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SEX DIFFERENCES IN THE MOTOR ABILITIES OF YOUNG MALE AND FEMALE HANDBALL PLAYERS

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AUTHORS: Zapartidis I., Nikolaidou M.-E., Vareltzis I., Kororos P.

Department of Physical Education and Sport Science, National and Kapodistrian University of Athens, Greece

Reprint request to:
Ilias Zapartidis
41 Ethnikis Antistasis st.,
Univercity of Athens
17237 Dafni, Greece
E-mail: elzapa@phed.uoa.gr

ABSTRACT: During adolescence, performance of males shows, on average, marked improvements in motor performance tests, while performance of females shows a slight improvement in some motor performance tests and a plateau in others. Research interest lies in the issue of sex differences in performance in the context of training protocols with the same frequency and training load, for young male and female athletes, who have similar performance demands and training experience. This study aimed at comparing the motor abilities of 214 male and 238 female handball players from four age groups (12-12.9, 13 13.9, 14-14.9, and 15-15.9 years). Five motor ability tests were administered: a) ball throwing velocity, b) standing long jump, c) 30-m running speed, d) 20-m shuttle run and e) sit and reach flexibility. ANCOVA was used to test for sex differences by age group with age, height and weight as covariates. Results showed that in the 12-12.9 age group males and females had similar performances in standing long jump and aerobic capacity. In the older age groups, and besides having the same performance demands and training experience, males performed better than females in motor abilities that are important for handball. It appears that sport-specific training is not sufficient to attenuate sex differences in motor performance of young handball players.

KEY WORDS: handball, young players, ball velocity, strength, speed

INTRODUCTION

Participation in organized physical activity constitutes the main factor due to which there is a significant increase in the physical activity level in different age groups and both sexes during adolescence. Performance in various motor tasks improves on average during childhood and adolescence and there appears to be a large overlap in the performance of males and females [9]. During adolescence, performance of females shows a slight improvement in some tasks and a plateau in others, while performances of males shows, on average, marked improvements [9].

Basic motor skills can be considered as a complete assessment of most body functions of daily physical activity. Actually, by assessing one's physical condition, the functionality of all body systems can also be assessed. It is important that the basic motor abilities (running, jumping and throwing) be systematically practised, since the developmental level of the various basic motor abilities is related to physical activity [1].

Sex differences in the motor performances of the general population are mostly small during childhood and appear to become established in adolescence. Males, with the exception of flexibility, perform, on average, better compared to females in motor tasks such as maximal running velocity, muscle power and aerobic capacity, with those differences being attenuated during adolescence [10].

Data on distance runners of 8-15 years of age show attenuated sex differences in measures of flexibility and muscle power prior to the age of 13. During adolescence, flexibility and power improved in males and reached a plateau in females. However, measures of muscle endurance and flexibility showed greater improvement both in males and females, from childhood through adolescence [3]. Malina et al. [9] reported that male divers in the age groups of 13 and under, 14-15 and 16-18 years performed significantly better in vertical jumping than females of the respective age groups, whereas female divers were significantly more flexible than males in all 3 age groups. Furthermore, 15-year-old and under male and female divers did not differ significantly in the medicine ball throw task, which is a measure of upper body power, but 16- to 18 year-old male divers outperformed the female ones [9]. On the other hand, no significant sex differences in any of the three age groups (13 and under, 14-15 and 16-18) were found in measures of sit-ups and agility [9].

Research interest lies, therefore, in the magnitude of sex differences in motor performances and physical abilities of young male and female players participating in the same sport. Handball is a team sport that demands from players, among other things, basic motor abilities such as speed, muscle power of upper and lower extremities and aerobic capacity [5]. Knowledge about players' performance throughout adolescence could provide valuable information for the special population of handball players, in order to compare this population with other athletic populations. Furthermore, the knowledge stemming from a general model of changes in performance during growth could motivate trainers to adjust their training regimens and to predict the talented male and female players. Therefore, the purpose of the present study was to compare the motor performance of male and female handball players in four different age groups. Such comparisons could assist trainers in implementing training sessions specific to each age group's needs in order to ultimately optimize performance in every maturity level of the young handball player.

MATERIALS AND METHODS

The sample consisted of 452 adolescent handball players (238 males and 214 females), divided into four age groups: a) 12-12.9 years (33 males, 41 females), b) 13-13.9 years (62 males, 63 females), c) 14-14.9 years (80 males, 62 females) and d) 15-15.9 years of age (61 males, 48 females). These 4 age groups will be referred to as the 12-, 13- 14- and 15-year age group hereafter. Decimal age was calculated as the difference between date of measurement and date of birth. All handball players competed in the highest league according to their age category and had a frequency of 3 training sessions per week. Furthermore, they had all been invited to train in youth pro-selection national groups. All players and their parents were informed about testing procedures and provided their written informed consent to participate in the study. Research procedures were approved by the Ethics Commission of the University of Athens.

In addition to body height and body mass, five tests of motor performance that have been shown to be important in handball were measured: 1) Ball throwing velocity, 2) standing long jump, 3) running speed, 4) flexibility, and 5) aerobic capacity. Ball velocity was measured from a standing position by use of a radar gun (Sports Radar 3300, Sports Electronics Inc, USA). The contra-lateral leg of the throwing hand was steadily planted on the ground. For the standing long jump test, handball players stood behind a line and jumped as far as possible, while allowing for arm swing and countermovement of the legs. Running speed was evaluated by maximal 30-m sprints from a standing position. Time was recorded using electronic photocells (Brower timing system, USA). In order to measure the flexibility of the hamstring muscles and the lower back articulations, the modified sit and reach test was used [6]. Aerobic capacity was assessed using a 20-m shuttle run test [8]. Subjects run back and forth on a 20-m course and must touch the 20-m line at the same time that a sound signal is emitted from a pre-recorded tape. Frequency of the sound signals is increased 0.5 km h^{-1} each minute from a starting speed of 8.5 km h^{-1}. The test stops when the subject is no longer able to follow the set pace. The respective maximal aerobic speed is then used as the aerobic index, and scores were expressed as the running speed at the last completed stage [8].

With the exception of the 20-m shuttle run test, all 4 other motor performance tests were performed twice and the best out of the two trials was selected for data analysis.

Statistics

Sex differences were initially tested for age, body height, body mass and playing experience in each age group. Sex differences in motor performance tests were evaluated in each age group using analysis of covariance with age, body height and body mass as covariates. Statistical significance was set at $p<0.05$.

RESULTS

Descriptive statistics for age, playing experience, body height and body mass are presented in Table 1. Age and playing experience did not differ between young male and female handball players in any of the age groups. In the 12-year age group, body height and body mass did not differ between male and female handball players, but in the older age groups, male handball players were significantly taller ($p<0.001$) and heavier ($p<0.001$) than the female ones.

Table 2 summarizes the descriptive statistics for the five performance variables of the motor ability tests by sex within each age group, as well as results of the ANCOVAs for the sex differences. Young male handball players performed significantly better than female

TABLE I. DESCRIPTIVE STATISTICS FOR PLAYING EXPERIENCE, AGE, BODY HEIGHT AND BODY MASS OF YOUNG MALE AND FEMALE HANDBALL PLAYERS

	Males			Females		
Age Group	n	Mean	SD	n	Mean	SD
12-12.9 yrs	33	12.5	0.3	41	12.5	0.3
Experience (yrs)		2.8	1.3		2.2	1.1
Height (cm)		163.0	9.0		159.8	6.2
Weight (kg)		56.7	12.7		54.1	8.1
13-13.9 yrs	62	13.7	0.2	63	13.5	0.3
Experience (yrs)		3.2	1.3		3.0	1.7
Height (cm)		171.2	7.0		161.8	5.2
Weight (kg)		67.3	12.4		55.2	7.0
14-14.9 yrs	80	14.4	0.2	62	14.4	0.2
Experience (yrs)		4.2	1.4		3.8	1.5
Height (cm)		175.5	5.7		165.1	6.5
Weight (kg)		70.2	12.1		58.6	7.9
15-15.9 yrs	61	15.3	0.2	48	15.3	0.2
Experience (yrs)		4.4	1.5		4.1	1.6
Height (cm)		178.1	6.3		164.9	6.6
Weight (kg)		75.8	12.6		60.0	7.9

TABLE 2. DESCRIPTIVE STATISTICS FOR MEASURES OF MOTOR ABILITIES AMONG HANDBALL PLAYERS BY SEX WITHIN COMPETITIVE AGE GROUPS AND RESULTS OF THE ANALYSES OF COVARIANCE WITH AGE, HEIGHT AND WEIGHT AS COVARIATES

Age Group / Variables	Males		Females		ANCOVA	
	n	Mean ± SD	n	Mean ± SD	F	p
12-12.9 yrs						
Ball velocity (km·h^{-1})	33	570.85 ± 90.4	40	500.85 ± 80.3	100.02	0.002
Standing long jump (cm)	33	178.94 ± 18.1	41	170.67 ± 18.9	3.19	ns
30-m sprint (s)	32	5.04 ± 0.3	41	5.19 ± 0.2	4.05	0.048
20-m shuttle run (km·h^{-1})	32	11.30 ± 1.0	41	11.01 ± 0.7	3.08	ns
sit and reach (cm)	33	24.80 ± 4.3	41	31.26 ± 6.7	22.20	< 0.001
13-13.9 yrs						
Ball velocity (km·h^{-1})	62	66.18 ± 7.0	63	54.71 ± 7.1	25.34	< 0.001
Standing long jump (cm)	62	190.98 ± 24.9	63	176.34 ± 17.3	9.79	<0.002
30-m sprint (s)	60	4.85 ± 0.3	63	5.10 ± 0.2	30.31	< 0.001
20-m shuttle run (km·h^{-1})	62	11.89 ± 1.0	63	11.25 ± 0.8	28.22	< 0.001
sit and reach (cm)	60	29.62 ± 7.8	59	35.41 ± 5.9	31.56	< 0.001
14-14.9 yrs						
Ball velocity (km·h^{-1})	80	71.19 ± 7.2	62	58.48 ± 6.2	30.86	< 0.001
Standing long jump (cm)	80	209.42 ± 21.5	61	181.87 ± 18.7	55.44	< 0.001
30-m sprint (s)	80	4.66 ± 0.2	62	5.05 ± 0.3	85.77	< 0.001
20-m shuttle run (km·h^{-1})	80	12.14 ± 0.8	61	11.16 ± 0.8	54.50	< 0.001
sit and reach (cm)	77	31.22 ± 7.5	58	37.58 ± 6.4	24.17	< 0.001
15-15.9 yrs						
Ball velocity (km·h^{-1})	61	74.46 ± 6.7	48	58.90 ± 4.7	50.31	< 0.001
Standing long jump (cm)	61	218.89 ± 18.9	48	187.19 ± 17.9	57.39	< 0.001
30-m sprint (s)	61	4.50 ± 0.2	48	5.00 ± 0.2	134.54	< 0.001
20-m shuttle run (km·h^{-1})	61	12.15 ± 0.9	48	11.27 ± 0.7	13.15	< 0.001
sit and reach (cm)	57	32.42 ± 6.3	46	36.67 ± 5.1	11.94	< 0.001

TABLE 3. AGE, BODY HEIGHT AND BODY MASS ADJUSTED MEANS AND 95% CONFIDENCE INTERVALS (CI) FOR MEASURES OF ABILITIES AMONG HANDBALL PLAYERS BY SEX WITHIN AGE GROUPS

Variables		Males		Females	
	Age group	mean	95% CI	mean	95% CI
Ball velocity (km·h^{-1})					
	12-12.9	57.1	54.5-59.8	51.4	49.1-53.8
	13-13.9	64.2	62.3-66.1	56.7	54.8-58.5
	14-14.9	69.0	67.4-70.6	61.3	59.4-63.1
	15-15.9	72.6	70.8-74.3	61.3	59.3-63.4
standing long jump (cm)					
	12-12.9	178.6	172.3-185.0	170.9	165.2-176.6
	13-13.9	190.0	184.9-195.1	177.3	172.2-182.3
	14-14.9	210.8	206.1-215.4	180.1	174.6-185.6
	15-15.9	221.3	215.9-226.6	184.1	177.8-190.5
30-m sprint (s)					
	12-12.9	5.05	4.96-5.15	5.18	5.10-5.27
	13-13.9	4.84	4.77-4.90	5.12	5.05-5.18
	14-14.9	4.61	4.55-4.68	5.11	5.04-5.18
	15-15.9	4.41	4.34-4.47	5.13	5.05-5.21
20-m suttle run (km·h^{-1})					
	12-12.9	11.3	11.0-11.6	11.0	10.7-11.2
	13-13.9	12.0	11.8-12.3	11.1	10.9-11.3
	14-14.9	12.3	12.1-12.4	11.0	10.8-11.2
	15-15.9	12.1	11.9-12.3	11.3	11.1-11.6
sit and reach (cm)					
	12-12.9	24.6	22.5-26.7	31.4	29.5-33.3
	13-13.9	28.1	26.1-30.0	37.0	35.0-39.0
	14-14.9	30.5	28.7-32.4	38.5	36.3-40.7
	15-15.9	31.7	29.9-33.6	37.5	35.4-39.7

ones in all tested variables, with the exception of the hip and hamstring flexibility variable, in which female handball players were significantly more flexible than males in each age group. In the 12-year-old age group, no significant differences between male and female handball players were found in the muscle power of the lower extremities and the aerobic capacity, as measured by the standing long jump and the 20-m shuttle run test, respectively. In this same age group, the higher performance of male compared to female handball players in running speed was almost found to be statistically significant.

Age, body height and mass adjusted means and 95% confidence intervals for the performance of male and female handball players are presented in Table 3. In addition to comparisons between male and female handball players, trends in performances across age groups were evident (Fig. 1). Performance in muscle power (ball velocity and standing long jump) improved across age in both sexes. Sex differences in ball velocity, standing long jump and running speed increased with age, while sex differences at the age of 12 were not so apparent for the standing long jump and the running speed test (Fig. 1b, 1c). The magnitude of the sex differences in ball velocity, standing long jump and running speed was largest among 15-year-old handball players. Aerobic capacity improved across age in males until the age of 14 and then it remained stable, with the peak increase occurring between the ages of 12 and 13 years. In females, aerobic capacity appeared stable over the range of the age groups tested (Fig. 1e). Flexibility increased with age in both sexes and female handball players were more flexible than male ones in each age group (Fig. 1d).

DISCUSSION

The issue of sex differences in motor abilities in the context of sport-specific training, which places similar performance demands on boys and girls who participate at relatively young ages, continues to attract scientific interest. This study aimed at providing related observations on possible sex differences in motor performance from a fairly large sample of Greek elite young male and female handball athletes.

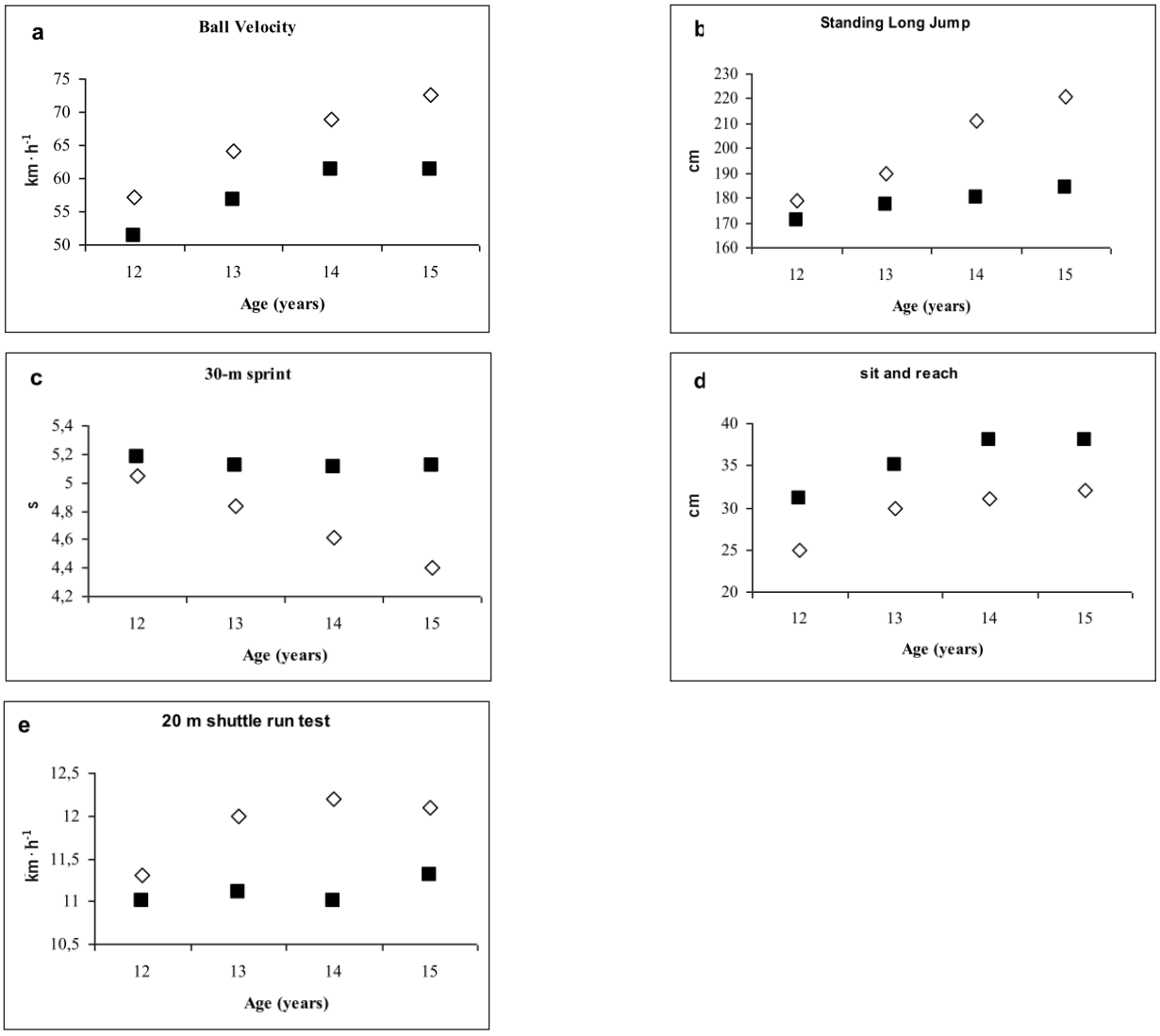

FIG. 1. AGE, BODY HEIGHT AND BODY MASS ADJUSTED MEANS FOR THE MEASURES OF MOTOR ABILITIES AMONG HANDBALL PLAYERS BY SEX WITHIN AGE GROUPS (MALES: OPEN TRIANGLES, FEMALES: FILLED SQUARES): A – BALL VELOCITY, B – STANDING LONG JUMP, C – 30-M SPRINT, D – SIT AND REACH TEST, E – 20 M SHUTTLE RUN TEST

Malina et al. [9] have documented that sex differences in motor performances of the general population of young children are rather small during childhood and early adolescence and become established in mid-to-late adolescence. Their observations suggest that while males tend to improve their motor performances throughout adolescence, females tend to reach a peak in their performances during early adolescence and either reach a plateau or demonstrate a decrease in performance towards late adolescence. With the exception of flexibility, males tend to perform, on average, better than females in the motor ability tests of speed, power and coordination, muscular endurance and agility [10]. In the present study, the sample was composed of elite young male and female handball players, who have the same training demands in terms of frequency and training load (3 days per week at 1.5-2 hours of training per day). Results showed that female handball players performed significantly better than males in the flexibility test (lower back and hamstrings) in all age groups (12-12.9 years, 13-13.9 years, 14-14.9 years and 15-15.9 years). The magnitude of sex differences between male and female handball players in this study was significantly greater for males in all measured motor ability tests and among all age groups, with the exception of the 12-year-old age group. At this age, motor performance of male and female handball players was similar for the lower body power test (standing long jump) and the aerobic capacity test, whereas a significant difference was observed for the upper body power test (ball velocity) (Table 2). It is interesting to observe that the magnitude of the sex difference in upper body power is similar until the age of 14 and then it increases significantly in the 15-year-old male compared to female handball athletes, whose motor performance reaches a plateau. Sex differences in the explosive power of upper and lower extremities probably reflect the adolescent growth spurt of males in strength and power [9]. Maximal gains in muscle strength and power occur, on average, after peak height velocity in both sexes, but the estimated gain in males is about twice as large as the one in females [10]. Furthermore, another performance measure capable of identifying sex differences in motor abilities is throwing, for it constitutes a fundamental human motor ability [11]. Sex differences in throwing motor ability are related to throwing distance and throwing velocity, where males attain higher performances than females in all age groups and competitive levels [12]. It appears that there are biological factors responsible for the observed sex differences in throwing performance between males and females. Ives et al. [7] reported significantly lower levels of neuromuscular coordination in maximally fast elbow flexion movements in female college-aged subjects compared to male ones. Lower aerobic capacity levels in females in all age groups seem to be mainly related to lower muscle mass and lower haemoglobin levels and blood volume found in females, probably due to higher testosterone levels observed in males as well as higher fat content and lower size of heart and lungs in females [4,14].

The observed sex differences in motor abilities of elite young male and female handball players present similarities as well as dissimilarities with previous results on elite adolescent distance runners [3] and elite adolescent divers [9]. Male and female distance runners had similar motor performance in the standing long jump and vertical jump before the age of 14, but at older ages, males performed better than females [3]. Young male divers performed better than female divers in the vertical jump until the age of 13, but at older ages, the magnitude of sex differences became greater in favour of male divers [9]. On the other hand, both female distance runners and divers performed significantly better than males in the sit and reach flexibility test in every age group. According to Malina et al. [9], similar sport-specific training regimens could probably decrease the magnitude of sex differences in motor abilities observed in the general population. Based on the results from this study, this appears to be valid until the 13-year age group, since after 13 years of age male handball athletes performed better in all motor ability tests than female handball athletes, with the exception of the sit and reach flexibility test. It is likely that hormonal activity during the adolescent growth spurt period and the anabolic action of androgens in males have a relatively strong effect during the age of 13-14 years and that any training stimulus is not able to outweigh this hormonal influence.

CONCLUSIONS

In conclusion, identification of sex differences in the motor performance of elite young male and female handball players is important for optimal formulation and implementation of sport-specific training regimens. Considering the high specificity in performance among the different playing positions in handball [2, 13], comparisons of sex differences in motor performance could also be expanded to playing position. There exists research information regarding differences in anthropometric and physical characteristics of 13-14-year-old female back court players, wings, pivots and goalkeepers [15,16]. It seems necessary to expand these observations to a wider age range to check for possible sex-related differences among young handball players of specific playing positions. These observations would provide researchers and trainers with a complete profile of normative data and would assist in formulating an elaborate process of talent identification and development.

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