Baltic Journal of Health and Physical Activity

Volume 4 | Issue 2 Article 5

2012

Age-Related Differences of Hamstring Flexibility in Male Soccer Players

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VERSITA
BALTIC JOURNAL OF HEALTH AND PHYSICAL ACTIVITY
© Gdansk University of Physical Education and Sport in Gdansk, Volume 4, No 2, 2012, 110-115
ORIGINAL ARTICLE
DOI: 10.2478/v10131-012-0012-1

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Authors' Contribution:
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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Key words: *neuromuscular fitness, range of motion, age, football*

Abstract

Background: *The aim of this study was to examine the relationship between age and hamstring flexibility of male soccer players and to provide reference data.*

Material/Methods: *The study comprised 698 male subjects. The largest group consisted of male adolescents (n = 597; aged 10-22 years, yrs), further subdivided into six two-year age groups; the other two groups being children (n = 21, younger than 10 yrs) and adult players (n = 80; older than 22 yrs). All of those who participated in our study were members of competitive soccer clubs. They were examined for anthropometric characteristics, body composition, and performed the sit-and-reach test (SAR).*

Results: *An analysis of variance revealed significant differences between age groups with respect to SAR ($F_{7,690} = 17.62$, $p<0.001$, $\eta^2 = 0.15$). Our findings indicated that the older the age group, the higher the SAR (e.g. 16.6±5.1 cm in the children's group, 20.7±7.5 cm in the under-16-yr-old group and 24.7±6.9 cm in the adult group). This result came in agreement with the significant and moderate correlation coefficient between age and SAR (r = 0.33, p < 0.001).*

Conclusions: *Although the cross-sectional design did not allow inferring a causal relationship between age and hamstring flexibility, it is reasonable to suppose that there are small gains in flexibility with development. Compared with previous findings, soccer players had similar values to the general population.*

Word count: 2,042
Tables: 1
Figures: 1
References: 36

Received: January 2012
Accepted: May 2012
Published: June 2012

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Introduction

Elite soccer players must have certain physiological characteristics which correspond to the metabolic demands of modern match play [1]. Studies in soccer players' physiological profile have focused on anaerobic threshold [2, 3, 4], anaerobic and aerobic power [5, 6], muscle strength [6] and training load [7]. Less attention has been given in the study of flexibility, which is considered as an essential element of physical fitness [8].

There is evidence that supports the beneficial role of hamstring flexibility (HF; hamstring refers to the posterior thigh muscle group which consists of biceps femoris, semimembranosus and semitendinosus muscles) on injury prevention [9-13] and performance in young soccer players [14-16]. For instance, elite Belgians players aged 12-16 years (yrs) scored better in the sit-and-reach test (SAR) than their non-elite counterparts [14]. Serbian soccer players, aged 11-14 yrs, scored better in SAR than a control group [15]. In addition, a comparison of the under-18 and under-16 squad of the Canadian national soccer team with a reference group showed greater flexibility among the soccer players [16]. On the other hand, in a comparison between starters and substitutes elite female players, no difference was found with regard to SAR [17].

In a recent series of studies on anthropometric characteristics, body composition [18], muscular endurance [19], force-velocity characteristics [20], aerobic [21] and anaerobic power [22], the main findings revealed the following: (a) significant differences between adolescent and adult players, (b) differences between players in the lower spectrum and those in the higher spectrum of adolescence, and (c) better scores in soccer players than in the general population. However, no research has ever been carried out with regard to HF in a large sample of young soccer players.

The available data from previous research on selected periods of adolescence reveal no consensus about the effect of development on HF. For instance, in a longitudinal cohort study of urban high school students, flexibility of hamstring muscles, lumbar extensor muscles and combined lower extremity-trunk muscles was not associated with increases in growth suggesting that growth was not a cause of decreased flexibility during adolescence [23]. Furthermore, no differences between Brazilian soccer players aged 10 yrs, 11 yrs, 12 yrs and 13 yrs were found with respect to this trait [24]. On the other hand, in a study of 12-16-yr-old soccer players flexibility correlated weakly but significantly with the skeletal age for those aged 13 yrs, 14 yrs, 15 yrs and 16 yrs [25]. Also, in a longitudinal study of a soccer players group and a control group between the age of 11 yrs and 14 yrs (n=16), a significant increase in flexibility with age was noticed in the former group but not in the latter one [15].

To sum up, from the hitherto knowledge regarding the development of flexibility in soccer players, two points should be highlighted: (a) adolescent soccer players have superior values than their non-sport or lower level counterparts, and (b) there is some inconsistency between findings on the development of flexibility across adolescence. Therefore, the aim of the present study is to investigate the development of flexibility across adolescence in soccer players with reference to the general population, to examine whether age groups in the higher spectrum of adolescence scored better in SAR than those in the lower spectrum, and whether there is a direct relationship between age and flexibility during this period.

Materials and Methods

Participants and procedures. In this study, a non-experimental, descriptive-correlation design was used to examine the effect of age on flexibility across adolescence. Testing procedures were performed at the beginning of the competition period of seasons 2009-10, 2010-11 and 2011-12. Written informed consent was received from all players or parents after verbal explanation of the experimental design and potential risks of the study.

Although it is difficult to define adolescence in terms of chronological age, because of variation in time of its onset and termination, it has been suggested to apply it to the range between 10 and 22 yrs of age in boys [26]. For the purpose of our study, we followed this definition.

In total, the study comprised 698 male subjects. The largest group consisted of male adolescents (n = 597; aged 10.1-22.0 years, yr), further classified into six two-year age groups; the other two groups being children (U10, n = 21, aged 7.3-10.0 yrs) and adult players (n = 80; aged

22.1-37.5 yrs). All of those who volunteered for this study were members of competitive soccer clubs (Table 1). The players were familiarized with the testing procedures used in this study through pre-investigation familiarization sessions. They visited our laboratory once; anthropometric and body composition data were obtained followed by the SAR.

Protocols and equipment. Height and body mass were measured using a stadiometer (SECA, Leicester, UK) and electronic scales (HD-351, Tanita, Illinois, USA), respectively. The percentage of body fat was calculated from the sum of 10 skinfolds using a skinfold calliper (Harpenden, West Sussex, UK), based on the formula proposed by Parizkova [27]. Flexibility, as a range of motion in a joint or group of joints [8], by definition is specific to a joint and one's flexibility can be assessed by measuring the joints' range of motion by a goniometer. On the other hand, it is impractical to give a battery of flexibility measures at various joints considering that other physical fitness parameters are all being assessed at the same time during typical physical fitness screening [28]. Moreover, recent studies support the SAR reliability [29].

Therefore, the SAR protocol [30] was employed for the assessment of HF in our study. Participants performed it twice with a 1-min break between the two trials and the better score was retained for subsequent analysis. In order to eliminate the effect of stretching, no warm-up was permitted prior to testing. Participants were asked to seat barefoot with the legs straight ahead in front of the sit-and-reach box and to move their fingertips forwards as far as possible with slow movements over the box. The box provided an advantage of 15 cm to the participant, i.e. when fingertips were over the soles, the score was 15 cm. Measurements were recorder to the nearest 0.25 cm.

Data and statistical analysis. Results were presented as mean±s (standard deviation). The relationship between age and flexibility was examined by Pearson's moment correlation coefficient (r). Differences between age groups were assessed using one-way analysis of variance. Correction for multiple comparisons was undertaken using the Bonferroni method. The significance level was set at alpha=0.05. Statistical analyses were performed using IBM SPSS v.20.0 statistical software (SPSS Inc., Chicago, IL, USA).

Tab. 1. Anthropometric data and sit-and-reach scores of participants

	Age groups								
	U10 (n=21)	U12 (n=33)	U14 (n=135)	U16 (n=212)	U18 (n=116)	U20 (n=56)	U22 (n=45)	Adult (n=80)	ANOVA
Age (yr)	9.0±0.8	11.1±0.6	13.1±0.5	15.0±0.5	17.0±0.5	19.1±0.7	20.8±0.5	26.6±3.5	$F_{7,690}$ = 1120.53, p< 0.001
Body mass (kg)	35.3±6.7	42.8±9.9	52.2±9.6	63.1±8.9	69.5±10.0	71.2±6.2	74.1±7.4	77.1±7.9	$F_{7,690}$ = 137.61, p< 0.001
Height (m)	1.37±0.06	1.47±0.07	1.61±0.09	1.72±0.07	1.76±0.06	1.77±0.05	1.77±0.06	1.79±0.06	$F_{7,690}$ = 190.50, p<0.001
BMI (kg·m^{-2})	18.7±2.5	19.7±3.3	19.9±2.3	21.4±2.4	22.5±2.9	22.8±1.8	23.6±2.0	23.9±1.8	$F_{7,690}$ = 36.12, p< 0.001
BF (%)	17.2±4.7	19.2±5.8	16.2±4.7	16.1±4.0	16.2±4.7	16.1±4.0	15.9±3.8	15.1±3.0	$F_{7,690}$= 4.06, p< 0.001
SAR (cm)	16.6±5.1	14.4±5.8	17.4±6.4	20.7±7.5	23.1±6.6	23.4±8.5	24.1±6.0	24.7±6.9	$F_{7,690}$= 17.62, p< 0.001

BMI – body mass index, BF – body fat, SAR – sit-and-reach

Results

Analysis of variance revealed significant differences between age groups with respect to SAR ($F_{7,690}$ = 17.62, p <0.001, η^2 = 0.15). SAR scores and post-hoc analysis results were presented in Table 1 and Figure 1, respectively. Even if it was statistically non-significant, it was remarkable that the under-12-yr-old age group (U12) scored lower than U10. Similar differences (approximately 3 cm) were recorded between U12 and U14, U14 and U16, and U16 and U18. The comparison between consecutive older age groups revealed non-significant and small differences (less than 0.7 cm).

The trait under examination was found to correlate moderately with age (r = 0.33, p<0.001). Compared with reference data reporting percentiles [31], the U12 group's mean score was between 30^{th} and 35^{th} percentile (P_{30}-P_{35}) of the age- and gender-matched general population, while respective values for the other groups were as follows: U14 P_{50}-P_{55}, U16 P_{50}-P_{55} and U18 P_{40}-P_{45}.

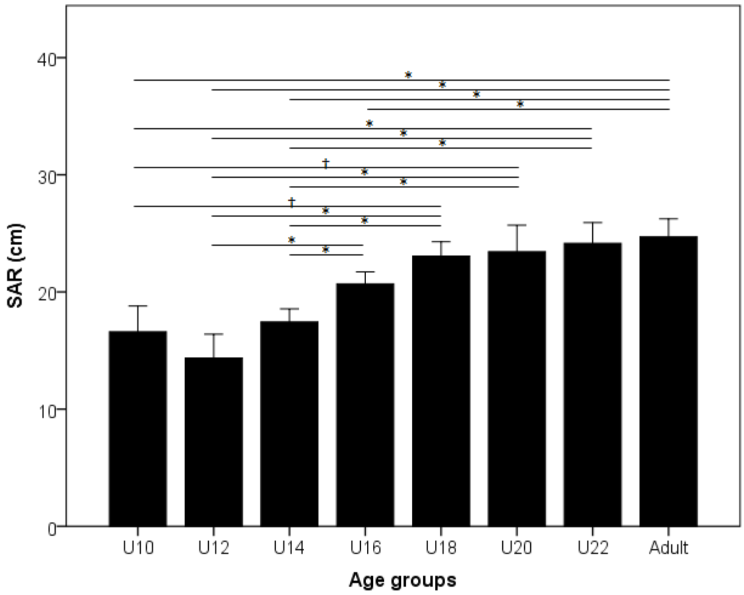

Fig. 1. Differences in sit-and-reach score (SAR) between age groups. Error bars represent standard error. *p<0.001, †p<0.01

Discussion

To the best of our knowledge, this was the first study that examined flexibility in a large sample of soccer players across adolescence. Firstly, we observed that during most of adolescence, male soccer players had similar scores in SAR to the general population. In addition, our data were scrutinized in the light of normative data for adolescents aged 15-19 yrs provided by the Canadian Society for Exercise Physiology, in which values superior to 28 cm were classified as excellent, 23-27 cm as very good, 18-22 cm as good, 13-17 cm as fair and lower than 12 cm as "needs improvement" [32]. According to this classification, scores of U16, U18 and U20 were characterized as "good" (3^{rd} in a 5-grade scale, i.e. average). In a study of European male adolescents, in which a modified version of SAR was employed, 13-yr-olds scored 18.4 cm, 14-yr-olds 18.7 cm, 15-yr-olds 20 cm, 16-yr-olds 20.8 cm and 17-yr-olds 22.2 cm [33]. These comparisons indicated that values of soccer players were close to mean values of the general population and the development of their HF followed a similar pattern to the reference data.

Secondly, we demonstrated that there were significant differences between two-year age groups, with those groups in the higher spectrum of adolescence exhibiting superior scores in SAR than those in the lower spectrum. As it was depicted in Figure 1, age groups in the lower spectrum of adolescence had lower values than the adult group, while groups in the upper spectrum of adolescence had higher values than the children group. This age-effect was supported by a direct relationship between age and flexibility (a statistically significant correlation).

There was a discrepancy between our results and those studies that reported an association between soccer performance and flexibility [14-16]. This inconsistency might be due to different methodological approaches employed in these studies (e.g. number of participants, level of excellence). Based on our findings, it was indicated that despite physical training, in which adolescent players were engaged, there was no training effect on flexibility. The moderate scores in sit-and-reach may be attributed to adaptation to playing soccer and lack of attention to flexibility training [34].

Moreover, stiffness can be associated with increased isometric and concentric force generation resulting in increased walking and running economy [35], and it can be an adaptation to soccer training. During soccer training a specific pattern of hip range of motion was found in professional soccer players, which appeared to be different from the control group [36]. Coaches and fitness trainers should be aware of development patterns of flexibility and the training should also be specialized according to age. Despite the lack of any conclusive evidence regarding the association between flexibility and sport performance, optimal levels of this parameter should be attained in order to promote injury prevention.

The main drawback of our study was the inherent limitation of any assessment method of flexibility to provide information about the overall flexibility. SAR was a measure of hamstring muscle flexibility. On the other hand, because it is a widely employed and easily administered test, there are many normative data of general population in order to evaluate soccer players' scores. A remarkable observation from the present study was that male adolescent players had similar scores to the general population, despite their sport experience and systematic training. Based on these findings, it is recommended to regularly monitor this physical fitness characteristic and to consider it in the design of any training or injury prevention programme.

Conclusions

Flexibility was significantly lower among those soccer players in the lower spectrum of adolescence than among their older counterparts. These findings are also in agreement with previous research on the general population suggesting a positive correlation between age and flexibility. However, what was novel was that quantifying such a pattern in soccer players revealed similar levels of flexibility with the general population, a finding that could be implemented in the training process by fitness trainers and physiotherapists for sport-related fitness improvement and injury prevention.

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