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Painfully ignorant? Impact of gender and aim of training on injuries in climbing

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ABSTRACT

Introduction Climbing has evolved from an obscure outdoor sport to a predominantly indoor sport with the rise of mainstream climbing on artificial walls. Reported climbing-related injuries were predominantly chronic and may be avoided with proper planning of training. All climbers, regardless of age and gender, are training on the same routes and perform similar movements; however, few studies have investigated gender-specific injuries in climbing.

Objectives Assess the distribution of chronic climbing injuries in an international population with gender-specific analyses and assess the impact of the person's training focus or aim of training on those injuries.

Methods A cross-sectional survey using a web-based item-driven questionnaire was created and promoted using social media and several climbing media stakeholders. All climbers engaged in either sport climbing, bouldering or traditional climbing were included.

Results The survey received 1513 responses (877 men, 427 women and 9 not reporting gender), of which 50.3% (n=665; 51.4% men and 48.0% women) had experienced an injury in the past 12 months. There were significant differences in injuries in feet/ankle (p=0.014), neck (p=0.03), head (p=0.0001), shoulder (p=0.001), elbow (p=0.021) and fingers (p=0.003).

Conclusion Over 50% of the climbers experienced an injury in the past 12 months. The most common injuries were to the shoulders (women) and fingers (men). There were significant differences between the genders regarding injury site and prevalence. The gender differences may be affected by the aim for training and the style of climbing.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Chronic injuries are more common in climbing than other individual sports.
⇒ Fingers have been assumed to be the most common site of injury. This 'truth' has been questioned by several studies lately.

WHAT THIS STUDY ADDS

⇒ All climbers, men and women alike, are training and performing on the same routes and boulders. Due to differences in anthropometrics onset of injuries differs for the genders.
⇒ There are significant differences between genders regarding the injury site and prevalence.
⇒ Shoulders are the most prevalent site of injury for women climbers, while the fingers still are the most prevalent site of injury for men.
⇒ The aim of the training seems to impact the rate of injury regardless of gender and level of performance.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ There are significant differences between genders regarding the injury site and prevalence. Future research on climbing injuries must include gender-specific analyses.
⇒ Injury prevention strategies must be differentiated for genders and level of performance.

BACKGROUND

Climbing, as a sport and research topic, is growing rapidly.[1 2] Climbing as a competitive indoor sport is divided into three disciplines: route, speed and bouldering. The different climbing styles are somewhat different in terms of duration, velocity and demand for muscle strength. Still, their similarities are the need for repetitive movements in training and the impact on the upper body.[3 4] Repetitive movements, including muscle lengthening, are one of the leading risk factors for chronic injury.[5]

Indoor climbing is based on designing movements on an otherwise blank wall using holds of different depths and sizes. The wall's steepness, the distance between holds, the depth and size of the holds, and the arrangement of the holds determines the difficulty of the movement and how strenuous it is.[6] The climb design for routes and boulders also decides what body parts take the most of the stress.[7 8] Finger injuries have long been considered the most prevalent site of chronic injuries in climbing.[9–12] More recently, Grønhaug *et al*[13] found that women international elite climbers have more injuries to the shoulders than fingers, and Krieger *et al*[14] found that ankles are more often injured than fingers in bouldering. Injuries are inevitably a part of sports, and climbing is no exception.[15]

Although climbing is considered a high-risk sport, the prevalence of severe injuries is low.[16] Importantly, the chronic injury rate is almost double compared with other Olympic sports,[17–19] and predominantly chronic injuries may be avoided with proper training planning.[16]

In the past decade, climbing has changed dramatically regarding how the routes and boulder problems on the indoor walls and competitions are designed,[20 21] giving way to different movement patterns at different performance levels. The movements have become bigger, involving jumps and frequently swinging on one arm while hanging from small edges. Furthermore, the overall level of performance is increasing, especially for women. Due to the change in the route setting, the training load has changed in terms of what muscles and joints are taking most of the load.[22]

To avoid injuries, it is vital to know the most common injuries at different performance levels and for each gender.[23] It has previously been suggested that the epidemiology of injuries would change due to the change in the design of routes and boulders.[20] Still, we do not know what the change in movement pattern and the increased level of performance means for the distribution of injuries across the genders.

Sports injuries are not independent or random incidents. Rather, injuries are multifactorial, including complex interactions of personality, psychological profile and the aim of the sport performed. Still, chronic injuries are more predictable than acute injuries.[24 25] Apart from short speculation on the reason for injuries to the fingers,[9] little is known about the impact of the aim of training on injuries. The two aims of this study on an international population are to assess the distribution of chronic climbing injuries with gender-specific analysis and to assess the impact of the person's training focus or aim on those injuries.

METHODS

The data were collected by a cross-sectional survey using a web-based item-driven questionnaire (Qualtrics). The questionnaire was open for respondents from Friday, 26 February 2021, to Saturday, 1 May 2021. The survey was promoted through social media and several climbing media stakeholders. All climbers engaged in either sport climbing, bouldering or traditional climbing were included. The questionnaire did not have separate categories for those predominantly identifying as performing alpine climbing, ice climbing or speed climbing.

To participate, the climbers had to be over 16 years old, provide consent to participate, and read and understand English. The survey contained 45 questions and was developed by the researchers. The questions were divided into the following sections: (1) sociodemographic and climbing demographics, (2) climbing during quarantine and COVID-19 restrictions and (3) injury and pain related to climbing. The questions were formatted for responses that were multiple choice (eg, select one or several answers), sliding scale (body weight, height and age), 5-point Likert scale graded responses (eg, strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree) and text-entry using open-ended responses. See online supplemental appendix A for the survey.

In the present paper, only questions related to demographics and injuries are presented. This includes questions related to injuries, including injury location(s), time out of training or training at a lower intensity and potential moderators such as gender, total climbing volume (eg, weekly frequency and session), climbing style(s), climbing performance level the past year and climbing experience (years of climbing) as well as aim of the training. The main outcome was injury/injuries (defined as the number of participants that responded 'yes' to having an injury in the last 12 months), with gender (women, men or non-binary) differences related to self-reported injury as the primary aim to examine.

Climbing performance in selected climbing style(s) was related to performance within the last year. Self-reported climbing performance has proven reliable compared with testing.[6] Comparative grading scales were based on Draper *et al*'s work.[26] The grouping of the level of performance in this study aligns with Grønhaug and Norberg[27] (see online supplemental material table 1).

Statistical analyses

For all descriptive statistics, categorical data was reported as n (%), whereas continuous data were reported as mean±SD. The χ^2 test was used to determine whether there were statistical differences between gender, injury location, climbing performance, climbing experience and climbing style among the injured climbers. Finally, the ORs were calculated to examine potential gender differences in injury locations and injury prevalence when conducting bouldering, route climbing, trad climbing or several climbing styles. All statistical analyses were computed using the IBM SPSS Statistics for Windows (V.28.0, IBM Corp., Armonk, NY, USA). Statistical significance was defined as $p<0.05$.

RESULTS

In total, 1519 climbers volunteered, consented to participate and completed the survey (table 1). Due to the recruitment process, the authors could not identify the number of potential climbers who declined to participate. Potential participants who did not complete the survey were excluded from further analyses. Due to lost and/or invalid responses, N differs in the analyses.

The survey received 1513 responses (877 men, 427 women and 9 not reporting gender), out of which 50.3% (n=665; 51.4% men and 48.0% women) had experienced an injury in the past 12 months (table 1). The participants were 34.5±12.3 years old (16–63 years) from 41 countries. Most respondents had more than 3 years of experience (table 2) and performed at an intermediate level or higher (table 1). Most respondents regularly trained in more than one discipline (table 3).

Table 1 Sociodemographics of the respondents are presented in terms of age, injury (yes/no) and level of performance for all respondents, men and women

	All respondents n=1317 (100%)	Men n=877 (66.6%)	Women n=427 (33.4%)
Age (years)			
	34.6±9.9	35.1±10.4	32.9±9.8
Injury last 12 months			
Yes	665 (50.3%)	451 (51.4%)	205 (48.0)
No	652 (49.7%)	426 (48.6)	222 (52.0)
Highest level routes			
<6b	282 (24.5%)	143 (19.1%)	136 (34.5%)
6b+ to 7a+	508 (44.2%)	332 (44.4%)	174 (44.2%)
7b to 8b	333 (29.0%)	257 (34.4%)	74 (18.8%)
8b+ to 8c+	23 (2.0%)	14 (1.9%)	9 (2.3%)
>9a	3 (0.3%)	2 (0.3%)	1 (0.3%)
Highest level bouldering			
<5+	37 (4.0%)	9 (1.4%)	28 (10.8%)
6a to 6c+	351 (38.4%)	220 (33.9%)	125 (48.4%)
7a to 7c	440 (48.1%)	352 (54.2%)	88 (34.0)
7c+ to 8a+	73 (8.0%)	56 (8.6%)	17 (6.6%)
>8b	13 (1.4%)	12 (1.8%)	1 (0.4%)

655 climbers reported 969 injuries. There were no differences in climbing experience (eg, less than 1 year, 1–2 years, 3–5 years, 6–10 years or more than 10 years) and injury prevalence (χ^2 test; p=0.426). For climbers only bouldering (n=296), there was a significant difference in injuries versus not injured (p<0.001) with a relative risk of 0.737 (95% CI 0.642–0.846). For the route (n=335) and traditional (n=65) climbers, there were no significant differences in injuries versus not injured the last year (p=0.702 and p=0.877) with a relative risk of 0.987 (95% CI 0.920–1.057), and 1.015 (95% CI 0.844–1.220). Participants who focus on all three disciplines (traditional climbing, route climbing and bouldering) have a relative risk of injuries at 1.461 (95% CI 1.069–1.996, p=0.016).

There was no significant difference in the rate of injuries between the genders (χ^2 test; p=0.330).

For the men climbers, 450 (51.4%) reported injuries in one or several locations. More specifically, 295 climbers (29.1%) reported an injury in one location, 101 climbers (10.0%) in two locations, 24 climbers (2.4%) in three locations, and 19 (1.8%) in four or more.

For the women climbers, 205 (48.0%) reported injuries in different locations, of which 131 climbers (26.4%) reported injuries in one location, 43 climbers (8.7%) in two locations, 16 climbers (3.2%) in three locations and 10 (1.8%) in four or more.

For specific details of location and gender comparisons, see table 4. Briefly, the women are injured less than men

Table 2 Climbing experience presented as years of climbing and training load presented for total training hours and weekly climbing hours

	All respondents N=1317	Per cent of cases	Men n=877	Per cent of cases	Women n=427	Per cent of cases
Climbing experience in years of climbing						
Less than 1 year	60	4.0	30	3.0	29	5.9
1–2 years	247	16.3	161	15.9	83	16.8
3–5 years	407	26.8	259	25.6	146	29.5
6–10 years	295	19.5	201	19.9	92	18.6
10 or more years	507	33.4	361	35.7	145	29.3
Total hours of training weekly						
1 hour or less	74	4.9	49	4.8	25	5.0
1–3 hours	284	18.7	199	19.7	83	16.7
4–7 hours	581	38.3	382	37.8	194	39.1
8–10 hours	368	24.3	248	24.5	119	24.0
10 or more hours	209	13.8	133	13.2	75	15.1
Total hours of climbing weekly						
1 hour or less	146	9.6	87	8.6	58	11.7
1–3 hours	363	23.9	244	24.1	118	23.8
4–7 hours	678	44.7	471	46.5	203	41.0
8–10 hours	208	13.7	134	13.2	71	14.3
10 or more hours	122	8.0	77	7.6	45	9.1

Table 3 Preferred style of climbing and aim of training. More than one answer was possible

	All respondents N=1317	Per cent of cases	Men n=877	Per cent of cases	Women n=427	Per cent of cases
Preferred style of climbing						
Bouldering	918	60.6	652	64.6	260	52.5
Route climbing	1072	70.8	693	68.6	374	75.6
Traditional	385	25.4	291	28.8	89	18.0
Bouldering and route	554	36.6	388	38.4	162	32.7
Route and traditional	292	19.3	223	22.1	66	13.3
All three disciplines	164	10.8	131	13.0	31	6.3
Aim of training						
Climb harder	996	65.8	696	69.0	294	59.4
Stay at the same level	195	12.9	132	13.1	62	12.5
General fitness	151	10.0	85	8.4	66	13.3
Improved general fitness	171	11.3	96	9.5	73	14.7

in the fingers (OR 0.579, 95% CI 0.429–0.78, p=0.003), elbows (OR 0.628, 95% CI 0.410–0.961, p=0.021) and ankle (OR 2.086, 95% CI 1.144–3.805, p=0.014). In contrast, men had less chance of being injured in the shoulders than women (OR 1.603, 95% CI 1.152–2.229, p=0.001). For the other locations, no significant differences were observed in the toe, calf, knee, thigh, hip, lower back, abdominal, chest, mid/upper back, upper arm, forearm, wrist (p=0.139–0.902), but for the neck (p=0.030) and head (p<0.001).

DISCUSSION

The novelty in this international study is the importance of gender-specific analysis of injuries. Only one previous paper presents a gender-specific analysis of chronic injuries in climbing.[9] The gender-specific analysis shows

Table 4 Location of injuries presented for all climbers, men and women, including a Pearson χ^2 analysis to compare the rate of injuries between the genders

	All respondents N=990	Per cent of cases	Men n=663	Per cent of cases	Women n=318	Per cent of cases	Pearson χ^2 men versus women
Toe	17	2.6	11	2.5	6	3.0	0.865
Foot/ankle	45	7.0	22	5.0	22	11.0	0.014
Calf	9	1.4	7	1.6	2	1.0	0.804
Knee	75	11.6	50	11.4	25	12.5	0.625
Thigh	18	2.8	12	2.7	6	3.0	0.902
Hip	29	4.5	16	3.6	13	6.5	0.236
Lower back	35	5.4	19	4.3	16	8.0	0.139
Abdominal	6	0.9	5	1.1	1	0.5	0.718
Chest	7	1.1	5	1.1	2	1.0	0.956
Mid/upper back	16	2.5	8	1.8	8	4.0	0.241
Neck	19	2.9	9	2.1	9	4.5	0.030
Head	5	0.8	1	0.2	3	1.5	0.000
Shoulder	165	25.6	94	21.4	70	35.0	0.001
Upper arm	32	5.0	24	5.5	8	4.0	0.627
Elbow	127	19.7	94	21.4	30	15.0	0.021
Forearm	33	5.1	27	6.2	6	3.0	0.290
Wrist	72	11.2	47	10.7	25	12.5	0.452
Finger	280	43.4	212	48.3	66	33.0	0.003

Table 5 Gender comparison of injuries in different levels of performance

Injury location	Total, N=655 (%)	Gender	<6b n=95	6b+ to 7a+ n=216	7b to 8b n=170	>8b+ n=10	Not reported level n=164
Ankle*	45 (6.8)	Women	9	6	1		6
		Men	2	6	8		7
Knee	75 (11.3)	Women	9	3	5	2	6
		Men	3	19	14		14
Hip	29 (4.4)	Women	2	5	2		4
		Men	2	6	3		5
Lower back	35 (5.3)	Women	4	6	3		3
		Men	2	8	5	1	3
Shoulder*	162 (24.5)	Women	16	29	14		10
		Men	7	31	32	2	20
Elbow*	125 (18.9)	Women	8	12	4	1	4
		Men	10	34	33	1	15
Forearm	31 (4.7)	Women		4			2
		Men	4	9	6		6
Wrist	69 (10.4)	Women	5	11	6	1	2
		Men	4	14	15	1	10
Finger*	267 (40.8)	Women	8	24	15	3	14
		Men	15	59	68	3	58

*Marks the anatomical locations with a significant difference in injury incidence between the genders, as found in table 4.

significant differences in the location and rate of injuries in men and women. This study finds significant differences in injuries for men and women in the feet/ankle (p=0.014), neck (p=0.03), head (p=0.0001), shoulder (p=0.001), elbow (p=0.021) and fingers (p=0.003) as shown in table 4. Furthermore, the gender-specific analyses shown in table 5 demonstrate that women climbers report more chronic injuries to the shoulders (35%) than the fingers (33%). In all but one previous study on chronic injuries in climbing,[13] fingers have been reported as the anatomical site with most injuries.[16 28–30] This study's findings on women shoulder injuries align with those of other overhead sports, such as handball and swimming.[31 32] In the paper from Grønhaug[9] and the present study, women climbers have more shoulder injuries than men climbers. The results should be interpreted carefully as there are possibly other contributors to these differences other than gender.

The results of the present study indicate a rise in shoulder injuries among women climbers, affecting more than 30%. In 2023, Grønhaug *et al*[13] reported shoulders (38%) and fingers (34%) as the most frequent locations of injuries among elite women climbers. Supported by present findings, women appear to be more exposed to shoulder injuries and not fingers, unlike men. Previous studies reported shoulder injuries at lower rates, less than 20%[33–35]; however, these studies did not conduct gender-specific analyses, so direct comparison is not possible. In the study by Grønhaug,[9] shoulder injuries was reported by 19.5% of climbers (21.9% of women and 18.7% of men) in the past 6 months. Comparing the findings in the present study, we see a 13% rise in shoulder injuries among women climbers.

Although direct comparisons between this and previous studies should be interpreted with caution, this possible rise in shoulder injuries in women climbers should at least be a consideration for injury prevention programmes. The difference in shoulder injuries may be due to a difference in the length, muscle strength and muscle mass in the arms.[36] Another possible explanation for this rise in shoulder injuries may be the indoor setting with a new focus on dynamic movement patterns. During the 5 years that separate the Grønhaug[9] study and the present, the style of route setting in the gyms has changed.[20] Lutter *et al*[2] speculated that the modern route setting in indoor venues for climbing might change how and where injuries appear. In modern route settings, the movement pattern is more focused on parkour-style jumping involving huge swings with straight arms and, at the same time, rotational movement in the upper body. Future research will show if there will be differences in the onset of climbing injuries between those who are predominantly climbing indoors versus outdoors.

Injuries to the fingers have previously been reported to be the most frequent site of injury in climbing[28 30 33–38] and places climbing among the Olympic sports with the

highest rate of injuries.[18 19 39] In the present study, fingers were still the most common site when all climbers were analysed together (43.4%) (table 4), as well as for the men climbers (48.3%). Of the women climbers, 33% report that they have had finger injuries in the past 12 months. The difference in the rate of injuries was significant (p=0.003) between genders (table 4). When compared with the gender-specific analyses in the Grønhaug paper,[9] the prevalence of injuries to the fingers has seen a slight rise (45.3% men and 29.2% women in 2018 vs 48.3% men and 33% women in the present study).

According to Auer *et al*[40] most injuries to the fingers were classified as union internationale des associations d'alpinisme (UIAA) level 1.[40] Thus few finger injuries are treated in hospital and most climbers avoid seeking healthcare.[41 42] For more details see online supplemental material table 2.

Another finding of the study is a possible rise in knee injuries. The increase in knee injuries is high for both genders, 2.8%–11.4% for men, and 7.3%–12.5% for women compared with previous studies.[9] In other studies, without gender-specific analysis, knees were reported to be injured in less than 10% of cases.[33–35] As for the shoulders, the modern route setting, as well as the rise in the popularity of bouldering, is possibly causing this rise in the number of injuries to the knees.[20 21]

Injuries to the lower limbs are more common for intermediate climbers (table 5). This may be due to a lack of experience or insufficient strength to withstand the rotational forces on the knees in modern competition-style bouldering.[43 44] Thus, the injuries may be prevented and effective knee injury protocols are used in other sports that may translate to climbing.[45]

For men climbers, injuries to the wrist have more than doubled, from 4.2% to 10.7%, when compared with the 2018 study,[9] while unchanged for the women (12.5%). The increase in injuries to the wrist is also evident when compared with other studies wiyhout gender specific analysis; Jones *et al*,[16] which reports 5% injuries to the wrist or Rohrbough *et al*,[28] who reported 7% 'wrist undercling injury'. In a study from 2012,[12] injuries to the wrist were reported to be less than 1%. When climbing with an 'open hand', the wrist is in a neutral position, and the wrist stabilisers cannot keep the wrist stable and locked.[46 47] Modern route settings often require an open-hand position as well as swinging from one arm. This demands specific strength training to prevent injuries.[48]

In our material with 1317 climbers from more than 41 countries (table 1), we could not find that experience in terms of years of climbing increased the probability of an injury. These findings are partly in contrast to previous research.[34 49–51] The reason why the more experienced are less injured might be explained as a selection bias. Those injured may have quit climbing, or those who responded might have had injuries previously and have learnt how to train to avoid injuries.

However, we did find that the level of performance is inflicting on the probability of an injury. Those operating at the experienced level (French 7b+ to 8b) had a higher injury rate than those in the higher and lower grades (table 5). To the authors' knowledge, there is only one other study with an analysis of the injuries at different levels of performance,[8] which confirms our findings.

Those who focus their training on improvement of performance are at a higher risk of having an injury, no matter what level of performance they are at. This suggestion is backed by the finding that the two groups that are most injured are the ones that either aim to climb harder/increase the level of performance (52.4% injured) and the ones aiming for improved general fitness (58.4% injured) (table 3). These findings are supported by a previous study that found that those who rapidly increase their level of performance have the highest probability of injury.[52] Interestingly, those who climb for general fitness with no aim for improving their fitness are the ones with the least injuries (35.4%) in our study. The psychological aspect and how different personalities might prevent or provoke injuries should be assessed in future studies.

While previous studies have either looked at injuries among boulderers[53] or analysed all climbers as one group, in the present study, we split the respondents into groups based on their main climbing focus (bouldering, route climbing, trad climbing). Those who state that they focus on all three disciplines (traditional climbing, route climbing and bouldering) have a higher probability of an injury (p=0.016) with a relative risk of 1.461 (95% CI 1.069–1.996). Furthermore, we found that those focusing on more than one discipline are at greater risk for injury, while those focusing on one discipline are less likely to have an injury (table 3).

The findings in the present study do not support the assumption that boulderers are more injured than others. We found boulderers to have a relative risk of 0.737 (95% CI 0.642–0.846), which is lower than route climbing 0.987 (95% CI 0.920–1.057) and trad climbing 1.015 (95% CI 0.844–1.220). Training quality and planning sessions well are more likely to increase performance. Lack of aim might increase the probability of lower training quality and impaired restitution. Hence, the likelihood of an injury rises as less planning, and unfocused training is shown to give a loading pattern with less variability, leading to injuries.[54 55]

LIMITATIONS

This study is based on an online questionnaire distributed internationally using social media. This gives a potential selection bias and is a major weakness of the study. We do not know how the questionnaire was spread out and who had access to it in terms of nationality or gender. The totals of the different performance levels are not balanced evenly or similarly for the genders. This is a weakness of the study. As the study is retrospective, there may be a recall bias. Some may have forgotten about an injury or its severity. This is a problem with all studies based on participants' memory and is not specific to this study. The lack of unsolicited medical examination of the

respondents' injuries is a weakness. Although it was stated clearly that the study was about chronic injuries, there are no guarantees that the respondents only reported chronic injuries.

A strength of the study is the large and international study population and the range of performance levels in this study. With over 1000 participants from more than 40 countries, this study is better situated with more generalisable data than previous studies on climbing injuries.

Previous research on chronic injuries in climbing typically includes small selections of participants with a wide range of methods and often of poor quality.[23] As the methods vary, it is not easy to compare results. Still, the present study indicates that the anticipated shift in the epidemiology of climbing injuries is ongoing.[20] This should impact the development of injury prevention programmes. Future studies may need to analyse climbing indoors and outdoors as different sports rather than the same sport.

CONCLUSION

Over 50% of the climbers experienced an injury in the past 12 months. The most common injuries were to the shoulders (women) and fingers (men). There were significant differences between the genders regarding injury site and prevalence. The gender differences may be affected by the aim for training and the style of climbing.

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