Motor skills among high school adolescents. Effect of the exercise program

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ABSTARCT

Purpose: To assess the basic motor skills and the effects of physical training improvement program in a group of adolescents.
Material and methods: The study group comprised 133 students (92 women and 41 men) aged 17 to 19 years. First, the subjects' motor skills were tested using the Eurofit Fitness Testing Battery. Second, the general improving program of physical training was implemented during the same school year. Third, the Eurofit test was repeated at one year after the initial one. The SPSS 15.0 software was used to analyse the data.
Results: At the first measurement, only 2/133 students performed all the Eurofit tests on satisfactory (above the national sample 50%) level. In four of nine domains the results were below representative national sample. A year later, after completion of the training program, 37/133 students (27.1%) performed all Eurofit domains above the 50^{th} percentile ($P<0.001$), the improvements were registered in previously deficit Eurofit Test constituencies.
Conclusions: A low level of physical fitness has been observed in majority of adolescents. A general program of physical training leads to improvement of motor skills in a significant number of adolescents and the performance in the Eurofit test domains.
Key words: adolescents, Eurofit Fitness Testing Battery, exercise, motor skills, physical training program.

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Received: 25.02. 2015
Accepted: 04.05.2015
Progress in Health Sciences
Vol. 5(1) 2015 pp 80-86

INTRODUCTION

Physical fitness is an important part of adolescent every day activity, and a necessary condition to achieve correct physical, motor, psychological, and social development [1,2]. Several studies show that the motor skills and movement coordination achieve the highest level in late adolescence, and decrease gradually above the age of 20 [3,4]. Physical activity is an important prerequisite for independent decisions concerning lifestyle, professional career, and leisure time activities. All these factors will affect future life and health of young people [5,6].

Several studies show deterioration of physical fitness among children and adolescents in developed countries, also in Poland [7-10]. Important potential reason, as indicated in the Polish National Institute of Public Health Report [11], is lowering of physical activity performed everyday by young people. TV-watching, computer based work and e-entertainment have become predominant leisure activities. Such behaviours led to sedentary lifestyle habits and may interplay, among other complications, with increasing rate of overweight and metabolic syndrome in young generation [12-14].

The term "motor activity" refers to movements coordination, extensiveness, strength of muscular contraction, and capacity to perform an effort [4]. It defines also neuro-muscular capacities, expressed as the level of strength, speed, endurance, and agility [4,15].

The objective of this study was to assess the level of motor skills and effects of general physical training improvement program in a group of school adolescents.

MATERIALS AND METHODS

Ethics Statement

The study has been approved by the Bioethical Committee of the Jagiellonian University (KBET/104/B/2007).

Sample Size

The subject group consisted of 133 high school students (aged 17-19 years) including 92 women and 41 men. Only students, who were healthy, haemodynamically stable, with no disabilities and who themselves and whose parents/legal guardians consented to participate, were included in the study. From the total cohort of 237 students attending the school at the index age group, 140 (59%) subjects fulfilled entrance criteria, gave consent, and participated in the first stage test; 133 students (95% of the initial group) completed the entire study. Reasons for dropping out were: sick leave from physical education (3 students), leaving this school (3 students), and refusal (1 student).

Data Collection

The measurements of motor skills took place during compulsory physical education (PE) classes, under PE teacher supervision. The Eurofit Physical Fitness Test Battery, approved by the Council of The Europe was used to measure following nine components [16,17]:

- Flamingo Balance tests single leg balance assesses the strength of the leg, pelvic, and trunk muscle as well as dynamic balance. Stand on the beam with shoes removed. Keep balance by holding the instructor's hand. While balancing on the preferred leg, the free leg is flexed at the knee and the foot of this leg held close to the buttocks. Start the watch as the instructor lets go. The total number of falls or loss of balance in 60 seconds is recorded.
- Plate Tapping tests speed of upper limb movement. Is a reaction test using a alternating wall tapping action which measures upper body reaction time, hand-eye quickness and coordination. The time taken to complete 25 cycles is recorded. Performed the test twice and the best result is recorded.
- Sit-and-Reach tests trunk flexibility. The score is recorded to the nearest centimeter or half inch as the distance reached by the hand. The level of the feet as the zero mark.
- Standing Broad Jump tests explosive leg power. The person stands behind a line marked on the ground with feet slightly apart. A two foot take-off and landing is used, with swinging of the arms and bending of the knees to provide forward drive. The subject attempts to jump as far as possible, landing on both feet without falling backwards. Three attempts are allowed. The measurement is taken from take-off line to the nearest point of contact on the landing (back of the heels). Record the longest distance jumped, the best of three attempts.
- Handgrip tests static arm strength. The subject holds the dynamometer in the hand to be tested, with the arm at right angles and the elbow by the side of the body. The best result from several trials for each hand is recorded, with at least 15 seconds recovery between each effort.
- Sit-Up in 30 seconds tests trunk strength. The maximum number of correctly performed sit ups in 30 seconds is recorded.
- Bent Arm Hang tests muscular endurance. The subject is assisted into position, the body lifted to a height so that the chin is level with the horizontal bar. The bar is grasped using an overhand grip (palms are facing away from body), with the hands shoulder width apart. The

timing starts when the subject is released. They should attempt to hold this position for as long as possible. Timing stops when the person's chin falls below the level of the bar or the head is tilted backward to enable the chin to stay level with the bar**.** Scoring: The total time is recorded in seconds.

- Shuttle Run tests running speed and agility. Record the total time taken to complete the 50 m course.
- Endurance shuttle-run tests cardiorespiratory endurance. This test involves continuous running between two lines 20m apart in time to recorded beeps. The subjects stand behind one of the lines facing the second line, and begin running when instructed by the recording. The speed at the start is quite slow. The subject continues running between the two lines, turning when signaled by the recorded beeps. The test is stopped if the subject fails to reach the line (within 2 meters) for two consecutive ends after a warning.

Social and demographic data were gathered and compared to adjusted national population sample. Based on the national sample, obtained the closest before our study [16], the 50th percentile level was used as the minimum requirement for our students to approve the result of each Eurofit test component as positive. The next stage was to introduce the general physical training improvement program. This exercise program was conducted according to the test station method [18], during compulsory PE classes (45 min twice a week) for next 8 months of a school year. The program consisted of exercises oriented to improve body physical functions: balance, agility and flexibility, resistance and strength of trunk and limbs muscles, and vigorous aerobic exercises aiming to improve cardiorespiratory fitness. Time, scope, and type of exercises were identical for all participants. The second assessment was performed exactly a year after the initial test using the same Eurofit Test methodology.

Data Analysis

The SPSS 15.0 software was used to analyze the data. Before analysis data were tested for normality of distribution using Shapiro-Wilk test. The impact of the physical exercises program on motor parameters was assessed using Student's *t*-test, if the variables had normal distribution and the Wilcoxon signed-rank test in the remaining cases. Statistical significance was reported as p values were <0.05.

RESULTS

The sample included 133 people, 92 women (69.2%) and 41 men (30.8%). At the first stage of measurements 73 students (54.9%) were 17 years old, and sixty (45.1%) at age of 18. Compared to the national peers' sample [16], the study group obtained lower results in four Eurofit components: Flamingo Balance test, Bent Arm Hang test, Shuttle Run test and Cardiovascular Endurance test**.** Only two students (one woman and one man) performed all the tests on the minimal or above acceptable 50 percentile level. A significant improvement was observed after completion of the exercise program, at the second Eurofit test, when 37 persons (27.1%), performed all the tests at least on 50th percentile, $P<0.0001$; 22 women (23.9%), $P=0.00004$, and 15 men (36.6%), $P=0.00018$.

At the first measurement, the median of falls during the "Flamingo Balance test" for entire group was 5 falls (Q1-Q3 3-7 falls), and it improved to 4. (Q1-Q3 2-6 falls) at the second stage; $P<.0001$. The number of falls decreased significantly among women (Me=5 [Q1-Q3 3-7 falls] vs. 4. [Q1-Q3 1.5-6 falls]), $P<0.0001$, and insignificantly among men (Me=5 [Q1-Q3 3-8 falls] vs. 5. [Q1-Q3 3-7 falls]).

At the "Plate Tapping test" the mean group value equalled 10.40s (SD=1.53) at the first stage, and 10.19s (SD=1.36) in the second, $P>0.05$. Among women this decrease (10.80s; SD=1.52 vs. 10.49s; SD=1.22) was significant, $P=0.040$. On both attempts, men performed this test significantly quicker than women, $P<0.001$.

At the "Sit-and-Reach test" mean value for entire group was 13.47cm; SD=6.27 at the first stage, and it decreased to 12.15 cm; SD=6.64 at the second stage, $P=0.001$. This decrease was significant ($P=0.006$) among women (13.58cm vs. 12.22cm), and insignificant among men (13.22cm vs. 11.97cm), $P>0.05$. Gender has no effect on results in this test, $P> 0.05$.

The mean value of the "Standing Broad Jump test", for entire group was 186.75cm (SD=35.20) at the first stage, and 185.93cm (SD=36.03) at the second. No significant differences were observed for the entire group, neither among women (168.45cm; SD=21.37 vs. 167.71cm; SD=19.30, respectively), nor among men (227.83cm; SD=23.48 vs. 226.83cm; SD=30.96, respectively). In this Eurofit domain, men preformed significantly better, $P<0.0001$.

At the "Handgrip Test" mean value for the whole group was 36.78kG; SD=9.67 at the first measurement, and 39.54kG; SD=10.78 at the second stage, $P<0.0001$. The significant increase between the first and the second stage was obtained for the whole group ($P<0.0001$). The difference was significant for women (31.42kG; SD=4.44 vs. 33.71kG; SD=5.34, $P<0.0001$) and for men (48.80kG; SD=7.06 vs. 52.61kG; SD=8.08). At both stages men performed better than women, $P<0.001$.

The median of sits completed during the "Sit-Ups 30 seconds test" was 23. (Q1-Q3 20-26) at

the first stage and 25; (Q1-Q3 22-28) at the second, *P*<0.0001. Significant improvements were recorded among women (21.17; SD=4.34 vs. 23.15, SD=4.51, *P*<0.0001) and among men (27.82; SD=3.92 vs. 29.68; SD=5.51, *P*=0.001). At both stages, men performed this test statistically better than women, *P*<0.001.

The exercise training had no effect on the "Bent arm hang test" results in the analysed group. At both attempts men had longer "bent arm hang time" than women, *P*<0.001, Table 1.

Table1. Eurofit test scores during the first (1) and the second (2) stage, for the studied adolescents, women, and men

Group	Flamingo Balance (n)	Plate Tapping (s)	Sit-and-Reach (cm)	Standing Broad Jump (cm)	Handgrip (kG)	Sit-Ups 30 seconds (n/30 s)	Bent Arm Hang (s)	Shuttle Run (s)	Cardiorespiratory Endurance (n)
Entire group 1 stage	5 (3-7)*	10.40 ±1.53	13.47± 6.27**	186.75±35.20	36.78±9.67**	23. (20-26)*	15.30±13.73	21.79±2.14**	47.33±27.85
Entire group 2 stage	4 (2-6)*	10.19 ±1.36	12.15± 6.64**	185.93±36.03	39.54±10.78**	25. (22-28)*	16.42±14.65	20.20±1.70**	50.38±27.74
Women 1 stage	5 (3-7)*	10.80 ±1.52**	13.58± 0,65**	168.45±21.37	31.42±4.44**	21.17±4.34**	9.40±8.78	22.71±1.85**	33.57±1.95
Women 2 stage	4 (1.5-6)*	10.49 ±1.22**	12.22± 0,69**	167.71±19.30	33.71±5.34**	23.15±4.51**	10.19±10.03	20.83±1.37**	35.91±1.80
Men 1 stage	5 (3-8)	9.47± 0.22	13.22± 0,98	227.83±23.48	48.80±7.06**	27.82±3.92**	28.54±13.67	19.70±0.96**	78.19±2.92
Men 2 stage	5 (3-7)	9.51± 0.20	11.97± 1,04	226.83±30.96	52.61±8.08**	29.68±5.51**	30.39±13.81	18.80±1.54**	82.82±2.70

* P<0.05; median, Quartile Q1-Q3, Wilcoxon's test

**P<0.05; standard deviation- values are mean±SD, cm- centimeter, n-number, s-seconds, Student's test

The mean hanging time of the "Bent Arm Hang test", was 15.30s; SD=13.73 in the first, and 16.42s; SD=14.65 at the second stage. In the group of women, respective values were: 9.40s; SD=8.78 vs. 10.19s; SD=10.03. Among men, the respective results were: 28.54s; SD=13.67 vs. 30.39s; SD=13.81.

For the whole group, the mean running time at the "Shuttle Run test" was 21.79s; SD=2.14) at the first stage, and it decreased to 20.20s; SD=1.70, *P*<0.0001 at the second stage. Significant differences were found between women (22.71s; SD=1.85 vs. 20.83s; SD=1.37, *P*<0.0001) and among men (19.70s; SD=0.96 vs. 18.80s, SD=1.54 respectively, *P*<0.0001). At both attempts men performed quicker than women, *P*<0.001.

The mean number of runs during the "Cardiorespiratory Endurance shuttle-run tests" was 47.33; SD=27.85 at the first stage, and 50.38; SD=27.74 at the second; the differences for the whole group, and separately in each gender group were not significant. During this test, at both attempts men performed more runs (78.19 and 82.82) than women (33.57 and 35.91), *P*<0.001 (Table 1).

DISCUSSION

This study tested the level of physical fitness among 17-19 years adolescents. It verified also effects of the general physical improvement training carried out during regular PE classes during the same school year. The sample included 56% of all students at the index age group attending this high school.

In comparison with the national sample, collected at the 90th, which was the closest sample available before this study commenced, the studied group presented weaker personal achievement and deficit of physical efficiency in 4 of 9 tested Eurofit domains, namely: the Flamingo balance, Bent Arm Hang test, Shuttle Run tests and Cardiorespiratory Endurance test [16]. The weakest results concerned the Flamingo balance test. It has been documented that 17-19 years old adolescents are near to the maximal life expected physical efficiency, which is

expected at the age of 20th [19]. The Flamingo balance test and the Shuttle Run tests asses neuromuscular coordination, which is likely to deteriorate quicker than muscular strength during personal life span [4,20]. Lower results of cardiorespiratory endurance were found mostly in the women's group, while men obtained higher results than the national sample both at the first and at the second stage [16]. Our male subjects performed 78 runs in the first stage and 83 runs in the second, which ranked them higher than not trained male students at the Bratislava University (61 runs), but below the trained students of the physical education and sport faculty (86 runs) in study published by Pistlova [21].

Completion of a general physical exercise program implemented during regular PE classes (45 min. class, twice a week during remaining school year) improved two out of the four deficient Eurofit domains. A significant amelioration of the balance test is of particular importance, since it assesses function of both the nervous and the motor systems simultaneously. Obtaining better balance control among 18-19 aged adolescents would support movement coordination in adulthood [22].

Fornal-Urban et al. indicate that the optimal motor coordination is obtained around the age of 20 and decreases gradually thereafter [23].

Slightly lower results, observed by Cieśla [24] among older group of Polish 20 to 22 years old physiotherapy students are in line with the above observation.

Improvement in the balance test was also registered in the women's group after completion of the training program (5.6 vs. 4.1 falls). The final result was better than the one found in the group of Slovak students (4.9 falls) [25].

The balance test results found in the men's group were worse than presented among older 20-22 aged, Turkish active sportsmen. Also in that group a further improvement was observed after intensive 8-week training, which indicates great potential for optimizing physical fitness in adult young men during shorter but intensive program [26].

The Shuttle Run test measures running speed and agility. Significantly better results in this test and also some improvement in the cardiorespiratory endurance would positively affect modifiable cardiovascular risk factor for adult life of examined adolescents. Improved in cardiorespiratory endurance and potentially continued regular exercise are expected to decrease a risk of overweight and obesity and cardiovascular atherosclerosis disease, which currently is one of the major health problem in Europe [11].

No improvement was registered at the Bent Arm Hang test; the male subjects obtained significantly better results than women. The difference is consistent with the observations of Crane et al. [27], who showed that functional strength is greater in men than in women throughout ontogenesis. However significant improvement in the Handgrip Test, registered both in the group of women and men, indicates that applied program more influence the hand and forearm strength than shoulder and arm muscle groups.

In our study a significant decrease of the Sit-and-Reach test results were observed. However, results obtained by our students at both approaches, were still above national sample [16].

The men participating in our studies obtained similar results compared to a group of Croatian students (Poles 11.9 vs. Croatian 12.3cm) [28].

Nevertheless, deterioration of the body flexibility discovered among our adolescents need to be addressed in future training program.

A relatively small group of pupils and disproportion in gender distribution are the main limitations of our study. Nevertheless, our sample covered 56% of all pupils attending the school at the index age group of 17 to 19 years.

In Poland roughly 1/3 of high school students are expected to continue university studies. Thus, for majority of these adolescents the moment when we performed this study was the final point when they could improve their physical abilities and understand importance of physical activity for their health at school, and before entering adult life. Also the fact, that only students, who agreed and whose parents/legal guardians gave a consent participated in the study, might cause a bias towards inclusion of persons who from the beginning better understood importance of physical activity for young people. Potentially the learning effect in adaptation to Eurofit test, could affect better results at the second attempt [29,30].

Nevertheless, divergent changes (improvement in some, lack or deterioration in other domains) indicate that the adaptation effect was not unanimous in the studied group.

Comparison to a historical national sample [16] needs some concerns, however this was the nearest available representative data set to which our first stage results could be referred.

CONCLUSIONS

A low level of physical fitness has been observed in the majority of high school adolescents (both women and men). The general exercise program leads to improvement of motor skills in a significant number of adolescents and the Eurofit domains having initially lower values.

Acknowledgments

The research was funded by the Jagiellonian University Medical College, Krakow, Poland.

Conflicts of interests

The authors declare no conflicts of interest.

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