Physical exercises improve cognitive abilities of 7-8 years old chess club’s students

Dmytro Vus\textsuperscript{1ABCDE}, Zhanneta Kozina\textsuperscript{1ABCD}, Iryna Sobko\textsuperscript{1CD}, Sergii Riabchykov\textsuperscript{2E}

\textsuperscript{1}Department of Olympic and Professional Sport, Sport Games and Tourism, H.S. Skovoroda Kharkiv National Pedagogical University, Kharkiv, Ukraine

\textsuperscript{2}The Science and Technical Establishment “Nuclear Fuel Cycle”, National Science Center Kharkov Institute of Physics and Technology, Kharkiv, Ukraine

Authors’ Contribution: A – Study design; B – Data collection; C – Statistical analysis; D – Manuscript Preparation; E – Software development

* Correspondent authors

DOI: https://doi.org/10.58962/HSTRPT.2023.4.1.20-33

How to site

Abstract

Background and purpose
Many studies show the positive impact of playing chess on the cognitive abilities, motor skills and psychophysiological characteristics of people. On the other hand, physical exercises are of great importance for the progress of kids’ cognitive features. In view of this, our study was aimed at determining the effect of physical exercises on cognitive abilities and psychophysiological functions of young chess players.

Material and methods
20 students (7-8 years old) of two different Ukrainian chess schools took part in the study. All of them attended chess lessons, but those from the experimental group (group E, 10 children) also did a set of general and special physical exercises during chess lectures, as compared to the kids from the control group (group K, 10 children). To monitor work efficiency and the speed of switching attention, an online platform, containing Schulte test and a test for determining the reaction time of choosing a point in space (“Ermakov test”), respectively, was employed. Results of the tests were compared using the independent-samples T-test.

Results
Statistically significant improvements in the values of the work efficiency and the average working time on the third Schulte table were revealed in the groups K and E after two months. The increase in the speed of switching attention was also statistically significant in both groups, however, in the group K this was observed only for the result of the first attempt of “Ermakov test”, while in the group E - to the results of the first, the third attempts and average of three attempts. Overall, our data revealed an increase in the cognitive abilities of younger schoolchildren, who did physical exercises during chess classes, compared to those chess school students, who only solved chess problems, played chess and listened to chess lectures. Surprisingly, there was no statistically significant increase in the results of “Ermakov test” in group E compared to group K after two months.

Conclusions
The novelty of the results is as follows: i) work efficiency (according to the Schulte test) in the experimental group showed a statistically significant improvement, indicating the important role of physical exercises for the cognitive development of young chess players; ii) in turn, the increase in speed of switching attention (by “Ermakov test”) of the children seemed to be independent on the physical training in the short-term period; iii) both the metacognitive approach for teaching chess, as well as regular physical training during chess lessons should result in the cognitive, psychophysiological development and, as consequence, in the improvement in chess performance of the young athletes.

Key words: chess, children, cognitive abilities, physical exercises, psychophysiological functions
Анотація

Дмитро Вус, Жаннета Козіна, Ірина Собко, Сергій Рябчиков. Фізичні вправи покращують когнітивні здібності учнів шахових гуртків віком 7-8 років

Обґрунтування і мета

Багато досліджень показують позитивний вплив гри в шахи на когнітивні здібності, моторні навички та психофізіологічні характеристики людей. З іншого боку, фізична активність має велике значення для розумового розвитку дітей. З огляду на ці факти, наше дослідження було спрямоване на визначення впливу фізичних вправ на когнітивні здібності та психофізіологічні показники юних шахістів.

Матеріали і методи

У досліджені взяли участь 20 учнів (віком 7-8 років) з двох різних українських шахових клубів. Усі вони відвідували заняття з шахів, але діти експериментальної групи (група Е, 10 дітей) також виконували комплекс загальних і спеціальних фізичних вправ під час заняття з шахів, порівняно з дітьми контрольної групи (група К, 10 дітей). Для моніторингу ефективності роботи та швидкості перемикання уваги використовували онлайн-платформу, що містила тест Шульте і тест на визначення часу реакції вибору точки у просторі («тест Єрмакова»), відповідно. Результати тестів порівнювали за допомогою критерію Стьюдента.

Результати

Статистично значущі покращення значень ефективності роботи та середнього часу роботи за третьою табличею Шульте виявлено у групах К та Е через два місяці. Збільшення швидкості перемикання уваги також було статистично значущим в обох групах, однак у групі К це спостерігалося лише для результату першої спроби «тесту Єрмакова», тоді як у групі Е - для результатів першої, третьої спроби і усерединених за трьома спробами результатів. В цілому, на основі отриманих результатів виявлено підвищення когнітивних здібностей дітей молодшого шкільного віку, які виконували фізичні вправи під час заняття шахами, порівняно з учнями шахової школи, які тільки займалися розв’язанням шахових задач, грою та слуханням лекцій з шахів. Цікаво, що через два місяці не виявлено статистично значущого підвищення результатів «тесту Єрмакова» у групі Е порівняно з групою К.

Висновки

Новизна отриманих результатів полягає в наступному: і) статистично значуще покращення ефективності роботи (за тестом Шульте) в експериментальній групі свідчить про важливу роль фізичних вправ для когнітивного розвитку юних шахістів; ii) з іншого боку, збільшення швидкості перемикання уваги дітей (за «тестом Єрмакова») у короткостроковому періоді виявилося незалежним від наявності чи відсутності тренувальних фізичних вправ під час шахових занять; iii) як метакогнітивний підхід до навчання шахів, так і регулярне виконання фізичних вправ під час уроків шахів повинні призвести до розумового, психофізіологічного розвитку і, як наслідок, до покращення шахових результатів юних спортсменів.

Ключові слова: шахи, діти, когнітивні здібності, фізичні вправи, психофізіологічні функції
Introduction

Among all intellectual non-gambling games, chess is one of the most popular due to its simple rules and aesthetic enjoyment of the game (as evidenced by the wide global community of chess fans), as well as the opportunity to participate in international championships and receive rewards [1]. As a rule, children learn to play chess at school age (moreover, chess is included to the school curriculum in Armenia [2, 3]), because many studies have shown the benefits of chess for the development of cognitive abilities [4], including memory and attention [5], academic performance [6, 7], including math grades [8], and logical thinking [4, 9] of children. Professional chess players have excellent short-term memory, high IQ and processing speed [10], high physical strength, strength of will and endurance [11]. There is no doubt, these characteristics are of particular importance in other sports, such as football, where logical thinking, as well as physical strength and endurance are essential for success [12]. Speed qualities, endurance, strength and agility help to successfully apply technical techniques and implement tactical tasks during the game [13].

On the other hand, high physical activity, especially during distance learning, is the basis of integral development of elementary school children, since good physical fitness contributes to the development of the intellectual and emotional spheres [14]. In particular, the involvement of young football players of 5-6 years old in interesting outdoor games formed the basic physical qualities and motor skills of athletes [13]. Jylänki P. and co-authors also showed that physical activity and fundamental motor skills enhanced cognitive abilities and academic performance of children aged 3-7 years [Jylänki, et al., 15], while combining mathematics lessons with physical exercises significantly improved intellectual abilities and motor skills of elementary school children [16]. In addition, the creative tasks performance of 308 children aged 8 to 12 years was reported to positively correlate with the body strength, running speed, and maximum volume of oxygen uptake, and as a consequence, an aerobic exercise intervention had a positive impact on creative task performance [17]. According to Serra L. and co-authors, girls of 7-10 years old, who practiced artistic gymnastics had better working memory abilities, than those who did not play any sports [Serra, et al., 18]. According to a literature review by Chan Y.S. and co-authors, rhythmic dancing improved attention in 8 year old children with attention deficit hyperactivity disorder [Chan, et al., 19].

Taking into account the results of the above studies, in order to achieve success in any sphere of life activity, including professional sports, it seems reasonable to promote a harmonious combination of physical and intellectual development of young athletes. Indeed, the inclusion of chess lessons in the training process of football players aged 10-12 years led to better results in concentrated attention tests, IQ and Technical tests [20]. On the other hand, young eSports players who exercised regularly, had facilitated cognitive aspects of gaming performance, than those who had poor physical fitness [21]. Indeed, Vouglanis T. and co-authors argue that during regular physical activity, the brain first activates body parts to make the necessary movements, and over time it starts to choose the right movements helping in developing professional success in a particular sport [Vouglanis, et al., 22]. Therefore, in the case of professional chess players, physical exercises are a platform for brain training and will help to better remember the movements of the pieces in the opening, use them in the right order, and calculate possible movements of the opponent [22].

The most effective pedagogical method of teaching elementary school children is the involvement of them in playful and at the same time intellectual activities, helping to create motivation for learning, as well as to develop cognitive, social, emotional, creative abilities and physical skills [23]. For example, guided play, having a clear learning goal, positively contributed to the development of children’s early math skills [24]. Furthermore, lesson plans should be aimed at transferring knowledge using figurative thinking, because children of 6-8 years old are in the stage of primary learning [5], i.e. they perceive images better than direct instructions [25, 26]. For example, to actively involve children in physical education, it is necessary to use mobile games [27, 28] and gymnastics in verses [14]. In particular, Samsudin S. and co-authors showed an increase in the physical activity of children aged 10-12 years who played mobile video games during the Covid-19 pandemic [Samsudin, et al., 28]. Also, mobile games are an effective method of developing the strength, agility, endurance and speed of football players aged 5-6 years [13]. Since the brain of a chess player is actively working during a chess game, both respiratory gymnastics and exercises focused on the development of endurance are included into the training program for highly qualified chess players. For example, the world chess champions G. Kasparov and M. Carlsen won their titles also due to good physical fitness maintained by regular physical exercises: barefoot running on sandy beaches [29].
and playing football [30], respectively. Generally, professional chess players have several individually selected sets of physical exercises, which are used depending on their annual schedules (for example, before start and after a chess game, an outdoor walk and a favorite sport — i.e., playing football, tennis — are very useful, respectively; in turn, during preparation for the championships intensive physical activity is preferred) [31]. Despite the positive role of physical activity on the integral development of children, as well as regular use of individual physical exercise sets by professional athletes, there is a lack of systematic studies on the impact of physical training on the intellectual abilities and psychophysiological functions of young chess players. Furthermore, according to the curriculums of Ukrainian chess clubs, physical exercises are only about 5% of the total training time. In view of the above, the following hypothesis was formulated: a well-selected set of physical exercises should improve cognitive abilities and psychophysiological functions for beginner chess players of elementary school age.

The purpose of the study: to reveal the effect of the physical exercises on cognitive abilities and psychophysiological functions of young chess players.

Material and methods

Participants and procedure

The experiment was performed among 7-8 years old beginner students of two Kharkiv region chess clubs in the academic year 2022/2023. In particular, 10 children from the control group and 10 children from the experimental group attended classes twice a week for two months (each child attended 18 classes in total). The children and their parents agreed to participate in the experiment. At the first and last lessons in each group, psychophysiological testing of young chess players was conducted. All tests were performed using a newly developed online platform available at https://tiiny.host/manage.

Children from the experimental group (E), in contrast to those of the control group (K), performed a following set of physical exercises during each 60 minute chess lesson (for 10 minutes at the beginning and 5 minutes in the middle of the lesson):

i) exercises from the gymnastics in verses "Little Wizards" (by Kozina) [14], i.e. "The sun floats in the sky", "A huge eagle swoops in the sky", "And now everyone feels fine!", etc. [14]. The original sequence of exercises, which are based on the child's natural movements and can be performed with the whole body at once, has been successfully used for over 20 years for the development of psychomotor and intellectual skills in children aged 1-7 years [14, 33]. In addition, figurative thinking of preschoolers and elementary school children significantly dominates over logical thinking, so it will be very interesting for them to do this gymnastics, imagining themselves as the main characters of the events described in the verses about nature [25, 26];

ii) respiratory exercises, representing a part of special physical exercises for chess players and aimed at endurance development. The most frequently employed exercise was as follows: to take 8 short breaths through the nose, then to exhale slowly through the mouth, and then to hold a breath for 3-5 seconds;

iii) general physical exercises: neck twists, i.e. moving chin, that is kept parallel to the floor, to the right or left shoulder and returning it to center; shoulder rotations, i.e. squeezing shoulder blades together, while rotating arms (extended straight out from the body parallel to the floor) so that the palms are facing the sky; making circles with arms, brought straight out from body at a shoulder height, parallel to the floor; reaching with the right/ left arm above head "to the sky" to the left/ right side with a slight hip and shoulder rotation to the left; "jumping Jack" - jumping from the neutral posture to one with the legs spread wide and the hands raised overhead in a clap (for endurance development) [34].

It should be emphasized that children from both groups K and E were not only listening to the chess lessons performed according to the regular program for Ukrainian chess clubs, but also participated in simultaneous game sessions, as well as in the club’s championships. Short video lectures (on chess openings) and problems (https://www.youtube.com/channel/UCuJgyPqQRgrA1MSOGn5ozNg) designed by the authors in order to strengthen the metacognitive approach in chess training and transferring of knowledge through figurative thinking, were also included into the chess lessons [25, 26]. Notably, metacognitive teaching strategies were proven to develop children into independent chess learners capable of monitoring and evaluating their progress, as well as to improve children’s motivation (e.g. motivated chess students will try to solve a difficult chess problem several times) [35].
Based on the results of Suminto E. and Concilianus L., who reported enhanced intellectual development in children participating in metacognitive chess training, as compared to those studying chess using the regular chess club program [Sumito, Concilianus, 35], we did the following: i) chess problems were classified in order to give children an intriguing hint (typical problem topics were e.g. "winning the horse", "a double attack", etc.); during teaching chess openings, children were not forced to learn the right movements, but they were shown the main ideas of each opening and game plans for white and black in its "critical" position [36]; in order to teach chess students to act as a team, to increase motivation to solve chess problems/to win the game, children of each group K and E were divided into competing teams during chess lessons [35].

Psychophysiological research methods

The psychophysiological status of a child was estimated in accordance with a test for measuring the reaction time of choosing a point in space ("Ermakov test"), while the indicators of his/her cognitive functions (i.e. the stability and the level of concentration of attention) were determined by Schulte test. These methods were successfully employed by Kozina Z. and Abrosimov E. to assess the impact of the game Go and physical exercises on cognitive abilities of children aged 6 years [37]. The above psychophysiological research techniques allow one to determine the most important characteristics of the nervous system such as strength, mobility of nervous processes (by measuring the reaction time of choosing a point in space) [38] and the indicators of cognitive functions (by Schulte test), determining performance of young athletes, especially their level of tactical actions.

An online platform was designed (https://tiny.host/manage), containing Schulte test and a test for determining the reaction time of choosing a point in space ("Ermakov test"). To measure the speed of switching attention, an analogue of the "Select a Button" software developed by Ermakov S.S. was employed, which had been successfully used recently e.g. to determine the psychophysiological characteristics of football players aged 12-16 years [39] and athletes with visual impairments [38]. By analogy with the work of Kozina Z. and Abrosimov E. the page code allows 3 attempts of the "Ermakov test" (15 seconds per each attempt, 2 seconds rest between two attempts) [37]. To start the test for measuring the reaction time of choosing a point in space (hereafter referred to as "Ermakov test"), the participant should click any of the 12 red circles placed on the screen. From that moment, a virtual stopwatch is activated and at the same time, one circle changes its colour to green. Next, the participant has to click on the green circle as quickly as possible, then after a successful click the other circle is highlighted in green - and he/she should click on it again, and so on. One of the most important indicators of the psychophysiological state is the number of correct button presses for 15 seconds [38].

The source code for Schulte test was developed especially for our experiment. In particular, the software allows 5 trials of the test, i.e. 5 different tables containing randomly arranged numbers from 1 to 25, as it was done in the research by Kozina and Abrosimov[37]. The participant should arrange the numbers in ascending order by clicking on the corresponding number in the table. After the child passes the first attempt of the test, a different Schulte table appears on the screen, and so on.

When processing the results, an important indicator of cognitive functions, i.e. "work efficiency", is calculated using the formula [40]:

$$WE = \frac{T1+T2+\ldots+T5}{5},$$  

(1)

where T1, T2, T3, T4 and T5 — time of passing first, second, third, fourth and fifth Schulte table (in seconds), respectively.

In addition, level of involvement in work (LIW) and mental stability (SA) were calculated according to the formulas given, e.g., in the paper of Popovych I.S. and coworkers [Popovych, et al., 40].

Statistical analysis

The independent-samples T-test was used to compare the averaged values of the tested parameters for the control and experimental groups [32, 41]. This test was also employed to uncover intra-group differences before and after the experiment. The IBM SPSS Statistics software (version 27) was used for mathematical processing of statistical data [42, 43].

Results

The first testing session (before the experiment) did not reveal statistically significant differences between the average values of the parameters obtained for the groups K and E, because the value of the significance level pK1-E1 exceeded 0.05 (parameter x, Table 1).
Indicators of cognitive and psychophysiological functions of children of 7-8 years from the experimental (E) and control (K) groups before (1) and after (2) the experiment

<table>
<thead>
<tr>
<th>Test data</th>
<th>Group</th>
<th>Statistical characteristics*</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>N</td>
<td></td>
</tr>
<tr>
<td>Schulte test, average work time on the third table, s</td>
<td>10</td>
<td>76.21</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>59.00</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>95.46</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>93.63</td>
</tr>
<tr>
<td>Schulte test, work efficiency (WE), s</td>
<td>10</td>
<td>72.64</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>62.51</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>96.87</td>
</tr>
<tr>
<td>Schulte test, level of involvement in work (LIW)</td>
<td>10</td>
<td>96.57</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>95.05</td>
</tr>
<tr>
<td>Schulte test, mental stability (SA)</td>
<td>10</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1.06</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1.07</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>1.12</td>
</tr>
<tr>
<td>Measuring the time of the reaction of choosing a point in space (&quot;Ermakov test&quot;) — average of 3 attempts, the number of correct button presses for 15 s</td>
<td>10</td>
<td>16.1</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>16.9</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>14.43</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>13.83</td>
</tr>
<tr>
<td>Measuring the time of the reaction of choosing a point in space (&quot;Ermakov test&quot;) — the first attempt, the number of correct button presses for 15 s</td>
<td>10</td>
<td>16.4</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>16.9</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>14.2</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>13.9</td>
</tr>
<tr>
<td>Measuring the time of the reaction of choosing a point in space (&quot;Ermakov test&quot;) — the third attempt, the number of correct button presses for 15 s</td>
<td>10</td>
<td>16.2</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>17.2</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>14.8</td>
</tr>
<tr>
<td></td>
<td>10</td>
<td>13.8</td>
</tr>
</tbody>
</table>

*Statistical characteristics are as follows: N — sample size, x — sample mean, S — standard deviation, m — standard error of the mean, t — the Student t-statistic coefficient, p — the significance level.

K1/E1, K2/E2 — control/ experimental group before (1) and after (2) the experiment.
K1-E1 — comparison of the control and the experimental groups of children before the experiment.
K1-K2 — comparison of the control and the experimental groups of children after the experiment.

In turn, as seen from Table 1, chess itself and in combination with physical exercises, had a positive effect on the cognitive abilities and the speed of switching attention of children aged 7-8 years. In particular, the improvement in the work efficiency indicator after the experiment was significant in both groups K and E at p<0.001, p<0.001, and the average work time on the third Schulte table - at p<0.001 and p<0.05, for the groups E and K, respectively. Moreover, in the control group of the chess club students, average work time on the third Schulte table and work efficiency decreased by 20 and 25%, respectively, compared to the values of these indicators before the experiment (Table 1). In turn, average work time on the third Schulte table and work efficiency of the group E, decreased by 37 and 35%, respectively, compared to the corresponding data before the experiment (table 1). Note that the "work efficiency" parameter itself is the average working time of children on 5 Schulte tables, so...
its decrease means an improvement in cognitive abilities.

The increase in the speed of switching attention is statistically significant in both groups at $p^{K1-E2}<0.05$, $p^{K2-E2}<0.05$, however, in the control group this applies only to the result of the first attempt of "Ermakov test", and in the experimental group — to the results of the first and third attempts, and the average value of 3 attempts of "Ermakov test" (Table 1). In the control group, the increase in the number of correct button presses for 15 s in the first attempt of "Ermakov test" was 15%, and in the experimental group — 22%, compared to the corresponding values before the experiment. Furthermore, the improvement of the results of the third attempt and the average value of 3 attempts of "Ermakov test" in the group E was 25 and 22%, respectively, compared to the corresponding values before the experiment (Table 1).

Finally, the results of the experiment indicate a significant ($p^{K2-E2}<0.05$) increase in the cognitive abilities of young chess players, who did physical exercises during chess lessons, compared to those, who studied chess according to the typical curriculum of Ukrainian chess clubs (Table 1). After the experiment, average work time on the third Schulte table and work efficiency were lower in group E, than in group K. Specifically, average work time on the third Schulte table and work efficiency in the experimental group decreased by 23 and 14%, respectively, compared to the control group. Surprisingly, after the experiment, no statistically significant improvement in the results of the "Ermakov test" was observed in the group E compared to the group K (Table 1).

**Discussion**

Chess is a very popular intellectual non-gambling game due to its proven benefits for: i) the development of logical thinking (that is of great importance for elementary school children possessing poorly developed logics [25, 26]) and emotional-volitional sphere; ii) fostering team collaboration and friendship-building among children; iii) and furthermore, chess can serve as an interesting hobby, as well as a strong protective factor against stress [4-6, 44]. Also, many studies showed that playing chess positively correlates with children's academic performance at school [7, 8, 45]. Next, Velea T. reported that psychophysiological characteristics (concentrated attention, IQ level), as well as technical skills of young football players aged 10-12 years, increased after 9 months of regular chess training [Velea, 20]. However, any long-term intellectual activity requires good physical fitness, as this will ensure sufficient oxygen flow to the brain, reduce mental fatigue and also provide good hand-eye coordination upon playing chess with a Blitz time control [15, 46]. Indeed, Seger I. and colleagues concluded that Swedish schoolchildren aged 13-14 years who did 30 min extra aerobic exercises under the supervision of physical education teachers twice a week for 4 weeks, improved their English and Swedish language grades compared to a group, which had only regular physical education lessons [Seger, et al., 47]. Also, Jylänki P. and co-authors showed that physical activity and motor skills improved cognitive abilities and academic performance of children aged 3-7 years [15]. Similarly, Magistro D. argues that physically active mathematics lessons for 2 years significantly enhanced cognitive functions and motor skills of elementary school children, and therefore, intellectual and physical development are tightly connected [16].

Therefore, despite the large number of available academic papers investigating the impact of chess on the cognitive abilities of children, youth and adults [4-6, 44], little is known of the role of physical exercises on intellectual functions of young chess players. In turn, a study of the cognitive functions of video game players by Sanz-Matesanz M. and co-authors showed that the athletes usually have good physical activity, but it was difficult to establish its effect on in-game performance [Sanz-Matesanz, et al., 48]. However, a literature review by Toth A.J. and co-authors reported an increase in attention and memory abilities, task switching and information processing in e-sportsmen who exercised [Toth, et al., 21]. In is worth noting that Kozina Z. and Abrosimov E. reported that physical exercises in combination with the game Go (group A) improved the cognitive abilities (according to Schulte test) and psychophysiological state (according to "Ermakov test") of children aged 6-7 years, compared to those who played only Go (group B), as well as those who studied according to the standard program of the extended day (group V) for one month [37].

The results of our experiment revealed a statistically significant decrease (by 14%, at $p^{K2-E2}<0.05$) of the average working time on 5 Schulte tables (improvement of work efficiency) of children aged 7-8 years who did physical exercises, compared to those who played chess and did not exercised (parameter x, Table 1). These data agree with the...
results of Kozina and Abrosimov [37], who showed that children of a similar age (6 years old) who played Go and did physical exercises (including gymnastics in verses "Little Wizards" by Kozina [14, 33, 39, 40]) (group A), improved work efficiency (according to Schulte test) by 18% at p<0.01 compared to those who only played Go (group B) [37]. Also, the authors Kozina Z. and Abrosimov E. concluded that the improvement of the work efficiency parameter was most pronounced in group A, because in group B the decrease in the average working time on 5 Schulte tables was statistically insignificant compared to group V, highlighting the important role of the combination of intellectual games and physical exercises for the most effective growth of cognitive abilities of children who are in the stage of primary learning, i.e. their cognitive processes are primarily related to the development of figurative, not logical thinking [5, 37]. In our study, there was no control group of children who did not play chess and did not do physical exercises, but we also observed a significant improvement in the work efficiency in group E compared to group K after the experiment (parameter x, Table 1), so it can be argued that the combination of chess (as in the case of the game Go) with physical exercises develops intellectual abilities better than chess itself. Interestingly, in the long-term period, playing chess contributed to the development of cognitive functions even when it is not combined with physical exercises. Specifically, the authors Mijarca R. and Rendi E. reported that attending a chess club for 27 weeks (1-2 times a week) improved memory, logical thinking and attention in 6-8-year-old children compared to those who did not participate in teaching chess [Mijarca, Rendi, 5].

The results of the analysis of the speed of switching attention (according to "Ermakov test") showed a statistically significant increase of this indicator in both groups K and E by 15-25% after the experiment, in comparison with the corresponding values before the experiment (parameter x, Table 1). However, there was no reliable increase in the number of correct button presses for 15 s in group E compared to group K (Table 1), presumably indicating no effect of the selected set of general and special physical exercises on the psychophysiological functions of children in the short-term period (two months). Indeed, the limited number of children and the short time period of the experiment could negatively affect the results of this research, so it is necessary to eliminate these drawbacks in further studies, in order to confirm or refute the obtained results regarding changes in the psychophysiological state of chess players doing physical exercises.

On the other hand, a statistically significant intra-group increase in the speed of switching attention in both groups K and E after the experiment (Table 1) does suggest an important role of chess training in the improvement of psychophysiological state of young chess players in the short-term period, since such a noticeable increase by 15-25% may be hardly observed after two months. For example, Kozina and Abrosimov [37] reported only ~6-17% spontaneous increase in number of correct button presses for 15 s in three attempts of "Ermakov test" for the group V of children, who did not play Go and did not exercise [37]. Besides, the authors Bushuyeva T.V. and Averyanova A.M. showed that the rate of growth of attention features (the level of stability (concentration) of attention and the speed of switching attention by Landolt’s Ring test, the level of concentration of attention by Munsterberg test) in third year school children (age 8-9 years) as compared to that in second year school children (age 7-8 years) is significantly lower than the improvement of attention features during the transition of children from the first (age 6-7 years) to the second (age 7-8 years) school year, and therefore, the spontaneous growth of attention characteristics at the age of 6-7 years is faster than at the age of 7-8 years [Bushuyeva, Averyanova, 49]. In view of the above, a statistically significant intra-group increase in the speed of attention switching in the control group of young chess players aged 7-8 years is less likely to be spontaneous than a similar increase in this parameter in the control group of children aged 6 years in the work of Kozina and Abrosimov [37].

It should be noted that within two months, both the control and experimental groups were introduced to elements of the metacognitive approach in chess training [35], which, in addition to improving chess skills, according to the authors Trincher R. and Robasto D., should also enhance the development of metacognitive abilities in children aged 5-11 years and psychomotor skills in children aged 5-7 years [36]. Thus, the metacognitive chess training combined with participation in chess club’s championships might also contribute to the observed improved psychophysiological functions (according to "Ermakov test", Table 1) of young chess players aged 7-8 years [36].

Interestingly, Stegariu V. and Abalasei B. concluded that the level of concentration of attention and spatial orientation in young chess players of 9 years old (studying chess since the first year of school) were higher than in the control group of school
children who studied French and Health education for two years, and this result came much earlier than the improvement of children's cognitive abilities (i.e. intellectual side of the game) [50]. Similarly, Mijarca R. and Rendi E. reported that children aged 6-8 years who participated in introductory chess lessons for 27 weeks improved the attention quality, visual memory, and logical thinking (manifested by the ability to understand a text) compared to those who were engaged in a preparatory class program (none of whom did physical exercises) [5].

Therefore, due to participating in chess lessons, children aged 9 years improved the level of concentration of attention (according to Stegariu V. and Abalasei B.), and children aged 6-8 years improved quality of attention (according to Mijarca R. and Rendi E.). Notably, given that changes in various attentional features are synchronous, i.e. they increase simultaneously as children grow up, then it should be assumed that the speed of switching attention also increased in the above experimental groups of children who studied chess [5, 50]. Indeed, Bushuyeva and Averyanova [49] studied dynamic changes in attention features in children of elementary school age, and observed the following:

i) a statistically significant (p<0.001) increase in the level of stability (concentration) and the speed of switching attention from low to medium level, as well as the level of concentration of attention — from low to high level in second year school children (age 7-8 years) compared to first year school children (age 6-7 years); ii) a statistically significant (p<0.001) increase in the level of stability (concentration) and the speed of switching attention to a high level, and in the level of concentration of attention — to a very high level in third year school children (age 8-9 years) compared to second year school children [49].

The results of Bushuyeva and Averyanova, indicated a positive correlation between different children’s attention features, i.e., increases in levels of stability (concentration) and concentration of attention were accompanied by an increase in the speed of switching attention.

Therefore, combining together the results of Stegariu and Abalasei [50], Mijarca and Rendi [5], Bushuyeva and Averyanova [49] it can be assumed that the speed of attention switching (according to "Ermakov test", Table 1) in groups K and E of children aged 7-8 years did significantly increase due to chess classes, and not due to other factors that were not taken into account during the experiment.

It is also interesting that children who played Go and did not exercised (group B), showed the most pronounced and statistically significant increase in the speed of attention switching after one month (according to "Ermakov test") compared to group V (children who neither played Go nor exercised), while in group A (children who played Go and exercised) this increase was less pronounced, because number of correct button presses for 15 s in group B at the end of the experiment was significantly higher than in group A [37]. The above results and our data together emphasize the role of intellectual games (but not physical exercises) in the improvement of attention features of children aged 6-8 years in the short-term period, which was also shown by the authors Stegariu and Abalasei [50].

Thus, from the analysis of our results and the works of other researchers, it follows that chess itself (with a strengthened metacognitive approach of teaching chess) may contribute to a rapid improvement in the speed of attention switching (according to "Ermakov test"), and a fast increase in intellectual abilities (according to Schulte test) can be achieved only with the help of a harmonious combination of chess training and physical exercises.

Conclusions

Based on the newly developed online platform, containing the following tasks: Schulte test (5 tables) and the test for determining the reaction time of choosing a point in space — "Ermakov test" (3 attempts, 15 seconds per each attempt), the effect of physical exercises on the cognitive abilities and psychophysiological functions of beginner chess players of 7-8 years old was investigated. In particular, two groups were tested — experimental (E, 10 children) and control (K, 10 children), before and after the experiment. Children of the both groups attended chess clubs 2 times a week for 2 months, and those of the group E, in contrast to the group K, performed a set of physical exercises, including gymnastics in verses "Little Wizards" by Kozina during 25% of chess lesson time.

The obtained results showed that chess itself, as well as chess in combination with physical exercises, induced the reliable growth of children's intellectual abilities (by Schulte test). In particular, the work efficiency parameter was improved for both groups K and E at p<0.05 and p=0.001, by 25 and 35%, respectively, compared to the correspondent values before the experiment. Furthermore, work efficiency increased in group E by 14% at p<0.05
compared to group K, revealing the important role of physical exercises for the best development of cognitive abilities of beginner chess players of elementary school age. In view of the above, it can be recommended to coaches of young chess players to include the above physical exercises in the program of each chess lesson in order to achieve a faster growth of athletes' chess performance (which requires high intellectual activity).

Our results also revealed that chess itself, as well as chess in combination with physical exercises, induced a statistically significant increase in the speed of switching attention (according to "Ermakov test") in both groups K and E by 15' and 22-25%, respectively, compared to the corresponding values before the experiment. However, there was no reliable growth in number of correct button presses for 15 s in group E compared to group K, which may indicate the predominant role of chess itself (in particular, with a strengthened metacognitive approach of teaching chess) for the development of psychophysiological functions in the short-term period. However, further studies are needed to better understand the effect of physical exercises on the speed of switching attention of young chess players.

The results of our work agree with the data of other researchers, reporting the positive effect of chess classes on the cognitive abilities and psychophysiological functions of children [4 — 6, 44]. A new result is that chess lessons in combination with the selected set of physical exercises induced better development of children's intellectual abilities.

In order to develop the most effective training program for the chess club’s students further studies of the impact of physical exercises on cognitive abilities and psychophysiological functions of young chess players are needed. In future experiments it seems reasonable: i) to test a control group of children who don’t play chess and don’t perform physical exercises; ii) to increase number of children in each group and the duration of the experiment; iii) to increase the number of attempts of "Ermakov test" to perform to ≥5, thus enabling calculation of the parameters of the the mobility and stability of nervous processes.

**Acknowledgments**

The authors wish to thank the head chess coaches of the "Bezliudivka" and "Gagarynets" chess schools (Kharkiv region, Ukraine) Kryvoruchenko M.J. and Petrosyanz Ye.P. for the opportunity to perform the experiment. We also are very grateful to the professor of H.S. Skovoroda Kharkiv National Pedagogical University Kozina Z. for the study design and fruitful discussion of the results. The authors really appreciate the help of the researcher Riabchykov S.D. for his essential impact in the design of the online test platform for the investigation of children’s cognitive abilities and psychophysiological functions.

Finally, the authors express their deep gratitude to all children, who participated in the research.

**Conflict of interest**

The authors declare that there is no conflict of interest.

**References**

8. Tachie SA, Ramathe JM. Metacognition application:


38. Ilintsikaya AS, Kozina ZhL, Barybina LN, Kolomiez NA, Cieśliska M, Stankiewicz B, Pilewska W. Author’s internet blog as information and communication technologies in the educational space within the physical education students. Physical education of students. 2014;18(1):22-26


Information about the authors

Dmytro Vus
seagull8887@gmail.com
https://orcid.org/0009-0003-8686-4722
Department of Olympic and professional sports, sports games and tourism,
Laboratory of biophysics, biomechanics and kinesiology,
H.S. Skovoroda Kharkiv National Pedagogical University
Altshevskih str. 29, Kharkiv, 61002, Ukraine

Zhanneta Kozina
zhanneta.kozina@gmail.com
https://orcid.org/0000-0001-5588-4825
Department of Olympic and professional sports, sports games and tourism,
Laboratory of biophysics, biomechanics and kinesiology,
H.S. Skovoroda Kharkiv National Pedagogical University
Altshevskih str. 29, Kharkiv, 61002, Ukraine

Iryna Sobko
sobko.ryina18@gmail.com
https://orcid.org/0000-0002-4920-9775
Department of Olympic and professional sports, sports games and tourism,
Laboratory of biophysics, biomechanics and kinesiology,
H.S. Skovoroda Kharkiv National Pedagogical University
Altshevskih str. 29, Kharkiv, 61002, Ukraine

Sergii Riabchykov
ryabchycov@kipt.kharkov.ua
https://orcid.org/0000-0003-2841-0872
National Science Center Kharkov Institute of Physics and Technology
Academichna Str. 1, Kharkiv, 61000, Ukraine

Інформація про авторів

Дмитро Вус
seagull8887@gmail.com
https://orcid.org/0009-0003-8686-4722
Кафедра олімпійського і професійного спорту, спортивних ігор та туризму,
Лабораторія біофізики, біомеханіки та кінезіології,
Харківський національний педагогічний університет імені Г.С. Сковороди
Вул. Алчевських, 29, Харків, 61002, Україна

Жаннета Козіна
zhanneta.kozina@gmail.com
https://orcid.org/0000-0001-5588-4825
Кафедра олімпійського і професійного спорту, спортивних ігор та туризму,
Лабораторія біофізики, біомеханіки та кінезіології,
Харківський національний педагогічний університет імені Г.С. Сковороди
Вул. Алчевських, 29, Харків, 61002, Україна
Ірина Собко
sobko.iryna18@gmail.com
https://orcid.org/0000-0002-4920-9775
Кафедра олімпійського і професійного спорту, спортивних ігор та туризму,
Лабораторія біофізики, біомеханіки та кінезіології,
Харківський національний педагогічний університет імені Г.С. Сковороди
Вул. Алчевських, 29, Харків, 61002, Україна

Сергій Рябчиков
ryabchycov@kipt.kharkov.ua
https://orcid.org/0000-0003-2841-0872
Національний науковий центр Харківський фізико - технічний інститут
Вул. Академічна, 1, Харків, 61000, Україна

This work is licensed under a Creative Commons Attribution 4.0 International License (CC BY 4.0)