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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

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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

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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 wspinaczkowej Uniwersytetu Medycznego w Łodzi oraz Akademickiego Klubu Sportowego jak i trzech centrów wspinaczkowych 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 wspinaczkowy (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 oceniające bycie instruktorem wspinaczki, odczuwalne obciążenie treningowe i palenie papierosów jako potencjalne czynniki ryzyka.

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

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 minimalize 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.

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.

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

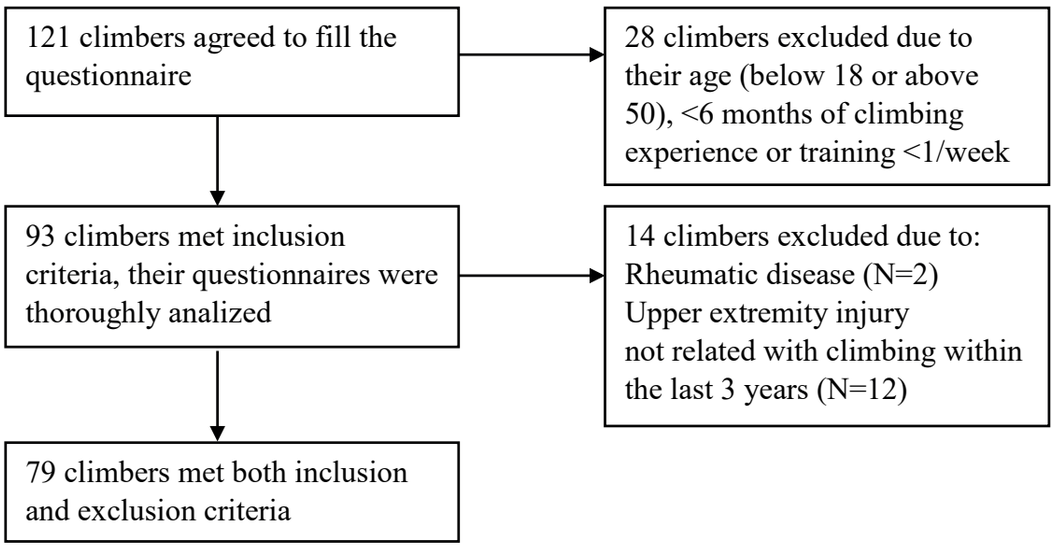

Figure 1. Flowchart of the study

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
Total	**28**	**51**

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.

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

Table 2. Distribution of injuries and pain

Localization	Cases of an injury	Cases of present pain	Cases of pain the past
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
Total	**44**	**34**	**50**

Table 3. Fingers affected by injuries

Affected finger	Cases of an injury	Cases of present pain	Cases of pain the past
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
Total	**32**	**22**	**34**

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.

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).

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.

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.*

Table 4. Risk factors for injuries

Variable	p value	Odds Ratio (OR)
Age	**0.0181**	**3.211 older than 30 vs. younger than 30**
Male gender	**0.0280**	**3.490**
Weight	**0.0266**	**1.051 for every extra kilogram**
BMI	0.5740	1.051 for every extra point in scale
Training frequency	**0.0440**	**1.821 for every extra training from 1–3/week**
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

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
Training frequency	**0.0175**	**13.200 for climbers training 3/week instead of 1/week**
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

Table 6. Risk factors for pain in the past

Variable	p value	Odds Ratio (OR)
Age	0.1065	2.348
Male gender	**0.0270**	**4.167**
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
Style of climbing	**0.0373**	**5.303 for AS+B vs AS**
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

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.

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