Sport climbers´ heart rate when climbing routes on the border of personal maximum

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Abstract
This paper is focused on the description of the heart rate process when RP attempt on the way of the climber´s personal maximum border. Research group included 44 persons in the age 28,41 ± 6,60 years (32 men, 12 women). It was found that the maximal heart rate reached came up to 90% HRmax. Furthermore, we found out the time decrease spent on the route with increasing difficulty. The work confirms the possibilities of using HR as identification tool for the sports climbing performance analysis, especially by individual knowledge of athlete concrete condition.

Key words:
Sport climbing, heart rate, adults

Souhrn
Příspěvek je zaměřen na popis průběhu srdeční frekvence při RP pokusu v cestě na hranici osobního maxima lezce. Výzkumný soubor tvořilo 44 osob ve věku 28,41 ± 6,60 let (32 mužů, 12 žen). Bylo zjištěno, že maximální dosažená SF dosahuje přes 90% SFmax . Dále jsme zjistili pokles času stráveného v cestě s narůstající obtížností. Práce potvrzuje možnosti využít SF jako identifikačního nástroje pro analýzu výkonu ve sportovním lezení, zvláště při individuální znalosti kondice konkrétního sportovce.

Klíčová slova:
Sportovní lezení, srdeční frekvence, dospělí

Introduction

Performance in sport climbing depends mainly on strength assumptions and coordination abilities. It is used primarily the strength of torso, muscles of shoulder girdle, muscles of forearm and fingers (Černá & Louka, 2009). For a variety of factors influencing performance in sports climbing, seems to be the most significant the strength abilities of upper limbs (Baláš, Pecha, Martin, & Cochrane, 2012). The time limit for overcoming the set route in lead climbing is 6 minutes. In competitive practice is the time reached up to 3 minutes. Overcoming of more difficult rock routes is from a few minutes up to tens of minutes. Here the long-distance force and endurance are important, and the role is also the climber´s physiological response to the burden.

Research studies in the field of sport climbing show correlation between climbing performance and physiological response to this burden, in the field of heart rate. This response depends on the time of climbing, inclination of the route, speed of movement, climbing style, difficulty of the route and climbing performance (Booth, et al,. 1999; Draper et al., 2008; Mermier et al., 1997). Time of the performance when lead climbing is not limited factor. In most of the cases it is the climber´s inability to perform following movement, or maintain the grab, thanks to the exhaustion of the wrist flexors muscles (Valenzuela, de la Villa, & Ferragut, 2015; Baláš & Šimkanin, 2014).

Studies dealing with the relation between performance and HR showed HR increase non-linearity. They ascribe this increase to the specific climbing position of upper limbs due to the position level of heart and isometric contractions inducing metabreflex (Sheel, 2004).

Consumption of oxygen while lead climbing up to the exhaustion is around the boundary of 40 ml.kg-1.min-1 (Draper, Jones, Fryer, Hodgson, & Blackwell, 2010; Watts, 2004). Heart rate while the same burdening increases in values in between 85 – 95% of the heart rate while running to exhaustion. The value given was found by repeated burdening while climbing the top rope style, with a predetermined climbing time. If the participant fell while attempt, he/she was roped down to the ground and continued in performance (Draper, Bird, Coleman, & Hodgson, 2006). Optionally continuous climbing performance until exhausted on the boulder wall (Baláš, Strejcová, & Panáčková, 2012). Disproportion between HR while climbing and while running confirmed also Magalhães et al. (2007), who compared the burdening at the same level of VO2max, and at the same duration. The HR value while climbing reached 91,3±4,3 HRmax compared to 68,2±5,1 while running.

The goal of our research is to find out the course of sport climbers´ heart rate when climbing in the RP style on the artificial wall, on the way on the border of their personal maximum and to closer describe the course of heart rate at the time of falling.

Methods

TThe group included 44 active climbers (32 men and 12 women), attending the artificial wall at least once a week. They were experienced climbers, managing climbing in RP style in nature terrain and on the artificial climbing wall.

Measuring of the heart rate was done using sport watch Polar M430 with chest band. Measuring was fulfilled with video record. Probands were asked to climb the route in RP style, on the border of their maximal reached performance in last year, with an explicit emphasis on finishing the route, eventually climb until the time they fell. Route difficulty had to correspond with the maximal overclimbed performance. If they finished without falling, while the measured route, measuring was not included to the researched group. Routes were built up in slightly overhanging up to overhanging profile, with constantly spaced difficulty without boulder locations. Their length varied between 22 metres (the most difficult routes) and 17 metres. Most of the participants were falling in the last third of the route. Distance between anchors did not exceed 2,5 meters. The climb time was determined by subtracting from the record. Time t0 was the moment, when climber stopped to touch the ground. Time of finishing the measuring t was in the moment of fall.

The value of maximal heart rate was determined by using formula according to Bartůňková et al. (2013), for active athletes (by men SF _max=220-age, by women: SF _max=230-age). Other recorded values were: weight, height, aerobic activity, climbing experiences. Difficulty of the climbed routes was recorded according to the information given at the start of each route.

Values measured by sport watch M430 were transferred by Polarflow application to the graphical record. Comparing time data differences from the video record and from the time course of HR in graph was found its value at the time of start (untouching the ground) and fall. Data gained were further processed using the Statistics program. While processing the data, we defined descriptive values of the group and we were finding out the correlation between some values. We also focused on expressing the percentage ratio between the maximum HR and its value achieved in climbing performance. Another parameter followed, or relation, was the correlation between the difficulty of the route and the time spent on it.

Results

The average age was 28,41 ± 6,60 years (women 28,83 ± 6,15 years and men 28,25 ± 6,85 years). The climbing performance of male climbers ranged from 6b to 8b + and female climbers 6a to 8b of the French classification scale. The average height was 176.06 cm ± 6.45 cm for men and 170.25 cm ± 6.55 cm for women. The weight of the men was 71.72kg ± 6.88kg. For women, the average weight was 57.67 kg ± 6.12 kg. Most of the tested individuals practiced other sports, mostly endurance (running, cycling, swimming ...), which they spent on recreational levels on an average of 2.5 hours a week. The results of the monitored group with the average values and the standard deviations are showed in Table 1. From these data it follows that the maximal achieved HR versus HRmax reaches values above 90%, specifically for men 95,40 ± 2,33% and for women 95,18 ± 2, 40%. Overall, without a gender difference, we get the value of 95.34 ± 2.32%. In both groups we find extreme values at the 90% maximum. For men 89.06% and for women 90.48%. At the other end of the spectrum, the measured values are close to 98.44%, for men 98.44% and 98.47% for women.

Table 1: Measured heart rate values (N=44)

	Average (±SD)	Minimum	Maximum
HRmax [pulse/min]	191,59 (±6,60)	175,00	205,00
Initial HR [pulse/min]	99,52 (±8,04)	87,00	130,00
Reached HR [pulse/min]	182,68 (±8,28)	165,00	200,00
Climbing time [s]	196,30 (±28,47)	149,00	267,00
HR/HRmax [%]	95,34 (±2,32)	89,06	98,47

The climbing time from the start until the fall is over 3 minutes. On average, the respondents spent 196 s ± 28 s (Table 5). Differentiated by difficulty of the way, the times vary in level 6 and 7 of the routes. While the participants spent an average of 218 s ± 22 s on route with easier difficulty, on the heavier difficulty route they spent significantly less 175 s ± 13 s (Table 2).

Table 2: Climbing times achieved by the difficulty of the route

	N	Average (±SD) [s]	Minimum [s]	Maximum [s]
Difficulty level 6	22	218,00 (±22,15)	175,00	267,00
Difficulty level 7	20	175,10 (±13,18)	149,00	207,00

Compared difficulty values and climbing time via Spearman correlation coefficient show specific dependency between the route difficulty values and climbing time, on the border of relevancy $p<0,05$ (Table 3). Negative correlation means the relation in the sense of indirect rate. This chart also results, that there is no statistically significant dependency between additional aerobic activities and the route difficulty, nor compared to climbing time.
Primarily, hyperoxia was used in urgent medicine.

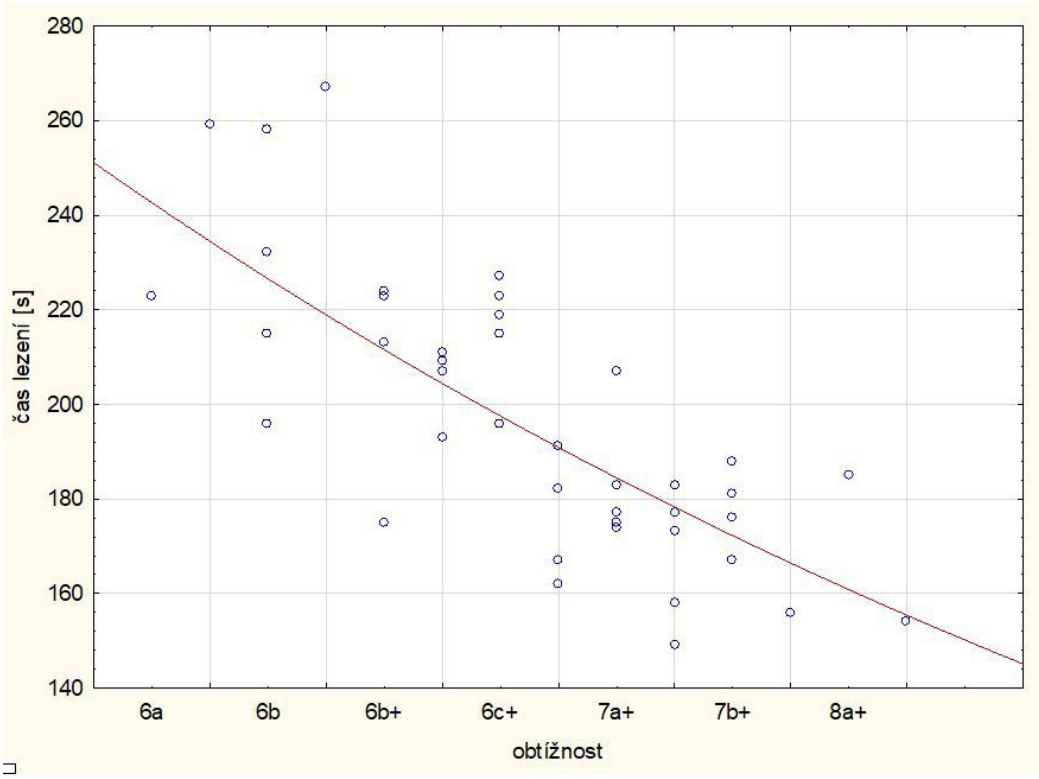
Table 3: Spearman correlation analysis p<0,05

	Difficulty	Activity	Climbing time
Difficulty	1,00	-0,06	-0,76*
Activity	-0,06	1,00	0,02
Climbing time	-0,76*	0,02	1,00

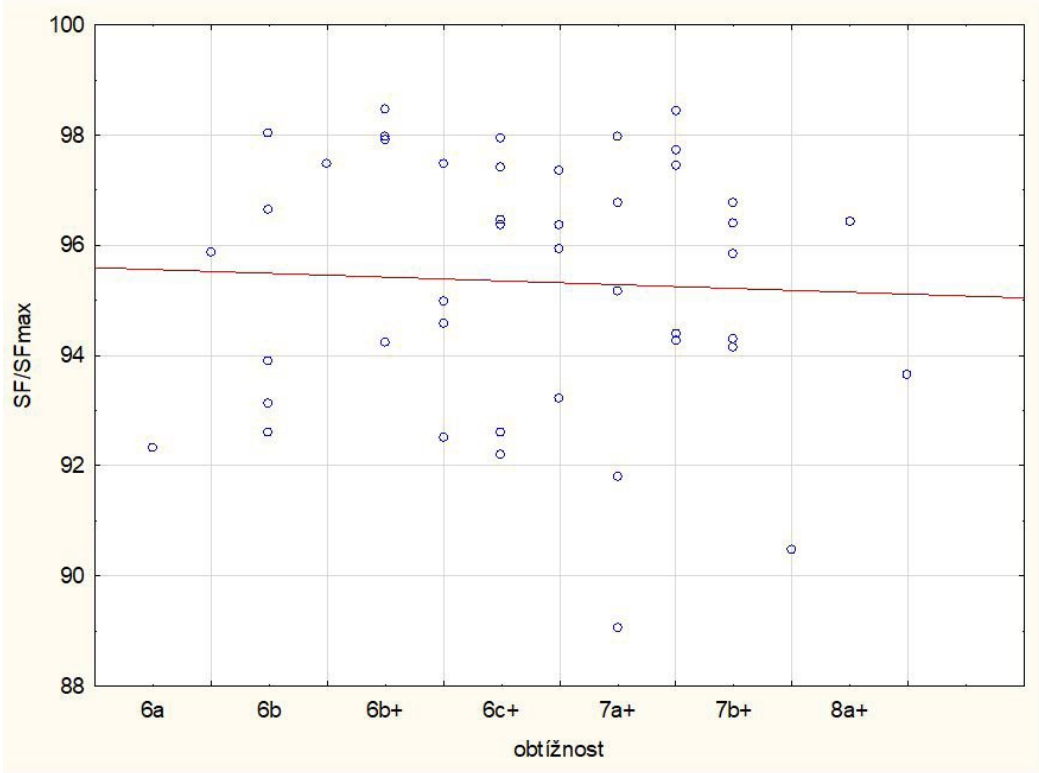
** statistically significant correlation*

Graph 1 shows the climbing time and the difficulty of the route. The graph shows the decline in time spent on the route with rise in difficulty. Graph 2 shows the relation between the difficulty of the path

Graph 1: Relation between the climbing time and route difficulty



Graph 2: Relation between the difficulty and ration of HR/HRmax



Discussion

Heart frequency while climbing, on the first end of rope in RP climbing style subject to several factors. Some of them are embedded in the very nature of climbing. Above all, the above-mentioned metabreflex, the position of the upper limbs with respect to the heart and the burden with predominance of isometric contractions (Sheel, 2004). The psychological difficulty of climbing performance is also debatable. The possibility of free fall can cause an increase in HR and thereby influence and alter performance. An important factor is the current anxiety disorder (Magiera et al., 2013). The research of the relation between performance in OS and DP climbing style, in which more significance and influence of psychic states can be manifested in performance, was dealt with by several studies. However, there was no significant difference between these styles in HR (Michailov, 2006). However, the study dealt with other climbing performance indicators, and HR monitoring was only a marginal matter. It should also be noted that the research group members were top climbers, with years of experience in the racing environment.

One of the first studies focusing on the performance relation in sport climbing, heart rate, oxygen consumption (VO2max), and the proportion of lactate in the bloodstream, highlight the differences between the maximum HR achieved in sport climbing and other sport activities, especially while running. When climbing easier routes HR moves around 70-80% HRmax, climbing to maximum reaches 90% HRmax (Sheel et al., 2003). The study of Magalhaes et al., (2007) is also interesting in this respect. In this study, they compared climbing and running performance. Both activities took place for the same length of time. In addition to the HR, the VO2max and other indicators were measured. The climbers passed test at the maximal climbing level when climbing the top rope and then run for the same time. In climbing, they reached 91.3 ± 4.3% HRmax, while only 68.2 ± 5.1 HRmax during run. This measurement showed that when performing at the limit of a personal maximum, HR moves 10% below the personal maximum HR limit. The measured value for our respondents reached 95% HRmax (Graph 2). It may be contradicted, that HR monitoring for climbing performance is highly doubtful (Baláš, 2016). We believe that HR monitoring can decide whether the climbing performance was at the maximum possible performance. Due to the HR and VO2max relationship, it is certainly not possible to talk about the absolute value of the power consumption in relation to oxygen consumption. However, since much of the work takes place in the forearm muscles – finger and wrist flexors – and in the shoulder region, the nonlinear relation between VO2max and HR is explained by the size for movement of the dominant muscle groups. Certainly, it would be interesting to study local oxygen consumption and in the same way the local concentration of lactate in the incriminated muscle groups. Perhaps there would be an adequate relationship between SF and climbing performance. Higher climbing performance is associated with the ability of higher local resistance to elevated lactate levels (Billat, Palleja, Charlaix, Rizzardo, & Janel, 1995).

The relationship between performance in sports climbing and supplemental aerobic capacity has not been confirmed. Due to the nature of performance in sport climbing, it is certainly more important for the local endurance of the muscles of the forearm. As research has shown, low aerobic fitness may limit climbing performance (de Geus et al., 2006; Dickson, Fryer, Blackwell, Draper, & Stoner, 2012). This unspecific aerobic fitness can affect the rate of recovery in the resting phase of large catches (Baláš & Šimkanin, 2014). Most authors agree that general aerobic activity has a positive effect on the regeneration of the organism both in the intermittent load and in the recovery phase after performance (Baláš & Šimkanin, 2014).

The measurement also shows an interesting relation between the climbing time and the difficulty of the route (Graph 1). This direction of dependence can be explained by climbing experience and a higher level of climbing skills. Climbing speed is related to the amount of energy output. While walking, the individual chooses the speed that delivers the most ideal ratio of energy to distance. The same reasoning could be applied to climbing also. According to research based on this reasoning, it has been shown that the chosen personal pace does not correspond to the lowest energy intensity (Rosponi, Schena, Leonardi, & Tosi, 2012). Climbers are more likely to choose the pace that suits to postpone fatigue of the forearm muscles. Faster movement avoids longer isometric contractions that do not support the circulation system, and do not allow the exchange of blood gases and catabolites. Knowledge of the path will significantly reduce the energy intensity due to the speed of passage (Espaňa-Romero et al., 2009). The speed of movement is related to personal experience both with the way and with the perception of the signals of the body itself and with the coor-

dination of individual movements and movement sequences. The duration of the output is influenced inter alia by the experience of the climber (Baláš, 2016).

Conclusion

TThis paper confirms that HR can be used as an identification tool for analysis of sport performance in the field of sport climbing on artificial walls and achieves values comparable to the personal maximum value of HR. Despite the awareness of the difference in VO2max and HR, we agree that climbing performance cannot be an absolute performance expressed in terms of oxygen consumption per kilogram of weight. Dominant engagement of forearm and shoulder arm muscles cannot be compared to performance in sports where large muscle groups are activated in larger quantities and where performance depends on their performance involved. Nevertheless, we dare to say that HR monitoring is appropriate for determining the value of climbing performance, especially when it comes to individual knowledge of the condition, abilities, and skills of an individual. We have also documented an interesting result of the relation between the route climbing time and climbing difficulty. Here we have shown a significant relation between these variables. It is an interesting indicator that points to the speed of climbing. However, we are cautious about making any conclusion in this respect. We dare to say that climbing speed is associated with greater climbing skills and greater experience. A more experienced climber is better able to learn, practice and memorize the route, so the time spent in it can be eliminated. Therefore, it cannot be said that this is a rule, but it gives some advantage.

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