

MUSCLE STRENGTH TEST PERFORMANCE CHANGES OVER TIME IN SERBIAN CHILDREN

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The aim of this study was to identify the changes in motor performance test over an interval of four decades in eleven-year-old children in Serbia. The secular trend of body height and weight showed constant increase over time, but positive influence on the motor performance was lacking. Most studies found some decline in various motor skills over different time periods. However, none of them investigated the standing long jump results over the period of four decades. Data were collected from three separate cross-sectional samples examined in 1971, 2014 and 2018. Measurements were conducted by a team of qualified testers, coordinated by the Faculty of Physical Culture from Belgrade in 1971, Serbian Institute of Sport and Sport Medicine in 2014, and authors of this study in 2018. Motor performance test that was evaluated including the standing long jump. Despite the average increase in longitudinal skeleton dimensions, an average distance of the long jump showed a significant decrease. Decreased values after four decades ranged between 10 % and 18 % depending on the sample. The results of this study raise serious concerns about the contemporary way of life of children and trends in their motor skills. Without changes in lifestyle and healthy nutritional habits, and most importantly, greater participation in organized physical activities that target at deficits in muscular fitness and motor skill performance early in childhood, these contemporary trends of motor test performance will most likely continue to decrease in the future.

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Key words: muscle changes, motor skills, leg strength, children

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Introduction

Insufficient level of physical activity has been identified to be one of the leading risk factor for global mortality worldwide (1). The rising levels of childhood obesity are likely to have major public health consequences since being overweight during childhood will most likely continue into adulthood. Low scoring in physical fitness tests are important risk

factor for many diseases like diabetes, cancer, high blood pressure, osteoporosis, lipid disorders, depression, anxiety etc (1).

Positive secular trends in height and weight have occurred in all socioeconomic groups in the first half of the twentieth century (2). The changes recorded from the 1960's through the 2000's are variable among countries (2). Secular changes were remarkably similar for boys and girls, and there is no doubt that children are becoming fatter (1, 3), so it's questionable if we could call this trend the "positive" one. With this trend, it would be surprising if performance on jumping tests were not declining (4). The trend of a decrease in acceleration has also been confirmed in some other studies on secular height trend conducted in Serbia (5, 6).

Unfavorable trends in children's weight status have been documented in many countries. Overweight prevalence remained high in most developed countries in the world (7). An increase was observed for both boys and girls (3, 7). However, in recent years, a stabilization in overweight prevalence has been suggested by researches from several different countries (8, 9). Some researchers suggest that this plateau in overweight prevalence may mask an increase in certain vulnerable groups of children (10).

In the period from 2002 to 2010, overweight prevalence increased predominantly in Eastern Europe compared to the rest of the Europe and US (3). Recent data showed that in 2016, approximately 50 million girls and approximately 74 million boys worldwide, were obese. That estimated pooled population-based data regarding trends from 1975 to 2016 in mean BMI in Eastern Europe showed an increase of 1.00 kg/m² per decade; for boys, there was a non-significant increase of 0.09 kg/m² per decade (3).

An important health marker in youth is muscle strength. For adequate and balanced children development, some form of resistance training is highly recommended as a part of regular daily activities (11). In addition to increased muscular strength, regular engagement in resistance exercises has the potential to influence several other aspects of health. It may result in improvement of body composition, increased bone mineral density, increased cardio-respiratory fitness, enhanced mental health and well-being and a more positive attitude towards lifetime physical activity (11).

Several studies and epidemiological research (12, 13) reported a decline in physical fitness in children and adolescents over time, suggesting that the present-day children and adolescents are not as active as their peers few decades ago. Evidence-based research (14, 15) showed a constant decrease over the past decades in children's participation in physical activity and organized community sport. An evident decreasing trend in youth muscular capabilities are observed in English, Spanish, Lithuania and Serbian primary school children and adolescents (13, 16-18).

However, studies on different muscle performance capabilities have shown divergent trends: for example, despite the decline in upper body strength, the leg muscle power increased (16), which could partially be explained by the constant bearing of larger body weight. Similarly increased body weight could lead to increased handgrip strength but it is not necessarily accompanied by the increase in lower body strength (19). Changes in fitness may depend on the population studied and tests applied, so it is necessary to use the same standardized procedures in the same population (20).

Moreover, muscular fitness in adolescents has been shown to be associated with cardiovascular problems and cardiovascular mortality later in life, independent of the aerobic capacity (21). The aerobic performance of children has declined over the last few decades in most of the countries. Sedentary lifestyle contributed to easy availability of energy-rich but low-micronutrient-content foods and declines in community-based physical activity have been implicated (22).

The aim

The present study was aimed at investigating how secular changes in body height and weight in Serbian children aged 11 have been changing since 1971, and how this changes influence the motor test

performance that requires muscle strength, being also depended on anthropometric characteristics such as body height and weight.

Materials and methods

Data Sources

An extensive review of the domestic literature was undertaken to locate studies that have published data on motor test performance or reported motor test performance of normal children and adolescents aged 11. Briefly, studies were selected via the online search of bibliographic databases and the University library catalogue and through a manual search of all hard copy monographs and PhD thesis at the University of Niš.

Inclusion/exclusion criteria

Data were collected from three separate cross-sectional samples examined in 1971 and 2014. Measurements were conducted by a team of qualified testers, coordinated by Faculty of Physical Culture from Belgrade in 1971 (23) and Serbian Institute of Sport and Sport Medicine in 2014 (24).

Data were collected in 2018 from elementary school children in Jagodina. The testing was conducted in the Faculty of Education exercise hall. Height was measured by a stadiometer. The subjects did not wear shoes, and height was converted to the nearest centimeter. Weight was measured using a digital scale (Tefal, France, accuracy of 0.1 kg). Body mass index was calculated by dividing weight (kilograms) by height (centimeters) squared and then multiplying the result by 10,000, in accordance with international standards.

The standing long jump test, also known as the standing broad jump, is the test used for the assessment of explosive muscle strength of lower extremities. It was a part of test batteries in both assessments. The participant stood behind the starting line and was instructed to push off explosively and jump as far as possible. The children had to land with the feet together and stay upright. The test was repeated twice, and the best score was retained to the nearest 0.1 cm.

Statistical analysis

All descriptive data were extracted into Excel (Microsoft Office) using a standardized data extraction table. The following descriptive data were extracted by one author and checked by another for accuracy: year of testing, sex, and age, because only data on children aged 11 years were included in further analysis.

The data are presented as mean \pm SD unless otherwise stated. Mean differences of the secular trends in leg strength between measurement points were analyzed. We calculated the effect size statistics as Cohen's *d* (standardized mean differences) and 95% confidence interval. The values of Cohen's

$d \sim 0.2$, ~ 0.5 and ~ 0.8 are considered as small, medium and large effect sizes, respectively.

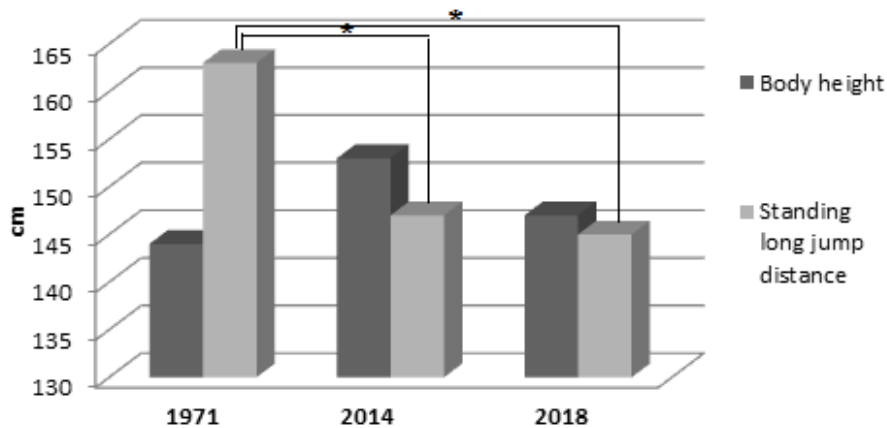
Results

The investigation included results from three different periods – the years 1971, 2014 and 2018. Mean (M) and standard deviation (SD) are presented in Table 1. The average value of standing long

jump height in 1971 was 163.2 cm for boys and 156.2 for girls in the sample of 848 eleven- year-old children, 431 boys and 417 girls. These values have been decreased in a recent measurement. In 2014, an average standing long jump for boys and girls was 147.5 cm and 134.9 cm, respectively. In 2018, an average standing long jump was 145.3 cm and 128.2 cm, respectively.

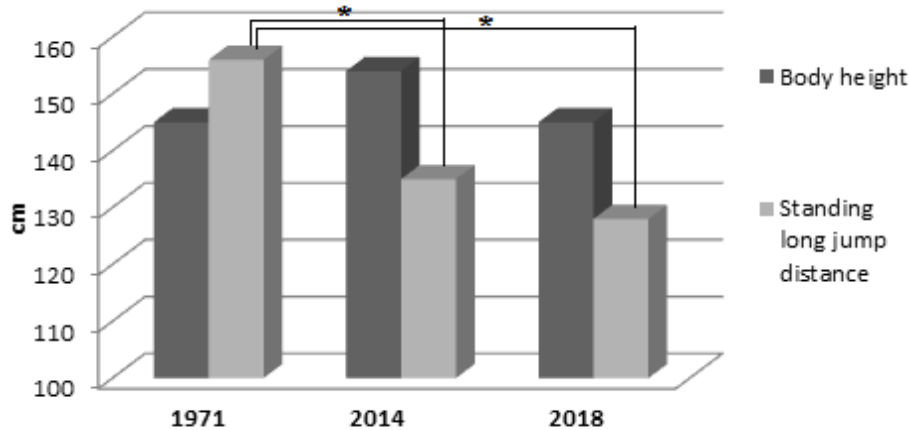
Table 1. Means and standard deviations from three different data point

Year of intervention	1971		2014		2018	
	Boys	Girls	Boys	Girls	Boys	Girls
Sample number (n)	431	417	50	57	48	44
Body height (cm)	144.02 (6.83)	144.99 (7.42)	153.07 (7.11)	154.04 (7.65)	147.44 (7.33)	145.36 (7.45)
Body weight (kg)	36.07 (6.80)	36.89 (7.15)	45.87 (11.84)	45.60 (10.29)	40.5 (9.20)	41.5 (8.80)
Standing long jump (cm)	163.21 (15.32)	156.21 (16.34)	147.52 (22.53)	134.93 (21.92)	145.3 (18.87)	128.2 (16.54)



* - Significant difference between measurements Cohen D, large differences

Graph 1. Body height and long distance jump in eleven years old boys



* - Significant difference between measurements Cohen D, large differences

Graph 2. Body height and long distance jump in eleven years old girls

The results showed significant differences in the standing long jump distance between the two periods (1971 and 2014). Cohen effect size are considered large as values for 11-year-old boys were $d = 0.84$ and for girls Cohen's $d = 1.09$. Mean difference between 1971 and 2018 also showed large Cohen's $d = 1.05$ and 1.75 , for boys and girls, respectively. Cohen effect size between two samples from 2014 and 2018 was considered small, 0.1 and 0.3 , for boys and girls, respectively.

Similar results in body height and weight between 1971 and 2014 showed significant effect size of $d = 1.28$; $d = 1.19$ for body height, and $d = 1.02$; $d = 1.04$ for body weight, for boys and girls, respectively. Most medium differences on basic anthropometric data were found between 1971 and 2018 for body height $d = 0.43$; $d = 0.14$ and for body weight $d = 0.5$; $d = 0.62$ for boys and girls, respectively. Between 2014 and 2018 there were large differences in mean difference between samples, $d = 0.85$; $d = 1.28$ on body height and medium differences $d = 0.37$; $d = 0.39$ on body weight, for boys and girls, respectively.

Discussion

In this study, we examined the secular trend of lower body muscle strength test performance in the last four decades. This is the first study to have quantified muscle strength performance changes in eleven-year-old children in Serbia in the longer period. Using data from previous studies from 1971 and those from 2009 and 2014, and comparing them with this study data, it can be observed that the standing long jump performances have declined remarkably over the past four decades (Graph 1 and 2).

The results of Cohen effects size showed large effects in all measurements between 1971 and two more intervention periods (2014 and 2018). Children in 1971 had lower height and body mass than their peers several decades after (Table 1). The largest difference was noted between measurements conducted in 1971 in children measured in different schools across the Republic of Serbia (23) and children measured only in Belgrade in 2014 (24). Difference in body height of eleven-year-old boys were increased in favor of recent measurements by 10 cm. A sample from 2018 from central Serbia showed 3 cm increases compared to the measurement conducted in 1971. Body weight showed similar increases of 10 kg and 4.5 kg, respectively. The previous study (6) that considered changes over the period 1971–2001 in 11-year-old children from the city of Novi Sad showed also a growing tendency of body weight. However, body weight increases during three decades were 4.3 kg in eleven-year-old girls, while in boys, weight increased by 3.4 kg over the period 1971–1991 and this trend failed to continue until 2001, most probably due to the economic situation in the country (6) or a small sample used in investigation. On the other hand, the previously mentioned investigation (6) found relatively small positive changes (less than 2 cm) in secular trends of body height during that period. Additionally, over the last decade, the secular trend of height has slowed down both in the world and Serbia (5).

An increase in height leads to proportional increase of longitudinal dimensions such as upper leg height which should logically positively affect the standing long jump performance. However, despite the average increase in longitudinal skeleton dimensions, an average distance of the long jump showed significant decrease over the same period. Results in the standing long jump (Table 1.) showed a decrease after four decades between 16 to 28 cm depen-

ding on sample and sex. Presented in percentages, there is a decrease in the standing long jump distances of 10 % to 18 % depending on the sample, which raises serious concerns about children's way of life today and the observed trends in their motor skills.

In the last decade, positive trends in body weight were identified for children and adolescents living in different parts of the world (2). On the other hand, most studies (13, 16-18) found some decline in various motor skills over different time periods. However, none of them compared the standing long jump results over the period of four decades.

A study (16) compared the standing long jump results in Spanish youths aged 12 - 17 years. They found a decrease of 12 cm after five years (2001/02-2006/07). Cohen ES was 0.5. A similar study on Estonians and Lithuanians children (18) found no significant change for Estonians in the standing long jump over the period of 10 years (1992-2002), while this decline was observed in Lithuanians.

Finally, there are limitations to this investigation as well. Muscular fitness was measured by only one field tests. Compared with testing in the laboratory, this test may result in errors due to the level of test performance and previous experience. Additionally, small sample size in recent sample groups (2014 and 2018) may contribute to research bias. A larger research sample and more motor performance test with same protocol are required to obtain more credible data regarding this important topic.

Conclusion

The results of our investigation have demonstrated that motor test performance in children aged 11 have been decreased substantially over the last four decades. Without changes in P.E. curriculum, healthy nutritional habits, and most importantly, greater participation in organized physical activities that target at deficits in muscular fitness and motor skill performance early in childhood, these contemporary trends of motor test performance will most likely continue to decrease in the future.

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doi:10.5633/amm.2019.0223**PROMENE U TESTU ZA PROCENU MIŠIĆNE SNAGE KOD DECE U SRBIJI**

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Cilj ove studije bio je ispitivanje promena u uspešnosti izvođenja motoričkog testa kod jedanaestogodišnjaka u Srbiji. Za praćenje u intervalu od četiri decenije izabran je motorički test za koji je potrebno ispoljavanje mišićne snage nogu. Sekularni trend telesne visine i težine pokazao je konstantno povećanje u odnosu na prošlost, ali je pozitivan uticaj na uspešnost u izvođenju motoričkog zadatka izostao. Većina prethodnih istraživanja utvrdila je određeni pad raznih motoričkih veština tokom različitih vremenskih perioda. Međutim, nijedno od njih nije se bavilo uspešnošću u skoku udalj u periodu dužem od četiri decenije. Podaci su prikupljeni sa tri odvojena uzorka ispitanika iz 1971, 2014. i 2018. godine. Merenja su sprovedena od strane kvalifikovanih merioca sa Fakulteta fizičke kulture iz Beograda 1971. godine, Instituta za sport i sportsku medicinu Srbije 2014. godine i autora ove studije 2018. godine. Testom skok udalj iz mesta ispitivanja je motorička sposobnost. Uprkos prosečnom povećanju longitudinalne dimenzionalnosti skeleta, prosečna dužina skoka udalj imala je trend opadanja. Smanjenje posle četiri decenije bilo je između 10 % i 18 % u zavisnosti od uzorka i pola. Rezultati ove studije izazivaju ozbiljnu zabrinutost o načinu života dece i trendovima u motoričkim sposobnostima. Bez promena u načinu života, stvaranja zdravih navika u ishrani, i što je najvažnije, većeg učešća u organizovanim fizičkim aktivnostima, pomenuti trendovi opadanja nivoa motoričkih sposobnosti najverovatnije će se nastaviti i u budućnosti.

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Ključne reči: mišićne promene, motoričke sposobnosti, snaga nogu, deca