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Original Article

Managing adaptive reserves of the autonomic nervous system in 15-16-year-old hockey players using the pranayama program with qigong exercises

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Abstract
Managing functional status in young ice hockey players is an important task of medical supervision in sports. The study aims to develop a program for increasing the adaptive reserves of the cardiovascular system by using the pranayama program with qigong exercises. Hockey players aged 15-16 years participated in the experiment (attackers and defenders). A program was developed for increasing the reactivity of the parasympathetic nervous system. The pranayama program with qigong elements was used in the competitive training period, three times per week at the end of training sessions. The program includes the following types of qigong exercises: preliminary qigong exercises, basic dynamic pranayama exercises, and breath-holding exercises. Two groups were formed: control (n = 29) and experimental (n = 28). The reactivity of the parasympathetic nervous system was assessed in an active orthostatic test according to the method of V.M. Mikhaylov (2000). The initial type of heart rate regulation was determined according to the method of N.I. Shlyk (2009) for establishing the reactions of the parasympathetic nervous system to breathing exercises. The effect of the Pranayama program on hockey players is expressed as: an increase in the reactivity of the parasympathetic nervous system in type I-II hockey players (the predominance of central mechanisms of heart rate regulation) and the absence of changes in type III-IV players (the predominance of autonomic mechanisms of heart rate regulation). Thus, the effectiveness of the Pranayama program in the competitive period has been proven only for hockey players with moderate and pronounced centralization in heart rate regulation.
Key words: reactivity, parasympathetic nervous system, breathing exercises, athletes, hockey

Introduction

In the long-term sports training of hockey players, the age of 15-16 years corresponds to the stage of sports performance enhancement. At this stage, motor activity becomes more complicated, and sports competition significantly increases (Tretyak V.A., Rotenberg R.B., Bure P.V., Bratash O.V., Sheruimov P.V., Sukhachev E.A., Uryupin N.N., Cherkas S.M., & Bochner D., 2019; Cherepov, E. A., Tseylikman, O. B., 2015). Successful adaptation of the cardiovascular system to physical activity requires increasing the functional reserves of both the peripheral and central components of the system, namely the parasympathetic and sympathetic nervous systems (Mikhaylov V.M., 2000).

There are data on the possibility of an indirect effect on the functional activity of the cardiovascular system through changes in the respiratory system (Kamenev L.I., Borisova O.N., & Kupeev R.V., 2018; Naik, G.S., Gaur, G.S., & Pal, G.K., 2018). Respiratory-cardiac interactions are due to the close functional relationship between the respiratory and cardiovascular bulbar centers. It is known that respiratory rate and tidal volume are associated with heart rate (Tzeng Y.C., Larsen P.D. & Galletly D.C., 2003), which causes respiratory sinus arrhythmia. Especially pronounced respiratory-cardiac interactions are observed during hypoxia. The literature describes that changes in respiratory patterns can affect not only heart rate but also heart rate variability (Gilfriche P., Arsac L.M., Daviaux Y., Diaz-Pineda J., Miard B., Morellec O., & André J.-M., 2018). In general, a decrease in the respiratory rate is associated with an increase in the cardiac period (Bruce E.N., 1996). Some scientists show that athletes have respiratory oscillations in the low-frequency range according to Fourier (Aubert A.E., Seps B., & Beckers F., 2003; Saboul D., Pialoux V., & Hautier C., 2014; Trubachev V.V., Gorbunov A.V., Trubacheva V.S., Nemtseva M.S., & Ogorodnikova M.S., 2015). There is a known phenomenon of cardiorespiratory synchronism proposed by V.M. Pokrovskiy et al. (Pokrovskiy V.M., 2010). Athletes with high fitness levels and stable competitive results are characterized by highly synchronized heart rate and respiration (Mikhaylov V.M., 2000; Młyńczak, M., & Krysztofiak, H., 2018). In youth sports, the range of cardiorespiratory synchronism increases with an increase in the intensity of physical activity, which is shown in studies on 13-14-year old athletes (Aleksanyants G.D, 2004).

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Breathing exercises are used for treatment of cardiovascular and respiratory diseases, vegetative and neurocirculatory dystonia (Alekseeva T.M., Kovzelev P.D., Topuzova M.P., Sergeeva T.V., & Tregub P.P., 2019). In sports, breathing exercises are used to increase the special performance of football players, to improve speed qualities and speed endurance in tennis players (Vysochin Yu.V., Denisenko Yu.P., & Chuev V.A., 2007; Veykut A.G., 2017) to stimulate vagus nerve activity at rest, and to accelerate recovery after stress (You, M., Laborde, S., Salvotti, C., Zammit, N., Mosley, E., & Dosseville, F., 2021).

The gentlest method of hypoxic-hypercapnic effects are breathing exercises from the East, which are widely used in health-enhancing physical activity. A very important principle of the eastern health-enhancing techniques is the control of both breathing and body posture (Razumov A.N., & Namsaraeva, G.T., 2011). In the ancient Chinese system of hatha yoga, there is a type of breathing exercises called "pranayama". Pranayama implies voluntary control of respiration (Saoji, A. A., Raghavendra, B. R., & Manjunath, N. K., 2019). The purpose of such breathing is to teach how to control the rhythm of breathing and to create moderate hypoxemia and hypercapnia. Breath control is also used in Chinese qigong exercises. The first qigong technique is breathing regulation, the second one is body posture regulation (Kwan O.A., 2007), which can help a hockey player to synchronize not only cardiac and respiratory rhythm but also improve the coordination of breath and movement.

Moreover, in our previous studies, it was found that the reactivity of the parasympathetic nervous system of 15-16-year-old hockey players in response to orthostasis was better than those of 13-14-year-olds but still remained worse than in 16-year-old elite ice hockey players from the national team (Surina-Marysheva, E., Erlikh, V., Medvedeva, I., Korableva, Y., & Kantyukov, S., 2018).

The aim of the study is to develop and test a program for increasing the adaptive reserves of the cardiovascular system through the use of pranayama exercises with qigong exercises.

Materials & Methods

Hockey players aged 15-16 years with a training experience of 9-10 years participated in the study (n = 57, forwards and defenders). In accordance with the Declaration of Helsinki, a voluntary informed written consent was obtained from the parents of hockey players. The study was approved by the university's ethics committee. Cardiac rhythm was recorded in the morning, 1.5-2.0 hours after eating.

The "Pranayama with qigong exercises" program was applied for six months 3 times a week in the final part of the training sessions. The duration of the program was 25-30 minutes. Two groups were randomly formed: control (n = 29) and experimental (n = 28). The technology for increasing the adaptive reserves was chosen to meet the following requirements: the program was performed simultaneously by a group of 20-25 players at the place of training; non-invasiveness of the means used; low energy cost of exercise. The initial type of heart rate regulation was determined by using the express method (Shlyk N.I., 2009). There are types with a moderate (type I) and significantly pronounced (type II) predominance of central regulatory mechanisms, as well as the types with a moderate (type III) and significantly pronounced (type IV) predominance of autonomous regulatory mechanisms. At the beginning of the program, the number of type I and II players was 24% (n = 7) in the control group and 46% (n = 13) in the experimental group. The number of type III and IV hockey players was 76% (n = 22) and 53%, respectively. In the control group, the final part of the training sessions was carried out according to the standard program, while in the experimental group the pranayama program was used. Pranayama training sessions were conducted by special instructors.

The Pranayama program. Preliminary qigong exercises. The 1st level of Zhong Yuan Qigong exercises were used, namely: “A child praying to Buddha”, “Hands of Buddha observing images”, “The divine dragon stirring sea” and “Hot sand” (Stepanyants M.T., 2001). Basic dynamic pranayama exercises. The basic exercises were: "Wave-like breathing"; "Lower (abdominal) breathing"; "Middle breathing"; "Upper breathing" and deep rhythmic breathing. Mantras: "Om Mani Padme Hum", Avalokitesvara six-syllable mantra (Feuerstein G., 2002). Breath-holding exercises. The following types of breath holding exercises were used: Breath holding during exhalation, Intensive breath holding, Breath holding during full inhalation (Kim D.T., 2002). Breathing exercises with visualization. Breathing exercises were used, which also require the activation of various analyzers (Kim D.T., 2000). Exercises for concentration of attention (Vostokov V.N., 2005).

The method of V. Mikhaylov for determining the reactivity of the parasympathetic nervous system in response to orthostasis by means of the 30:15 ratio. The reactivity of the parasympathetic nervous system was measured using an active orthostatic test. All measurements were performed with the VNS-Micro ECG system (Russia). Data recording started with the fifth systole after the transition from a prone position to a standing position within one minute. As a result of such a transition, a part of the circulating blood goes to the lower extremities, which leads to a decrease in venous return. To maintain hemodynamics, a number of regulatory mechanisms are sequentially activated in response. During the first 15 heart contractions, an increase in the heart rate (HR) occurs, due to the release of catecholamines, then the mechanisms of baroreflex regulation are activated. Therefore, the activity of the parasympathetic nervous system increases with a simultaneous decrease in heart rate. The data obtained during the orthostatic test demonstrates that the so-called "hollow" appears approximately at the 15th systole and a "small peak" - at the 30th systole (Figure 1). After this, the sympathetic nervous system is activated, which causes an increase in heart rate and a decrease in cardiac intervals. Then the renin-angiotensin-aldosterone mechanism is activated, which results in heart rate recovery. The 30:15 ratio is calculated as the ratio of the maximum value of the R-R interval (approximately 30th systole after the transition to a standing position) to the minimum value (approximately 15th systole). The ratio characterizes the reactivity of the parasympathetic nervous system. Reference values: 1.25-1.75 - normal reaction; 1.0-1.25 - delayed response; less than 1.0 is a paradoxical reaction.

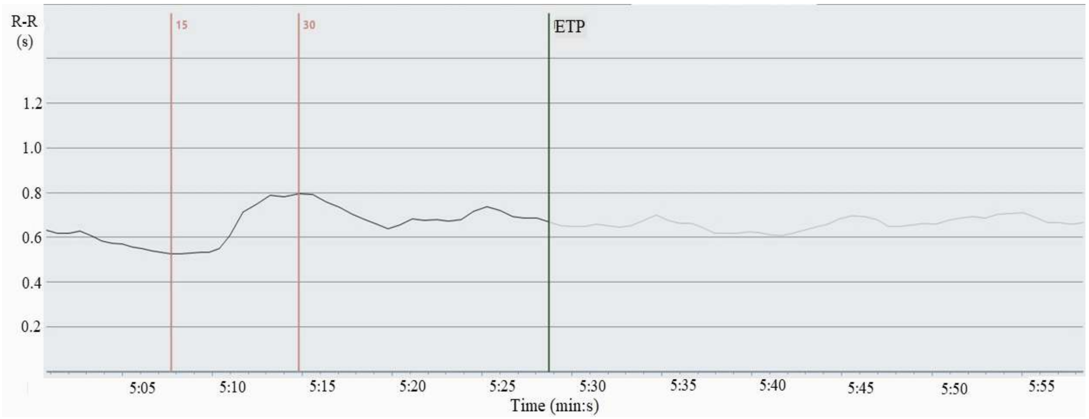

Figure 1. The 30:15 ratio calculation. Note: ETP – End of the period of transition

Statistical processing of the data obtained was carried out by nonparametric methods according to the Mann-Whitney and Wilcoxon criteria in the Statistica 10.0 program.

Results

After the Pranayama training program, in the hockey players of the experimental group, there was an increase in the 30:15 ratio. Statistically significant differences were recorded both within the experimental group and between groups (Table 1).

Table 1 - Dynamics of the 30:15 ratio in response to orthostasis in hockey players 15-16 years old

Group	Period		p_1 p_2
	July M±m; SD	February M±m; SD	
Control (n=29)	1.26±0.04; 0.22	1.23±0.03; 0.17	p_1 =0.552 (W)
Experimental (n=28)	1.28±0.05; 0.26	1.40±0.05; 0.27	p_2 =0.031 (W)
p_3; p_4	p_1 =0.880 (M-U)	p_2 =0.014 (M-U)	

Note: p1 - statistical significance of differences between indicators in the control group (July-February); p2 - statistical significance of differences between indicators in the experimental group (July-February); p3 - statistical significance of differences between indicators of the control and experimental groups (July); p4 - statistical significance of differences between indicators of the control and experimental groups (February); M-U - Mann-Whitney test for unrelated samples; W - Wilcoxon test for related samples.

In percentage terms, the increase in the 30:15 ratio by February was 68% in the experimental group and 45% in the control group (Figure 2).

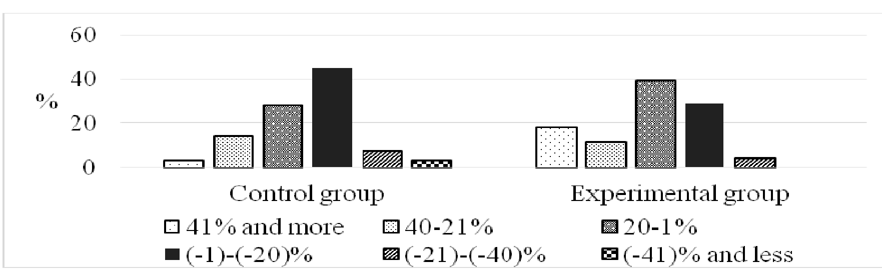

Figure 2 - In-group distribution of the 30:15 ratio in hockey players aged 15-16 years in February compared to July (%)

When analyzing the changes in the 30:15 ratio depending on the type of regulation, it was revealed that in type I-II hockey players by February, the changes were similar to the dynamics in the experimental group (Table 2). When analyzing the in-group dynamics, it was revealed that the 30:15 ratio in the experimental group increased in 77% of the hockey players, of which the increase of more than 20% was recorded in 39% of the players (Figure 3). In the control group, these changes were different and amounted to 43% and 14%, respectively.

Table 2 - Dynamics of the 30:15 ratio in response to orthostasis in type I-II hockey players

Group	Period		p_1 p_2
	July M±m; SD	February M±m; SD	
Control (n=7)	1.27±0.09; 0.25	1.23±0.04; 0.10	p_1 =0.600 (W)
Experimental (n=13)	1.19±0.05; 0.19	1.39±0.08; 0.27	p_2 =0.050 (W)
p_3; p_4	p_3 =0.393 (M-U)	p_4 =0.211 (M-U)	

Note: p1 - statistical significance of differences between indicators in the control group (July-February); p2 - statistical significance of differences between indicators in the experimental group (July-February); p3 - statistical significance of differences between indicators of the control and experimental groups (July); p4 - statistical significance of differences between indicators of the control and experimental groups (February); M-U - Mann-Whitney test for unrelated samples; W - Wilcoxon test for related samples.

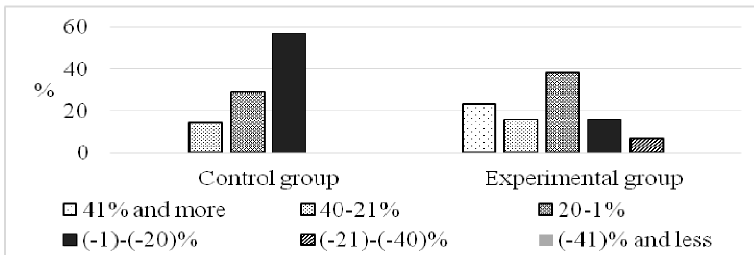

Figure 3 - In-group distribution of the 30:15 ratio in type I-II hockey players in February compared to July (%)

In the dynamics of sports training (July-February), in type III-IV hockey players of both groups, there were no changes in the reactivity of the parasympathetic nervous system in response to orthostasis (Table 3). However, in February, intergroup differences were recorded (Table 3).

Table 3 - Dynamics of the 30:15 ratio in response to orthostasis in type III-IV hockey players

Group	Period		p_1 p_2
	July M±m; σ	February M±m; σ	
Control (n=22)	1.25±0.05; 0.22	1.24±0.04; 0.19	p_1 =0.702 (W)
Experimental (n=15)	1.35±0.07; 0.29	1.40±0.07; 0.28	p_2 =0.182 (W)
p_3; p_4	p_3 =0.421 (M-U)	p_4 =0.043 (M-U)	

Note: p1 - statistical significance of differences between indicators in the control group (July-February); p2 - statistical significance of differences between indicators in the experimental group (July-February); p3 - statistical significance of differences between indicators of the control and experimental groups (July); p4 - statistical significance of differences between indicators of the control and experimental groups (February); M-U - Mann-Whitney test for unrelated samples; W - Wilcoxon test for related samples.

The intragroup distribution according to the dynamics of the 30: 15 ratio in type III-IV hockey players of both groups did not fundamentally differ (Figure 4). The increase in the 30:15 ratio of more than 20% from the initial level was recorded in 23% of the control group and in 40% of the experimental group.

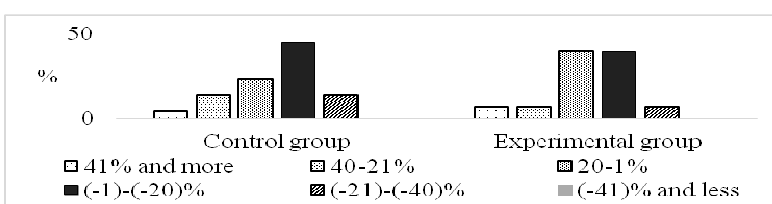

Figure 4 - In-group distribution of the 30:15 ratio in type III-IV hockey players in February compared to July (%)

Discussion

The reactivity of the parasympathetic nervous system in response to orthostasis in hockey players 15-16 years old was initially less in terms of the 30:15 ratio compared to their peers from the national team (Mikhayjlov V.M., Fil'kina O.M., & Shanina T.G., 2009; Surina-Marysheva E.F., Erlikh V.V., Korablyova Y.B.,

Krivokhizhina L.V., & Kantyukov S.A, 2018; Surina-Marysheva, E., Erlikh, V., Krivokhizhina, L., Marchenko, K., & Kantyukov, S., 2019). At the same time, the 30:15 ratio is significant in predicting sports performance (Surina-Marysheva E., Erlikh V., Medvedeva I., Korableva Y., & Kantyukov S., 2018).
The use of the Pranayama program contributed to an increase in the reactivity of the parasympathetic nervous system, as well as to an increase in the adaptive reserves of the regulatory component of the cardiovascular system in type I-II hockey players. For type III-IV hockey players, the changes were minor. It is believed that respiratory sinus arrhythmia, which inevitably occurs during breathing exercises, reflects primarily vagal activity, since afferentation from irritant receptors and intrathoracic pressure is transmitted to the nucleus of tractus solitarii through the vagus nerve. The synaptic relay from the nucleus of tractus solitarii ambiguously represents the beginning of the efferent path of the vagus nerve to the sinoatrial node. The heartbeat slows down during expiration, when positive intrapulmonary pressure stimulates the pressure receptors, and increases during inspiration when the pressure decreases. It is known that with deep slow breathing at a rate of 6 cycles per minute (0.1 Hz), respiratory sinus arrhythmia is maximal, which is due to synchronization with the baroreflex frequency (Vaschillo E.G, Vaschillo B., & Lehrer P.M., 2006). Moreover, the power of high-frequency spectrum waves has a close relationship with respiration, which leads to a pronounced respiratory sinus arrhythmia in athletes (Mikhaylov V.M., 2000) and indicates a high plasticity of the nerve centers involved in cardiorespiratory interactions.

Regular training increases both functional reserves and the plasticity of cardiorespiratory interactions (Trubachev V.V., Gorbunov A.V., Trubacheva V.S., Nemtseva M.S., & Ogorodnikova M.S., 2015), which allows to quickly adjust the performance of all body systems to meet energy needs. However, at the age of 15-16 years, an increase in the adaptive reserves of the parasympathetic nervous system under the influence of eastern breathing exercises occurred only in type I-II hockey players, in whom, on the contrary, respiratory sinus arrhythmia is less pronounced (low-frequency and very low-frequency oscillations prevail in cardiac rhythm). Apparently, this is an age-related feature of the autonomic nervous system of type I-II players. Reduced background activity of autonomic regulatory mechanisms in type I-II hockey players at this age can be compensated by an increase in the functional reserves of the parasympathetic nervous system. In case of exposure on the mechanisms of cardiorespiratory interaction of the bulbar centers of the autonomic nervous system there is an increase in the excitability of n.vagus centers in the baroreflexes of hemodynamic regulation. The high background autonomic activity of the parasympathetic nervous system even at rest, apparently, does not allow to achieve the same changes in type III-IV hockey players aged 15-16 years.

Conclusion

The use of eastern breathing exercises in the competitive period of training contributes to an increase in the adaptive reserves of the parasympathetic nervous system in 15-16-year-old hockey players with a predominance of central mechanisms of heart rate regulation. For hockey players with moderate and pronounced autonomy in heart rate regulation, the effectiveness of the Pranayama program has not been proven, which requires further research with different exercise intensity or duration. The results obtained can be used for developing the programs of medical supervision for young hockey players.

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References

Tretyak V.A., Rotenberg R.B., Bure P.V., Bratash O.V., Sheruimov P.V., Sukhachev E.A., Uryupin N.N., Cherkas S.M., & Bochner D. (2019) National program of hockey training. Moscow: Russian Ice Hockey Federation.

Cherepov, E. A., Tseylikman, O. B. (2015). Dynamics of stress tolerance of pupils within sportized physical education. Teoriya i Praktika Fizicheskoy Kultury, 2015-January (9), pp. 97-99.

Mikhaylov V.M. (2000) Heart rate variability. Practical experience. Ivanovo: Publishing house of the Ivanovo state medical Academy

Młyńczak, M., & Krysztofiak, H. (2018). Discovery of causal paths in cardiorespiratory parameters: a time-independent approach in elite athletes. *Frontiers in physiology*, *9*, 1455.

Kamenev L.I., Borisova O.N., & Kupeev R.V. (2018) Mechanosensory respiratory muscles in sanatorium practice. *Journal of new medical technologies*: eEdition, 2, pp.165-170.

Naik, G. S., Gaur, G. S., & Pal, G. K. (2018). Effect of modified slow breathing exercise on perceived stress and basal cardiovascular parameters. *International journal of yoga*, *11*(1), 53.

Tzeng Y.C., Larsen P.D. & Galletly D.C. (2003) Cardioventilatory coupling in resting human subjects. *Exp. Physiol.* 88, pp.775–782

Gilfriche P., Arsac L.M., Daviaux Y., Diaz-Pineda J., Miard B., Morellec O., &André J.-M. (2018) Highly sensitive index of cardiac autonomic control based on time-varying respiration derived from ECG. *Am J Physiol Regul Integr Comp Physiol.* Sep;315(3), R469–78.

Bruce E.N. (1996) Temporal variations in the pattern of breathing. *J. Appl. Physiol.* 80, pp.1079–1087

Aubert A.E., Seps B., & Beckers F. (2003) Heart rate variability in athletes. Sports Med., 33(12), pp.889-919

Saboul D., Pialoux V., & Hautier C. (2014) The breathing effect of the LF/HF ratio in the heart rate variability measurements of athletes. *Eur. J. Sport Sci,* 14(Suppl.1), pp. S282-288

Trubachev V.V., Gorbunov A.V., Trubacheva V.S., Nemtseva M.S., & Ogorodnikova M.S. (2015) Analysis of respiratory-cardiac interactions in athletes and non-athletes with an imposed respiratory rate. *Russian Journal of Physiology,* 101(2), pp. 238-248

Pokrovskiy V.M. (2010) Cardiorespiratory synchronism in the assessment of the regulatory and adaptive capacities of the body (edited by V.M. Pokrovskiy). Krasnodar: Kuban-kniga publishing house.

Aleksanyants G.D. (2004) Use of phenomenon of cardiorespiratory synchronism for estimation of regulative-adaptive opportunities of organism of young athletes. *Theory and Practice of Physical Culture,* 8, pp. 25-26.

Alekseeva T.M., Kovzelev P.D., Topuzova M.P., Sergeeva T.V., & Tregub P.P. (2019) Hypercapnic-hypoxic respiratory training as a method of post-conditioning in stroke survivors*. Arterial'naya Gipertenziya (Arterial Hypertension),* 25(2), pp. 134-142.

Vysochin Yu.V., Denisenko Yu.P., & Chuev V.A. (2007) Physiological foundations of special training of football players. Naberezhnye Chelny: KamGIFK Publishing House.

Veykut A.G. (2017) Development of high-speed endurance in tennis players by means of respiratory technologies. *Bulletin of the Adyghe State University*. 203 (3), pp. 114-119

You, M., Laborde, S., Salvotti, C., Zammit, N., Mosley, E., & Dosseville, F. (2021). Influence of a single slow-paced breathing session on cardiac vagal activity in athletes. *International Journal of Mental Health and Addiction*, 1-13.

Razumov A.N., & Namsaraeva G.T. (2011) Natural Philosophical Foundations and Genesis of Qigong, Indian and Tibetan Yoga. Enduring empirical effectiveness. *Voprosy kurortologii, fizioterapii i lechebnoy fizicheskoy kul'tury.* 1, pp. 34-38.

Saoji, A. A., Raghavendra, B. R., & Manjunath, N. K. (2019). Effects of yogic breath regulation: A narrative review of scientific evidence. *Journal of Ayurveda and integrative medicine*, *10*(1), 50-58.

Kwan O.A. (2007) Theory and methodology of health-improving Chinese gymnastics Zhong Yuan Qigong. Chelyabinsk: Publishing House of the Ural State University of Physical Culture.

Surina-Marysheva, E., Erlikh, V., Medvedeva, I., Korableva, Y., & Kantyukov, S. (2018). Heart rate variability features in elite hockey players aged 15–16 and sports selection efficiency in youth ice hockey. *Human*. *Sport*. *Medicine*, 18(4), pp.47-51.https://doi.org/10.14529/hsm180407

Shlyk N.I. (2009) Heart rate and type of regulation in children, adolescents and athletes. Izhevsk: Publishing house "Udmurtia University"

Stepanyants M.T. (2001) Eastern Philosophy: An Introductory Course. Moscow: Vostochnaya literatura.

Feuerstein G. (2002) The Encyclopedia of Yoga. Moscow: Fair-Press.

Kim D.T. (2000) The use of eastern health-improving systems in the professional training of specialists. Khabarovsk: Ves' mir publishing house.

Vostokov V.N. (2005) *Your yoga. Tashkent: Uzbekistan*

Mikhayjlov V.M., Fil'kina O.M., & Shanina T.G. (2009) Heart rate variability physiological norm parameters limits in healthy teenagers in dependence of sex and training level. *Ultrasound and functional diagnostics*, 3, pp. 67-73

Surina-Marysheva E.F., Erlikh V.V., Korablyova Y.B., Krivokhizhina L.V., & Kantyukov S.A (2018) Heart rate variability in 13-16-year-old hockey players *Gazzetta Medica Italiana Archivo per le Scienze Mediche*, 177(3), pp.88-96

Surina-Marysheva, E., Erlikh, V., Krivokhizhina, L., Marchenko, K., & Kantyukov, S. (2019). Features of heart rate variability in hockey players aged 15-16 years in sports training. *Journal of Physical Education and Sport*, *19*(4), 2533-2538.

Vaschillo E.G., Vaschillo B., &Lehrer P.M. (2006) Characteristics of resonance in heart rate variability stimulated by biofeedback *Appl Psychophysiol Biofeedback*, 31(2), pp.129-142