

# Sex differences in the motor performances of elite young divers

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## ABSTRACT

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Ital J Sport Sci 2005; 12: 18-23

*Objective:* To evaluate sex differences in the motor performances of elite young divers by competitive age groups.

*Methods:* Five tests of motor performance were administered to a sample of 281 elite divers, 123 males 8.5-18.5 years and 158 females 8.9-18.5 years of age. The tests were selected to measure components of skill and fitness deemed important to diving: vertical jump, seated medicine ball throw, timed sit-ups, sit and reach, and a quadrant jump. Divers were classified by competitive age categories: 13 years and under, 14-15 years, and 16-18 years. Sex differences in performance by age group were tested with analyses of covariance (ANCOVA) with age, height and weight as covariates.

*Results:* Male divers performed significantly better than female divers in the vertical jump, while female divers performed significantly better in the sit and reach within each age group. Male and female divers did not differ significantly in the medicine ball throw in the two younger age groups, but males performed the throw significantly better than females in the oldest age group. Male and female divers did not differ significantly in sit-ups and the quadrant jump in each of the three age groups.

*Conclusion:* Sex differences in motor performances of elite young divers are negligible until late adolescence, when the male adolescent spurts in muscle mass, specifically upper body musculature and in strength and power contribute to sex differences in several performance items. Similar training protocols in elite young athletes perhaps reduce the magnitude of sex differences in performances noted in the general population of youth.

**KEYWORDS:** diving, power, flexibility, agility, muscular endurance

## INTRODUCTION

Age - and sex- associated variation in the motor performances of children and adolescents is well documented. Performances in a variety of tasks (e.g., grip and pull strength, flexed arm hang, sit-ups, standing long jump, vertical jump, throw for distance, running speed, agility) improve, on average, with age during childhood and there is much overlap in the performances of boys and girls. During adolescence, performances of girls show a slight increase in some tasks and a plateau in others, while those of boys show, on average, marked improvements. Hence, sex differences are magnified. Balance (beam walk) increases gradually during childhood and adolescence, and sex differences are negligible. Flexibility of the lower back and upper thighs as measured by the sit and reach tends to be stable in girls and to decline in boys during childhood, and then increases considerably during adolescence. Flexibility is, on average, greater in girls than in boys at all ages during childhood and

adolescence (Malina et al., 2004).

A question of interest is the magnitude of sex differences in the motor performances of elite young athletes participating in the same sport in which the performance demands for boys and girls are essentially the same, for example, distance running, diving, down hill skiing. Observations on a mixed-longitudinal sample of elite young distance runners from 8 to 15 years indicate attenuated sex differences in measures of agility and explosive power prior to 13 years of age. During the adolescent spurt, agility and power improved in males and reached a plateau in females. On the other hand, measures of upper body muscular endurance and flexibility were greater from childhood through adolescence, respectively, in males and females (Eisenmann and Malina, 2003). The present study extends these observations to elite divers. It specifically considers age- and sex-associated variation in five measures of motor performance in Junior Olympic divers participating in the same competitive age groups.

## METHODS

The sample included 281 divers, 123 males 8.5-18.5 years and 158 females 8.9-18.5 years of age. All were participants in the 1991 and 1992 Speedo/U.S. Diving Junior Olympic Championships. Participants were successful in regional competitions throughout the country in order to qualify for the national competitions. Divers competed in three age groups: 13 years and under, 14-15 years, and 16-18 years. The project was approved by United States Diving; consent of a parent and/or guardian and consent of individual divers were also obtained.

In addition to height and weight, five tests of motor performance were administered. Growth and physique characteristics of the divers have been previously reported (Malina and Geithner, 1993; Geithner and Malina, 1993; Geithner et al., 2004). Tests were selected to measure components of skill and fitness deemed important to diving: explosive power of the lower extremities - vertical jump, explosive power of the upper body - seated medicine ball throw, abdominal muscular strength and endurance - timed sit-ups, lower back and upper thigh flexibility - sit and reach, and total body agility - quadrant jump (O'Brien, 1993). Details of the protocols for each test are summarized in Table 1. Decimal age was calculated as the difference between date of observation and date of birth.

The divers were classified by competitive age categories for the Junior Olympic competition: 13

years and under, 14 and 15 years, and 16 to 18 years. Sex-specific means and standard deviations for age, height, weight and performance variables were calculated for each age group. Sex differences were initially tested for age, height and weight in each age group. Sex differences in performance were evaluated in each age group using analysis of covariance (ANCOVA) with age, height and weight as covariates.

## RESULTS

Descriptive statistics for age, height and weight are summarized in Table 2. Age did not differ between male and female divers in each of the age groups. In the 13 years and under group, females were significantly taller ( $p < 0.01$ ) and heavier ( $p < 0.05$ ). Height and weight did not differ between male and female divers in the 14-15 year age group, but in the oldest age group, 16-18 years, males were significantly taller ( $p < 0.01$ ) and heavier ( $p < 0.01$ ).

Means and standard deviations for the five performance variables and results of the ANCOVAs are summarized by sex within each age group in Table 3. Male divers performed significantly better than female divers in explosive power of the lower extremities (vertical jump) in each of the three age groups, while female divers were significantly more flexible in the lower back and upper thighs (sit and reach) than male divers in each of the three age groups. Male and female divers did not differ

Table 1 - Test protocols for performance items used with Junior Olympic divers

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**VERTICAL-JUMP** - The subject stands with his/her preferred side toward and touching the wall (with a mounted tape measure), and then reaches up with the arm next to the wall without lifting the heels off the floor. The height of the reach of the tip of the middle finger is recorded to the nearest 0.5 inch. The subject then leaps from a crouched position, extending the arms as high as possible and touching the tape measure with the fingertips. The point on the tape reached by the finger tips at the highest point of the jump is recorded to the nearest 0.5 inch. The height of the jump is the difference between the standing reach height and the height reached during the jump. The highest of three jumps is used. Inches were converted to centimeters.

**SEATED MEDICINE BALL THROW** - A one kg medicine ball is used. The subject is seated on a mat with his/her back facing the area to which the ball is thrown and with the feet extended and slightly apart. With the arms extended forward and downward, and the ball held in both hands between the legs, the subject vigorously throws the medicine ball backwards over his/her head as far as possible. The distance is recorded to the nearest 0.5 foot. The best of three throws is used. Feet were converted to meters.

**TIMED SIT-UPS** - The subject lies on a mat in a supine position with fingers laced tightly behind the neck and the elbows pointing directly forward. Both knees are flexed. With both feet being held down, the subject curls the trunk until the elbows touch the thighs and then returns to the starting position. There is no trunk rotation. The subject repeats this motion as rapidly as possible for 20 seconds. The score is the number of completed sit-ups in 20 seconds.

**SIT AND REACH** - The subject sits, without shoes, at the sit and reach box with the knees fully extended and the feet flat against the box. The arms are extended forward with one hand placed on top of the other. The subject then reaches directly forward, palms down, as far as possible along the measuring scale four times and holds the position of maximum reach (for at least one second) on the fourth trial. The score is the maximum reach to the nearest centimeter.

**QUADRANT JUMP** - A starting line and a quadrant are marked on the floor (quadrant separators are three feet long and cross each other at right angles) and quadrant numbers are marked. The subject stands at the starting line. At the starting signal, the subject jumps with both feet successively (in sequence) into quadrants 1, 2, 3, 4, 1, 2, etc. The pattern is continued as rapidly as possible for 10 seconds. The score for each trial is determined as follows: (a) one point is awarded each time the subject lands with both feet entirely within the correct quadrant during the 10 second trial; (b) a penalty of 0.5 point is subtracted each time the subject touches a line and for each time the subject lands with one or both feet in an incorrect quadrant. The subject's score is the number of correct jumps less the penalty deduction. The average of two, 10 second trials is the subject's score..

Adapted from O'Brien (1993).

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Table 2 - Sample sizes and descriptive statistics for age, height and weight of divers by sex within competitive age groups.

Age Group/Variables	Males			Females		
	n	Mean	SD	n	Mean	SD
<i>13 years and under</i>						
Age, yrs	44	12.0	1.1	54	12.3	1.2
Weight, kg		38.2	7.7		41.7	7.4
Height, cm		144.6	8.8		151.4	7.7
<i>14-15 years</i>						
Age, yrs	30	14.7	0.6	49	14.7	0.6
Weight, kg		51.5	9.0		51.7	5.6
Height, cm		161.1	7.5		159.4	5.3
<i>16-18 years</i>						
Age, yrs	49	17.3	0.8	55	17.1	0.9
Weight, kg		66.3	7.8		57.0	5.2
Height, cm		172.4	5.5		161.6	5.4

significantly in upper body power (medicine ball throw) in the 13 and under and 14-15 year age groups, but among divers 16-18 years, males performed the medicine ball throw significantly better than females. In contrast, male and female divers did not differ significantly in abdominal muscular strength and endurance (sit-ups) and in total body agility (quadrant jump) in each of the three age groups.

Age, height and weight adjusted means and 95% confidence intervals for the performances of male and female divers are summarized in Figure 1. In addition to comparisons of male and female divers, trends in performances across age groups were evident. Performances in the two power items (Figures 1a and 1b) improved across age in both sexes. Sex differences in the vertical jump increased with age, while sex differences in the medicine ball throw were not apparent in the two younger age groups and were apparent in the oldest age group. Abdominal strength and endurance (sit-ups) showed no sex difference and the age trend was similar in both male and female divers. Sit-up performance increased from the 13 years and under divers to 14-15 year old divers and then was stable (Figure 1c). Lower back and upper thigh flexibility (sit and reach) increased with age in both sexes and female divers were more flexible than male divers in each age group. The magnitude of the sex difference in flexibility was largest among 14-15 year old divers and similar in the younger and older age groups (Figure 1d). Total body agility (quadrant jump) showed a pattern of age group variation similar to that for sit-ups, i.e., an increase from 13 and under divers to 14-15 year old divers and then a stable level. Sex differences in the quadrant jump in each age group were small (Figure 1e).

## DISCUSSION

Sex differences in the motor performances of the general population of youth are rather small during childhood and become established in adolescence. With the exception of flexibility, males tend to attain, on average, higher performances than females in standard tests of speed (dashes), power and coordination (vertical jump, standing long jump, throw for distance), muscular endurance (flexed arm hang) and agility (shuttle runs) from about 8 years of age on and the difference between sexes increases during adolescence (Malina et al., 2004). Among elite youth divers, sex differences in abdominal muscular strength and endurance (sit-ups) and in total body agility (quadrant jump) were not significant in each of the three age groups, while sex differences in upper body power (medicine ball throw) were not significant in the 13 and under and 14-15 year age groups. In contrast, male divers performed significantly better than female divers in explosive power of the lower extremities (vertical jump) in each of the three competition age groups, and significantly better in the medicine ball throw only in the oldest age group. Female divers were significantly more flexible in the lower back and upper thighs (sit and reach) than male divers in each of the three age groups.

The male and female divers in this sample had similar training frequencies and volumes, about 5 days of training per week and about 3 hours per training session (Malina and Geithner, 1993). Since the training and performance demands of diving are similar for both sexes, it is likely that sport-specific training reduced or eliminated sex differences in the performance items requiring agility, abdominal muscular strength and endurance, and upper body power. The sex difference in upper body power becomes significant only in the oldest age group, 16-18 years, i.e., late in the male adolescent spurt. Maximal gains in upper body strength occur, on average, after peak velocity of growth in height (peak height velocity) in both sexes, but the estimated gain in boys is approximately twice as great as in girls. The trend is similar to the medicine ball in through boys, but corresponding data for girls does not indicate a clear spurt (Malina et al., 2004). Though significant, the difference in explosive power of the lower extremities (vertical jump) is small in divers 13 years and under, 1.8 cm, but is magnified in the two older age groups. As the case for upper body power, this probably reflects the male adolescent spurt in strength and power. Maximal gains in the vertical jump occur after peak height velocity, though comparable data for boys and girls are lacking (Malina et al., 2004).

Table 3 - Sample sizes and descriptive statistics for measures of performance among divers by sex within competitive age groups, and results of the analyses of covariance

Age Group/Variables	n	Males		n	Females		ANCOVA <sup>1</sup>	
		Mean	SD		Mean	SD	F	p
<i>13 years and under</i>								
Vertical jump, cm	42	37.2	5.7	51	35.4	6.4	4.59	<0.05
Medicine ball throw, m	42	3.0	0.7	52	3.1	0.6	1.75	ns
Sit-ups, n/20 sec	42	39.8	6.4	52	39.7	5.7	0.001	ns
Sit and reach, cm	43	34.9	4.2	52	39.4	5.1	13.87	<0.001
Quadrant jump, n/10 sec	43	19.9	2.7	52	20.6	2.9	0.82	ns
<i>14-15 years</i>								
Vertical jump, cm	30	47.0	7.1	45	39.4	7.6	18.35	<0.001
Medicine ball throw, m	30	3.8	0.9	47	3.7	0.7	0.55	ns
Sit-ups, n/20 sec	29	43.2	5.6	47	42.9	4.8	0.001	ns
Sit and reach, cm	30	38.2	5.0	47	44.5	4.0	43.84	<0.001
Quadrant jump, n/10 sec	29	21.9	3.2	45	22.8	2.8	2.05	ns
<i>16-18 years</i>								
Vertical jump, cm	45	56.9	8.5	51	41.5	7.4	36.07	<0.001
Medicine ball throw, m	47	5.4	1.2	53	3.9	0.7	13.57	<0.001
Sit-ups, n/20 sec	46	43.7	5.9	50	43.3	4.4	0.41	ns
Sit and reach, cm	47	43.5	4.3	53	46.1	3.7	9.47	<0.01
Quadrant jump, n/10 sec	46	22.6	2.6	53	22.3	2.5	0.03	ns

<sup>1</sup>Results of analyses of covariance with age, height and weight as covariates.

Table 4. Age, height and weight adjusted means and 95% confidence intervals (CI) for measures of motor performance among divers by sex within competitive age groups.

Performance variable Age Group	Males		Females		
	Mean	95% CI	Mean	95% CI	
Vertical jump, cm	13 and under	37.8	35.9 – 39.8	34.9	33.2 – 36.6
	14-15	46.9	44.2 – 49.6	39.4	37.3 – 41.6
	16-18	55.9	53.1 – 58.8	42.4	39.7 – 45.0
Medicine ball throw, m	13 and under	3.2	3.0 – 3.4	3.0	2.8 – 3.2
	14-15	3.8	3.5 – 4.1	3.7	3.5 – 3.9
	16-18	5.1	4.8 – 5.4	4.2	3.9 – 4.5
Sit-ups, n/20 sec	13 and under	39.8	37.9 – 41.7	39.9	38.1 – 41.5
	14-15	43.0	41.0 – 44.9	43.0	41.5 – 44.5
	16-18	44.0	42.1 – 45.9	43.1	41.3 – 44.8
Sit and reach, cm	13 and under	35.3	33.8 – 36.7	39.2	37.9 – 40.5
	14-15	38.1	36.6 – 39.6	44.6	43.4 – 45.8
	16-18	43.1	41.6 – 44.5	46.5	45.2 – 47.9
Quadrant jump, n/10 sec	13 and under	19.9	19.1 – 20.8	20.5	19.7 – 21.3
	14-15	21.8	20.7 – 22.9	22.8	21.9 – 23.7
	16-18	22.4	21.4 – 23.3	22.5	21.7 – 23.3

The pattern of sex differences in elite divers is similar to that in elite distance runners (Eisenmann and Malina, 2003). Male and female runners did not differ significantly in two measures of agility, the quadrant jump and side leap, across all ages from 10 to 17 years. Results were similar for a figure-8 run (agility)

and the standing long and vertical jumps before 14 years of age; at older ages males performed better. In contrast, male runners performed consistently better in the flexed arm hang (upper body muscular strength and endurance), while female runners performed consistently better in the sit and reach (flexibility).

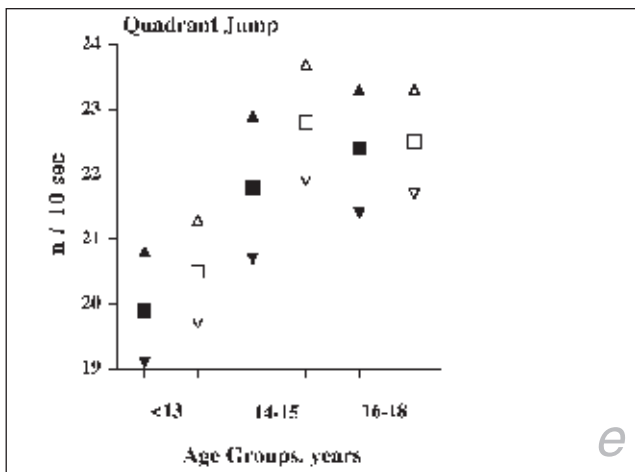
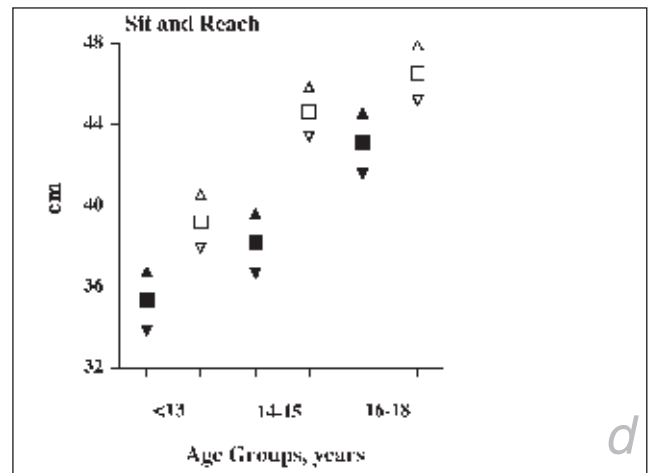
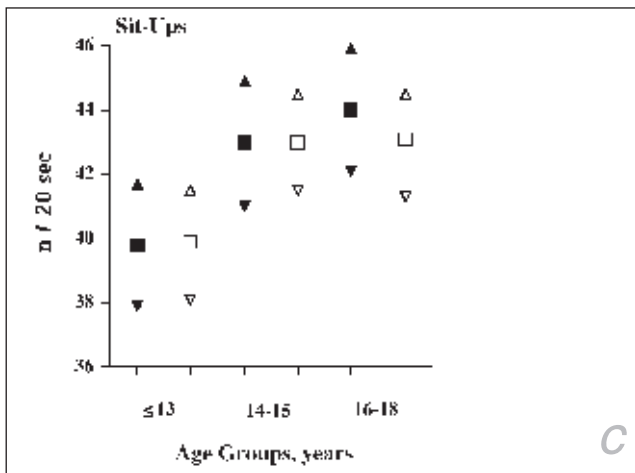
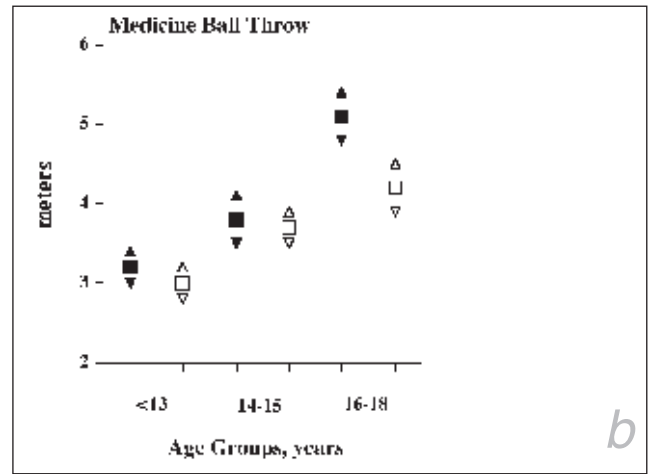
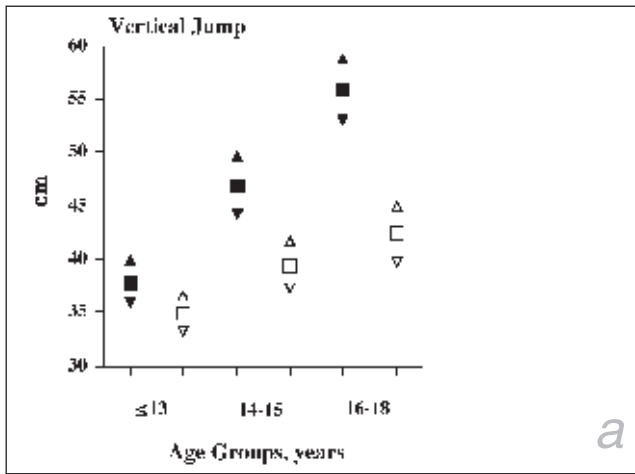


Fig. 1 - Age, height and weight adjusted means ( $\pm 95\%$  confidence intervals) for the measures of motor performance among divers by sex within competitive age groups (males filled squares and triangles [95% CI]; females open squares and triangles [95% CI]):  
 a - vertical jump,  
 b - medicine ball throw,  
 c - sit-ups,  
 d - sit and reach,  
 e - quadrant jump.

The observations on both elite divers and distance runners thus suggest that sex differences in motor performance are negligible until late adolescence, when the male adolescent spurts in muscle mass, specifically upper body musculature and in strength and power contribute to sex differences in several

performance items at this time. The changes occur after peak height velocity. Similar training protocols in elite young athletes perhaps reduce the magnitude of sex differences in performances noted in the general population of youth.

The observations on elite young athletes in diving

and distance running need to be expanded to young athletes in other sports. Such comparisons may shed further light on the issue of sex differences in performance in the context of sport-specific training of boys and girls beginning at relatively young ages.

#### ACKNOWLEDGMENTS

The assistance and support of members of the U.S. Diving Talent Identification Committee are recognized and greatly appreciated: Steven J. Anderson, William W. Heusner (†), Dennis Golden and Janet L. Gabriel.

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