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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, the human spleen shows a decrease in volume, in range from 8% to 56%, depending on the work intensity. **Aim:** To evaluate the percentage of the decrease in splenic volume after the treadmill exercise at specific workloads: aerobic threshold intensity, anaerobic threshold intensity, submaximal intensity and maximal intensity. **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 testing consisted of treadmill ergospirometry test. This data was crucial for the second testing where subjects were exercising on treadmill at specific workloads. Four specific workloads were determined: treadmill exercise at aerobic threshold intensity (1st workload), anaerobic threshold intensity (2nd workload), submaximal intensity (3rd workload) and maximal intensity (4th workload). 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:** Elite long-distance runners showed greater spleen contraction than recreational runners after four 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, regarding the splenic volume after exercise at four specific workloads ( $p > 0.05$ ). **Conclusion:** Elite long-distance runners had greater decrease in splenic volume than recreational runners, after exercise at four specific workloads, without significant difference. Greatest decrease happened in elite long-distance runners, after exercise at submaximal intensity - 49% decrease in splenic volume.

**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, the human spleen shows a decrease in volume, in range from 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 at specific loads such as: 75, 150, 200 W (9).

## 2. AIM

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

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### 3. 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. At first workload subject was running 10 minutes, at second 10 minutes, at third 3-5 minutes, at last workload up to 2 minutes.

First testing (treadmill ergospirometry) was conducted in "Pro-Fit Health. Strength and Conditioning" center, Sarajevo. This data was crucial for the second testing which was conducted in the Health Center "Dom zdravlja Centar", Sarajevo, where subjects exercising on treadmill at specific workloads. 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 level (3). 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 an-

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

teroposterior 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  $21,8 \pm 2,9$  years), and eight recreational runners (six males and two females, aged  $24,5 \pm 0,8$  yrs).

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. Additionally, there was no statistically significant difference between the spleen volumes before the workout regarding each group separately.

### 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 determined workloads.

Subjects achieve the workloads level on different treadmill 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. Flamm et al. set the loads as: zero-load, 50% maximal oxygen uptake (VO<sub>2</sub> max), 75% VO<sub>2</sub> max and 100% VO<sub>2</sub> 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 VO<sub>2</sub> max, and subjects needed to exercise at this load for different durations: 5, 10, and 15 minutes (3). 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% VO<sub>2</sub> max represents the value below everybody's anaerobic threshold (3). After 5 minutes of running at 60% VO<sub>2</sub> 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. After the exercise to exhaustion, elite runners showed 46% reduction, while recreational runners 41% reduction in spleen volume.

Stewart et al. showed that immediately after the incremental test, the spleen volume was  $43.5 \pm 4.4\%$  of initial volume, in recovery after 10 minutes  $71.8 \pm 6.2\%$ , after 20 minutes  $90.6 \pm 5.1\%$ , after 30 minutes  $99.4 \pm 5.4\%$ , after 40 minutes  $102.9 \pm 3.9\%$ . 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% VO<sub>2</sub> max, 75% VO<sub>2</sub> max, 100% VO<sub>2</sub> 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 VO<sub>2</sub> max) ran 5 minutes at 100% VO<sub>2</sub> max. Flamm et al. have shown that after working at zero load, the spleen volume increased 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 % VO<sub>2</sub> max spleen contracted 8%, at 75% VO<sub>2</sub> max contracted 29%, at 100% VO<sub>2</sub> max contracted 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 at 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

Elite long-distance runners showed greater decrease in splenic volume than recreational runners, after exercise at four specific workloads. Greatest decrease in splenic volume 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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- **Conflicts of interest:** None declared.
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