# Influence of sport climbing on selected physical abilities and heart rate

**Lenka Černá, Patrik Černý, Zuzana Lhotová, Hana Kabešová**
*Department of Physical Education and Sport, Faculty of Education, University of Jan Evangelista Purkyně in Ústí nad Labem*

**Abstract**
*The goal of the research is to find out the influence of 11-week long intervention program of sports climbing on the chosen physical abilities and values of maximal heart rate. The research group was made up by adults (n=22) in age 26,4 years (±9,9). The improvement was proven in tests of upper limbs muscle strength, flexibility and coordination. We did not register significant changes in the values of maximal heart rate while climbing. For the improvement of muscle ability is this intervention sufficient. If the goal of intervention is improvement of climbing performance then the range of the intervention must be bigger.*

**Key words:**
*Sports climbing, adults, muscle ability, heart rate*

**Souhrn**
*Cílem šetření je zjistit vliv 11týdenního intervenčního programu sportovního lezení na vybrané pohybové schopnosti a hodnoty maximální srdeční frekvence. Výzkumný soubor tvořily dospělé osoby (n=22) ve věku 26,4 let (±9,9). Prokázalo se zlepšení v testech svalové síly horních končetin, flexibility i rovnováhy. V hodnotách maximální srdeční frekvence při lezení jsme statisticky významné změny nezaznamenali. Pro zlepšení svalové zdatnosti se takto pojatá intervence jeví dostačující, pokud by bylo cílem intervence zlepšení lezeckého výkonu, pak by musel být rozsah intervence větší.*

**Klíčová slova:**
*Sportovní lezení, dospělí, svalová zdatnost, srdeční frekvence*

## Introduction

Sports climbing is offset of mountain climbing, which is practised on the rocks or artificial walls. In contrast with original mountain climbing, where the goal was to conquer the peak by any method, for sport climbing is characteristic the effort to conquer as highest difficulty as possible. The difficulty of climber´s performance determines the style of conquering of route and degree of difficulty. Vomáčko et al. (2011) define sport climbing as the direction of climbing, where physical problems predominate over psychic. Elements of danger in sport climbing are reduced by using process protection (Sheel, 2004), which is in the sport routes on rocks prepared by the route maker and in the small artificial walls built in small distances. Routes of sport character are fitted with anchors, fixed rings or fixed pro elements, which in the event of a falling catch the climber. Falls in sport routes are fairly common and mostly safe.

Sport climbing belongs to the activities that need a high level of strength and endurance abilities. The performance in sport climbing is influenced by number of factors, from which the strength of the upper limbs seems to be the most striking (Baláš, Pecha, Martin, & Cochrane, 2012; Došla & Meško, 2015; Vomáčko et al., 2011). It means we can to a large extent influence performance in sport climbing by variables, which can be influenced by training (Mermier, Janot, Parker, & Swan, 2000).

The time of performance for conquering climbing route while climbing artificial walls is in the order of a few minutes. While this time, the heart rate of climber rises together with rising climbing effort and difficulty of the route (Sheel, 2004; Sheel, Seddon, Knight, Mc Kenzie, & Warburton R., 2003). It was documented that the heart rate values by climbers come up to approximately 80 – 90 % of maximal heart rate, which is achieved while running (Billat, Palleja, Charlaix, Rizzardo, & Janel, 1995) or on cycloergometer (Sheel et al., 2003). Changes in values of heart rate documents Cesur et al. (2012), who found decline in values of heart rate by adults in the end of route after 8-week climbing training, compared to the initial values. They rationalize this decline by managing skills and techniques, which has a significant part in energetic output while climbing movement.

There has been published a few studies investigating the influence of short intervention programmes of sports climbing on chosen components of capability. The influencing of chosen components of capability by intervention program of sports climbing by prepubescents was applied in the studies (Baláš, Strejcová, Malý, Malá, & Martin, 2009; Schlegel, Fialová, Ulrichová, & Frainšic, 2012). After 10 weeks of regular climbing the artificial walls in out-of-school interest activities was improved the strength and muscular endurance of the upper limbs by children (Baláš, 2007; Schlegel et al., 2012). Differences appeared also in coordination, significant improvement by children in the Flamingo test (Schlegel et al., 2012). However, Baláš (2007) does not confirm the improvement in coordination. By older age categories has been repeatedly proven improvement of strength abilities. Muehlbauer, Stuerchler, & Granacher (2012) had been observing a significant increase of upper trunk muscles strength and increase of hand force after 8-week training program on artificial wall by adults with sedentary job. Higher hand force maintained also after 8 weeks without training. Intervention program by adolescents in the form of a climbing course had been verifying Heitkamp, Wörner, & Horstmann (2005), who found by post-intervention probands higher strength gains than those in the control group which did not go through intervention. Černá, Černý, & Kabešová (2016) have proven that inclusion of motion program – climbing artificial walls may in relatively short time improve strength abilities of upper limbs by adults.

The aim of our research is to find out influence of 11-week intervention program of sports climbing on selected physical abilities and compare values of maximal heart rate while climbing in the beginning and in the end of intervention.

## Methods

The research group was made by adults (n=22, 3 men, 19 women), who went through 11-week course of climbing artificial wall. None of tested people had previous experience with climbing. The course was made up by one lesson per week with a total length of 90 minutes. Each lesson included a warm up in the initial and preparatory part by special climbing exercises low above ground. In the main part, there was individual climbing the routes in pair. Before the beginning of course was made the first measuring (pretest) and after 11 weeks, when had the tested people regularly attended climbing lessons, was measuring repeated (posttest). Following components were measured: hand dynamometry, endurance in pull-up with overhand grip, endurance in hanging position with one hand, standing on one leg with eyes closed, deep bow in sitting position, chest bending in lying on belly position.

Tests were chosen on the basis of study of studies, which are dealing with factors that influence performance in climbing (Baláš et al., 2012; Došla & Meško, 2015; Vomáčko et al., 2011) and influence of climbing on physical abilities (Baláš, 2007; Muehlbauer et al., 2012; Schlegel et al., 2012). Furthermore, we were considering their similarity with climbing performance while choosing tests. Applied tests are described in the following text.

### Hand dynamometry

This test measures short-time static-strength ability of hand flexors and fingers and is a part of Eurofittest for adults (18-65) (Havel & Hnízdil, 2009). The maximal strength of hand grip was measured with electronic hand dynamometer Camry, model EH101. Tested person was invited to grip dynamometer with maximal strength of dominant hand. Test was applied in the standing position, in position with arm close to the body. Tested people have available two attempts, the better from attempts was recorded.

### Endurance in pull-up with overhand grip

This test measures endurance static-strength ability of arms and shoulder girdle and is a part of test batteries Unifittest (6-60) (Měkota et al., 2002), Fitnessgram (Suchomel, 2003) a Eurofittest (Šimonek, 2012). The time during the test person holds in pull-up with overhand grip on horizontal bar is measured. Tested person was placed into initial position in pull-up with overhand grip with his/her chin over the horizontal bar. The aim was to hold the position for as long time as possible. As soon as chin descended under level of horizontal bar the test was ended. Time was recorded with accuracy of 1 second.

**Endurance in hanging position with one hand**

The test measures endurance static-strength ability of dominant hand, arm and shoulder girdle. Test was used in intervention studies focused on climbing artificial wall (Baláš, 2007; Schlegel et al., 2012). It is applied due to the similarity with the climbing movement. Tested person performs hanging position with both hands on horizontal bar, then he/she release one hand. The examiner may hold tested person while taking proper position and prevent rotating his/her body. The time of endurance in hanging position with dominant hand is measuring with accuracy of 1 second.

**Standing on one leg with eyes closed**

In this test was tested static balance ability. The tested person stood up on one leg on a hard mat. With the sole of the second foot he leaned on the knee of the same leg, he laid his hands on his hips and closed eyes. Once he set this basic position, the time had begun to be count. This test has been repeated for three times over and the results of attempts were calculated in the end (Havel & Hnízdil, 2010).

In the test was measured flexibility – suppleness and muscle elasticity in the lumbar spine and hip joint. For the test was necessary bench, desk for placing tape and tape measure. Tested person sat down on hard mat with legs together, stretched his legs so his heels touched the perpendicular wall of the bench, and hands were stretched forward. Tested person began to slowly lean forward and hold on in the utmost position for 2 seconds. On the desk, which was above the bench was placed tape with scale from 0-50 centimetres. The value in the place of foot support was 15 centimetres.  Measured values obtained in centimetres are added od subtracted from the foot support. Of total two attempts was counted the better one (Havel & Hnízdil, 2010).

**Chest bend**

This test measures strength and mobility of trunk extensors and is a part of test battery Fitnessgram Fitnessgram (Šimonek, 2012). Tested person lied on his/her belly, arms held close to the body and pressed from side to thighs. Tested person slowly performed chest bend and eyes were concentrated to the sign on the ground. We measured distance between chin and ground in centimetres. Head was in the extension of trunk and legs stayed on the mat. Maximal value is 30 centimetres, bigger bend is not performed or measured neither.

**Measuring of heart rate**

While climbing performance, record of heart rate was accomplished by 15 people from the test group. Measuring was performed twice, for the first time in the initial part of lesson and for the second time in the final one. Probands climbed the route in the same profile and in the same difficulty in style toprope, which means that they were belayed from above. Record was performed by Sporttester Polar M400. The record of heart rate was evaluated by web application Polar flow. Observed variable was maximal heart rate.

**Statistical analysis**

For anthropometric characteristics and describe of results in motoric tests by individual groups divided according to the field of study and gender was used methods of descriptive analysis. Differences in performances in individual tests in pretest and posttest was compared in the Wilcoxon test for comparing paired values. For data processing were used Microsoft Excel and Statistics programmes.

*Table 1. Anthropometric characteristics of the observed group*

| | **N** | **Average** | **Minimum** | **Maximum** | **SD** |
|---|---|---|---|---|---|
| **Age (years)** | 22 | 26,4 | 19,0 | 50,0 | 9,9 |
| **Weight (kg)** | 22 | 62,5 | 50,0 | 87,0 | 9,6 |
| **Height (cm)** | 22 | 168,5 | 158,0 | 185,0 | 7,5 |
| **BMI** | 22 | 22,0 | 17,3 | 29,4 | 3,0 |

Table 2. *Changes of results in motoric tests in pretest and posttest*

| Variables | Pretest/posttest | Average | SD | p |
|---|---|---|---|---|
| **Hand dynamometry (N)** | Pretest | 29,2 | 5,7 | 0,0001* |
| | Posttest | 31,9 | 6,4 | |
| **Endurance in pull-up (s)** | Pretest | 5,2 | 6 | 0,0004* |
| | Posttest | 7,1 | 6 | |
| **Endurance in hanging position (s)** | Pretest | 2,3 | 2,5 | 0,0001* |
| | Posttest | 4,2 | 3,2 | |
| **Standing on one leg (s)** | Pretest | 24,6 | 13,8 | 0,0007* |
| | Posttest | 39,6 | 21,8 | |
| **Deep bend (cm)** | Pretest | 22,9 | 8,8 | 0,0001* |
| | Posttest | 25 | 9,1 | |
| **Chest bend (cm)** | Pretest | 20,4 | 4,6 | 0,0001* |
| | Posttest | 24,5 | 4,5 | |

*Explanatory notes: SD = determinative deviation, p = calculated value of Wilcoxon paired test*

** differences are significant jsou významné at the probability level p<0,05*

## Results

Average results in motoric tests evince improvement after completing 11-week climbing artificial walls course. Statistic importance of improvement in motoric tests was evaluated by Wilcoxon paired test for dependent variables. Significantly eminent improvement was found in all motoric tests.

Maximal values of heart rate are shown in Table 3. The first measuring was performed in the first climbing lesson, the second one in the last lesson.

Table 3. *Values of maximal heart rate*

| Proband | 1.measuring | 2.measuring | Difference |
|---|---|---|---|
| **1** | 189 | 180 | -9 |
| **2** | 200 | 190 | -10 |
| **3** | 194 | 190 | -4 |
| **4** | 190 | 193 | 3 |
| **5** | 178 | 179 | 1 |

| | | | |
|---|---|---|---|
| **6** | 165 | 171 | 6 |
| **7** | 184 | 177 | -7 |
| **8** | 171 | 173 | 2 |
| **9** | 188 | 181 | -7 |
| **10** | 173 | 181 | 8 |
| **11** | 161 | 162 | 1 |
| **12** | 163 | 160 | -3 |
| **13** | 182 | 175 | -7 |
| **14** | 191 | 185 | -6 |
| **15** | 197 | 189 | -8 |

*Table 4. Comparing of maximal heart rate in pretest and posttest*

| | **N** | **T** | **Z** | **p-value** |
|---|---|---|---|---|
| **1. measuring x 2. measuring** | 15 | 30,50 | 1,68 | 0,09 |

Difference in maximal heart rate between measuring number 1 in the beginning of intervention program and measuring number 2 in the end of intervention program is not statistically important. Although the decline in maximal heart rate by most of the probands is obvious, these differences are not significant, which confirms the Wilcoxon test result (p<0,05).

## Discussion

In our study came up to significant improvement in all motoric tests which were used. It can be judged that also short-time intervention program may contribute to increase of adults muscle capability, which is also confirmed by other published studies to this time (Černá et al., 2016; Muehlbauer et al., 2012).

Tested people in our study have significantly improved themselves in the tests referring to the increase of upper limbs strength, represented tests of hand dynamometry, endurance in pull-up with overhand grip and endurance in hanging position with one hand. Increase of grip strength already after 8-week climbing course documents (Muehlbauer et al., 2012). Černá et al. (2016) confirms significant increase in grip strength and in hanging position with one hand. Tested people in our study evince also significant improvement in the balance test. Although the certain connections between climbing and balance ability exist (Vomáčko et al., 2011) we believe that we can not this discovery overestimate. The result may be partly influenced by learning effect which has become evident in the second measuring where probands could apply experience from measuring in pretest. Improvement in the trunk and lower limbs mobility tests is also documented. Whereas improvement in the chest bend test can be explained by increase of the body centre strength in connection with increase of strength while climbing and similar results also evidence previous study Černá et al. (2016), by unsportsmanlike, we explain improvement in the deep bend in sitting position test more likely by the attending in organised warm up in the beginning of every lesson, than by actual effect of climbing.

The difference in maximal heart rate between measuring number one in the beginning of intervention program and measuring number 2 in the end of intervention program is not statistically important. Our findings are different from results found in study Cesur et al. (2012), who declare significant decline of heart rate values in the end of climbing intervention program compared to initial values. Measuring was performed in the peak of the route. Research done so far suggests that heart rate in the route declines with increasing experience of climbers. This is dependent by better economy of more experienced climber´s movement. Janot, Steffen, & Porcari (2000) proved higher heart rate by starting climbers against recreational climbers with higher experience. Also Bertuzzi, Franchini, Kokubun, & Kiss (2007) presents, that better climbing technique and economics of movement by more experienced climbers has influence on physiologic response of organism. We expected that by our group will also become evident improvement in the technique and higher experience in the end of intervention, which will lead to lower values of measured heart rate, which did not happen. The explanation may be that although tested people managed the basic technique of climbing movements, movement in vertical direction is still not natural for them. Inter-muscle coordination and muscle tension do not match underwent burdening. Experiences obtained after 11-week intervention are not sufficient for applying the technique by economical way.

## Conclusions

Tested people proved increase of performance in the test referring to the improvement of muscle capability in the end of 11-week intervention program. Significant improvement was proven in muscle strength, flexibility and balance tests.

In maximal heart rate values while climbing in the beginning and in the end of intervention program was not proven any significant differences.

For improvement of muscle capability appears this intervention as sufficient. If its aim is to improve climbing performance then the change of length or frequence of lessons is needed.

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Author: Mgr. Lenka Černá, Ph.D.
E-mail: lenka.cerna@ujep.cz