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Original Article

Effect of yoga on biological age indicators of 14-15-year-old girls

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Abstract:
Introduction: To increase students' interest in physical activity, new fitness technologies that are relevant today are being introduced. A popular area of health fitness is Yoga with a mental-regulatory focus, which allows you to increase activity and prevent age-related diseases. *Objective:* The research is dedicated to testing the impact of Yoga on the biological age of schoolchildren. The purpose of the article is to determine the effectiveness of the influence of Yoga in the process of physical education on indicators of the biological age of girls at 14-15 years. *Materials and methods:* In total, the experiment lasted for one semester (30 classes). It was attended by 83 girls of 10th grade (14-15 years old) of Ternopil Secondary School, who were divided into a control group (CG) - 41 girls and an experimental group (EG) - 42 girls, who are classified as the main medical group. Physical education lessons were traditionally held with CG girls in accordance with the current physical education curriculum. Classes with EG girls were conducted using Yoga for beginners. It has been familiarized with the types of breathing which are used in the practice of Yoga: full yogic breathing (diaphragmatic), middle (chest) and upper (clavicular) breathing. The classic complex "Surya Namaskara" ("The Sun God") was offered, which consists of 12 asanas with gradual complication. Improving the effectiveness of the proposed exercises was ensured by the appropriate conditions for their implementation: the creation of a positive psycho-emotional atmosphere through the acquisition of skills of proper breathing and relaxation of the body; musical accompaniment (slow music with natural motives, if classes were held in the hall); outdoor activities; regular exercises at home. To determine the biological age in the experiment, a method according to V.P. Voitenko was chosen, which reflects the individual, actually achieved level of morphofunctional maturity of individual tissues, organs, systems and the organism as a whole. *Results:* The introduction of an experimental program of Yoga improved the biological age of EG girls ($p < 0.05$). The indicators of the respiratory system ($p < 0.05$) and static balancing ($p < 0.01$) in EG increased especially in comparison with CG. In addition, EG girls have increased interest in physical education and the desire for independent study at home. *Conclusion:* The results of the research indicate a positive effect of Yoga on the physiological parameters of the body of girls 14-15 years old and increase interest in this type of exercise.
Key words*:* **Yoga, biological age, girls, physical education**.

Introduction.

Health provides an opportunity for full harmonious development of personality and plays a decisive role at different stages of human life. This is especially true for student youth, when physical and mental potential is still being formed, the basis of professional and creative growth is formed, participation in family-building and reproductive activities. Due to this school children health is one of the important indicators of social well-being. It is both a determinant and a basis for the development of the entire population, ensuring the future of the state. The causes of many diseases in schoolchildren are primarily related to lifestyle.

Information overload, stressful situations, modernization of the educational process require from growing and developing organism high intensity. This, together with other negative factors, leads to functional disorders, and later to pathology. And a sick child, when he grows up, is more likely to become an unhealthy adult. About two-thirds of premature deaths and one-third of all adult illnesses are due to conditions and behaviors in youth: smoking, alcohol, lack of physical activity, unprotected sex and violence (Moiseienko, 2019).

One of the ways to combat the problems of low physical activity, as a major factor in the deterioration of the health of young students, mandatory introduction of recommendations into the curriculum with the use of activating teaching methods was revealed, as well as methods of using non-traditional methods and means of physical education (Pantsova, 2014). The development of modern fitness technologies create ample opportunities for their implementation in the system of physical education of schoolchildren. Analyzing the programs of fitness and school physical education, common tasks were identified, in particular: strengthening health system, education of physical qualities, growth of general and special working capacity, formation of correct posture and correction of defects, improvement of vitality and psycho-emotional state, counteraction to

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daily stresses, that is relevant in the educational process and life of students (Ferreira-Vorkapic et al., 2015; Gumenyuk et al., 2018).

One of the popular areas of fitness is Yoga with a mental-regulatory focus (specific direction). Fitness yoga, yoga aerobics - an effective training program for physically active people, which helps to find harmony between body and mind (Govindaraj et al., 2016). Regular and properly organized classes increase human activity, prevent the emergence of age-related diseases, and therefore is one of the important steps to reduce the biological age of person and the opportunity to continue an active and full life. Biological age is defined as the general psychophysical capacity and viability of the organism, which is determined on the basis of biological tests, through comparison with certain parameters inherent in this age (Sereda et al., 2017).

Analysis of the literature confirms that the constant use of yoga exercises (asanas) helps to maintain muscle strength, tone, bone density, joint mobility, improve posture, balance, reduce body weight (Sivananda, 2004; Desikachar & Cravens, 2011; Sereda et al., 2020). In combination with the Pranayama respiratory system, regular yoga practice can help to maintain normal blood circulation and respiratory function (Innes et al., 2005). Yoga, over a period of time, leads to improved rates of oxygen consumption, respiratory rate, and heart rate (Thomas & Centeio, 2020).

Performing yoga exercises is associated with the natural synchronization between breathing and movement. According to the principle of biological feedback, slow movements promote even, slow, deep breathing. This activates the parasympathetic part of the autonomic nervous system and promotes a feeling of relaxation, which can affect heart rate and blood pressure (Ross & Thomas, 2010). Yoga is psychophysiological in nature due to the focus on posture and breathing. Concentrating on breathing during exercise helps to increase the state of relaxation. Therefore, yoga is shown to combat stress (Maglia et al., 2019; Goldsby, 2020), anxiety and depression (Saeed et al., 2019; Nóra, 2021), helps to improve mental health (Noggle, 2012; Hartley et al., 2018). Analyzing the above, we can conclude that yoga has a positive effect on all systems of human body - circulatory, respiratory, digestive, nervous, endocrine, immune, integumentary, musculoskeletal system, as well as reduce the aging process.

To raise students' interest in physical exercises with each subsequent school year, in the curriculum for physical education of schoolchildren, in addition to traditional, new non-traditional and currently relevant means of physical education are constantly introduced. Thus, the classes already use: dancesport, aerobic dance, Tae Bo, badminton, floorball (Gumenyuk et al., 2020). According to an oral survey conducted in the final physical education lesson at the end of the previous school year, yoga exercises are interesting and in demand for most girls (85%). Since yoga classes show a great interest among girls and allow to implement common health tasks, which are defined in the curriculum for physical education of schoolchildren, it is advisable to test their effectiveness in practice.

Thus, the relevance of the study is due, on the one hand, the significant interest of girls and the wide range of modern fitness technologies, in particular yoga, in the implementation of physical education of schoolchildren and on the other hand - the need to test its effectiveness on health of girls at age of 14-15 years and the feasibility of including this type of exercise in the process of physical education of schoolchildren.

Given the above, the **purpose** of the article is to determine the effectiveness of the effectiveness of Yoga on indicators of the biological age of girls at 14-15 years.

Material & methods

The following research methods were used to solve the tasks: theoretical analysis and generalization of data from scientific and methodological literature, surveys, pedagogical experiment, physiological methods, determination of biological age, pedagogical observation and methods of mathematical statistics.

At the beginning of the school year, a confirmatory experiment was conducted to determine the biological age of girls aged 14-15 years, as an informative indicator of human health is the ratio of its calendar age to biological.

Biological age (BA) is a collective concept that reflects the individual, actually achieved level of morphofunctional maturity of individual tissues, organs, systems and the body as a whole. Biological age is determined by various methods. There are very complex options, they use modern medical equipment. To determine the biological age in the experiment, the method was chosen according to V. Voitenko (Voitenko et al., 1989). The following formula is offered for girls:

$$BA = 17,4+ 0,82 \cdot HSAq - 0,005 \cdot SBP + 0,16 \cdot DBP + 0,35 \cdot PP - 0,004 \cdot VC + 0,04 \cdot IBH - 0,06 \cdot EBH - 0,11 \cdot SB$$

SBP - systolic blood pressure, mm Hg;
DBP - diastolic blood pressure, mm Hg;
PP - arterial pulse pressure, the difference between systolic and diastolic, mm Hg;
VC - vital capacity of the lungs, ml;
IBH - inspiration breath-hold, s;
EBH – exhale breath-hold, s;

SB - static balancing with eye closed on the left leg without shoes, arms lowered along the torso, s;

HSAq - health self-assessment by questions, scores;

Appropriate biological age indicates to which age population the subjects belong. Calculated by formula:

$$ABA\ (women) = 0{,}581 \bullet CA + 17{,}24,$$

where CA is the calendar age.

The rate of aging was defined as the ratio of biological age to proper biological age:

$$BA / PBA$$

Statistical analysis. The results of the research were processed using the software package Statistica 6.0. The obtained indicators had a normal distribution (according to the Shapiro-Wilke criterion). The results were described by the arithmetic mean (M) and the standard deviation (σ). Significance of differences was determined by Student's t-test (p).

The experiment involved 83 girls of 10th grade (14-15 years) of Ternopil Secondary School, which were divided into a control group (CG) - 41 girls and an experimental group (EG) - 42 girls. The experiment involved girls who, according to their state of health, belong to the main medical group. All participants were informed and agreed to participate in the research. The research was conducted during one semester from September to January in 2019.

Classes with girls in the experimental groups were conducted using Yoga for beginners. With the girls of the control group physical education lessons were traditionally held in accordance with the current curriculum in physical education. The program of classes with EG girls was calculated for 30 lessons. The first two classes involved determining the biological age of girls, as well as acquaintance with the theory of Yoga, the rules of exercise. To do this, they were offered visual videos of the exercises, focusing on the choice of clothes for classes. The following classes were practical. Much attention was paid to the types of breathing during Yoga. The students were introduced to the following types of breathing used in Yoga practice:

full yogic breathing, which includes lower (diaphragmatic) breathing - during inhalation the abdomen is slightly bulging, on exhalation - is drawn in with simultaneous tightening of the pelvic floor muscles;

middle (chest) breathing - is performed by expanding the chest during exhalation and lowering it during exhalation;

upper (clavicular) breathing - occurs by raising and lowering the clavicle.

The simplest exercises of the Pranayama system were also used - breathing exercises that affect the flow of energy that creates balance in the body and mind, namely: breathing with frequent and rapid changes of inhalations and exhalations - "blacksmith's bellows"; nasal breathing with alternating nostrils; breathing with inhalations through the right nostril and exhalations through the left nostril; breathing with stepped delays during inhalation or exhalation; mouth breathing; breathing accompanied by a vibrating sound during exhalation or inhalation - "the sound of a bee"; breathing with an emphasis on sharp exhalations through the nose, with pulling the abdomen to the spine (20-30 breathing cycles) - "flame breathing". Breathing exercises were constantly used at the beginning of the lesson, in the final part to relax, as well as in the process of performing complexes.

Practical classes involved direct study and performance of asanas. We started with two or three repetitions of one bunch of exercises, gradually increasing to 5-6 times. At first, in one lesson, it was suggested to do one or two exercises. Further, their number also increased as the asanas were studied and the girls' bodies adapted to the load. In the first practical classes, the girls were offered the initial classic complex "Surya Namaskar" ("sun salutation") "Surya Namaskara" ("The Sun God"), which consists of 12 asanas (The 12 Names of Surya) (Fig. 1). All of them are performed in a strict sequence and in a certain rhythm of breathing.

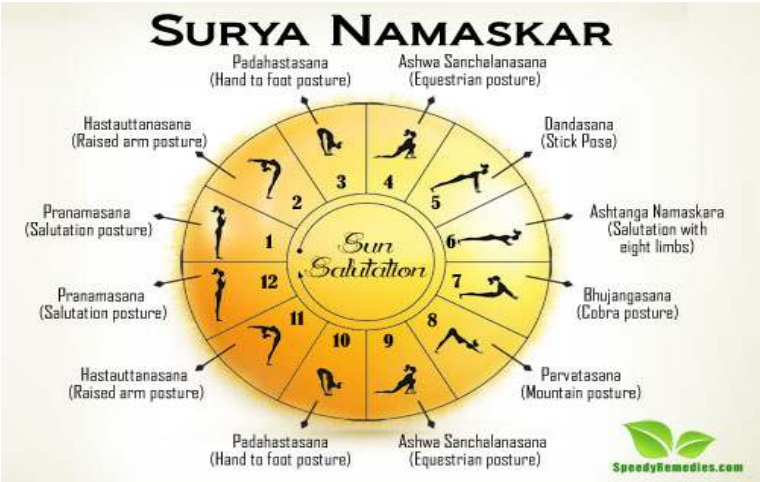

Fig. 1. Surya Namaskar «Salutations to the Sun»

Execution of this complex was accompanied by uniform and smooth breathing according to the following scheme: 1st asana - inhale and exhale; 2nd asana - inhale; 3rd asana - exhale; 4th asana - inhale, 5th asana - exhale; 6th asana - inhale and exhale; 7th asana - inhale; 8th asana - exhale; 9th asana - inhale; 10th asana - exhale; 11th asana - inhale; 12th asana - exhale (Surya Namaskar, 2017).

Later asanas were replaced by others, or their sequence changed. The sets of exercises included: Anantasana (Side-Reclining Leg Lift); Adho Mukha Shwanasana (Downward Facing Dog); Ardha Matsyendrasana (Half Spinal Twist Pose); Artha Chakrasana (Half Wheel Pose); Baddha Konasana - Bound Angle Pose and other exercises (Hatha yoga, 2016).

Improving the effectiveness of the proposed exercises was ensured by the appropriate conditions for their implementation: the creation of a positive psycho-emotional atmosphere through the acquisition of skills of proper breathing and relaxation of the body; musical accompaniment (slow music with natural motives if classes were held in the hall); outdoor activities; regular exercises at home. To perform the exercises on their own at home, the girls were offered videos that served as an example for performing the exercises at home. Thus, the habit of regular independent classes was stimulated (Unagrande Yoga Clube. 2018).

Results.

Before the experiment, the homogeneity of the groups was determined by analyzing physiological parameters. At the beginning of the school year, a confirmatory experiment was conducted to determine the biological age of girls at the age 14-15 years, as an informative indicator of human health is the ratio of its calendar age to biological. Physiological parameters of girls EG and CG did not differ ($p \geq 0.05$). Most girls were characterized by low blood pressure, both in CG and EG (Table 1). VC was also characterized by lower than normal values and averaged on 2500 ml. Breath-hold indicators in girls of both groups ranged from 42 ± 0.82 and 41 ± 0.78 s on inhale ($p \geq 0.05$) and 21 ± 0.44 and 22 ± 0.51 s on exhale ($p \geq 0.05$). These are the only indicators that were closest to the norm. With eyes closed, girls held positions for an average of 28 ± 0.66 s CG and 29 ± 0.35 s EG ($p \geq 0.05$).

Prior to the experiment, the HSAq in girls of both groups were low and there were no significant differences ($p \leq 0.05$). Among the positive answers to the questions there were such questions as "Do you have a headache?", "Is it easy to wake up from any noise", "Can you say that you are tearful" and others, which indicated an unsatisfactory level of well-being.

After analyzing the objective and subjective indicators, we determined the biological age of the body of girls at th age 14-15 years. The results surprised the subjects themselves. Determining the biological age according to the method of V.P. Voitenko, the lowest indicator of biological age was recorded - 28 years, and the largest - 45 years. No girl was found whose biological age corresponded to the calendar. Appropriate biological age (ABA) was also calculated. According to the results of the calculations, the girls belong to the age population of 25.33 ± 0.24 years.

It should be noted that in addition to informativeness, the proposed method showed great interest in girls to determine their own biological age. The use of such a technique helped to increase interest in classes, as well as stimulated the desire of girls to bring the identified indicators closer to their own calendar age. Taking into account the results of the observational experiment, the desire of the girls to include in the system of classes a set of yoga exercises, an experimental program of classes was proposed, which implemented the task of physical education of schoolchildren..

After the introduction of yoga in the process of physical education, a re-assessment of the compliance of the biological age of girls 14-15 years of EG and CG calendar. The application of the yoga program had a positive effect on the improvement of previously identified indicators of biological age of EG girls, compared with CG ($p \leq 0.05$) (Tab. 1).

After the experiment, the rate of SBP in girls of EG improved and amounted to 118 ± 3.12 mm Hg. ($p \leq 0.05$). At the same time, DPB had no significant changes ($p > 0.05$). The indicators of VC and breath-hold also became better ($p \leq 0.05$). In EG after the experiment VC was recorded in the range of 3000 ± 280 ml. In CG, this figure remained virtually unchanged and was 2600 ± 301 ml ($p \leq 0.05$). EG girls improved the mean breath-hold on exhalation to 52 ± 2.30 s ($p \leq 0.05$) and inhalation on 36 ± 1.1 s ($p \leq 0.05$). In CG, the breath-hold time remained unchanged ($p \geq 0.05$). After the experiment in EG girls, most of the studied parameters differed significantly from CG ($p \leq 0.05$).

Such changes in physiological parameters, in a relatively short time, are associated with a constant emphasis on proper breathing during exercise, which has a positive effect on the functions of the cardiovascular and respiratory systems of girls.

The use of yoga exercises had a positive effect on static balancing. Prior to the experiment, CG and EG did not differ significantly in terms of SB ($p \geq 0.05$). At the end of the experiment, the EG girls significantly improved the retention time to 52 ± 2.04 s, compared with the beginning of the experiment ($p \leq 0.01$) and with CG ($p \leq 0.05$). Positive changes were also reflected in health self-assessment: HSAq in EG improved after the experiment ($p \leq 0.05$) and compared to CG ($p \leq 0.05$).

Tab.1 Indicators of biological age of girls 14-15 years old (M±σ)

Indicators of biological age	Before the experiment		After the experiment	
	CG	EG	CG	EG
SBP - systolic blood pressure, mm Hg	110 ±6,31	112±5,23#	112±5,22*	118±3,12*#
DBP - diastolic blood pressure, mm Hg	64±2,81	66±3,11	62±3,14	67±5,16
PP - pulse pressure, the difference between systolic and diastolic, mm Hg	40±3,14	40±2,83	42±4,10	48±2,66
VC - vital capacity of the lungs, ml	2500±211	2500±188#	2600±301*	3000±280*#
IBH - inspiration breath-hold, s	42±0,82	41±0,78#	41±1,01	52±2,30#
EBH – exhale breath-hold, s	21±0,44	22±0,51#	23±0,62*	36±1,1*#
SB - static balancing, s	28±0,66	29±0,35#	28±1,44**	52±2,04**#
HSAq – health self-assessment in questions, score	9,4±2,1	8,6±2,6#	8,2±2,4*	4,1±1,76*#
BA – biological age, years	32,07±6,22	32,51±7,02#	31,88±4,11**	25,16±3,21**#
ABA – appropriate biological age, years	25,33±1,46	25,43±1,52	25,33±1,46	25,43±1,52
Aging rate, c.u.	1,25±0,10	1,25±0,22#	1,24±0,46**	0,99±0,30**#

Note: * - significant differences between CG and EG at p≤0.05 (Student's criterion); ** - significant differences between CG and EG at p≤0.01 (Student's criterion); # -significant differences in EG before and after the experiment at p≤0.05 (Student's criterion); no significant differences between CG before and after the experiment were found.

Analyzing the indicators of biological age in general, we can draw the following conclusions. After using yoga exercises in EG, the lowest rate of biological age was 21 years, and the highest - 33 years, what means - the rates decreased. The lowest biological age indicator was recorded in the CG - 24 years, and the highest - 48. All students according to the ABA indicators belonged to one age population. Prior to the experiment, CG and EG were characterized mainly by an accelerated rate of aging (1.25 units). After participating in the experiment in girls EG significantly decreased the rate of aging - 0.99 c.u. (p≥0.01), which indicates its slowdown due to the strengthening of regulatory processes of the cardiorespiratory system.

Discussion

The results of our research revealed the effectiveness of yoga classes for the successful implementation of the tasks specified in the curriculum for physical education of schoolchildren (Ferreira-Vorkapic et al., 2015; Luu & Hall, 2016;). The expediency of the proposed complexes corresponds to the interest of girls in this type of exercise, which is confirmed by the results of the research.

Analysis of the results of some physiological indicators confirmed the data that yoga has a positive effect on the cardiovascular and respiratory systems (Chaya, 2005; Innes et al., 2005; Thomas & Centeio, 2020). There is information in the literature that yoga did not affect the change in blood pressure (Papp, et al., 2013). But it is worth noting that these data were obtained from a sample of people aged 25-60 years, who had slightly elevated blood pressure.

The results of self-assessment of health show that regular and properly organized yoga classes increase activity, have a positive effect on well-being, lowering the threshold of morbidity and stress (Yang, 2007; Strehli et al., 2020).

Improving the time of static balancing of girls coincides with the opinion of scientists that regular exercise (asanas) helps to maintain muscle strength, tone and balance of the whole body. Our study confirmed that yoga is one of the important steps to reduce the biological age of a person and the ability to continue an active and full life (Sereda 2017; Vhavle et al., 2019). The exercises offered in the program of classes really had a positive effect on the indicators of the biological age of girls aged 14-15 years.

New are the data on the features of studying yoga exercises. Due to the fact that for most girls yoga was a new and unknown type of exercise, we in our research proved the possibility of mastering and performing such exercises in physical education of schoolchildren.

It was found that the introduction and use of new and interesting methods of health assessment, in our case, the method of determining biological age, helps to increase interest in their own health, as well as the role of physical education in solving health problems.

According to the results of the assessment of the biological age of girls aged 14-15 years to the calendar, it was found that the inclusion of yoga in the program of physical education of schoolchildren will maintain and improve physiological indicators, and thus positively affect their health.

Conclusions

Be determination of the actual biological age of girls aged 14-15 years, it was found that in almost all subjects it exceeded the indicators of the appropriate biological age. Most girls aged 14-15 are characterized by

accelerated aging. Lack of a healthy lifestyle and low level of physical activity lead to a sharply accelerated rate of aging of student youth, which reflects the general trend of deteriorating quality of life, health, low level of physical fitness and puts the task of preventing premature aging as one of the strategic.

A popular area of health fitness is Yoga with a mentally and regulatory focus on the human body. Regular and properly organized classes can improve well-being, prevent age-related diseases, and therefore are one of the important steps to reduce the biological age of a person. The introduction of an experimental program of yoga improved the biological age of EG girls ($p < 0.05$). The indicators of the respiratory system ($p < 0.05$) and static balancing ($p < 0.01$) in EG increased especially in comparison with CG. In addition, EG girls have increased interest in physical education and the desire for independent study at home.

The results of the study indicate a positive effect of yoga on the physiological parameters of the body of girls 14-15 years and their increased interest in this type of exercise. Therefore, we consider it expedient to recommend to include yoga classes in the program of physical education of schoolchildren.

This study does not fully disclose all aspects of the effectiveness of yoga. In future, we set a task to test its effectiveness for boys and the impact on physical fitness, as well as to develop programs for the development of certain physical qualities with the help of this type of fitness.

Conflict of interest

The authors declare no conflict of interest.

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