Impact of athletic recovery parameters of hemodynamics in disabled powerlifters with cerebral palsy

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Abstract

Purpose: Sport as one of physical culture components renders extremely complex impact on various environments and is enormously popular. In Poland disabled powerlifting represents top world standards. Aim of work: aims at examination of impact of biological regeneration on blood pressure and pulse in CP class 4, 5, 6, 7, 8 disabled power-lifters with normal upper extremities function.

Material: The research material comprised twenty 18-30 years old disabled power-lifters with cerebral palsy and normal function of upper extremities who are active members of "Start-Impel" sports club in Wroclaw. The research was carried out in 2 identical cycles on the same disabled sportsmen. Cycle I comprised primary research, while Cycle II, as secondary research, was carried out 5 months later. The micro-cycles were identical as regards training and biological regeneration schedules on particular weekdays, which guaranteed optimal research conditions.

Results: Results of the research allowed formation of the following parameters of pressure and pulse dynamics: 1. Post-training systolic blood pressure shows increasing dynamics; 2. During training meso-cycle with biological regeneration in Group A systolic pressure parameters were considerably lower than during the meso-cycle without biological renovation; 3. Diastolic pressure measured before training in both groups remains at 70–80 mm Hg, while post-training pressure increases to 82–86 mm Hg; 4. Post-training pulse measures are always higher than starting measures.

Conclusions: Combination of strength training and complex biological regeneration has positive impact on dynamics of blood pressure and pulse hemodynamic parameters, which in turn boosts training effectiveness.

Keywords: hemodynamics, biological regeneration, Para-Olympic sports, powerlifting

Introduction

Sport as one of physical culture components has an extremely complex impact on various environments and enjoys enormous popularity, both as regards active participation and passive observation of sports events [1-3]. Performing sports has a positive influence on many aspects of life. People with disabilities are prone to lead sedentary lifestyles which increase the risk of various chronic diseases. Diminished activity may contribute to reduced health-related quality of life. Cerebral palsy (CP) is one of the reasons of disability which limits activity with all its consequences. For this reason health care providers implement programs of trainings and encourage people with CP to participate in sports programs. Groff and coworkers [4] conducted a survey among athletes with CP competing in the 2005 CP World Championships to examine the effect of adaptive sports participation on influence on quality of life. The results indicate that sport positively influenced their overall health (84.9%), quality of life (80.8%), quality of family life (53.4%), and quality of social life (56.1%).

The participation in sports for disabled persons continues to expand. The reasons of growing interest in sports vary from rehabilitation and recreational purposes to elite competitions such as Paralympic athletes. CP became one of the six impairment group in which athletes with disabilities may compete. Disorders occurring in cerebral palsy are not limited to the movement-related disorders. Paralympic medicine must face also such problems as communication difficulties, increased muscle tone, convulsive disorders and fatigue from intense training which may result in dehydration, thermoregulatory problems or induce seizures [5]. Therefore, not only monitoring health condition and hemodynamic parameters during exercise but also the proper recovery after training seems to be very important. Moreover, proper planning of athletic training and complex recovery treatment is a vital issue for athletes in general as well as those with disabilities [6-11]

There is still not enough data regarding the effectives of training in comparison to the impact on the body physiology. Scoon GS. (2006) and Dec (1979) claim that no research on bodily reactions as regards cardiac capacity of powerlifters with disability has been carried out, and use of the outcome of research on able-bodied sportsmen diminishes efficacy of their application in the training of sportsmen with disability [7,12] This study was performed to shed more light on training athletes with CP. The aim of the work was to examine of the impact of athletic recovery treatment on blood pressure and heart rate of disabled power-lifters with CP in sport-medical classes CP 4, 5, 6, 7, 8 with normal function of the upper extremities.

Material and Methods

Subjects

The study group consisted of twenty 18-30 year old disabled athletes with CP with normal function of their

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upper extremities that are active members of *Start-Impel* sports club in Wroclaw. It is the only sports center in Wroclaw where disabled power-lifters with CP may train, and it is also the only so numerous section of powerlifters with disability in Poland. All athletes were classified in accordance with the "General Medical Classification in Disabled Sport"[13], and study groups were formed accordingly.

Athletes with disability are classified into medical groups and classes, in accordance with international regulations. CP is classified as medical group 4. In 1982, at the meeting of the Presidium of the *Cerebral Palsy International Sport and Recreation Association* within the group 8 CP medical classes were distinguished [13-14] Athletes in Group A had spastic paresis in lower extremities, which substantially impaired their mobility. This group was comprised of ten athletes that required orthopaedic appliances, including two athletes in CP class 4 and eight athletes in CP class 5. The main impairment of athletes in Group B was minimal spastic paresis, which substantially affected their mobility. It consisted of ten athletes suffering from slight or trace spastic paresis that could walk without help of any appliances, including four athletes in CP class 6, one athlete in CP class 7 and five athletes in CP class 8.

Methods

The entire research was carried out in two identical cycles performed on the same study groups. One cycle lasted eight weeks. Blood pressure and heart rate were measured and analyzed. The measurements were taken before and after training as well as before and after recovery treatment.

The first cycle is referred in this paper as the primary research (Cycle I), while the second – as the secondary research (Cycle II). The Cycle II was carried out 5 months after the end of Cycle I. Each cycle comprised two separate meso-cycles – the first one was based only on trainings and the second one on trainings followed by recovery treatment. Each mesocycle comprised four weekly micro-cycles.

Each training took place on five consecutive days in each week, Monday through Friday, for about 90 minutes a day, in the afternoons from 4.00 to 5.30 p.m., and in the second mesocycle it was followed by athletic recovery treatment. All micro-cycles encompassed identical training and recovery treatment on particular weekdays, which ensured optimal research conditions. The training schedule is presented in Figure 1.

Training meso-cycle comprised only a set of weight exercises for shoulder girdle muscles and special barbell exercises. The set of exercises was developed by a coach for each athlete on an individual basis taking into account his condition, age, years of practicing competitive sports and weight category. Based on those factors daily training load for each athlete was scheduled.

Training mesocycle with recovery treatment comprised the same set of exercises as in the training mesocycle followed by the athletic recovery treatment accordingly:

1) classical dry upper extremities massage delivered each day for 15 minutes directly after training;
2) once a week (Wednesday) two full cycles of Finnish sauna;
3) twice a week (Tuesday and Thursday) underwater massage of both upper extremities and shoulder girdle with a manually controlled water-jet;
4) twice a week (Monday and Friday) alternating Swiss shower.

The study was approved by the Committee of Senate for Research Ethics at University of Physical Education in Wroclaw. Written informed consent was obtained prior to the patient entering the study. The study was conducted in compliance with the ethical principles originating in or derived from the Declaration of Helsinki.

Statistics

The analyses were performed using the Statistica package software (version 9, StatSoft). The following variables were calculated: arithmetic mean, standard deviation (s), and variation coefficient (*v*). Assessment of statistical significance between means for two groups was performed with use of a t-Student test, and in case of bigger amount of comparable means one-way analysis of variance (ANOVA test) was applied, with comparison of least significant difference in LSD test. A p value less than 0.05 was considered statistically significant.

Results

Blood pressure and heart rate in Cycle I

Comparative analysis of hemodynamic parameters in the Cycle I encompassing training without recovery treatment proved that no significant differences observed in adaptive reactions to weight trainings between Groups A and B.

The most interesting findings are as follows. Statistically significant differences in systolic blood pressure were recorded on the 4th day of the second microcycle after training (p=0.011) and on the last day of the fourth microcycle (p=0.016), which was not significant for 40 measurements taken. Statistically significant differences in diastolic blood pressure in Groups A and B were recorded in two cases before training (on the second and fourth day of the third microcycle: p=0.023 and p=0.041 respectively) and in two cases after training (on the third day of the first microcycle p=0.017 and on the fourth day of the fourth microcycle p=0.016). Reduced systolic blood pressure was recorded after the training (136±8.06 mm Hg) as compared to pre-training measurement (140±8.31 mm Hg) only in one case (on the fourth day of the third microcycle) and was not statistically significant. Pre-training diastolic blood pressure parameters in both groups ranged from 70 to 80 mm Hg, but after training they slightly increased to 82–86 mm Hg, however the change was not statistically significant. Post-training heart rate occurred to be always higher than pre-training heart rate. Heart rate significantly differed only in two cases: on the fifth day of the third microcycle and on the fourth day of the fourth microcycle). Identical processes were observed in Group B as well, which means that in the first mesocycle no case post-training reduction of systolic blood pressure was recorded. It is worth pointing out that out of 20 measures of pre- and post-training systolic blood pressure taken in Group B only in 6 cases a significant increase was noted.

Comparative analysis of pre- and post-training diastolic blood pressure parameters in the first mesocycle without recovery treatment showed two patterns. Selected results of analysis of variance and post-hoc test are presented in Table 1.

After 15 trainings diastolic blood pressure rate in Group A demonstrated an increasing tendency, whereas in five cases a decreasing tendency was observed. Only in 4 cases the said changes were statistically significant. In Group B a decreasing tendency was observed in 3 cases, whereas in 17 cases diastolic blood pressure rate increased, including 7 cases in which they were statistically significant.

After 20 trainings of the first mesocycle heart rate parameters in Group A were higher than before the training cycle. Statistically significant increase in heart rate was observed in 15 cases, whereas in the remaining five cases it was statistically insignificant. In Group B during the first training mesocycle no decrease in heart rate was recorded, while in 17 cases the heart rate increase was statistically significant, and in 3 cases the changes did not qualify as statistically significant.

In the second mesocycle with recovery treatment systolic blood pressure demonstrated an increasing tendency in both groups. In Group A only one case of reduced systolic blood pressure value by the end of training was reported. On the first day of the first microcycle pre-training systolic blood pressure reading in Group A was at a level of 131.60±8.72 mm Hg, while at the end of the training it dropped to 131.30±8.71 mm Hg, hence the difference was not significant (p=0.0905). Statistically significant changes in post-training systolic

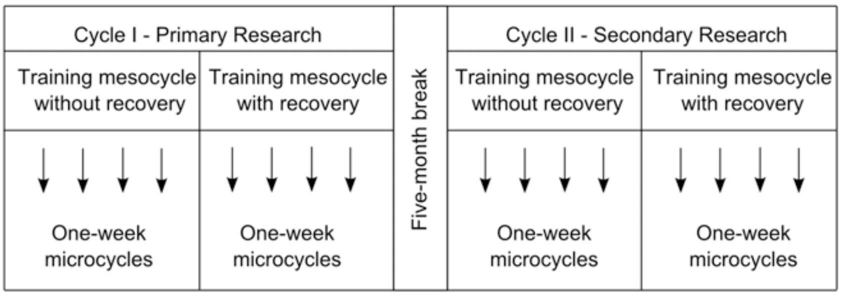

Figure 1. Diagram of the study schedule.

Table 1. Evaluation of means of blood pressure and heart rate in selected days of training during Cycle I and II – first meso-cycle without athletic recovery – variance analysis and LSD.

Parameter	Cycle	Group	F-Snedecor		I mesocycle, pre-training										I mesocycle, post-training			
					1 day, 1 mesocycle							5 day, 4 microcycle			1 day, microcycle 1			5 day, micro-cycle 4
			F	p	5W14	1K11	5K14	1W21	5W24	1K21	5K24	5K14	5W24	5K24	5K14	1K21	5K24	5K24
Blood pressure / Systolic	I	A	4,07	**0,000**	0,973	0,151	0,631	0,631	0,391	0,706	0,142	0,655	0,411	0,151	0,337	0,288	0,973	0,320
		B	3,12	**0,001**	**0,004**	**0,004**	**0,000**	0,138	**0,010**	**0,047**	**0,001**	0,173	0,761	0,544	0,183	0,347	0,564	0,448
	II	A	3,75	**0,000**	0,682	0,056	**0,002**	0,512	0,838	0,838	**0,026**	**0,007**	0,838	0,067	0,220	0,087	0,743	0,368
		B	6,75	**0,000**	**0,018**	**0,011**	**0,000**	0,683	**0,014**	**0,000**	**0,000**	**0,020**	0,928	**0,001**	**0,031**	0,318	**0,001**	0,257
Blood pressure / Diastolic	I	A	2,22	**0,019**	0,622	0,067	0,198	0,951	0,076	0,356	0,296	0,076	0,198	0,126	**0,002**	**0,007**	**0,005**	0,805
		B	3,42	**0,000**	0,529	**0,010**	**0,010**	0,875	0,118	**0,010**	**0,000**	**0,048**	0,346	**0,003**	1,000	1,000	0,320	0,320
	II	A	7,70	**0,000**	**0,043**	**0,002**	**0,000**	0,798	0,670	**0,023**	**0,000**	**0,015**	**0,015**	0,076	0,203	0,349	0,551	0,496
		B	15,11	**0,000**	0,107	**0,001**	**0,000**	**0,000**	**0,002**	0,158	0,736	**0,004**	**0,000**	0,052	0,252	**0,000**	**0,000**	**0,000**
Heart rate	I	A	3,56	**0,000**	**0,028**	0,291	**0,036**	0,880	**0,046**	0,132	0,762	**0,000**	0,840	**0,013**	0,291	0,650	0,450	0,072
		B	4,58	**0,000**	0,558	**0,021**	0,103	0,179	0,320	**0,002**	0,179	**0,028**	0,115	0,055	0,482	0,380	0,320	0,769
	II	A	7,92	**0,000**	0,513	**0,000**	**0,000**	0,414	0,369	**0,000**	**0,000**	**0,001**	0,806	**0,000**	0,870	0,806	0,414	0,513
		B	15,99	**0,000**	0,258	**0,000**	**0,000**	**0,007**	0,091	**0,000**	**0,000**	**0,000**	0,571	0,000	0,010	0,003	0,000	0,214

* F-Snedecor – F-distribution; F – test function value; p - probability values less than 0.05 denote statistically significant - marked in bold; LSD - least significant difference; symbols indicating the day of the study are designed as follows (e.g. 5W14): first number indicates micro-cycle day, second capital letter indicates type of measurement (W-pre-training; K-post-training); third number indicates mesocycle (1-first; 2-second); fourth number indicates microcycle number (from 1 to 4).

blood pressure were reported in 7 cases. In group B only one case of reduced systolic blood pressure was recorded for 20 measurements taken. On the first day of the fourth microcycle pre-training average value of systolic blood pressure was 134.20±11.61 mm Hg, and before the end of the training it demonstrated insignificant decrease dropping to 131.80±7.42 mm Hg (p=0.463). Out of all 20 measurements taken six were statistically significant, which means that normotonic hemodynamic adaptive reactions to high-intensity weight training dominated.

Comparative analysis of the dynamics of post-training diastolic blood pressure values in Group A in the second mesocycle showed an increase in fifteen cases, and a decrease in five, where in 4 cases the change was statistically significant. While in Group B, in the same time in 17 cases diastolic blood pressure increased but only in 3 cases it decreased. In 7 cases the change was statistically significant. Statistical analysis of pre- and post-training heart rate parameters in Group A during the mesocycle with recovery treatment showed increase in all cases, but in 13 cases the change was statistically significant. Whereas in Group B, 19 cases of post-training increased heart rate were recorded, 8 of which qualify as statistically significant.

In the Group A, after massage treatment a constantly decreasing values of systolic blood pressure was observed. Reduction in systolic blood pressure after delivery of local massage treatment was recorded in all 20 cases, 14 of which were statistically significant. Similar changes were observed in systolic blood pressure behavior in the Group B. The decrease in systolic blood pressure after delivery of local massage treatment was recorded in all 20 cases, 13 of which were statistically significant. Analysis of parameters of diastolic blood pressure after delivery of local massage treatment in Group A showed an increase in 14 cases, while in six a decreasing tendency was observed. In 6 out of 20 cases changes in diastolic blood pressure dynamics after delivery of local massage were statistically significant. In Group B there were 18 cases of reduced diastolic blood pressure values and two cases of increased diastolic blood pressure values after delivery of local massage treatment. In 6 out of 20 cases changes in diastolic blood pressure after delivery of local massage were statistically significant.

Heart rate dynamics after delivery of local massage treatment in Group A proved that the restoration mechanism in all 20 cases contributed to a decreasing tendency. Statistic analysis of post-massage heart rate showed that in 13 cases it significantly decreased, while in 7 cases the decrease was statistically insignificant. Heart rate dynamics in Group B followed a similar pattern. In Group B in 19 cases post-massage heart rate dropped and only in one a significantly insignificant increase in heart rate from 79.40±1.48 beats/min. to 79.80±1.48 beats/min. was observed. Statistical analysis showed that in 12 cases heart rate reduction after local massage treatment was statistically significant. Heart rate parameters measured after the treatment in Groups A and B fluctuated about the pre-training heart rate range. In the Group A, pre-training and after-massage heart rate varied from 75 to 85 beats per minute. The tendency in Group B was similar.

Comparative analysis of systolic blood pressure parameters measured after massage and hydrotherapy treatments showed an increase in all cases. In the Group

Table 2. Evaluation of means of blood pressure and heart rate in selected days of training during Cycle I and II – second meso-cycle pre-training measurements – variance analysis and LSD.

Parameter		Cycle	Group	II meso-cycle, pre-training 1 day 1 micro-cycle							5 day 4 micro-cycle		
				5W24	1K21	5K24	1M21	5M24	1D21	5D24	5K24	5M24	5D24
Blood pressure	Systolic	I	A	0,706	0,918	0,320	**0,000**	0,124	0,133	0,304	0,537	0,057	0,515
			B	0,262	0,605	**0,044**	0,693	0,303	0,584	0,317	0,363	**0,033**	0,903
		II	A	0,390	0,390	**0,004**	0,967	**0,042**	**0,006**	**0,000**	**0,042**	0,236	**0,006**
			B	**0,039**	**0,002**	**0,000**	0,468	**0,005**	**0,031**	**0,000**	**0,001**	0,440	**0,007**
	Diastolic	I	A	0,087	0,325	0,269	0,758	0,498	0,389	0,498	**0,005**	0,296	**0,018**
			B	0,086	**0,006**	**0,000**	**0,023**	0,144	**0,000**	**0,001**	**0,043**	0,793	0,106
		II	A	0,496	**0,043**	**0,001**	0,349	0,149	**0,001**	**0,000**	**0,000**	**0,035**	**0,000**
			B	0,201	**0,002**	**0,000**	0,252	**0,005**	**0,000**	**0,000**	**0,004**	0,122	**0,000**
Heart rate		I	A	0,064	0,098	0,650	0,268	0,801	0,339	0,762	**0,022**	0,109	0,032
			B	0,725	0,063	1,000	0,145	**0,007**	0,063	0,199	0,725	**0,018**	0,103
		II	A	0,935	**0,001**	**0,000**	0,193	**0,029**	**0,001**	0,000	0,000	0,036	0,000
			B	0,308	**0,000**	**0,000**	0,571	0,734	**0,000**	**0,000**	**0,000**	0,175	**0,000**

* probability values less than 0.05 denote statistically significant - marked in bold; LSD - least significant difference; symbols indicating the day of the study are designed as follows (e.g. 5W24): first number indicates micro-cycle day, second capital letter indicates type of measurement (W-pre-training; K-post-training; M-after massage; D-after athlete recovery); third number indicates mesocycle (1-first; 2-second); fourth number indicates microcycle number (from 1 to 4).

A, in 14 cases systolic blood pressure significantly increased after the treatments. The adaptive responses to hydrotherapy treatment were similar in the Group B. After hydrotherapy treatment, in 10 out of 20 cases an increase in systolic blood pressure was statistically significant, while in the remaining 10 cases the increase was statistically insignificant. It was also noted that systolic blood pressure parameters had a tendency to increase after delivery of hydrotherapy treatment. Comparative analysis of diastolic blood pressure dynamics after delivery of hydrotherapy treatments in the Group A showed that in 17 out of 20 cases it increased, and in 3 cases decreased. In 9 chases the change was statistically significant. In the Group B an increase in diastolic blood pressure after hydrotherapy treatments was reported in 19 cases, and only in one case diastolic blood pressure rate was reduced. 10 out of 20 changes were statistically significant.

Comparative analysis of diastolic blood pressure dynamics after delivery of local massage and hydrotherapy treatments showed idiosyncratic characteristics. For instance, in Group A after delivery of local massage treatment diastolic blood pressure parameters decreased in 14 cases out of 20, while in 6 cases were reduced. After delivery of hydrotherapy treatment only in 3 cases diastolic blood pressure decreased, while in as many as in 17 cases it increased. Similar tendency was observed in the Group B, where in 18 cases diastolic blood pressure decreased after delivery of local massage treatment, and in 2 cases it increased, whereas after delivery of hydrotherapy treatments diastolic blood pressure increased in as many as 19 cases out of 20.

Comparative analysis of heart rate dynamics after delivery of hydrotherapy treatment in the Group A showed that heart rate parameters in 19 cases were higher than parameters recorded after local massage. In 9 cases the change was statistically significant. In the Group B after hydrotherapy treatments heart rate in all cases was higher as compared to the rate recorded after local massage. Only in 4 cases the change was statistically insignificant. The results of analysis of variance and post-hoc test of measurements performed during second mesocycle before training are presented in Table 2.

The results of measurement performed after training and recovery treatment are presented in Table 3.

Analysis of blood pressure and heart rate dynamics in Cycle II

Comparative analysis of blood pressure and heart rate parameters in Cycle II in both groups confirms most characteristics observed in Cycle I.

Discussion

The increased interest in sports among disabled pose several challenges as regards intensive seeking for training support measures. One of the most vital methodological aspects of competitive sports is necessity to include complex recovery treatment in training and contest program [2-3] Complex athletic recovery treatment incorporated into trainings and competitions cycle is recommended in contemporary studies as an indispensable element of the entire preparation system [10,15-16] Analysis of hemodynamic parameters aimed at diagnosing athletes condition, their adaptability and form find a broad application in competitive sports [17-21]

The present study included athletes with CP. The

Table 3. Evaluation of means of blood pressure and heart rate in selected days of training during Cycle I and II – second meso-cycle pre-training measurements – variance analysis and LSD.

Parameter		Cycle	Group	II mesocycle post-training							II meso-cycle post massage			II meso-cycle post recovery	
				1 day 1 micro-cycle					5 day, 4 micro-cycle		1 day 1 micro-cycle			5 day 4 micro	1day 1 micro.
				5K24	1M21	5M24	1D21	5D24	5M24	5D24	5M24	1D21	5D24	5D24	5D24
Blood pressure	Systolic	I	A	0,273	**0,000**	0,151	0,161	0,259	**0,012**	0,973	**0,016**	**0,015**	**0,000**	**0,011**	**0,012**
			B	0,131	0,363	0,123	0,976	0,627	**0,003**	0,303	0,524	0,347	0,164	**0,044**	0,649
		II	A	0,042	0,413	0,236	0,051	**0,006**	0,390	0,437	**0,047**	**0,006**	**0,000**	0,103	0,390
			B	**0,022**	**0,016**	0,750	0,318	0,104	**0,010**	0,496	**0,035**	0,148	**0,000**	0,053	**0,010**
	Diastolic	I	A	0,902	0,198	0,099	0,902	0,758	0,076	0,666	0,712	0,243	0,325	0,177	0,853
			B	0,320	0,637	0,192	0,374	0,564	**0,023**	0,675	0,402	0,175	0,296	0,061	0,753
		II	A	0,127	**0,003**	0,551	0,203	**0,012**	**0,035**	0,307	**0,019**	**0,000**	**0,000**	**0,002**	0,203
			B	0,281	0,052	0,787	**0,038**	**0,014**	0,179	0,158	0,093	0,000	0,000	**0,007**	0,685
Heart rate		I	A	0,228	**0,006**	0,057	0,480	0,175	0,480	0,880	0,392	**0,041**	0,160	0,579	0,512
			B	0,063	**0,001**	**0,000**	1,000	0,558	**0,007**	0,199	0,199	**0,001**	**0,007**	**0,000**	0,558
		II	A	0,567	0,052	0,289	0,935	**0,019**	0,104	0,074	0,369	**0,043**	**0,000**	**0,001**	**0,024**
			B	0,428	**0,000**	**0,000**	0,910	0,650	**0,000**	0,214	0,365	**0,000**	**0,000**	**0,000**	0,734

* probability values less than 0.05 denote statistically significant - marked in bold; LSD - least significant difference; symbols indicating the day of the study are designed as follows (e.g. 5W24): first number indicates microcycle day, second capital letter indicates type of measurement (K-post-training; M-after massage; D-after athlete recovery); third number indicates mesocycle (1-first; 2-second); fourth number indicates micro-cycle number (from 1 to 4).

two identical research cycles were conducted twice on the same athletes (Groups A and B) at a 5-month interval, since it was impossible to match a control group characterized by similar parameters to those study groups. However, a 5-month interval can satisfy the conditions for obtaining reliable research results. The obtained results allow to come to conclusion that characteristics of selected functions of the cardiovascular system in the Cycle II do not differ substantially from outcomes observed in the Cycle I. Therefore, those observations on selected hemodynamic functions confirm a positive impact of athletic recovery treatment on the increase of training efficacy in power-lifters with CP that was drawn in Cycle I.

The overall changes in systolic and diastolic blood pressure as well as in heart rate observed in the Cycle I in the Groups A and B proved that hemodynamic adaptive responses to high-intensity training without recovery were in both Groups A and B identical. The research outcomes allowed for drawing up the characteristics of the blood pressure and heart rate dynamics in powerlifters with CP.

In majority of the cases a stable increasing dynamics in post-training systolic blood pressure readings was observed. Similar findings were reported also by other researchers [19;22;23]. Pre-training diastolic blood pressure parameters in both groups increased slightly after the training, however the change is not statistically significant. Many researchers underline the multifactorial relations among hemodynamics components [14-27].

The detailed analysis of systolic blood pressure showed some characteristic behaviors. During training micro-cycles systolic blood pressure demonstrated a tendency to regular fluctuations within normotonic limits, while post-training it showed an increasing dynamics. In the Group A its values were considerably lower during the training mesocycle with athletic recovery treatment than without. During the training mesocycle followed by athletic recovery treatment in the Group B the input systolic pressure parameters were within the limits typical for the mesocycle without athletic recovery treatment, however the limits were wider. Comparative analysis of the changes in the systolic blood pressure values obtained in the Cycle I to the specialist literature allows for a conclusion that systolic blood pressure adaptive responses to high-intensity weight training in Groups A and B follow the pattern of normotonic changes [24,28-30] The observed finding result from a multi-factor impact on athletes hemodynamics [22, 26-27, 31]

Local massage was delivered to muscles that were most loaded during training. After delivery of this treatment during the second training mesocycle, a tendency to substantial decrease in systolic blood pressure was observed as compared to relevant post-training parameters. Similar finding were presented in other studies [28, 32] After delivery of hydrotherapy treatments systolic blood pressure parameters in both groups were considerably higher as compared to relevant parameters recorded after delivery of local massage treatment and they were within the range of post-training parameters, which was also observed by Strack [28]. Local massage treatment had a recovering effect on diastolic blood pressure lowering it to pre-training rates. The data obtained in the study prove that local massage treatment had a definitely greater normalizing effect on systolic than on diastolic blood pressure values. Local massage treatment in all cases had an effect on heart rate lowering it to pre-training rates and the results were statistically significant. However, the findings regarding influence of local massage on haemodynamics are interesting, the topic require further research.

The results of the study indicate that systolic blood pressure parameters had a tendency to increase after delivery of hydrotherapy treatment, which means that the hydrotherapy treatments have a significant impact on athletes' hemodynamics. The research proved that hydrotherapy treatments are the source of significant load and therefore the methods of its application, especially after high-intensity weight training require further research. In the present study hydrotherapy treatments resulted in adaptive changes in diastolic blood pressure that are typical for post-training parameters. Therefore, it can be assumed that diastolic blood pressure dynamics is multidirectional in nature, as opposed to systolic blood pressure dynamics, where a stable increasing tendency was observed. As reported in the study and by other researchers, hydrotherapy treatments increase heart rate to the post-training parameters [25,33-34]. Small heart rate dynamics prove that the cardiovascular system is healthy and well regulated [33-34]. Hydrotherapy treatments and local massage delivered after high-intensity training have statistically significant impact on athletes heart rate and blood pressure and significantly boost hemodynamic processes.

Conclusions:

1. Combination of strength training with complex athletic recovery treatment has positive impact on dynamics of blood pressure and heart rate hemodynamic parameters, which in turn boosts training effectiveness in disabled powerlifters with CP.
2. The research proved that hydrotherapy treatment is a source of significant load and therefore the methods of its application, especially after intensive weight training require thorough research.

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Conflict of interests

The authors declare that there is no conflict of interests.

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