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Most Often Injured Anatomical Locations and Injury Prevention of CrossFit Athletes

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The study aimed to analyze acute injuries and their localizations amongst people practicing CrossFit and provide some guidelines and possibilities for prevention. The research included 54 participants practicing CrossFit in Bulgaria. The participants filled out a questionnaire, which included open and closed questions about type, severity, location, and the reasons for the appearance of injuries. The results showed 61 acute injuries among the participants. The most prevalent injuries for both sexes were the lumbar spine (24.6%), knee (16.4%) and shoulder (14.8%). Slight injuries (29.5%) and minimal injuries (27.9%) were the most frequently reported. The main reasons for the injuries were overtraining (42.9 %) and fatigue (36.4 %). Most participants (74.1%) had not trained with a licensed CrossFit instructor, and 66.7% had not taken precautions. The distribution of the injuries according to their number and location was similar to the one described in the scientific literature.

Key words: CrossFit, musculoskeletal injuries, acute injuries, anatomical locations

Introduction

Approximately 74% of all athletes who practice some sport (even unprofessionally) suffer a moderate or severe injury yearly [8]. CrossFit is often associated with a risk of musculoskeletal injuries as a result of the high intensity of the training load [15] and the complexity of execution of the training sets of exercises in combination with little or no breaks between the sets [18]. Weisenthal [22] provides the following definition of musculoskeletal injuries in CrossFit: "any muscle, tendon, bone, joint, or ligament injury sustained while doing CrossFit that resulted in your consultation with a physician, or health care provider, and that caused you to stop or reduce your usual physical activity, your typical participation in CrossFit, or caused you to have

surgery." In sports practice, to prevent injuries, warm-up and stretching exercises are done before the main load [13] which aims to increase the range of motion, activate blood circulation, and prepare the muscles and joints for the forthcoming load [9]. The specialists in CrossFit emphasize instructors' competence and their personal work with athletes in injury prevention [12, 20].

This study aimed to analyze acute injuries and their localizations amongst people practicing CrossFit and provide some guidelines and possibilities for prevention.

Material and Methods

In order to assess the level of injuries in the previous year (12 months), we had the participants fill out a online questionnaire, which included open and closed questions about severity, location, and the reasons for the appearance of injuries in the following anatomical locations: head, neck, shoulder, upper arm, elbow, forearm, wrist and hand, chest, abdomen, thoracic spine, lumbar spine, pelvis and buttock (bones), hip and groin (muscles), thigh, knee, lower leg, ankle, foot. Participants could point to more than one injured location [17, 24, 25]. According to the severity of injuries and the time needed for recovery, the injuries were divided into slight (1/2 days), minimal (1-3 days), mild (4-7 days), moderate (8-28 days), and severe (over 28 days) [6]. The study was conducted in accordance with the principles set forth in the Declaration of Helsinki for research on humans [23].

For the purposes of the analysis, we used Chi-square and Z-test to determine the differences in the distribution of injuries, their incidence, location, and severity. We used frequency analysis as well. The statistical processing of the data was done with the software package SPSS V.25. The accepted statistical significance level was $p < 0.05$. In the tables and in the text, the values are presented as numbers and percentages of total injuries or cases.

Results

The survey was conducted among 54 participants practicing CrossFit in Bulgaria. Injuries for the study period have been reported by 27 people practicing CrossFit in their free time - 15 men (mean age 30.8 ± 3.53 years), with an average training experience of 3.6 ± 2.05 years, with an average of 3.7 ± 0.75 training sessions per week and 12 women (mean age 32.9 ± 2.03 years), with an average training experience of 3.7 ± 1.12 years, with an average of 3.6 ± 0.71 training sessions a week.

The total number of injuries reported by the participants was 61 (**Table 1**). The men reported 33, and the women reported 28 acute injuries over a year, without significant differences between them ($p > 0.05$). Since we found no significant sex-related differences in injuries across anatomical locations, we analyzed the data for the combined group. The distribution of the injuries was relatively equal for both genders. The men reported injuries in another two anatomical locations - thigh and the forearm.

The most frequently injured anatomical locations of the whole researched group were the lumbar spine with 15 injuries (24.6%), the knee with 10 injuries (16.4%), the shoulder with 9 injuries (14.8%), and the ankle with 6 injuries (9.8%) (**Table 1**). The total number of injuries in the anatomical location lumbar spine was significantly higher than the ones reported in the anatomical locations ankle ($p < 0.05$), elbow ($p < 0.05$), lower leg ($p < 0.05$), neck ($p < 0.05$), foot ($p < 0.01$), thigh ($p < 0.05$), and forearm ($p < 0.05$). Regarding the anatomical location of the knee, we found significant differences between the injuries reported in this anatomical location and the forearm ($p < 0.05$).

The slight injuries were the most frequent for the whole researched group -18, which were significant more than the eight moderate injuries ($p < 0.05$) and the five severe injuries ($p < 0,01$). The women reported 11 slight injuries, significant more than the eight slight injuries reported by the men ($p < 0.05$) (**Table 1**).

Table 1. Most often injured anatomical locations and severity of injuries

	Total (n=61)	**Men (n=33)**	**Z test**	**Women (n=28)**
Anatomical locations	**N (%) of injuries**	**N (%) of injuries**		**N (%) of injuries**
lumbar spine	15 (24.6%)	8 (13.1%)	$p > 0.05$	7 (11.5%)
knee	10 (16.4%)	6 (9.8%)	$p > 0.05$	4 (6.6%)
shoulder	9 (14.8%)	5 (8.2%)	$p > 0.05$	4 (6.6%)
ankle	6 (9.8%)	3 (4.9%)	$p > 0.05$	3 (4.9%)
elbow	5 (8.2%)	2 (3.3%)	$p > 0.05$	3 (4.9%)
lower leg	5 (8.2%)	2 (3.3%)	$p > 0.05$	3 (4.9%)
neck	3 (4.9%)	1 (1.6%)	$p > 0.05$	2 (3.3%)
foot	3 (4.9%)	1 (1.6%)	$p > 0.05$	2 (3.3%)
thigh	3 (4.9%)	3 (4.9%)		
forearm	2 (3.3%)	2 (3.3%)		
Severity of injuries	**N (%) of injuries**	**N (%) of injuries**		**N (%) of injuries**
slight	18 (29.5%)	7 (11.5%)	**$p < 0.05$**	11 (18%)
minimal	17 (27.9%)	7 (11.5%)	$p > 0.05$	10 (16.4%)
mild	13 (21.3%)	9 (14.8%)	$p > 0.05$	4 (6.6%)
moderate	8 (13.1%)	6 (9.8%)	$p > 0.05$	2 (3.3%)
severe	5 (8.2%)	4 (6.6%)	$p > 0.05$	1 (1.6%)

Both genders reported severe injuries (over 28 days) in the anatomical locations of the lumbar spine. The men also reported injuries in the knee and shoulder. Men reported moderate injuries (8-28 days) in the anatomical locations of the lumbar spine (2) and knee (2) and one injury in the anatomical locations of the shoulder and thigh.

The women reported two moderate injuries in the anatomical locations of the lumbar spine and knee over the research period. The distribution of the injuries regarding the other severity types was relatively the same for both genders (**Table 2**).

Table 2. Injury distribution according to severity and anatomical location

	Injured anatomical locations									
CrossFit participants	**Lumbar spine**	**Knee**	**Shoulder**	**Ankle**	**Elbow**	**lower leg**	**Foot**	**Neck**	**Thigh**	**Forearm**
Male (n=15)	1^{b}, 3^{c}, 2^{d}, 2^{e}	2^{b}, 1^{c}, 2^{d}, 1^{e}	1^{b}, 2^{c}, 1^{d}, 1^{e}	1^{a}, 1^{b}, 1^{c}	1^{a}, 1^{b}	2^{a}	1^{b}	1^{a}	1^{a}, 1^{c}, 1^{d}	1^{a}, 1^{c}
Female (n=12)	2^{a}, 2^{b}, 1^{c}, 1^{d}, 1^{e}	1^{b}, 2^{c}, 1^{d}	1^{a}, 2^{b}, 1^{c}	1^{a}, 2^{b}	1^{a}, 2^{b}	2^{a}, 1^{b}	2^{a}	2^{a}		

Legend: slight ½ days symptoms – **a**; minimal 1-3 days symptoms – **b**; mild 4-7 days symptoms – **c**; moderate 8-28 days symptoms – **d**; severe over 28 days symptoms – **e**

The leading reason for injuries was overtraining, which differs significantly from a skipping a warm-up ($p < 0.05$) and the technical fault ($p < 0.01$). The accumulation of fatigue was the next most frequently reported, which similarly differs significantly from a warm-up ($p < 0.05$) and the technical fault ($p < 0.05$). The researched individuals were able to give more than one correct answer (**Table 3**).

Table 3. Reasons for injuries

Reasons	**Total n (%)**	**Men n (%)**	**Women n (%)**
Overtraining	33 (42.9 %)	18 (54.6%)	15 (45.5%)
Fatigue	28 (36.4 %)	12 (42.9%)	16 (57.1%)
Skipping a warm-up	10 (13 %)	7 (70%)	3 (30%)
Technical fault	6 (7.8 %)	4 (66.7%)	2 (33.3%)

Most of the participants in the research reported they had not used safety measures (a belt, knee pads, wrist braces, swath) in CrossFit training sessions. Their number was significantly higher than that of the participants who used safety measures occasionally ($p < 0.05$) and that of the participants who used safety measures in each training session ($p < 0.05$). (**Table 4**). Twenty of the researched athletes had not used a licensed

CrossFit instructor's services. Their number was significantly higher than those who trained with a CrossFit instructor ($p < 0.05$) (**Table 4**).

Table 4. Safety measures and training sessions with an instructor

Safety Measures	**Total n (%)**	**Men n (%)**	**Women n (%)**
Do not use	18 (66.7%)	8 (44.4%)	10 (55.6%)
Occasionally	4 (14.8%)	2 (50%)	2 (50%)
Use	5 (18.5%)	5 (100%)	
Training session with an instructor	**Total n (%)**	**Men n (%)**	**Women n (%)**
No	20 (74.1%)	13 (65%)	7 (35%)
Yes	7 (25.9%)	2 (28.6%)	5 (71.4%)

Discussion

The summary analysis of traumatism in power sports is 1-2 injuries per athlete a year or 2-4 injuries per 1000 training hours [14]. The average number of injuries among the participatnts in our survey was 1.1 annually.

The most common acute injuries in both sexes were those in the lumbar spine (24.6%), knee (16.4%) and shoulder (14.8%) (**Table 1**), similar to the injuries found in other CrossFit athletes [5, 15, 22]. The injuries in the anatomical location of the shoulder most often appear as a result of gymnastics exercises, and those in the anatomical locations of the lumbar spine and knees – as a result of the strength exercises [7, 10, 15].

Pain in the lumbar spine is one of the major injuries reported by 32% of active athletes [1]. It could be provoked by insufficiently developed muscles, an impaired technique of execution of the movements, overtraining, abrupt or twisting movements, weight lifting, and holding a static, strenuous posture for a more extended period [11]. Some of the exercises used in CrossFit training sessions that could lead to injuries in the area of the waist are deadlifts, squats, medicine ball throws, and variations in the execution of abdominal crunches.

The knee is another very often injured location in sports because knees take part in executing many multi-joint movements and functional loads. A survey on traumatism in sports [12] found that injuries in the anatomical location of the knee were approximately 15% of all CrossFit injuries. Knee injuries due to CrossFit training sessions can often be provoked by the execution of various squats, step-ups, leg extensions, box jumps, and running.

The shoulder was the third most often traumatized anatomical location in our study (**Table 1**). Shoulders play a crucial role in executing various complex multijoint exercises performed with a significant amplitude and rotation, holding the weight or achieving stability in a particular phase of the execution of the exercise [4]. Exercises such as snatch and muscle-ups increase the risk of injury due to the high compression the movements exert on the supporting shoulder joint [16]. Almost all CrossFit exercises include those with shoulder strain. Combined with the longer duration of the training and shorter rest and recovery periods, CrossFit increases the risk of injury [5]. Although the training of elite athletes in CrossFit includes up to 7 workouts per week lasting up to 2-3 hours, the injury to the shoulder joints is no different from that of other sports [22]. Other CrossFit exercises that can provoke pain in the shoulders and the rotation cuff are throwing exercises, shoulder fly's, rope slams, pullups, bench presses, and shoulder presses.

The ankle injuries (9.8%) were the next most frequent among the groups we researched (**Table 1**). Many sets of CrossFit exercises are related to landing after a jump, a subsequent rotation, and a twist in the ankle joint when performing gymnastics exercises [3]. The fast and frequent change of direction requires strength, stability, and mobility of the ankles. Improper technique, overtraining, and insufficient balance when running various distances, box jumps, lateral agility drills, and others may also provoke ankle injuries.

The injuries in the anatomic location of the elbow take from 3rd to 5th place (up to 12% of the total injuries) in frequency in CrossFit [19]. They took the 4th place in the group we researched, with a total of 8.2% of the injuries (**Table 1**). During CrossFit training sessions, elbows usually perform repetitive movements, which can be dynamic when flexing the elbow joint or static when holding and carrying weights. The injuries in this anatomical location appear due to overtraining, hyperextension, or because of another injury (a hit, for example). They are often provoked when performing gymnastics exercises and movements from Olympic weight lifting [19].

The researched men and women reported 61 injuries over the research period. Regarding the severity of injuries, slight injuries (29.5%) and minimal injuries (27.9%), requiring shorter recovery periods, were the dominant ones (**Table 1**).

The primary reasons for the injuries were overtraining (42.9%) and fatigue in 36.4% of the cases of traumatism (**Table 3**). One of the leading causes of musculoskeletal injuries in CrossFit is the extensive training loads that exceed the athlete's capacity [2].

Most of the CrossFit athletes we researched did not use safety measures (66.7%) and did not train with a licensed CrossFit instructor (74.1%) (**Table 4**). The role of CrossFit instructors is to observe the adequate and dosed load during training [12, 20, 21], especially for beginners practicing CrossFit less than a year and less than three workouts per week, to prevent injuries [12].

We recommend that CrossFit training sessions emphasize the gradual development of the motor qualities of strength and endurance, which will ensure the optimal time for the organism to get ready for the continuous increase in the intensity of the workload. That requires the stricter observation of the principle of progressive overload, which

enables the organism to adapt adequately to the increasing load requirements. The pain appearing in some anatomic locations should not be neglected but be perceived as a limiting factor. When it is impossible to work with a particular daily intensity, training should be reduced to the state adequate to the momentary functional state of the organism, especially in group training sessions.

Conclusions

The number and location of injuries among athletes in this study is similar to that described in the scientific literature for CrossFit athletes. The severity of injuries in our study group was low. Further research among CrossFit practitioners is highly recommended to prevent musculoskeletal injuries regarding using protective equipment (such as belts, knee pads, shoulder protectors, etc.), proper warm-up and stretching, and training sessions with a licensed instructor.

Limitations

The limitations of this study include the small sample size and the study's retrospective nature based on self-reported data. In its current form, this questionnaire study provides indicative data on injuries in this sport. Further standardized and more extensive studies are needed to provide sufficient data on injuries suffered by CrossFit practitioners to take adequate measures to reduce them.

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