HEART RATE AS AN INDICATOR OF SPORT CLIMBING INTENSITY

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The objective of our research project was to introduce heart rate during sport climbing as one of the possible indicators of climbing intensity. For the purpose of our research, 11 sport climbers climbed three routes of varying grades of difficulty. The heart rate of the climbers was measured and climbing intensity was calculated. It was shown that, in spite of high local climbing intensity, general climbing intensity was rather low. Analysing the results, we wondered if the measured values actually reflected increased intensity or if they were a sign of some other phenomenon that was not monitored. Changes in heart rate during sport climbing can appear due to various factors, which can not all be completely controlled. Therefore, monitoring heart rate during sport climbing as an intensity indicator seems quite dubious.

Keywords: Sport climbing, heart rate, climbing intensity.

INTRODUCTION

The success of a climber depends mostly on climbing technique (Goddard & Neumann, 1993). The best climber in a competition is the one that makes the least mistakes during climbing. Although movement appears rather slow, climbing is a race with time. When not in a competition, a climber has to reach the top before the muscles are completely exhausted and co-ordination collapses, which is a common cause for the termination of climbing (by falling). In climbing competition, however, the available time is set before the competition and is equal for all competitors. In both cases, rational use of energy is of the utmost importance. A climber can make the best use of energy available with suitable psychological preparation and technically faultless tactical climbing (Leskošek, 2003).

Climbing involves the factors of physical strength (power, endurance, flexibility) as well as technique (co-ordination) (Goddard & Neumann, 1993). Those factors are closely related to success in climbing (Ulaga, 1999). Apart from movement abilities, an important role in successful sport climbing is played also by the morphological characteristics of a climber (Watts, 1999). Together with muscular strength, anaerobic and aerobic strength, and lung capacity, they form the profile of a climber. Scientists still argue about the role of general endurance in the achievement of success in climbing. Watts (1999) finds research on various indicators of general endurance to be sensible. According to Goddard and Neumann (1993), general endurance has no considerable impact on climbing, except in the case of the effect of aerobic endurance on body mass regulation, regeneration and handling stressful situations.

Climbing is a physical activity that is stressful for the human organism. Stress is each (psychophysical) activity that changes the natural balance of the organism. During climbing, numerous processes establishing a new balance are triggered in the organism. Reactions of an individual to the load present while climbing can be observed by means of various subjective (feeling assessment, shortness of breath, sweating, facial blush) and objective indicators (heart rate, lactate concentration in the blood, VO_2, ventilation, V CO_2, acid-basic balance, etc.) (Fox et al., 1993).

Within the framework of our research project, we tried to establish the best method for monitoring heart frequency during climbing, which is a mature procedure as it has long been studied and used in the assessment of load intensity. Heart rate reflects the intensity of the given load reasonably well if the intensity of the load is sub maximal and lasts for a sufficiently long period of time (Ušaj, 1995). In climbing, however, this does not appear very often. Apart from the quality of measured data during climbing, we were interested in the intensity of loads while climbing walls of varying difficulty (climbing intensity).

METHODS

Sample of subjects

Our sampling group consisted of 11 sport climbers (body mass 71 ± 8.7 kg, height 176 ± 9.2 cm,

age 25 ± 4.2 years, HR_{max} 199 ± 7.8 beats. min^{-1}, HRmin 54 ± 7.9 beats. min^{-1}, climbing period 7 ± 3.7 years). The subjects were all capable of climbing walls of the 7th grade of difficulty. They felt healthy on the day of the test.

Sample of variables

The average heart rate was monitored at two different moments: during climbing and at standstill. Each subject measured their own heart rate and their maximal heart rate while running was measured, too. Climbing intensity was calculated according to the following formula:

$$HR\ (\%) = \frac{100 \times (HR_{aver} - HR_{min})}{(HR_{max} - HR_{min})}$$

HR_{min} – heart rate at standstill (in the morning before getting up)
HR_{max} – maximal heart rate during the 400 m run
HR_{aver} – average heart rate in the last 15 s of climbing and
$(HR_{max} - HR_{min})$ – maximal heart rate reserve

Conducting the test

- The subjects were acquainted with the objective of the research project and their assignments. They all signed a statement that they were co-operating of their own free will.
- The measurement on each one of the subjects was carried out in the course of one day, in one hour's time.
- The subjects warmed up for 10 minutes before the test started (static and dynamic gymnastic exercises for general and specific warming-up), during which there was no climbing. After the tests were taken, the subjects were resting for as long as their heart rate took to decrease to approximately the same level as the one measured before the climb.
- Each subject climbed three routes. The routes were assessed by 4c, 5c and 6b French grades. Each subject climbed each route for about two minutes. The average heart rate was calculated from the four samples acquired within the last 15 seconds. After the climb, each subject rested for 15 minutes. During the rest period the heart rate measurements showed that it decreased to approximately the same level as the one measured before the climb.
- Each subject had to measure HR_{min} in the morning in a lying position. They measured their HR_{max} in 400 m run.
- All subjects climbed the routes "on sight" (making a first attempt at climbing via an unknown route), fixing their protection as they went along.

Methods of data analysis

The heart rate was measured by means of a Polar heart rate meter. The data were then analysed using a SPSS statistical program.

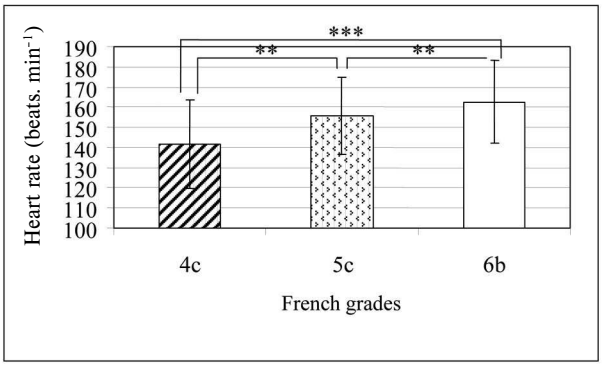
The main statistical parameters, i.e. arithmetic mean, standard deviation, were measured.

The differences in heart rate in climbing routes of difficulty 4c, 5c and 6b were tested with variance analysis and t-test for dependent samples.

RESULTS AND DISCUSSION

The results of heart rate measurement during climbing routes of different grades show that the average heart rate in the last 15 seconds of climbing a 4c grade route is 142 ± 22 beats. min^{-1}, 5c is 156 ± 19 beats. min^{-1} and 6a is 163 ± 21 beats. min^{-1} (Fig. 1). Similar results were obtained also by Mermier et al. (1997). The subjects had an average heart rate of 142 ± 19 beats. min^{-1} while climbing a 5a grade route. During the climbing of the route which had a 5c grade, the heart rate was 155 ± 15 beats. min^{-1} whereas while climbing a 7a grade route the heart rate was 163 ± 15 beats. min^{-1}. Janot et al. (2000) found that in the case of beginner climbers their heart rate was higher in comparison to recreational climbers. Dominic et al. (1999) tested subjects who climbed a 10 m vertical wall. There were differences found between the heart rate of inexperienced and experienced climbers. The differences between both groups were found only during vertical wall climbing, while horizontal wall climbing showed no differences. The differences in vertical wall climbing can be explained as being caused by fear of heights (Mace, 1979), which is very distinctive in novice climbers. In cases of horizontal walls, by contrast, there is no influence of fear of heights and hence there are smaller heart rate differences.

Fig. 1
Average heart rate in the last 15 seconds of climbing and standard deviations (** P < 0.01, *** P < 0.01) – statically significant

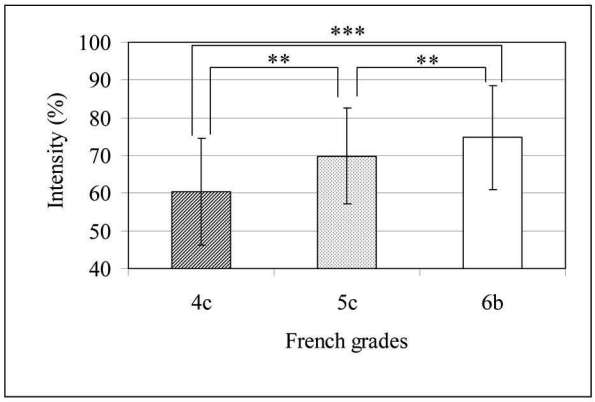


It can be concluded that a reaction of the human organism to load is only one of the possible causes for the increase of heart rate during climbing. The increases in heart rate were attributed to the occurrence of increased isometric muscular contractions in the upper limbs (Mermier et al., 1997). Another cause can also be anxiety caused by fear of heights (Billat et al., 1995), which is manifested in muscular tension. The blood pressure increases and consequently the heart rate also increases (Goddard & Neumann, 1993). Scientists have also found out that arm movements above the shoulder level can much more greatly increase heart rate in comparison to arm movement below the shoulder level (Parker, 1989). It is not necessary, therefore, for heart rate to increase as a consequence of increased load during climbing. It can also increase as a consequence of the fear of heights or changed arm position during climbing.

The difference in heart rate between routes of difficulty 4c and 5c was 14 beats . min^{-1}, and 7 beats . min^{-1} between routes 5c and 6b (Fig. 1). The differences in intensity in single routes are statistically significant (P = = 0.001 and P = 0.006). This difference can be explained by different configurations of climbing routes. The two most difficult routes (5c and 6b) ran across an overhang, which required different climbing technique than the easier route (4c), which ran across steep plates, but didn't include an overhang. Climbing overhangs require a climber to activate the abdominal muscles, which causes an increase in blood pressure, and consequently a higher heart rate (Goddard & Neumann, 1993). While climbing, overhang blockades are also used. A blockade is the isometric holding of a cling with the hand bent in the elbow, lasting for a few seconds. It is a well know fact that the isometrically produced force of the muscles of the forearm, as well as the shoulder and neck muscles, while working above the head, increases the heart rate (Åstrand et al., 2003; Larsson et al., 1996). Regarding the stated facts, no single factor causes changes to heart rate during climbing. It would be equally impossible to identify only one prevailing factor. There is probably a number of factors that, each in its own way, influence heart rate changes.

Heart rate (climbing intensity) in the routes of difficulty 4c, 5c and 6b is shown in Fig. 2. The intensity in the route of difficulty 4c was 60 ± 14%. In the direction of difficulty 5c it was 70 ± 13% and, in the route of difficulty 6b it was 75 ± 14%. The difference in intensity between the routes is 10% and 5% and is statistically significant (P = 0.001 and P = 0.006). The intensity between 60% and 70% can be classified only into the second degree of intensity estimation (Swaim & Edwards, 2002) and is very low. The climbing intensity in the route of difficulty 6b is 75%, but is still low. As the difficulty increases, the difference in intensity also increases. In spite of that, general intensity during climbing is still rather low. Heart rate during climbing can increase due to factors such as fear of heights, isometrical development of force, change in arm position, increased tension of abdominal muscles, etc. It can therefore be concluded that the need for more blood, which is characteristic for the activities of general endurance, is not the cause of increased heart rate during climbing (Goddard & Neumann, 1993). The increased heart rate is due to the presence of the mentioned factors. General endurance, therefore, is probably not the restrictive factor in climbing and is not of significance for success in climbing.

Fig. 2
Intensity in the last 15 seconds of climbing and standard deviations (** P < 0.01, *** P < 0.01) – statically significant



CONCLUSIONS

The increase of heart rate during climbing is due to numerous factors. Some of them are very hard to measure. Their estimation would be too subjective for being further used in scientific research. At the same time, the load to the organism is far too local and doesn't have any significant impact on the change in heart rate during climbing. For all these reasons, the use of heart rate as an indicator of climbing intensity is dubious.

During climbing, the heart muscle is never fully loaded. As a rule, the large muscles are only partly activated, while small muscles are fully activated. Small muscles tire easily (because blood lactate is increased), (Booth et al., 1999; Mermier et al., 1997) therefore coordination collapses and climbing is stopped (Goddard & Neumann, 1993). As the exhaustion of arm muscles (local exhaustion), and not the exhaustion of the entire organism (general exhaustion), is a limiting factor, training of general endurance is recommended, but not absolutely necessary, for sport climbers.

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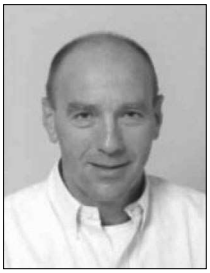
SRDEČNÍ FREKVENCE JAKO INDIKÁTOR ZÁTĚŽE PŘI SPORTOVNÍM LEZENÍ

(Souhrn anglického textu)

Cílem našeho výzkumného projektu bylo zavést srdeční frekvenci jako jeden z možných indikátorů zátěže při sportovním lezení. Za účelem našeho výzkumu absolvovalo 11 sportovních horolezců tři trasy o různých stupních náročnosti. Byla měřena srdeční frekvence horolezců a počítána zátěž při lezení. Při analýze výsledků jsme sledovali, zda naměřené hodnoty skutečně odrážejí zvýšenou zátěž, nebo zda jsou znakem nějakého jiného jevu, který nebyl monitorován. Změny srdeční frekvence při sportovním lezení mohou nastat v důsledku různých faktorů, které nelze v úplnosti kontrolovat. Monitorování srdeční frekvence jako indikátoru zátěže při sportovním lezení se tedy jeví jako značně pochybné.

Klíčová slova: sportovní lezení, srdeční frekvence, zátěž.

Ass. prof. Stojan Burnik, Ph.D.



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