

Autonomic support of central hemodynamics and physical working capacity in female swimmers and runners in a one-year training cycle

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swimming at a distance of 50–200 m, running at a distance of 400 m, women, sport qualification from third-class to Master of Sports of International Class, heart rate variability, central hemodynamics, physical performance, periods of the training process.

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The aim of the work is to assess dynamic changes in heart rate variability (HRV), central hemodynamics and physical performance in female swimmers at a distance of 50–200 meters and female runners at a distance of 400 meters in the preparatory and competitive periods of the training process.

Materials and methods. At the beginning of the preparatory period and at the end of the competitive period, 11 female swimmers were examined, including 1 athlete – Master of Sports of Ukraine (MSU), 7 athletes – Candidate Masters of Sports (CMS), 1 – first-class athlete, 2 – second-class athletes, and 22 female runners, including 1 athlete – Master of Sports of Ukraine of International Class (MSUIC), 3 athletes – Candidate Masters of Sports, 7 first-class athletes, 8 – second-class athletes and 3 – third-class athletes.

Time- and frequency domain methods of HRV analysis were used to assess the mechanisms of heart neurohumoral regulation. Central hemodynamic parameters were examined by an automated tetrapolar rheography according to W. Kubiček et al. (1970) modified by Yu. T. Pushkar et al. (1970). Physical working capacity (PWC) was measured using a submaximal PWC₁₇₀ test. The functional state index (FSI) was calculated according to the formula that we had proposed and patented.

Results. Analysis of HRV indices in female swimmers revealed the prevalence of parasympathetic influences in the competitive period. There was a central hemodynamics-related significant decrease in cardiac index (CI) in the competitive period, although its value corresponded to the eukinetic circulatory type (CT). The ratio of CTs was 18.2 %: 81.8 %: 0.0 %, hypokinetic, eukinetic and hyperkinetic CT, respectively, indicating a tendency towards eukinetic CT prevalence over hypokinetic one ($P = 0.075$) and the absence of athletes with physiologically unfavorable hyperkinetic CT. The PWC_{170kg} value increased by an average of 12.44 %, from $12.860 \pm 0.732 \text{ kgm} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ to $14.460 \pm 0.823 \text{ kgm} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ ($P = 0.002$), and FSI – of 22.21 % ($P = 0.0005$) and corresponding to “below average” score. In the competitive period, 2 CMS female athletes qualified for MSU, 1 first-class athlete qualified for CMS, and 2 second-class athletes achieved the first-class sport qualification.

Conclusions. Female swimmers demonstrated the significant prevalence of parasympathetic effects of the ANS, the tendency towards the eukinetic CT predominance and the absence of hyperkinetic CT, significantly increased PWC_{170kg} value by 12.44 % and FSI – by 22.21 % in the competitive period as compared with the preparatory period. The correlation analysis to assess both periods revealed the important relationship between heart rate (HR) and autonomic rhythm index (ARI), HR and indicator of the adequacy of regulation processes (IARP), indicating that training-induced bradycardia shifted the autonomic balance towards the predominance of the parasympathetic arm of the ANS. Decreased ARI caused the decrease in CI, resulting in the transformation of hyperkinetic CT into eukinetic one and the absence of physiologically unfavorable hyperkinetic CT in the athletes. The increased functional state of female swimmers in the competitive period helped to achieve improvements in their athletic performance.

Ключові слова:

плавання на дистанції 50–200 м, біг на дистанції 400 м, жінки, кваліфікація від III розряду до майстра спорту міжнародного класу, варіабельність серцевого ритму, центральна гемодинаміка, фізична працездатність, періоди тренувального процесу.

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Вегетативне забезпечення центральної гемодинаміки та фізичної працездатності плавчих і жінок-бігунів у річному циклі тренувального процесу

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Мета роботи – оцінювання динамічних змін показників варіабельності серцевого ритму (ВСР), центральної гемодинаміки та фізичної працездатності у представниць плавання на дистанції 50–200 м і жінок-бігунів на 400 м у підготовчому і змагальному періодах тренувального процесу.

Матеріали та методи. На початку підготовчого та повторно наприкінці змагального періоду обстежили 11 плавчих (1 майстер спорту України, 7 кандидатів у майстри спорту (КМС), 1 першорозрядниця, 2 спортсменки II розряду) та 22 жінок-бігунів (1 майстер спорту України міжнародного класу, 3 КМС, 7 першорозрядниць, 8 спортсменок II розряду, 3 – III розряду).

Для оцінювання стану механізмів нейрогуморальної регуляції серця використовували математичний і спектральний методи аналізу ВСР. Центральну гемодинаміку вивчали методом автоматизованої тетраполярної реографії за W. Kubiček et al. (1970) у модифікації Ю. Т. Пушкаря та співавт. (1970). Фізичну працездатність визначали з використанням субмаксимального тесту PWC₁₇₀. ІФС розраховували за формулою, що запропонована та запатентована авторами.

Результати. Аналіз показників ВСР у плавчих показав превалювання у змагальному періоді парасимпатичних впливів АНС. З боку центральної гемодинаміки у змагальному періоді, незважаючи на те, що величини серцевого індексу відповідали еукінетичному типу кровообігу (ТК), відбулося вірогідне зменшення СІ. Співвідношення між гіпокінетичним, еукінетичним і гіперкінетичним ТК – 18,2 %: 81,8 %: 0,0 % відповідно; отже, є тенденція до переважання еукінетичного ТК над гіпокінетичним ($p = 0,075$) і відсутності спортсменок із фізіологічно невігідним гіперкінетичним ТК. Величина PWC_{170kg} збільшилася в середньому на 12,44 % (з $12,860 \pm 0,732 \text{ кгм} \cdot \text{хв}^{-1} \cdot \text{кг}^{-1}$ до $14,460 \pm 0,823 \text{ кгм} \cdot \text{хв}^{-1} \cdot \text{кг}^{-1}$, $p = 0,002$), а ІФС – на 22,21 % ($p = 0,0005$), що відповідає оцінці «нижче середньої». У змагальному періоді 2 спортсменки кваліфікації КМС виконали норматив майстра спорту України, одна першорозрядниця стала КМС, а дві спортсменки, які мали II розряд, – першорозрядницями.

Висновки. У змагальному періоді, порівнюючи з підготовчим, у представниць плавання виявили вірогідне превалювання парасимпатичних впливів АНС, тенденцію до переважання еукінетичного ТК із відсутністю спортсменок із гіперкінетичним ТК, вірогідне підвищення PWC_{170kr} на 12,44 % та ИФС на 22,21 %. Кореляційний аналіз, здійснений в обох періодах, показав важливий зв'язок між ЧСС і ВПР, ЧСС і ПАПР, а це свідчить, що брадикардія, яка розвивається під впливом фізичних тренувань, зміщує вегетативний баланс у бік переважання парасимпатичного відділу АНС. Зниження ВПР призводить до зменшення СИ, що спричиняє трансформацію гіперкінетичного ТК в еукінетичний, і відсутності спортсменок із фізіологічно невігідним гіперкінетичним ТК. Підвищення функціонального стану пловчих у змагальному періоді сприяло зростанню спортивних результатів.

Вегетативное обеспечение центральной гемодинамики и физической работоспособности пловчих и бегуний в годовом цикле тренировочного процесса

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Цель работы – оценка динамических изменений показателей variability сердечного ритма, центральной гемодинамики и физической работоспособности у представительниц плавания на дистанции 50–200 м и бегуний на 400 м в подготовительном и соревновательном периодах тренировочного процесса.

Материалы и методы. В начале подготовительного и повторно в конце соревновательного периода обследовали 11 пловчих (1 мастер спорта Украины, 7 кандидаток в мастера спорта (КМС), 1 перворазрядница, 2 спортсменки II разряда) и 22 бегуний (1 мастер спорта Украины международного класса, 3 КМС, 7 перворазрядниц, 8 спортсменок II разряда и 3 – III разряда).

Для оценки состояния механизмов нейрогуморальной регуляции сердца использовали математический и спектральный методы анализа ВСР. Центральную гемодинамику изучали методом автоматизированной тетраполярной реографии по W. Kubicek et al. (1970) в модификации Ю. Т. Пушкаря и соавт. (1970). Физическую работоспособность определяли с использованием субмаксимального теста PWC_{170kr} . ИФС рассчитывали по формуле, предложенной и запатентованной авторами.

Результаты. Анализ показателей ВСР у пловчих показал превалирование в соревновательном периоде парасимпатических влияний АНС. Со стороны центральной гемодинамики в соревновательном периоде, несмотря на то, что величина сердечного индекса соответствовала эукинетиному ТК, произошло достоверное уменьшение СИ. Соотношение между гипокинетическим, эукинетиным и гиперкинетиным типом кровообращения (ТК) – 18,2 %: 81,8 %: 0,0 % соответственно, что свидетельствовало о тенденции к превалированию эукинетиного ТК над гипокинетическим ($p = 0,075$) и отсутствию спортсменок с физиологически невыгодным гиперкинетиным ТК. Величина PWC_{170kr} увеличилась в среднем на 12,44 % ($с 12,860 \pm 0,732 \text{ кгм} \cdot \text{мин}^{-1} \cdot \text{кг}^{-1}$ до $14,460 \pm 0,823 \text{ кгм} \cdot \text{мин}^{-1} \cdot \text{кг}^{-1}$, $p = 0,002$), а ИФС – на 22,21 % ($p = 0,0005$) и соответствовал оценке «ниже средней». В соревновательном периоде 2 спортсменки квалификации КМС выполнили норматив мастера спорта Украины, одна перворазрядница стала КМС, а две спортсменки II разряда – перворазрядницами.

Выводы. В соревновательном периоде по сравнению с подготовительным у представительниц плавания выявили достоверное превалирование парасимпатических влияний АНС, тенденцию к превалированию эукинетиного ТК с отсутствием спортсменок с гиперкинетиным ТК, достоверное повышение PWC_{170kr} на 12,44 % и ИФС на 22,21 %. Корреляционный анализ, проведенный в обоих периодах, показал важную связь между ЧСС и ВПР, ЧСС и ПАПР, свидетельствующую о том, что развивающаяся под воздействием физических тренировок брадикардия смещает вегетативный баланс в сторону преобладания парасимпатического отдела АНС. Снижение ВПР обуславливает уменьшение СИ, приводящего к трансформации гиперкинетиного ТК в эукинетиный, и отсутствие спортсменок с физиологически невыгодным гиперкинетиным ТК. Повышение функционального состояния пловчих в соревновательном периоде способствовало росту спортивных результатов.

Ключевые слова:

плавание на дистанции 50–200 м, бег на дистанции 400 м, женщины, квалификация от III разряда до мастера спорта международного класса, variability сердечного ритма, центральная гемодинамика, физическая работоспособность, периоды тренировочного процесса.

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The most important feature of sports medicine is dynamic functional variations in the state of athletes throughout a sports season with the most expressed shifts in the competitive period with their return to standards in the transition period, when athletes almost do not train [2]. This fact is of great interest for specialists in sports medicine since it allows tracing changes in the functional state of athletes in the one-year training cycle as their athletic performance improves [4]. However, many of these examinations are complicated by some organizational constraints arising from a lack of motivation among athletes who were already officially allowed to compete, or those participating in a sports training camp in another area, to be repeatedly examined with loading tests or additionally prior to the responsible start [9]. This would explain, among other things, the small number of athletes in the examined groups and relatively few of these studies [4–9].

In the available to us national and foreign sports medicine literature, we have not found studies on the dynamic

state of heart rate variability (HRV), central hemodynamics and physical performance in female swimmers at a distance of 50–200 meters. Therefore, as a comparison, we used data obtained from the examination of 400-meter female runners with corresponded sports qualifications.

Running was chosen for comparison to analyze and discuss the results based not on the gradations of sprinters or middle-distance runners, but on the time of maximum intensity exercise performed by athletes at a competitive distance and the predominance of cyclic exercise with anaerobic-glycolytic pathway in the training process.

Even though female swimmers compete in the range of event distances (from 50 to 200 meters), it is worth mentioning that a 100-meter distance is the most basic and frequent, which is covered in 58.50–133.5 s depending on the sports qualifications and swimming stroke. The selected for comparison female runners were qualified from MSIC to third-class athletes and covered the distance of 400 meters

in 51.35–107.0 s, this means that the time spent to cover the competitive distance could be considered equal.

Limited number of studies on the dynamic indices of HRV, central hemodynamics and physical performance in athletes during the preparatory and competitive periods of the training process as well as the lack of dynamic examinations among female swimmers have led us to conduct this study.

Aim

The aim of the work is to assess dynamic changes in HRV, central hemodynamics and physical performance in female swimmers at the distance of 50–200 meters and female runners at the distance of 400 meters in the preparatory and competitive periods of the training process.

Materials and methods

A sample ($n = 11$) was formed from the group of female swimmers ($n = 44$) qualifying Master of Sports of International Class (MSIC), Master of Sports (MS), Candidate Master of Sports (CMS), first- and second-class athletes. The mean age of the participants was 14.80 ± 0.44 years, the swimming experience was 7.30 ± 0.59 years. The athletes were examined at the beginning of the preparatory period and at the end of the competitive period in the one-year training cycle. At the beginning of the preparatory period, the group of female swimmers consisted of 1 athlete qualified for Master of Sports of Ukraine, 7 CMS athletes, 1 first-class athlete and 2 second-class athletes.

The comparison group was represented by 22 female runners at a distance of 400 m (mean age 16.80 ± 0.67 years, running experience – 4.40 ± 0.68 years). In the preparatory period of the training cycle, this group consisted of 1 MSIC athlete, 3 CMS athletes, 7 first-class athletes, 8 second-class athletes and 3 third-class athletes.

Time- and frequency domain methods of HRV analysis were used to assess the mechanisms of heart neurohumoral regulation, activity of segmental and suprasegmental levels of the autonomous nervous system (ANS) [4]. 5-min short-term ECG recordings were used in accordance with the International Standard [10].

ANS indicators were analyzed using stress-index (SI) as an integral indicator of HRV. According to the recommendation of R. M. Baevskii [1], vagotonia was verified if the SI was less than 50 relative units (r. u.), eutonia – if the SI was within the range of 51–99 r. u. and sympathicotonia – if the SI was more than 200 r. u.

Central hemodynamics was examined by an automated tetrapolar rheography according to W. Kubiček et al. (1970) Yu. T. Pushkar's et al. modified (1970). Stroke volume (SV) and cardiac output (CO), stroke volume index (SVI) and cardiac index (CI), systemic vascular resistance (SVR) and systemic vascular resistance index (SVRI) were calculated.

Physical working capacity (PWC) was measured using a common technique on a cycle ergometer via submaximal PWC₁₇₀ test [11], and a relative value of physical working capacity (PWC_{170/kg}) was calculated. The functional state index (FSI) was estimated according to the formula proposed and patented by the authors [9].

Statistical analysis was performed using Statistica 13 for Windows (StatSoft Inc., license No. JPZ804I382130ARCN10-J). All data were expressed as mean (M) \pm standard error (m). The significance of differences was analyzed by two-tailed t-test. The difference between two subsets of data was considered statistically significant at a level of P (P-value) less than 0.05. Pairwise Pearson correlation was used to analyze the association between HRV indices, central hemodynamics and PWC parameters.

Results

It is known that the assessment of HRV is the most objective, informative and sensitive method for evaluating the functional state and sports physical preparedness.

Analysis of HRV indices in the preparatory and competitive periods of the training process among female swimmers showed a significant increase in mode (Mo) from 0.785 ± 0.040 s to 0.900 ± 0.058 s, ($P = 0.004$), representing the correspondence between the level of the cardiovascular system functioning, and a decrease in indicator of the adequacy of regulation processes (IARP) from 42.161 ± 4.500 %/s to 36.028 ± 4.011 %/s ($P = 0.038$), indicating a correspondence between the level of sinus node functioning and sympathetic activity. These two indices pointed out directly the prevalence of the parasympathetic influences of the ANS in the competitive period. The parasympathetic arm of the ANS tended to prevail based on changes in most of the other time-domain HRV indices, albeit not statistically significant. Thus, in the competitive period, there was a downward trend in amplitude mode (AMo) from 31.379 ± 2.700 % to 29.366 ± 2.365 % ($P = 0.182$), autonomic rhythm index (ARI) from 3.401 ± 0.182 1/s² to 3.307 ± 0.443 1/s² ($P = 0.752$), SI from 61.397 ± 22.781 r. u. to 51.875 ± 10.346 r. u. ($P = 0.124$).

According to the classification proposed by R. M. Baevskii [1], 4 athletes were identified with vagotonia (36.4 %), 6 athletes – with eutonia (54.5 %) and 1 athlete (9.1 %) – with sympathicotonia, thereby affirming the trend towards the prevalence of athletes with eutonia over vagotonics ($P = 0.574$) and sympathotonics ($P = 0.221$) in the preparatory period. In the competitive period, the ratio between the values of the autonomic tone was as follows: 54.5 %: 45.5 %: 0.0 %, vagotonics, eutonics and sympathotonics, respectively, so a favorable trend to the prevalence of vagotonics over eutonics was found ($P = 0.766$). A valuable finding was the absence of swimmers with SI values corresponding to sympathicotonia. In confirmation of the above, there was a predicted physiologically favorable downward trend in HR from 66.8 ± 3.85 bpm to 62.4 ± 2.95 bpm ($P = 0.067$) in the competitive period.

There was a central hemodynamics-related significant decrease in CI from 3.178 ± 0.168 to 2.958 ± 0.128 l·min⁻¹·m⁻² ($P = 0.05$) in the competitive period, although its value corresponded to the eukinetic circulatory type (CT). The percentage ratio of CT in the preparatory period was 18.2 %: 45.4 %: 36.4 %, hypokinetic, eukinetic and hyperkinetic CT, respectively, indicating a trend to the eukinetic CT domination over hypokinetic ($P = 0.502$) and hyperkinetic ones ($P = 0.785$). In the competitive period, the ratio between CT was 18.2 %: 81.8 %: 0.0 %, hypokinetic, eukinetic and hyperkinetic CT, respectively, demonstrating a trend

to the prevalence of eukinetic CT over hypokinetic one ($P = 0.075$) and the absence of athletes with physiologically unfavorable hyperkinetic CT.

In the competitive period, the relative value of PWC and FSI showed statistically significant shifts. So, the $PWC_{170/kg}$ value increased by an average of 12.44 %, from $12.86 \pm 0.732 \text{ kgm} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ to $14.46 \pm 0.823 \text{ kgm} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ ($P = 0.002$).

In the same period, the FSI increased from 4.957 ± 0.357 r. u. to 6.058 ± 0.406 r. u. or 22.21 % ($P = 0.0005$), and scored "below average", whereas its value corresponded to "low" score in the preparatory period. This was the result of a decrease in the number of female swimmers with "low" score from 9 (81.8 %) to 6 (54.5 %), and an increase in the number of female athletes with "below average" score from 2 (18.2 %) to 5 (45.5 %).

Correlation analysis between the examined parameters in the preparatory period revealed the presence of 21 statistically significant correlations. Positive correlations were found between HR and ARI ($r = 0.748$, $P = 0.008$), HR and IARP ($r = 0.790$, $P = 0.004$), HR and LF % ($r = 0.691$, $P = 0.019$), SVR and Mo ($r = 0.601$, $P = 0.05$), SVR and HF ($r = 0.631$, $P = 0.037$), SVR and HF % ($r = 0.716$, $P = 0.013$), SVRI and Mo ($r = 0.716$, $P = 0.013$), SVRI and HF ($r = 0.781$, $P = 0.005$), SVRI and HF % ($r = 0.688$, $P = 0.019$).

Negative correlations were revealed between HR and Mo ($r = -0.719$, $P = 0.013$), HR and HF ($r = -0.687$, $P = 0.02$), HR and HF % ($r = -0.779$, $P = 0.005$), SVI and IARP ($r = -0.596$, $P = 0.05$), SVR and AMo ($r = -0.597$, $P = 0.05$), SVR and ARI ($r = -0.797$, $P = 0.003$), SVR and IARP ($r = -0.758$, $P = 0.007$), SVR and LF % ($r = -0.623$, $P = 0.041$), SVR and LF/HF ($r = -0.612$, $P = 0.045$), SVRI and ARI ($r = -0.720$, $P = 0.012$), SVRI and IARP ($r = -0.734$, $P = 0.01$), SVRI and LF/HF ($r = -0.589$, $P = 0.05$).

The presence of 18 statistically significant correlations was revealed between the studied indicators in female swimmers in the competitive period. Positive correlations were between HR and ARI ($r = 0.645$, $P = 0.03$), HR and IARP ($r = 0.766$, $P = 0.006$), HR and LF % ($r = 0.627$, $P = 0.03$), SVI and HF ($r = 0.596$, $P = 0.05$), CI and ARI ($r = 0.675$, $P = 0.02$), SVR and D ($r = 0.586$, $P = 0.05$).

Negative correlation were found between HR and Mo ($r = -0.726$, $P = 0.01$), HR and variation range (D) ($r = -0.585$, $P = 0.05$), HR and HF ($r = -0.780$, $P = 0.005$), HR and HF % ($r = -0.627$, $P = 0.03$), CI and D ($r = -0.642$, $P = 0.03$), SVR and AMo ($r = -0.680$, $P = 0.02$), SVR and autonomic equilibrium index (AMo/D) ($r = -0.611$, $P = 0.04$), SVR and ARI ($r = -0.592$, $P = 0.05$), SVR and SI ($r = -0.644$, $P = 0.03$), SVRI and AMo ($r = -0.708$, $P = 0.01$), SVRI and AMo/D ($r = -0.654$, $P = 0.02$), SVRI and SI ($r = -0.668$, $P = 0.02$).

The dynamics of the athletic performance improvements in female swimmers during the one-year training cycle was interesting. In the competitive period, 2 CMS female athletes qualified for MSU, 1 first-class athlete qualified for CMS, and 2 second-class female athletes qualified for first-class athletes. Thus, by the end of the competitive period, there were 3 MSU athletes, 6 CMS athletes and 2 first-class athletes in the examined group.

The data of the 400-meter female runners in the preparatory period demonstrated the parasympathetic influence prevalence, the presence of CI values corresponding

to the eukinetic CT, the $PWC_{170/kg}$ value of $17.11 \pm 0.73 \text{ kgm} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$, and FSI – 7.048 ± 0.34 r. u. In the competitive period, the parasympathetic influences of the ANS remained, there was a transformation of eukinetic CT into hypokinetic one with the hyperkinetic CT absence among athletes, an increase in the value of $PWC_{170/kg}$ to $19.72 \pm 0.74 \text{ kgm} \cdot \text{min}^{-1} \cdot \text{kg}^{-1}$ and FSI – to 7.963 ± 0.330 r. u. Significant changes occurred in athletic performance, since at the end of the study, the distribution by sports qualification was as follows: 1 MSIC athlete, 1 MS athlete, 4 CMS athletes, 7 first-class athletes and 9 second-class athletes.

Discussion

As shown, female swimmers demonstrated significant prevalence of the parasympathetic influences of the ANS, the trend towards the predominance of eukinetic CT with the absence of hyperkinetic CT one, the significant increase in the relative value of PWC and FSI, some favorable correlations and improved athletic performance in the competitive period compared with the preparatory one.

From a sports physiology standpoint, we have considered the most important relationships between HR and ARI, HR and IARP, CI and ARI, CI and D, found in the preparatory and competitive periods in female swimmers. Training physical exercise resulted in the decreased resting HR in female swimmers, producing the preconditions for the decrease in ARI and IARP, which are involved in the autonomic balance, shifting it towards the parasympathetic regulation prevalence. Subsequently, we have seen the CI decreased to optimal values, increased number of female athletes with eukinetic CT due to the decreased number of female athletes with hyperkinetic CT.

In the competitive period compared with the preparatory one, 400-meter female runners ($n = 22$) showed very similar changes, which were reflected in certain enhancement of parasympathetic activity, transformation of eukinetic CT into hypokinetic one and the absence of runners with hyperkinetic CT, the significant increase in $PWC_{170/kg}$ by 15.25 % ($P < 0.05$) and FSI by 12.98 % ($P < 0.05$), as well as the increased number of athletes with "average" score of the functional state due to the decreased number of those with "low" and "below average" scores [5].

The correlation analysis to assess relationships in female runners revealed the associations between increased $PWC_{170/kg}$ and improved functional state with the decreased CI to the values corresponding to the hypokinetic CT and the SI corresponding to the parasympathetic effects of the ANS prevalence. And yet the main fact that occurred in the competitive period was the positive shifts in athletic performance among the 400-meter female runners.

Thus, the examination data analysis of female short-distances swimmers from the preparatory to the competitive period, compared with the data obtained in female 400-meter runners, was informative about the same reactions of the ANS, central hemodynamics, physical performance and the FSI. These included the increased parasympathetic effects of the ANS in the competitive period, the decreased CI to the values corresponding to physiologically more beneficial hypokinetic CT, the significantly increased physical performance and FSI values, and, most importantly, improved athletic performance.

Conclusions

1. Female swimmers demonstrated the significant prevalence of parasympathetic effects of the ANS, the tendency towards the eukinetic CT predominance and the absence of hyperkinetic CT, significantly increased PWC_{170/kg} value by 12.44 % and FSI – by 22.21 % in the competitive period as compared with the preparatory period.

2. The correlation analysis to assess both periods revealed the important relationships between HR and ARI, HR and IARP, indicating that training-induced bradycardia shifted the autonomic balance towards the predominance of the parasympathetic arm of the ANS.

3. Decreased ARI caused the decrease in CI, resulting in the transformation of hyperkinetic CT into eukinetic one and the absence of physiologically unfavorable hyperkinetic CT in the athletes.

4. The increased functional state of female swimmers in the competitive period helped to achieve improvements in their athletic performance since there were 3 MSU athletes, 6 CMS athletes and 2 first-class athletes by the end of study in the examined group.

5. The similar reactions of the ANS, central hemodynamics, physical performance and FSI were observed in female swimmers at the short distances of 50–200 meters and female 400-meter runners during the transition from the preparatory to the competitive period, which was due to the comparable time of maximum intensity exercise performed by athletes at competitive distances and the predominance of cyclic exercise with anaerobic-glycolytic pathway in the training process.

Prospects for further research are to study the impact of training loads on the indices of HRV, central hemodynamics and physical performance parameters in athletes of other sports from the preparatory to the competitive period of the training process.

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