ORIGINAL ARTICLE

Comparison of physical fitness levels of adolescents according to sports participation: martial arts, team sports and non-sports

Authors' Contribution:
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B Data Collection
C Statistical Analysis
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Abstract

Background & Study Aim: There are limited studies on the physical fitness of adolescent martial arts athletes. This study aimed to knowledge about the physical fitness levels of adolescents according to sports participation: martial arts, team sports and non-sports.

Material & Methods: A total of 236 volunteers participated in this study: 84 martial arts athletes (16.57 years ± 1.06), 72 team sports athletes (16.61 years ± 1.16) and 80 non-sports participants (16.78 years ± 0.98) were investigated. According to AAHPERD and FITNESSGRAM batteries, valid and reliable tests were used to evaluate the physical fitness levels

Results: Significant differences were found between the results of three sports groups for body weight, body mass index, body height, body fat, skinfold thicknesses, muscular endurance, flexibility and aerobic capacity ($p<0.05$). Although muscular endurance and flexibility in the martial arts group were significantly higher ($p<0.05$) than in the team sports and non-sports groups, body height and aerobic capacity in the martial arts group were significantly lower ($p<0.05$) than in the team sports group. The martial arts group had significantly lower body fat and skinfold thickness values ($p<0.05$) than the non-sports groups.

Conclusions: The results of this study set forth the positive effects of martial art training on health-related physical fitness for adolescents. Compared to non-sports participation, martial arts has a more positive effect on muscular endurance and flexibility than team sports in adolescents. Therefore, these are important empirical evidence in order to martial arts in a wide range to promote the element of the physical education and the form of the physical activity in leisure time.

Key words: aerobic capacity • body composition • flexibility • IPAQ_ • MET • muscular fitness • science of martial arts

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Introduction

Adolescence – usually defined as the period of rapid growth between childhood and adulthood, including physiological, psychological and social development.

Metabolic Equivalent of Task (MET) – a physiological measure expressing the energy cost of physical activities and is defined as the ratio of metabolic rate during a specific physical activity to a reference metabolic rate, set by convention to 3.5 ml $O_2 \cdot kg^{-1} \cdot min^{-1}$

Physical fitness is defined as "a set of attributes or characteristics that people have or achieve that relates to their ability to perform physical activity" [1]. Additionally, being physically fit has been described as "the ability to carry out daily tasks with vigor and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies" [2]. Physical fitness is one of the factors that contribute to performance in sport. Previous studies have demonstrated the positive effects of physical activity and sport on physical health and fitness and psychological well-being [3-12] and also intellect development [13, 14].

Adolescence is usually defined as the period of rapid growth between childhood and adulthood, including physiological, psychological and social development [15]. The components of health related physical fitness are cardiovascular endurance, muscular strength and endurance, flexibility, and body composition [4]. These components change during this period [4, 16]. Moreover, physical activity and sports participation have benefits on mental and physical health for adolescents [17]. Previous studies have shown that time spent doing physical activity during childhood and adolescents years is important and early engagement in sport during these periods has been suggested as being a determinant of later performance in some sports [18-20].

Some studies have shown that practising martial arts provides various physiological benefits in young adults [21,22] and the elderly [23-25]. These benefits include increases in all health related physical fitness indicators [22, 26-28]. Several studies have emphasized the importance of fundamental physical fitness elements such as flexibility, muscular strength, body control and coordination for martial arts athletes [23-25, 29-31]. High performance in martial arts requires technique, tactics and a high physical fitness level [31-33]. Despite these citations and their widespread acceptance, there have been few published articles showing the relation between different sports types and physical fitness in adolescent athletes [34, 35]. The role of martial arts in improving the physical fitness level during late adolescent years is not well known. It was hypothesized that changes in physical fitness indicators will differ for adolescents who partake in martial arts training compared to adolescents who partake in team sports or adolescents who do not partake in any sporting activity.

This study aimed to knowledge about the physical fitness levels of adolescents according to sports participation: martial arts, team sports and non-sports.

Material and methods

Subjects and Test Procedures

In this study, 236 male volunteers within the age range of 15-18 years were investigated. Their mean age, height, body weight and body mass index were 16.65±1.06 years, 1.75±0.06 m, 67.48±9.06 kg and 21.80±2.28 kg/m^2 respectively. The data related to the descriptive and clinical characteristics of the subjects were collected by a personal information form. Participants signed an informed consent form approved by the Health Department of the Turkish National Police in Ankara Turkey. The approval number is 3471-182823. The author confirms that this study meets the guidelines of the Helsinki declaration. The same investigator directed all tests at the same time of day for each participant.

Sports Participation

Sports participation was assessed by school records, the International Physical Activity Questionnaire (IPAQ) and a self-reported question about current sports participation "Do you participate in a sporting activity such as karate, judo, wrestling, taekwondo, aikido, football, basketball, handball, volleyball or other sport?" Data from the IPAQ was used to estimate total weekly physical activity by weighting the reported minutes per week within each activity category according to the Metabolic Equivalent of Task (MET) energy expenditure estimate assigned to each category of activity (walking, moderate, and vigorous activities) [36].

According to the school records and self-reported data, the eligibility criteria for sports participants were as follows:

Age: between 15 and 18 years old
Sex: male

Training time: participation in martial arts sports (aikido, wrestling, judo or karate) or team sports (basketball, football, handball or volleyball) for at least six months under the supervision of trained coaches prior to the start of the study.

The IPAQ score: vigorous-intensity activity on at least three days achieving a minimum total physical activity score of at least 1500 MET-minutes/week or, during the week, any combination of walking,

moderate-intensity or vigorous-intensity activities achieving a minimum total physical activity score of at least 3000 MET-minutes/week [36].

According to the school records and self-reported data, the eligibility criteria for non-sports participants were as follows:

Age: between 15 and 18 years old
Sex: male

Subjects did not participate in any sporting activity under the supervision of a trained coach for at least six months prior to the start of the study.

The IPAQ score is less than 600 MET-minutes/week (total scores from five or more days with any combination of walking, moderate-intensity or vigorous intensity activities) [36].

According to these criteria, 156 subjects were classified as sports participants (84 martial arts and 72 team sports) and 80 subjects were classified as non-sports participants. No significant difference was found for age between sports participants and non-sport participants. There is no significant difference between martial arts and team sports participants regarding age and training time.

Body Composition Assessment

The body weight of the participants in underclothes was measured to the nearest 100 g with a precision scale and the body height was measured to the nearest 5 mm with a Holtain stadiometer . Body mass index (BMI) was calculated using the formula: weight (kg) divided by height (m) squared. Skinfold thicknesses were measured from three different anatomical regions (pectoral, abdominal, and thigh) with a Holtain skinfold caliper at the dominant side of the body by the same person [37]. The percentage of body fat was determined by the Jackson and Pollock formula [38].

Aerobic Capacity Assessment

The 1-Mile Run Test was used to estimate the aerobic capacities of the participants . Participants were instructed and encouraged to complete the distance as quickly as possible. The time to complete the test was recorded. Cureton's equation [39] was used to predict VO_{2max} ($ml \times kg^{-1} \times min^{-1}$).

VO_{2max} = 0.21 (Age x Gender) – 0.84 (BMI) – 8.41 (Time) + 0.34 ($Time^2$) + 108.94

Muscle Endurance and Strength Measurements

The curl up test was used to assess muscular endurance. The total number of curl ups was recorded in 30 and 60 seconds.

Handgrip strength of participants was measured by using a Takei5101 handgrip dynamometer. The test was performed by the dominant side in the sitting position with the shoulder of the tested arm adducted, the elbow flexed at 90°. The participants squeezed the dynamometer as hard as possible with maximal isometric contractions for 5 seconds, on dominant hands. The highest value (kg) from three trial with a rest period of at least 60 seconds was used for determination of maximal grip strength [40].

Flexibility Measurement

Flexibility was evaluated by the sit and reach test. After 10 minutes warm-up, the participants placed bottom of their feet approximately hip-width against side of testing box with knees straight. They kept their knees extended and placed the right hand over the left, and slowly reached forward as far as they could by sliding their hands along the measuring board. Reaches short of the toes were recorded as negative forward reach scores, and reaches beyond the toes were recorded as positive forward reach scores in centimetres to the nearest 0.5 cm using the scale on the box [40].

Statistical Analysis

Means and standard deviations are given as descriptive statistics. The One-way ANOVA test was used for comparing means according to the sport participation groups. The Tukey post hoc test was used to follow-up with the sport participation group factor. For all statistics the significance level was set at $p<0.05$. Data were analysed using the SPSS 13.

Results

Significant differences were found between the results of the three groups for body weight, body mass index, body height, body fat, skinfold thicknesses, muscular endurance, flexibility and aerobic capacity ($p<0.05$). Although muscular endurance and flexibility in martial arts participants were significantly higher ($p<0.05$) than in team sports and non-sports participants, body height in martial arts participants was significantly lower ($p<0.05$) than in team sports and non-sports participants. Aerobic capacity in martial arts participants was significantly higher ($p<0.05$) than in the non-sports participants, but significantly lower than in team sports participants. There are no significant

differences for body fat, skinfold thicknesses and muscular strength between martial arts and team sports participants. However, body fat and skinfold thicknesses were significantly ($p<0.05$) lower in martial arts participants than in non-sports participants (Table 1).

Discussion

In general, the results of the present study have supported the hypothesis and produced a profile for martial arts athletes. The main results of this study show that participation in martial arts caused different changes in physical fitness parameters compared to non-sports and team sport participation during adolescent years. It was found that there is no significant difference in body composition indicators between martial arts and team sports athletes. However, the martial arts and team sports athletes have significantly ($p<0.05$) lower body mass, BMI, body fat and skinfold thickness values than those in the non-sports group. These results suggest that regular sports participation and physical activity helps to eliminate unnecessary body fat in adolescents. As previously mentioned by Mynarski *et al.* [41] martial arts athletes took part in sports training which meets the criteria of daily physical activity for unnecessary body fat. The results of this research support previous studies regarding body composition indicators [4, 16]. According to the CDC, regular physical activity and sports participation performed on most days of the week helps control weight and improves strength, builds lean muscle, and decreases body fat [4]. Previous studies [26, 28, 32] suggested that martial arts athletes should have low body fat. Martial arts athletes presented lower percent body fat compared with others [29, 42-45].

Table 1. The means (M) and standard deviations (SD) of all dependent variables.

Variables	martial arts (n=84)	team sports (n=72)	non-sports (n=80)	MA-TS Difference		MA-NonS Difference		TS-NonS Difference		p[1]
	M±SD	M±SD	M±SD	%	p[a]	%	p[b]	%	p[c]	
physical characteristics										
age (years)	16.57±1.06	16.61±1.16	16.78±0.98	−0.24	ns	−1.21	NS	−0.98	ns	ns
body weight (kg)	64.92±9.43	67.29±7.67	70.34±9.10	−3.53	ns	−7.71	.000*	−4.33	ns	.001*
body height (cm)	173.55±6.08	178.03±6.58	175.96±5.56	−2.52	.000*	−1.37	.031*	1.17	ns	.000*
BMI (kg/m^2)	21.50±2.41	21.20±1.77	22.68±2.34	1.40	ns	−5.19	.002*	−6.50	.000*	.000*
training age (months)	27.00±16.53	28.04±16.92	n/a	−3.71	ns	n/a	n/a	n/a	n/a	n/a
body composition										
body fat (%)	9.62±4.26	9.42±3.81	13.66±5.67	2.08	ns	−29.57	.000*	−31.00	.000*	.000*
pectoral skinfold (mm)	7.00±3.58	6.57±2.69	9.77±6.13	6.53	ns	−28.34	.000*	−32.73	.000*	.000*
abdominal skinfold (mm)	15.92±7.45	15.59±6.92	22.78±9.70	2.10	ns	−30.14	.000*	−31.58	.000*	.000*
thigh skinfold (mm)	14.07±5.29	14.08±4.70	18.41±6.52	−0.08	ns	−23.58	.000*	−23.52	.000*	.000*
muscular fitness										
muscular endurance (Curl up) 30s	29.06±3.62	26.47±2.95	25.95±3.09	9.77	.000*	11.98	.000*	2.01	ns	.000*
muscular Endurance (Curl up) 60s	54.52±7.41	49.60±6.06	48.68±6.23	9.93	.000*	12.02	.000*	1.89	ns	.000*
muscular Strength (Hand Grip) (kg)	37.56±7.48	38.28±5.29	38.24±5.88	−1.87	ns	−1.77	ns	0.11	ns	ns
flexibility (cm)	14.78±5.96	9.98±5.33	9.94±7.35	48.06	.000*	48.68	.000*	0.42	ns	.000*
aerobic capacity (ml.kg-1.min-1)	53.48±2.96	54.84±2.44	52.09±3.45	−2.48	.014*	2.66	.009*	5.27	.000*	.000*

data were shown as mean ± standard deviation.
$p < 0.05$; results of the comparison between two type of sports
p[1]: results of the comparison among three approaches (one-way anova).
according to post-hoc multiple comparisons;
p[a]: difference between martial arts (MA) and team sports (TS)
p[b]: difference between martial arts (MA) and non-sport (NonS)
p[c]: difference between team sports (TS) and non-sport (NonS)
ns: not significant
n/a: not applicable

The important findings of this study are that muscular endurance and flexibility in martial arts participants were significantly higher ($p<0.05$) than team sports and non-sports participants. While the martial arts participants' muscular endurance was 54.52±7.41, the muscular endurance values in the team sports and non-sports groups were 49.60±6.06 and 48.68±6.23 respectively. Previous research [22] showed an association between muscular endurance and martial arts performance. In the Douris *et al.* [22] study, the *soo bahk do* practitioners averaged 66.1 sit ups compared with 37.3 sit ups for the sedentary group. According to Douris *et al.* [22], martial art training appears to improve muscular strength and endurance by its action of performing kicks, punches, and blocks. In this research, it was found that there were no significant differences for muscular strength according to the hand grip test between martial arts and non-sports participants.

Similarly Douris *et al.* [22] and Fong *et al.* [28] found that the difference for muscular strength between the martial arts and the sedentary groups was not significant. Franchini *et al.* [44] found that there is no significant difference for absolute or relative strength between elite or non-elite judo players. However, Lan et al. [29] reported that martial art practitioners displayed greater muscular strength than sedentary subjects' norms in the elderly. These different results can be explained by the difference in the age group of the participants. Flexibility and aerobic capacity increase in martial arts athletes. The martial arts practitioners showed higher flexibility and aerobic capacity than their sedentary counterparts [24, 29]. Hong *et al.* [24] and Lan *et al.* [29] showed that long term regular *tai chi chuan* practitioners possessed better trunk and hamstring flexibility than their sedentary counterparts. Moreover, *soo bahk do* [22] and taekwondo [26, 28] athletes were significantly more flexible than their sedentary counterparts. In this current study, the martial arts participants' flexibility score is nearly 49 % higher than non-sports and 32.46 % higher than team sports participants. Previous studies showed that martial arts such as karate [21, 46, 47], *soo bahk do* [[22, 29] taekwondo [26, 48] and judokas [49] have improved aerobic capacity. Tai chi [24], *soo bahk do* [22, 29], judokas [49] and taekwondo [26] practitioners had a 19%, 31.8%, 15.8% and 20% greater aerobic capacity respectively than their sedentary counterparts. Similar to the findings of the earlier studies, the results of the present study indicate that aerobic capacity in martial arts participants was greater than non-sports participants. However, in this study the martial arts participants had only 2.66% greater aerobic capacity than non-sports participants but 2.48% less aerobic capacity than team sports.

The significant differences probably resulted from the difference in the type of training program between the martial arts and team sports participants. Fong *et al.* found that there is no conclusive evidence to prove that taekwondo training can improve aerobic fitness [28]. According to coaches and athletes, aerobic capacity is a vital component of a successful team sport performance. However, higher anaerobic capacity may be an important requirement for martial arts which is closely connected with sports injuries risks [44, 50]. Aerobic capacity affects an athlete's performance in team sports such as football, basketball, handball and volleyball more than in martial arts due to the structure and duration of the games [34]. This can explain why team sports athletes had greater aerobic capacity than martial arts participants.

Conclusions

Physical activity and sports participation provides physical fitness improvement for adolescents. The results of this study set forth the positive effects of martial art training on health-related physical fitness for adolescents. Compared to non-sports participation, martial arts has a more positive effect on muscular endurance and flexibility than team sports in adolescents. The results of this study could be used to guide martial arts training for adolescents athletes. Therefore, these are important empirical evidence in order to martial arts in a wide range to promote the element of the physical education and the form of the physical activity in leisure time.

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Highlights

Cardiovascular endurance, muscular strength and endurance, flexibility, and body composition change during adolescent period. Martial art training has positive effect on these health-related physical fitness elements for adolescents.

Conflict of interest

Author declares that there are no conflict of interests.

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