Original Article

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Physiology Section

Comparison of Effect of Regular Unstructured Physical Training and Athletic Level Training on Body Composition and Cardio Respiratory Fitness in Adolescents

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ABSTRACT

Background: Childhood obesity and hypertension are global problems that are on the rise in India. Improving physical activity is an accepted main line of strategy for overcoming poor body composition, hypertension and reduced cardio respiratory fitness (CRF) all of which are considered as independent risk factors for the development of future cardiovascular complications.

Aim: Present study was conducted to evaluate the effect of regular unstructured physical training and athletic level training on anthropometric measures, body composition, blood pressure and cardio respiratory fitness in adolescents.

Settings and Design: This is a collaborative study between the Department of physiology, Jawaharlal Institute of Postgraduate Medical Education and Research and Residential school, Jawahar Navodhya Vidyalaya, Puducherry, India.

Method and Material: Student volunteers in the age group of 12-17 years were classified into athletes (group 1) and physically active non-athletes (group 2). Parameters measured and calculated were weight, height, body mass index, waist and hip circumference, body fat percentage (BF%), fat free mass (FFM), Systolic (SBP) & Diastolic blood pressure (DBP), Mean arterial pressure (MAP), Rate pressure product (RPP) and Predicted VO_2 max.

Statistical Analysis used: Mean difference between the groups was analysed using unpaired Student's t–test. All statistical analysis was carried out for two-tailed significance at the 5 % level using SPSS version 19 (SPSSInc, USA).

Results: Anthropometric measures, body composition measures and blood pressure values of both the group students were within the normal limits. There was no significant difference in anthropometric and body composition parameters between the group 1 and group 2 students. DBP, MAP and RPP were significantly lower in group 1 students when compared to group 2 students. VO_2 max values were more in group 1 girls as compared to group 2 girls while the values of boys were comparable between the two groups.

Conclusion: Regular unstructured physical activity for 60 minutes daily for the duration of one year can help the students to maintain their anthropometric parameters, body composition measures and CRF at par with the athletes of the same age and gender. However, athletic level training further reduces the cardiovascular load of the adolescent students.

Key words: Physical activity, Body composition, Fat free mass, Cardio respiratory fitness

INTRODUCTION

As we are moving into 21st century, alarming global health trends are emerging in developing countries like India, as indicated by a rapid increase in obesity, hypertension and decreased level of physical fitness among youth [1-3]. Studies done on Indian school children reported a high prevalence of overweight and obesity [4] and the prevalence of hypertension and prehypertension was found to be 2.8% and 2% respectively even in rural Indian children [5]. Physical activity and improved dietary patterns are accepted strategies to overcome poor body composition, hypertension and reduced cardio respiratory fitness (CRF) in adolescents which are considered as independent risk factors for the development of future cardiovascular complications in adulthood [6-8]. Global School based Student Health Survey (GSHS) states that in India, only 37.5% of students had met the WHO physical activity recommendations [9]. Every student typically spends 8-10 hours in school from his/her early childhood to adolescence. The positive health behavior imparted in childhood continues even in adulthood [10]. This necessitates the reconsideration of the role of the schools in addressing these problems. Hence, schools can become central element in ensuring the students' participation in adequate physical activity to develop healthy lifestyles [11]. International guidelines recommend that children and adolescents should participate in physical activity for a minimum of 60 minutes a day which is developmentally appropriate, enjoyable, and involves a variety of activities [2,11,12]. One hour physical activity can be spread throughout the day in school during physical education classes (PE), recess period, during intramural sports and in before-school and after-school programmes [2]. Participation in competitive sport such as interscholastic sport events and/or vigorous recreational exercise is gaining popularity due to the documented health benefits [13]. This is a welcome trend as students who participate in one or more sports events report multiple positive health behaviours and lesser negative health behaviours than students who do not participate in sports [14].

BMI is a simple internationally accepted method to assess weight-related health as it is strongly associated with adiposity, disease risk and cardiovascular mortality. But its major limitation is that it does not differentiate between weight that is fat (fat mass) and weight that is muscle (fat-free mass), and therefore may lead to misclassification of muscular individuals as overweight [15]. Previous studies demonstrate that estimation of Body fat percentage (BF%) by skin fold measurements reflects the body's adipose tissue level better than BMI [16]. Maximal oxygen consumption (VO_2max) is the maximum capacity of a subject to transport (uptake) oxygen and utilise it during exercise and is the criterion measure of cardio respiratory fitness (CRF) [17]. Direct assessment of VO_2max is the best method for assessing CRF but it is time consuming, limited to laboratory set up and difficult to administer on large populations. Rockport Walk Fitness Test (RWFT) is an acceptable field test to measure CRF through the estimation of maximal oxygen consumption (VO_2max), in large groups and is easy to administer with minimal requirements for school children [18,19].

In India, there is paucity of studies on unsupervised unstructured physical activity in adolescents. Therefore, the present study was conceived to study the relative effect of unsupervised unstructured physical activity of at least 60 minutes daily and athletic level training on body composition, cardiovascular parameters and cardio respiratory fitness in adolescents of both gender in a co-educational residential school provided with fully subsidised school mess.

SUBJECTS AND METHODS

This is a cross sectional study done by the Department of Physiology, Jawaharlal Institute of Postgraduate Medical Education & Research (JIPMER), Puducherry, India, in collaboration with residential school Jawahar Navodaya Vidyalaya, Puducherry. The study was approved by JIPMER scientific advisory committee and JIPMER ethics committee for human studies. Written informed consent from either the parents or the local guardians and written assent from the volunteer students were taken after explaining the experimental protocol.

Participants

Students in the school were in the age group of 12-17 years. They were full time school residents and food was provided to them from fully subsidised school mess. Students with any co-morbidity in which exercise was contra-indicated, were excluded from the study.

Volunteered athletes from the school were classified into group 1 (n=79; 45 boys & 34 girls). We have defined athlete as a student who had represented the school at state, national or international level athletic interscholastic sport event and was undergoing supervised physical training. Physical training for athletes was for at least 25 hours a week with minimum of 2 hours duration per day, for six days a week. Athletic training was supervised by physical education instructors. The athlete students were participating in various aerobic interscholastic sports events in any of the following sports events: football, volleyball, badminton, khokho, basketball and kabaddi. Rest of the non-athletic students (n=422) in the school were participating in the unstructured physical activity for minimum of one hour duration daily as a part of their school curriculum. Outdoor activity choices included jogging, skipping, yoga, playing football, basketball, khokho, badminton, basketball and gardening and indoor activity choices included gymnasium, music, drawing and craft. Volunteered students were age and gender matched for group 1 students and included in group 2 (n=158; 90 boys & 68 girls). The groups were further classified based on gender for comparison of parameters.

Data Collection

Anthropometric Measures: All the anthropometric and skin fold thickness measurements were made by anthropometrist certified by International Society for the Advancement of Kinanthropometry (ISAK). Students weight was measured using a digital weighing scale to the nearest 0.1 kg and height was recorded on vertical stadiometer to the nearest 0.1 cm. Body Mass Index (BMI) was calculated by using Quetelet formula i.e. body weight in kilograms/ height in meter square. Waist circumference (WC) was measured at the midpoint between lower rib margin and iliac crest at the end of expiration and hip circumference (HC) was measured at the maximal circumference over the buttocks using anthropometric tape (CESCROF Sports Equipment Limited, Porto Alegre - Rio Grande do Sul, Brazil).

Body Composition Measures: Body density was determined based on Durnin and Rahaman equation [20] for boys and Durnin and Womersley equation [21] for girls using skin fold thickness from four sites (biceps, triceps, subscapular, suprailiac). Skin fold thickness was measured using Clinical plicometer innovare (CESCROF Sports Equipment Limited, Porto Alegre - Rio Grande do Sul, Brazil). Measurements were taken in triplicate to the nearest 0.1mm by the same investigator and the average measurement was used in data analysis. Then the BF% was calculated using Siri equation (BF% = (495/body density) – 450). Total body fat (kg) was obtained by multiplying BF% by weight and dividing by 100. Fat free mass (FFM) was calculated by subtracting body fat (kg) from body weight (kg).

Blood Pressure: After giving 5 minutes of rest in sitting posture to the students, brachial systolic (SBP) and DBP and Heart rate (HR) were recorded on semi-automatic non-invasive BP monitor (CITIZEN CH432B, Japan). Pulse Pressure (PP) = SBP – DBP, Mean arterial pressure (MAP = DBP + PP/3), and Rate pressure product (RPP = [HR × SBP]/ 100) were calculated for each recording. Three BP and HR recordings at 2 minutes intervals were taken and the lowest of these values was included for the present study.

Cardio Respiratory Fitness: Students were asked to refrain from any vigorous intensity physical activity 24 hours prior to the day of RWFT and report to the 400 meters track two hours after taking light breakfast. They were instructed to walk as fast as possible for one mile on the track. Time for completion was noted using stopwatch. Followed by recording of number of pulse beat for 15 seconds from brachial artery and multiplied by four to obtain one minute recovery HR (beats/min). Body weight adjusted VO_2max (mL/ kg of body weight/ min) score was calculated using the following equation (18;19):

Girls: VO_2max = 139.168 – (0.88 X age in years) – (0.077 X weight in lb.) – (3.265 X walk time in minutes) – (0.156 X heart rate).

Boys: Add 6.318 to the equation for females above.

Absolute VO_2max is calculated by multiplying the VO_2max adjusted for body weight by the corresponding body weight of the individual. VO_2max adjusted for FFM is calculated by dividing the absolute VO_2max by the corresponding FFM.

STATISTICAL ANALYSIS

Mean difference between the groups was analyzed using unpaired Student's t– test. All statistical analysis was carried out for two-tailed significance at the 5 % level using SPSS version 19 (SPSSInc, USA).

RESULTS

[Table/Fig-1] show that there was no significant difference in height, weight, BMI, waist and hip circumference between group 1 and group 2 students of both gender. Also, there was no significant intragroup gender difference in both group 1 and group 2 students in these parameters. As expected, BF% was significantly higher in girls as compared to boys in both group 1 and group 2 students. In [Table/Fig-2]. Intragroup comparison shows that FFM was significantly higher in boys as compared to girls in both the groups. Intergroup comparison shows that FFM was higher in group 1 girls as compared to group 2 girls. However, the FFM values were comparable between group 1 and group 2 boys. Intergroup comparison shows that VO_2max body weight was higher in group 1 students as compared to group 2 students of both the gender and intragroup comparison showed that VO_2max body weight was higher in the boys as compared to girls in both the groups. Absolute VO_2max values were significantly higher in boys than in girls in both

Parameters			Height (m)	Weight (kg)	BMI	Waist (cm)	Hip (cm)
Group 1	Female (FG1)	(n=34)	1.53±0.08	46.59±6.72	19.81±2.17	58.86±4.65	76.79±15.27
	Male (MG1)	(n=45)	1.56±0.10	47.21±9.39	19.23±2.10	59.80±8.21	74.50±9.49
Group 2	Female (FG2)	(n=68)	1.52±0.09	45.29±8.24	19.50±2.27	57.82±9.82	76.86±11.24
	Male (MG2)	(n=90)	1.58±0.13	49.07±10.63	19.47±2.17	59.54±8.04	74.64±10.13
p values	FG1 vs FG2		0.464	0.430	0.512	0.598	0.980
	MG1 vs MG2		0.403	0.338	0.552	0.860	0.940
	FG2 vs MG2		0.001	0.017	0.925	0.239	0.204
	FG1 vs MG1		0.207	0.745	0.241	0.582	0.448

[Table/Fig-1]: Comparison of anthropometric measures between group 1 and group 2 adolescents

Group 1 – Adolescents who underwent athlete level training; Group 2 - adolescents who underwent regular unstructured physical training. WHR – Waist to Hip ratio. Analysis between groups was done by unpaired Student t– test. $p < 0.05$ is considered statistically significant

Parameters			BF %	FFM (kg)	VO_2max (BW)	VO_2max (abs)	VO_2max FFM
Group 1	Female (FG1)	(n=34)	30.19±3.95	33.19±4.39	54.40±5.00	2522.40±357.70	67.82±22.08
	Male (MG1)	(n=45)	16.38±5.59	39.45±8.07	60.76±4.49	2851.67±515.68	67.88±16.66
Group 2	Female (FG2)	(n=68)	29.64±3.84	31.19±4.79	48.70±3.21	2204.48±416.62	65.50±13.96
	Male (MG2)	(n=90)	17.25±5.13	40.60±9.15	55.48±3.55	2722.64±618.53	67.28±5.78
p values	FG1 vs FG2		0.533	0.046	< 0.001	< 0.001	0.520
	MG1 vs MG2		0.384	0.505	< 0.001	0.242	0.759
	FG2 vs MG2		< 0.001	< 0.001	< 0.001	< 0.001	0.277
	FG1 vs MG1		< 0.001	< 0.001	< 0.001	0.002	0.988

[Table/Fig-2]: Comparison of body composition and cardiorespiratory finess between group 1 and group 2 adolescents

Group 1 – Adolescents who underwent athlete level training; Group 2 - adolescents who underwent regular unstructured physical training. FFM- Fat Free Mass, VO_2max (BW)– VO_2max adjusted for body weight, VO_2max (abs) - VO_2max absolute, VO_2max FFM – VO_2max adjusted for fat free mass, Analysis between groups was done by unpaired Student t –test. $p< 0.05$ is considered statistically significant

Parameters			SBP (mmHg)	DBP (mmHg)	MAP (mmHg)	PP	HR (beats/min)	RPP
Group 1	Female (FG1)	(n=34)	109.06±8.16	63.88±6.87	78.94±6.64	45.18±6.55	76.38±10.01	8330.44±1291.36
	Male (MG1)	(n=45)	106.67±7.01	64.40±7.51	78.49±6.21	42.27±8.32	79.20±7.68	8434.22±876.80
Group 2	Female (FG2)	(n=68)	111.84±9.15	67.97±4.50	82.59±4.85	43.87±8.97	80.44±10.80	8993.06±1414.82
	Male (MG2)	(n=90)	110.86±11.57	67.86±10.32	82.22±9.71	43.00±10.11	80.70±11.34	8944.22±1554.40
p values	FG1 vs FG2		0.137	<0.001	0.002	0.452	0.070	0.024
	MG1 vs MG2		0.027	0.048	0.020	0.675	0.425	0.043
	FG2 vs MG2		0.565	0.932	0.576	0.776	0.885	0.840
	FG1 vs MG1		0.166	0.754	0.097	0.757	0.161	0.672

[Table/Fig-3]: Comparison of Cardiovascular parameters between group 1 and group 2 adolescents

Group 1 – Adolescents who underwent athlete level training; Group 2 - adolescents who underwent structured physical training. SBP – systolic blood pressure, DBP - diastolic blood pressure, PP – Pulse pressure, HR – Heart rate. Analysis between groups was done by unpaired Student t–test. $p < 0.05$ is considered statistically significant

the groups and intergroup comparison shows that absolute VO_2max values were higher in group 1 girls as compared to group 2 girls with no difference being observed between group 1 and group 2 boys. VO_2max values adjusted for FFM showed no difference between the groups and between boys and girls.

[Table/Fig-3] shows that DBP, MAP and RPP were significantly lower in group 1 students of both genders when compared to group 2 students. There was no significant difference in other cardiovascular parameters between the groups.

DISCUSSION

We observed that the anthropometric measures of boys and girls in both the groups (group 1 and group 2) were within the normal limits according to available national studies [22,23]. However, there is no national reference data available for the hip circumference of adolescents. BMI values and BF% values of boys and girls in both the groups were within the 5th and 95th percentile of the available national reference data [22,24]. Hence, students from both the groups can neither be considered underweight nor overweight based on BMI and BF% values. Further, the VO_2max body weight values of both the group students were in superior category in both the genders according to Heywood classification [25,26]. None of the students in our study was either hypertensive or prehypertensive [SBP, DBP or both more than 95th percentile for age, sex and height was considered hypertension and between 90th and 95th percentile was considered as pre hypertension [27]. These findings suggest that students of both the groups have optimal body composition measures, BP and CRF. This observation can be attributed to the regular physical activity practiced by both group 1 and group 2 students of both genders and the availability of balanced diet to all. Our findings also substantiate the international recommendations that one hour of physical activity daily is sufficient for the optimum development of adolescents and reducing their cardiovascular risk later in the life.

Absence of significant difference in anthropometric (height, weight, BMI, waist and hip circumference) and body composition (BF%, FFM) parameters between group 1 and group 2 students, except for the higher FFM being observed in group 1 girls as compared to group 2 girls demonstrates that regular participation of group 2 students in unstructured physical activity helped them in optimising their anthropometric and body composition parameters at par with the athletes (group 1) of the respective age and gender.

However, there was significantly lesser DBP, MAP and RPP in group 1 students when compared to group 2 students. Also, there was no significant trend towards decrease in HR when compared with non-athletes. Decrease in RPP represents decrease in sympathetic activity and decreased work load on the heart whereas; decrease in HR, DBP & MAP represents increase in parasympathetic activity in group 1 students when compared to group 2 students. Therefore, our study demonstrates that athletic level training leads to autonomic resetting towards parasympathetic dominance as compared to regular structured physical activity training which allows them to reduce their cardiovascular work load.

Aerobic training when practiced for considerable time, has a substantial effect on stroke volume (SV) and, therefore, on the individual's future aerobic performance. Training increases the size of the heart mainly, the ventricles thereby, increasing the inotropic action of the heart [28]. Current scientific evidence supports the view that maximal cardiac output is the principal limiting factor for VO_2max during aerobic performance [29]. Every form of physical activity (mild to severe intensity) improves the cardiac output but athletic level training increases the size of heart and SV which is reflected in greater resting cardiac output. Higher resting CO may have resulted in comparatively lower cardiovascular parameters in group 1 students as compared to group 2 students in our study.

Previous studies also demonstrate that there is linear relationship between physical activity and health status, such that a further increase in physical activity and fitness will lead to additional improvements in health status [30].

We also observed better CRF in group 1 girls than group 2 girls while the CRF was comparable between group 1 and group 2 boys. Previous studies have shown strong relation between FFM and CRF [31]. The significant difference in CRF between group 1 and 2 girls can be explained by their significant difference in FFM and the absence of significant difference between group 1 and group 2 boys can be explained by the absence of significant difference in their FFM. Further when the VO_2max values were adjusted for FFM, the difference observed between group 1 and group 2 girls got abolished thus, confirming the strong relation between FFM and CRF. VO_2max values adjusted for body weight is commonly used to compare CRF of two groups with different body weight. In this study when the CRF was compared based on VO_2max values adjusted for body weight then there is significant difference in both the gender. The presence of significant difference in CRF in boys based on VO_2max adjusted for body weight, even though their anthropometric and body composition measures are similar lacks a better explanation. Hence, we suggest that for the better evaluation of CRF, we can consider the absolute VO_2max and VO_2max values adjusted for FFM along with VO_2max adjusted for body weight.

Further to analyse the effect of gender on body composition and CRF in two groups, we compared boys and girls. The findings consistent in both the groups were increased BF% in girls and increased FFM and CRF (both VO_2max adjusted for body weight and absolute VO_2max) in boys. Blood pressure was comparable between boys and girls in both the groups while the height and weight was more in boys in group 2 alone. The girls showing increased BF% than boys goes hand in hand with the reference values got from North Indian children [32] while boys showing increased CRF than girls was also well established in previous studies [25,26]. The difference in the CRF between boys and girls can once again be explained by the significant difference in their FFM values. Again by comparing their VO_2max adjusted for FFM, the difference in CRF gets abolished in both the groups.

To conclude, our study demonstrates that even regular unstructured physical activity for one hour daily duration for one year can help the students to maintain their body composition measures and CRF at par with the athletes of same age and gender. However, athletic level training helps in further reducing the cardiovascular load of the students. Further, the difference in CRF due to physical activity and gender difference is primarily because of the difference in their FFM.

Strengths and Limitations: Present study was done in the co-educational residential school with fully subsidised school mess. This could help us overcome the limitation of providing adequate nutrition to the students. Also, there was equal opportunity available to the students of both genders for physical activity and athletic training as all students were full time school residents. Major limitation of our study was that the direct measurement of VO_2max could not be done. Also, recording of biochemical parameters (blood sugar, catecholamine levels, urine analysis), detailed dietary history and muscle mitochondrial levels were also not done which would have helped us in better explaining the findings obtained in our study. In future, we are planning to do longitudinal study avoiding these limitations.

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