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# Maximal Anaerobic Muscular Power Before and After Exposure to Chronic Hypoxia

Author's Contribution
A – Study Design
B – Data Collection
C – Statistical Analysis
D – Data Interpretation
E – Manuscript Preparation
F – Literature Search
G – Funds Collection

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***Key words:*** *anaerobic performance, maximal power, high-altitude, hypoxia*

## *Abstract*

***Background:*** *The recent data on muscle biopsies (changes in ATP, phosphocreatine and glycogen stores, glycolytic enzyme activities, LA concentration) proves that maximal anaerobic power (Pmax) measured during short-term, high intensity-exercise is not altered by hypobaric hypoxia up to the altitudes 5200-5500m. During the exercise lasting for 30s or more (i.e. the Wingate Test) the results occured to be conflicting. It is mainly due to lower participation of aerobic metabolism during this test. Taking into consideration the above mentioned facts, this study is to investigate the changes in anaerobic muscle power after 4-6 weeks of chronic hypoxia exposure.*

***Material and methods:*** *The maximal muscular anaerobic power was measured in nine subjects before (B) and after (A) a prolonged exposure to a high altitude (above 4500 m asl). The subject performed the 30s Wingate Test twice before and after a high mountain expedition. Body composition was estimated (B) and (A) the exposure to a high altitude by bioimpedential method.*

***Results/Conclusions:*** *We have shown a few significant differences in the value of peak power [W] 689.5 118 and 580 112, maximal power [W] 683 117 and 574 111, maximal power [W • kg$^{-1}$] 9.61 0.95 and 8.68 0.97, respectively, before and after a high-altitude exposure. The fatigue index was significantly lower after the expedition, and we can see similar changes in the value of time to approach maximal power [s]. We have also shown that there are no significant changes in most anthropometric and physical values. There is only one significant difference between the pre- and post-expedition period with value of FAT.*

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## Background

High-altitude exposure impairs both maximal aerobic and anaerobic performance. It is known that maximal aerobic power ($VO_{2max}$) decreases proportionally to the altitude increase. It is the consequence of reduced oxygen pressure ($PO_2$) and low haemoglobin $O_2$ saturation. Many authors claimed that anaerobic muscle power output and blood lactate accumulation during short, supramaximal exercise are substantially unaffected by hypoxia if the length of exposure does not exceed 4-5 weeks. After this period the decrease of muscle mass may become an important factor contributing to the maximal anaerobic muscle power output. However, there is no evidence that anaerobic metabolism processes were regulated enough to sustain energy consumption during chronic hypoxia, but on the other hand, enhanced fatty acid metabolism may spare carbohydrates for metabolic fuel in conditions of extreme hypoxic limitation. Due to this fact, we have examined the effect of four weeks' exposure to high altitude on body composition and anaerobic performance.

## Material and methods

Nine healthy males (mean age 26.9 4.3) volunteered for this study. Table 1 illustrates the anthropological characteristics of the examined group. They were members of high-mountain "Pamir 2005 Expedition," and they had spent over four weeks at the altitude between 4500-6500 m. Two weeks before and after the exposure to hypoxia they performed supramaximal cycloergometic exercise (30s Wingate Test) introduced by Bar Or [1,2]. After warming up, the subject began pedalling as rapidly as possible during 30s against a heavy resistance of 0.74N • $kg^{-1}$ body mass. The load was applied before the subject started his work. During the test we measured the following values: amount of total work, peak and maximal power output, fatigue index, time to approaching the peak power, time of sustained peak power.

Body composition was estimated by the bioimpedential method using the Tanita Body Fat Monitor/Scale Analyser TBF-300.

Conventional statistical methods were used to analyse the data, significantly different from the respective values in the consecutive bouts of exercise and differences between anthropometric values before and after expeditions being considered at the level of $P<0.05$.

## Results

The physical characteristic of the subjects are presented in Table 1. It is shown that there are no significant changes in most anthropometric and physical values in this group (Fig. 1). There is only one significant difference between the pre- and post-expedition period with value of FAT (Fig. 1a). Fat mass in [kg] before (B) and after (A) expedition was10 2.1 and 7.9 1.7, respectively, and in [% of total body weight] was (B) and (A) 13 3.0 and 11.5 3, respectively.

We have also shown a few significant differences in the value of peak power [W] 689.5 118 and 580 112, maximal power [W] 683 117 and 574 111, maximal power [W • $kg^{-1}$] 9.61 0.95 and 8.68 0.97, respectively before and after high-altitude exposure. The fatigue index was significantly lower after the expedition and similar changes can be observed in the value of the time to approach maximal power [s] (Table 2).

Table 1. Anthropometric and physical characteristics of the examined group.

| | Age [year] | Height [cm] | Weight [kg] | BMI [$kg \cdot m^{2-1}$] | BMR [kcal] | FAT [%] | FAT [kg] | FFM [kg] | TBW [kg] | BSA [$m^2$] |
|---|---|---|---|---|---|---|---|---|---|---|
| Before N=9 | 26.9 ± 4.3 | 177.6 ± 5.1 | 71.7 ± 7.6 | 22.7 ± 2.0 | 1749 ± 152 | 13.9 ± 3.0 | 10.0 ± 2.1 | 61.8 ± 6.8 | 45.2 ± 5.0 | 1.88 ± 0.12 |
| After N=9 | | | 69.9 ± 7.5 | 22.2 ± 1.7 | 1724 ± 158 | 11.5 ± 3.2* | 7.9 ± 1.7* | 62.0 ± 7.9 | 45.4 ± 5.8 | 1.87 ± 1.2 |
| | | | | | | P<0.05 | P<0.05 | | | |

Values are means ± SD, N - no. of subject,
* Difference from after the expedition (as determined by paired t-test)
BMI – body mass index , BSA – body surface area, BMR – basic metabolic rate, FFM- free fat mass, TBW- total body water

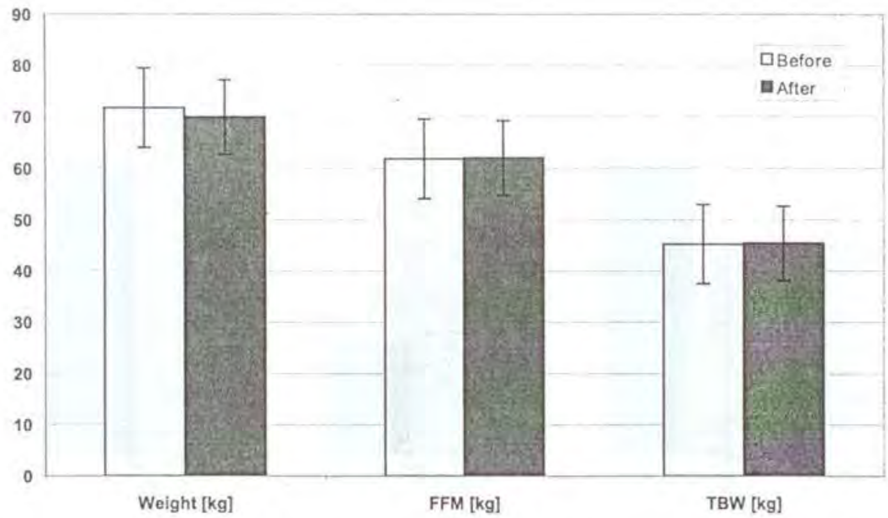


Fig. 1. Anthropometric and physical characteristics of the examined group (there are no significant changes)

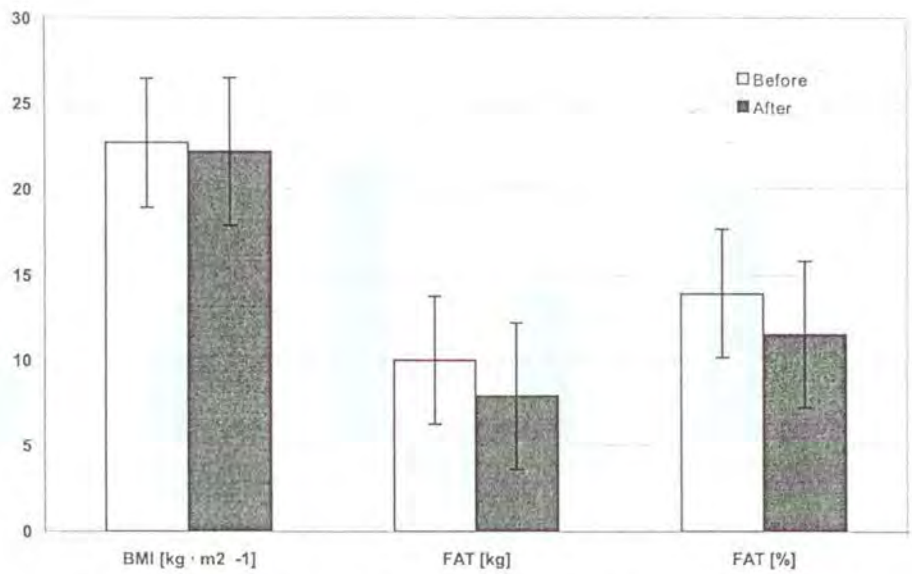


Fig.1a. Anthropometric and physical characteristics of the examined group (there are significant changes)

Table 2. Physiological characteristics of the in anaerobic muscle performance- 30s Wingate Test in examined subjects before and after the expedition

| | Peak Power [W] | Total work [KJ] | Total work $[J \cdot kg^{-1}]$ | Power max [W] | Power max $[W \cdot kg^{-1}]$ | Fatigue index [%] | Time to approach Pmax [s] | Time of sustain Pmax [s] |
|---|---|---|---|---|---|---|---|---|
| Before N=9 | 689.5 ± 118 | 17 ± 2.5 | 242 ± 16.2 | 683.7 ± 117 | 9.61 ± 0.95 | 18.8 ± 4.3 | 4.0 ± 0.5 | 4.66 ± 1.1 |
| After N=9 | 580.6 ± 112* | 15 ± 2.3 | 222 ± 16.9 | 574.0 ± 111* | 8.68 ± 0.97* | 16.0 ± 3.5* | 5.42 ± 2.4* | 4.46 ± 0.7 |
| | P<0.05 | | | P<0.05 | P<0.05 | P<0.05 | P<0.05 | |

Values are means ± SD, n - no. of subject,
* Difference from after the expedition (as determined by paired t-test)

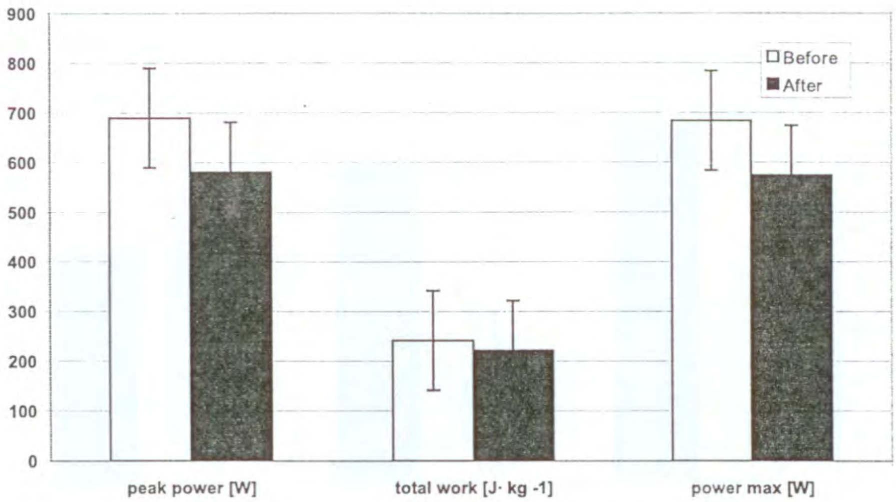


Fig. 2. Physiological characteristics of the examined group in anaerobic muscle performance before and after the expedition during the 30s Wingate Test

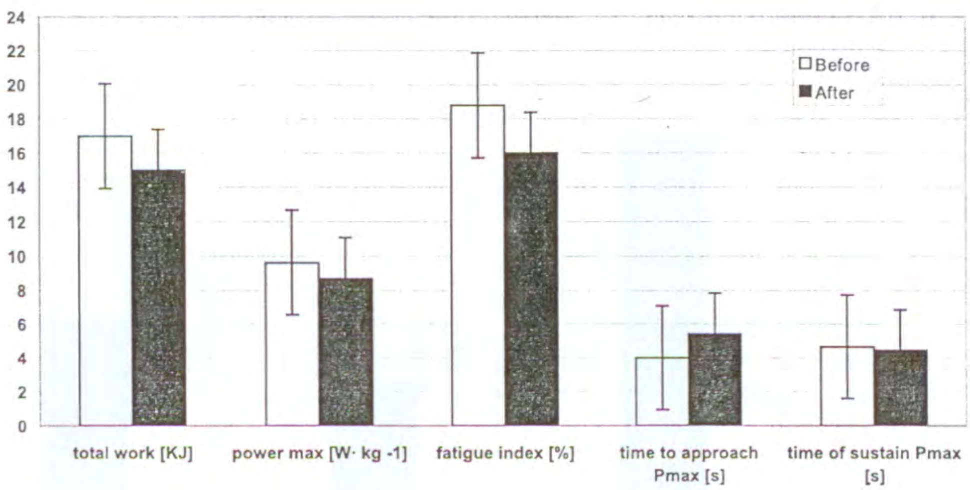


Fig. 2a. Physiological characteristics of the examined group in anaerobic muscle performance before and after the expedition during the 30s Wingate Test

## Discussion

Our studies have shown that there are no significant changes in most of the body composition's parameters between the pre- and post-expeditions period. There is only one significant difference in the value of FAT measured in [%] of body mass or in [kg], and that may prove enhanced fatty acid metabolism during long-lasting expeditions or high-altitude stress. It may suggest that long trekking to the base camp influences the increase in fat utilization and in losing fat mass. This mechanism may spare carbohydrates for metabolic fuel under conditions of extreme hypoxic limitation [3,4], but, on the other hand, it is not so obvious because glucose (glycogen) metabolism uses $O_2$ more efficiently.

Many authors have presented evidence that anaerobic muscle power output and blood lactate accumulation during short supramaximal exercise are substantially unaffected by chronic hypoxia [5,6,7]. We have shown many significant differences between anaerobic performance parameters before and after the expedition, contrary to what had been expected. It can be the consequence of reduced muscle mass and/or of muscle deterioration. There is some evidence from muscle biopsies taken from the vasus lateralis muscles of mountaineers after a 6-8 week sojourn at a high altitude. The reduction of the fibre cross-sectional area was found, which was accompanied by a decrease in the volume density of the mitochondria. On the other hand, it was showen that the anaerobic peak power was not affected by severe hypoxia within the first 3 weeks of exposure; thereafter, it decreased by about 25% probably as a result of muscle deterioration [8,9]. Whereas in acute hypoxia $VO_{2max}$ is primarily reduced by a lack of $O_2$, in chronic hypoxia a decrease in muscle mass may become an important factor contributing to the limitation of the maximal aerobic and anaerobic performance. However, in our study there is no evidence of muscle deterioration, but we also can not exclude it.

## Conclusions

- Long lasting expedition may contribute to losing muscle mass and/or fat mass.
- The bioimpedential method is not good enough to prove muscle deterioration or to exclude it.
- Our work has shown maximal anaerobic power decrease after exposure to chronic hypoxia but its explanation is still not clear.
- Further studies are needed to explain the effect of chronic hypoxia on decreases in anaerobic muscle power output, anaerobic metabolic pathways and the changes of body composition's parameters.

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