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Fat Oxidation While Hiking and Mountaineering - An Analysis from Dom (4545 Meter) - The Highest Mountain in Switzerland

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Abstract

The aim of this study was to calculate based on theoretical assumptions how many meters of altitude an alpinist has to make in order to burn one kilo of fat. One kilo of fat has around 8000 kcal respectively 33000kj. The rate of maximal fat oxidation is probably around 65 - 75% VO2max intensity burning 0.5 to 0.6 g fat per minute. Although this relatively high intensity cannot be performed for several hours consequently hints exist that for longer exercises intensity of 50-60% VO2max is probably better suited. Concerning amount of fat burnt it has to be considered that around one fourth in fat tissue is water and as a consequence 1 gram of human fat tissue has only 0.75 gram pure fat. This gives a maximum of 45-50 Gramm fat tissue oxidized per hour yielding to theoretically 20h physical activity. On the other side while mountaineering in pre-alps terrain or when reaching SAC cottages around 400-600 meters altitude per hour are absolved. Well-trained alpinists and elite alpinists even reach more than 1000 meters during several hours. Taking the assumption that 500 meters per hour are absolved this yields to about 10000 meters for one kg body fat tissue. Thereby it has to be considered that while physical activity is performed other energy substrates such as carbohydrates and proteins are used while intensity is increased. The aim to burn one kilo of fat is probably not always reached when climbing the highest mountain in Switzerland Dom with 4545 meter. Although during a mountaineering week it is probably possible to absolve up to 10'000 meters and demanding descents are absolved additionally implying the preventive effect on metabolic and cardiovascular system of mountaineering for the human body.

Keywords: Fat oxidation; Meters above sea level; Dom 4545 m

Introduction

Mountaineering has gained increased attraction and it is assumed that nowadays more than 40 million tourists per year visit places higher than 2000 meters annually [1-3]. On the same time, based on epidemiological findings humans from western societies are getting fatter and fatter [4,5]. This is a result of the increasing inactivity due to the fact that skeletal muscle is the only organ able to burn long-chain fatty acids from which triglycerides from adipose tissues are built and can be oxidized in mitochondria [6-8]. Furthermore, the anabolic metabolism predisposes for many other illnesses such as metabolic syndrome, diabetes mellitus, hypertonia and further cardiovascular affections [7]. Different factors influence fat oxidation, whereby arbitrarily training status, exercise intensity, exercise duration, exercise type, used muscle mass, age and sarcopenia, gender and metabolic disturbances can be mentioned [5]. In the following effects of mountaineering respectively absolved meters of height on the caloric aspect of adipose tissue are discussed with the aim to get parameters to compare concerning the preventive potential of mountaineering.

Different factors are important for fat oxidation, whereby in a first step exercise intensity can be mentioned. Concerning that with increasing intensity fat oxidation decreases relatively and as a counter reaction carbohydrate oxidation increases [9-11]. In relatively high intensities of 65-75% VO2max rate of maximum fat oxidation peaks, however these high intensities cannot be kept for a longer exercise time (several hours) [12-15]. With such high intensity's body´s own intramuscular substrates should be emptied within hours and intensity has to be reduced [16]. As a consequence hints exist, that for longer time of exercising an intensity of 50-60% VO2max should be better suited [5]. With increasing intensity carbohydrate oxidation and lactate oxidation in muscle fiber and in plasma is increased [17]. The accumulation of lactate in Plasma correlates with a decrease in fat oxidation with increasing intensity of exercise [9]. In the range of a lactate concentration of 2 mmol/l [10,12,13] to 2.5 mmol/l [5,10] intensity with maximum fat oxidation seems to be whereby this is probably independent from kind of movement (e.g. running versus cycling), other hints exist [5,18].

To mention is, that the relative share of fat for energy production is within an intensity of 55-75% VO2max constant at around 50% [13]. With 65% VO2max with 0.5 to 0.6 g fat per min the highest fat oxidation is achieved [9]. If assuming that energy of one gram fat is 9.3 kcal or 38.9 kJ, it becomes obvious that per hour maximal 1400 kj fat is burnt [11,17]. However it is important to consider, that body tissue also has a relatively high share of water, reducing caloric value to around 7 kcal respectively 28 kj per gram body fat tissue. This implies that around 20 h in the range of highest fat oxidation is necessary to burn one kg body fat tissue depending strongly from training state (very well trained alpinists probably less than 10 hours) and depends on further parameters such as used muscle mass, age or gender.

The important aspect of training state is to keep in mind having high relevance for fat metabolism. It is accepted knowledge that the capacity for fat oxidation depends from physical activity [18]. Adjustments from training yielding from a metabolic point of view to an increased fat and a reduced carbohydrate usage and e.g. marathon runners know, that fat metabolism has to be trained with long distance runs while glycogen stores are not sufficient for exercises lasting longer than two hours or more [19]. The same is true for mountaineering, whereby the important glycogen store in skeletal muscle and liver (up to 150 gram glycogen, about 10 % of liver weight) and two third on musculature (up to one percent of body weight) and therefore ca. 300 - 500 gram is the range of availability. Furthermore it has to be considered, that additional carbohydrates can be produced via gluconeogenesis via protein catabolism. Based on these hints due to the fact that mountaineering endures several hours with relatively low intensity that potentially up to 60 percent of used energy is from fat oxidation [20]. To sum up, long lasting endurance sports with low intensity's yield to a higher fat oxidation than exercising with middle intensities [21].

Concrete Calculation Based on Dom Ascent (4545 Meter)

In the following based on theoretical aspects of fat oxidation the ascent of the highest mountain in Switzerland Dom with 4545 Meter is analyzed. Starting in Randa on 1439 Meter above sea level first through larch wood to Dom Cottage on 3256 Meter above sea level. The next day ascent is continued via Festijoch (Point 3723 Meter above sea level) on the 4545 Meter high Dom yielding to a total of 3106 meters (without considering counter ascent). When counting counters ascents e.g. on glaciers 3500 meters result.

Taking into account that e.g. on the route via the somehow more difficult but not more beautiful Festigrat some more difficult technical passages result with short contact to rock increasing physical and psychical requirements. The secure descent from peak has to be taken into account and so another 3106 Meter downhill has to be absolved. As a consequence approximately - together with the existing base metabolism - within two days the caloric usage of 1 kg fat is undoubtedly achieved by some alpinists. Nutrition is however often consumed and only partly delivered by fat oxidation. It has to be considered that during such mountaineering tours for security reasons a sufficient intake of fluids e.g. warm tea is necessary refilling partly glykogenstores in liver and skeletal muscle. Furthermore, the theoretic caloric intake can be calculated based on the above with the law of the conservation of energy. Law of energy conservation states that potential energy is calculated by [kj] = m [kg] x g [m/sec2] x h [m] ist [22]. This has to be delivered in a certain time yielding to the physical performance correlate of Watt. Taking a person with 75 kg body weight absolving an ascent of 1000 meters altitude this yields to 75 kg multiplicated by 9.81m/sec2 with 1000 m yielding to 750'000 Joule respectively 750kj. Considering that the body needs to use biologically exploitable energy carrier in order to deliver physical performance (a lot of energy is used for heat - in this special context probably an advantage-only one fourth of energy can be used as mechanic energy) and the often referenced value of efficiency factor of 0.23 is taken into account around 3000 kj per 1000 meters result [23-26]. It has to be considered, that for downhill especially eccentric muscle work is performed, with the respective predisposition for the development of a muscle sooreness while in the same time only partly using cardiopulmonary system [23-26] (Figure 1).

Figure 1: Dom in the middle beside Täschhorn in the right and Südlenz and Nadelhorn on the left.

Trying to embed findings in already conducted analyses evidence from ski-mountaineering can be taken [27-29]. For

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example it was shown that ski mountaineers choose a rate of optimum ascent rate in order to move efficiently while in the meantime conserving glycogen stores [27]. Calculations concerning the energy usage exist and therefore for the largest ski mountaineering race of the West Alps the Patrouille des Glaciers (PDG) from Zermatt to Arolla and Verbier analyses exist [28]. The analyzed alpinists needed for the race from Zermatt to Arolla (27 km distance and 2113 meters) [28] in average 5 h 7 min ± 44 min and for the race from Arolla to Verbier 5 h 51 min ± 53 min (26 km distance and 1881 meters). Ski mountaineers needed in average 19'200 ± 3'200 kj for the race Zermatt - Arolla respectively 22'600 ± 2'900 kj for the race Arolla-Verbier [28]. The capability to uptake energy was analyzed and astonishingly while for the first part of the race energy intake was analyzed and only 20% of used energy was restored. In average alpinists lost -1.5 ± 1.1 kg, which is only partly due to fluid losses and it is getting obvious that a lot of energy probably mainly in fat form is necessary [28,29].

From the above mentioned it's getting obvious, that only large mountaineering tours reach the caloric intake of 1kg fat. Although during mountaineering weeks in the high alps this can be achieved without problems. Trying to estimate caloric intake with another method the concept of performance km can be mentioned [30]. About 100 meters ascent as well as 200 meters descent as well as one km of horizontal distance are the same performance correlates. For PDG a total of 53 km distance and 3994 meters height are absolved yielding to around 110 performance km. Per Performance km around 400 kj are burnt, which is relatively high and probably a result of the extreme climate conditions such as deep temperatures but also a result in the way that some parts of the race are above 3500 meters [31]. It's getting obvious that when calculating for Dom, which is often climbed by feet and not with backcountry skis in ascent 30 and in descent additional 15 performance km are absolved and also to consider around 5 Kilometer horizontal distance. It's getting obvious that astonishingly around 1 kg body fat tissue is burnt.

Conclusion

The aim of this small study was to analyze how many meters of altitude have to be made in order to burn the caloric equivalent of one kilo of body fat tissue Therefore a mountaineering tour to the highest mountain in Switzerland Dom with 4545 meters was analyzed. It was getting obvious, that based on theoretic assumptions -together with the base metabolism-within two days the caloric intake of one kg fat is undoubtedly reached by some alpinists.

To summarize it can be mentioned, that exercise intensity's around 65% VO2max probably are the range with maximum fat oxidation, whereby reducing to 50% VO2max for long lasting exercises allows increasing total amount [5]. During such exercises 0.5-0.6 gram pure fat is burnt, which is due to additional water in body fat tissue around 45-50 gram body fat tissue with around 1400 kj. Mountaineering is often done in the mentioned intensity zone and it becomes evident that around 20h of mountaineering are necessary to lose one kilo of body fat.

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