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Original Article

The effect of physical activity on biological age and body composition in 18–19-year-old girls

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Abstract:
Nowadays, the state of hypokinesia and hypodynamia of the population is increasing, especially in young people, who begin showing negative changes in such markers of human activity as biological age and body aging rate and body component composition. The study of the relationship between these indicators of human status and physical activity continues to be relevant. *Research aim is* to determine the mutual influence of physical activity over the biological age and component composition of the body of girls aged 18-19. *Research materials and methods***.** 514 female students of the Technical University aged 18-19 (Irkutsk, Russia) were examined during our research. According to the method of Gorelkin and Pinkhassov (2010), the girls' biological age and the rate of aging were determined. The component composition of the girls' body was determines according to the method of J. Matiegka (1921). The research was conducted using the International physical activity questionnaire, IPAQ-SF (Craid Cora L et. al., 2003) to study the volume of the girls' weekly physical activity. *Research results*. 74.4% of girls with high physical activity (>150 minutes per week) have a delayed type of aging rate. They have the highest (41.7%) muscle mass content and the lowest (12.3%) body fat content, biological age is 1.7 years less than chronological (calendar) one. 67.3% of girls with low weekly physical activity (<150 minutes) have an accelerated type of aging, an increase in the average biological age by 6.2 years, compared with their chronological age, the amount of fat in the body component composition is 2.3 times more, the body muscle mass is 32.8% less than in girls with high physical activity. *Conclusions.* The research results confirm the correlation and the influence of physical activity volume over the girls' aged 18-19 biological age, the type of the body aging rate and th e body component composition.
Key Words*:* **physical activity, biological age, chronological age, component composition of the body**

Introduction

In the physical education of young people, an important role is given to the physical activity individualization principle, as one of the important methodological principles of the educational process organization (Ashanin et al., 2018; Gumenyuk et al., 2021; Belousko, 2022). It provides for the need to assess the age, gender, health status, level of physical and functional fitness, and the state of biological maturity of a young organism. In recent years, an assessment of an individual's biological age has been used to increase the effectiveness of sports and wellness technologies aimed at improving physical and somatic health (Sitovsky et al., 2019; Prysiazhniuk et al., 2021; Sereda, 2021).

A person's biological age is considered by researchers as a marker of general health state (Kang et al., 2018), an indicator of tolerance to physical and mental stress (Gallo et al., 2020), the state of the body component composition (Sindeeva et al., 2015), the rate and degree of the body aging, the influence of environmental the state in the territory of residence, etc. This is due to the fact that biological age and adaptive processes can vary greatly in different periods of the organism's development. Under ideal conditions, the passport age should coincide with the biological age (Prysiazhniuk et al., 2018). If the biological age exceeds the

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chronological (calendar) one, it can be assumed that this person has signs of premature aging of the body. If the biological age lags behind the passport age, this indicates a longer life expectancy.

It is known that one of the factors affecting human health, physical development and thus his\her biological age is physical activity (Chekhovska et al., 2020; Bakiko et al., 2020). Recently, pronounced physical inactivity has been observed among students of various countries (Zhang et.al., 2019; Setiakarnawijaya et al., 2021), which led to a lag in physical development and deterioration of physical health. The COVID-19 pandemic has led to an even greater deterioration of the situation with students' physical inactivity due to the difficulties of regular exercise classes and lack of physical loads (Huckins, 2021; Kolokoltsev et al., 2021). The authors, using a comparative analysis, established a lower physical activity of students during the pandemic, compared with previous years of study. According to S. Romero-Blanco et al. (2020), the physical activity and sedentary lifestyle of students was significantly higher during the quarantine for coronavirus than before the outbreak of infection. In recent years, an increase in the rate of student youth's aging has been registered in some European countries (Prysiazhniuk et al., 2021), in Asian countries (Dao Chanh Thuc, 2018) and the American continent (Belsky et al., 2015; Bacil et al., 2015). It can be said that the current epidemiological and socio-economic situation in the world contributes to a further decrease in motor activity among young people and an increase in their biological age, which is reflected in the level of health.

Brazilian researchers (Basil et al., 2015) showed that with an increase in biological and chronological age among children and adolescents, their motor activity decreases, and data from Belsky et al. (2015) indicate that rapidly aging people had low indicators of physical fitness. According to the authors, they had a decrease in cognitive functions and poor health. However, regular physical activity increases a person's level of physical and somatic health against the background of a decrease in the value of the indicator of his\her biological age (Pavanello et al., 2019). For a young organism, it is important to establish the fact of the relationship between the rate of aging and biological age, which can be predictors of a person's life quality. Researchers claim that the determination of biological age makes it possible to influence the effectiveness of athletes' training and the results of youth football matches (Ajman, Tomac, 2019; Goto et al., 2019) to identify and develop talented sports youth (Lesinski et al., 2020). Despite the available literature data on the relationship between biological age and human physical activity, most research works have been conducted on middle-aged and elderly people. The authors failed to fully disclose the specifics and features of this relationship in girls with different levels of weekly physical activity. This fact led us to conduct a research project on establishing the relationship between the biological age of adolescent girls and the WHO recommended amount of weekly physical activity. We believe that the data obtained can be used to assess the biological age of girls as an informative indicator of their physical health.

Research aim is to determine the mutual influence of physical activity over the biological age and component composition of the body of girls aged 18-19.

Material & methods

The work in the research project was carried out in the 2021-22 academic year at the Technical University (Irkutsk, Russia). 514 female students aged 18-19 (18.5±0.3) with a good state of health for physical education. Before starting the study, all students gave their written consent to participate in the project. These actions do not violate the principles of biomedical research, according to the Helsinki Declaration of 2008.

The determination of the biological age (BA) of the girls was carried out according to the method of mass screening examinations according to the formula: BA= ARC × (CA -18) +18. To find the coefficient of aging rate (ARC), which determines the relationship between body markers and the girls' age, the formula was used (Gorelkin, Pinkhasov, 2010):

$$ARC = \frac{WC \times BM}{HC \times BL^2 \times (14{,}7 + 0{,}26 \times RL + 0{,}001 \times RL^2)}$$

ARC - aging rate coefficient, CA - calendar age, RL - difference between calendar age and ontogenetic norm age in years (for girls RL=CA-18), WC - waist circumference (cm), BM - body weight (kg), HC - hip circumference (cm), BL - body length (m). The girls' anthropometry was carried out using generally accepted measurement methods (International Standards for Anthropometric Assessment, 2001).

According to the value of the aging rate coefficient (ARC), all girls are divided into 3 groups (Table 1).

Table 1. Design characteristics of the girls' biological age (A.Gorelkin and B.Pinkhasov, 2010).

Group	Number of girls	Compliance with calendar age	ARC meaning	Type of aging speed
A	142	No	<0.95	Delayed
B	171	Yes	От 0.96 до 1.05	Normal
C	201	No	> 1.05	Accelerated

To study the effect of weekly physical activity on the girls' biological age, a questionnaire was conducted using the International physical activity questionnaire, IPAQ-SF (Craid Cora L et. al., 2003). The number of minutes of daily physical activity during the last week was determined. In the adult population, it should be at least 150 minutes per week (WHO Global recommendations on physical activity for health, 2010).

To determine the relationship of biological age with the component composition of the body, the method of J. Matiegka (1921) was used. The average value of the absolute and percentage content of fat, muscle and bone tissue in the body of the examined girls was calculated. For parametric processing and calculation of the received project data, a package of application programs «Statistica 6.1» and «Microsoft Excel» was used.

Results

The girls' with different aging rates and with different weekly physical activity indicators of the biological age values are shown in Table 2.

Table 2. Biological age of girls with different weekly physical activity and aging rate (M±m).

Group / aging rate	Physical activity, min\week			
	Low (< 150)		High (> 150)	
	Biological age, years			
A (delayed)	n=70	17.6±0.2	n=72	16.8±0.2*
B (normal)	n=82	21.8±0.6#	n=89	18.4±0.5*#
C (accelerated)	n=102	34.7±2.2#	n=99	19.8±1.9*#
Average biological age	24.7±1.4		18.3±1.1*	

Note. #significance of the difference in indicators of biological age with the girls' aging rate ($p<0.05$);
* significance of the difference between the indicators of biological age with different weekly physical activity of girls ($p<0.05$)

Analysis of the results from Table 2 showed that in group «A» the biological age of girls with physical activity < 150 minutes per week was significantly less by 23.8% compared to group «B» and 97.7% less compared to group «C», $p<0.05$. In girls of group «A» with weekly physical activity > 150 minutes per week, the biological age is significantly lower by 9.5% compared to the biological age of girls of group «B» and 17.8% less than in girls of group «C», $p<0.05$.

In girls of group «B» with high physical activity, the biological age corresponds to the calendar one. In girls of the same group «B» with a low volume of weekly physical activity, the biological age exceeded the calendar one by 3.3 years (17.8%). We assume that these girls had low physical activity throughout their lives, despite the fact that their ARC is in the normal range.

In girls of group «C» with high physical activity, the biological age is 1.3 years older than the calendar one and almost corresponds to it. In girls of group «C» with low weekly physical activity (<150 minutes), the biological age was 16.2 (87.5%) years older than their calendar one and almost 2 times more than in girls of the same group «C» with physical activity > 150 minutes.

Girls in group «B» with low physical activity (< 150 minutes per week) have a significantly lower biological age by 59.2% than girls in group «C», $p<0.05$. In girls of group «B» with high weekly physical activity (> 150 minutes), the biological age is significantly less by 7.6% than in girls in group «C», $p<0.05$ (Table 2).

In girls of all groups with low physical activity (< 150 minutes per week), the average biological age was 6.2 (33.5%) years older than the calendar one. In girls of all groups with high physical activity (> 150 minutes per week), the average biological age was 0.2 (1.1%) years less than the calendar one. The number of girls with different weekly physical activity and different aging rate coefficient (ARC) is shown in Figure 1.

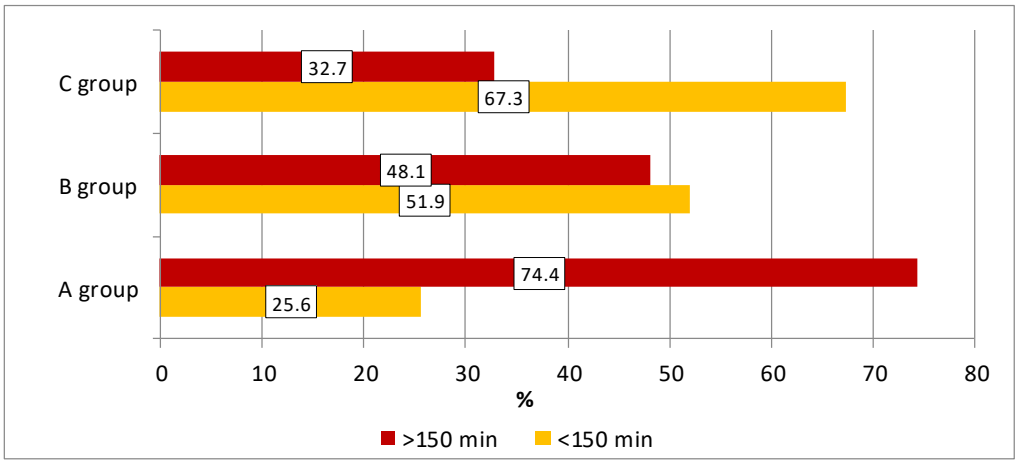

Fig. 1. Number of girls with different ARC values and weekly physical activity

The largest number of girls (74.4%) with a delayed type of aging rate and high weekly physical activity (>150 minutes) were registered in group A. The smallest number of such girls (32.7%) was registered in group «C». Girls with low weekly physical activity (<150 minutes) and accelerated type of aging were most registered in group «C» (67.3%). The number of girls with different physical activity and normal type of aging rate in group «B» did not differ. Physical activity affects the metabolic processes, as a result of which the percentage of components in the human body composition may change. We conducted a study of the component composition of girls with different amounts of weekly physical activity (Table 3).

Table 3. The girls' body component composition (M±m).

Mass component, kg	Physical activity, min\week					
	Low (< 150)			High (> 150)		
	Group A	Group B	Group C	Group A	Group B	Group C
Fat	12.6±0.42	14.7±0.52#	28.8±0.65#	11.4±0.21*	13.3±0.24*#	17.6±0.57*#
Muscle	21.3±0.34	22.7±0.22#	20.2±0.27#	24.5±0.37*	24.4±0.43*	22.5±0.46*#
Bone	9.5±0.20	9.2±0.23	9.1±0.24	9.1±0.27	9.5±0.29	9.3±0.33

Note. # significance of the difference in the indicators of the biological age of girls with different body component composition (KSS) ($p < 0.05$);

* significance of the difference in the biological age of girls with different weekly physical activity ($p < 0.05$)

It was found that the content of fat and muscle mass in the component composition of the girls' body have significant differences depending on the values of ARC and the levels of weekly physical activity.

The highest body fat content was observed in girls in group «C» with low weekly physical activity (28.8±0.65 kg). The lowest indicator of the fat component content was found in girls of group «A» with the same amount of physical activity per week, $p<0.05$. Among girls with high weekly physical activity, the highest body fat mass index was recorded in group «C» (17.6±0.57 kg), the lowest value of this indicator was recorded in girls of group «A» (11.4±0.21 kg), $p<0.05$.

Our research results indicate that the high weekly physical activity of girls contributes to the normal amount of fat in their body. The results of the survey of girls with different aging rate coefficient (ARC) and physical activity level < 150 minutes per week indicate a significantly low content of muscle mass in their body, compared with the amount of muscle component in the body of girls with high weekly physical activity. The lowest amount of muscle mass (20.2±0.27 kg) was registered in girls of group «C» with accelerated type of aging and low weekly physical activity. The highest index of muscle mass (24.5 ± 0.37 kg) are girls of group «A» with a slow rate of aging and a high level of weekly physical activity, $p < 0.05$.

We have not found significant differences between the indicators of the content of the bone component in the body of all girls with different levels of weekly physical activity and different coefficient of aging rate, $p > 0.05$. The percentage of the main body components of girls with different weekly physical activity and the coefficient of aging rate (ARC) is shown in Figure 2.

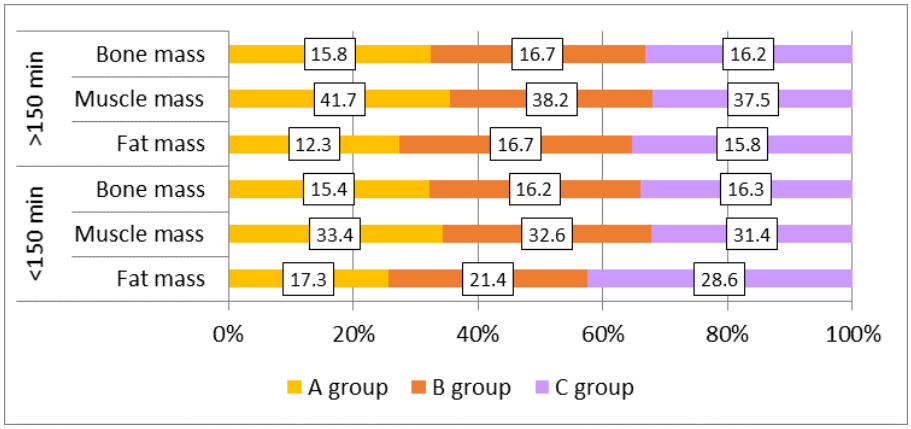

Fig.2. The component composition of the girls' with different weekly physical activity and type of aging body

As can be seen from Figure 2, the highest content of muscle mass (41.7%) and the minimum percentage of fat mass (12.3%) are girls of group «A» with high weekly physical activity (> 150 minutes) and with a slow type of aging rate of the body. An unfavorable health situation was found in girls of group «C» with an accelerated aging variant and a low level of weekly physical activity. In the body of girls of this group, the lowest content of muscle mass (31.4%) and the highest content of fat mass (28.6%) were found relative to the component composition of the body of girls from other groups with the same low level of weekly physical activity.

The results of the research project analysis indicate that high weekly physical activity causes an increase in muscle mass, a decrease in the content of the fat component of the body and the coefficient of aging of the girls' body.

Dicussion

Low physical activity of young people in various countries leads to deterioration of physical and somatic health and a decrease in the quality of life (Zhang et.al., 2019; Bakiko et al., 2020; Setiakarnawijaya et al., 2021). This situation calls for the search for effective means and methods to increase physical activity, reduce hypokinesia of the population, which is especially important in the conditions of the epidemic caused by the COVID-19 coronavirus and the transition to a remote format of work and training (Huckins, 2021; Kolokoltsev et al., 2021).

In recent years, various branches of sports science and practice have used different methods for determining biological age as an integral indicator of improving health and associated with the influence of various factors of the external and internal environment over the human body (Sindeeva et al., 2015; Kang et al., 2018). Studies of a person's biological age in the field of physical activity of various population groups are being conducted (Gallo et al., 2020; Prysiazhniuk et al., 2021). The scientific study of the problems of young people's physical activity related to biological age and the component composition of the body is incomplete. Therefore, the continuation of the study of this issue seems relevant.

Our research project is dedicated to studying the influence of different weekly physical activity levels over the biological age of girls aged 18-19. It was reliably established that 74.4% of the girls surveyed by us who had physical activity >150 minutes a week, the biological age was less than chronological (calendar) one. Accelerated type of aging was registered in 67.3% of girls with a low level of weekly physical activity. A similar relationship between different amounts of physical activity and biological age was experimentally studied by S. Prysiazhniuk et al., (2018) in the educational process of students' physical education. As a result of their work, the authors obtained data on the existence of such a relationship. The analysis of the project results obtained by us established a reliable statistical relationship between these markers of the girls' aged 18-19 life cycle, which does not contradict the data of other authors who studied biological age and physical activity (Dao Chanh Thuc, 2018; Pavanello et al., 2019).

It is known that regular physical activity can have a significant impact over the component composition of the human body. We found that girls with a low level of weekly physical activity and a high coefficient of the aging rate of the body have the highest content of fat mass in the body. Girls with a high level of weekly physical activity have a delayed type of aging of the body and a low body fat content. The highest content of muscle mass was found in girls with a delayed type of aging and a high level of weekly physical activity. Our data may indicate that the fulfillment by girls of the weekly physical activity volume recommended by WHO Global recommendations on physical activity for health (2010) ensures that they maintain the optimal quantitative level of fat and muscle tissue in the body and maintain a balance between biological and calendar age. The same conclusions were made in the research work of V. Sindeeva et al. (2015). Our research confirms the influence of physical activity on biological age, the rate of aging, the component composition of the body of girls and the presence of a close relationship between these markers.

Conclusions

As a result of our research project, the relationship between the volume of physical activity, biological age, the aging rate and the component composition of the body in girls aged 18-19 has been established.

In girls with high physical activity (>150 minutes per week) and a delayed type of aging rate, the biological age was 1.7 years less than the calendar one. Among girls with low weekly physical activity (<150 minutes), the biological age exceeds the calendar one by almost 2 times in girls with an accelerated type of aging of the body. In the examined girls with low physical activity (< 150 minutes per week), the average biological age was 6.2 years older than the calendar one. The average biological age of girls with high physical activity (> 150 minutes per week) was 0.2 years less than the calendar one.

The results of the component composition of the body analysis showed that among all the surveyed participants of the project, girls with high physical activity (> 150 minutes per week) and a slow type of aging rate have the highest content of muscle mass (41.7%) and the lowest content of body fat (12.3%). It was found that in girls with a low level of weekly physical activity (< 150 minutes), the amount of fat in the component composition of the body is 2.3 times more, the muscle mass of the body is 32.8% less than in girls with high physical activity.

We believe that the presence of a delayed or normal type of the aging rate of the body, the correspondence of the biological age to the chronological (calendar) one, compliance with a high regime of physical activity are the most comfortable combination for the development and vital activity of the examined girls' body. Accelerated type of aging, low physical activity, high fat content in the body increase the biological age of girls, reduce their quality of life and can be predictors of possible future somatic diseases.

The conducted research allows drawing a conclusion that biological age, the type of aging rate, the component composition of the body and the amount of physical activity have a mutual influence and are markers of the health status of a person of any age.

Conflicts of interest. The authors declare no conflict of interest.

References:

Ajman, H, & Tomac, Z. (2019). Differences in biological age of the best U11 and U13 teams in Croatia. *Journal of Human Sport and Exercise*, *14,* 2375-2379. https://doi.org/10.14198/jhse.2019.14.Proc5.52

Ashanin, V., Druz, V., Pyatisotskaya, S., Zhernovnikova, Y., Aleksieieva, I., Aleksenko, Y., Yefremenko, A., & Pilipko, O. (2018). Methods for determining the biological age of different children. *Journal of Physical Education and Sport, 18 (Supplement issue 4*), Art 270, pp. 1845 - 1849. https://doi.org/10.7752/jpes.2018.s4270

Bacil, E., Mazzardo, Júnior O., Rech, C., Legnani, R., & Campos, W. (2015). Physical activity and biological maturation: a systematic review. *Revista Paulista de Pediatria*, *33*, 114–21. (In Portuguese). https://doi.org/10.1016/j.rpped.2014.11.003

Bakiko, I., Savchuk, S., Dmitruk, V., Radchenko, O., & Nikolaev, S. (2020). Assessment of the physical health of students of middle and upper grades. *Journal of Physical Education and Sport,* Vol 20 (Supplement issue 1), Art 39, 286–290, https://doi.org/10.7752/jpes.2020.s1039

Belousko, D. (2022). Methods of studying the attractiveness of motor activity for students. *Health, Physical Culture and Sports*, *25*(1), 24-31. Retrieved from http://journal.asu.ru/zosh/article/view/11144

Belsky, D.W., Caspi, A., Houts, R., Cohen, H.J., Corcoran, D.L., Danese, A., Harrington , H., Israel,S., Levine,M.E., Schaefer, J.D., Sugden, K., Williams, B., Yashin,A.I., Poulton,R., & Moffitt, T. E. (2015). Quantification of biological aging in young adults. *Proc Natl Acad Sci USA*, 112:E4104–10. https://doi.org/10.1073/pnas.1506264112

Chekhovska, M., Shevtsiv, L., Zhdanova, O., & Chekhovska, L. (2020). Fitness in school physical education lessons. *Journal of Physical Education and Sport,* Vol 20 (Supplement issue 1), Art 60 pp 420 – 424, DOI:10.7752/jpes.2020.s1060

Craid, Cora L., Marshall, Alison L., Sjostrom, M., Bauman, Adrian E., Booth, Michael L., Ainsworth, Barbara E., Pratt, M., Ekelund, U., Yngve, A. Sallis, James F., & Oja, P. (2003). International Physical Activity Questionnaire: 12-Country Reliability and Validity. *Medicine Science in Sports Exercise, 35 (8),* 1381-1395. https://doi.org/10.1249/01.MSS.0000078924.61453.FB.

Dao Chanh Thuc. (2018). The influence of physical activities on biological age parameters of females from 17 to 18 years old. *Journal of Sports Medicine and Therapy*, 3, 075- 079.

Gallo, L.A., Gallo, T.F., Young, S.L., Moritz, K.M., & Akison, L.K. (2020). The Impact of Isolation Measures Due to COVID-19 on Energy Intake and Physical Activity Levels in Australian University Students. *Nutrients,* 12(6),1865. https://doi.org/10.3390/nu12061865

Gorelkin A. G., & Pinkhasov B. B. (2010). A method for determining the biological age of a person and the rate of aging. *Bulletin,* 12, Published on April 27. Patent No. 238774 Russian Federation. 2008130456/1 (in Russian)

Goto, H., Morris, J.G., & Nevill, M.E. (2019). Influence of biological maturity on the match performance of 8-to 16-year-old, elite, male, youth soccer players. *Journal of Strength and Conditioning Research, 33(11*), 3078-3084. https://doi.org/10.1519/jsc.0000000000002510

Gumenyuk, S., Sereda, I., Hulka, O., Lavrin, H., Ladyka, P., & Kuz, Y. (2021). Effect of yoga on biological age indicators of 14-15-year-old girls. *Journal of Physical Education and Sport*, Vol 21 (Suppl. issue 5), Art 392, pp 2956-2962. https://doi.org/10.7752/jpes.2021.s5392

Huckins, J.F., daSilva, A.W., Wang, W., Hedlund, E., Rogers, C., Nepal, S.K., Wu, J., Obuchi, M., Murphy, E.I., Meyer, M.L., Wagner, D.D., Holtzheimer, P.E., & Campbell, A.T. (2020). Mental Health and Behavior of College Students During the Early Phases of the COVID-19 Pandemic: Longitudinal Smartphone and Ecological Momentary Assessment Study. *J Med Internet Res*, 22e20185. https://doi.org/10.2196/20185

International Standards for Anthropometric Assessment. (2001). http://www.ceap.br/material/MAT17032011184632.pdf

Kang, Y.G., Suh, E., Lee, J.W., Kim, D.W., Cho, K.H., & Bae, C.Y. (2018). Biological age as a health index for mortality and major age-related disease incidence in Koreans: National Health Insurance Service - Health screening 11-year follow-up study. *Clin Interv Aging*, 13, 429-436. https://doi.org/10.2147/CIA.S157014

Kolokoltsev, M., Kuznetsova, L., Romanova, E., Shirshova, E., Volkov, A., Solodovnik, A., & Gnilitskaya, E. (2021). Physical activity of people who recovered from COVID-19. *Journal of Physical Education and Sport*, Vol 21 (Suppl. issue 6), Art 433, pp. 3265 – 3272. https://doi.org/10.7752/jpes.2021.s6433

Lesinski, M., Schmelcher, A., Herz, M., Puta, C., Gabriel, H., Arampatzis, A., Laube, G., Büsch, D., & Granacher, U. (2020). Maturation-, age-, and sex-specific anthropometric and physical fitness percentiles of German elite young athletes. *Plos One*, *15(8).* https://doi.org/10.1371/journal.pone.0237423

Matiegka, J. (1921). The testing of physical efficiency. *Am. J. Phys. Anthropol.,* 4, 3, 223–230.

Pavanello, Campisi, Tona, Lin, Iliceto (2019). Exploring epigenetic age in response to intensive relaxing training: a pilot study to slow down biological age. *International Journal of Environmental Research and Public Health, 16*, 3074. https://doi.org/10.3390/ijerph16173074

Prysiazhniuk, S., Pryimakov, O., Iermakov, S., Oleniev, D., Eider, J., & Mazurok, N. (2021). Influence of weekly physical exercises on indicators of biological age of student's youth. *Physical education of students*, *25(1),* 58-6. https://doi.org/10.15561/20755279.2021.0108

Prysiazhniuk, S., Tolubko, V., Oleniev, D., Parczevskyy, Y., Prontenko, K., Griban, G., & Zhyrnov, O. (2018). The influence of physical activities on biological age parameters of the first-year female students from the special medical department. *Journal of Physical Education and Sport*, *18(2),* Art 81, pp. 561-564. https://doi.org/10.7752/jpes.2018.02081

Romero-Blanco, C., Rodriguez-Almagro, J., Onieva-Zafra, M.D., Parra-Fernandez, M.L., Prado-Laguna, M.D., & Hernandez-Martinez, A. (2020). Physical Activity and Sedentary Lifestyle in University Students: Changes during Confinement Due to the COVID-19 Pandemic. *International Journal of Environmental Research and Public Health,* 17(18), 6567. https://doi.org/10.3390/ijerph17186567

Sereda, I., Lavrin, H., Kucher, T., Grygus, I., Napierała, M., Muszkieta, R., Zukow, W., Smoleńska, O., Ostrowska, M., Hagner-Derengowska, M., & Kałużny, K. (2021). Effect of yoga exercises on the senior schoolchildren's biological age during physical education. *Journal of Physical Education and Sport*, *Vol 21 (Suppl. issue 5),* Art 370, pp. 2782 – 2789. https://doi.org/10.7752/jpes.2021.s5370

Sereda, I., Lavrin, H., Kucher, T., Grygus, I., Napierała, M., Muszkieta, R., Zukow, W., Smoleńska, O., Ostrowska, M., Hagner-Derengowska, M., & Kałużny, K. (2021). Effect of yoga exercises on the senior schoolchildren's biological age during physical education. *Journal of Physical Education and Sport*, Vol 21 (Suppl. issue 5), Art 370, pp 2782 – 2789. https://doi.org/10.7752/jpes.2021.s5370

Setiakarnawijaya, Y., Safadilla, E., Rahmadani, E.A, Robianto, A, & Fachrezzy, F. (2021). Android-based physical fitness software guidance. *Journal of Physical Education and Sport*, *Vol 21 (Suppl. issue 4)*, Art 295, pp. 2313-2319. https://doi.org/10.7752/jpes.2021.s4295

Sindeeva, L.B., Nikolaev, V.G., Kochetova, T.F., & Kovrigina O.A. (2015). Component composition of the body as a criteria of biological age. *Siberian Medical Review*, *5*, 61-65 (in Russian)

Sitovskyi, A., Maksymchuk, B., Kuzmenko, V., Nosko, Y., Korytko, Z., Bahinska, O., Marchenko, O., Nikolaienko, V., Matviichuk, T., Solovyov, V., Khurtenko, O., Slyusarenko, N., Zhorova, I., & Maksymchuk, I. (2019). Differentiated approach to physical education of adolescents with different speed of biological development. *Journal of Physical Education and Sport*, Vol. 19 (3), Art 222, pp. 1532-1543. https://doi.org/10.7752/jpes.2019.03222

WHO. *Global recommendations on physical activity for health* (2010). Available from: http://www.whogis.com/dietphysicalactivity/factsheet_recommendations/ru/ (date of access: 14.09.2019).

Zhang, Z., Chen, B., & Chen, W. (2019). The mediating effect of perceived health on the relationship between physical activity and subjective well-being in Chinese college students. *Journal of American College Health,* 1-8. https://doi.org/10.1080/07448481.2019.1645676