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# Finger range of motion and joint circumferences in rock climbers

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## Abstract

Background. Fingers of climbers are an area where operating forces reach the highest values, thus they are susceptible for overloading. The aim of this study was to determine what kind of morphological changes climbing causes in the anatomical structures of climbers' fingers and whether these changes affect their function. Materials and methods. The study group consisted of 27 climbers and 26 non-climbers as a control group. Research consisted of an original questionnaire and measurements of the range of motion and circumferences of finger joints. Results. Limited finger flexion in all distal interphalangeal (DIP) and proximal interphalangeal (PIP) joints in the study group was reported, as well as the contours of some DIP joints were enlarged. Correlation between the time of climbing and fingers' joints circumference value has been found. The examined climbers also declared affected grip precision in performing daily tasks. Conclusions. Climbers have limited flexion and increased finger joint circumferences, mostly in distal parts of fingers. There is a relationship between the duration of training and the intensity of morphological changes – the longer the training duration, the smaller the joints' circumferences. Changes in anatomy of the fingers may cause functional limitation and thus difficulties in performing precise tasks during daily activities.

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**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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## abstract

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## INTRODUCTION

Rock climbing is a physical activity that involves covering difficult climbing routes that are marked out on natural rocks or artificial walls. This sport improves general fitness because only harmonious work of the whole body allows one to master optimal movements, which burden the body with the least energy expenditure. It requires strong muscles of the limbs needed to move the body against gravity, as well as the abdominal and back muscles stabilizing the trunk and keeping it as close to the wall as possible [1].

This sport is becoming increasingly popular and no longer the domain of only small groups of committed passionate individuals. An increasing number of artificial climbing walls, variety of courses, sections and competitions in all age groups and at various levels of difficulty are conducive to development of this discipline. From the group of new adepts of rock climbing more and more individuals are deciding to intensify their training by joining clubs or local teams and even becoming professional climbers [2].

Due to the substantial importance of upper limb effort, rock climbing in the first place essentially involves the anatomical structures of the palm and fingers. It is a result of a specific character of grip types used during dynamic climbing as well as during static rest on the wall. Several types of grip were distinguished considering the way of placing the fingers on grips as the main criterion. The two basic ones are “open” and “closed”. The former, also known as a “bow”, is characterized by flexion of proximal interphalangeal joints (PIP) to about 90° (or more) and extension in distal interphalangeal joints (DIP) (Fig. 1a) [3, 4]. In the second grip, also called “outstretched”, the palm remains opened, the climber leans on the distal phalanges but, in contrast to the bow grip, flexion in PIP joints does not exceed 60°, and the DIP joints are also in flexion, which usually is bigger than in PIP joints (Fig.1b) [3, 5]. Additionally, other various types of grip which are modifications of the two basic types can be distinguished (Fig. 1c,d).

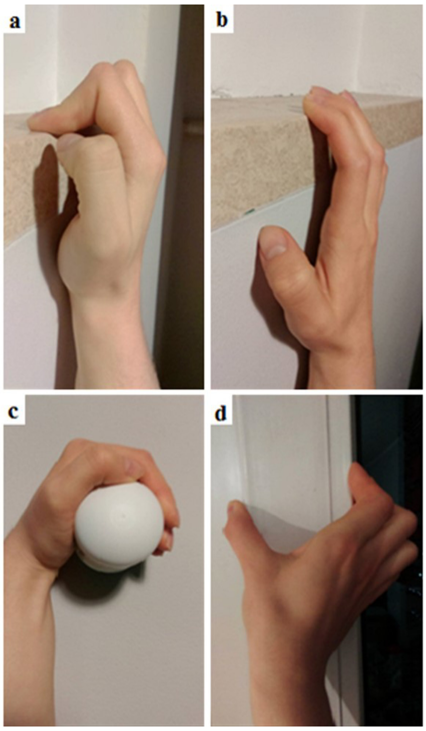


Fig. 1. Types of climbing grip: a – “open”; b – “closed”; c-d – examples of modifications (own material)

Excessively loaded tendons, joint capsules and ligaments of the hand are prone to overload syndromes that are the main cause of climbers' complaints [6]. The risk of overloading depends on various factors that can be divided into internal and external ones. Among others, internal factors consist of age, the stage of climber's growth and individual constitution features of the locomotor system [1]. Also other internal factors which appear during puberty, such as an increase in the burst of sexual hormones and a radical weight loss may reduce resistance to overloads [6]. External risk factors include too intensive training, too short time of regeneration, unfamiliarity with the climbing technique or improperly fitted shoes [1].

Dynamic climbing often requires movement during which the body weight lies just on one or two fingers – mainly when feet lose contact with rock steps. As a result, large forces impact the PIP joints and flexors pulleys that often leads to its injury. Most often it concerns fingers III and IV as they are mostly used. Increasing the angle of flexion increases tension of the tendon which hardly pushes on pulleys thus, in consequence, can lead to partial or complete rupture – the most vulnerable tendons are A2 and A4 pulleys. These tears are observed in 50–60% of climbers working at high intensity, while use of the closed grip generates a greater risk of injuries than the use of the open grip [7, 8]. Another injury resulting from fingers overload is bursitis or flexors tendinitis. The closed grip is indicated as the most common cause of those injuries, as the tendon sheath is wedged between the tensed tendon and flexors pulley [1]. Repeated micro-traumas may lead to fatigue fracture. The probability of its occurrence is particularly large in puberty while bone epiphysis is weakened and as the growth plate starts to close [6].

Climbers – as a group practicing intensive physical activity and exposed to significantly higher loads on fingers compared to non-climbing persons – present characteristic changes in the overloaded tissue structure, which is a sign of adaptation to strenuous training [9]. In the case of the bone tissue, a thickening of the cortical layer is observed. This phenomenon proves that climbing leads to bone remodeling that appears as production of new bone tissue and its morphological changes [10, 11].

The hypertrophic changes also include remodeling of the connective tissue – tendons and flexors pulleys, volar plate and even joint capsule – manifested as a general thickening of finger tissues and increased joint contours [12]. Characteristic degenerative changes of tendons include thickening of its fibers with increased space between their fasciculi. Also thickening of tendon sheaths caused by accumulation of too much synovial fluid is noticeable. If the tendon has no sheath, changes appear as a nonspecific thickening of adjacent soft tissues [13]. The volar plate during closed grip acts against extension in DIP joints. Presumably, loading in extension leads to the remodeling of the volar plate in this joint. It could be confirmed by the fact that in PIP joints, which are not loaded in extension during climbing, such intensified adaptive changes were not stated despite these joints being exposed to similar loads as DIP [12]. Effusion in joints irritates synovium leading to its inflammation and overgrowth. Hypertrophic synovium produces more joint fluid, which appears as spongy joint swelling [14].

The aim of this study was to investigate the influence of rock climbing on anatomical structures of fingers, to check if the training period significantly affects the extent of adaptive changes and to assess whether those processes affect the function of climbers' fingers.

## MATERIAL AND METHODS

The study population consisted of 53 participants – 27 of them (17 men and 10 women) were active climbers composing the study group and next 26 (20 men and 6 women) non climbing persons composed the control group with similar somatic features. The mean age was 27.1 (SD = 7.54) years in study group and 25.5 (SD = 3.54) years in the control group. The mean time of climbing practice in the study group was 4.04 (SD = 0.76) years while a single training session mean time was 2.6 (SD = 0.69) hours and average number of training was 3.7 (SD = 0.83) times per week. None of the participants had been diagnosed with any trauma or disease that could influence the morphological or functional condition of the fingers.

The assessment consisted of two parts. The first one was an original questionnaire composed of 15 questions, single- or multi-answer type, that asked about climbing time, intensity and frequency of climbing training sessions and subjective observations of fingers shape and function in the time of the study and before starting climbing training.

The second part of the assessment included measurement of joints circumferences and the range of motion of all fingers of each participant in both groups. In all measurements fingers were numbered sequentially starting from the thumb identified as a finger I ending on the small finger identified as finger V. The measurement of the joint circumference was taken by the measuring tape at the level of joint fissure. The range of motion was measured by a goniometer. The measurements of joint circumferences were performed in the PIP and DIP joints of fingers I–V and the IP joints of the thumbs. The range of active flexion was measured in DIP,PIP (IP in thumbs) and metacarpophalangeal (MCP) joints (Fig. 2–4). Together, 530 fingers were assessed – 1484 joint ROM and 954 joint circumferences values were obtained.

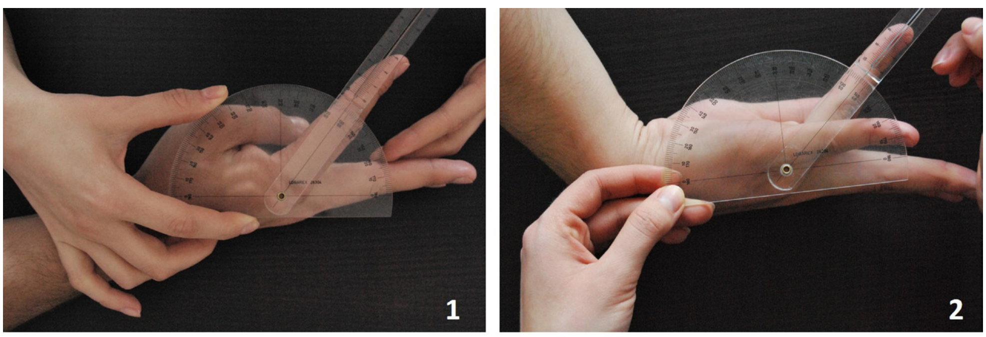


Fig. 2. Measurement of active flexion ROM in MCP joint: 1 – finger II; 2 – finger IV (own material)

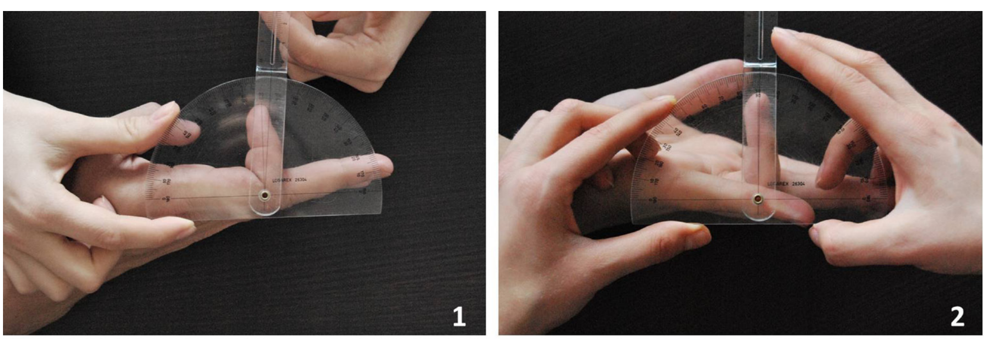


Fig. 3. Measurement of active flexion ROM in PIP joint: 1 – finger II; 2 – finger IV (own material)

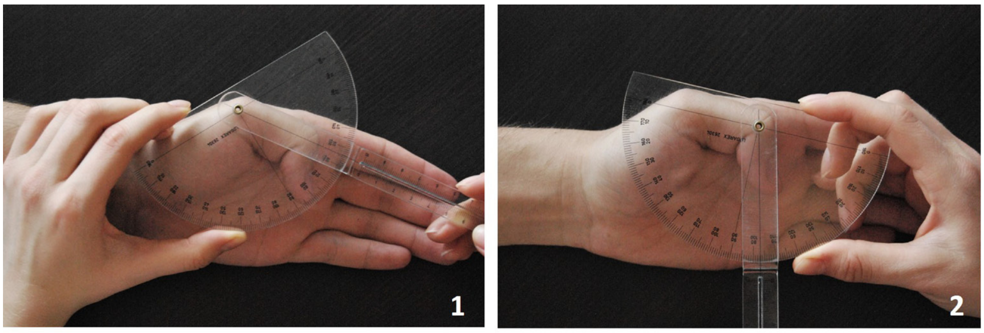


Fig. 4. Measurement of active flexion ROM in thumb: 1 – in MCP joint; 2 – in IP joint (own material)

## Statistical analysis

Statistica 12.5 (StatSoft Inc.) software was used to statistically analyze the obtained data. Accordance with normal distribution was assessed with the Shapiro-Wilk test. The significance of differences between independent variables was assessed with a non-parametric U Mann-Whitney test. Analysis of relationships between qualitative variables was made with a Pearson Chi-Square test and a Spearman correlation coefficient. The results were considered statistically significant at $p < 0.05$.

# Results

## Analysis of ROM measurement

The analysis of differences between mean values of flexion ROM in both groups, compared with the U Mann-Whitney test, showed a decreased ROM in the study group. Except for joints of the thumbs, significant differences were shown for all PIP and DIP joints of fingers II–V of both hands (Table 1).

Table 1. Differences in fingers ROM between climbers and non-climbers (only statistically significant results were included)

| Variable | Climbers (n = 27) [deg.] | | p | Control group (n = 26) [deg.] | |
|---|---|---|---|---|---|
| | $\bar{x}$ | SD | | $\bar{x}$ | SD |
| KP2PIP | 103.52 | 9.30 | 0.0000 | 113.62 | 5.40 |
| KP2DIP | 59.33 | 13.20 | 0.0207 | 67.81 | 10.88 |
| KP3PIP | 99.52 | 9.85 | 0.0000 | 113.23 | 4.57 |
| KP3DIP | 57.85 | 12.56 | 0.0000 | 72.38 | 8.35 |
| KP4PIP | 98.15 | 11.28 | 0.0021 | 107.38 | 9.76 |
| KP4DIP | 55.19 | 10.87 | 0.0000 | 70.54 | 8.58 |
| KP5PIP | 89.81 | 12.28 | 0.0007 | 99.54 | 10.99 |
| KP5DIP | 57.04 | 11.54 | 0.0045 | 65.31 | 9.59 |
| KL2PIP | 101.48 | 12.77 | 0.0000 | 113.50 | 6.07 |
| KL2DIP | 59.56 | 11.93 | 0.0399 | 66.35 | 8.53 |
| KL3PIP | 97.89 | 14.70 | 0.0000 | 112.04 | 5.09 |
| KL3DIP | 58.89 | 12.19 | 0.0015 | 68.04 | 10.28 |
| KL4PIP | 100.11 | 13.29 | 0.0003 | 112.54 | 6.72 |
| KL4DIP | 53.81 | 11.79 | 0.0000 | 68.08 | 8.79 |
| KL5PIP | 87.85 | 14.34 | 0.0041 | 99.42 | 11.44 |
| KL5DIP | 50.93 | 13.16 | 0.0000 | 65.31 | 9.18 |

K – measurement of joint ROM, P – right hand, L – left hand, 2-5 – number of finger

## Analysis of joint circumferences measurement

During assessment of joint circumference, a differentiation by sex was applied due to natural differences in size between male and female hands. Thus – due to too small a sample – women were excluded from this analysis. In male climbers, increased values of joint circumferences compared to non-climbing men were found. Statistically significant differences were noticed in the DIP joints of the IV$^{th}$ fingers in both hands (OP4DIP, OL4DIP) and in DIP of the IIIrd finger of the right hand (OP3DIP) (Table 2).

Table 2. Differences of joint circumference values between climbers and non-climbers (only statistically significant results were included)

| Variable | Climbers (n = 17) [deg.] | | p | Non-climbers (n = 20) [deg.] | |
|---|---|---|---|---|---|
| | $\bar{x}$ | SD | | $\bar{x}$ | SD |
| OP3DIP | 63.18 | 3.17 | 0.0355 | 60.90 | 2.61 |
| OP4DIP | 58.41 | 3.16 | 0.0077 | 55.30 | 2.32 |
| OL4DIP | 57.41 | 3.32 | 0.0205 | 54.95 | 2.58 |

O – joint circumference measurement, P – right hand, L – left hand, 2-5 – finger number

## Subjective assessment of morphological and functional changes

The surveyed climbers (n = 27) provided information about their subjective observations concerning changes in the shape and function of their fingers compared to the condition before they started climbing. Twenty-five (93%) of them noticed changes in the shape of fingers. The percentage of answers regarding the condition of fingers included in the questionnaire was shown in Table 3.

Table 3. Morphological and functional changes reported by the surveyed climbers (n = 27)

| Reported change | n | % |
|---|---|---|
| Increased joint contours | 24 | 89 |
| Thickened skin | 22 | 81 |
| Fingers swelling | 8 | 30 |
| Hindered flexion | 9 | 33 |
| Hindered extension | 16 | 59 |
| Difficulty in precise operations | 8 | 30 |

## Analysis of correlation between morphological changes and overall climbing duration

A statistically significant correlation was found between overall climbing duration and morphological changes of periarticular tissues. In order to evaluate this relationship Spearman correlation coefficient was used (Table 4). The coefficient (r) was negative, therefore, the longer overall climbing duration, the smaller joints circumference values.

Table 4. Analysis of the correlation between overall climbing duration and joint circumference values in the examined climbers (only statistically significant results included)

| Pair of variables | Spearman correlation coefficient (n = 27) | |
|---|---|---|
| | r | p |
| overall climbing duration & OP4DIP | -0.39 | 0.0451 |
| overall climbing duration & OP1IPP | -0.42 | 0.0284 |
| overall climbing duration & OL2PIP | -0.41 | 0.0329 |
| overall climbing duration & OL2DIP | -0.42 | 0.0277 |
| overall climbing duration & OL3PIP | -0.42 | 0.0300 |
| overall climbing duration & OL4DIP | -0.39 | 0.0453 |
| overall climbing duration & OL1IPP | -0.51 | 0.0063 |

O – joint circumference measurement, P – right hand, L – left hand, 2-5 – finger number

## ANALYSIS OF MORPHOLOGICAL FEATURES ON THE FINGER FUNCTION

The Pearson Chi-square test was used to evaluate the relationship between morphological changes of the fingers – such as increased joint contours, thickened skin, fingers swelling or twisting – and limitation in their function expressed as hindered flexion or extension and/or difficulty in performing precise movements. We found significant results for increased joint contours and thickened skin in relationship to the limitation of finger extension. In the group of climbers who noticed hindered finger extension, 100% of them (16 persons) confirmed increased joint contours while, in climbers who did not notice that limitation, increased joint contours was declared by 73% (8 persons). Thickened skin was noticed by 100% climbers with limited extension while amongst those with no extension limitation only 55% (6 persons) noticed skin thickening (Table 5).

Table 5. Analysis of the relationship between morphological changes and extension limitation in the study group

| Variable | No extension limitation | | p | Limited extension | |
|---|---|---|---|---|---|
| | n | % | | n | % |
| increased joint contours | 11 | 73 | 0.02672 | 16 | 100 |
| thickened skin | 11 | 55 | 0.00281 | 16 | 100 |

## DISCUSSION

Practicing rock climbing is more and more often chosen as a recreational or professional sport. It is related to the occurrence of fingers traumas and changes in their shapes, which is an adaptive response to the overloads characteristic of this sport [15]. This study investigates how rock climbing affects remodeling of finger tissues and whether it may influence their function.

According to Schreiber et al. [12], remodeling fingers as an adaptive response of a morphological character is expressed as thickening of their structures. Their research shows that the largest differences in thickness are observed in the flexor pulleys. The authors explain this phenomenon by the fact that only through massive adaptive processes, can the pulleys adapt to forces that exceed their normal resistance to rupture. The ultrasonography examinations showed that in climbers' pulley A2 is 63% and pulley A4 is 68% thicker in both hands than in non-climbing persons. Comparing particular fingers, the biggest changes in pulley A2 were in fingers V (86% thicker than in the control group), IV (69%) and III (62%). For pulley A4 these values were mostly visible in finger IV (76% thicker in climbers), while fingers III and V were both 69% thicker. Significant differences concerned also the volar plate – in the DIP joint of finger III it was 76% (and in finger IV – 67%) thicker than in the control group. For the PIP joint, these differences were smaller but also statistically significant for fingers IV and V – they were respectively 17% and 27% thicker in climbers. Also statistically significant differences were found for tendons' thickness at the level of middle phalanx. Their diameter, measured in the sagittal plane was 21% bigger in finger IV and 16% in finger III [12]. These features were also found in climbers investigated in our study. The same changes noticed in a 26-year-old female climber were marked in Fig. 5. Thickening of both pulleys and volar plate is markedly visible.

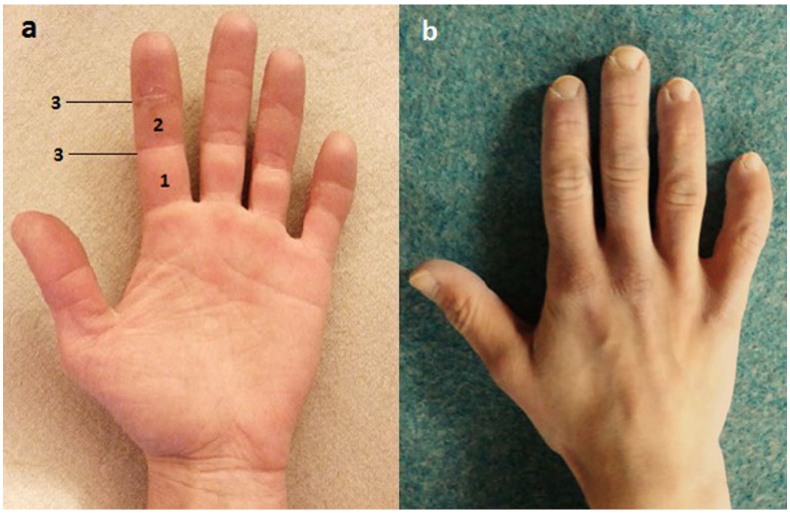


Fig. 5. Climber's hand. a – palmar view: 1 – thickening of A2 pulley, 2 – thickening of A4 pulley, thickening of volar plate; b – dorsal view (own material)

As described by Swędzioł, thickening of the joint tissues is located first in fingers III and IV. With time, it can occur also in all other fingers [14]. Our results are similar – a statistically significant increase in joint circumferences in fingers III and IV of the right hand and in finger IV of the left hand was found in the study group compared to the group of non-climbing men.

Hahn et al. [11] investigated the effect of long term rock climbing on bone condition. They performed X-ray examination in a group of 31 persons practicing climbing for over 10 years and in a group of 67 non-climbers. The comparison of both groups showed marked thickening of the cortical bone layer in climbers. These changes were the biggest in distal phalanges, the average in middle ones, while the smallest in proximal phalanges. This suggests that the adaptive response of the cortical bone layer is the greater, the more distally the structure is located. Those authors related it to stretching and twisting forces, the intensity of which is the highest in this area [11]. It can be assumed that these forces, acting the most on distal parts of fingers, causes the most visible changes not only in bone, tissue but also in soft tissues. This assumption stays in accordance with our results that showed the biggest thickening of fingers structures in several DIP joints.

Other studies conducted by Klauser et al. [2] in a group of 34 climbers with ultrasound imaging elicited thickening of joint capsules in 32% of the assessed fingers and excessive concentration of fluid inside the joint in 21% of them. Thickening of tendon sheaths was observed in 17% fingers and concentration of fluid in tendons surroundings in 34%. The above data concern symptomatic fingers. In symptomatic as well as in asymptomatic fingers, an excessive amount of fibrous tissue was found around the phalanges between the bone and tendons. Also thickening of flexors pulleys was noticed as compared to the control group. The pulleys were mostly thickened in climbers with explicit clinical symptoms (thickening reached values over 0.13 cm), while the smallest thickening was noticed in asymptomatic subjects (values equal or below 0.1 cm) [2]. In another study, Klauser et al. [7] describe results of ultrasound imaging performed on a group of 52 climbers. They found markedly thickened pulleys system and presence of cysts in tendon sheaths. Also Swędzioł describes joint swelling of inflammatory origin as one of the result of finger overloading [14]. Our results seem to correlate with those obtained by Klauser [7]. We observed that periarticular structures tend to be thinner in climbers with the longest training period, in comparison to those who had practiced climbing for a shorter time. This dependence could also be confirmed by subjective feelings of climbers investigated in our study. Amongst those who practiced climbing for 3–5 years, 57% noticed finger swelling, while in subjects who practiced for over 6 years – only 25%. It implicates that increased joint contours at an early and average stage of training is the result of temporary tissue swelling of inflammatory origin, while in climbers practicing for a longer time these changes are slightly marked and have a character of tissue fibrosis.

Schöffl et al. carried out a study on 19 members of the German Junior National team revealing a decrease in ROM in fingers in 32% of them [16]. Our results are consistent with theirs, as in our study group we also found a decrease of ROM compared to the control group. Climbers' subjective feelings confirm these outcomes – 33% of them showed limitation of flexion, and as many as 59% showed limitation of extension. Amongst all goniometric measurements, statistically significant differences concerned 16 of 28 joints in both hands – that were all DIP and PIP joints. No significant differences concerned any MCP joint in our study. It seems to confirm Hahn's statement about the location of changes mainly in distal parts of fingers due to the largest force values acting in this location [11]. In our opinion, the abovementioned facts indicate that there is a plain relationship between changes in fingers shape and decrease in their joint's ROM that may result in functional problems during daily activities.

Folkl describing traumas that can occur in climbers indicates that most of them are located in the upper limbs. In almost half of 439 investigated climbers, the pain and functional limitations during daily activities, as a result of trauma, appeared for over 10 days per month. Moreover, the finger traumas occur most often in the age period of 25–34 years [17]. The mean age of participants in our study was 27.1 years and remains in the range reported by Folkl [17], thus the occurrence of traumas and microtraumas could be one of the factors affecting the ROM and finger function in the investigated subjects.

We hope that our study will contribute to a better understanding of reactions to the long-term action of large overloads in the fingers and the associated effects of tissue remodeling. This knowledge may be helpful in designing well balanced training plans to provide the smallest possible damage to climber's locomotor system.

## CONCLUSIONS

1. Individuals practicing rock climbing have a reduced range of active flexion and enlarged joint contours in finger joints.
2. There is a relationship between overall rock climbing duration and the intensity of morphological changes of the fingers – the longer the time of practicing climbing, the smaller the values of the circumference of the joint circumferences in comparison to people with a shorter climbing time
3. Changes in the morphological structure of climbers' fingers may cause a subjectively perceived limitation of their functions and, therefore, difficulties in performing precise movements.

## REFERENCES

[1] Ginszt M, Goniewicz M, Ginszt A. Analiza przyczyn i następstw urazów u dzieci i młodzieży uprawiających wspinaczkę sportową [Analysis of the causes and consequences of injuries in children and adolescent sport climbers]. Hygeia Public Health 2012;47(1):23-27. Polish.

[2] Klauser A, Bodner G, Frauscher F, Gabl M, Zur Nedden D. Finger injuries in extreme rock climbers assessment of high-resolution ultrasonography. Am J Sports Med. 1999;27(6):733-737. https://doi.org/10.1177/03635465990270060801

[3] Ręgwelski T. Podstawy technik wspinania [Basics of climbing techniques]. In: Drożdż P, editor. 100 porad gór [100 tips for mountains], vol. 1. Kraków: Góry Books; 2011, 69-78. Polish.

[4] Schweizer A. Biomechanical properties of the crimp grip position in rock climbers. J Biomech. 2001;34(2):217-223. https://doi.org/10.1016/S0021-9290(00)00184-6

[5] Ręgwelski T. Mały leksykon technik wspinania [A small lexicon of climbing techniques]. In: Drożdż P, editor. 100 porad gór [100 tips for mountains], vol. 2. Kraków: Góry Books; 2012, 65-81. Polish.

[6] Bayer T, Schöffl VR, Lenhart M, Herold T. Epiphyseal stress fractures of finger phalanges in adolescent climbing athletes: a 3.0-Tesla magnetic resonance imaging evaluation. Skeletal Radiol. 2013;42(11):1521-1525. https://doi.org/10.1007/s00256-013-1694-4

[7] Klauser A, Frauscher F, Bodner G, et al. Value of high-resolution ultrasound in the evaluation of finger injuries in extreme sport climbers. Ultraschall Med. 2000;21(2):73-78. https://doi.org/10.1055/s-2000-316

[8] Schweizer A. Sport climbing from a medical point of view. Swiss Med Wkly. 2012;142:w13688. https://doi.org/10.4414/smw.2012.13688

[9] Sylvester AD, Christensen AM, Kramer PA. Factors influencing osteological changes in the hands and fingers of rock climbers. J Anat. 2006;209(5):597-609. https://doi.org/10.1111/j.1469-7580.2006.00640.x

[10] Schöffl VR, Hochholzer T, Imhoff AB, Schöffl I. Radiographic adaptations to the stress of high-level rock climbing in junior athletes: a 5-year longitudinal study of the German Junior National Team and a group of recreational climbers. Am J Sports Med. 2007;35(1):86-92. https://doi.org/10.1177/0363546506293256

[11] Hahn F, Erschbaumer M, Allenspach P, Rufibach K, Schweizer A. Physiological bone responses in the fingers after more than 10 years of high-level sport climbing: analysis of cortical parameters. Wilderness Environ Med. 2012;23(1):31-36. https://doi.org/10.1016/j.wem.2011.12.006

[12] Schreiber T, Allenspach P, Seifert B, Schweizer A. Connective tissue adaptations in the fingers of performance sport climbers. Eur J Sport Sci. 2015;15(8):696-702. https://doi.org/10.1080/17461391.2015.1048747

[13] Kainberger F, Mittermaier F, Seidl G, Parth E, Weinstabl R. Imaging of tendons – adaptation, degeneration, rupture. Eur J Radiol. 1997;25(3):209-222. https://doi.org/10.1016/S0720-048X(97)00058-2

[14] Swędzioł W. Ręka wspinacza. Przyczyny powstawania zespołów przeciążeniowych u wspinaczy sportowych [Climber's hand. Causes of overuse syndromes in sport climbers]. Magazyn Górski 2001;2:68-73. Polish.

[15] Peterson C, Ceraulo A. Caring for climbers. Curr Sports Med Rep. 2015;14(5):397-403. https://doi.org/10.1249/JSR.0000000000000200

[16] Schöffl V, Hochholzer T, Imhoff A. Radiographic changes in the hands and fingers of young, high-level climbers. Am J Sports Med. 2004;32(7):1688-1694. https://doi.org/10.1177/0363546503262805

[17] Folkl AK. Characterizing the consequences of chronic climbing-related injury in sport climbers and boulderers. Wilderness Environ Med. 2013;24(2):153-158. https://doi.org/10.1016/j.wem.2012.11.010

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