

ORIGINAL PAPER

**ANALYSIS OF RISK FACTORS FOR UPPER EXTREMITY ACUTE AND CHRONIC INJURIES, PAIN AND DISABILITY IN CLIMBERS**

Analiza czynników ryzyka urazów, bólu oraz niepełnosprawności kończyny górnej wśród wspinaczy

Marcin Mostowy<sup>1</sup>, Aleksandra Sibilska<sup>2</sup>, Marcin Piwnik<sup>3</sup>, Adam Kwapisz<sup>2</sup>

<sup>1</sup>Orthopedic and Trauma Department, Veteran's Memorial Teaching Hospital in Lodz,  
Medical University of Lodz, Poland

<sup>2</sup>Clinic of Orthopedics and Pediatric Orthopedics, Medical University of Lodz, Poland

<sup>3</sup>Clinic of Orthopedic and Posttraumatic Rehabilitation, University Clinical Hospital  
Military Memorial Medical Academy - Central Veterans' Hospital in Lodz, Poland

**ABSTRACT**

**Introduction**

Climbing gains increasing popularity. However, there is no agreement among risk factors for injuries and existence of pain symptom in climbers.

**Aim**

Finding relationships between injuries, pain or disability in climbers and various factors like: age, gender, weight, BMI, training frequency, training experience, style of climbing (bouldering- performed ropeless to low heights vs. rope indoor climbing – performed on artificial rock structures using a protective belt and rope), being a climbing instructor and smoking cigarettes.

**Materials and methods**

The surveys from 79 climbers, members of the climbing section of the Medical University of Lodz and Academic Sports Club as well as three climbing centers in Lodz, were analyzed.

**Results and conclusions**

Forty four injuries were reported. Four injury risk factors were significant: age above 30 years ( $OR=3.211$ ,  $p=0.0181$ ), male gender ( $OR=3.49$ ,  $p=0.0280$ ), higher weight ( $OR=1.051$ ,  $p=0.0266$ ) and higher training frequency ( $OR=1.821$ ,  $p=0.0440$ ). 23% of group suffered from pain in the present and 25% in the past. Risk factor for present pain was higher training frequency ( $OR=13.2$ ,  $p=0.0175$ ) and for pain in the past it was male gender ( $OR=4.167$ ,  $p=0.027$ ) and climbing style ( $OR=5.303$ ,  $p=0.0373$  for bouldering and rope-climbing vs only rope-climbing). For disability, lower weight ( $r = -0.6936$ ,  $p=0.0059$ ) and BMI ( $r = -0.7577$ ,  $p=0.0017$ ) were confirmed as risk factors. To our knowledge, this is the first study to investigate risk factors for pain and disability in climbers and the first one assessing being a climbing instructor, perceptible training burden or smoking cigarettes as potential risk factors.

**Key words:** climbing, overuse injuries, bouldering, rope climbing

**STRESZCZENIE**

**Wstęp**

Wspinaczka jest sportem zyskującym na popularności. W literaturze brak jest zgodności na temat czynników ryzyka urazów i występowania objawu bólu wśród wspinaczy.

### Cel

Wykazanie związków pomiędzy urazami, bólem i niepełnosprawnością wśród wspinaczy, a czynnikami takimi jak wiek, płeć, masa ciała, BMI, częstotliwość treningów, staż treningowy, styl uprawianej wspinaczki (bouldering – wspinaczka na małe wysokości bez asekuracji liną lub wspinaczka na większe wysokości na sztucznych ściankach z zastosowaniem asekuracji liną), bycie instruktorem wspinaczki oraz palenie papierosów.

### Materiały i metody

Przeanalizowano kwestionariusze wypełnione przez 79 wspinaczy, członków sekcji wspinackiej Uniwersytetu Medycznego w Łodzi oraz Akademickiego Klubu Sportowego jak i trzech centrów wspinackich w Łodzi.

### Wyniki i wnioski

Zgłoszone zostały 44 urazy. Wykryto cztery istotne statystycznie czynniki ryzyka urazów: wiek powyżej 30 lat ( $OR=3.211$ ,  $p=0.0181$ ), płeć męska ( $OR=3.49$ ,  $p=0.0280$ ), wyższa masa ciała ( $OR=1.051$ ,  $p=0.0266$ ) oraz wyższa częstotliwość treningów ( $OR=1.821$ ,  $p=0.0440$ ). Dwadzieścia trzy procent wspinaczy doświadczało obecnego bólu, a 25% - bólu w przeszłości. Czynnikiem ryzyka wystąpienia bólu obecnego była wyższa częstotliwość treningów ( $OR=13.2$ ,  $p=0.0175$ ), a bólu w przeszłości: płeć męska ( $OR=4.167$ ,  $p=0.027$ ) oraz styl wspinackowy ( $OR=5.303$ ,  $p=0.0373$  przy porównaniu osób trenujących zarówno bouldering, jak i wspinaczkę z asekuracją, do osób trenujących tylko wspinaczkę z asekuracją). Czynnikami ryzyka niepełnosprawności była mniejsza masa ciała ( $r=-0.6936$ ,  $p=0.0059$ ) oraz niższe BMI ( $r=-0.7577$ ,  $p=0.0017$ ). Według naszej wiedzy, jest to pierwsze badanie podejmujące temat czynników ryzyka bólu i niepełnosprawności wśród wspinaczy oraz pierwsze ocenające bycie instruktorem wspinaczki, odczuwalne obciążenie treningowe i palenie papierosów jako potencjalne czynniki ryzyka.

**Słowa kluczowe:** wspinaczka, urazy przeciążeniowe, bouldering, wspinaczka z asekuracją

*Author responsible for correspondence:*

Mostowy Marcin, Orthopedic and Trauma Department University Clinical Hospital Military Memorial Medical Academy - Central Veterans' Hospital in Lodz; Żeromskiego 113, 90-549 Łódź, Poland  
mostowymarcin1@gmail.com

*Date received: 14<sup>th</sup> April 2019*

*Date accepted: 29<sup>th</sup> June 2019*

### Introduction

Climbing gains increasing popularity. In 1989 there were approximately 100 000 outdoor climbers in USA, in 2017 this number increased to 2 790 000 outdoor and 4 905 000 indoor bouldering participants, according to Outdoor Industry Association report (Addiss and Baker, 1989; Association OI. *Outdoor Recreation Participation Report 2017*, 2017). This tendency is believed to continue due to climbing incorporation into Tokio's Olimpic Games in 2020 (Lutter et al., 2017).

Injuries of upper extremity are often among climbers (Folkl, 2013). They vary from light abrasions, through more severe like Superior Labrum Anterior and Posterior (SLAP) lesions, flexor digitorum tendons' pulleys injuries, rotator cuff tears; to bony fractures like hamate fractures and phalangeal epiphyseal stress fractures. The most often injured part of upper extremity are flexor digitorum tendons' pulleys (Bayer and Schweizer, 2009; Blanchette et al., 2015; Chang et al., 2016; Crowley, 2012; Desaldeleer and Le Nen, 2016; Lutter et al., 2016; Merritt and Huang, 2011).

The literature lacks agreement on numerous risk factors for climbing injuries of upper extremity: gender, Body Mass Index, age, climbing experience, climbing style (bouldering- performed ropeless to low heights vs. rope indoor climbing – performed on artificial rock structures using a protective belt and rope), proficiency of climber and training frequency. (Backe et al., 2009; Hasler et al., 2012; Jones et al., 2008; Josephsen et al., 2007; Lion et al., 2016; van Middelkoop et al., 2015; Nelson et al., 2017; Neuhof et al., 2006; Pieber et al., 2012; Schöffl et al., 2013; Woollings et al., 2015; Wright et al., 2001). Another issue is disability and pain, only two papers on this topic were found. These studies however did not assess risk factors, just epidemiology (Folkl, 2013; van Middelkoop et al., 2015). Upper extremity overuse pain and disability are common in climbers and therefore are not to be neglected (Folkl, 2013).

## Aim

There is no agreement about the risk factors for an injury in climbers and literature pertaining to pain or disability is scanty. Therefore the aim of this paper was to determine the impact of various demographic and lifestyle factors on the risk of injuries and on the level of pain and disability in indoor climbers' population. Authors believe the results of our study can be important for climbers and/ or trainers, who may consider modifying their training patterns in order to minimize injury-caused training absence.

## Materials and methods

Our study was a survey. The questionnaires were collected among members of the climbing section of the Medical University of Lodz, Academic Sports Club and 3 climbing centers in Lodz, summarily about 150 people.

Our self-designed questionnaire consisted of four sets of questions covering different issues:

- 1) Demographics: age, gender, weight, height, chronic diseases, nicotine or steroids usage.
- 2) Climbing exposure: training experience, training frequency, time of training unit, climbing style, climbing proficiency (the hardest finished route), subjective level of training burden (training - induced physical fatigue), being a climbing instructor.
- 3) Injuries within the last 3 years: whether the injury happened during climbing, localization and type of an injury, way of treatment, time of comeback to training.
- 4) Pain characteristics: localization, onset (during warm up, during climbing, after the training, not connected with training), duration and intensity (Visual Analog Scale).

The level of upper extremity disability was assessed using Quick-DASH scale (Beaton et al., 2005). The study protocol was approved by Ethical Board of Medical University of Lodz (Decision number RNN 200/19/KE, 12. March 2019).

Inclusion criteria were at least 6 months of training, minimal training frequency once a week and being 18 to 50 years old. Excluded were participants with rheumatic

diseases, steroid intake and upper extremity injury not related with climbing within the last 3 years, as shown in the Figure 1.

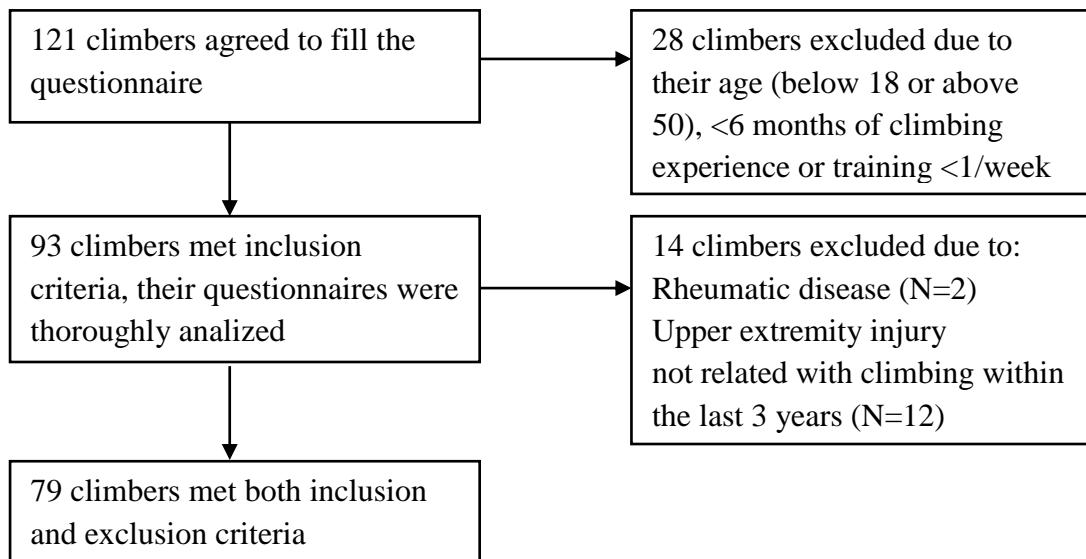


Figure 1. Flowchart of the study

Responses were further analyzed statistically, using Statistica 13 software. The statistical methods were Chi square and logistic regression tests, accordingly to the type of the assessed variable. The outcomes were Odds Ratio (OR) for Chi square and correlation coefficient (*r*) for logistic regression tests. The significant *p* value was set at <0.05.

## Results

A hundred and twenty one climbers filled the questionnaire, however only 79 met study criteria. Fifty one of them were males and 28 females aged as shown in the Table 1.

Table 1. Age and gender of respondents

Age groups	Females	Males
19-24	9	15
25-30	9	11
30-40	8	16
40-50	2	9
<b>Total</b>	<b>28</b>	<b>51</b>

### Epidemiology, injuries

Twenty seven out of 79 respondents reported climbing – related injuries in the previous 3 years. Some of them sustained multiple traumas, so concisely 44 climbing – related injuries were reported. The injury rate was 0.56 per respondent. None of traumas were treated operatively and, in most cases, (37 out of 44) the only applied therapy was rest. The remaining seven cases were treated with immobilization. In 24

cases climbers came back to training within 2 weeks, in 9 cases it took between 2 to 4 weeks, in 5 cases between 4 to 8 weeks and in 6 cases between 8 to 16 weeks. Tables 2 and 3 present injuries and pain distribution.

Table 2. Distribution of injuries and pain

<b>Localization</b>	<b>Cases of an injury</b>	<b>Cases of present pain</b>	<b>Cases of pain the past</b>
Shoulder	6	4	9
Arm	2	2	2
Elbow	1	5	2
Forearm	3	0	0
Wrist	0	1	3
Metacarpus	0	0	0
Fingers together	32	22	34
<b>Total</b>	<b>44</b>	<b>34</b>	<b>50</b>

Table 3. Fingers affected by injuries

<b>Affected finger</b>	<b>Cases of an injury</b>	<b>Cases of present pain</b>	<b>Cases of pain the past</b>
1st finger	0	0	4
2nd finger	1	5	4
3rd finger	14	9	12
4th finger	14	6	9
5th finger	2	2	5
Unknown finger	1	0	0
<b>Total</b>	<b>32</b>	<b>22</b>	<b>34</b>

#### *Epidemiology, pain*

Eighteen out of 79 climbers reported persistent present pain with mean VAS score=4.39, SD=5.77. Some of them they reported more than one localization of pain. The onset of pain varied: in 1 case it began during warm-up, in 8 cases during climbing, in 22 cases after the training session and there were 3 onsets without perceived link with training session.

Twenty out of 79 climbers reported persistent pain in the past with mean VAS score=4.65, SD=3.6. Similarly, a part of them experienced episodes of pain in multiple regions of upper extremity. The pain began during warm-up in 4 episodes, during climbing in 27 episodes, after the training session in 6 episodes and in 13 episodes onset of pain was not associated with training session. The duration of pain varied: less than 2 weeks in 12 cases, 2 to 4 weeks in 3 cases, 1 to 3 months in 22 cases, 3 to 6 months in 1 case and more than half a year in 4 cases.

#### *Epidemiology, disabling pain*

In our assessment we distinguished two types of pain: one that did not disrupt extremity function, and one that did. The disability caused by pain was measured with Quick-DASH score. Climbers were asked to fill it only in case of present pain, which 14 of them did. The mean Quick-DASH score was 10.23, SD=11.75.

### *Risk factors for injuries*

Four risk factors for an injury were confirmed: age above 30 years (OR=3.211, p=0.0181), male gender (OR=3.49, p=0.0280), higher weight (OR=1.051, p=0.0266) and higher training frequency (OR=1.821, p=0.0440), as shown in Table 4.

Table 4. Risk factors for injuries

Variable	p value	Odds Ratio (OR)
<b>Age</b>	<b>0.0181</b>	<b>3.211 older than 30 vs. younger than 30</b>
<b>Male gender</b>	<b>0.0280</b>	<b>3.490</b>
<b>Weight</b>	<b>0.0266</b>	<b>1.051 for every extra kilogram</b>
BMI	0.5740	1.051 for every extra point in scale
<b>Training frequency</b>	<b>0.0440</b>	<b>1.821 for every extra training from 1-3/week</b>
Perceptible training burden	0.7609	1.059 for every extra point in scale
Style of climbing	0.5674	1.346 for AS+B vs AS
Being a climbing instructor	0.7772	1.307
Training proficiency	0.1209	1.114 for every extra level of finished route
Smoking cigarettes	0.2284	3.125

Abbreviations: AS- assecuration (rope-climbing) B- bouldering

### *Risk factors for pain*

Climbers training three times a week more susceptible to pain than those training once a week (OR=13.2, p=0.0175). 8.33% of the group training once a week suffer from present persistent pain, while in group training more frequently the prevalence of pain reaches 37,5% (Table 5).

Table 5. Risk factors for present pain

Variable	p value	Odds Ratio (OR)
Age	0.9891	0.993
Male gender	0.3659	1.640
Weight	0.2672	1.027 for every extra kilogram
BMI	0.3772	1.097 for every extra point in scale
<b>Training frequency</b>	<b>0.0175</b>	<b>13.200 for climbers training 3/week instead of 1/week</b>
Perceptible training burden	0.2868	0.786 for every extra point in scale
Style of climbing	0.0768	0.295 for AS+B vs AS
Being a climbing instructor	0.8782	1.193
Training proficiency	0.6573	0.968 for every extra level of finished route
Smoking cigarettes	0.8782	1.193

Abbreviations: AS- assecuration (rope-climbing) B- bouldering

Pain experienced in the past was associated with male gender (OR=4.167, p=0.027) with 10,71% prevalence in females and 33,33% in males, and climbing style

(OR=5.303, p=0.0373 for bouldering and rope-climbing vs only rope-climbing), as shown in the Table 6.

Table 6. Risk factors for pain in the past

Variable	p value	Odds Ratio (OR)
Age	0.1065	2.348
<b>Male gender</b>	<b>0.0270</b>	<b>4.167</b>
Weight	0.1001	1.039 for every extra kilogram
BMI	0.7960	1.025 for every extra point in scale
Training frequency	0.1274	3.030 for every extra training from 1-3/week
Perceptible training burden	0.3139	1.243 for every extra point in scale
<b>Style of climbing</b>	<b>0.0373</b>	<b>5.303 for AS+B vs AS</b>
Being a climbing instructor	0.4436	2.074
Training proficiency	0.0765	1.147 for every extra level of finished route
Smoking cigarettes	0.7784	0.724

Abbreviations: AS- assecuration (rope-climbing) B- bouldering

There was no link between any of assessed variables and level of pain.

#### *Risk factors for disabling pain*

In the logistic regression test confirmed were correlations of lower weight ( $r= -0.6936$ ,  $p=0.0059$ ) and BMI ( $r= -0.7577$ ,  $p=0.0017$ ) with higher Quick-DASH score.

## Discussion

### *Injuries*

In our study four risk factors for an injury were confirmed: age above 30 years, male gender, higher weight and higher training frequency.

The first confirmed risk factor was age above 30 years (OR=3.211,  $p=0.0181$ ). One study confirmed older age association with higher risk for an injury (Pieber et al., 2012). There are some other papers denying it, however none of them assessed the same age frames as our study and in Neuhof et al. study older age was confirmed as risk factor for more severe injuries (Hasler et al., 2012; Jones et al., 2008; Neuhof et al., 2006; Wright et al., 2001). There was also a paper presenting younger age as risk factor for an injury. The authors however compared only three age groups: beneath 20 years old, 20 to 45 years old and above 45 years old (Backe et al., 2009).

Male sex was also confirmed as risk factor with OR=3.49,  $p=0.0280$ . Gender is a deliberated risk factor. Backe et al. confirmed it with OR=1.77, Wright et al. with OR=2.39 and Pieber et al. reported that males are more prone to the annular ligaments' injuries (OR=1.96) and to the lateral epicondylitis (OR=3.47) (Backe et al., 2009; Pieber et al., 2012; Wright et al., 2001). There were also studies that did not confirm male gender as risk factor for an injury, however the methodology of some of them was different than in our study (Hasler et al., 2012; Jones et al., 2008; Josephsen et al., 2007; van Middelkoop et al., 2015; Nelson et al., 2017; Neuhof et al., 2006; Woollings et al., 2015). For example, Woolings et al. investigated injuries in youths (11-19 years old) and in the study of Josephsen only boulderers were investigated, so it is hard to compare results (Josephsen et al., 2007; Woollings et al., 2015). In van Middelkoop's paper male gender was close to achieving the statistical significance with OR=1.44,  $p=0.10$  (van

Middelkoop et al., 2015). Interesting was the study of Nelson et al, in which females were shown to be at bigger risk of upper arm/ shoulder injury ( $OR=2.05$ ,  $p=0.02$ ) (Nelson et al., 2017).

The third risk factor was higher weight ( $OR=1.051$  for every extra kilogram,  $p=0.0266$ ). In two papers assessing weight itself (not BMI) as potential risk factor it was not confirmed. However in one of them higher weight was shown to increase time-loss after an injury and the second one assessed only boulderers (Josephsen et al., 2007; Woollings et al., 2015). Interestingly, while in our study higher weight was confirmed as risk factor for an injury, BMI was not. Backe et al. and Lion et al. reported association between BMI and risk of injury, while in two other studies this link was not reported (Backe et al., 2009; Josephsen et al., 2007; Lion et al., 2016; Neuhof et al., 2006). Unfortunately, not all authors analyzed weight as a risk factor apart from BMI analysis (Backe et al., 2009; Lion et al., 2016).

The last factor for an injury proved in our study was higher training frequency with  $OR=1.821$  for every extra training from 1 to 3 trainings per week ( $p=0.0440$ ). This finding is consistent with three different papers (Jones et al., 2008; Nelson et al., 2017; Neuhof et al., 2006). Lion et al. denied training frequency as risk factor, but in his study all respondents trained at least twice a week. It may have lowered impact of that variable, because differences in training frequency within assessed group were smaller than in our study (Lion et al., 2016).

Controversial is the impact of climbing experience on the risk of an injury. Majority of the literature do not confirm this, including our study (Backe et al., 2009; Hasler et al., 2012; Jones et al., 2008; Neuhof et al., 2006; Wright et al., 2001). In one paper the effect of climbing for more than ten years was  $OR=0.64$ ,  $p$  value= $0.06$ , so if the bigger group was investigated it could show a protective impact (Backe et al., 2009). Two studies linked longer climbing experience with increased risk of an injury, but one of them was conducted during world climbing championships, so the heterogeneity of the proficiency within the group was low, while in our study surveys were collected in four different open-accessed climbing centers. (Hasler et al., 2012; Wright et al., 2001). Another not fully elucidated issue is whether climbing style influences on the risk of an injury. According to Backe et al. participating in bouldering is a risk factor for an injury (but only for men with high BMI), while in van Middelkoop's study bouldering was shown to be a risk factor only in univariate analysis (Backe et al., 2009; van Middelkoop et al., 2015). It is difficult to examine the impact of specific climbing style because not many athletes climb in only one style. That was a case also in our study, however there was no significant difference of risk of an injury between climbers who trained only rope climbing and climbers who trained both rope climbing and bouldering.

Another potential risk factor is the proficiency of climber, measured by difficulty of finished routes. It was not confirmed in our study, just as in five different papers (Hasler et al., 2012; Jones et al., 2008; van Middelkoop et al., 2015; Nelson et al., 2017; Woollings et al., 2015). There were however three papers confirming it. Once again one of them was conducted during world climbing championships making the group non-representative for a common population and the second one only revealed a link of higher proficiency with injuries of hands (Lion et al., 2016; Neuhof et al., 2006; Wright et al., 2001).

Being an instructor, perceptible training burden or smoking cigarettes was not confirmed as risk factors for injuries in climbers. We failed to find any studies assessing these variables.

### *Pain*

Higher training frequency (OR=13.2 when training 3 times per week instead of once a week, p=0.0175), male gender (OR = 4.167, p=0.027) and climbing style (AS+B vs AS OR=5.303, p=0.0373) were associated with higher risk of pain. Higher training frequency enhanced the risk of pain even greater than risk of an injury.

We only found one study pertaining to pain in climbers, published by Folkl et al. Unfortunately, they did not assess risk factors for pain, only described pain epidemiology and what is more, the study investigated the pain of whole body, not only upper extremity. (Folkl, 2013)

### *Disabling pain*

Lower weight ( $r= -0.6936$ ,  $p=0.0059$ ) and BMI ( $r= -0.7577$ ,  $p=0.0017$ ) were confirmed as risk factors for higher Quick-DASH score. Our proposal to elucidate the phenomenon is that heavier climbers had more muscle mass and were stronger, so it was easier for them to compensate the loss of function. Unfortunately, muscularity or strength of participants was not assessed. Two papers pertained to the issue of disability in climbers, but it was impossible to compare their results with ours, because neither of these papers evaluated risk factors (Folkl, 2013; van Middelkoop et al., 2015).

### *Strengths and limitations*

Our study has all limitations associated with retrospective design. Selection bias is possible due to the fact injured or suffering climbers may not have been attending climbing centers in the time of the study. Another limitation is recall bias, which could lead to incomplete reporting of minor injuries. On the other hand, in our study surveys were collected personally to avoid using the Internet, which distinguishes our study among others. They were collected personally, because collecting the surveys through the Internet can affect honesty of results (Folkl, 2013; Lion et al., 2016; Nelson et al., 2017; Neuhof et al., 2006; Pieber et al., 2012). The group size was limited, which decreases the power of our study. However, in order to make a group representative the surveys were collected in four different climbing centers, decreasing the impact of specific training routines or methods used in a given climbing center.

## **Conclusions**

To our knowledge, this is the first study to investigate risk factors for pain and disability in climbers and the first one assessing being an instructor, perceptible training burden or smoking cigarettes as potential risk factors. Following risk factors were confirmed:

1. Age above 30 years, higher training frequency, male gender and higher weight for upper extremity injuries.
2. Higher training frequency, male gender and climbing style for upper extremity pain.
3. Lower weight and BMI for upper extremity disability.

## **ACKNOWLEDGEMENTS**

Authors would like to acknowledge MS Mateusz Kobierecki for proof reading.

## **REFERENCES**

**Addiss, D.G. and Baker, S.P.** (1989), "Mountaineering and rock-climbing injuries in US National Parks", *Annals of Emergency Medicine*, Vol. 18 No. 9, pp. 975–979.

- Association OI. Outdoor Recreation Participation Report 2017.** (2017). [https://outdoorindustry.org/wp-content/uploads/2017/05/2017-Outdoor-Recreation-Participation-Report\\_FINAL.pdf](https://outdoorindustry.org/wp-content/uploads/2017/05/2017-Outdoor-Recreation-Participation-Report_FINAL.pdf), date of access: 2019.06.29.
- Backe, S., Ericson, L., Janson, S. and Timpka, T.** (2009), "Rock climbing injury rates and associated risk factors in a general climbing population", *Scandinavian Journal of Medicine and Science in Sports*, Vol. 19 No. 6, pp. 850–856.
- Bayer, T. and Schweizer, A.** (2009), "Stress fracture of the hook of the hamate as a result of intensive climbing", *Journal of Hand Surgery (European Volume)*, Vol. 34 No. 2, pp. 276–277.
- Beaton, D.E., Wright, J.G. and Katz, J.N.** (2005), "Development of the QuickDASH", *The Journal of Bone & Joint Surgery*, Vol. 87 No. 5, pp. 1038–1046.
- Blanchette, M.-A., Pham, A.-T. and Grenier, J.-M.** (2015), "Conservative treatment of a rock climber with a SLAP lesion: a case report.", *The Journal of the Canadian Chiropractic Association*, Vol. 59 No. 3, pp. 238–44.
- Chang, C.Y., Torriani, M. and Huang, A.J.** (2016), "Rock Climbing Injuries: Acute and Chronic Repetitive Trauma", *Current Problems in Diagnostic Radiology*, Elsevier, Vol. 45 No. 3, pp. 205–214.
- Crowley, T.** (2012), "The Flexor Tendon Pulley System and Rock Climbing", *Journal of Hand and Microsurgery*, Vol. 04 No. 01, pp. 25–29.
- Desaldeleer, A.S. and Le Nen, D.** (2016), "Bilateral fracture of the base of the middle phalanx in a climber: Literature review and a case report", *Orthopaedics and Traumatology: Surgery and Research*, Elsevier Masson SAS, Vol. 102 No. 3, pp. 409–411.
- Folkl, A.K.** (2013), "Characterizing the consequences of chronic climbing-related injury in sport climbers and boulderers", *Wilderness and Environmental Medicine*, Elsevier Inc., Vol. 24 No. 2, pp. 153–158.
- Hasler, R.M., Bach, P., Brodmann, M., Heim, D., Spycher, J., Schotzau, A., Evangelopoulos, D.S., et al.** (2012), "A pilot case-control study of behavioral aspects and risk factors in Swiss climbers", *European Journal of Emergency Medicine*, Vol. 19 No. 2, pp. 73–76.
- Jones, G., Asghar, A. and Llewellyn, D.J.** (2008), "The epidemiology of rock-climbing injuries", *British Journal of Sports Medicine*, Vol. 42 No. 9, pp. 773–778.
- Josephsen, G., Shinneman, S., Tamayo-Sarver, J., Josephsen, K., Boulware, D., Hunt, M. and **Pham, H.** (2007), "Injuries in bouldering: A prospective study", *Wilderness and Environmental Medicine*, Elsevier, Vol. 18 No. 4, pp. 271–280.
- Lion, A., van der Zwaard, B.C., Remillieux, S., Perrin, P.P. and Buatois, S.** (2016), "Risk factors of hand climbing-related injuries", *Scandinavian Journal of Medicine & Science in Sports*, Vol. 26 No. 7, pp. 739–744.
- Lutter, C., El-Sheikh, Y., Schöffl, I. and Schöffl, V.** (2017), "Sport climbing: Medical considerations for this new Olympic discipline", *British Journal of Sports Medicine*, Vol. 51 No. 1, pp. 2–3.
- Lutter, C., Schweizer, A., Hochholzer, T., Bayer, T. and Schöffl, V.** (2016), "Pulling Harder than the Hamate Tolerates: Evaluation of Hamate Injuries in Rock Climbing and Bouldering", *Wilderness and Environmental Medicine*, Vol. 27 No. 4, pp. 492–499.
- Merritt, A.L. and Huang, J.I.** (2011), "Hand injuries in rock climbing", *Journal of Hand Surgery*, Elsevier Inc., Vol. 36 No. 11, pp. 1859–1861.
- van Middelkoop, M., Bruens, M., Coert, J., Selles, R., Verhagen, E., Bierma-Zeinstra, S.M. and Koes, B.** (2015), "Incidence and Risk Factors for Upper Extremity Climbing Injuries in Indoor Climbers", *International Journal of Sports Medicine*, Vol. 36 No. 10, pp. 837–842.

- Nelson, C.E., Rayan, G.M., Judd, D.I., Ding, K. and Stoner, J.A.** (2017), "Survey of Hand and Upper Extremity Injuries Among Rock Climbers", *Hand*, Vol. 12 No. 4, pp. 389–394.
- Neuhof, A., Hennig, F., Schöffl, I. and Schöffl, V.** (2006), "INJURY RISK EVALUATION IN SPORT CLIMBING.pdf", pp. 794–800.
- Pieber, K., Angelmaier, L., Csapo, R. and Herceg, M.** (2012), "Acute injuries and overuse syndromes in sport climbing and bouldering in Austria: a descriptive epidemiological studyAkute Verletzungen und Überlastungssyndrome beim Sportklettern und Bouldern in Österreich – eine deskriptive epidemiologische Studie", *Wiener Klinische Wochenschrift*, Vol. 124 No. 11–12, pp. 357–362.
- Schöffl, V.R., Hoffmann, G. and Küpper, T.** (2013), "Acute injury risk and severity in indoor climbing - A prospective analysis of 515,337 indoor climbing wall visits in 5 years", *Wilderness and Environmental Medicine*, Vol. 24 No. 3, pp. 187–194.
- Woollings, K.Y., McKay, C.D., Kang, J., Meeuwisse, W.H. and Emery, C.A.** (2015), "Incidence, mechanism and risk factors for injury in youth rock climbers", *British Journal of Sports Medicine*, Vol. 49 No. 1, pp. 44–50.
- Wright, D.M., Royle, T.J. and Marshall, T.** (2001), "Indoor rock climbing: Who gets injured?", *British Journal of Sports Medicine*, Vol. 35 No. 3, pp. 181–185.

*Authors reported no source of funding.  
Authors declared no conflict of interest.*