the knee joint and aligned it with the motor axis using a laser beam preinstalled into the head of dynamometer. A range of motion of 60° was set from 30° to 90° knee flexion (full extension considered 0°). In our previous study this protocol using the same device showed a good reproducibility[14]. Testing was performed at 60°/s for both the concentric and eccentric strength of the quadriceps (Qc and Qe, respectively) and hamstring (Hc and He, respectively). Gravity error torque was recorded for every subject and results and determined values were used to correct the torque data for the effects of gravity[15,16].

Prior to testing each participant performed 2 sub-maximal and 1 maximal repetition at a given velocity and mode of contraction. Those participants who experienced pain or discomfort during trial repetitions were not tested on that particular leg. Each participant performed 5 maximal contractions in the following order: (1) five consecutive concentric Q and H contractions followed by a 60-s pause, (2) five eccentric Q contractions followed by a 60-s pause, (3) five eccentric H contractions. When testing of one side was completed, a 3-min break followed during which the machine setting was changed to accommodate for the opposite leg. The first tested leg was assigned randomly for each subject. There was no verbal encouragement during the test.

Data analysis

Data were processed and presented using the SPSS for Windows 16.0 statistical package. The main outcome measure was the peak torque (PT) which was later normalized for body weight (BW) and expressed as PT/kg BW[17]. We also calculated the following strength ratios: the Hc/Qc ratio (HQR) and the dynamic control ratio (DCR) – He/Qc[18]. Finally, we calculated the relative strength difference between the dominant (D) and non-dominant (ND) leg for all testing conditions – a neuromuscular measure known in literature as the bilateral strength asymmetry using the following formula: [1– (PT non dominant/PT dominant)]×100. Based on some previous studies the dominant limb of basketball players was defined as the one used preferably in a single-legged jump[11,19]. The results were further divided according to a player's age. We divided players into two age groups according to the FIBA (International Basketball Federation) classification: cadets 17 years and under, seniors >19 years[20].

Separate multivariate analyses of variance (MANOVA) with Bonferroni adjustments with the correction for body weight and height were used to examine any differences in (1) normalized Q and H peak torques, (2) strength ratios and (3) bilateral strength asymmetry indices according to sex and age group. Both main effects and interactions among fixed factors were examined in all MANOVAs.

Finally, repeated-measures analysis of variance (ANOVA) was used to compare (1) the bilateral strength asymmetry among all tested conditions, i.e., different muscle groups (Q and H) and (2) muscle-contraction modes (concentric and eccentric). The level of significance was set at $p<0.05$.

Results

Bilateral strength asymmetry

The results regarding the existence of bilateral strength asymmetry (ANOVA using factor side for each muscle and contraction type separately) are presented in Table 2. Regardless of sex, there was no significant side related differences in the strength of the Q and H in the cadets group ($p>0.05$ for all instances). However, a significant difference ($F=9.34$, $p=0.01$) in the favor of D side in Qc strength was noted in the male senior group. Among female senior players asymmetry was noted in Qe strength in favor of D side ($F=6.15$, $p=0.04$).

TABLE 2
CONCENTRIC AND ECCENTRIC PEAK TORQUE TO BODY WEIGHT (NM/KGBW) OF QUADRICEPS AND HAMSTRINGS IN MALE AND FEMALE BASKETBALL PLAYERS OF DIFFERENT AGE GROUPS

Age Category		MALES					FEMALES				
		$\overline{X}$ (SD)	$\overline{X}$ (SD)	Bilateral comparison			$\overline{X}$ (SD)	$\overline{X}$ (SD)	Bilateral comparison		
		ND	D	Mean diff. (%*)	F value	Sig.	ND	D	Mean diff. in Nm/kg (%)	F value	Sig.
Cadets	Q*con*	2.83 (0.23)†	2.79 (0.39)†	0.05 (1.43)	1.43	0.72	2.41 (0.25)	2.31 (0.32)	0.09 (4.33)	4.74	0.05
	Q*ecc*	2.92 (0.43)	3.02 (0.45)	–0.10 (3.31)	0.92	0.37	2.66 (0.65)	2.64 (0.67)	0.02 (0.76)	0.05	0.84
$N_{males}=10$ $N_{females}=14$	H*con*	1.49 (0.19)†	1.60 (0.18)†	–0.12 (6.88)	1.59	0.25	1.29 (0.15)	1.32 (0.17)	–0.03 (2.27)	1.85	0.20
	H*ecc*	1.65 (0.13)†,‡	1.65 (0.17)	–0.01 (0.00)	0.02	0.89	1.47 (0.23)‡	1.53 (0.25)‡	–0.06 (3.92)	1.83	0.20
Seniors	Q*con*	2.43 (0.32)	2.67 (0.28)†	–0.24 (8.99)	9.34	0.01	2.24 (0.30)	2.29 (0.27)	–0.05 (2.18)	0.72	0.42
	Q*ecc*	2.72 (0.63)	2.96 (0.47)‡	–0.23 (8.12)	2.88	0.12	2.53 (0.50)‡	2.75 (0.40)‡	–0.22 (8.00)	6.15	0.04
$N_{males}=14$ $N_{females}=10$	H*con*	1.65 (0.17)†,§	1.66 (0.20)†	–0.01 (0.60)	0.04	0.84	1.33 (0.20)	1.38 (0.24)	–0.04 (3.62)	1.20	0.31
	H*ecc*	1.74 (0.32)	1.82 (0.19)†,§	–0.08 (4.40)	0.97	0.34	1.52 (0.28)‡	1.54 (0.28)‡	–0.01 (1.30)	0.03	0.86

* – The bilateral strength difference represented as percentage using formula (1 – non-dominant/dominant)*100
† – Significantly higher PT/BW when compared with females with correction for body weight and height ($p<0.05$ for all instances; the strongest difference was observed for Qconc in cadets, $p<0.0001$)
‡ – Significantly higher eccentric strength in comparison with concentric strength of the same muscle (muscle group)
§ – Significantly higher PT/BW when compared with cadets with correction for body weight and height (for Hcon-ND $F=6.21$, $p=0.02$; for Hecc-D $F=4.53$, $p=0.046$)
D – dominant, ND – non dominant

TABLE 3
CONVENTIONAL (HCON/QCON) AND DYNAMIC CONTROL RATIO (HECC/QCON) IN MALE AND FEMALE BASKETBALL PLAYERS OF DIFFERENT AGE GROUPS

Age Category	Strength ratio	MALES $\bar{X}$ (SD) ND	MALES $\bar{X}$ (SD) D	Mean diff.	F value	Sig.	FEMALES $\bar{X}$ (SD) ND	FEMALES $\bar{X}$ (SD) D	Mean diff.	F value	Sig.
Cadets	HQR	0.53 (0.07)	0.57 (0.05)	0.05	2.15	0.19	0.54 (0.04)	0.57 (0.05)	0.04	11.23	0.01
$N_{males}=10$ $N_{females}=14$	DCR	0.58 (0.06)	0.59 (0.06)*	0.01	0.26	0.63	0.61 (0.09)	0.66 (0.08)	0.05	8.54	0.01
Seniors	HQR	0.68 (0.09)†	0.62 (0.08)	0.06	3.20	0.10	0.59 (0.05)§	0.60 (0.09)	0.01	0.10	0.76
$N_{males}=14$ $N_{females}=10$	DCR	0.72 (0.13)‡	0.68 (0.11)	0.03	0.68	0.43	0.68 (0.09)	0.67 (0.11)	0.01	0.05	0.82

* – Significantly lower DCR when compared to females (F=9.03, p=0.007)
† – Significantly higher strength ratio when compared to cadets (F=12.15, p=0.002)
‡ – Significantly higher strength ratio when compared to cadets (F=5.66, p=0.03)
§ – Significantly higher strength ratio when compared to cadets (F=7.51, p=0.01)

Gender related differences

Gender related differences were evaluated using MANOVA for the factor sex and proper correction for body weight and height with subsequent ANOVAs for univariate differences. On the multivariate level males were stronger than females in both age groups (F=5.82, p=0.003; F=2.83, p=0.047 for cadets and seniors, respectively), while significant differences on univariate level are presented in Table 2 and marked with †. On the univariate level male players were stronger than their female counterparts for the majority of concentric strength values, especially for the D quadriceps. The dominance effect in eccentric strength: males vs. females, was not as prominent.

Type of contraction

The influence of the type of contraction was evaluated using ANOVA for repeated measures with factor contraction type where concentric and eccentric strength of the same Q and H were compared. Although all eccentric values were respectively higher than their concentric counterparts (for both sexes), a statistically significant difference (p<0.05) was reached mainly in females (Table 2, marked with ‡).

Conventional and dynamic control ratios were calculated for the dominant and non-dominant side and compared for bilateral differences, gender and age group differences. There were significant bilateral differences in HQR and DCR only in female cadets in favor of the D side. Gender related difference in strength ratio was noted in DCR in cadet players, where males had lower DCR than females: 0.59 *vs*. 0.66, respectively (Table 3). There were also some age related differences in strength ratios where seniors reached higher HQR and DCR than cadets. In females, however, the difference existed only for HQR, while there was no significant difference in DCR.

Discussion

The main findings of the present study indicate that (1) bilateral strength asymmetry does not exist in cadets but it is noticeable in senior basketball players and is targeting quadriceps in both sexes (2) there are gender related strength differences that are mainly related to Qc and Hc strength in both age groups (males being stronger than females) (3) when corrected for weight and height age related strength differences were relatively small and were observed only in males in relation to H (4) superiority of Qe and He over Qc and Hc was more pronounced in female than in males basketball player.

The concentric strength of the Q plays an important role in the vertical jump[21] which is the most basic motor element of the basketball game. In cadet players the majority of training is related to skill, while later on, when skill is acquired, training goals shifts to further strength and power development and the development of the higher vertical jump performance. In that phase of training senior players probably master their ability to take off from preferred leg which in turn leads to the bilateral strength asymmetry of the muscles involved in jumping. Strength asymmetry as observed in our study, could be attributed more to the better neuromuscular control during vertical jumping than to the strength itself, as we must take into account the lack of age related differences between cadets and senior players (after correction for body weight and height). It seems that senior players are capable of better motor recruitment of Q than their cadet's counterparts and that jumping performance in this age group may be better than in cadets (they are using strength better). The fact that in female players Qe (and not Qc) strength was involved could be explained by the same ratio as described above, considering the fact that concentric strengthening of the muscle will lead to increase in both concentric and eccentric strength[22].

Interestingly, when the strength differences between the ND and D side were expressed as percentage, all differences were below 15%, the statistically selected cutoff for increased risk of injury as proposed in other papers[11,12,23]. Noteworthy, none of the players presented with a previous knee injury. In spite of that, 9% difference in Qc strength between D and ND sides in males, and 8% difference in Qe strength between D and ND sides in females was statistically significant (Table 1). However, statistical significance may not be equivalent to clinical importance namely it is hard to speculate whether this difference will predispose those players to injury or not and therefore a prospective follow-up is needed to evaluate such hypothesis. Our findings regarding strength asymmetry are comparable with other studies where D side strength values for Q and H were higher than ND[7-9,11] (Table 4). Nevertheless only one paper actually explored the effect of dominance indicating that significant differences could be exclusively identified in senior players with a history of knee injuries[11].

The age-related normalized Qc and Qe PT values observed in our male group were generally in agreement with previous studies (Table 4), while females have scored somewhat better than what has been previously reported. On the other hand the parallel normalized Hc and He PT in males were lower than previously reported especially in eccentric mode of contraction, while females have once again scored better than reported by other studies. However, the specific isokinetic dynamometer

TABLE 4
REPORTED QUADRICEPS AND HAMSTRINGS PEAK TORQUE TO BODY WEIGHT (PT/BW) AT 60°/S AND STRENGTH RATIOS IN BASKETBALL PLAYERS

Author	Year	Sex	Age	N	Type of Contraction	Extensors PT/BW		Flexors PT/BW		Strength ratios	
						D CON (ECC)	ND CON (ECC)	D CON (ECC)	ND CON (ECC)	HQR D (ND)	DCR D (ND)
Zakas[30]	1995	Male	24	8	Con	3.33	×	2.23	×	0.67	×
			26	10	Con	2.88	×	2.16	×	0.75	×
			22	10	Con	2.99	×	2.05	×	0.69	×
			20	16	Con	3.16	×	2.30	×	0.73	×
			21	17	Con	3.13	×	2.18	×	0.70	×
Theoharopoulos[19]	2000	Male	21	12	Con	3.27	3.16	2.13	1.99	0.65(0.63)	×
Buchanan[8]	2003	Male	11–13	10	Con	1.37	1.24	0.66	0.59	0.47(0.46)	×
			15–17	9	Con	2.28	2.04	0.99	0.98	0.43(0.47)	×
		Female	11–13	11	Con	1.60	1.43	0.65	0.62	0.41(0.51)	×
			15–17	11	Con	1.57	1.40	0.80	0.75	0.47(0.43)	×
Gerodimos[10]	2003	Male	12	30	Con and Ecc	2.09(2.81)	×	1.31(1.79)	×	0.62	0.87
			13	30	Con and Ecc	2.24(2.90)	×	1.44(1.87)	×	0.64	0.84
			14	30	Con and Ecc	2.45(3.18)	×	1.71(2.19)	×	0.70	0.89
			15	30	Con and Ecc	2.53(3.32)	×	1.70(2.20)	×	0.68	0.87
			16	30	Con and Ecc	2.73(3.42)	×	1.78(2.29)	×	0.66	0.85
			17	30	Con and Ecc	2.76(3.69)	×	1.84(2.28)	×	0.68	0.84
Bamac[7]	2008	Male	24	20	Con	2.91	×	1.47	×	0.49	×
Buchanan[9]	2009	Male	9–10	6	Con	1.56	1.42	0.83	0.74	0.54(0.52)	×
			12–13	11	Con	1.96	1.85	1.01	0.92	0.52(0.50)	×
			16–22	7	Con	2.31	2.37	1.46	1.41	0.64(0.61)	×
		Female	9–10	7	Con	1.56	1.44	0.79	0.68	0.62(0.49)	×
			12–13	10	Con	1.72	1.65	0.80	0.74	0.45(0.44)	×
			16–22	9	Con	1.83	1.77	1.07	0.96	0.58(0.55)	×
Schiltz[11]	2009	Male	19	10	Con	3.20	3.09	1.93	1.77	0.60(0.57)	×
			28	15	Con	3.00	2.65	1.90	1.74	0.63(0.66)	×
Hadzic.	2009	Male	16	11	Con and Ecc	2.79(3.02)	2.83(2.92)	1.60(1.65)	1.49(1.65)	0.57(0.53)	0.59(0.58)
			23	15	Con and Ecc	2.67(2.96)	2.43(2.72)	1.66(1.82)	1.65(1.74)	0.62(0.68)	0.68(0.72)
		Female	15	14	Con and Ecc	2.31(2.64)	2.41(2.66)	1.32(1.53)	1.29(1.47)	0.57(0.54)	0.66(0.61)
			21	10	Con and Ecc	2.29(2.75)	2.24(2.53)	1.38(1.54)	1.33(1.52)	0.60(0.59)	0.67(0.68)

Legend: D – dominant, ND – non dominant, CON – concentric, ECC – eccentric device used during the testing must be accounted for here, as some studies have confirmed that isokinetic data are device specific and dependent[24] and even software dependent[25]. This is of course not true for strength ratios and Table 4 shows that HQR was almost completely in concordance with previous findings, while DCR values in our study were lower than those reported by Gerodimos indicating weak He strength in our group[10].

Sex related strength differences on a univariate level (with correction for body weight and height) in both age groups were mainly related to Qc strength and were more pronounced on the D than the ND side. This finding is probably indicating the important implication of neurological factors in eccentric strength production[26] where the effect of body mass may not play such an important role. Our finding is comparable with other studies[8,9] where mean strength values for Q and H were typically higher for men vs. women players.

Age related strength differences in our study were small and in concordance with findings reported in previous papers[8,9]. Significant age related strength differences were observed only in males, where senior players had significantly higher PT/BW than cadets: for Hc-ND $F=6.21$, $p=0.02$ and for Hecc-D $F=4.53$, $p=0.046$.

The analysis of eccentric vs. concentric strength values has revealed that the most consistent eccentric to concentric difference was noted in senior females where normalized eccentric strength values were significantly higher than normalized concentric strength values for both muscle groups and sides. In the male senior players Qe strength was significantly higher than Qc only on the dominant side which may be correlated with our hypothesis that strength asymmetry observed in our study may be related to better neuromuscular control and electromechanical efficiency of the dominant Q by senior players[27]. In cadets (both sexes) significant differences existed only for H while Qe strength (although higher than Qc) did not reach the level of significance. Such findings were already reported in some papers. The ratio between eccentric and concentric strength of the same muscle group (as can be calculated from our data) was higher in senior than in cadets in both sexes, indicating the possibility that eccentric muscle capacity is better in seniors. After suggesting that more work is needed for examination of changes in eccentric strength with age De Ste Croix[28] has concluded that prepubertal children have a lower capacity for generating eccentric compared to concentric torque[29] which can in part support the findings in our study.

Conclusion

The results of our study indicate that significant strength asymmetry in senior basketball players may exist in spite of the fact that bilateral difference is below the clinically relevant cut-off values of 10–15%. Further research is needed to evaluate the clinical importance of such strength asymmetry. Apart from that our study has mainly supported previous findings regarding age and gender related strength differences, and has given some insight into the less explored issue of eccentric strength development in younger players.

Bilateral strength asymmetry does not exist in cadets but it is noticeable in senior basketball players and is targeting quadriceps in both sexes. Coaches should keep this in mind when prescribing strength training for basketball players. This study offers an excellent review of currently available scientific information in regard to quadriceps and hamstrings strength values in basketball players that can be used for setting goals of training and/or rehabilitation of basketball players.

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REFERENCES

1. DELEXTRAT A, COHEN D, J Strength Cond Res, 22 (2008) 1066, DOI:10.1519/JSC.0b013e3181739d9b. — 2. DELEXTRAT A, COHEN D, J Strength Cond Res, 23 (2009) 1974, DOI: 10.1519/JSC.0b013e3181b 86a7e. — 3. AGEL J, OLSON DE, DICK R, ARENDT EA, MARSHALL SW, SIKKA RS, J Athl Train, 42 (2007) 202. — 4. VIDEMSEK M, KARPLJUK D, MLINAR S, MESKO M, STIHEC J, Coll Antropol, 34 973. — 5. MYER GD, FORD KR, BARBER FOSS KD, LIU C, NICK TG, HEWETT TE, Clin J Sport Med, 19 (2009) 3, DOI: 10.1097/JSM.0b013e318190bddb. — 6. DAUTY M, DUPRE M, POTIRON-JOSSE M, DUBOIS C, Isokinetics and Exercise Science, 15 (2007) 37. — 7. BAMAC B, COLAK T, OZBEK A, COLAK S, CINEL Y, YENIGUN O, Kinesiology, 40 (2008) 182. — 8. BUCHANAN PA, VARDAXIS VG, J Athl Train, 38 (2003) 231. — 9. BUCHANAN PA, VARDAXIS VG, J Strength Cond Res, 23 (2009) 406, DOI: 10.1519/JSC.0b013e3181942140. — 10. GERODIMOS V, MANDOU V, ZAFEIRIDIS A, IOAKIMIDIS P, STAVROPOULOS N, KELLIS S, J Sports Med Phys Fitness, 43 (2003) 444. — 11. SCHILTZ M, LEHANCE C, MAQUET D, BURY T, CRIELAARD JM, CROISIER JL, J Athl Train, 44 (2009) 39, DOI: 10.4085/1062-6050-44.1.39. — 12. CROISIER JL, GANTEAUME S, BINET J, GENTY M, FERRET JM, Am J Sports Med, 36 (2008) 1469, DOI: 10.1177/0363546508316764. — 13. LEHANCE C, BINET J, BURY T, CROISIER JL, Scand J Med Sci Sports, 19 (2009) 243, DOI: 10.1111/j.1600-0838.2008.00780.x. — 14. DERVISEVIC E, HADZIC V, KARPLJUK D, RADJO I, Isokinetics and Exercise Science, 14 (2006) 269. — 15. KELLIS E, BALTZOPOULOS V, Med Sci Sports Exerc, 28 (1996) 900. — 16. BALTZOPOULOS V, WILLIAMS JG, BRODIE DA, J Orthop Sports Phys Ther, 13 (1991) 138. — 17. JARIC S, Sports Medicine, 32 (2002) 615. — 18. DVIR Z, Clin Biomech (Bristol, Avon), 11 (1996) 135. — 19. THEOHAROPOULOS A, TSITSKARIS G, NIKOPOULOU M, TSAKLIS P, Journal of Strength and Conditioning Research, 14 (2000) 457. — 20. FIBA, Basketball basics: basketball categories, accessed 3.11. 2010. Available from: http://www.fiba.com/ pages/eng/fc/baskBasi/cate/p/openNodeIDs/928/selNodeID/928/seni.html — 21. FORD KR, MYER GD, BRENT JL, HEWETT TE, J Strength Cond Res, 23 (2009) 1327, 10. 1519/JSC.0b013e31819bbea4. — 22. COLLIANDER EB, TESCH PA, Acta Physiol Scand, 140 (1990) 31. — 23. CROISIER JL, FORTHOMME B, NAMUROIS MH, VANDERTHOMMEN M, CRIELAARD JM, Am J Sports Med, 30 (2002) 199. — 24. HUPLI M, SAINIO P, HURRI H, ALARANTA H, J Spinal Disord, 10 (1997) 391. — 25. SCHONLE C, KLING P, BAUMER C, CARSTENSEN S, KUSS A, LEPTHIN HJ, Z Orthop Ihre Grenzgeb, 133 (1995) 84. — 26. WEBBER S, KRIELLAARS D, J Appl

Physiol, 83 (1997) 40. — 27. SEGER JY, THORSTENSSON A, Eur J Appl Physiol, 81 (2000) 54. — 28. DE STE CROIX M, DEIGHAN M, ARMSTRONG N, Sports Med, 33 (2003) 727. — 29. DE STE CROIX M, DEIGHAN M, ARMSTRONG N, Int J Sports Med, 28 (2007) 768, DOI: 10.1055/s-2007-964985. — 30. ZAKAS A, MANDROUKAS K, VAMVAKOUDIS E, CHRISTOULAS K, AGGELOPOULOU N, J Sports Med Phys Fitness, 35 (1995) 199.

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BILATERALNA KONCENTRIČNA I EKSCENTRIČNA EVALUACIJA IZOKINETIČKE SNAGE KVADRICEPSA I MIŠIĆA STRAŽNJE LOŽE U KOŠARKAŠA

S A Ž E T A K

Cilj istraživanja bio je ispitati postojanje bilateralne asimetrije u zdravih košarkaša različite dobi, budući da dokazi upućuju na to da je to možda fenomen povezan s dobi koji se razvija tijekom godina treninga. Pedeset zdravih igrača (26 muškaraca i 24 žena) sudjelovalo je u istraživanju. Kvadriceps (Q) i mišić stražnje lože (H) testirani su koncentrično i ekscentrično pri 60 ° / s. Glavna je mjera bila tjelesna težina normalizirana na najveći okretni moment (PT / BW). Također su izračunati različiti omjeri snaga kao i bilateralne razlike u snazi. Glavni rezultati pokazuju: (1) bilateralna asimetrija snage primijećena je u starijih košarkaša i odnosi se uglavnom na Q (2) neke spolno povezane razlike u snazi uglavnom su povezane s koncentričnom snagom Q i H (3) kada se korigiraju za težinu i visinu, razlike u snazi povezane s dobi su relativno male i primijećene su samo u odnosu na snagu H u muškaraca (4) superiornost ekscentričnih nad koncentričnim vrijednostima snage Q i H bila je više izražena u žena nego u muškaraca. Asimetrija snage u starijih košarkaša može se više pripisati boljoj neuromuskularnoj kontroli tijekom vertikalnog skakanja nego samoj snazi, budući da nije bilo dobnih razlika između kadeta i starijih igrača.