ISOKINETIC STRENGTH OF KNEE FLEXORS AND EXTENSORS OF ADOLESCENT SOCCER PLAYERS AND ITS CHANGES BASED ON MOVEMENT SPEED AND AGE

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BACKGROUND: During childhood and adolescence there is growth in muscle strength. The dynamics of change in muscle strength and its causes have not yet been fully clarified and may differ within individuals and specific groups. The knowledge of current isokinetic strength levels among athletes of varying ages and disciplines represents important information from the point of view of sport performance, as well as health prevention.

OBJECTIVE: The aim of this study is to determine within a group of highly trained adolescent soccer players (n = 45; age = 17 ± 1.2 years; body height 178.4 ± 5.3 cm, body weight 68.5 ± 7.6 kg) the isokinetic strength of knee flexors and extensors and to judge whether it is significantly influenced by age and movement speed.

METHODS: A group of players was further divided according to age into 3 subgroups – U16 (n = 16); U17 (n = 14); U18 (n = 15). Unilateral strength was measured by the isokinetic dynamometer ISOMED 2000 (D. & R. Ferstl GmbH, Hemau, Germany) at angular speeds of $60° \times s^{-1}$, $180° \times s^{-1}$ and $360° \times s^{-1}$. The parameter evaluated was the isokinetic peak torque (PT; Nm).

RESULTS: The ANOVA results demonstrate that there was a significant decrease in the PT within the entire group of players with an increase in speed during both flexion and extension (dominant extremity: $p < 0.001$ resp. $p < 0.019$; non-dominant extremity: $p < 0.001$; resp. $p < 0.001$). The difference in PT among the age categories was not significant for both flexors and extensors at the speed of $60° \times s^{-1}$ ($p = 0.005$; resp. $p = 0.036$) and the speed of $180° \times s^{-1}$ ($p = 0.036$; resp. $p = 0.033$). However, significant differences in PT among individual categories were confirmed only in some cases and, by contrast, an insignificant decrease was marked with nondominant leg extensors.

CONCLUSIONS: The results of this study indicated the state of the strength readiness of the highly trained soccer players in the junior category and the potential shortcomings in the concept of strength preparation within a leading club in the Czech Republic. These results contributed to the deepening of knowledge about changes in strength with age and confirmed the importance of applying diagnostics during systematic long-term sport preparation.

Keywords: Soccer, isokinetics, diagnostics, youth.

INTRODUCTION

It is generally accepted that during childhood and adolescence muscle strength changes take place. This is, however, a complicated problem, since these changes can progress differently in terms of inter-individual differences (maturation, body size, etc.), muscle groups, types of muscle action, sex specificity, etc. Body height and the lever arm's role in muscle strength play a key role in strength development; however, some changes during development are independent of body size and are probably caused by the development of the nervous system. Understanding this field is also influenced by nuances in the applied testing procedures (Bar-Or, 1996; De Ste Croix, 2007; Faigenbaum, 2008; Forbes, Bullers et al., 2009).

Isokinetic dynamometry is considered an objective and reliable diagnostic tool. Its foremost advantages are high reliability, standardization, the possibility to identify the strength level in the entire extent of the movement and determine in this way positions, at which the best and the worst value of PT is reached (Baltzopoulos & Brodie, 1989; Dvir, 2004). Isokinetic strength measurements are numerous in the literature; however, fewer pieces of work have been focused on the evaluated changes of the isokinetic strength of the lower extremities in children and youth (Bellew & Malone, 2000; Weir, 2000). The questions of developmental changes in isokinetic strength were summarized in the overview study by De Ste Croix, Deighan and Armstrong (2003), who, among other things, note that although some information on the strength relationships between the knee extensors and flexors for children exist, data on the age trends which affect these muscles are limited. The results of these isokinetic measurements also confirm that the PT values are influenced by the speeds used during testing and that, in accordance with the Hill Curve, the PT decreases with an increasing speed of movement (Chan & Maffulli, 1996).

Isokinetic testing of muscle strength is used for evaluating the effects of training programs, especially for identifying muscle weakening and its compensation and for the identification of imbalance and prior injuries (Baltzopoulos & Brodie, 1989; Brown, 2000; Houweling, Head, & Hamzeh, 2009; Perrine, 1993). The number of injuries to young players is lower than the number of mature highly trained soccer players, but the treatment time is longer for young players (Hawkins et al., 2001). The number of injuries increases according to increasing age and in the age category from 17 to 20 years injury occurrence is almost the same as in the adult category (Bahr et al., 2008).

The results of case studies concentrating on the strength of young soccer players' lower limbs have confirmed the rising trend in strength related to chronological age. Results are not definite regarding the developmental period, flexors or respectively, extensors, the contraction type and speed measurement. The study of young soccer players aged from 12 to 18 years (Forbes, Sutcliffe et al., 2009) has confirmed that the absolute PT increases with the chronological age of the players. The rise of PT was almost linear in the age group from 11 to 14 years, then the major PT growth was in the age group from 15 to 18 years and then, in the age group from 18 to 20 years, the growth was almost linear again. Authors point out that a similar trend has not been proven in tennis players nor in youth without a sport specialization. That is the reason why the authors suppose that soccer training specifically has a strong impact on muscle strength development and particularly on lower limb progress. Kellis S., Gerodimos, Kellis E. and Manou (2001) note that age affects the strength of the dominant leg (DL) and non-dominant leg (NL) and that in the age growth period young soccer players gain better trained lower limbs and the bilateral difference decreases. Gür, Akova, Pündük and Küçükoğlu (1999) monitored a group of players younger than 21 years old and a group of players older than 21 and they found that PT grows with age only in the dominant leg. Authors supposed that the differences were present mostly due to training elements rather than age factors. Forbes, Bullers et al. (2009) pointed out that the influence of the actual pubertal state compared to the maximal amount of strength is higher than that of age itself. Lehance, Binet, Bury and Croisier (2009) compared the flexors' and extensors' knee strength of the player groups U17, U21 and adult players at the speed of $60° \times s^{-1}$ and $240° \times s^{-1}$. They found absolute growth of the concentric PT in all cases. Statistically significant differences for both speeds were identified only for the concentric extensors' strength. No significant difference was confirmed by expressing PT with regard to body weight. Higher growth in extensors compared to the flexors could be, according to the authors, caused by a lack of attention to hamstring strengthening. The results of some studies do not correspond with the trend of increasing strength related to chronological age. For example, De Ste Croix, Deighan and Armstrong (2003) have pointed out that, although age has a strong effect on strength development, the rate of anatomical growth and maturation vary independently and their effects do not correlate to chronological age.

It is clear that the questions about isokinetic knee flexors' and the extensors' strength of the DL and NL within the different age periods, in different specific groups and according to the speed measured are not yet well answered. The goal of this study is to determine the isokinetic knee strength of flexors and extensors by highly trained adolescent soccer players and to evaluate whether the chronological age and the speed of the movement significantly affect the strength of the knee joint flexors and extensors.

METHODOLOGY

The group of tested soccer players was formed by 45 members of the SK Sigma soccer team (age 17 ± 1.2 years; height 178.4 ± 5.3 cm; weight 68.5 ± 7.6 kg). 44 players had DL on their right, 1 player had DL on their left (a dominant lower limb was determined as the one which is preferred by players for kicking the ball). The players were divided into three subgroups according to their age category U16 (n = 16; height 175.5 ± 4.9 cm; weight 63.4 ± 6.9), U17 (n = 14; height 181.9 ± 4.1 cm; weight 73.4 ± 7.2), U18 (n = 15; height 181.0 ± 5.0 cm; weight 69.2 ± 5.7). All tested players, as well as their parents, were fully informed about the goal and methodology of the measurements. They agreed with the testing process and with the use of the data for further research. Players with acute medical problems were excluded from the research. The day before testing, the players were not exposed to any high training pressure.

Just before testing the players went through non-specific warm up exercises, which included cycling on a bicycle ergometer for 6 minutes with a rising load and 5 minutes of auto-stretching exercises controlled by a physiotherapist. Unilateral strength of the concentric contraction of the flexors and extensors of the knee was measured with an isokinetic dynamometer ISOMED 2000 (D. & R. Ferstl GmbH, Hemau, Germany). Players were tested in the sitting position and they held handgrips alongside the seat, the seat back was reclined by 15 grades. For fixation in the area of the pelvis and thigh fixed belts were used, shoulders were fixed by a shoulder rest in the ventral-dorsal and cranial-caudal direction. The axis of the dynamometer rotation was the same as the axis of the knee rotation (lateral femoral condyle). The arm of the dynamometer lever was fixed to the distal part of the lower leg and the lower edge of the training pad was placed 2.5 cm over the medial apex malleolus. The seat settings were stored in PC memory before measuring the right leg and were automatically activated in the process of measuring the left leg. The angular speed parameters $60° \times s^{-1}$, $180° \times s^{-1}$ and $360° \times s^{-1}$ were used for measurement and the gravitational correction was activated as well. The testing protocol was made up of two contraction sets in each of the measured speed values. In the first – the warm up set – players made five reciprocal contractions (concentric contraction to flexion, followed by concentric contraction to the extension) with a progressive raise in the contraction strength of the player until the maximal contraction strength was achieved. After a 30 seconds rest period, a set of six repetitions with the maximal contraction strength followed. The rest time during the measurements at particular speeds was 1 minute and the rest time between the measurement of the right and left leg was 3 minutes. During the testing process, the players were motivated to reach the best results and they were provided with concurrent visual feed back in the form of an isokinetic strength curve displayed on the dynamometer monitor. The result of the measurement was the absolute PT (Nm) in the process of concentric flexion, respectively extension in the knee joint.

The two way ANOVA was used to determine the significance of the PT differences between groups ($p < 0.05$). The statistical significance of the differences between age categories was verified by the post hoc – LSD test. Effect size was assessed by the coefficient "Eta square" (0.01–0.05 low effect; 0.06–0.13 middle effect; > 0.14 large effect); (Cohen, 1988). Statistical analysis was performed using the data analysis software system STATISTICA, version 10.

RESULTS

Isokinetic muscle strength DL and NL values at various speeds by the entire tested group of soccer players for given age categories are noted in TABLE 1 and TABLE 2. As expected, the tested players reached higher values for extensors than flexors at all speeds. The highest values were measured at a speed of $60° \times s^{-1}$ for all players and for all age categories. Evaluation of isokinetic muscle strength at three angular speeds for the entire group confirmed that PT was significantly lower for DL and NL with an increasing speed for both flexion and extension. The value of the effect for these differences was high [DL: $F(2.84) = 99.80$; $p < 0.001$; $\eta^2 = 0.703$, resp. $F(2.84) = 327.35$; $p < 0.001$; $\eta^2 = 0.886$]; [NL: $F(2.84) = 91.26$; $p < 0.001$; $\eta^2 = 0.684$; resp. $F(2.84) = 267.27$; $p < 0.001$; $\eta^2 = 0.864$]. Detailed comparison of the average values reached at particular speeds with the help of the LSD post – hoc test confirmed statistically significant differences between all speeds used (not mentioned in the enclosed tables).

ANOVA results (TABLES 3–5) show statistically significant differences in muscle strength (without consideration for lateral preferences) among age categories for flexors as well as extensors at the speed of $60° \times s^{-1}$ and $180° \times s^{-1}$. The size of these differences was high. At the speed of $360° \times s^{-1}$ important differences were not confirmed.

TABLE 1
Peak torque (Nm) by the flexion of the knee joint for the dominant and non-dominant leg – basic statistical characteristics (n = 45)

		Flexion DL			Flexion NL		
		M	Med	SD	M	Med	SD
Entire group	**$60° \times s^{-1}$**	123.3	121,0	19,37	120.6	120.0	18.61
	$180° \times s^{-1}$	102.6	102.0	18.17	102.0	106.0	17.31
	$360° \times s^{-1}$	79.2	82.0	20.79	80.8	85.0	23.62
U16	**$60° \times s^{-1}$**	113.0	115.0	18.21	109.9	112.5	17.29
	$180° \times s^{-1}$	93.6	94.5	16.19	94.8	96.0	17.00
	$360° \times s^{-1}$	73.9	78.0	13.40	72.5	69.5	20.04
U17	**$60° \times s^{-1}$**	125.6	122.0	15.33	123.2	124.0	13.27
	$180° \times s^{-1}$	106.3	107.5	18.29	103.0	106.0	18.97
	$360° \times s^{-1}$	78.8	84.5	27.46	84.0	88.0	27.99
U18	**$60° \times s^{-1}$**	132.0	130.0	19.96	129.6	136.0	19.53
	$180° \times s^{-1}$	108.8	105.0	17.27	108.9	111.0	13.70
	$360° \times s^{-1}$	85.0	87.0	19.94	86.6	90.0	21.68

Legend: M – average, Med – median, SD – standard deviation, DL – dominant leg, NL – non-dominant leg

TABLE 2
Peak torque (Nm) by the extension of the knee joint for the dominant and non-dominant leg – basic statistics characteristics (n = 45)

		Extension DL			Extension NL		
		M	**Med**	**SD**	**M**	**Med**	**SD**
Entire group	**60° × s⁻¹**	212.9	213.0	35.93	209.7	208.0	33.32
	180° × s⁻¹	152.5	151.0	21.99	150.7	144.0	22.26
	360° × s⁻¹	115.4	118.0	26.54	114.8	115.0	29.73
U16	**60° × s⁻¹**	189.2	189.5	34.00	192.3	209.6	32.32
	180° × s⁻¹	139.9	139.5	17.41	142.5	140.0	16.02
	360° × s⁻¹	106.3	106.0	21.88	106.7	108.0	22.80
U17	**60° × s⁻¹**	226.3	227.0	23.00	222.5	222.5	25.66
	180° × s⁻¹	159.9	165.0	17.44	156.2	159.5	25.79
	360° × s⁻¹	121.8	128.0	29.23	123.1	132.0	39.29
U18	**60° × s⁻¹**	225.8	216.0	36.42	216.2	217.0	34.72
	180° × s⁻¹	159.0	151.0	25.13	154.4	148.0	23.27
	360° × s⁻¹	119.1	127.0	27.49	115.8	120.0	25.30

Legend: M – average, Med – median, SD – standard deviation, DL – dominant leg, NL – non-dominant leg

TABLE 3
Differences in the isokinetic strength by flexion and extension of the knee joint among the age categories at the speed $60° \times s^{-1}$ (n = 45)

	FLEXION			EXTENSION		
	F	**p**	**η^2**	**F**	**p**	**η^2**
Age	5.821	**0.005**	**0.217**	6.103	**0.036**	**0.225**
Lat	1.703	0.199	0.038	0.971	0.330	0.022
Age × Lat	0.013	0.987	0.000	1.164	0.321	0.052

Legend: Lat – laterality factor, F – testing criteria level, p – level of statistical significance, η^2 – Eta square
Statistically significant values are in bold characters

TABLE 4
Differences in the isokinetic strength by flexion and extension of the knee joint among the age categories at the speed $180° \times s^{-1}$ (n = 45)

	FLEXION			EXTENSION		
	F	**p**	**η^2**	**F**	**p**	**η^2**
Age	3.595	**0.036**	**0.146**	3.675	**0.033**	**0.148**
Lat	0.134	0.716	0.003	0.537	0.467	0.012
Age × Lat	0.480	0.622	0.022	0.771	0.469	0.035

Legend: Lat– laterality factor, F – testing criteria level, p – level of statistical significance, η^2 – Eta square
Statistically significant values are in bold characters

TABLE 5
Differences in the isokinetic strength by flexion and extension of the knee joint among the age categories for the speed 360° × s^{-1} (n = 45)

	FLEXION			EXTENSION		
	F	p	η^2	F	p	η^2
Age	1.543	0.225	0.068	1.466	0.242	0.065
Lat	0.480	0.492	0.011	0.036	0.849	0.000
Age × Lat	0.550	0.580	0.025	0.243	0.784	0.011

Legend: Lat – laterality factor, F – testing criteria level, p – level of statistical significance, η^2 – Eta square
Statistically significant values are in bold characters

The LSD post – hoc test, on the other hand, confirmed significant differences only in some cases between categories. For the speed of 60° × s^{-1} by DL between the categories of U16 and U 18, in flexion (p = 0.005), between the categories of U16 and U17, U16 and U18 in extension (p < 0.001, resp. p < 0.001). Between categories U17 and U18 no significant differences were confirmed. For NL a significant difference was confirmed for the categories U16 and U18, in the case of flexion and also extension (p = 0.005, resp. p = 0.019) and between U16 and U17 in extension (p = 0.004). Differences between the categories U17 and U18 were not statistically significant. At the speed of 180 × s^{-1}1 for DL, statistically significant differences were confirmed for the categories of U16 and U17 in extension (p = 0.045) and U16 and U18 in flexion and extension (p = 0.025, resp. p = 0.048). In NL, statistically significant differences were confirmed only for the U16 and U18 categories (p = 0.044) in flexion.

DISCUSSION

The knowledge of the muscle strength of the knee joint flexors and extensors in soccer players is necessary from the point of view of productivity as well as injury prevention (Lehance et al., 2009). The average PT for the players from our group was at the speed of 60° × s^{-1} for DL for flexion 123.3 Nm, for extension 212.9 Nm, for NL 120.6 Nm, resp. 209.7 Nm. When we compare the average PT values of our group of players with those values noted by Lehance et al. (2009) during flexion, resp. DL extension, with Belgian players in the category U17 (128 Nm, resp. 194 Nm) we can say that both groups of players reached similar results. In comparison with values measured by Forbes et al. (2009) with 18 year-old British soccer players at the speed of 60° × s^{-1}, the players from our group were substantially stronger (DL 99.7 Nm, resp. 181.8 Nm, NL 94,5 Nm, resp. 182.7 Nm). We can also compare results from our tested group with the results of the group from the same club, but in the category U19 (Botek et al., 2010). The older players were substantially stronger (DL 165.36 Nm versus 233.64 Nm; NL 169.86 Nm versus 243.93 Nm) and even if we consider the higher average weight of the older group (M = 73.4 ± 4.9) we assume that these differences could not have been caused only by age, but also by the goals and content of the training process.

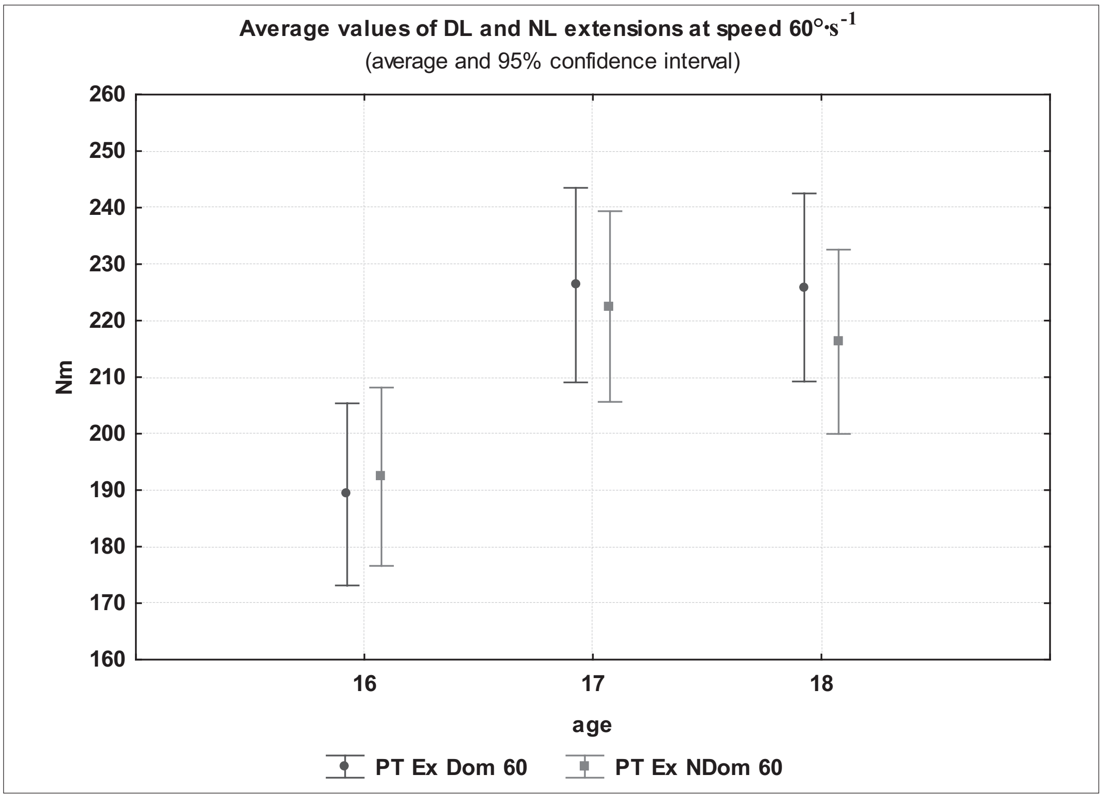
A further finding of our study was that PT values in flexion and extension for DL and also NL were significantly lower with increasing speed. This trend was also confirmed by Dvir and David (1996); Lehance et al. (2009); Malý, Zahálka and Malá (2010); Kellis et al. (2001). These authors explain this decrease by the fact, that, at high speed levels, muscle contraction is accomplished only by a fraction of the muscle fiber, mostly that muscle fiber, which ismorphologically adapted to high speed work. Another reason mentioned is the fact, that for making such a movement at such a high speed, passive components, i.e., the non-contractile muscle elements, participate to a greater extent. Iga, George, Lees and Reilly (2009). With the use of isokinetic dynamometry 15 year old soccer players compared favorably with their contemporaries who were not regularly involved in sport activities. For this purpose they were measured at speeds of 60° × s^{-1} and 250° × s^{-1}. While the difference in PT at the speed of 60° × s^{-1} was only from 15 to 18%, at the speed of 250° × s^{-1} soccer players were significantly stronger by 25 to 37%. The results show that training preparation and play performance itself in soccer require the development of muscle strength, particularly at the higher speed levels, which is not yet well developed in adolescents from the common population.

We confirmed by observing the group of players in our study that the age factor significantly influenced the isokinetic strength level. A detailed comparison of the PT with DL as well as NL between the categories nearest to each other, with the help of the LSD *post-hoc* test, confirmed statistically important differences in PT at the speed of 60° × s^{-1} only between categories U16 and U17 in the case of extension. Differences in the case of flexion were "on the borderline of statistical significance" (p = 0.062). The difference between the categories U17 and U18 were statistically insignificant in flexion as well as extension. In the case of extension the differences were on the borderline of statistical significance (p = 0.054). A more detailed analysis shows that statistically significant differences in muscle strength between age categories' flexors and extensors at the speed of $60° \times s^{-1}$ and $180° \times s^{-1}$ were influenced first and foremost by a more pronounced trend of the strength increase between the U16 and U17 categories. On the other hand for the U17 and U18 categories at the speed of $60° \times s^{-1}$ for the DL extension we noted PT stagnation and for the NL even a decrease (Fig. 1). This finding suggests that within the oldest category monitored, sufficient attention is not given to strength training. With regard to the importance of strength for accomplishing specific movements in current soccer (Verheijen, 1998) we consider this finding important. This detailed retrospective data analysis of the training process showed us that the stagnation of strength in the U18 category was not determined by the limit of muscle strength development, but by mistakes in strength training.

Inter-individual data analysis related to his or her medical history furthermore helped us to determine that the imbalance of the flexor and extensor knee joint strength in the case of some of the observed players can be the key factor for the development of repeated micro traumas to the knee flexors. This misbalance in the isokinetic dynamometry can be best expressed by the examination of the flexor to the extensor strength ratio – the so called H/Q ratio (Houweling et al., 2009; Lehance et al., 2009; Sangnier & Tourney-Chollet, 2007). Differences in the strength between the U16 and U18 groups are in accordance with the results of other studies (Forbes et al., 2009). At the highest speed of $360°\cdot s^{-1}$ a statistically significant difference was not confirmed in any case. During the result interpretation in this speed it is also necessary to take into consideration problems related to the validity and reliability of the isokinetic testing at high speeds (Dvir, 2004).

The growth of the PT connected to the young soccer player's chronological age growth is also mentioned in the results of the Forbes, Bullers et al. (2009) study. In the case of the PT's expression relative to the player's weight authors found out that the U18 group of players wasn't significantly stronger than the U16 and U15 group of players. Kellis et al. (2001) measured isokinetic strength at speeds of $60° \times s^{-1}$, $120° \times s^{-1}$ and $180° \times s^{-1}$ with young Greek players and they determined a significant increase of muscle strength corresponding to the player's age from 10 to 18 years. When we compare average PT values during flexion, respectively, the

Fig. 1
Muscle strength in connection with age during extension at the speed of $60°\cdot s^{-1}$



Legend: PT Ex Dom 60 – Peak Torque extension of the dominant leg at the speed of $60° \times s^{-1}$, PT Ex Ndom 60 – Peak Torque extension of the non-dominant leg at the speed of $60° \times s^{-1}$

extension for DL in the monitored player's group in the U17 category at the speed of 60° × s^{-1} (125 Nm, resp. 226 Nm) with the values of the Greek players of the same age (140 Nm, resp. 213 Nm), we can say that our players lag behind the Greek players in hamstring strength. It can be assumed that this condition can be undesirable, particularly from the point of view of injury prevention. Similarly Lehance et al. (2009) noted a statistically significant difference between Belgian players in the U17 and U21 groups at the speed of 60° × s^{-1} for the dominant DL. Average results in the U17 players' group were 128 Nm during flexion and 194 Nm during extension, values not greatly different from the values in the U17 group of our group of players. These authors further state that in the expression of the isokinetic testing results of muscle strength compared to body weight, 17 year old highly trained soccer players have already reached a muscle strength of the flexor and extensor of the knee very close to their maximal level. From this point of view there are the very interesting results of the De Ste Croix et al. (2001) study. These authors came to the conclusion that age is a non-significantly explanatory variable of isokinetic knee torque once stature and mass are accounted for. Gür et al. (1999) evaluated the difference between players up to 21 years of age and the adult category of the Turkish soccer league at the speeds of 30° × s^{-1}, 180° × s^{-1}, 240° × s^{-1} and 300° × s^{-1} and except for the lowest speed they found a significant difference in the strength of the quadriceps and hamstrings only for DL. In comparison, the muscle strength level for Turkish soccer players up to 21 years old for DL was on average 86 Nm for flexion and 144 Nm for extension. The players in our U18 group reached an average value of 85 Nm, respectively 119 Nm.

CONCLUSIONS

This study of the soccer players in the age group from 16 to 18 years old evaluated the muscle strength preparation by the young highly trained soccer players in the Teen Sport Center SK Sigma Olomouc, CR. The study confirmed that an increase in the speed of the movement leads to a decrease in isokinetic strength. It also confirmed that muscle strength increases with age. In the group of 17 and 18 years old soccer players the differences in the PT for flexors, resp. extensors of DL and NL were not important. In the case of NL extensors we recorded a small decrease in PT, which can indicate a lack in the strength training for the oldest players' group. Results of the study partly deepen the knowledge of the changes in muscle strength, with connection to age, including its production at higher, more specific, speeds. They showed the importance of diagnostics during systematic long term sport preparation, specifically the importance of strength diagnostics and training in contemporary soccer.

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IZOKINETICKÁ SÍLA FLEXORŮ A EXTENZORŮ KOLENA U ADOLESCENTNÍCH FOTBALISTŮ A JEJÍ ZMĚNY S RYCHLOSTÍ POHYBU A S VĚKEM

(Souhrn anglického textu)

VÝCHODISKA: Během dětství a dospívání dochází k nárůstu svalové síly. Dynamika změn svalové síly a její příčiny nejsou dosud plně objasněny a mohou se lišit mezi jednotlivci a specifickými skupinami. Znalost aktuální úrovně izokinetické síly u sportovců různého věku a disciplín představuje důležitou informaci z hlediska sportovního výkonu i zdravotní prevence.

CÍLE: Cílem studie je určit u skupiny elitních adolescentních fotbalistů (n = 45, věk = 17 ± 1,2 let, tělesná výška 178,4 ± 5,3 cm, hmotnost 68,5 ± 7,6 kg) izokinetickou sílu flexorů a extenzorů kolena a posoudit, zda je významně ovlivněna věkem a rychlostí pohybu.

METODIKA: Skupina hráčů byla dále rozdělena podle věku do 3 podskupin – U16 (n = 16), U17 (n = 14), U18 (n = 15). Unilaterální síla byla měřena izokinetickým dynamometrem ISOMED 2000 (D. & R. Ferstl GmbH, Hemau, Německo) v úhlové rychlosti $60° \times s^{-1}$, $180° \times s^{-1}$ a $360° \times s^{-1}$. Hodnoceným parametrem byl maximální moment síly (PT, Nm).

VÝSLEDKY: Výsledky ANOVA ukázaly, že v rámci celé skupiny hráčů došlo u flexe i extenze k výraznému poklesu PT se zvýšením rychlosti (dominantní končetina: p < 0,001 resp. P < 0,019, nedominantní končetina: p < 0,001; resp. P < 0,001). Rozdíl v PT mezi věkovými kategoriemi nebyl významný jak pro flexory, tak ani pro extenzory při rychlosti $60° \times s^{-1}$ (p = 0,005; resp. p = 0,036) i při rychlosti $180° \times s^{-1}$ (p = 0,036; resp. p = 0,033). Významné rozdíly v PT mezi jednotlivými kategoriemi byly potvrzeny jen v některých případech a naopak byl zaznamenán nevýznamný pokles u extenzorů nedominantní končetiny.

ZÁVĚRY: Výsledky studie ukazují na stav silové připravenosti elitních mladých fotbalistů a na možné nedostatky v koncepci tréninku síly u předního klubu České republiky. Výsledky přispěly k prohloubení znalostí o změnách síly s věkem a potvrdily důležitost uplatňování diagnostiky v rámci systematické dlouhodobé sportovní přípravy.

Klíčová slova: fotbal, izokinetika, diagnostika, mládež.

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