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Research article

Daily physical activity and physical fitness in 11-to 15-year-old trained and untrained Turkish boys

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Abstract
The aims of this study were to assess levels and patterns of physical activity (PA) in relation to age and regular sport activity, and to examine its relationship to physical fitness in trained and untrained boys. One hundred forty-seven 11-to 15-year-old boys (73 trained and 74 untrained) participated in this study. Trained boys, comprised of 26 soccer, 25 handball and 22 volleyball players, had been training regularly for at least one year. The intensity, duration and frequency of PA were assessed from four complete days of heart rate monitoring with 15-seconds sampling intervals. Aerobic fitness was assessed by determining peakVO_2 with a portable breath-by-breath gas analyzer (Cosmed K4b^2) and the running speeds at fixed lactate concentrations during an incremental running test. Anaerobic fitness was evaluated with the Wingate Anaerobic Test. Skinfold thicknesses from eight sites and Tanner stages of pubic hair were also obtained. Based on 15-s heart rate data, instead of continuous activity, multiple short bouts of moderate and vigorous PA, lasting up to one minute, were characteristic of daily PA patterns of both trained and untrained boys. PA levels of trained boys were higher than untrained boys ($p < 0.01$) and the levels of PA decreased with age and maturation in both groups ($p < 0.05$). Daily PA variables were related to body fatness in both groups ($p < 0.05$), but the relationships were not consistent in the trained group. Daily PA variables were also related to aerobic fitness in the untrained group ($p < 0.05$) and these relationships were somewhat better with vigorous PA, whereas in the trained group, none of the PA variables were related to any of the aerobic fitness indices ($p > 0.05$). No relationship was observed between PA variables and anaerobic fitness in either group ($p > 0.05$). It seems that such relationships may somewhat depend on the fitness level of the subjects.

Key words: Physical activity, training, aerobic and anaerobic fitness, body fatness, children.

Introduction

There is substantial evidence that sufficient PA during childhood and adolescence has beneficial effects on both short and long term health outcomes (Saakslahti et al., 2004; Strong et al., 2005). In a systematic literature review, Strong et al. (2005) emphasized the importance of PA as an integral part of a health enhancing lifestyle. Therefore, the assessment of the amount and intensity of PA in free-living conditions is important for understanding relations between PA and health. Moreover, there is also growing evidence that PA patterns track from childhood into adolescence and from adolescence into adulthood (Friedman et al., 2008; Telama et al., 2005; Trudeau et al., 2004). Probably for these reasons, in recent years, considerable research effort has been devoted to a greater understanding of children's PA as a modifiable lifestyle behavior.

The assessment of habitual PA among children is one of the most difficult tasks. Although several subjective and objective methods exist to assess PA, each of these methods has certain limitations (Armstrong and Welsman, 2006; Corder et al., 2008). However, it has been suggested that the more accurate estimates of PA, especially for children, come from objective measures with at least four complete days of monitoring (Corder et al., 2008; Trost et al., 2000). Heart rate (HR) monitoring is one of the most commonly used objective measures for assessing PA in children and adolescents (Armstrong and Welsman, 2006; Epstein et al., 2001). Previously, using objective measures, such as HR monitors, accelerometers or pedometers, studies have assessed the PA levels of children from a large number of different countries (Armstrong and Welsman, 2006; Epstein et al., 2001; Riddoch et al., 2004). However, despite the fact that habitual PA of children and adolescents is influenced by their culture and living environment (Biddle and Fuchs, 2009), there has been no objective data regarding the PA levels of Turkish children.

PA is defined as any bodily movement produced by skeletal muscles that result in energy expenditure (Caspersen et al., 1985), and is an umbrella term with multiple subcategories such as play, dance, transportation, exercise, sport and other leisure activities. Therefore, PA is different from regular sport activity or exercise training, which is only one subset of PA (Caspersen et al., 1985). However, when compared to non-athletic children, much less is known about the overall PA levels of athletic children (Falgairette et al., 1996; Hikihara, et al., 2007; Ribeyre et al., 2000). Moreover, to our knowledge, objective data comparing the PA levels of athletic and non-athletic children in relation to age are not available.

There are many factors, including heredity, maturation, age, nutrition and other behavioral and environmental factors that combine to influence the physical fitness of children and youth (Pangrazi and Corbin, 2001). As well as these factors, the level of PA can be considered as another behavioral factor that is able to influence physical fitness, as is the case in adults (Berthouze et al., 1995; Haskell et al., 2007; Kostka et al., 1997). However, the role that regular and habitual PA may play in promoting aerobic and anaerobic fitness in children is not clear.

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In pediatric literature, considerable emphasis has been placed on the relationship between habitual PA and aerobic fitness. However, the results of these studies are not consistent. Some studies have shown such a relationship (Boreham et al., 1997; Dencker et al., 2006; Ekelund et al., 2001; Falgairette et al., 1996; Gutin et al., 2005; Kristensen et al., 2010; Rowlands et al., 1999; Ruiz et al., 2006), whereas others have not (Armstrong et al., 1998; 2000; Janz et al., 1992; Katzmarzyk et al., 1998; Rowlands et al., 1999; Welsman and Armstrong, 1992; Weymans and Reybrouck, 1989). In the majority of these studies, PA has been assessed either by subjective methods (Boreham et al., 1997; Katzmarzyk et al., 1998; Weymans and Reybrouck, 1989) or by objective measures with limited duration of monitoring (Armstrong et al., 1998; 2000; Janz et al., 1992; Rowlands et al., 1999; Welsman and Armstrong, 1992), and aerobic fitness has also been estimated without direct measurement of oxygen consumption (Boreham et al., 1997; Falgairette et al., 1996; Katzmarzyk et al., 1998; Kristensen et al., 2010; Rowlands et al., 1999; Ruiz et al., 2006). Therefore, the reason for these inconsistent results may partly depend upon the methods used to assess both habitual PA and aerobic fitness. Moreover, although the PA patterns of young people are characterized by short bouts of intense activity (Bailey et al., 1995; Baquet et al., 2007; Berman et al., 1998) and many activities in daily life, as well as in sports that are both aerobic and anaerobic in nature. To date, only one study has examined the relationship between PA and anaerobic fitness in children (Armstrong et al., 1998).

Therefore, the aims of the present study were twofold: first, to assess the patterns and levels of objectively measured PA in relation to age and regular sport activity in a sample of 11-15 year old Turkish boys; and secondly, to examine the relationships of daily PA to aerobic and anaerobic fitness, fatness, age and sexual maturation in this sample of trained and untrained boys.

Methods

Subjects

One hundred seventy-four male volunteers (93 untrained and 81 trained), from one public primary school and three sport clubs in Ankara, Turkey, consented to participate in this study. Written informed consent was obtained from each subject and their parents after a detailed description of the purpose and procedures of the study. The study received ethical approval from the Ethical Committee of Hacettepe University, Ankara, Turkey. Interviews with parents and coaches indicated that all subjects were healthy and attended schools and clubs regularly. The decimal age of the subjects was computed from the date of birth and the date of data collection. Five age groups (11, 12, 13, 14 and 15 y) were constructed using one-year intervals, for example, the 11-year age group included observations between 10.50 and 11.49 years. Twenty-seven subjects were excluded from the analysis (8 in the trained and 19 in the untrained group) because they were unable to complete all the test procedures or HR monitoring was incomplete. Thus, a total of 147 subjects were included in the study, with 73 athletes (age range: 10.5 to 15.3 y) in the trained group and 74 boys (age range: 10.6 to 15.4 y) in the untrained group. The athletes, comprised of 26 soccer players, 25 handball players and 22 volleyball players, had been training regularly in their respective sport activity for at least 1 year, with 2-3 hours per day and 3 days per week. The mean (±SD) training age of the athletes for each age group (from 11 to 15 y respectively) were as follows: 1.2 (0.4), 1.3 (0.4), 1.5 (0.7), 2.0 (0.8) and 2.1 (1.0) y. Furthermore, both trained and untrained boys participated in regular physical education classes (2 hours per week) as part of the school curriculum. However, untrained boys were not involved in any systematic training program.

Testing procedures

In this cross-sectional study, all tests were completed between the months of December to May. For each subject, all tests were completed within 4 weeks (maximum 28 days) and subjects were randomly tested with regard to training status and age groups. The tests were administered in the following order: sexual maturation, anthropometric measurements, Wingate Anaerobic Test (WAnT), modified shuttle run test (MSRT) and habitual HR monitoring. The last three tests were conducted at least 2 days apart from each other. The WAnT and MSRT were performed under indoor conditions, where the average temperature and relative humidity were 20.1°C and 41.2%, respectively (Hanna Instruments, HI 8564, Italy). The subjects were familiar with these test procedures before actual testing. All subjects were instructed to refrain from strenuous activity for at least one day prior to testing, as well as to abstain from eating for at least two hours before the performance tests.

Sexual maturity

The self assessment method was used to evaluate the sexual maturation of the subjects (Faulkner, 1996). For self assessment of maturity, pictures illustrating and briefly describing the five stages of pubic hair development described by Tanner (Tanner, 1962) were given to the subjects individually. Identical instructions about these forms were also given individually. Each of the subjects was instructed to view and select carefully which stage most closely reflected their current appearance. For individual privacy, each of the subjects rated themselves in a private room and forms were returned within an envelope. To assess test retest reliability, a random sample of five subjects in each Tanner stage (totally 25 subjects) rated himself twice (one week apart) with the same procedures and an intraclass correlation coefficient (ICC) of 0.89 was obtained between ratings on two occasions. Frequency distribution of Tanner stages in trained and untrained subjects is presented in Table 1. The chi square analysis revealed that, within each age group, there were no significant differences between trained and untrained subjects in sexual maturity ($p > 0.05$).

Anthropometry

Stature and body mass were measured using a stadiometer (Holtain Ltd., UK) and a calibrated electronic scale (Seca, France) to the closest 0.1 cm and 0.1 kg, respectively, with the subject wearing light exercise clothing without

Table 1. Frequency distribution of Tanner stages classified by chronological age groups in trained and untrained subjects. Data are presented as the number (%).

	Age Groups					
Tanner Stage	11 yr	12 yr	13 yr	14 yr	15 yr	Total
Trained Group						
I	5 (33.3%)	1 (6.7%)	0 (0%)	0 (0%)	0 (0%)	6
II	10 (66.7%)	10 (66.7%)	2 (14.3%)	0 (0%)	0 (0%)	22
III	0 (0%)	2 (13.3%)	9 (64.3%)	2 (14.3%)	1 (6.7%)	14
IV	0 (0%)	2 (13.3%)	3 (21.4%)	8 (57.1%)	3 (20.0%)	16
V	0 (0%)	0 (0%)	0 (0%)	4 (28.6%)	11 (73.3%)	15
Untrained Group						
I	8 (53.3%)	0 (0%)	0 (0%)	0 (0%)	0 (0%)	8
II	7 (46.7%)	10 (66.7%)	3 (21.4%)	1 (6.7%)	0 (0%)	21
III	0 (0%)	5 (33.3%)	9 (64.3%)	4 (26.7%)	2 (13.3%)	20
IV	0 (0%)	0 (0%)	2 (14.3%)	7 (46.7%)	4 (26.7%)	13
V	0 (0%)	0 (0%)	0 (0%)	3 (20.0%)	9 (60.0%)	12

shoes. Thickness of eight skinfolds (biceps, triceps, subscapular, chest, suprailiac, abdominal, thigh and medial calf) was measured with a skinfold caliper (Holtain Ltd, UK) to the nearest 0.2 mm, on the right side of the body, using standard procedures (Lohman et al., 1991). Skinfold thicknesses were measured in duplicate or triplicate, according to the criteria (Lohman et al., 1991), and the mean of the two closest values was used for the analysis. The sum of the eight skinfolds (ΣSKF) was used as an indicator of fatness. In addition, the percentage of body fat (%BF) was also estimated from triceps and subscapular skinfold thicknesses using Slaughter's equations (Slaughter et al., 1988). Fat free mass (FFM) was calculated as body mass minus fat mass that was determined as body mass multiplied by %BF. One investigator performed all the anthropometric measurements. The ICCs were greater than 0.98 for all skinfold measurements in a subsample of 25 randomly selected subjects.

Wingate anaerobic test

Anaerobic fitness was evaluated with the WAnT, which was performed on a computerized cycle ergometer (Monark 834E, Varberg, Sweden). Before the test, each subject was informed about the test protocol. The seat height and handlebars were adjusted for optimal comfort and pedalling efficiency and the feet were firmly strapped to the pedals with toe clips. After a standardized 3 min warm up involving pedalling at 60-70 rpm interspersed with three all out sprints lasting 2 to 3 seconds, the subject rested for 5 min (Inbar et al., 1996). During the rest period, the subject was instructed to perform the test as fast and as hard as possible and was asked to remain seated throughout the test. Then the WAnT was initiated against minimal resistance. Following 3 to 4 seconds of rolling start, a predetermined 0.070 kg per kg of body mass was applied as test resistance for 30 seconds (Inbar et al., 1996). Verbal encouragement was given to every subject to maintain as high a pedalling rate as possible throughout the 30-s test duration. On completion of the test, the subject was instructed to pedal slowly to assist recovery. The highest value during the 30-s was defined as peak power, and mean power output was the average of all values obtained during the test. Peak and mean power were expressed in absolute (W) and relative units of body mass ($W \cdot kg^{-1}$). The reliability coefficient was determined in a randomly selected subsample (n = 25) who performed the WAnT twice, 2-3 days apart. The ICCs were 0.95 for both peak and mean power.

Measurement of aerobic fitness

Aerobic fitness was assessed using the MSRT, which was performed on an indoor 60 m circular track marked with cones every 20 m. The running pace was dictated by acoustic signals (Prosport, Tumer Electronics, Turkey), emitted at every 20 m intervals in accordance with predetermined running speed (RS), and the subjects had to be within 1 m of the cones with each sound signal. Each stage of the test lasted 3 min with constant running pace was separated by 1-min rest intervals. The initial warm-up RS was set at 6 $km \cdot h^{-1}$ and RS was then increased by 1 $km \cdot h^{-1}$ every three minutes until the subject could not maintain the running pace and/or volitional exhaustion. The subjects were encouraged verbally throughout the MSRT to maintain the required velocity as long as possible and to produce a maximal effort. The MSRT was terminated when the subject displayed signs of exhaustion (hyperpnoea, unsteady gait, facial flushing, sweating) and stopped running voluntarily or could not keep up with the running pace despite verbal encouragement. During each of the 1-min rest intervals, and upon termination of the test a 25-µL capillary blood sample was taken from the earlobe and analyzed immediately for whole blood lactate (La) concentration by means of an electro enzymatic method using the YSI 1500 Sport Lactate Analyzer (Yellow Springs Inst., Yellow Springs, Ohio, USA). By using the La values, La-running velocity curves were obtained for each subject. Thereafter, the RSs at fixed values of 2.5 ($RS_{2.5}$), 3.0 ($RS_{3.0}$), 3.5 ($RS_{3.5}$) and 4.0 ($RS_{4.0}$) $mmol \cdot L^{-1}$ La were computed by using interpolation technique with a minimum R value of 0.987.

During the MSRT, breath-by-breath oxygen uptake (VO_2) and HR were also measured with a Cosmed K4b^2 portable metabolic unit (Cosmed, Rome, Italy) and a Polar HR monitor, respectively. The metabolic unit and the La analyzer were regularly calibrated according to the manufacturers' instructions. At the end of each testing session, the data stored in the Cosmed K4b[2] unit were downloaded to a laptop using the manufacturers' software (Cosmed, Data Management Software, Version 7.3a). Breath-by-breath data were averaged over 5-s time intervals and subsequently imported into an Excel spreadsheet for further analyses. Thereafter, average VO_2 and HR during the last minute of each 3-min running stage was calculated, and the highest values of VO_2 and HR were used as peak responses. For each subject, the RS obtained at the last stage of the test was adjusted with elapsed running time, which was measured with run timer (Prosport, Tumer Electronics, Turkey), and defined as the peak RS of the subjects. An exhaustive effort was verified, and tests were accepted if the peak HR exceeded 190 $b \cdot min^{-1}$ (Rowland et al., 1997). In order to assess test retest reliability, 22 randomly selected subjects performed MSRT twice, 3-4 days apart. The ICCs for peak VO_2, peak HR, peak La and peak RS were 0.90, 0.93, 0.86 and 0.98, respectively. Moreover, the ICCs varied from 0.82 to 0.87 for submaximal RSs corresponding to fixed La concentrations.

Habitual HR monitoring

In this study, HR monitors were used for assessing habitual PA. The HR was recorded continuously every 15 seconds over 4 days (three randomly selected weekdays and one randomly selected weekend day) by using a waterproof HR monitoring system. The monitoring system consisted of a wireless and own coded (eliminates interference from other HR monitors) transmitter with comfortable and soft material chest strap (Wear Link 31 transmitter, Polar Electro Oy, Kempele, Finland), which was fixed to the chest and a receiver (S610i, Polar Electro Oy, Kempele, Finland). This was worn as a watch on the wrist. The recording capacity of the receiver was 66 hours and 10 minutes when the HR data was recorded at 15 seconds intervals.

After placing the monitoring system on subjects' chest and wrist, the investigator instructed the subjects and their parents on the use and removal of the system. Subjects were also instructed to maintain their regular daily activities and to record the time, at which they went to sleep, awoke, and at which they participated sporting activity including school physical education and training at sport clubs during the days monitored. Furthermore, subjects were also asked to complete a brief questionnaire regarding any discomfort related to the device. Ninety-four percent of the subjects did not complain about it interfering with their routine daily life.

At the end of each recording period, the HR data stored in the receiver were downloaded to a laptop using a Polar infrared interface for analysis with the Polar precision performance software (Version 4.01.029, Polar Electro Oy, Kempele, Finland). As well as this software, a Microsoft Excel based macro was also used for further analyses of the HR data. As for the quality of data, HR recordings were rejected and repeated on the same day of the next week if more than 2% of the daily data was erroneous (below $HR_{min.}$ and above $HR_{max.}$) for each monitoring day.

Each of the 15-s HR records obtained during waking time (HR_{waking}) was converted to the corresponding percentage of HR reserve (%HRR). The following equation was used for this purpose: [%HRR = [(HR_{waking} - $HR_{min.}$) / ($HR_{max.}$ - $HR_{min.}$)] x 100] (Gavarry et al., 1998; Falgairette et al., 1996). In this equation, $HR_{max.}$ was determined as the highest HR recorded during any 5-s period of the MSRT. Furthermore, $HR_{min.}$ was calculated as the lowest mean sleeping HR obtained for the four separate nighttime periods comprised between one hour after the subject's bedtime and one hour before waking up (Slooten et al., 1994).

Physical activity assessment

All PA variables examined in this study were calculated from the HR_{waking} (without sleeping time) for each of the four monitoring days. Then, the mean of these four values was assumed representative of the subjects' daily PA level and used for the final analysis.

The mean %HRR was computed to provide an index of total daily PA. The volume of accumulated activity, the duration of maximum sustained bout and the number of sustained bouts of activity were also calculated for two different relative intensities based on the individual's HRR which were classified as moderate physical activity (MPA) (between 50%-70% HRR) and vigorous physical activity (VPA) (above 70% HRR) (Gavarry et al., 1998; 2003). It has been suggested that the lower threshold for aerobic fitness effects is 50% of HRR (Epstein et al., 2001; Massin et al., 2005; Slooten et al., 1994). This threshold was therefore used for the cut off point for the assessment of daily PA.

The volume of accumulated PA (in minutes) was determined as the sum of the time at which HRs (with or without any time interval) were greater than or equal to these relative intensities. The duration of a maximum sustained bout of PA (in minutes) was calculated from the maximum length of the consecutive time interval at which HRs (without any time interval) were greater than, or equal to these relative intensities. Furthermore, the number of sustained bouts of PA (in number) was also calculated as the sum of the frequency of bouts lasting between 15 s to 60 s (1st Duration), from 60 s to 120 s (2nd Duration), and more than 120 s (3rd Duration) at which HRs (without any time interval) were greater than or equal to these relative intensities.

Statistical analyses

Mean values and standard deviations were calculated for all variables. Independent samples t-tests were used to compare the physical characteristics and the physical fitness of trained and untrained subjects. Age and group (trained vs. untrained) differences in habitual PA were analysed by a two-way (age x training) analysis of variance. When ANOVA revealed a significant difference, Tukey's HSD method was used for pairwise multiple comparisons. Differences in distribution of Tanner stages for each age group were tested by using the chi-square test. Analysis of variance (two-way mixed model) was used to calculate intraclass correlation coefficients (ICCs). Relationships between PA and age, fitness and fatness variables were assessed with Pearson's correlation coefficients (r). Spearman's correlation coefficients (r_s) were also computed to examine relationships between PA variables and maturation. The alpha level of statistical significance was set at $p< 0.05$ for all analyses. All statistical analyses were performed with the Statistical Package for the Social Sciences (SPSS Inc., Chicago, IL, USA).

Results

Physical characteristics of trained and untrained subjects are presented in Table 2. No significant difference was found in decimal age ($p > 0.05$), and as indicated in Table 1, there was no significant difference between the trained and untrained groups in sexual maturity ($p > 0.05$). Although body mass did not significantly differ between the trained and untrained groups ($p > 0.05$), athletic boys, active in team sports, including handball, volleyball and soccer, were taller, leaner, and had lower body fat than non-athletic boys ($p < 0.05$).

Table 2. Physical characteristics of trained and untrained subjects. Values are means (±SD).

	Trained subjects (n=73)	Untrained subjects (n=74)
Decimal age (years)	13.0 (1.5)	12.9 (1.4)
Stature (m)	1.61 (0.14)	1.54 (.13) **
Body mass (kg)	48.5 (11.3)	47.3 (12.4)
ΣSKF (mm)	71.3 (18.2)	97.5 (49.5) ***
Body fat (%)	14.2 (3.3)	18.9 (9.2) ***
FFM (kg)	41.7 (10.0)	37.9 (8.9) *

ΣSKF = sum of the eight skinfolds (biceps, triceps, subscapular, chest, suprailliac, abdominal, thigh, medial calf); FFM = fat free mass; *, ** and *** denote significant difference from trained subjects at $p < 0.05$, $p < 0.01$ and $p < 0.001$ respectively.

Aerobic fitness variables of trained and untrained boys are presented in Table 3. Both absolute and relative peak VO_2 and peak RS were significantly higher ($p < 0.01$), and peak HR was significantly lower ($p < 0.01$) in the trained than in the untrained group. The peak La concentration tended to be higher in the trained group, but the difference did not reach statistical significance ($p > 0.05$). Furthermore, submaximal RSs of trained boys at four different fixed La concentrations were significantly higher ($p < 0.01$) than those of untrained boys. Peak and mean power values of trained and untrained boys are displayed in Table 3. As expected, both absolute and relative values of peak and mean power were significantly greater ($p < 0.01$) in the trained than in the untrained group.

The daily PA variables of trained and untrained boys aged between 11 and 15 years are presented in Table 4. Analysis of variance revealed that although %HRR significantly decreased with increasing age ($p < 0.05$), the only significant difference was detected between 11 and 15 years of age ($p < 0.05$). The volume of accumulated MPA and VPA showed a slight tendency to decrease with age, though not significantly ($p > 0.05$). The duration of maximum sustained bouts of activity did not change with age ($p > 0.05$). When the daily number of sustained bouts were considered, the 1st duration of MPA and VPA were also significantly reduced with age ($p \le 0.01$), and differences were significant between 11-14 and 11-15 years for VPA ($p < 0.05$), and 12-14 years for MPA ($p < 0.05$). Furthermore, the 2nd duration of MPA and VPA also tended to decrease with age, but the effect of age on these variables were not significant ($p > 0.05$). In terms of differences between the trained and untrained groups, all of the examined variables of daily PA were significantly higher in the trained group than in the untrained group ($p < 0.01$).

Table 3. Aerobic and anaerobic fitness of trained and untrained subjects. Values are means (±SD).

	Trained Subjects (n=73)	Untrained Subjects (n=74)
	Aerobic Fitness	
Peak VO_2 ($L·min^{-1}$)	2.5 (.6)	2.1 (.5) ***
Peak VO_2 ($mL·kg^{-1}·min^{-1}$)	50.7 (3.8)	45.4 (5.1) ***
Peak HR ($b·min^{-1}$)	197.3 (5.1)	203.1 (6.2) ***
Peak La ($mmol·L^{-1}$)	7.9 (2.0)	7.6 (1.9)
Peak RS ($km·h^{-1}$)	13.8 (1.2)	12.4 (1.2) ***
$RS_{2.5}$ ($km·h^{-1}$)	10.2 (.9)	8.0 (.8) ***
$RS_{3.0}$ ($km·h^{-1}$)	10.7 (.9)	8.7 (.8) ***
$RS_{3.5}$ ($km·h^{-1}$)	11.1 (.9)	9.2 (.8) ***
$RS_{4.0}$ ($km·h^{-1}$)	11.4 (.9)	9.6 (.8) ***
	Anaerobic Fitness	
Peak power (W)	447.5 (146.7)	388.9 (117.1) **
Peak power ($W·kg^{-1}$)	9.1 (1.3)	8.2 (1.2) ***
Mean power (W)	319.4 (101.1)	275.2 (82.9) **
Mean power ($W·kg^{-1}$)	6.5 (.8)	5.8 (.8) ***

HR = heart rate; La = blood lactate; RS = running speed; $RS_{2.5}$, $RS_{3.0}$, $RS_{3.5}$ and $RS_{4.0}$ = submaximal running speeds corresponding to fixed blood lactate concentrations of 2.5, 3.0, 3.5 and 4.0 $mmol·L^{-1}$ respectively; ** and *** denote significant difference from trained subjects at $p < 0.01$ and $p < 0.001$ respectively.

The relationships between daily PA variables and decimal age, sexual maturation, fatness, aerobic and anaerobic fitness of trained and untrained boys are displayed in Table 5. In general, especially for untrained boys, only low to moderate but significant relationships were found between daily PA variables and age, maturation, fatness and aerobic fitness.

As displayed in Table 5, %HRR was negatively and significantly correlated with decimal age in both trained and untrained groups ($p < 0.05$). Accumulated VPA was also negatively correlated with age in only untrained group ($p < 0.05$). However, not only %HRR, but also accumulated MPA and VPA were significantly and negatively related with maturation in both groups ($p < 0.05$). In terms of the daily number of sustained bouts, both the 1st and the 2nd duration of MPA and VPA were significantly and negatively related to age and maturation in the trained group ($p < 0.05$), but these inverse relationships were obtained only for the 1st duration of MPA and VPA in the untrained group.

As shown in Table 5, there were significant negative correlations between daily PA variables and body fatness (ΣSKF and %BF) ($p < 0.05$). The magnitude of the observed correlations ranged from -0.24 to -0.30 and -0.23 to -0.43 for trained and untrained subjects, respectively. The inverse relationships between different variables of PA and fatness were more prominent for untrained than for trained boys. In addition, these relationships were stronger for ΣSKF than for %BF in both groups.

Although significant positive correlations were found between daily PA variables and aerobic fitness (peak VO_2, peak RS and submaximal RSs corresponding

Table 4. Daily physical activity levels of trained and untrained boys from 11 to 15 years of age. Values are means (±SD).

T/U (n)		11 yr 15 / 15	12 yr 15 / 15	13 yr 14 / 14	14 yr 14 / 15	15 yr 15 / 15	Age Effect	Training Effect	Age x Training
%HRR [a, b]	T	27.4 (1.9)	25.9 (3.3)	24.7 (2.0)	26.6 (2.3)	25.3 (2.5)	.021	<.001	.535
	U	24.5 (3.8)	24.5 (2.4)	23.2 (3.6)	23.3 (3.3)	22.1 (3.2)			
Volume of Accumulated Activity									
MPA [b] (min·day^{-1})	T	64.9 (14.0)	58.4 (18.0)	55.6 (17.2)	54.8 (13.3)	55.6 (17.4)	.131	<.001	.747
	U	39.8 (20.3)	43.7 (15.0)	35.9 (21.6)	33.3 (13.9)	30.6 (16.7)			
VPA [b] (min·day^{-1})	T	31.8 (13.5)	28.1 (13.5)	28.7 (14.7)	29.8 (14.3)	26.2 (11.5)	.365	<.001	.947
	U	16.1 (11.1)	12.4 (5.3)	11.6 (8.7)	9.9 (8.3)	10.0 (7.8)			
Duration of Maximum Sustained Bouts									
MPA [b] (min·day^{-1})	T	5.5 (1.9)	4.8 (1.7)	4.7 (1.4)	4.8 (1.7)	5.0 (2.0)	.645	<.001	.636
	U	3.4 (1.2)	3.8 (1.3)	3.0 (1.3)	3.4 (1.2)	3.0 (1.5)			
VPA [b] (min·day^{-1})	T	5.5 (2.1)	5.7 (2.8)	5.6 (2.4)	6.0 (2.7)	5.8 (2.3)	.950	<.001	.935
	U	3.1 (2.0)	2.9 (1.6)	2.3 (1.4)	2.8 (1.6)	2.9 (1.8)			
Daily Number of Sustained Bouts									
MPA [a, b] 1st Duration	T	49.6 (11.9)	50.8 (17.9)	41.3 (14.5)	45.2 (14.2)	42.8 (12.8)	.010	<.001	.677
	U	42.1 (18.2)	43.7 (10.6)	35.1 (14.7)	28.9 (12.4)	31.4 (17.8)			
MPA [b] 2nd Duration	T	10.8 (2.8)	9.6 (3.5)	9.1 (2.6)	8.9 (2.5)	8.2 (2.7)	.093	<.001	.688
	U	6.6 (3.9)	7.6 (3.0)	5.5 (3.4)	6.1 (2.8)	5.5 (3.3)			
MPA [b] 3rd Duration	T	6.0 (2.4)	5.0 (2.2)	5.7 (2.5)	5.2 (2.3)	5.8 (3.1)	.900	<.001	.623
	U	3.0 (2.4)	3.3 (1.8)	3.1 (2.7)	2.9 (1.9)	2.2 (1.5)			
VPA [a, b] 1st Duration	T	14.2 (5.9)	14.0 (7.3)	11.8 (6.4)	11.5 (4.2)	11.2 (3.9)	.008	<.001	.946
	U	10.0 (5.5)	9.0 (3.2)	6.5 (3.5)	5.2 (3.7)	5.5 (5.6)			
VPA [b] 2nd Duration	T	3.7 (1.4)	3.6 (2.0)	3.6 (2.4)	2.8 (1.7)	2.6 (1.5)	.073	<.001	.995
	U	2.4 (2.2)	2.2 (1.1)	2.1 (1.9)	1.4 (1.0)	1.5 (1.6)			
VPA [b] 3rd Duration	T	4.0 (2.2)	3.1 (1.5)	3.6 (1.9)	3.9 (1.6)	3.1 (1.5)	.469	<.001	.704
	U	1.4 (1.2)	1.2 (.8)	1.1 (1.6)	1.4 (1.3)	1.3 (1.1)			

Age Groups (n = 147); P value.

T = trained; U = untrained; %HRR = percentage of heart rate reserve; MPA = moderate physical activity; VPA = vigorous physical activity; "a" denotes significant age effect; "b" denotes significant training effect.

to fixed La concentrations) in the untrained group ($p < 0.05$), there were no significant correlations between these variables in the trained group ($p > 0.05$). It is interesting to note that the magnitude of the correlations tended to be slightly higher when the peak VO_2 was related to VPA rather than to MPA or %HRR. Furthermore, except for the 3rd duration of MPA, the peak RS and RSs at fixed La concentrations were significantly and positively related to VPA ($p < 0.05$), but not related to MPA or %HRR ($p > 0.05$) in the untrained group.

Finally, in terms of the relationship between PA and anaerobic fitness, neither peak nor mean power values were related to any of the daily PA variables in both trained and untrained boys ($p > 0.05$).

Discussion

In the present study, intensity, duration and frequency of habitual PA, and its relationship with aerobic and anaerobic fitness were examined with regard to regular sport activity in 11-15 year old boys. No previous study has examined such relationships separately for trained athletic and non-athletic subjects. Thus, the main contribution of this study with respect to the existing literature is that it provides information about how this relationship is influenced by training status. In this study, using %HRR method indicative of intensity, the duration and frequency of habitual PA of 147 boys (73 trained and 74 untrained) were assessed by four complete days of HR monitoring with 15-s sampling intervals. Both maximal (Peak VO_2 and Peak RS) and submaximal (RSs at fixed La concentrations) indices of aerobic fitness were also assessed with objective measures. Furthermore, anaerobic fitness was evaluated by measuring peak and mean power outputs during WAnT. The results of this study revealed that the duration and frequency of PA were positively related to both maximal and submaximal indices of aerobic fitness in the untrained group, and these relationships were somewhat better with vigorous intensity of PA (>70% HRR). However, in the trained group, none of the PA variables was related to any of the aerobic fitness indices. Furthermore, no relationship was observed between PA and anaerobic fitness in either group. It appears that such relationships may depend on the fitness level of the subjects.

This study has also provided the first report of PA levels in a youth Turkish population as measured by HR monitoring. Although HR monitoring is one of the most commonly used objective measures for assessing PA in children and adolescents (Armstrong and Welsman, 2006; Epstein et al., 2001), direct comparisons of the current results with those of other studies are difficult, because of

Table 5. Correlation coefficients (r) between daily physical activity variables and age, maturation, fatness, aerobic and anaerobic fitness for trained and untrained subjects.

		Volume of Accumulated Activity (min.day^{-1})		Duration of Maximum Sustained Bouts (min.day^{-1})		Daily Number of Sustained Bouts					
						MPA			VPA		
	%HRR	MPA	VPA	MPA	VPA	1st Dur.	2nd Dur.	3rd Dur.	1st Dur.	2nd Dur.	3rd Dur.
Trained (n = 73)											
Decimal age (years)	-.25*	-.23	-.15	-.08	.02	-.24*	-.30*	-.03	-.25*	-.26*	-.13
Maturation †	-.31**	-.36**	-.24*	-.15	-.02	-.31**	-.41**	-.18	-.30*	-.36**	-.21
ΣSKF (mm)	-.13	-.27*	-.21	-.24*	-.30**	-.07	-.29*	-.22	-.13	-.14	-.12
Body fat (%)	-.07	-.21	-.16	-.18	-.25*	-.07	-.20	-.18	-.11	-.12	-.06
Peak VO_2 (mL·kg^{-1}·min^{-1})	.03	.08	.13	.14	.16	.04	.12	.04	.20	.20	-.02
Peak RS (km.h^{-1})	-.16	-.06	-.01	.01	.16	-.11	-.06	.04	.01	-.09	-.08
$RS_{2.5}$ (km·h^{-1})	-.11	-.12	.13	-.15	.18	.03	-.05	-.15	.13	.13	.02
$RS_{3.0}$ (km·h^{-1})	-.16	-.14	.09	-.14	.17	-.02	-.07	-.13	.10	.09	-.01
$RS_{3.5}$ (km·h^{-1})	-.20	-.15	.06	-.13	.15	-.06	-.09	-.11	.06	.06	-.04
$RS_{4.0}$ (km·h^{-1})	-.21	-.14	.06	-.13	.16	-.08	-.08	-.07	.05	.05	-.05
Peak power (W·kg^{-1})	-.15	-.12	-.04	.07	.07	-.17	-.08	.02	-.12	.01	-.08
Mean power (W·kg^{-1})	-.12	-.11	-.07	.05	.06	-.13	-.05	.01	-.11	-.08	-.12
Untrained (n = 74)											
Decimal age (years)	-.24*	-.22	-.24*	-.14	-.03	-.31**	-.15	-.12	-.36**	-.21	.03
Maturation †	-.23*	-.25*	-.25*	-.14	-.04	-.32**	-.21	-.14	-.45**	-.27*	.01
ΣSKF (mm)	-.43**	-.34**	-.33**	-.29*	-.26*	-.26*	-.28*	-.38**	-.26*	-.33**	-.26*
Body fat (%)	-.38**	-.28*	-.27*	-.23*	-.23*	-.19	-.23*	-.33**	-.19	-.24*	-.23*
Peak VO_2 (mL·kg^{-1}·min^{-1})	.35**	.29*	.42**	.32**	.38**	.24*	.22	.32**	.38**	.47**	.42**
Peak RS (km·h^{-1})	.20	.18	.28*	.12	.32**	.08	.17	.24*	.08	.24*	.37**
$RS_{2.5}$ (km·h^{-1})	.05	.01	.21	.01	.23*	.08	-.11	.04	.07	.24*	.13
$RS_{3.0}$ (km·h^{-1})	.09	.04	.25*	.02	.25*	.10	-.09	.08	.07	.24*	.17
$RS_{3.5}$ (km·h^{-1})	.12	.06	.29*	.02	.26*	.10	-.05	.10	.05	.23*	.18
$RS_{4.0}$ (km·h^{-1})	.17	.10	.29*	.06	.27*	.11	.01	.14	.08	.25*	.25*
Peak power (W·kg^{-1})	-.05	.01	-.01	.07	.03	-.17	.04	.11	-.13	-.06	.12
Mean power (W·kg^{-1})	.05	.06	.07	.10	.10	-.10	.03	.19	-.14	.02	.15

† = Spearman's coefficients (r_s); See Table 2, 3 and 4 for an explanation of other abbreviations. * $p < 0.05$; ** $p < 0.01$

differences in methodology, age of sample and interpretation of the HR data. Despite these difficulties, comparisons could be made among the studies that used similar age range and definition of activity intensities. Using %HRR method and the same intensity criteria as in this study, Gavarry et al. (1998) reported that the average (±SD) daily accumulated times spent in MPA and VPA were 50 (27) min and 19 (16) min, respectively, for 11-16 year old French school boys. This could be compared to 37 (18) min and 12 (8) min of accumulated MPA and VPA per day for 11-15 year old untrained Turkish boys, and 58 (16) min and 29 (13) min of daily times spent at the same intensity levels for trained boys in the present study. Moreover, some studies provided %peak VO_2 as a definition of activity intensity (Ekelund et al., 2000; Riddoch et al., 1991) that is generally equivalent to %HRR (Epstein et al., 2001). Ekelund et al. (2000) reported 26 (17) min and 7 (7) min of daily accumulated PA at an intensity above %50 and %70 peak VO_2, respectively, for 14-15 year old Swedish school boys. Riddoch et al. (1991) found that 11-16 year old Irish school boys accumulated 24 (5) min of MPA and 8 (2) min of VPA per day. Furthermore, Welsman and Armstrong (1992) defined MPA and VPA as the time spent with HR above 140 and 160 b·min^{-1}, respectively, and they reported 36 (18) min of daily MPA and 18 (12) min of daily VPA for 11-16 year old British school boys. It could be assumed that socio-cultural and environmental differences between countries may influence activity patterns and thereby may contribute to this difference. Nevertheless, it seems that the French school boys were more physically active while the Turkish school boys were at least as physically active as their Swedish and British peers.

In terms of all PA variables examined in this study, the trained subjects showed significantly higher daily values compared to the untrained group. In fact, the daily PA differences between two groups were more prominent for VPA, this was probably due, in part, to randomly monitored training days. Objective PA data comparing the athletic and non-athletic children in free-living conditions are very scarce in the literature (Falgairette et al., 1996; Hikihara, et al., 2007; Ribeyre et al., 2000). Therefore, the influence of regular sport activity on habitual or spontaneous activity levels in children and adolescents (possible compensatory or stimulating effects) is not well known. Using the HR monitoring, Falgairette et al. (1996) found that the daily habitual PA (time spent with HRs greater than 140 and 160 b·min^{-1}) levels of 6-11 year old boys physically active in a sports club were similar to that of the untrained boys. They suggested that the children who were active in a sports club had less spontaneous activity levels (Falgairette et al., 1996). However, Hikihara et al. (2007), in a study of 16-18 year old boys, found that times spent in moderate and vigorous activities, assessed with accelerometer, were significantly higher in trained than in untrained adolescents. It has been suggested that exercise training in daily life might lead to increase in daily habitual PA levels of adolescents (Hikihara, et al., 2007). Ribeyre et al. (2000), in a study of 16-19 year old adolescents, also reported similar findings, in that PA level and mean daily energy expenditure of athletic boys in free-living conditions were significantly higher than those of non-athletic counterparts. Thus, the results of this study are in accordance with the findings of Hikihara et al. (2007) and Ribeyre et al. (2000), but opposite to the findings of Falgairette et al. (1996). It seems that the effect of regular sport activity on habitual PA may depend on the content and length of the intervention exercise and the age of the subjects. Nevertheless, these results may indicate that trained boys are at least as spontaneously active as their untrained counterparts and trained boys may not necessarily compensate their elevated daily activity level by having a more sedentary lifestyle.

In previous studies, sustained PA was analyzed as the number or percentage of children who were experienced 5, 10 and 20 min of sustained bouts with the HR exceeding MPA and VPA thresholds. It had been suggested that sustained bouts of MPA or VPA for such durations (especially 10 and 20 min bouts) were not characteristic of most young people's PA patterns (Al-Nakeeb et al., 2007; Armstrong and Welsman, 2006; Armstrong et al., 2000; Gilson et al., 2001). Therefore, in this study, a different approach was used for the analysis of sustained bouts of MPA and VPA, in that both the daily duration of maximum sustained bout (in minutes) and the daily number of sustained bouts (in number) of different durations (1^{st} duration: up to 60 s; 2^{nd} duration: from 60 s to 120 s; 3^{rd} duration: >120 s) were calculated for each intensity level. No other HR monitoring study has reported data in this manner. The average (±SD) daily duration of maximum sustained bouts of MPA and VPA for 11-15 year old trained boys were 5.0 (1.7) min and 5.7 (2.4) min respectively, and those for untrained boys were 3.3 (1.3) min and 2.8 (1.7) min respectively. In accordance with the findings of the observational study (Bailey et al., 1995), the current results clearly indicated that both MPA and VPA were not sustained for extended periods of time in the daily life of children. When the daily number of sustained bouts was considered, the highest number of bouts was observed for the 1^{st} duration of MPA (with a mean (±SD) daily value of 46.0 (14.5) times and 36.2 (15.8) times for trained and untrained boys, respectively), followed by the 1^{st} duration of VPA (with a mean (±SD) daily value of 12.6 (5.7) times and 7.2 (4.7) times for trained and untrained boys, respectively). These results indicated that as duration of bouts of MPA and VPA increased the daily frequency of sustained bouts decreased. Taken together, these results confirm that short intermittent bouts of MPA and VPA are more likely to characterize the nature of children's activity than continuous activity.

Although this study was cross-sectional in nature, the results indicated that the levels of daily PA in both trained and untrained subjects decreased with increasing chronological age and sexual maturation from 11 to 15 years. In fact, generally only weak to moderate, but significant inverse relationships were observed between most of the daily PA variables and both age and maturation. It was interesting to note that these relationships tended to be slightly higher for maturation than for age and were quite similar in both trained and untrained subjects. No study to date has examined such relationships in trained subjects. Nevertheless, the current results for the untrained subjects are in accordance with previous studies that found age (Armstrong et al., 2000; Welsman and Armstrong, 2000; Gavarry et al., 2003; Riddoch et al., 2004; Thompson et al., 2003) or maturity (Armstrong et al., 2000; Janz et al., 1992; Riddoch et al., 2007; Thompson et al., 2003) related declines in habitual PA of children and adolescents. Moreover, a recent literature review indicated that the PA levels of European children declined as they moved through adolescence (Armstrong and Welsman, 2006). However, as displayed in Table 5, the duration of maximum sustained bouts of MPA and VPA in both groups was not related to either age or sexual maturation. Thus, in contrast to other daily PA variables, the duration of maximum sustained bouts did not change with age or maturation in either group of subjects. To our knowledge, such a result has not been reported before and needs to be confirmed by further studies.

Examination of the relationship between daily PA and physical fitness was another purpose of the present study. As shown in Table 5, body fatness, expressed as the sum of eight skinfolds and %BF, was negatively and significantly related to almost all of the daily PA variables in the untrained group. However, these inverse relationships were weak to moderate in magnitude, ranging from -0.23 to -0.43, and tended to be higher for ΣSKF than for %BF. The latter may indicate that using the ΣSKF from different sites may better reflect total body fatness than using the population specific equations. Nevertheless, for the untrained group, the results revealed that the subjects with higher daily PA level tended to be slightly leaner than the subjects with lower daily PA level. In other words, subjects who had a higher body fatness tended to be less active as well. Although some of the previous studies did not find a significant relationship between PA and body fatness (Armstrong et al., 2000; Armstrong et al., 1990; Al-Nakeeb et al., 2007; Ekelund et al., 2001; Welsman and Armstrong, 2000), the results of this study as well as those of other reports (Falgairette et al., 1996; Gutin et al., 2005; Janz et al., 1992; Ruiz et al., 2006; Zarrouk et al., 2009) indicated a weak to moderate but significant inverse relationship between PA and body fatness in children and adolescents. This was also corroborated by a meta-analysis which demonstrated that PA level in children was weakly to moderately associated with body fatness and habitual PA explained only a small proportion of the variance in fatness (Rowlands et al., 2000).

Moreover, in relation to aerobic fitness, both maximal and submaximal indices were assessed in this study. It was found that, for the untrained group only, daily PA variables were positively and significantly related to both maximal (peak VO_2 and peak RS) and submaximal (RSs at fixed La concentrations) indices of aerobic fitness. These relationships, albeit weak to moderate, and ranged from 0.23 to 0.47 (Table 5), could be interpreted as untrained subjects who had a higher aerobic fitness level also tended to be slightly more physically active in daily life. There are a number of factors that influence aerobic fitness, such as pulmonary diffusing capacity, cardiac output, oxygen carrying capacity of the blood, skeletal muscle characteristics, oxidative enzymes and peripheral diffusion capacity (Bassett and Howley, 2000). It has been suggested that genetic factors modify all of these (Bouchard et al., 1992). According to the most recent data, 22 genes associated with aerobic performance (Beunen et al., 2010). Results from twin and family studies have suggested that about 50% to 60% of variance in aerobic fitness could be accounted for by genetic factors (Bouchard et al., 1999; Gaskill et al., 2001; Maes et al., 1996; Perusse et al., 2001; Sundet et al., 1994). Two of the twin-based studies with large sample sizes reported a heritability of more than 60% for peak VO_2 (Maes et al., 1996; Sundet et al., 1994). Therefore, it might be assumed that, at most, 40% to 50% of the variance in aerobic fitness remains to be accounted for by all other environmental and behavioral factors including PA. It was not unexpected that there are inconsistent findings in the literature regarding the relationship between PA and aerobic fitness in children and adolescents. Some earlier studies failed to show such a relationship (Armstrong et al., 1998; 2000; Janz et al., 1992; Katzmarzyk et al., 1998; Welsman and Armstrong, 1992; Weymans and Reybrouck, 1989). It had been suggested that the levels of habitual PA in children were not of the intensity, duration and frequency necessary to exert a training effect upon aerobic fitness (Armstrong et al., 1998; 2000; Welsman and Armstrong, 1992; Weymans and Reybrouck, 1989). It was also possible that any relationships might be obscured by the strong genetic component to fitness and the influences of normal growth and maturation. In training studies, it was also reported that the similar program of intensity, duration and frequency that was expected to produce 15-20% improvement in peak VO_2 of adults produced little (5-6%) change in peak VO_2 of children (Baquet et al., 2003; Rowland, 2005). In a review of training studies in children, Baquet et al. (2003) suggested that intensities higher than 80% of maximal HR were necessary to expect a significant improvement in peak VO_2. However, in previous studies that failed to show a significant relationship between PA and aerobic fitness, habitual PA had been assessed either by subjective methods (Katzmarzyk et al., 1998; Weymans and Reybrouck, 1989) or by objective measures with less than four complete days of monitoring (Armstrong et al., 1998; 2000; Janz et al., 1992; Welsman and Armstrong, 1992). In addition, in one of the studies, aerobic fitness had been estimated without direct measurement of oxygen consumption (Katzmarzyk et al., 1998). However, a number of more recent studies, in which objective measures were used, corroborated the finding that a generally weak to moderate positive relationship existed between habitual PA and aerobic fitness in children and adolescents (Dencker et al., 2006; Ekelund et al., 2001; Falgairette et al., 1996; Gutin et al., 2005; Hikihara, et al., 2007; Kristensen et al., 2010; Ruiz et al., 2006). Thus, another reason for these inconsistent findings may partly depend upon the methods used to assess both habitual PA and aerobic fitness. The use of objective measures for the assessment of both PA and aerobic fitness might strengthen the current findings of this study. Nevertheless, the lack of a strong relationship between daily PA, aerobic fitness and body fatness in this study as well as in other recent reports (Dencker et al., 2006; Ekelund et al., 2001; Falgairette et al., 1996; Gutin et al., 2005; Kristensen et al., 2010; Zarrouk et al., 2009) may indicate that other potential factors such as heredity, diet and socio-cultural conditions are likely to be more dominant factors than daily PA in determining aerobic fitness and fatness levels in children and adolescents. As shown in Table 5, it is notable that the magnitude of the positive correlations tended to be slightly higher when the peak VO_2 was related to VPA rather than to MPA or %HRR. Furthermore, the peak RS and submaximal RSs at fixed La concentrations were also significantly and positively related to VPA, but not related to MPA or %HRR in the untrained group. Similarly, it had been previously reported that aerobic fitness was somewhat better related to VPA than to MPA or total daily PA in children and adolescents (Dencker et al., 2006; Gutin et al., 2005). Thus, taken together, these results suggest that higher intensity PA (>70% HRR) may be more important than total daily PA or moderate intensity PA in influencing children's aerobic fitness levels. Further studies are needed to clarify which dimension of PA is more beneficial for cardiovascular fitness.

In contrast to the untrained group, daily PA variables in the trained group were not related to any indices of aerobic fitness. Moreover, the relationships between daily PA variables and body fatness were also weaker in the trained group and did not reach statistical significance in most cases. In other words, as shown in Table 5, when the trained and untrained groups were analyzed separately, group-dependent relationships were observed between daily PA variables, aerobic fitness indices and body fatness in this sample of athletic and non-athletic children. It seems that such relationships may somewhat depend on the fitness level of the subjects. The cross-sectional nature of the present study precludes any firm conclusion regarding the causality of these relationships. Nevertheless, the current results suggest that, in terms of the effect on physical fitness, habitual PA may be more important for untrained subjects than for trained subjects. Thus, compared with their trained athletic counterparts, non-athletic children and adolescents may be more likely to improve their physical fitness level by increasing their daily habitual PA level. A possible explanation of this finding may be that as trained subjects have already significantly lower body fatness and higher aerobic fitness levels, the amount of daily PA in trained subjects may not be high enough to produce further enhancement of their physical fitness level. It seems that this finding may be due, in part, to a ceiling effect. No previous study, to our knowledge, has examined such relationships separately for trained athletic and non-athletic subjects. These results also need to be confirmed by future studies.

As presented in Table 3, both peak and mean power values for the trained subjects were significantly greater than those for the untrained subjects. Again, these differences may also be attributed to the cumulative effect of exercise training or genetic predisposition. Relatively few studies have examined the trainability of anaerobic fitness in children and adolescents. Previous studies revealed a significant improvement in anaerobic fitness of athletic (Mosher et al. 1985; Diallo et al. 2001) and non-athletic (Rotstein et al. 1986; Obert et al. 2001) boys following plyometric and interval training programmes. However, it was suggested that training did not improve children's peak and mean power as much as it did in adults. (Al-Hazzaa et al. 2000; Van Praagh and Dore, 2002). A recent literature review of training studies suggested that anaerobic fitness in children was to some degree trainable with the appropriate and adequate training stimulus (not less than 90% of maximal effort) (Matos and Winsley, 2007). The authors also reported that, in children, training-induced gains ranged from 3% to 10% for mean power, and from 4% to 20% for peak power (Matos and Winsley, 2007). It seems that regular sport activity or exercise training may play a role in promoting anaerobic fitness in this age of children. However, regarding the anaerobic fitness-habitual PA relationship, neither peak nor mean power values were related to any of the PA variables in both trained and untrained subjects. It seems that variations in peak and mean power are determined by factors other than daily habitual PA. It has been suggested that anaerobic fitness is also primarily genetically determined (Beunen et al., 2010; Calvo et al., 2002; Issurin et al., 2004; Simoneau and Bouchard, 1998). Simoneau and Bouchard (1998) reported that important determinants of anaerobic performance such as muscle fiber type proportion and glycolytic enzyme capacity of muscle were influenced by genetic factors. The authors have proposed that genetic factors account for approximately 50% of the total variance in maximal anaerobic performance phenotype (Simoneau and Bouchard, 1998). Based on the most recent data, it was reported that 20 genes associated with strength or anaerobic phenotypes (Beunen et al., 2010). Calvo et al. (2002) have also investigated genetic influences on anaerobic fitness. Using the WAnT, the authors report heritabilities of 74% for the peak power and of 84% for the mean power (Calvo et al., 2002). To date, only one other study appears to have examined the relationship between anaerobic fitness and habitual PA in children. Using the HR monitoring method and the WAnT, as in this study, Armstrong et al. (1998) reported that no significant relationship was found between habitual PA and either peak or mean power values in 12 year old untrained British children, which would support the results of the current study. In view of these results, it appears that children's habitual PA, which is typically characterized by short intermittent bursts of moderate to vigorous activity (Bailey et al., 1995; Berman et al., 1998; Baquet et al., 2007), may not be of sufficient volume to improve anaerobic fitness. The methods of analysing HR data and sampling frequency may also lack sufficient sensitivity to detect and quantify short intermittent bursts of activity and, therefore any possible relationship may be masked. This issue may need to be examined further for future studies in which more sensitive methods with more frequent sampling intervals could be employed.

Conclusion

In this study, daily habitual PA, as measured by four complete days of HR monitoring, was examined in relation to age and regular sport activity (trained vs. untrained groups) in 11-15 year old boys. In addition, the relationships of daily PA to body fatness, aerobic and anaerobic fitness, age and sexual maturation were also examined separately in boys with and without regular sport activity. Based on the results of this study the following conclusions were drawn. This study has provided the first objectively measured PA data in Turkish children and adolescents and it seems that the Turkish school boys were at least as physically active as their European counterparts. Daily PA levels of boys with regular sport activity were higher compared to those without regular sport activity. Based on the 15-s HR data, both MPA and VPA were not sustained for long periods of time throughout the day. Instead of continuous activity, multiple short bouts of MPA and VPA, lasting up to one minute, were characteristic of daily PA patterns of both trained and untrained boys. In general, only low to moderate relationships were found between daily PA variables and age, maturation, fatness and aerobic fitness. Except for the maximum sustained bouts of MPA and VPA, the levels of daily PA decreased with age and maturation in both trained and untrained boys. Daily PA variables were negatively related to body fatness in both groups, but the relationships were weaker in the trained group and did not reach significance in most cases. Daily PA variables were also positively related to both maximal and submaximal indices of aerobic fitness in the untrained group and these relationships were more marked when VPA was considered. Thus, higher intensity PA (>70% HRR) may be more important than total daily PA or moderate intensity PA in influencing children's aerobic fitness levels. Further studies are needed to clarify which dimension of PA is more beneficial for cardiovascular fitness. However, in the trained group, none of the daily PA variables was related to any of the aerobic fitness indices. This may be due, in part, to a ceiling effect in the trained group. It seems that such relationships may somewhat depend on the fitness level of the subjects. Finally, neither peak nor mean power values were related to any of the daily PA variables in both trained and untrained subjects. It appears that variations in anaerobic fitness levels are determined by factors other than habitual PA. Such relationships may be obscured by the strong genetic component to fitness. Nonetheless, this relationship may need to be examined further.

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Key points

- PA levels of trained boys were higher than untrained boys and the levels of PA decreased with age and maturation in both groups.
- Based on the 15-s HR data, instead of continuous activity, multiple short bouts of moderate and vigorous PA, lasting up to one minute, were characteristic of daily PA patterns of both trained and untrained boys.
- Daily PA variables were related to aerobic fitness in the untrained group and these relationships were somewhat better with vigorous PA (>70% HRR), whereas in the trained group, none of the PA variables were related to any of the aerobic fitness indices.
- Neither peak nor mean power values were related to any of the daily PA variables in both trained and untrained groups.

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