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Influence of tilt up on the activity of autonomic nervous system in professional swimmers

Wpływ pionizacji na aktywność autonomicznego układu nerwowego u wyczynowych pływaków

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Abstract

Introduction. Evaluation of heart rate variability (HRV) constitutes a useful tool in the analysis of changes in the autonomic nervous system (ANS), occurring as an adaptation to physical exercise. Changing body position from supine to standing upright is reflected by higher activity of the sympathetic ANS component. The aim of this study was to analyze the effect of tilting up on the activity of ANS in professional swimmers.

Material and methods. The study included 10 healthy swimmers in the transitory phase of their training cycle, and the control group comprising 31 healthy volunteers. The evaluation of ANS activity was based on the temporal and spectral indices of HRV, as well as on the analysis of changes in arterial blood pressure and heart rate at rest and during Tilt-Up Test (TUT), determined prior to and after the training.

Results. Prior to the training, the tilting up of swimmers was reflected by a significant decrease in: rMSSD, pNN50, HF, NHF, as well as by an increase in VLF and LF/HF ($p < 0.05$). After the training, a significant decrease in: pNN50, HF and NHF was documented after position changes, along with an increase in NLF and LF/HF ($p < 0.05$).

Conclusions. The change of position (tilt up) induced significant changes in all studied vegetative indices, suggesting an increase in sympathetic tone. The TUT protocol used in this study can be useful in the evaluation of the vegetative response of athletes to external stimulation; this application can be important in the context of overtraining prevention.

Key words: autonomic nervous system, physical exercise, heart rate variability, tilt up, swimmers

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Introduction

Evaluation of heart rate variability (HRV) is a valuable albeit indirect measure of autonomic activity [1]. The analysis of HRV is a non-invasive method of determining the influence of the autonomic nervous system (ANS) on heart rate. HRV indices reflect cooperation between the sympathetic and parasympathetic nervous system in regulating the frequency of impulses (pacemaker activity) of the sinoatrial node. Heart rhythm is to a large extent modulated by the balance between parasympathetic part (slowing down) and sympathetic part (accelerating). The examination of HRV seems potentially helpful in understanding the role of ANS in the processes of adaptation to physical exercise [2].

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Most previous studies addressing the function of ANS in athletes were based on the examination of individuals remaining in a supine position [3, 4], and only a few authors used Tilt-Up Test (TUT) to document changes that occur in a vertical position [5].

Whenever a standing position is resumed, about 700 ml of blood is displaced into the lower limbs due to the influence of gravity forces, and stored in local volumetric vessels; this is reflected by central hypovolemia and decompression of arterial baroreceptors. As a result, compensative reflex mechanisms of cardiovascular system are activated in response to changing body position [6, 7]. These mechanisms are modulated by the activation of ANS, which is examined during TUT.

Disorders observed as a result of resuming vertical position are associated with excessive or reduced sympathetic activity [8].

Swimming is a sports discipline which somehow forces athletes to retain a specific 'horizontal' position of body in water. During training, swimmers spend considerable amount of time in a horizontal position. In view of such body position and functional variability of the vegetative system one can suppose that swimmers are characterized by more pronounced HRV than individuals from general population. Furthermore, their different response to verticalization during a change in body position can be expected.

The aim of this study was to analyze the effect of tilt up on the activity of ANS manifested by HRV indices in professional swimmers in the transitory phase of their training cycle and in individuals who did not practice sport.

Material and methods

The study included 10 professional swimmers (experimental group), among them 5 women and 5 men, with the mean age of 21 ± 2 years (range 19–23 years) and training experience of 10 ± 3 years. The control group comprised individuals who neither currently nor previously practiced any sports discipline. These individuals participated in 60-minute sessions of physical activity twice a week on average, either as a part of physical education classes included in their study curriculum or on their own. Thirty-one controls were examined, including 9 women and 22 men, mean age 20 ± 1 years (range 19–21 years).

The inclusion criteria of the study included negative history of cardiovascular disorders, diabetes, obesity, neurological disorders, using medications influencing the activity of ANS, other medications, and such stimulants as coffee, cigarettes, and caffeine-containing drinks. All participants had normal arterial blood pressure and heart rate and showed normal sinus rhythm on electrocardiography (ECG).

The swimmers were examined twice during the transitory phase of their training cycle: prior to and after the training. In contrast, the controls were examined only once, in a period corresponding to that the swimmers were tested.

The examination took place at conditions promoting the comfort of the subjects: at a massage room, at 24°C, during the morning hours, and at least 12 hours after the last training session (in the case of swimmers).

After a 20-minute rest in a supine position, arterial blood pressure was measured and a 10-minute electrocardiogram was recorded. Subsequently, each participant was asked to change his/her position from supine to standing upright for 5 minutes. During this time, continuous ECG was recorded and arterial blood pressure was measured in the 1st (in the initial 15 seconds) and 5th minute of the test. The Tilt-Up Test is used in cardiology to evaluate patients with syncope in whom cardiac syncope, carotid sinus syndrome, as well as orthostatic, neurological, psychiatric, and metabolic syncope were excluded. Recommended duration of the test is 45 minutes for verticalization up to 60°. However, we followed the American Neurological Association standards for Tilt Up testing [6] as the aim of the study was the evaluation of simple cardiovascular adaptation reflexes during the initial 5 minutes after changing body position [9].

Resting electrocardiograms and those obtained during the Tilt-Up Test were recorded with a three-channel digital recorder AsPEKT 700, which registers electrocardiographic signaling without compression on PCMCIA semiconductor memory cards. The measurements of arterial pressure were obtained with HOMEDICS MiBody 360 sphygmomanometer.

Prior to HRV analysis, the fragments containing R-R intervals determined by sinus stimulation were selected. The R-R intervals representing the extra-sinus stimulation were excluded, as well as the artifacts that were mistakenly identified as stimulation by the analyzer. After the preparation of electrocardiograms, the variability of sinus rhythm was evaluated by means of temporal and spectral analysis at proper, predefined time periods. The analysis was conducted with HolCARD 24W software, version 5.11.00 (Aspel, Poland). The following components of the temporal analysis of HRV were determined: mRR — average R-R interval of the sinus rhythm, SDNN — standard deviation of the average R-R intervals of the sinus rhythm (in ms); a global index which describes the total variability of sinus rhythm; rMSSD — square root of the mean squared difference of successive R-R intervals (in ms); a measure which refers to the short-term variability, and correlates with the high-frequency component of spectral analysis; pNN50 — proportion of successive R-R intervals that differ by more than 50 ms, expressed in %, which correlates significantly with rMSSD. Also the measures determined during the spectral analysis were studied: TP (total power), total spectral power at the whole range of frequencies (0.0033–0.15 Hz); LF (low frequency), low-frequency component (0.04–0.15 Hz), modulated by the sympathetic system, associated with the cyclic changes of arterial pressure, and dependent upon baroreceptor activity;

Table 1. Comparison of mean indices of temporal and spectral heart rate variability (HRV) analysis determined in a supine and standing position in the group of swimmers (n = 10) prior to the training

HRV index	Supine position		Standing upright		p*
	Mean	SD	Mean	SD	
mRR [ms]	902.90	102.50	760.10	78.29	**0.005**
SDNN [ms]	94.80	54.71	97.20	28.92	0.507
SDANN [ms]	49.80	34.53	54.70	22.14	0.221
rMSSD [ms]	82.10	42.91	45.50	25.45	**0.010**
pNN50 (%)	28.37	17.44	10.41	9.70	**0.005**
TP [ms^2]	1942.00	909.17	1829.10	610.77	0.878
HF [ms^2]	716.40	441.14	410.10	213.95	**0.005**
LF [ms^2]	603.50	208.29	587.70	231.44	0.878
VLF [ms^2]	329.60	193.15	462.20	144.95	**0.046**
NHF [NU]	44.48	8.09	30.31	4.87	**0.005**
NLF [NU]	40.96	6.05	46.85	11.26	0.138
LF/HF	0.96	0.28	1.58	0.50	0.006

*$p < 0.05$ — statistical significance; mean — arithmetic mean; SD — standard deviation; mRR — mean duration of cardiac cycle; SDNN — standard deviation of sinus RR intervals; rMSSD — root of mean of squares of RR differences; pNN50 — percentage of differences greater than 50 ms between adjacent sinus RR intervals; TP — total power; HF — high frequency power; LF — low frequency power; VLF — power of very low frequency spectrum; NHF — normalized HF power; NLF — normalized LF power, statistical significance

HF (high frequency), high-frequency component (0.15––0.4 Hz), variability modulated by the parasympathetic system, associated with breathing; LF/HF, low-frequency to high-frequency component ratio, defines mutual relationships of the components of vegetative modulation; and normalized values of the HRV spectral indices: NLF (LF//[TP-VLF]*100) and NHF (HF/[TP-VLF]*100).

The protocol of the study was approved by the Local Bioethical Committee of the Jagiellonian University (approval no. KBET/26/B/2012). All qualified individuals gave their informed written consent to participate in the study.

Statistical analysis

Non-parametric tests for small samples were used. The differences between dependent variables were analyzed with the Wilcoxon test, while the differences between the experimental and the control group were tested with the non-parametric Mann-Whitney U test. The analysis was conducted with SPSS v. 17 software. The results were presented as arithmetic means and their standard deviations (SD). The level of statistical significance was set at $p < 0.05$.

Results

Influence of TUT on the ANS activity in swimmers during the transitory phase of their training cycle

Prior to the training, changing position from supine to standing upright was reflected by an increase in LF/HF ratio, considered a marker of increased sympathetic tone. Moreover, we observed an increase in VLF, but the diagnostic value of this heart rate variability measure has not been confirmed [2]. Also a significant decrease in rMSSD, pNN50, HF, and NHF was documented, unambiguously pointing to a decrease in parasympathetic tone in response to tilt up (Table 1).

Compared with the pre-training measurement, swimmers remaining in a supine position after the training showed lower values of rMSSD, pNN50, HF, and NHF (Figure 1). This suggests an increase in sympathetic activity immediately after the training. Verticalization was reflected by a decrease in pNN50 and NHF, along with an increase in NLF and LF/HF, suggesting standing up-related enhancement of adrenergic activity (Table 2).

Influence of TUT on the activity of ANS in the control group

When examined at rest, the controls showed sympathetic-parasympathetic balance (Table 3). Changing body position during TUT was reflected by a significant increase in NLF and LF/HF, pointing to the activation of the sympathetic component of ANS. In turn, a decrease in pNN50 and NHF indicates a reduction of parasympathetic tone in response to standing up. Finally, an increase in SDNN and VLF may correspond to parallel changes in the tone of both components of ANS.

Comparison of changes in the activity of ANS in swimmers and in the controls

Compared with individuals who did not practice any sport, swimmers were characterized by significantly higher values of HRV indices at rest in a supine position: rMSSD, pNN50,

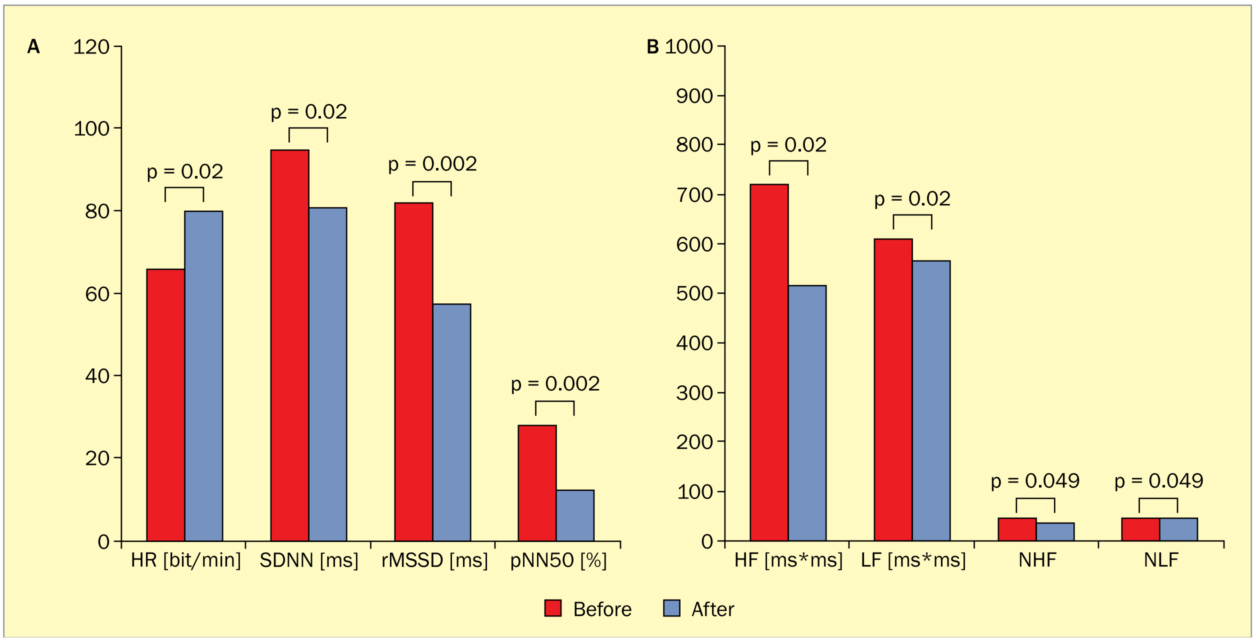

Figure 1A, **B.** Comparison of the resting values of temporal (**A**) and spectral (**B**) heart rate variability indices determined prior to and after the training in swimmers; statistical significance $p < 0.05$; HF — high frequency power; LF — low frequency power; NHF — normalized HF power; NLF — normalized LF power; HR — heart rate; SDNN — standard deviation of sinus RR intervals; rMSSD — root of mean of squares of RR differences; pNN50 — percentage of differences greater than 50 ms between adjacent sinus RR intervals

Table 2. Comparison of mean indices of temporal and spectral heart rate variability (HRV) analysis determined in a supine and standing position in the group of swimmers (n = 10) after the training

HRV index	Supine position		Standing upright		p*
	Mean	SD	Mean	SD	
mRR [ms]	751.90	100.80	689.60	65.11	**0.005**
SDNN [ms]	81.00	33.58	72.80	17.66	0.444
SDANN [ms]	46.60	13.91	43.30	17.30	0.362
rMSSD [ms]	57.90	25.82	29.80	11.56	0.059
pNN50 (%)	12.55	13.73	5.50	4.11	**0.046**
TP [ms^2]	1839.50	912.61	1351.10	314.53	0.114
HF [ms^2]	516.60	248.26	307.80	114.84	**0.028**
LF [ms^2]	566.90	237.00	490.40	109.68	0.475
VLF [ms^2]	415.40	312.35	336.50	104.68	0.646
NHF [NU]	37.41	4.30	31.06	5.07	**0.012**
NLF [NU]	42.52	5.41	51.28	7.30	**0.006**
LF/HF	1.16	0.26	1.71	0.49	**0.006**

*$p < 0.05$ — statistical significance (*explanation of abbreviations — see Table 1*)

LF, HF, and NHF (Table 4). Moreover, swimmers were characterized by longer average R-R sinus rhythm interval and lower heart rate than their peers. Lower values of rMSSD and pNN50 point to lower parasympathetic activity of the controls.

Only slight intergroup differences in HRV indices were documented upon verticalization. The only exceptions pertained to mRR, SDNN, VLF, and HR in the 1st minute of TUT, all being significantly higher in swimmers (Table 5). Also the comparison of post-training temporal and spectral

Table 3. Comparison of mean indices of temporal and spectral heart rate variability (HRV) analysis determined in a supine and standing position in the control group (n = 31)

HRV index	Supine position		Standing upright		p*
	Mean	SD	Mean	SD	
mRR [ms]	744.09	67.51	698.45	71.26	**0.002**
SDNN [ms]	68.00	24.40	74.06	19.11	**0.011**
SDANN [ms]	37.83	14.67	41.61	16.28	0.230
rMSSD [ms]	41.32	20.77	36.45	20.05	0.070
pNN50 (%)	14.08	10.73	8.39	7.12	**0.002**
TP [ms^2]	1533.00	605.16	1415.74	463.23	0.065
HF [ms^2]	496.22	255.92	380.22	224.91	**0.003**
LF [ms^2]	445.22	137.07	451.16	121.20	0.631
VLF [ms^2]	295.22	113.53	350.48	103.81	**0.009**
NHF [NU]	40.35	6.57	35.06	7.01	**0.001**
NLF [NU]	39.85	8.06	46.93	9.18	**0.0002**
LF/HF	1.03	0.35	1.43	0.51	**0.0003**

*$p < 0.05$ — statistical significance (*explanation of abbreviations — see Table 1*)

Table 4. Comparison of mean indices of temporal and spectral heart rate variability (HRV) analysis determined in a supine position in swimmers examined prior to the training and the controls

HRV index	Swimmers (n = 10)		Controls (n = 31)		p*
	Mean	SD	Mean	SD	
mRR [ms]	902.90	102.50	744.09	67.51	**0.00004**
SDNN [ms]	94.80	54.71	68.00	24.40	0.119
SDANN [ms]	49.80	34.53	37.83	14.67	0.286
rMSSD [ms]	71.40	46.92	41.32	20.77	**0.026**
pNN50 (%)	28.37	17.44	14.08	10.73	**0.036**
TP [ms^2]	1942.00	909.17	1533.00	605.16	0.222
HF [ms^2]	716.40	441.14	496.22	255.92	0.119
LF [ms^2]	603.50	208.29	445.22	137.07	**0.036**
VLF [ms^2]	329.60	193.15	295.22	113.53	0.940
NHF [NU]	44.48	8.09	40.35	6.57	0.211
NLF [NU]	40.96	6.05	39.85	8.06	0.686
LF/HF	0.96	0.28	1.03	0.35	0.893
HR (beats/min)	66.45	12.39	80.63	7.63	**0.006**
SBP [mm Hg]	118.20	8.44	132.6	13.35	0.463
DBP [mm Hg]	77.40	3.21	75.6	5.54	0.940

*$p < 0.05$ — statistical significance; HR — heart rate; SBP — systolic blood pressure; DBP — diastolic blood pressure (*explanation of other abbreviations — see Table 1*)

HRV indices of swimmers, determined both in a supine position and during TUT, and respective parameters of the controls did not reveal any statistically significant differences.

Discussion

Our study revealed that standing up constitutes a strong activator of the sympathetic part of ANS. The Tilt-Up test

Table 5. Comparison of mean indices of temporal and spectral heart rate variability (HRV) analysis determined during Tilt-Up Test in swimmers examined prior to the training and the controls

HRV index	Swimmers (n = 10)		Controls (n = 31)		p*
	mean	SD	mean	SD	
mRR [ms]	**760.10**	**78.29**	**698.45**	**71.26**	**0.022**
SDNN [ms]	**97.20**	**28.92**	**74.06**	**19.11**	**0.025**
SDANN [ms]	54.70	22.14	41.61	16.28	0.097
rMSSD [ms]	45.50	25.45	36.45	20.05	0.362
pNN50 (%)	10.41	9.70	8.39	7.12	0.574
TP [ms^2]	1829.10	610.77	1415.74	463.23	0.061
HF [ms^2]	410.10	213.95	380.22	224.91	0.564
LF [ms^2]	587.70	231.44	451.16	121.20	0.086
VLF [ms^2]	**462.20**	**144.95**	**350.48**	**103.81**	**0.022**
NHF [NU]	30.31	4.87	35.06	7.01	0.050
NLF [NU]	46.85	11.26	46.93	9.18	0.987
LF/HF	1.58	0.50	1.43	0.51	0.494
HR 1' TUT	**78.93**	**14.89**	**85.90**	**11.20**	**0.046**
SBP 1' TUT	117.80	1.92	126.8	16.51	0.393
DBP 1' TUT	74.40	4.34	75.8	7.08	0.540
HR 5' TUT	82.00	10.07	74.6	8.38	0.190
SBP 5' TUT	125.00	6.16	125.4	12.62	0.988
DBP 5' TUT	78.60	6.31	78.2	7.72	0.643

*$p < 0.05$ — statistical significance; 1' TUT — measurement in the 1st minute of Tilt-Up Test; 5' TUT — measurement in the 5th minute of Tilt-Up Test (*explanation of other abbreviations — see Table 4*)

used in this study seems to be a proper tool for indirect evaluation of the dynamics of changes occurring in ANS of professional athletes, as well as of individuals who do not practice any sport discipline and show moderate level of physical activity.

Both in the group of athletes and in the controls TUT was reflected by a similar extent of changes in the indices of ANS response. Both examined groups showed an increase in LF/HF, suggesting enhanced sympathetic activity. Moreover, one should note a decrease in pNN50, NHF, and HF, pointing to a verticalization-related decrease in parasympathetic tone. Similar relationships between change in body position and HRV indices mentioned above were previously reported by other authors [5, 11].

In both studied groups, the response to TUT was characterized by a considerable decrease in the mean duration of cardiac cycle (mRR). Additionally, a marked increase in SDNN was documented in the controls. These findings can be interpreted as increased activity of sympathetic component with simultaneous change in the quality of parasympathetic tone.

It should be emphasized that changes in studied HRV indices were more significant in the controls than in the experimental group. Consequently, it can be concluded that tilt up exerts stronger effect on the ANS of individuals characterized by moderate physical activity than in the case of professional athletes. Therefore, one of our initial hypotheses associated with the specific position of swimmer's body in water was not confirmed. We assumed that the TUT-related changes of ANS parameters will be more pronounced in swimmers rather than in the controls. However, our study did not confirm the abovementioned assumption. Conversely, standing up caused more evident changes in cardiovascular function of individuals characterized by a moderate degree of physical activity than in the swimmers. This phenomenon can be explained by the fact that verticalization-related adaptation of the cardiovascular system, and especially baroreceptors, does not dramatically impair the body function in high-class athletes. This results from the so-called plasticity of the autonomic nervous system. The TUT-related changes in the ANS of swimmers did not differ from widely accepted norms. Therefore, there is a need for further studies analyzing the influence of venous pressure and cardiac preload on the homeostasis of cardiovascular system, as well as the effect of hydrostatic pressure on venous return.

Differences in HRV indices determined at rest in trained and non-trained individuals have been a subject of many studies. In most of them, the temporal analysis revealed that the trained individuals showed significantly longer R-R interval, as well as higher SDNN, pNN50, and rMSSD than the subjects of similar age and body weight, who were not characterized by an active lifestyle [10, 11]. Our study revealed that, compared with individuals showing moderate physical activity, swimmers are characterized by an increase in parasympathetic modulation and a decrease in sympathetic modulation. Similar results were previously reported by Carter [12], who performed a longitudinal study of adult runners.

Among the spectral indices, this study revealed that, compared with the controls, swimmers showed significant increase in LF. Searching through available literature we did not find any conclusive data regarding the evaluation of LF in trained and non-trained individuals. The values of spectral indices (HF and LF) reported by Melanson [10] were similar to those determined in our study. The resting value of LF reflects both sympathetic and parasympathetic modulation. Higher values of HRV indices in swimmers correspond to greater heart rate variability, resulting from parasympathetic modulation [1].

Noticeably, more changes in HRV indices were documented at rest than following a change in body position. Therefore, it can be concluded that tilt up exerts similar effect on analyzed HRV indices in athletes and in controls.

Significant differences in studied HRV indices were also evident when the pre-training results of swimmers were compared with values obtained in the control group. This finding would suggest that athletes are adapted to physical exercise. It should be remembered that the average training experience of studied swimmers equaled to 10 years, and therefore their adaptation probably progressed gradually throughout years of training. This hypothesis is consistent with previous reports according to which short periods of training are not reflected by significant changes in the indices of heart rate variability. In contrast, longer periods of training lead to changes in HRV parameters. An increase in such indices as rMSSD, pNN50, NLF, and LF/HF was documented as early as after 12 weeks of training [11].

On the basis of our findings and the review of literature it can be concluded that heart rate variability increases as a result of sports training [2, 4], and trained individuals are characterized by a greater heart rate variability than non-trained subjects of corresponding age.

In conclusion, our study revealed that TUT constitutes an important indirect method for analyzing the influence of ANS on the heart rhythm of swimmers. Moreover, our findings confirmed the hypothesis according to which heart rate variability increases as a result of physical training, since the trained individuals were characterized by higher values of both time and frequency domain HRV analysis indices compared with the untrained subjects.

Perhaps, determination of HRV would constitute an important tool for monitoring the adaptation of an athlete to physical exercise during training process. This substantiates further studies dealing with the problem in question.

Further research should explain the character of changes in the activity of ANS in athletes, not only in response to verticalization but also during other tests used to evaluate cardiovascular reflexes. In order to obtain comprehensive and detailed information on athlete's reactions, such studies should be performed during various phases of training cycle and consider other factors that influence swimmer's body in water. This would enable more precise programming of training process, without harmful overload which can frequently lead to overtraining.

Conclusions

Tilt up induced significant changes in all studied vegetative indices, suggesting an increase in sympathetic tone. The TUT protocol used in this study can be useful in the evaluation of the vegetative response of athletes to external stimulation; this application can be important in the context of overtraining prevention.

Examination of heart rate variability constitutes a useful tool in the analysis of changes in ANS, occurring as an adaptation to physical exercise.

Conflict of interest

None declared.

Streszczenie

Wstęp. Analiza zatokowego rytmu pracy serca (HRV) stanowi przydatne narzędzie służące do oceny procesów adaptacyjnych organizmu do wysiłku fizycznego, zachodzących w autonomicznym układzie nerwowym (ANS). Zmiana pozycji ciała z leżącej na stojącą powoduje większą aktywność składowej współczulnej ANS.

Celem pracy była ocena wpływu pionizacji na czynność ANS u wyczynowych pływaków.

Materiał i metody. Badaniami objęto 10 zdrowych pływaków (5 kobiet, 5 mężczyzn, śr. wieku 21 ± 2 lata) w okresie treningu przejściowego oraz 31 zdrowych ochotników, którzy stanowili grupę kontrolną. Oceny aktywności ANS oparto na wskaźnikach analizy czasowej i częstotliwościowej HRV, zmianach ciśnienia tętniczego i częstości rytmu serca w spoczynku, podczas testu zmiany pozycji ciała (TUT) w okresie przed treningiem i po nim.

Wyniki. U pływaków przed treningiem podczas pionizacji zanotowano istotne statystycznie zmniejszenie wartości wskaźników: rMSSD, pNN50, HF, NHF oraz wzrost wartości VLF, LF/HF ($p < 0,05$). Po treningu podczas pionizacji, w porównaniu z pozycją leżącą, zanotowano istotne statystycznie zmniejszenie wartości wskaźników: pNN50, HF, NHF oraz wzrost NLF, LF/HF ($p < 0,05$).

Wnioski. Bodziec pionizacyjny spowodował istotną zmianę wszystkich ocenianych parametrów układu wegetatywnego, wskazując na wzrost napięcia składowej współczulnej. Po treningu u pływaków odpowiedź na stymulację była mniejsza. Zastosowany TUT może być przydatny w ocenie zdolności reagowania układu wegetatywnego sportowców na bodźce zewnętrzne, co wydaje się istotne w kontekście zapobiegania występowania zespołu przetrenowania.

Słowa kluczowe: autonomiczny układ nerwowy, wysiłek fizyczny, zmienność rytmu zatokowego serca, pionizacja, pływacy

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Komentarz

Autorzy pracy zatytułowanej „Wpływ pionizacji na aktywność autonomicznego układu nerwowego u wyczynowych pływaków" podjęli interesujący temat wykorzystania stosowanej klinicznie próby ortostatycznej do oceny aktywności autonomicznego układu nerwowego u wytrenowanych sportowców. Do opisu zmian tej aktywności przyjęto statystyczne czasowe oraz, coraz powszechniej wykorzystywane, częstotliwościowe wskaźniki zmienności rytmu serca. Przebadano 10 aktywnie trenujących sportowców oraz 31 umiarkowanie aktywnych fizycznie osób stanowiących grupę kontrolną. Podczas badania rejestrowano w sposób ciągły sygnał EKG oraz wartości skurczowego i rozkurczowego ciśnienia tętniczego (HOMEDICS MiBody 360) w trzech wybranych punktach czasowych. Analizę danych przeprowadzono za pomocą komercyjnie dostępnego programu HolCARD 24W v. 5.11.00 (Aspel, Poland).

W artykule postawiono śmiałą hipotezę o możliwości wykorzystania baterii wskaźników czasowo-częstotliwościowych do charakterystyki odpowiedzi regulacyjnej układu krążenia na bodziec grawitacyjny w grupie wyczynowo trenujących pływaków oraz oszacowania, na tej podstawie, indywidualnego stopnia obciążenia treningowego (przetrenowania). O ile wybór zastosowanego bodźca oraz grupy badanych wydaje się nieprzypadkowy, ponieważ autorzy rozważają możliwość odmiennej krążeniowej odpowiedzi regulacyjnej u pływaków ze względu na długotrwałe przebywanie w pozycji poziomej w środowisku o sztucznie zmniejszonym polu grawitacyjnym, o tyle wybór grupy kontrolnej nie został dostatecznie uzasadniony. Dane na temat adaptacji organizmu do wysiłków fizycznych są dobrze udokumentowane, a zatem porównanie grupy czynnie uprawiających sport zawodników z osobami o umiarkowanej aktywności fizycznej nie wnosi dodatkowej informacji, co zresztą potwierdzają przedstawione w pracy wyniki. Dla zbadania wpływu zmiennego pola grawitacyjnego na odpowiedź krążeniową interesujące byłoby zapewne porównanie różnych grup zawodników, na przykład pływaków z biegaczami lub kolarzami.

Ze względu na przyjętą formułę badania pewne wątpliwości budzi także sposób wyznaczania wtórnych charakterystyk częstotliwościowych. Po pierwsze, aktywna próba pionizacyjna różni się od biernego testu ortostatycznego, chociażby w zakresie występowania w tej pierwszej komponentu pompy mięśniowej ograniczającej efekt zalegania krwi w dolnej połowie ciała, a więc odpowiedź hemodynamiczna nie będzie prawdopodobnie tak silna, jak podczas próby biernej. Po drugie, należy oczekiwać, że dynamika odpowiedzi krążeniowej nie zamknie się w okresie 5 minut (okres rejestracji badania), co skutkuje osłabieniem założenia o stacjonarności analizowanych przebiegów. Znajduje to swoje odbicie we wzroście składowych z zakresu VLF. Po trzecie, należy pamiętać, że arbitralne przyjęcie przedziałów funkcji gęstości widmowej mocy na VLF, LF i HF może utrudnić lub zafałszować interpretację zmian charakterystyki częstotliwościowej. Ogólnie znanym faktem jest adaptacyjne zmniejszenie częstości skurczów serca i rytmu oddechowego u sportowców oraz wzrost niemiarowości zatokowej. Wielokrotnie obserwuje się u takich osób rytmikę oddechową o częstości 8–10 oddechów na minutę, co znajduje swoje odzwierciedlenie w obszarze widma wiązanym z aktywnością współczulną (LF). Dlatego, w celu uniknięcia niejednoznaczności interpretacyjnych, zaleca się monitorowania czynności oddechowej, czego (prawdopodobnie z uwagi na ograniczenia sprzętowe) autorzy nie wykonali.

Ostrożności wymaga także interpretacja wskaźnika LF/HF, powszechnie wykorzystywanego jako ilustracja równowagi współczulno-przywspółczulnej. Przede wszystkim nie można pomijać jego czysto matematycznej natury. Jego wartość zależy bowiem od trzech możliwych scenariuszy: wzrostu lub spadku licznika, mianownika albo obu jednocześnie. Ten ostatni przypadek wydaje się dotyczyć otrzymanych wyników. Z przedstawionych danych tabelarycznych można wnosić, że o wartości wskaźnika LF/HF zadecydował istotny spadek składowej HF i względnie mniejszy spadek składowej z obszaru LF (wiązanej zwyczajowo z aktywnością współczulną).

Z powodu dużej zmienności osobniczej, a w przypadku funkcji widmowej gęstości mocy — również czasowej, pożądane wydaje się rozważenie możliwości porównania wartości względnych wyznaczanych wskaźników, a nie ich wartości bezwzględnych.

Przedstawione wyniki wskazują na bardzo wstępny charakter pracy, wydaje się jednak, że po zmodyfikowaniu samego protokołu badań oraz optymalnym doborze mierzonych wskaźników jej kontynuacja może przynieść wiele interesujących spostrzeżeń w zakresie monitorowania procesu treningowego oraz adaptacji do wysiłków fizycznych.

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