Original article
DOI: 10.14529/hsm220311

POSTURAL IMBALANCE IS ACCOMPANIED BY CHANGES IN CARDIAC RHYTHM AND CONDUCTION IN YOUNG ATHLETES

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Abstract. **Aim.** The aim of the study was to identify the correlation between postural balance and changes in cardiac rhythm and conduction in athletes ages 16–18. **Materials and methods.** The study involved 266 male athletes (training experience – 6–10 years, representatives of 5 sports, namely athletics, swimming, speed skating, cross-country skiing, wrestling) in the recovery period. For each subject a 12-lead ECG recording was obtained (rest, PWC170 test, 5-minute recovery) and force platform data (2 tests with open and closed eyes) were collected. **Results.** It was found that 50.38% of athletes have changes in rhythm and conduction, namely incomplete right bundle branch block (IRBBB), extrasystole, early repolarization (ER), sinoatrial (SA) block (1st degree) and pacemaker migration. After examination all athletes were divided into 2 groups: 1 – no ECG changes (n = 132); 0 – ECG changes (n = 134). It was found that analyzing ECG data without dividing by sport did not allow us to establish differences in postural balance, which was associated with a high variability of the maximum and minimum individual values. **Conclusion.** The subsequent analysis of force platform data was performed based on sports disciplines, and it showed significant differences between the groups of athletes. The data obtained confirm the correlation between postural balance and ECG. These differences were determined by specific patterns of motor actions, which activated compensatory mechanisms resulting in the development of rhythm and conduction disturbances.

Keywords: athletes, postural balance, electrocardiogram, rhythm and conduction disturbances

Acknowledgements. The research was carried out within the framework of the state assignment of the Ministry of Education and Science of the Russian Federation: FENU-2020-0022 (No 2020072ГЗ).

For citation: Epishev V.V., Korableva Yu.B., Naumova K.A., Laffaye G., Delafontaine A. Postural imbalance is accompanied by changes in cardiac rhythm and conduction in young athletes. *Human. Sport. Medicine*. 2022;22(3):91–101. DOI: 10.14529/hsm220311

Научная статья
УДК 796.012.49
DOI: 10.14529/hsm220311

СВЯЗЬ ПОСТУРАЛЬНЫХ НАРУШЕНИЙ С ИЗМЕНЕНИЕМ РИТМА И ПРОВОДИМОСТИ СЕРДЦА У ЮНЫХ СПОРТСМЕНОВ

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Аннотация. **Цель:** установить взаимосвязь между постуральным балансом и изменениями сердечного ритма и проводимости у спортсменов 16–18 лет. **Материалы и методы.** В исследовании приняли участие 266 спортсменов мужского пола (спортивный опыт 6–10 лет, 5 видов спорта: легкая атлетика, плавание, конькобежный спорт, лыжные гонки, борьба) в восстановительном периоде. У каждого участника исследования регистрировали ЭКГ в 12 отведениях (покой, тест PWC170, 5-минутное восстановление) и собирали данные стабилометрии (2 пробы с открытыми и закрытыми глазами). **Результаты.** Установлено, что у 50,38 % спортсменов отмечаются изменения ритма и проводимости в виде неполной блокады правой ножки пучка Гиса, экстрасистолии, ранней реполяризации, синоатриальной блокады степени I и миграции водителя ритма. После обследования всех спортсменов поделили на 2 группы: 1 – без изменений ЭКГ (n = 132); 0 – изменения ЭКГ (n = 134). Выяснилось, что анализ данных ЭКГ без разделения по видам спорта не позволил установить различия в постуральном балансе, что связано с высокой вариабельностью максимальных и минимальных индивидуальных значений. **Заключение.** Последующий анализ стабилометрических данных, проведенный с учетом деления по спортивным дисциплинам, продемонстрировал существенные различия между группами спортсменов. Полученные данные подтверждают корреляцию между постуральным балансом и ЭКГ. Установленные различия обусловлены специфическими паттернами двигательных действий, активирующими компенсаторные механизмы, что приводило к развитию нарушений ритма и проводимости.

Ключевые слова: спортсмены, постуральный баланс, электрокардиограмма, нарушения ритма и проводимости

Благодарности. Работа выполнена в рамках госзадания Министерства науки и высшего образования РФ FENU-2020-0022 (№ 2020072ГЗ).

Для цитирования: Postural imbalance is accompanied by changes in cardiac rhythm and conduction in young athletes / V.V. Epishev, Yu.B. Korableva, K.A. Naumova et al. // Человек. Спорт. Медицина. 2022. Т. 22, № 3. С. 91–101. DOI: 10.14529/hsm220311

Introduction. Regular sports activities are associated with structural and electrical changes in the heart [53], which can manifest themselves on the electrocardiogram (ECG) in the form of changes in rhythm and conduction.

A significant increase in functional changes in rhythm and conduction in athletes is an urgent problem in sports physiology [13]. Some researchers argue that arrhythmias are physiological features of the athletic heart [49], others regard them as pre-pathological changes in the heart muscle [15, 51]. At the same time, there is no doubt about the influence of the autonomic nervous system on the development of these changes [6].

The specificity of motor activity in sport is associated with irritants of the sensory and musculoskeletal systems. In cyclic sports, athletes are regularly influenced by angular and Coriolis accelerations, as a result of which a certain motor stereotype develops, which is resistant only to this type of activity [38]. Cumulation of these accelerations can cause changes in sensorimotor coordination and dysfunction of the autonomic nervous system [42].

In acyclic sports, complex coordination tasks can lead to the development of physical and sensory fatigue, which, in turn, negatively affects the maintenance of an upright posture [29, 30]. Consequently, the effects of muscle and sensory loads add up. The autonomic nervous system forms specific changes in the musculoskeletal and cardiovascular systems [22, 25, 26].

Posture is a static movement that is provided by the tonic activity of the extensor muscles, which maintain the common center of mass (CCM) due to the constant mutual movement of body parts [32]. The main components that provide the tone of the postural muscles (a group of muscles whose main function is to maintain an upright posture) are the following: the muscle component due to the mechanical properties of muscle fibers, i.e. their elasticity; the nervous component, associated with the activity of the nervous system, including an unconditioned reflex caused by muscle stretching ("reflex tone") [10]. It is known that three sensory systems of the body are involved in maintaining an upright posture: visual, vestibular, and proprioceptive [40].

Changes in the postural muscles may be one of the causes of autonomic dysfunction [50]. A number of studies have established a significant correlation between the mechanisms of vertical posture and the functional state of the body [7], in particular the cardiovascular system (CVS) [2, 21].

At the same time, there are not enough studies on the relationships between the indicators of an upright posture and changes in rhythm and conduction in athletes. Establishing such a correlation with ECG data will clarify the nature of functional changes in rhythm and conduction in athletes.

Aim. The aim of the study was to identify the correlation between postural balance and changes in cardiac rhythm and conduction in athletes ages 16–18.

Methods. The study was approved by the institutional review committee and complied with the principles of the Declaration of Helsinki. Prior to the study participants' informed consent was obtained in a written form. The authors confirm that this research meets the ethical guidelines and legal requirements of the Russian Federation.

Participants. The study involved 266 male athletes ages 16–18 (training experience – 6–10 years, representatives of 5 sports, namely athletics, swimming, speed skating, cross-country skiing, wrestling) in the recovery period. The study took place in the daytime, 24–36 hours after training. Each participant was informed that on the day of the study it was necessary to avoid caffeine-containing products and physical activity.

ECG measurement. ECG recording was performed three times in 12 standard leads using the SCHILLER AT-104. The following data were collected:

1. Initial electrocardiogram (ECG) in a sitting position;
2. Continuous ECG during exercise (bicycle ergometry, PWC170 test, Bruce protocol 50/25);
3. ECG after a 5-minute rest.

The 12-lead electrocardiogram is a more accurate screening tool. Contemporary risk stratification and treatment protocols may allow for safe return to sport on a case-by-case basis [47].

Postural balance detection was carried out in a two-legged European stance (heels together, toes apart) and consisted of 2 tests, 30 s each (head straight with open and closed eyes). Force platform data were obtained in accordance with the recommendations on performing clinical stabilometry [44]. Contact force between legs and the ground were recorded by using the MBN Stabilo (Russia) force platform with the following technical parameters:

- platform size – 500×400×100 mm,
- load range – from 20 to 150 kg,
- coordinate measurement accuracy – 1 mm,
- coordinate discretization – 1 mm,
- sensor polling rate – 100 Hz.

The participants stood barefoot on the force plate in a comfortable pose for at least 1 minute while keeping the feet separated at the same distance as the width of the hips. To avoid some transition phenomena, data recording was performed 10 seconds after a participant took a standing position on the force plate.

The recording was performed once during 60 seconds to analyze 6 parameters:

AREA-CC (mm^2) – the mean and standard deviation (SD) of the 95% ellipse area; MVELO (mm/s) – the COP velocity; FP RMS COP (mm) – the root mean square deviation of the COP in the frontal plane; SP RMS COP (mm) – the root mean square deviation of the COP in the sagittal plane; FP ML COP (mm) – the mean location of the COP in the frontal plane; SP ML COP (mm) – the mean location of the COP in the sagittal plane.

Statistical analysis. Athletes were divided into 2 groups depending on their sports discipline and ECG data: 1 – no changes in the ECG (n = 132); 0 – changes in the ECG (n = 134) (Table 1). Comparative analysis was performed by means of variation statistics using the Statistica V.10.0 program.

Table 1

The distribution of athletes by sport and ECG changes (n = 266)

Sports discipline	Group 1, n = 132	Group 0, n = 134
Cyclic	Speed skaters, n = 10	Speed skaters, n = 10
	Runners, n = 48	Runners, n = 48
	Swimmers, n = 30	Swimmers, n = 30
	Cross-country skiers, n = 22	Cross-country skiers, n = 24
Acyclic	Wrestlers, n = 22	Wrestlers, n = 22

Results

1. Electrocardiographic study. Analysis of electrocardiograms of 266 athletes showed that 50.38% (n = 134) had changes in rhythm and conduction, namely incomplete right bundle branch block (IRBBB), extrasystole, early repolarization (ER), sinoatrial (SA) block (1st degree) and pacemaker migration. Based on the identified changes in rhythm and conduction, their frequency distribution was obtained (Fig. 1).

IRBBB (constant) was detected in 39.55% of athletes: in runners – 30.19%, swimmers – 30.19%, skiers – 22.64%, wrestlers – 9.43%, speed skaters – 7.55%.

Extrasystole (supraventricular) was detected in 26.85% of athletes: swimmers and wrestlers – 27.78% each, skiers – 22.22%, runners – 19.44% and skaters – 2.78%.

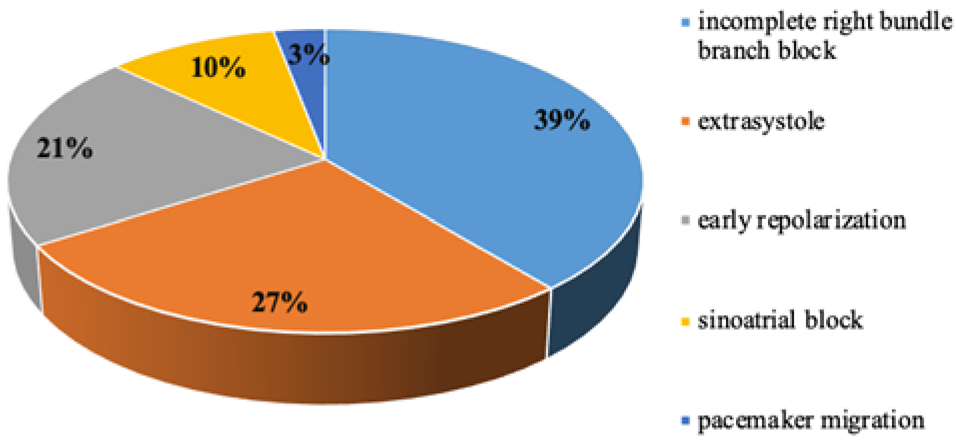

Fig. 1. Distribution of changes in rhythm and conduction in athletes

ER was detected in 20.89% of athletes: runners – 67.86%, speed skaters – 17.86%; wrestlers – 10.71% and skiers – 3.57%. This phenomenon was not found among swimmers.

Degree I SA block was detected in 9.69% of athletes (10 athletes during the exercise test, 3 athletes during a 5-minute rest). The highest percentage of SA block was observed among runners – 38.46%, skiers – 23.09%, swimmers – 23.09%, wrestlers – 15.38%.

Pacemaker migration was observed in 2.99% of athletes during the exercise test and disappeared immediately after exercise. The highest percentage of pacemaker migration was found among wrestlers – 50.00%, runners – 25.00% and swimmers – 25.00%.

2. Posture study. Ranking by ECG results without data on sport (Table 2) showed the absence of statistically significant differences, which was mostly determined by the high variability of the maximum and minimum individual values.

For example, the scatter of FP RMS COP values in the frontal plane in the test with eyes open in group 1 was 30.18 mm, with eyes closed – 77.02 mm, in group 2 – 39.63 mm and 115.97 mm, respectively. Therefore, in spite of the presence or absence of rhythm and conduction disturbances, the type of sport is of decisive importance in stabilometric data. Statistical analysis by means of variation statistics is possible only when the sample is ranked by sport.

The division of athletes with respect to the type of sport (speed skating, athletics, swimming, cross-country skiing, wrestling) made it possible to identify specific relationships between ECG changes and stabilometric data (Table 3).

Table 2

Stabilometry of athletes with and without rhythm disturbances (open and closed eyes) (M ± m, min-max)

Parameter		Open eyes (1)	Close eyes (2)	Open eyes (1)	Close eyes (2)
		No ECG changes (Group 1)		ECG changes (Group 0)	
FP RMS COP (mm)	M ± m min–max	7,53 ± 5,63 0,58–30,76	13,83 ± 12,91 0,84–77,86	12,22 ± 8,90 1,56–40,92	19,58 ± 18,27 0,90–116,87
SP RMS COP (mm)	M ± m min–max	17,79 ± 18,06 1,82–144,00	22,54 ± 20,58 2,68–140,48	23,42 ± 24,57 2,54–206,40	25,77 ± 20,01 5,65–122,99
MVELO (mm/s)	M ± m min–max	11,86 ± 3,72 5,95–33,72	15,88 ± 5,28 6,84–33,78	12,23 ± 3,49 6,53–23,92	16,75 ± 5,61 6,84–33,24
AREA-CC (mm2)	M ± m min–max	76,59 ± 56,08 16,59–455,16	120,74 ± 93,52 8,05–582,76	104,88 ± 75,74 1,35–604,53	151,17 ± 115,60 20,71–735,70
FP ML COP (mm)	M ± m min–max	3,23 ± 10,76 –19,54–53,07	3,94 ± 10,00 –16,06–47,70	4,86 ± 9,59 –10,79–49,35	4,55 ± 10,45 –12,88–55,59
SP ML COP (mm)	M ± m min–max	5,18 ± 22,32 –47,77–56,29	5,54 ± 21,22 –47,23–50,20	5,02 ± 19,88 –40,85–47,56	4,97 ± 18,25 –40,53–48,81

Note: there are no statistically significant differences ($p > 0.05$).

Table 3

Comparison of stabilometric parameters depending on the type of sport and rhythm and conduction (M ± m)

Parameter	No ECG changes (Group 1)		ECG changes (Group 2)	
	Open eyes	Close eyes	Open eyes	Close eyes
Athletics				
FP RMS COP (mm)	**4.43 ± 0.18**	**9.98 ± 0.75**	**9.50 ± 0.67**	**16.31 ± 1.24**
SP RMS COP (mm)	**13.40 ± 1.00**	**17.37 ± 1.95**	**23.18 ± 2.17**	**23.58 ± 2.47**
MVELO (mm/s)	10.16 ± 0.23	14.18 ± 0.34	11.24 ± 0.28	15.69 ± 0.34
AREA-CC (mm2)	**54.75 ± 2.47**	**84.54 ± 4.40**	**94.24 ± 6.87**	**133.67 ± 14.90**
FP ML COP (mm)	**2.47 ± 0.90**	**3.07 ± 0.18**	**1.34 ± 0.66**	**1.11 ± 0.14**
SP ML COP (mm)	10.99 ± 1.06	10.31 ± 2.75	10.14 ± 2.42	8.57 ± 1.46
Swimming				
Parameter	No ECG changes (Group 1)		ECG changes (Group 2)	
	Open eyes	Close eyes	Open eyes	Close eyes
FP RMS COP (mm)	**7.43 ± 0.29**	**15.21 ± 1.34**	**17.76 ± 1.20**	**27.92 ± 2.98**
SP RMS COP (mm)	**18.97 ± 2.34**	28.48 ± 4.47	**30.65 ± 6.72**	32.38 ± 3.00
MVELO (mm/s)	**13.91 ± 0.33**	19.58 ± 0.78	**15.05 ± 0.50**	20.15 ± 0.78
AREA-CC (mm2)	**79.89 ± 5.53**	**160.16 ± 17.85**	**140.82 ± 8.56**	**208.81 ± 17.10**
FP ML COP (mm)	**4.22 ± 0.08**	**4.72 ± 0.01**	**7.34 ± 0.20**	**6.58 ± 0.23**
SP ML COP (mm)	**–5.15 ± 0.03**	**–5.13 ± 0.05**	**0.42 ± 0.02**	**1.20 ± 0.07**
Speed skating				
Parameter	No ECG changes (Group 1)		ECG changes (Group 2)	
	Open eyes	Close eyes	Open eyes	Close eyes
FP RMS COP (mm)	9.86 ± 2.88	18.37 ± 7.47	12.92 ± 2.19	15.73 ± 1.95
SP RMS COP (mm)	**10.95 ± 1.97**	**15.03 ± 3.27**	**19.64 ± 2.81**	**20.14 ± 3.48**
MVELO (mm/s)	10.57 ± 0.51	14.13 ± 1.35	12.25 ± 0.98	15.71 ± 0.95
AREA-CC (mm2)	**64.53 ± 9.24**	**102.75 ± 20.89**	**112.91 ± 20.84**	**119.94 ± 11.06**
FP ML COP (mm)	**0.78 ± 0.06**	**1.32 ± 0.59**	**8.36 ± 2.56**	**7.10 ± 0.28**
SP ML COP (mm)	**5.83 ± 1.89**	**2.66 ± 0.03**	**–7.07 ± 0.40**	**–4.26 ± 0.98**
Wrestling				
Parameter	No ECG changes (Group 1)		ECG changes (Group 2)	
	Open eyes	Close eyes	Open eyes	Close eyes
FP RMS COP (mm)	**5.53 ± 0.95**	**10.42 ± 2.55**	**10.78 ± 1.24**	**14.07 ± 1.65**
SP RMS COP (mm)	19.95 ± 4.60	29.24 ± 3.52	22.06 ± 2.95	27.39 ± 4.50
MVELO (mm/s)	10.70 ± 0.39	13.47 ± 0.83	10.22 ± 0.47	13.71 ± 0.68
AREA-CC (mm2)	**68.44 ± 8.36**	123.59 ± 22.86	**86.93 ± 9.04**	120.63 ± 18.78
FP ML COP (mm)	5.18 ± 0.86	6.53 ± 0.75	6.86 ± 0.62	6.47 ± 0.77
SP ML COP (mm)	7.20 ± 1.73	8.82 ± 2.25	10.01 ± 2.50	8.19 ± 2.07
Cross-country skiing				
Parameter	No ECG changes (Group 1)		ECG changes (Group 2)	
	Open eyes	Close eyes	Open eyes	Close eyes
FP RMS COP (mm)	10.70 ± 0.93	**15.95 ± 1.71**	11.37 ± 1.06	**21.70 ± 4.70**
SP RMS COP (mm)	**25.99 ± 5.82**	**16.86 ± 2.49**	**16.73 ± 2.04**	**21.46 ± 2.19**
MVELO (mm/s)	14.27 ± 1.03	**13.31 ± 0.51**	12.30 ± 0.42	**17.37 ± 0.88**
AREA-CC (mm2)	128.61 ± 17.23	**100.94 ± 6.95**	91.68 ± 9.40	**147.21 ± 18.91**
FP ML COP (mm)	2.73 ± 0.09	6.57 ± 0.80	5.15 ± 0.60	5.74 ± 0.08
SP ML COP (mm)	**4.38 ± 0.72**	2.22 ± 0.81	**1.25 ± 0.06**	3.34 ± 0.01

Note: significant values are shown in bold type ($p < 0.05$).

Discussion. The percentage of athletes with ECG changes (50.38%) is consistent with the data of A. Pelliccia, who established various changes in rhythm and conduction in 60.00% of athletes [41]. Degree I SA block, as well as pacemaker migration, IRBBB, ER are most likely associated with increased vagus nerve tone. Extrasystole, on the contrary, may be associated with an increase in the tone of the sympathetic nervous system [28]. Sinus bradycardia (<60 beats / min) was considered as a variant of the norm [43].

Changes in rhythm and conduction recorded during the stress test were of a single character. These changes were not accompanied by pathological symptoms (short-term loss of consciousness, episodes of syncope, episodes of weakness, dizziness). During exercise tests, changes in rhythm and conduction in the ECG disappeared. Therefore, all recorded changes in rhythm and conduction can be attributed to functional variants of the sports norm. These changes are not an indication for any restrictions in the training process because are benign in nature.

The use of stabilometry is a generally accepted method for diagnosing postural balance, assessing the functional state of the vestibular apparatus and its spatial orientation [20]. It is known that specific changes in the musculoskeletal system lead to compensatory reactions aimed at maintaining postural balance and correcting the position of the common center of pressure [22, 25].

1. Athletics. Runners with rhythm and conduction disturbances showed higher values for FP RMS COP, SP RMS COP AREA-CC and FP ML COP in tests with open and closed eyes. It is known that the larger the standard deviation, the more unstable the athlete, therefore, the balance control system of these athletes is overstrained [46]. Therefore, the protective mechanism of reprogramming innate motor patterns is activated, disrupting the coordination of movements from the central nervous system [5, 26]. As a result, overloads appear in the locomotor system [22], changes occur in leg joints and the spinal motion segments (SMS). This leads to a change in the breathing and postural pattern due to the spread of disorders to other SMS and an increase in the number of trigger points (TP) [12]. According to theory of motor-visceral reflexes proposed by M.R. Mogendovich [4, 35, 36] in the myofascial structures associated with the heart (sacrospinalis, serratus posterior superior, musculus pectoralis major – to the left), myofascial trigger points develop, as well as responses from the Prefrontal Cortex and Autonomic Nervous System, which can be the cause of rhythm and conduction disturbances [8, 37].

Considering the large number of differences in the parameters of postural balance among athletes, it can be argued that, in addition to the abovementioned disturbances, there is a decreased sensitivity of sensory systems that provide information about body position [52]. In particular, high AREA-CC values in athletes with rhythm and conduction disturbances indicate problems with posturally significant elements of the musculoskeletal system [23], since it is known that changes in the sensitivity of proprio and mechanoreceptors of the feet [19], ankle joint, axial muscles of the trunk lead to late detection of body oscillations and relative difficulty in identifying their localization and speed [48].

Consequently, runners with rhythm and conduction disturbances require more muscular effort to maintain an upright posture. Overstrain and dysfunction of the postural muscles lead to impaired venous return from the lower extremities (gastrocnemius muscle, soleus) and abdominal cavity (rectus abdominis muscle, abdominal external oblique muscle), as well as to changes in external respiration (extensors of the spine, quadratus lumborum muscles, diaphragm). Consequently, there is impaired innervation of the muscles reflexively associated with the heart. The lack of necessary therapeutic and corrective measures can lead to pathological changes in the cardiovascular system and diseases of the heart and blood vessels [17].

2. Swimming. The training loads of swimmers are characterized by a predominantly horizontal position while holding the foot parallel to the lower leg, which leads to static overstrain and hypertonicity of the flexor muscles of the foot, causing an imbalance in the agonist-antagonist system. This can lead to impaired ankle stabilization and reduced body stability. As a result of disturbance in the key elements of the postural system (cervical spine, ankle joint), there is an overstrain of the muscles involved in respiration, and the formation of myofascial trigger points occur. As a result of changes in the anatomical and physiological relationships, the autonomic innervation of not only muscles but also the heart can be disrupted [33].

Stabilometric data among the groups of swimmers with and without rhythm and conduction disturbances revealed the greatest number of differences in comparison with other sports. This may reflect the specificity of training in a horizontal position in the water.

Differences were found for all parameters in the test with open eyes and FP RMS COP, AREA-CC, FP ML COP and SP ML COP. At the same time, swimmers with ECG changes, in contrast to representatives of other sports, had the highest AREA-CC (eyes closed) – 208.81 ± ± 17.10 mm^2, FP ML COP – 27.92 ± 2.98 mm and SP ML COP – 32.38 ± 3.00 mm.

As noted above, the greater the value of the standard deviation, the higher the load on the balance control system. The leading factor, in addition to anatomical and physiological disorders of the lower leg muscles, may be the changes in the cervical spine, the load on which is much higher than in other sports. It is known that displacement of the head forward by every centimeter increases the load on the cervical spine exponentially [45]. In addition, forward head posture affects cervical tonic reflexes [14]. On the one hand, these changes can affect the vestibular function, and on the other, the compensatory postural response in the form of flexing the pelvis and lower extremities [16], tilting head back and shifting the shoulders forward [27].

Consequently, a high level of fluctuations in the CCP and 95% ellipse area in swimmers with rhythm and conduction disturbances indicate compensatory load redistribution in the musculoskeletal system, which is probably the key factor in the development of cardiac disorders [31].

3. Speed skating. Statistically significant differences were found in SP ML COP, AREA-CC, FP ML COP and SP ML COP in both tests. A specific feature of speed skaters with rhythm and conduction disturbances is COP displacement posteriorly and to the right (FP ML COP – 8.36 ± 2.56 mm, SP ML COP – 7.07 ± 0.40 mm for open eyes and FP ML COP – 7.10 ± 0.28 mm, SP ML COP – 4.26 ± 0.98 mm for eyes closed), which may indicate weakness or lower leg muscle coordination impairment [9]. Tone-strength imbalance in the sagittal plane can lead to a bilateral increase in the tone of the iliopsoas muscles [24]. Dorsal displacement and opposite rotation of the pelvis occur, as well as there are changes in the tone of the muscles of the chest area, which are integrative responses to impulses from internal organs, primarily the lungs and heart. A compensatory increase in the area of support, presumably due to changes in proprioception, leads to increased stress on the ankle [1]. Mechanical compression of the vessels of the lower extremities and impaired venous return can affect heart function and cause changes in rhythm and conduction [34].

4. Wrestling. Statistically significant differences ($p \leq 0.05$) were found in two parameters: FP RMS COP (in both tests) and AREA-CC (open eyes). Possibly, a more pronounced shift of the center of pressure to the right in wrestlers with rhythm and conduction disturbances (10.78 ± 1.24 mm for open eyes, 14.07 ± 1.65 mm for eyes closed) is associated with the feature of the stance (right-sided). This leads to the stabilization of the center of mass in the frontal plane and, as a consequence, the formation of a hip strategy for maintaining an upright posture [39]. The resulting asymmetries in the musculoskeletal system change the tone of the anti-gravity muscles (mainly large muscles of the trunk and muscles that extend the proximal segments of the limbs: quadratus lumborum muscle, scalene muscles, iliopsoas, transverse abdominal muscles) with the help of motor-visceral muscle connections (innervation of the heart) and visceral-motor reflexes (the relationship between the heart and muscles). In segmental muscles, autonomic dysfunction, similar to those that occurs with myofascial syndrome, can develop. This is manifested by painful muscle indurations accompanied by both segmental autonomic disorders and psychoatonomic reactions to pain. In turn, the development of functional disorders, the risk of secondary deformities of the spine and changes in autonomic reactions are possible, which may be the main factor in the development of ECG changes in wrestlers [18].

5. Cross-country skiing. Statistically significant differences were found in 5 stabilometric parameters: for open eyes – SP RMS COP and SP ML COP; for closed eyes – FP RMS COP, SP RMS COP, MVELO, AREA-CC. The key, in our opinion, difference in the SP RMS COP parameter was found in both samples. In skiers with rhythm and conduction disturbances, oscillations in the sagittal plane are more pronounced, which indicate a pronounced ankle strategy for maintaining an upright posture. High values of oscillations in the sagittal plane indicate hypertonicity of the lower leg muscles [11], which results in constriction of arterial and venous vessels, an increase in total peripheral vascular resistance, an increase in systemic arterial pressure, and maintenance of cardiac output at an increased level [3]. This can lead to an increase in the effort of the heart spent on providing the necessary blood flow and pressure in the capillaries. The resulting imbalance in the cardiovascular system can be the leading mechanism in the formation of autonomic dysfunctions, which provokes the formation of rhythm and conduction disturbances in skiers.

Conclusion. The results of the study convincingly show the relationship between postural balance and the rhythm and conduction of the heart in athletes ages 16–18 and allow drawing the following conclusions:

1. The incidence of rhythm and conduction disturbances in athletes ages 16–18 is 50.3% and it has the following structure: incomplete right bundle branch block – 39.55%, extrasystole – 26.85%, early repolarization – 20.89%, sinoatrial block – 9.69%, pacemaker migration – 2.99% (these are functional variants of the norm).

2. Analysis of the relationship between force platform data and ECG data in athletes ages 16–18 should be carried out taking into account their sports discipline as the orientation of the training loads determines the strategy of maintaining an upright posture.

3. Each sport has a pronounced specificity of the relationship between postural balance and ECG, which "triggers" compensatory mechanisms and leads to the development of rhythm and conduction disturbances.

We assume that further research will help create a method for early diagnosis of rhythm and conduction disturbances in athletes to significantly reduce the incidence of diseases of the cardiovascular system.

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The article was submitted 26.04.2022
Статья поступила в редакцию 26.04.2022