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Changes in Splenic Volume After the Treadmill Exercise at Specific Workloads in Elite Long-distance Runners and Recreational Runners

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ABSTRACT

Introduction: Spleen acts as blood reservoir both in animals and human beings. Spleen contracts during the exercise and so augment the systemic circulation and helps body to maintain longer on high intensity exercise. Reviewing all available literature, it was shown that spleen volume decreases by 8% to 56% depending on the work intensity. **Aim:** To evaluate the percentage of the decrease in splenic volume at specific workloads: aerobic threshold, anaerobic threshold, submaximal and maximal intensity. **Material and Methods:** This prospective study with repeated measurements included 16 healthy subjects, divided in two groups. First group consisted of 8 elite long-distance runners and second group of 8 recreational runners. First workload was designed to be when participant achieves the aerobic threshold. Second work load was when anaerobic threshold was achieved. Third work load was described as submaximal load, meaning load above the anaerobic threshold but still not the maximal level of intensity. Fourth load was the maximal load, meaning exercise to exhaustion. First testing (ergospirometry) was conducted in "Pro-Fit Health. Strength and Conditioning" centre, Sarajevo. This data was crucial for the second testing which was conducted in the Health Centre "Dom zdravljaCentar", Sarajevo. Workloads were controlled by the speed of treadmill, for each subject individually regarding the ergospirometry test. Ultrasound measurement of spleen was done before and after each workload. **Results:** Spleen contraction was the biggest after the 3rd workload in elite long-distance runners: 51% spleen volume before the workout. Elite long-distance runners had greater spleen contraction than the recreational runners after all workloads, but without statistical significant difference. **Conclusion:** Elite long-distance runners had greater decrease in splenic volume, after exercise at four specific workloads, than recreational runners.

Keywords: Splenic volume, treadmill exercise, runners.

1. INTRODUCTION

Beside its other functions, spleen has an important role during exercise(1,2). Spleen acts as blood reservoir both in animals and human beings(1,2). Spleen contracts during the exercise and so augment the systemic circulation and helps body to maintain longer on high intensity exercise.

It is known that spleen volume decreases during exercise. Different stressors, protocols, participants and methods were used to prove this statement(3-8). Our focus was on the results obtained after exercise on treadmill or cycle ergometer. Reviewing all available literature, it was shown that spleen volume decreases by 8% to 56% depending on the work intensity(1).

However, it was not shown how much does the spleen contracts

during the exercise, differentiating the workloads at aerobic and anaerobic threshold, submaximal and maximal level intensity. Other studies included workloads set regarding the percentage of maximal oxygen uptake(3,5), some of studies included cycle ergometer exercise to exhaustion(3,6), cycle ergometry on specific loads such as: 75, 150, 200 W(9). We aimed to see how much does the spleen contracts at specific workloads: aerobic and anaerobic threshold, submaximal and maximal level intensity.

2. AIM

To evaluate the percentage of the decrease in splenic volume at specific workloads: aerobic threshold, anaerobic threshold, submaximal and maximal intensity.

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3. MATERIAL AND METHODS

This prospective study with repeated measurements included 16 healthy subjects, divided in two groups. First group consisted of 8 elite long-distance runners and second group of 8 recreational runners. Written informed consent was taken for each subject. Ethical approval was obtained from Ethical committee of the Medical Faculty, University of Sarajevo. This investigation was done according to ethical principles of Helsinki declaration.

Inclusion criteria for both groups were: age 18-25 and Bosnian-Herzegovinian nationality white people. For group of elite long-distance runners: national competitors with international participation. For recreational runners: running 3-5 times per week, non-competitive level.

Exclusion criteria were used: a) any clinical or laboratory evidence of infection within at least 4 weeks prior to testing, b) any hematopoietic diseases, c) genetic diseases (thalassemia and sickle cell anaemia), d) lymphadenopathy, e) liver disease (cirrhosis or portal hypertension), f) renal failure, g) history of splenic trauma, h) non-traumatic benign splenic lesions, i) malignant lesions, j) pregnancy, k) splenectomy. All subjects had normal complete blood count.

First workload was designed to be when participant achieves the aerobic threshold. Second workload was when anaerobic threshold was achieved. Third workload was described as submaximal load, meaning load above the anaerobic threshold but still not the maximal level of intensity. Fourth load was the maximal load, meaning exercise to exhaustion. On first workload subject was running 10 minutes, on second 10 minutes, on third 3-5 minutes, on last workload up to 2 minutes.

First testing (ergospirometry) was conducted in "Pro-Fit Health. Strength and Conditioning" centre, Sarajevo. This data was crucial for the second testing which was conducted in the Health Centre "Dom zdravlja Centar", Sarajevo. Workloads were controlled by the speed of treadmill, for each subject individually regarding the ergospirometry test. Ultrasound measurement of spleen was done before and after each workload. The break between each workload was 30 minutes, which is enough for spleen to recover to initial volume levels. Subjects were asked not practice hard 72 hours prior to testing, not to take excessive caffeine or other stimulants.

Examinations were performed using GE LOGIQ P9 ultrasound machine equipped with GE 1.5 RS convex probe. Subjects were placed in supine or right posterior oblique position. Spleen was scanned during suspended respiration.

Splenic length is defined as maximum distance of spleen in longitudinal plane. Splenic width and depth are assessed in transverse plane. Width is the maximum anteroposterior dimension, while depth is the mediolateral

distance from hilum to the outer convex surface. Spleen volume was calculated using the standard ellipsoid formula: $0,524 \times \text{length} \times \text{width} \times \text{depth}$. All ultrasound measurements were taken by the same physician (experienced in abdominal ultrasonography).

4. RESULTS

The study included 16 subjects, divided into two groups: eight elite long-distance runners (four males and four females, aged $21,8 \pm 2,9$ yrs), and eight recreational runners (six males and two females, aged $24,5 \pm 0,8$ yrs).

Spleen contraction was similar between the groups after the workloads. Spleen contraction was the biggest after the 3rd workload in elite long-distance runners. Smallest contraction was in group of recreational runners after the 1st workload. Statistically significant difference was not found between the groups after the specific loads. However elite long-distance runners had greater spleen contraction than the recreational runners after all workloads.

	Group	N	%spleen volume before the workout	SD	Significance between groups
after 1 st workload	elite long-distance runners	8	73,17	±15,16	p>0,05
	recreational runners	8	79,65	±8,28	
after 2 nd workload	elite long-distance runners	8	65,18	±15,26	p>0,05
	recreational runners	8	71,96	±8,32	
after 3 rd workload	elite long-distance runners	8	51,35	±12,78	p>0,05
	recreational runners	8	61,04	±7,98	
after 4 th workload	elite long-distance runners	8	53,76	±12,36	p>0,05
	recreational runners	8	59,46	±6,79	

Table 1. Spleen volume percentages after the four specific workloads.

5. DISCUSSION

Regarding the splenic volume decrease during exercise, this is the first study to determine the workloads as follows: aerobic and anaerobic threshold, submaximal and maximal level intensity. This is important because the aim was to evaluate how much does the spleen contracts after the exercise at the four specific workloads. The two groups are similar regarding the energy system they are predominantly using – aerobic energy system, and therefore it was interesting to evaluate how would they react at the determined workloads.

Subjects achieve workloads level on different speed, therefore the ergospirometry test was crucial in order to proceed to second testing. To the best of our knowledge, other studies did not use elite athletes for proving the splenic volume decrease during exercise, and that is also one of the specifics of our investigation. Term "elite" is often used in sport and sport science, but there is no clear definition what does it really mean(10). However, we assume that we had elite long-distance runners in our study, because they are national and international competitors, who make substantial results for our country.

Reviewing the literature, different exercise protocols were used in order to evaluate the spleen volume changes. Flammet al. set the loads as: zero-load, 50% maximal oxygen uptake (VO₂ max), 75% VO₂ max and 100% VO₂

max, and made also spleen measurement in a recovery phase that consisted of running to zero-load(5). Stewart et al. set the load as 60% of VO₂ max, and subjects needed to exercise at this load for different durations: 5, 10, and 15 minutes(3) nine men cycled at an intensity of 60% maximal O₂. Subjects also did the incremental cycling to exhaustion and spleen measurements were made after this test in recovery phase. Laub et al. set loads as: 75, 150, 200 W(9). Other authors used the protocol simply saying: cycle ergometer exercise to exhaustion.

Stewart et al. stated that 60% VO₂ max represents the value below everybody's anaerobic threshold(3) nine men cycled at an intensity of 60% maximal O₂. After 5 minutes of running at 60% VO₂ max they showed a 28% reduction in spleen volume, after 10 minutes 30% reduction, and after 15 minutes 36% spleen volume reduction. In the incremental cycle to exhaustion, the subjects showed a 56% reduction in spleen volume. In our study, in aerobic phase (first workload) elite long-distance runners showed 27% reduction, while recreational runners showed 21% reduction.

Stewart et al. showed that immediately after the incremental test, the spleen volume was 43.5 ± 4.4% of initial volume, in recovery after 10 minutes 71.8 ± 6.2%, after 20 minutes 90.6 ± 5.1%, after 30 minutes 99.4 ± 5.4%, after 40 minutes 102.9 ± 3.9%. Due to these results, we decided in our study that the break between the workloads would be 30 minutes.

Flamm et al. set the workloads in an interesting way. In the protocol scheme, they ran 5 minutes on each workload: 50% VO₂ max, 75% VO₂ max, 100% VO₂ max(5). Critically speaking, it can be concluded that it was probably not realistic that subjects who are not very ready (regarding the values of VO₂ max) ran 5 minutes at 100% VO₂ max. Flamm et al. have shown that after working at zero load, the spleen volume increased by 5% (which is interesting and can suggest a possible increase in volumes in order to meet the readiness of the organism for high intensity training), at load 50 % VO₂ max spleen contracted by 8%, at 75% VO₂ max contracted by 29%, at 100% VO₂ max contracted by 46%. In recovery phase, volume increased.

In our study, subjects on third workload ran for 3-5 minutes (they all succeeded in this), and on the fourth workload they ran until exhaustion, and it lasted for up to 2 minutes (literature says that in high intensity anaerobic effort, the organism can withstand up to 2 minutes). Our results suggest greater contraction after submaximal level than maximal level. Probably, the duration of the activity on fourth workload was too short, for the spleen to contract more. Moreover, Nikolic points out that, above the anaerobic threshold, maximum concentration of lactate at fixed level, occurs only after the third minute, precisely between the fourth and the fifth minute(11). These metabolic changes might suggest why spleen contracted more on third workload.

Additionally, Laub et al. showed progressive decrease of spleen radioactivity to 34% of initial value(9). Sandler et al. suggested 43% reduction of spleen radioactivity

immediately post-exercise(4). Froelich et al. stated 39% decrease of splenic volume(6).

6. CONCLUSION

There was no statistically significant difference between elite long-distance runners and recreational runners in spleen volume change after the exercise at four specific workloads. Elite long-distance runners had greater decrease in splenic volume, after exercise at four specific workloads. Biggest contraction happened in elite long-distance runners after the third workload (submaximal level intensity) – 49% decrease in splenic volume.

Author's Contribution: All authors gave substantial contribution to the conception or design of the work, in the acquisition, analysis and interpretation of data for the work. All authors had role in drafting the work and revising it critically for important intellectual content. Each author gave final approval of the version to be published and they agreed to be accountable for all aspects of the work in ensuring the questions related to the accuracy or integrity of any part of the work.

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REFERENCES

1. Shephard RJ. Responses of the human spleen to exercise. *J Sports Sci.* 2016; 34(10): 929-936.
2. Stewart IB, McKenzie DC. The human spleen during physiological stress. *Sports Med Auckl NZ.* 2002; 32(6): 361-369.
3. Stewart IB, Warburton DER, Hodges ANH, Lyster DM, McKenzie DC. Cardiovascular and splenic responses to exercise in humans. *J Appl Physiol Bethesda Md.* 1985. 2003 Apr; 94(4): 1619-1626.
4. Sandler MP, Kronenberg MW, Forman MB, Wolfe OH, Clanton JA, Partain CL. Dynamic fluctuations in blood and spleen radioactivity: splenic contraction and relation to clinical radionuclide volume calculations. *J Am Coll Cardiol.* 1984 May; 3(5): 1205-1211.
5. Flamm SD, Taki J, Moore R, Lewis SF, Keech F, Maltais F, et al. Redistribution of regional and organ blood volume and effect on cardiac function in relation to upright exercise intensity in healthy human subjects. *Circulation.* 1990 May; 81(5): 1550-1559.
6. Froelich JW, Strauss HW, Moore RH, McKusick KA. Redistribution of visceral blood volume in upright exercise in healthy volunteers. *J Nucl Med Off Publ Soc Nucl Med.* 1988 Oct; 29(10): 1714-1718.
7. Frances ME, Dujic Z, Shoemaker JK. Splenic constriction during isometric handgrip exercise in humans. *Appl Physiol Nutr Metab Physiol Appl Nutr Metab.* 2008 Oct; 33(5): 990-996.
8. Engan HK, Lodin-Sundström A, Schagatay F, Schagatay E. The effect of climbing Mount Everest on spleen contraction and increase in hemoglobin concentration during breath holding and exercise. *High Alt Med Biol.* 2014 Apr; 15(1): 52-57.
9. Laub M, Hvid-Jacobsen K, Hovind P, Kanstrup IL, Christensen NJ, Nielsen SL. Spleen emptying and venous hematocrit in humans during exercise. *J Appl Physiol Bethesda Md* 1985. 1993 Mar; 74(3): 1024-1026.
10. Williams A, Day S, Stebbings G, Erskine R. What does 'elite' mean in sport and why does it matter? *The Sport and Exercise Scientist.* 2017; (51): 6.
11. Nikolic Z. Fiziologija fizičke aktivnosti. Beograd: Fakultet sporta i fizičkog vaspitanja Univerziteta u Beogradu, 2003.