Physical fitness in children and adolescents in rural and urban areas

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ABSTRACT

Objective: the aim of the research was to determine the differences in fitness components among children and adolescents from urban and rural areas. Design/method: A sample of 5076 school children (2877) and adolescents (2199) from urban and rural areas from the region of Strumica (Macedonia). Physical fitness is estimated with 7 tests and that: standing long jump, sit-ups, bent arm hang, handgrip, sit and reach, speed-agility, shuttle run 4x10 and three-minute step test. The differences in fitness tests, anthropometric measures and body composition by place of residence were examined by one-way analysis of covariance. Results: Rural children and adolescent have lower height, body mass BMI and body fat % and had higher muscular mass % cardiorespiratory fitness and speed-agility (all $p < 0.001$), than urban young people. Regarding muscular fitness, the results differed depending on the fitness test selected. Rural children and adolescent had a better performance in standing long jump, handgrip strength bent arm hang while they had a lower performance in sit-ups in 30 s (all $p < 0.001$), compared to their urban peers. Effect size was small-medium (Cohen's d = 0.1–0.5). Conclusion: children and adolescents from the rural environment show better results in cardiorespiratory fitness, muscle fitness of the upper and lower extremities and have better coordination, speed and agility in comparison with their urban peers. The place of residence, apart from other environmental factors, should be taken into account when building a state strategy and interventions through which it will promote physical activity and health. **Keywords:** Physical fitness; Residence characteristics; Children; Adolescents.

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INTRODUCTION

Physical fitness is defined as the ability of body to function effectively, to enjoy leisure, to be healthy, to resist disease, and to cope with emergency situations. Physical fitness is categorized into two categories that have similar meaning: health-related (health state and well-being), skill-related (the ability to perform certain aspects of sports or occupations) (Hian et al., 2013). Physical fitness components such as muscular fitness (Ruiz et al., 2009), flexibility, cardiorespiratory fitness (Olds et al., 2006; Photiou et al., 2008) and speed-agility (Ortega et al., 2008), are strongly related to health in children and adolescent and must be considered when assessing one's health status.

Physical fitness is partially genetically determined, but it can also be influences by environmental factors. Physical activity is one of the main determinants of the physical fitness (Ruiz et al., 2006; Hussey et al., 2007). Life in areas with different popular size can be associated with different dietary habits, access to sports facilities and the possibility of physical activity, among other things. This exposure to the environment can affect lifestyle and cardiovascular risk (Roemmich et al., 2006; De Vries et al., 2007), and this may be related to the level of physical fitness.

Several studies have researched the relation between the place of residence (urban or rural) and the level of physical fitness in children and adolescents all around the world, e.g. USA (McMurray et al., 1999), Turkey (Özdirenç et al., 2005), Switzerland (Kriemler et al., 2008), Cyprus (Tinazci & Emiroglu, 2009), Greece (Tsimeas et al., 2005), Mexico, (Peña Reyes et al., 2003), Australia (Dollman et al., 2002) and Oman (Albarwani et al., 2009), Spain, Slovak and observed inconsistent results.

The differences between the places of residence are specific in different countries and regions, and the obtained data from different countries are necessary for better understanding the relation between the place of residence and the physical fitness of young people. In addition, habits related to physical education and lifestyle in schools can be distinguished between children and adolescents, and it is interesting to further investigate whether the relationship between place of residence and fitness is different between children and adolescents.

The aim of the research was to determine the differences in the various components of physical fitness among urban and rural children who live in the municipality of Strumica, Republic of Macedonia. In addition, the survey included the differences in the anthropometric characteristics, the body composition and the social status among urban and rural children and adolescents.

METHODS

The research was conducted on a sample of 5076 respondents, representing 97% of the total population of students at the researched age, from the primary schools in the Municipality of Strumica, Republic of Macedonia. There are 9 primary schools in the municipality, out of which 5 are in rural and 4 in urban areas. The sample is divided into two sub-units according to gender and that 2610 (1821 from urban and 789 rural) male respondents and 2466 (1723 urban and 743 rural) female respondents. The average age of the respondents of the two gender was 9,94 ±2,41 years.

In the example entered all students from whom parents gave their consent to participate in the project and they were psycho-physically healthy and regularly attendant physical and health education. The respondents were treated in accordance with the Helsinki Declaration.

The measurement was realized in March, April and May 2013, in standard school conditions at regular classes in physical and health education. The measurement was carried out by experts in the field of kinesiology and medicine, who trained in the past to measure certain tests and measures.

Anthropometric measurements

Anthropometric measurements were taken according to standard methodology of International Society for the Advancement in Kinanthropometry (ISAK). Weight was measured in underwear and without shoes with an medical decimal weight scales, to the nearest 0.1 kg, and height was measured barefoot in the Frankfort horizontal plane with a telescopic height measuring instrument (Martin's anthropometer) to the nearest 0.1 cm. Body mass index (BMI) was calculated as body weight in kilograms divided by the square of height in meters.

The components of the body composition are determined by the method of bioelectric impedance. Measurement is realized with the help of Body Composition Monitor, model "OMRON - BF511", by helping measure the body weight, fatty tissue and muscle mass percentage. Before starting the measurement in Body Composition Monitor, the gender, age and body height parameters of the respondents are entered. In order to ensure that the results obtained from the measurement, i.e. the assessment of the body composition are as accurate as possible and precise before each measurement were fulfilled the preconditions that recommends ACSM (2005) and Heyward (2006).

Evaluation of Physical Fitness

Prior to starting the study, the researchers involved in the project undertook training sessions in order to guarantee the standardization, validation, and reliability of the measurements (Moreno et al., 2003). Seven tests, forming part of the EUROFIT battery, validated and standardized by the European Council, were applied in the following order:

Sit and Reach test. With the subject seated on the floor and using a standardized support, the maximum distance reached with the tip of the fingers by forward flexion of the trunk is measured. Test indicative of amplitude of movement or flexibility.

Hand Grip test. With the use of a digital Takei TKK 5101 dynamometer (range, 1-100 kg), the maximum grip strength was measured for both hands.

Standing broad jump test. The maximum horizontal distance attained, with feet together, was measured. This test evaluates lower limb explosive-strength.

Bent Arm Hang test. A standardized test was used to measure the maximum time hanging from a fixed bar. This test estimates the upper limb endurance- strength.

Sit-ups 30 sek. Maximum number of sit ups achieved in 30 seconds. This test measures the endurance of the abdominal muscles.

Shuttle run: 4×10 meters. This test provides an integral evaluation of the speed of movement, agility and coordination. The subject does four shuttle runs as fast as possible between 2 lines 10 meters apart. At each end the subject places or picks up an object (a sponge) beside the line on the floor.

3 minute step test. The aerobic capacity has been estimated by means of a 3-minute step test. The respondent had a task, for 3 minutes, to get up and get down of a bench 30,5 cm high, in four cycles (up, up, down, down), with standardized rhythm of 96 beats in a minute (bmp), which was dictated by the metronome. Before beginning of the test we have measured the heart frequency, whereas the children, even in the stand-by state had sub maximal value in terms of the age, were not exposed to burdening. The heart rate was measured by means of the monitor Polar RS800 for registration of the heart frequency. As a result was taken the heart frequency measured one minute after the test (Post exercise pulse rate).

The socioeconomic status of the students is evaluated with the help of the international scale, named Family Affluence Scale (FAS), which includes four questions. The scale had been formulated by WHO- Health Behaviour and School Aged Children Study, in 1997 (Currie et al., 1997).

Statistical methods

Regarding the statistical analysis, the characteristics of the sample are presented as mean (standard deviation) or frequencies (percentages) stratified by gender and age. The normal distribution of the applied variables was verified by the Kolmogorov-Smirnov method. The differences in the anthropometric measures, the body condition and the fitness tests among urban and rural children and adolescents have been determined by one-way analysis of covariance (ANCOVA) including, socioeconomic status, age and gender as covariates. Mean differences among rural and urban data and 95% Confidence Interval (CI) were calculated. Effect size statistics was assessed using Cohen's d (standardized mean differences and 95% CI). Taking into account the cut-off established by Cohen, the effect size can be small (~0.2), medium (~0.5) or large (~0.8). Interactions of gender (boys and girls) and age group (children and adolescents) with urban and rural residence were studied in all the models. Bonferroni adjustments for multiple comparisons were used. The significance level was set at 5% and all calculations were performed using SPSS v.22.0 software for Windows.

RESULTS

The chart characteristics of the sample by gender and age are shown in Table 1. Table 2 shows the data on the anthropometric and physical fitness variables in relation to the place of residence. Descriptive data, mean differences, effect size and 95%CI are presented. Statistically significant differences were found in all researched variables, except in the variable sit and reach. The ANCOVA analyses showed that rural children and adolescent have lower height ($p = 0.007$; mean difference = 0,6 cm; Cohen's d = 0.13), body mass ($p < 0.001$; mean difference = 1.3 kg; Cohen's d = 0.03), BMI ($p = 0.002$; mean difference = 0.3 kg/m^2; Cohen's d = 0.04) and body fat % ($p < 0.001$; mean difference = 1,5 %; Cohen's d = 0.25) than their urban peers. Rural children and adolescent had higher muscular mass % ($p = 0.016$; mean difference =0.22%; Cohen's d = 0.19), cardiorespiratory fitness ($p < 0.001$; mean difference = 3,43; Cohen's d = 0.16) and speed-agility ($p < 0.001$; mean differences = 0.58 s; Cohen's d = 0.46) than urban young people. Regarding muscular fitness, the results differed depending on the fitness test selected. Rural children and adolescent had a better performance in standing long jump ($p < 0.001$; mean difference = 2.87 cm; Cohen's d = 0.21), handgrip strength ($p < 0.001$; mean difference = 0.37 kg; Cohen's d = 0.26), bent arm hang ($p < 0.001$; mean difference = 1,18 s; Cohen's d = 0.23) while they had a lower performance in sit-ups in 30 s ($p < 0.001$; mean difference = 0.90 n; Cohen's d = 0.08), compared to their urban peers.

On some muscular fitness tests can be negatively affected by excess body mass, particularly those that require lifting the body mass (called weight-bearing activities) such as standing long jump and bent arm hang tests. Because statistically significant differences were determined in body mass between urban and rural children and adolescents we tested whether BMI and fatty tissue were treated as covariance body weight, resulting in a change in the obtained results. When all analyses were repeated adjusting for anthropometric variables (body mass, BMI and body fat %), the results remained unchanged in all physical fitness tests. Also, when the tests: standing long jump and bent arm hang we divided with the body mass, the results remained unchanged.

Table 1. Characteristics of the study sample by gender and age.

Variable	Boys				Girls			
	Children (N= 1486)		Adolescents (N= 1124)		Children (N= 1391)		Adolescents (N= 1075)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age (y)	8.14	1.33	12.29	1.07	8.13	1.38	12.33	1.06
Height	133.10	9.54	157.01	10.75	132.98	10.26	156.14	7.98
Weight	32.79	9.68	51.34	14.19	32.55	9.51	51.10	12.14
BMI	18.30	3.49	20.59	4.10	18.22	3.48	20.89	4.16
Body fat	22.36	7.82	20.24	8.52	21.96	8.45	25.14	7.81
Muscular mass	30.48	3.55	36.51	3.40	30.09	2.88	32.96	2.48
Muscular fitness								
Standing long jump	122.66	23.07	161.63	28.96	107.89	19.63	131.42	21.57
Sit-ups	13.61	4.81	18.90	4.35	11.24	4.76	15.33	4.00
Bent arm hang	5.36	5.52	10.66	11.15	2.92	3.57	3.73	4.82
Handgrip	15.00	9.37	43.50	18.31	12.39	8.14	33.65	12.35
Handgrip weight	0.44	0.24	0.85	0.29	0.35	0.20	0.66	0.22
Flexibility								
Sit and reach	16.47	5.31	15.47	6.87	17.74	5.36	19.82	6.81
Speed-agility								
Shuttle run 4x10	13.90	1.54	12.15	1.17	14.82	1.54	13.33	1.21
Cardiorespiratory fitness								
3 min. step test	/	/	112.67	19.36	/	/	130.33	18.97

The associations were consistent in boys and girls, and in children and adolescents for most of the fitness tests studied. It was not found a clear age and gender interaction in any fitness tests. A borderline significant age-interaction was found for sit-ups 30 s test ($p = 0.005$) and bent arm hang test ($p = 0.005$). A borderline significant gender-interaction was found for Standing long jump test ($p = 0.002$), handgrip strength test ($p = 0.040$) and three minute step test ($p = 0.010$).

DISCUSSION

The results from our research indicate that students of different residential status differ significantly in anthropometric measures, the body composition and the level of physical fitness. Rural children and adolescents had a healthier anthropometric, cardiorespiratory fitness, speed-agility and muscular fitness (except for sit-ups) profile than their urban peers. There were no statistically significant differences in the flexibility between urban and rural children and adolescents. However, all fitness tests show small mean differences and small to medium size effects among rural and urban participants, that can explain a large percentage of the variance in fitness (e.g. genetics).

Table 2. Anthropometric and physical fitness indicators in rural and urban children and adolescents.

Variable	Urban		Rural		Mean differences			Effect size	
	Mean	SE	Mean	SE	Mean	SE	95% CI	C' *d*	
Height	143.42	0.12	142.83	0.18	0.59	0.22	0.16 to 1.01	0.13	-0.62 to 0.64
Weight	41.12	0.17	39.83	0.26	1.29	0.31	0.68 to 1.90	0.03	-0.51 to 0.71
BMI	19.45	0.06	19.10	0.10	0.35	0.12	0.13 to 0.58	0.04	-0.09 to 0.25
Body fat	22.84	0.14	21.33	0.21	1.51	0.25	1.01 to 2.01	0.20	-0.07 to 0.61
Muscular mass	32.18	0.05	32.39	0.07	-0.22	0.09	-0.39 to -0.04	0.19	-0.32 to 0.02
Muscular fitness									
Standing long jump	128.18	0.37	131.06	0.57	-2.87	0.68	-4.21 to -1.54	0.21	-1.19 to 1.35
Sit-ups	14.76	0.07	13.86	0.11	0.90	0.13	0.64 to 1.16	0.08	-0.09 to 0.36
Bent arm hang	5.17	0.11	6.35	0.17	-1.18	0.21	-1.59 to -0.77	0.23	-0.46 to 0.17
Handgrip	25.65	0.20	27.51	0.31	-1.86	0.37	-2.58 to -1.13	0.26	-0.89 to 0.74
Handgrip weight	0.56	0.00	0.62	0.01	-0.05	0.01	-0.07 to -0.04	0.33	-0.34 to -0.31
Flexibility									
Sit and reach	17.35	0.10	17.20	0.16	0.15	0.19	-0.22 to 0.52	0.01	-0.20 to 0.33
Speed-agility									
Shuttle run 4x10	13.82	0.02	13.25	0.03	0.58	0.04	0.50 to 0.65	0.46	0.40 to 0.53
Cardiorespiratory fitness									
3 min. step test	122.22	0.50	118.79	0.69	3.43	0.85	1.76 to 5.11	0.16	-0.91 to 1.66

Analyses were adjusted by gender and age. Values are adjusted means (SE, standard errors of the means). Mean differences (urban – rural) are expressed as mean (SE) and 95% Confidence interval. Effect size statistics are expressed as Cohen's d (C' d) and 95% Confidence interval. There was no missing data for the variables shown (n = 2569).

Recent researches have shown contradictory results with regard to children and adolescents living in urban and rural areas, but large number of researches are largely in line with the results obtained in these researches (Dollman et al., 2002; Kriemler et al., 2008; Albarwani et al., 2009). Rural children and adolescents have higher level of fitness compared to their urban peers. The research that was obtained in Australia suggests that rural children had higher level of cardiorespiratory fitness compared to children in urban areas. According to our research, the results obtained on rural Swiss children (Kriemler et al., 2008) and Oman adolescents (Albarwani et al., 2009), who had a higher level of cardiorespiratory fitness compared to their urban peers. Contrary to these studies, a US based research suggests that urban children have a higher level of cardiorespiratory fitness compared to their peers living in a rural environment (McMurray et al., 1999).

In other studies are determined different results in relation to each fitness test. For example, urban children from Mexico have shown better results in the explosive strength and strength of abdominal muscles, but weaker results in grip strength tests compared to children living in a rural environment. Among the Cypriot urban and rural children (Tinazci et al., 2009) were found differences in fitness tests - standing broad jump, sit-ups, 20 m shuttle run, and hand grip; while differences were not found in equilibrium balance tests - flamingo, sit and reach, plate tapping and speed shuttle run. On the other hand, in a study realized in Greece no differences in physical fitness were determined (flexibility, cardiorespiratory, muscular fitness, and speed and agility) between children from and rural areas. A research realized in Croatia showed that children from urban areas show better results in the fitness test - 20 m dash, standing long jump and timed sit-ups. Urban and rural boys and girls do not differ significantly in the flexibility. Also, in the research of Hian et al. (2013) and Eiben et al. (2005) is determined that children from urban areas achieve better results in certain fitness tests than their peers who live in rural areas. According to Loucaides et al. (2004) this is due to equipment availability and transportations were better in urban than rural areas. Schools in urban areas also had better facilities such as field, track and others if compared with rural schools (Hian et al., 2013). However, these conclusions may be valid in developed countries and big cities. Strumica belongs to the group of medium-sized towns and there are generally no differences in the material, spatial equipment of the schools that are located in the city area and the surrounding villages.

The results of our research further point to high consistency with regard to gender and age groups. Similar tendencies have been determined for fitness and place of residence for boys, girls, children and adolescents. Less consistent results were obtained ion urban and rural Mexican children (Peña Reyes et al., 2003), where 3 (flexibility, speed and cardiovascular fitness) of 6 tests for assessing physical fitness showed different results between gender and age groups (6 to 9 years in relation to 10 to 13 years).

The results of the research indicate that children from urban areas achieve better results only in the fitness test sit-ups 30 s in relation to children from rural areas. Similar results were obtained in Mexican and Spanish children where the same was used - sit-ups test: the abdominal strength and endurance was better in urban than in rural children (Peña Reyes et al., 2003). These authors reported that sit-ups appeared a more familiar test to the urban than to the rural children. On the other hand, Turkish rural children have achieved better results than urban children (Özdirenç et al., 2005) in this test. However, the results should be accepted with a certain precautionary approach, because the urban and rural areas in the literature and in different countries are differently defined, which can partly explain the consistency of the results in these studies.

Our results also suggest that rural children have lower height, body weight, BMI values, a lower percentage of fat tissue and a higher percentage of muscle mass compared to their urban peers. The results of previous surveys conducted in Europe indicate that children living in urban areas are higher than their peers from rural areas, and in many countries these differences remain in adulthood. The reasons are the changes in public health, nutrition and in the general living conditions that are related to urbanization.

The increasing prevalence of sedentary lifestyle, especially among children living in urban environment, reduces overall physical activity, which also reduces the level of physical fitness and achievements. The results of our research suggest that boys and girls from rural areas achieve better results in tests for assessing physical fitness. The assumption is that children in the rural environment have more spontaneous physical activity on open space and more use of outer terrains than children living in urban areas, and this is probably the reason why they achieve better results, especially in the abilities in which the energy component diminishes. Despite the mentioned factors for the differences in the fitness level a huge influence has the socio-cultural differences between the urban and rural children.

The physical fitness in childhood and adolescence is positively related with present and future health-related outcomes such as risk за total fatness, high blood, hyperinsulinemia, abdominal adiposity, insulin resistance, skeletal health and mental health (Ortega et al., 2008). Therefore it is inevitable physical education curriculum can provide students with substantially more physical activity during physical education classes. Sallis et al. (1997) point of the fact that by raising the quality of teaching in physical education 97% of elementary school students may be potentially assisted.

The environment can have small impact on certain fitness related health, since residence area and housing type differences were small for majority of tests. It is important to note that the place of residence and the appropriate external motivation should be taken into account when building a state strategy and interventions through which it will promote physical activity and health.

This research has some limitations. Owing to its cross-sectional design, which does not allow determining the cause and effect relations between the variables. Moreover, the lack of the school data does not allow adjusting the analysis for clustering within the schools. The differences in adulthood, especially between children and adolescents, can affect the results of physical fitness; lack of information about sexual maturation status of the sample represents another limitation. A relatively large sample of a whole set of physical fitness components and balanced sample of children and adolescents, which allowed us to observe that age does not seem to affect the rural vs. urban differences on fitness, are notable strengths of this study.

CONCLUSION

Based on the obtained results, it can be concluded that children and adolescents from the rural environment show better results in cardiorespiratory fitness, muscle fitness of the upper and lower extremities and have better coordination, speed and agility from their urban peers. Because average differences and effect size were small for all the health indicators, the obtained results suggest that the environment may have light influence of many health-related factors, including fitness. The place of residence, apart from other environmental factors, should be taken into account when building a state strategy and interventions through which it will promote physical activity and health.

REFERENCES

ACSM (American College of Sports Medicine) Health-Related physical Fitness Assessment Manual. Baltimore: Lippincott Williams and Wilkins, 2005.

Albarwani D Phil, S.; Al-Hashmi, K.; Al-Abri, M.; Jaju, D. & Hassan, M. O. Effects of overweight and leisure-time activities on aerobic fitness in urban and rural adolescents. Metabolic syndrome and related disorders, 7(4),:369-74, 2009. https://doi.org/10.1089/met.2008.0052

Currie, C. E.; Elton, R. A.; Todd, J. & Platt, S. Indicators of socioeconomic status for adolescents: the WHO Health Behaviour in School-aged Children Survey. Health education research, 12(3):385-97, 1997. https://doi.org/10.1093/her/12.3.385

De Vries, S. I.; Bakker, I.; Van Mechelen, W. & Hopman-Rock, M. Determinants of activity-friendly neighborhoods for children: results from the SPACE study. American journal of health promotion, 21(4 supplement):312-6, 2007. https://doi.org/10.4278/0890-1171-21.4s.312

Dollman, J.; Norton, K. & Tucker, G. Anthropometry, fitness and physical activity of urban and rural South Australian children. Pediatric Exercise Science, 14(3):297-312, 2002. https://doi.org/10.1123/pes.14.3.297

Eiben, O. G.; Barabás, A. & Németh, Á. Comparison of growth, maturation, and physical fitness of Hungarian urban and rural boys and girls. J. Hum. Ecol, 17(2):93-100, 2005. https://doi.org/10.1080/09709274.2005.11905762

Gutin, B.; Yin, Z.; Humphries, M. C. & Barbeau, P. Relations of moderate and vigorous physical activity to fitness and fatness in adolescents. The American journal of clinical nutrition, 81(4):746-50, 2005. https://doi.org/10.1093/ajcn/81.4.746

Heyward, V. H. Advanced fitness assessment and exercise prescription, 5th edition. Champaign: Human Kinetics Publishers, 2006.

Hian, T. C.; Mahmud, Z. F. & Choong, T. Y. Physical fitness level between urban and rural students-case study. Procedia-Social and Behavioral Sciences, 90:847-52, 2013. https://doi.org/10.1016/j.sbspro.2013.07.160

Hussey, J.; Bell, C.; Bennett, K.; O'dwyer, J. & Gormley, J. Relationship between the intensity of physical activity, inactivity, cardiorespiratory fitness and body composition in 7–10-year-old Dublin children. British journal of sports medicine, 41(5):311-6, 2007. https://doi.org/10.1136/bjsm.2006.032045

ISAK, editor. International standards for anthropometric assessment. Sydney: ISAK, 2001.

Kriemler, S.; Manser-Wenger, S.; Zahner, L.; Braun-Fahrländer, C.; Schindler, C. & Puder, J. J. Reduced cardiorespiratory fitness, low physical activity and an urban environment are independently associated with increased cardiovascular risk in children. Diabetologia, 51(8):1408-15, 2008. https://doi.org/10.1007/s00125-008-1067-z

Loucaides, C. A.; Chedzoy, S. M. & Bennett, N. Differences in physical activity levels between urban and rural school children in Cyprus. Health education research, 19(2):138-47, 2004. https://doi.org/10.1093/her/cyg014

McMurray, R. G.; Harrell, J. S.; Bangdiwala, S. I. & Deng, S. Cardiovascular disease risk factors and obesity of rural and urban elementary school children. The Journal of Rural Health, 15(4):365-74, 1999. https://doi.org/10.1111/j.1748-0361.1999.tb00760.x

Moreno, L. A.; Joyanes, M.; Mesana, M. I.; González-Gross, M.; Gil, C. M.; Sarría, A. et al. Harmonization of anthropometric measurements for a multicenter nutrition survey in Spanish adolescents. Nutrition, 19:481-6, 2003. https://doi.org/10.1016/S0899-9007(03)00040-6

Olds, T.; Tomkinson, G.; Léger, L. & Cazorla, G. Worldwide variation in the performance of children and adolescents: an analysis of 109 studies of the 20-m shuttle run test in 37 countries. Journal of sports sciences, 24(10):1025-38, 2006. https://doi.org/10.1080/02640410500432193

Ortega, F. B.; Ruiz, J. R.; Castillo, M. J. & Sjöström, M. Physical fitness in childhood and adolescence: a powerful marker of health. International journal of obesity, 32(1):1-11, 2008. https://doi.org/10.1038/sj.ijo.0803774

Özdirenç, M.; Özcan, A.; Akin, F. & Gelecek, N. Physical fitness in rural children compared with urban children in Turkey. Pediatrics International, 47(1):26-31, 2005. https://doi.org/10.1111/j.1442-200x.2004.02008.x

Peña Reyes, M. E.; Tan, S. K. & Malina, R. M. (). Urban–rural contrasts in the physical fitness of school children in Oaxaca, Mexico. American Journal of Human Biology, 15(6):800-13, 2003. https://doi.org/10.1002/ajhb.10218

Photiou, A.; Anning, J. H.; Mészáros, J.; Vajda, I.; Mészáros, Z.; Sziva, A.; ... & Ng, N. Lifestyle, body composition, and physical fitness changes in Hungarian school boys (1975–2005). Research quarterly for exercise and sport, 79(2):166-73, 2008. https://doi.org/10.1080/02701367.2008.10599480

Roemmich, J. N.; Epstein, L. H.; Raja, S.; Yin, L.; Robinson, J. & Winiewicz, D. Association of access to parks and recreational facilities with the physical activity of young children. Preventive medicine, 43(6):437-41, 2006. https://doi.org/10.1016/j.ypmed.2006.07.007

Ruiz, J. R.; Castro-Piñero, J.; Artero, E. G.; Ortega, F. B.; Sjöström, M.; Suni, J. & Castillo, M. J. Predictive validity of health-related fitness in youth: a systematic review. British journal of sports medicine, (12):909-23, 2009. https://doi.org/10.1136/bjsm.2008.056499

Ruiz, J. R.; Rizzo, N. S.; Hurtig-Wennlöf, A.; Ortega, F. B.; Wärnberg, J. & Sjöström, M. Relations of total physical activity and intensity to fitness and fatness in children: the European Youth Heart Study. The American journal of clinical nutrition, 84(2):299-303, 2006. https://doi.org/10.1093/ajcn/84.2.299

Sallis, J. F.; McKenzie, T. L.; Alcaraz, J. E.; Kolody, B.; Faucette, N. & Hovell, M. F. The effects of a 2-year physical education program (SPARK) on physical activity and fitness in elementary school students. Sports, Play and Active Recreation for Kids. American journal of public health, 87(8):1328-34, 1997. https://doi.org/10.2105/AJPH.87.8.1328

Tinazci, C. & Emiroglu, O. Physical fitness of rural children compared with urban children in North Cyprus: a normative study. Journal of physical activity and health, 6(1):88-92, 2009. https://doi.org/10.1123/jpah.6.1.88

Tsimeas, P. D.; Tsiokanos, A. L.; Koutedakis, Y.; Tsigilis, N. & Kellis, S. Does living in urban or rural settings affect aspects of physical fitness in children? An allometric approach. British journal of sports medicine, 39(9):671-4, 2005. https://doi.org/10.1136/bjsm.2004.017384