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Gender and Maturation Differences in Health-Related Physical Fitness and Physical Activity in Turkish Children

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Abstract: The aim of this study was to assess health - related physical fitness and physical activity parameters among children and to determine whether there were any significant gender and maturation differences. A total of 853 Turkish school children comprised of male prepubertal (n = 212), female prepubertal (n = 199), male pubertal (n = 222) and female pubertal (n = 218) children selected from the suburban schools of the Anatolian district of Istanbul were enrolled into this study. The health-related physical fitness properties included body composition, muscular strength, elasticity and aerobic fitness test and measurements. For estimation of the level of physical activity and daily energy expenditure the Bouchard's 3 day activity record was employed. The intensity of physical activity was divided into three groups with those having a MET of less than 4 considered sedentary, those with MET of 4-7 light while those with of MET >7 were considered to have Moderate-Vigorous Physical Activity (MVPA). The univariate 2 (gender) X 2 (maturation) ANOVA and co-variance tests were used to compare group means for body composition, physical fitness and physical activity. Evaluation of body fat ratio of the children revealed a significantly higher value for girls. The Max VO_2 and handgrip strength was greater in the male gender while maturation differences showed a similar pattern favoring the pubertal period. The flexibility of the pubertal girls was significantly better than their male counterparts. The duration of physical activity was significantly longer in the males than female children. The duration of light activity among girls was longer than that of boys whereas the duration of MVPA in boys was significantly longer than that of girls. On the other hand the duration of MVPA among the prepubertal children was significantly higher than that of children in the pubertal period.

Key words: Physical fitness, health-related physical activity, puberty, pre-puberty

INTRODUCTION

Considering the fact that previously conducted studies have established an association between physical activity and physical fitness on the one hand and cardiovascular and respiratory development (Pate, 1993; Zorba, 2000), reduction in the risk of cardiovascular diseases (Heyward, 1991; Tolfrey *et al*., 1998) reduction in the mortality and morbidity ratios (Zorba, 2000; Salminen *et al*., 1993) on the other hand together with other benefits, it is imperative that an investigation into both physical activity and physical fitness be conducted.

The physiological consequence of physical activity is in the form of increased energy expenditure and an increase in the cardiac and respiratory functions. This in turn plays an important role in the prevention of several diseases (Kriska and Caspessen, 1997). Physical activity is an important factor to consider in the maintenance of normal growth and development during the growth period in children. Due to its important association with good health, growth and motor development physical activity has become the focus of several investigations (Baranowski *et al*., 1992).

Moreover, there is no gold standard to establish the accuracy of physical activity. For this reason, methods selected to evaluate physical activity may vary according to the structure of the study. In evaluating physical activity it is necessary to ensure that the method is valid, that it is not inhibitory and that it is easily applicable and specific to the intensity of the physical activity. Among the methods employed for large populations the self-report method is the most practical and cheaper method (Bauman *et al*., 2006).

Physical fitness refers to the ability to successfully withstand the movements in a physical activity (Gutin *et al*., 1992). For children and adolescents, poor physical fitness does not only lead to the failure

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of sport performance but also result in the raising of sedentary individuals with increased risk of health problems and adults who were maladapted to the society. Obesity, especially, in addition to being a physical problem is also considered a psychological problem (Kallis, 1996). Researches suggest that an active lifestyle during childhood reduces the risk of health problems in later years (Ridgers *et al*., 2006).

As children grow, they become taller and heavier, the amount of lean and fat issue increases, their organs increase in size and so on. Different parts of the body grow at different rates and at different times. Adolescence is a period of dynamic physical and biological change. During puberty there are noticeable changes in body size and shape, in the relative proportions of muscles, fat and bone and in a variety of physiological functions (Baxter-Jones *et al*., 2005).

On the other hand, biological maturation refers to progress towards the biologically mature state and is not absolutely linked to time in a chronological sense. The process of maturation has two components: timing and tempo. The former refers to the age at which specific maturational events occur (e.g., age when menarche is attained, age at the beginning of breast development, age at the appearance of pubic hair, or age at maximum growth during the adolescent growth spurt). Tempo refers to the rate at which maturation progress i.e., how quickly or slowly an individual passes from the initial stages of sexual maturation to the mature state (Baxter-Jones *et al*., 2005).

Based on the previous studies, the present study was conducted on 2005, with an aim to determine whether gender and maturation differences would have an effect on not only the properties of physical fitness but also physical activities among both pubertal and pre-pubertal male and female children.

MATERIALS AND METHODS

Subjects: A total of 853 Turkish children made up of prepubertal male (n = 212), prepubertal female (n = 159), pubertal male (n = 224) and pubertal female (n = 218) children were enrolled in the study. The children were selected from non-licensed sporting children attending state-run sports schools from the Anatolian region of Istanbul. All subjects were healthy and participated regularly in the schools' physical education classes. Classification into prepubertal and pubertal periods was done based on the chronological age (Muratli, 1997; Selcuk, 1994).

Anthropometric assessment: Body height was measured using a Seca stadiometer to the nearest 0.1 cm and body mass was measured to the nearest 0.1 kg using medical scales.

Body composition: The measurement of skinfold thickness was obtained with the Holtain caliper (Crymych, U.K). Skinfold measurements were taken at four sites: the triceps (vertical fold midway between the olecranon process and the acromium process), biceps (vertical fold at the same level as the triceps skinfold), subscapular (oblique skinfold 1 cm below the inferior angle of the scapula) and suprailiac (the diagonal fold immediately above the crest of the ilium on a vertical line from the anterior axillary fold). Each skinfold was measured twice. Where the reading differed by >1 mm, a third reading was taken and the mean value recorded (Tamer, 2000). In calculating the body density use was calculated by the Dumin-Womersly, 1974 formula while the Siria's formul (Siria, 1956)was employed for estimation of body fat ratio. After the estimation of percentage body fat both the fatty and fat-free body weights were calculated.

Physical fitness: Aerobic fitness was estimated indirectly according to the children's performance on a 20 m shuttle run endurance test. Subjects were made to run at a speed of 8.5 km h^{-1} and increased at various stages of the exercise. The subjects run between two lines 20 m apart, in alternating directions, in a backward and forward fashion at a pace dictated by a sound signal from an audio tape which progressively got faster (0.5 km h^{-1} every min). The period at which the exercise was terminated was recorded as the test result. Based on the results obtained the Max VO_2 value was estimated in mL^{-1} kg^{-1} min^{-1} (Leger, 1988).

The handgrip strength and flexibility (sit and reach) was assessed by a Eurofit test battery. All the children were previously tested by the Eurofit test and familiarity with the test requirements ensured. Special attention was paid to motivate the children during the test periods (Eurofit, 1988).

Physical activity: Physical activity was assessed using the protocol of Bouchard. The protocol of Bouchard was conducted three times, two weekdays (two consecutive days) and one weekend. A day before the test session the children were advised to avoid from vigorous exercise. Activities were categorized according to the energy calculation scale into 1-9 groups. The average energy consumption calculated as the kilocalories per kilogram per day (kcal $kg^{-1}day^{-1}$) at 15 min intervals was used to compute the daily energy expenditure (Bouchard *et al*., 1983). The level of physical activity was obtained by dividing the daily energy expenditure from the Bouchard's protocol by the basal metabolic rate (Davies *et al*., 1995). To determine the basal metabolic rate the Harris-Benedict formula was employed (Roza and Shizgal, 1984).

The intensity of physical activity, was divided into three physical activity classes according to energy expenditure in the Bouchard's protocol as sedentary <4 MET activities (Activity 2- Activity 5), light 4-7 MET activities (Activity 6-Activity 8) and moderate-intensity >7 MET activities (Activity 9) (Verschuur and Kemper, 1985).

The 3 day leisure assessment was conducted on the basis of sleep (Activity 1) and the other times spent out of school (5 hours per day on weekdays).

Statistical analysis: As a definitive statistical analysis means (X) and Standard Deviation (SD) values were calculated. The Univariate 2 (gender) X 2 (maturation) ANOVA and covariance were used to compare group means for anthropometric parameters, body composition, physical fitness and physical activity. All statistical calculations were conducted using the SPSS (version 11) package software program.

RESULTS

Anthropometric properties, body composition, physical fitness, level of physical activity and intensity of physical activity are shown in Table 1-5, respectively.

Pubertal male and female children were taller than their prepubertal counterparts ($p<0.001$). Pubertal female children on the other hand were taller than their male counterparts ($p<0.05$). Pubertal male and female children weighed heavier than their prepubertal counterparts ($p<0.001$).

The values for the biceps in prepubertal and pubertal males was found to be significantly lower than girls of similar age ($p<0.001$). At the same time, values for prepubertal girls were significantly lower than those of pubertal girls ($p<0.05$). The triceps measured lower in both the prepubertal and pubertal boys than girls of similar age ($p<0.001$). Values for prepubertal male children were found to be significantly lower than those of pubertal male children ($p<0.01$). The subscapula value was higher in girls than in boys ($p<0.01$) and also in pubertal children than in prepubertal children ($p<0.001$). The suprailiac values for the prepubertal males were lower than those of pubertal males while that of prepubertal females was lower than that of male pubertal children ($p<0.001$). The values for pubertal boys were significantly lower than those of pubertal girls ($p<0.001$). The body fat ratio of the prepubertal boys and girls was lower than that for pubertal boys and girls ($p<0.001$). The fatty weight was higher both in girls than boys and for pubertal children than for prepubertal children ($p<0.001$). The fat-free weights of both pubertal boys and girls were found to be significantly higher than those of prepubertal boys and girls ($p<0.001$).

The Max VO_2 level was higher in boys than in girls as well as in pubertal children than prepubertal children ($p<0.01$). The handgrip strength in prepubertal male children was significantly higher than that of prepubertal female children ($p<0.001$). Values for prepubertal male and female children were found to be significantly lower than those of pubertal male and female children ($p<0.001$). Flexibility scores for pubertal girls were significantly higher than those of the pubertal male children ($p<0.001$).

The DEE and BMR were significantly higher both in male children than females ($p<0.01$) and in pubertal children than those in prepuberty ($p<0.001$) The FAD values for both prepubertal and pubertal boys were higher than their female counterparts ($p<0.001$). The values for pubertal children was in turn higher than those for prepubertal children among boys ($p<0.001$).

The duration of light intensity physical activity carried out by the prepubertal and pubertal males was shorter than that for females ($p<0.001$). The duration of MVPA was found to be significantly longer both in males than in females and in prepubertal children than in pubertal children ($p<0.001$).

DISCUSSION

This study was conducted with the objective of determining how differences in gender and maturation affected the properties of physical fitness and physical activities among pubertal male-female and prepubertal male-female children.

Growth and development is dependent on environmental as well as hereditary factors and is regulated by the hormonal system (Muratli, 1997). Growth is the increase in body dimensions, the result of hyperplasia (an increase in the cell number), hypertrophy (increase in cellular size) or increase in intercellular structures (Malina and Bauchard, 1991). Height and body weight are practical variables used to determine the rate of growth and development.

In present study, the height of children in pubertal stage of development was found to be significantly higher than that of prepubertal children. Pubertal girls were also taller than prepubertal boys. Body weight also exhibited maturational differences (Table 1).

Studies showing that height and body weight was greater in girls than in boys (Chen, 1991; Molinari and Hermanussen, 2005) with a tendency to increase with age (Malina and Bouchard, 1991) are available.

Table 1: Arithmetic means X± Standard deviation (SD) of the anthropometric properties of Prepubertal and Pubertal female and male children and ANOVA test results

Variables	Prepubertal male	Prepubertal female	Pubertal male	Pubertal female
Age (years) †	10.04±0.81	10.14±0.74	12.98±0.66	13.01±0.84
Height (cm) ‡	144.11±7.4	144.78±6.60	156.24±8.10	159.22±8.42
Body weight (kg) †	38.84±7.91	39.08±8.84	48.98±9.72	50.12±8.35

†Maturation difference, ‡Gender+ Maturation difference

Table 2: Arithmetic Means (X) ± Standard Deviation (SD) of Body composition of Prepubertal Female and Male Children and ANOVA test results

Body Composition	Prepubertal male	Prepubertal female	Pubertal male	Pubertal female
Biceps‡	6.72±3.25	7.48±3.02	6.68±3.11	7.69±4.12
Triceps‡	11.46±5.28	12.81±4.52	12.06±4.28	12.84±4.09
Subscapula ‡	8.01±5.05	9.44±4.29	9.06±4.67	10.40±3.96
Suprailiac‡	8.52±5.87	8.41±3.97	9.33±4.21	10.51±4.41
Body fat ratio (%)*	18.64±4.85	24.89±4.02	19.47±4.23	25.88±5.06
Fatty weight‡	7.24±4.01	9.72±3.12	9.52±3.84	12.97±3.68
Fat-free weight†	31.60±4.86	29.36±4.28	39.37±4.65	37.15±4.63

* Gender difference†Maturation difference‡Gender+ Maturation difference

Table 3: Arithmetic means (X) ± Standard deviation (SD) values for health-related physical fitness among prepubertal and pubertal female and male children and ANOVA test results

Variables	Prepubertal male	Prepubertal female	Prepubertal male	Prepubertal female
Max VO_2‡	32.12±5.29	28.02±4.57	36.22±5.77	30.14±4.52
Handgrip Strength‡	17.13±3.33	15.04±3.21	25.41±5.08	24.66±4.59
Flexibility*	17.88±5.27	18.10±5.89	17.31±6.27	19.18±6.98

* Gender difference, ‡Gender+Maturation difference

Girls at this stage of development are taller and heavier than boys because they are thought to be in their period of rapid growth. With maturation the increase in height and weight in both girls and boys are thought to be due to the fact that they are in their periods of normal growth. Throughout childhood and adolescence body composition demonstrates a dynamic pattern. These changes can be summarized as being that due to increases in bone mineral density, changes in body water content and the resultant increase and decrease, respectively in the fat-free body weight and fatty tissue. The differences due to gender are reflected by the differences in fatty mass between girls and boys (Baxter-Jones *et al*., 2005, Malina and Bauchard, 1991).

In present study, the biceps, triceps, subscapula, suprailiac and fatty weight demonstrated differences in both gender and maturation. The body fat ratio is another fatty value in which girls showed higher values than boys. The fat-free body weight demonstrated an increase with age (Table 2).

Studies demonstrating higher body fat ratios in girls than in boys (Cale and Almond, 1992; Christos *et al*., 2006; Lohman, 1987) which increases with age (Malina and Bouchard, 1991; Tekelioglu, 1999) are available.

Children from their sixth to tenth year of age exhibit a progressive increase in oxygen demand. In the late school-age period, there was a decrease in the oxygen up-take. With the beginning of adolescence period, the oxygen up-take is evidently increased. However, among girls, due to the maturation process, it is maintained at a certain level (Muratli, 1997). The difference in the Max VO_2 that exists between the two genders increases at puberty but the most appropriate period for development of aerobic system is the rapid growth period of adolescence. The development of the aerobic system is greater in boys than in girls (Christos, *et al*., 2006; Malina and Bouchard 1991).

In present study, significant differences in the Max VO_2 value in favor of both the male gender and children during their pubertal stage of maturation were observed (Table 3).

Parallel to our findings, studies in which the Max VO_2 values have been found to be significantly greater in boys (Guerra *et al*., 2002; MacDougall *et al*., 1983) and tending to increase with age (Malina Bouchard, 1991; Armstrong *et al*., 1991) are available.

Among boys, whereas the total muscle mass constitute only 25% of body weight at birth, in adults it may be well over 40%. Although no such rate of increase is observable among girls, the development still continues. This high rate of increase is thought to be due to the changes in hormonal levels associated with testosterone production. In girls however, elevation in estrogen level that causes an increase in the body fats occurs (Willmore and Costill, 1994).

The handgrip strength in prepubertal children in this study showed differences in favor of the male gender. There was a maturation difference also favoring the pubertal period (Table 3).

Similarly, there are studies in which the handgrip strength was found to be greater in males (Rowe, 1992) with significant maturation differences (Loko *et al*., 2000). The flexibility of children remains constant between 5 and 8 years of age. It peaks at 12-13 years of age after which it declines with advancing age. During pre-adolescence, because muscle tissue elongates in response to the increased bone length a decrease in flexibility during the period of rapid growth is observed. At all ages, girls are more flexible than boys with the greatest gender difference seen during the adolescence leap and sexual maturation (Malina and Bouchard, 1991).

The flexibility values for girls have been found to be higher than that for boys as in this study (Table 3). Studies demonstrating higher flexibility values for girls are available (Goslin and Burden, 1986; Willmore and Costill, 1996).

Table 4: Arithmetic means (X) ± Standard Deviation (SD) values for level of physical activity among prepubertal and pubertal female and male children and ANOVA test results

Variables	Prepubertal male	Prepubertal female	Prepubertal male	Pubertal female
Daily energy Expenditure (DEE) (kcal)‡	2009.82±211.31	1921.94±178.23	2361.84±220.21	2167.61±199.21
Basal Metabolic Rate (BMR)‡	1244.18±133.83	1213.58±93.14	1419.46±171.81	1347.98±98.91
Physical activity level (PAL)‡	1.61±0.51	1.58±0.44	1.66±0.67	1.60±0.58

* Gender difference, ‡Gender+Maturation difference

Table 5: Arithmetic means (X) ± Standard Deviation (SD) of physical activity intensity in prepubertal and pubertal female and male children and ANOVA test results

Variables	Prepubertal male (%) (h/week)	Prepubertal female(%) (h/week)	Pubertal male (%) (h/week)	Pubertal female (%) (h/week)
Sedentary	68.08	67.41	69.84	71.91
	35.33±6.24	35.01±7.83	36.20±7.01	37.30±9.10
Light*	18.98	25.30	21.04	25.07
	9.85±2.83	13.14±3.04	10.92±2.78	13.00±2.92
MVPA‡	12.94	7.29	9.12	3.02
	6.71±2.12	3.78±1.34	4.73±1.89	1.57±1.38

*Gender difference, ‡Gender+Maturation difference

Apart from the flexibility property the body fat ratio and the lower fat-free body mass have been thought to negatively affect the Max VO_2 and strength performance in girls. Also, hemoglobin levels and differences in hormonal changes have been suggested as being responsible for the differences between the genders.

During the process of normal growth and development in children, physical activity appears as an important issue. Many good habits are acquired early in life. Acquisition and development of health habits are no exception (Baranowski *et al.*, 1984). It is therefore necessary to start disease prevention programs at these ages. The habit of physical activity has a vital role in protection against childhood obesity which results from the imbalance between energy intake and expenditure (Pate, 1993). Assessment of physical activity status in pre-adolescence children is essential, because physical activity has several psychological and physiological effects on the health of the child both in childhood and adulthood (Harro, 1997).

In this study, the level of physical activity in boys was found to be significantly higher than that in girls. Among male children a difference in maturation in favor of puberty was observed (Table 4). The duration of light activity in girls was longer than that in boys, whereas the MVPA duration of boys was longer. The MVPA duration of children in the prepubertal period, however, was longer than that in children in the pubertal period (Table 5).

In studies conducted using different methods it has been found that male children and adolescents were more active than girls (Cale and Almond, 1992; Sallis *et al.*, 1998), while girls had longer duration of light activity (Tamer, 2000; Myers *et al.*, 1996) with the MVPA duration of male children being higher than that of female children (Bradley *et al.*, 2000; Faucette *et al.*, 1995).

The fact that the boys were appeared to be more physically active and also preferred to engage in MVPA than girls is thought to be the result of the higher body fat content and its resultant weight burden which encourages a more sedentary lifestyle in girls as well as the structural differences in the socio-cultural properties.

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