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Original article

RESEARCH ON THE USE OF CROSSFIT TOOLS IN THE PHYSICAL TRAINING OF JUDO ATHLETES

STANCIU CRISTIAN[1], ENE-VOICULESCU VIRGIL[2], POMOHACI MARCEL[1]

Abstract

Aim. CrossFit is recognized as the fastest growing high-intensity functional training and conditioning program worldwide. New, science-based functional training techniques and programs for athletes are needed to reduce injury risk and improve performance. The effort in combat sports is dynamic, requires all motor skills and favors the formation of special motor skills and dynamic stereotypes. In the training process in combat sports, general and specific physical training plays an important role, constituting an essential factor for achieving performance at the highest level.

Methods. The purpose of the paper is to review the literature to identify the main crossfit tools used in judo. For this, the open access articles published in English during 2020-2022 were downloaded from the Web of Science database. They were analyzed, systematized and bibliometrically processed using the WOSviewer program.

Conclusions. Preliminary data suggest that CrossFit practice is associated with higher levels of sense of community, satisfaction, and motivation. Functional training can improve physical flexibility and motor coordination in athletes. It can stimulate the body's proprioceptors, increase athletes' confidence, making training more effective and useful. The level of development of the athletes' special resistance to intensive training and competitive influences are the sure factors of success in the athletes' competitive activity. The use of CrossFit elements in the training activities of athletes of various types of combat, allows to achieve a significant increase in the level of special fitness. Resistance training programs for judo athletes should include goals that increase their ability to move efficiently, develop strength, speed, and explosiveness, and promote resistance to injury. The design of training programs will bring a plus in the capitalization of the most effective exercises and their use in the development of the motor capacity of the athletes. The physical training of the athletes is the basis of the development of the motor capacity, without which they cannot carry out their activity in good conditions.

Key words: review, crossfit, physical preparation, judo

Introduction

Secondary data such as journal articles and, proceeding papers were analysed to obtain an image of the current stage in research with the topic CrossFit. The quantitative structure of the bibliometric analysis makes it ideal for this purpose. In the current study, a bibliometric analysis was performed to identify, organize, and analyse trends in the proposed research area. For our purpose we used the Web of Science Core Collection.

The methodology was applied to generate a complete search of the WOS database using the syntax: “CrossFit” in the title, abstract and keywords of the papers. To refine the search, one filter was applied to the dataset: “year of publication” (1990 – present May 2023). The application of these filter resulted in 535 documents that constitute the data set to be analysed. Excel software was used for data extraction from Web of Science Core Collection and Vosviewer software for bibliometric analysis of the results.

Methods

Out of the total of 535 articles identified, 533 were published in the last 10 years, which shows the interest of researchers in the given topic (Table 1). The distribution of papers according to the first 5 Web of Science Categories is shown in Table 2. It is observed that more than half of the articles fall under the Sport Sciences category.

The co-occurrence of all keywords identified in the selected articles (minimum 5 co-occurrence) was determined. (Figure 1).

[1] PhD student, Doctoral School of Social Sciences and Humanities, Faculty of Physical Education and Sport, Craiova University, Str. A. I. Cuza nr.13, Craiova, România, RO-200585, cristian.stanciu1989@yahoo.com
”Lucian Blaga” University of Sibiu, Faculty of Sciences, Sibiu, Romania
[2] Professor PhD supervisor, Doctoral School of Social Sciences and Humanities, Faculty of Physical Education and Sport, Craiova University, Str. A. I. Cuza nr.13, Craiova, România, RO-200585, virgil.ene@anmb.ro

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Table 1 Year of publication in WOS within the last 10 years

No	Publication Year	Frequency	Percentage of total sample
1	2023	17	3.18
2	2022	96	18.03
3	2021	78	14.64
4	2020	95	17.82
5	2019	85	15.94
6	2018	49	9.20
7	2017	33	6.20
8	2016	27	5.06
9	2015	30	5.62
11	2013	8	1.50
	Total	533	100.00

Source: Developed by authors, based on WOS database

Table 2 Distribution of papers according with the first 5 Web of Science Categories

No	Web of Science Categories	Frequency	Percentage of total sample
1	Sport Sciences	270	50.47
2	Hospitality Leisure Sport Tourism	48	8.97
3	Orthopedics	34	6.35
4	Public Environmental Occupational Health	31	5.79
5	Environmental Sciences	24	4.48
6	Other	128	23.93
	Total	535	100

Source: Developed by authors, based on WOS database

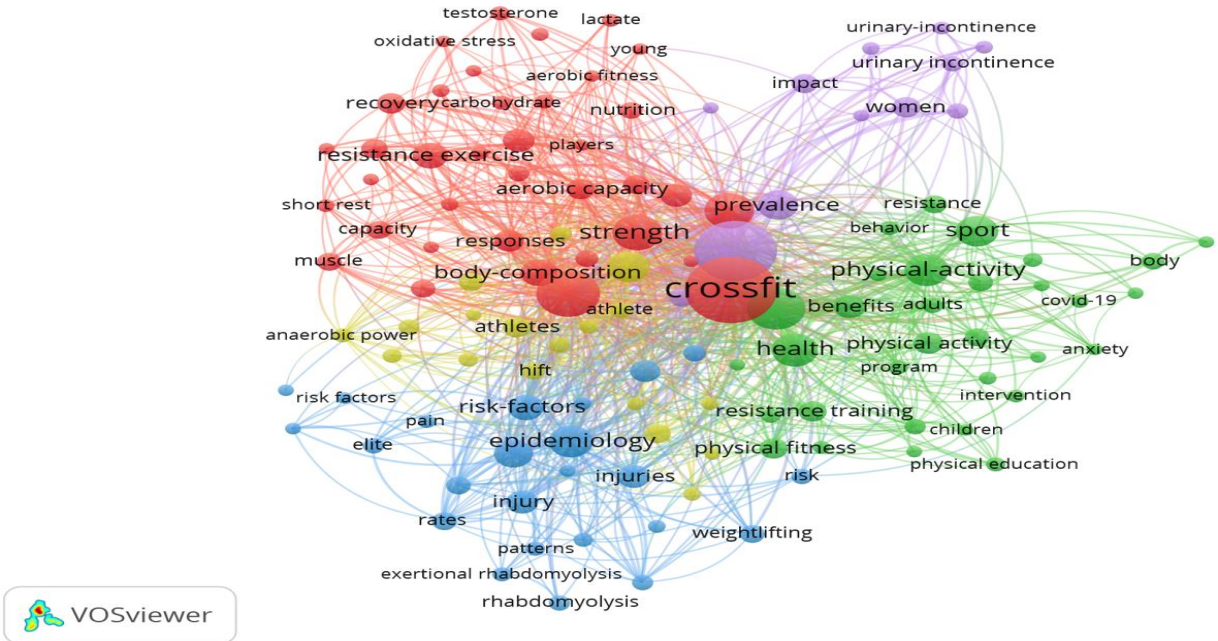

Figure 1 Key words occurrence in analysed papers
Source: Own processed data on VOSviewer, version 1.6.15 (Nees Jan van Eck; Ludo Waltman, 2022)

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From the total of 1801 keywords identified, 123 have an occurrence of at least 5. They are grouped into 5 clusters. Table 3 presents the main keywords identified and their occurrence.

In order to see who are the most influential authors on this topic worldwide, co-authorship was determined on the condition that the authors have at least three published works. A total of 1940 authors and co-authors of the 553 articles resulted, of which 103 had at least 3 articles published on this topic. The authors with the largest number of articles on this topic, the number of published articles, the number of citations and total link strength are presented in table 3 Figure 2. The 1940 authors are affiliated with 752 organizations from 56 countries, (USA with 230 articles cited 2167 times; Brazil 101 articles, cited 573 times; Spain with 41 articles, cited 314 times). Approximately 29% of the articles on CrossFit were published in 5 journals: Medicine and Sciences in Sports and Exercises (69); Sports (31); International Journal of Environment and Public Health (24); Journal of Sports Medicine and Physical Fitness (17) and Rbne Revista Brasiliera de Nutricao Esportiva (14).

Table 3 All key words occurrence and their total link strength in the identified papers

Key words	Occurrences	Total link strength
CrossFit	154	584
Exercise	126	579
Performance	75	363
Fitness	64	325
Strength	46	241
Power	45	223
Epidemiology	37	215
Physical Activity	35	199
Health	39	193
High intensity functional training	33	165

Source: Developed by authors, based on Voswiewer version 1.6.18

Table 4 The most prolific authors on the topic of CrossFit

Key words	Documents (no)	Citations (no)	Total link strength
Ferito Yuri	31	262	61
Stone Whitley	7	12	51
Sobrero Gina	7	6	50
Heinrich Katie	25	327	44
Margine Gerald	15	138	28
Tibana Ramires A.	9	113	21

Source: Developed by authors, based on Voswiewer version 1.6.18

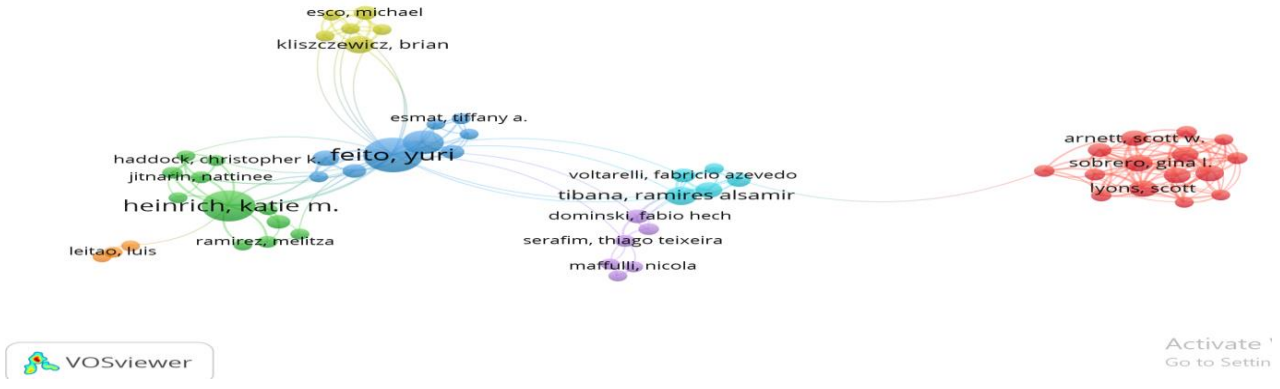

Figure 2 The most important authors and their authorship on the CrossFit topic
Source: Own processed data on VOSviewer, version 1.6.15 (Nees Jan van Eck; Ludo Waltman, 2022)

With the help of the Vosviewer program, 10,319 terms were extracted from the titles and abstracts of the articles, of which 247 have an occurrence of at least 10. They are divided into 3 clusters, the most important terms selected per cluster being: cluster 1 (red) - cross sectorial studies; CrossFit athletes, CrossFit participants, CrossFit practitioner, cluster 2 (green) – aerobic capacity, body mass, body fat percentage, body composition, body mass, body weight; cluster 3 (blue)– development, significant improvement, experiment, experimental group, higher level. The 3 clusters in which the common terms are grouped can be found in Figure 3.

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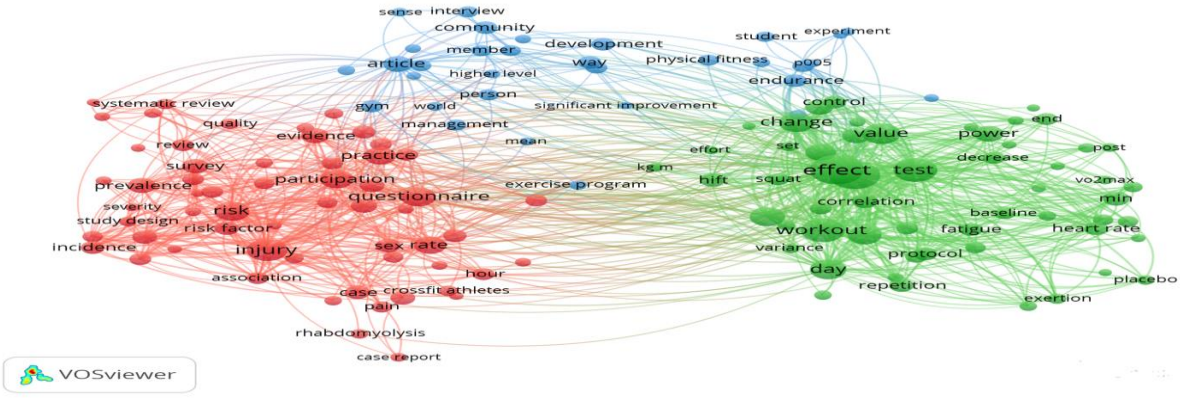

Figure 3 Key terms extracted from titles and abstracts
Source: Own processed data on VOSviewer, version 1.6.15 (Nees Jan van Eck; Ludo Waltman, 2022)

Williamson et al. show that process-first goals seem to be the most effective type of goal for improving performance and improving certain psychological outcomes (eg, self-efficacy). Second, self-referential goals (e.g., process, performance, and mastery) often lead to positive outcomes, whereas goals based on normative comparisons do not improve performance and result in some maladaptive psychological outcomes. Third, non-specific goals appear to be as effective as specific goals for improving sports performance (Williamson et al., 2022).

Another study highlighted the self-regulation process, which is linked to athletes' emotions and facilitates the optimization of their sports performance. The social environment could be considered a significant facilitator of self-regulation and sports performance. Specifically, athletes can focus on their social environment (opponents) when they have to set goals and choose appropriate strategies to achieve them (anticipatory thinking phase), monitor and manage their actions and emotions (performance phase) and make self-judgments and choose self-reactions (self-reflection). Coaches, who represent the social environment, can observe, intervene and facilitate these complicated processes (Sakalidis et al., 2022).

Motivation has a great impact on sports activities. A paper that examined the impact of effective team communication skills on the development of athletes' motivation when it comes to their professional development, as well as the impact of motivation on the development of sports skills demonstrates the effectiveness of effective communication skills in physical activity for the motivation of athletes (Wang, 2022).

A meta-analysis of 17 specialist articles carried out with the aim of identifying the perception of student athletes regarding involvement in sport, highlighted a number of benefits and a positive relationship between sport and study (Fernanda Porto Maciel et al., 2023).

One of the most used conceptual frameworks for studying motivation in sports is the goal orientation theory. The motivational climate oriented towards self-mastery is related to the orientation of the goal towards the task and respectively the motivational climate towards performance is related to the orientation of the goal towards the own ego(Mitsova, 2019).

Tusak M. et al. conducted a study aimed at identifying the motivation of Slovenian athletes of different ages practicing nine different sports disciplines (basketball, football, handball, water polo, ice hockey, ski jumping, alpine skiing, sport climbing and judo). The authors of the study used different motivation concepts such as achievement motivation, incentive motivation, participation motivation, goal orientation, satisfaction and enjoyment in sport, self-efficacy, effort and ability attributions. The most popular motivational framework in sport has been the social-cognitive perspective. The result was the realization of a dynamic interactive model of sports motivation that explains the possible behaviors and motivation in sports situations. The findings of the study show important differences between these groups and suggest that the specific sport discipline also has a specific imprint within motivation (Tušak et al., 2022).

In judo it is shown that motivation is certainly one of the most important elements in the structure of personality and is therefore considered an important factor that explains social behavior. A certain risk may be that some athletes have high demands on their coach (Gorner et al., 2019). Coaches should meet the basic psychological needs of judokas to trigger an increase in more self-determined forms of motivation, which could lead to improved self-confidence and reduced levels of anxiety states (Pulido et al., 2017).

Outstanding performance in individual sports is based on intrinsic motivation. In recent years, motivation has been assessed through a self-reported measurement tool that emphasizes knowing an athlete down to the finest details.

In the sports environment, many techniques and methods of mental training adapted to the competition have been imposed. Among these, Neuro Linguistic Programming should be mentioned (NLP). The methodology and technique of this program is different and focuses mainly on setting goals and improving the management of the athlete's mental states. An experiment shows that there is a significant improvement in mental abilities in athletes trained through this technique. Specifically, emotional, attentional and cognitive control, motivation and self-confidence are improved. The training technique is effective in both training and competition situations (Boughattas et al., 2017).

Evidence from the literature shows that motivation is the most important factor for the development of human resources, and the authorities of the National Judo Federations must focus their attention on motivational strategies to enhance the performance and develop the human resources of their country in this sport (Mohammadali Noudehi et al., 2017).

How individuals demonstrate their competence can influence their motivation to enact a behavior in training or performance (Felix Zurita Ortega et al., 2016). Self-determined motivation promotes athletes' self-determined situational motivation before a competition, which in turn predicts their sports performance. Autonomy of coaches facilitates self-determined motivation and sports performance (Gillet et al., 2010).

The planning and application of the judo training process is the result of the coach's thinking. Subjective measures of training tasks are useful tools that should be used with confidence by coaches. Olivia J. et al. shows that the type of training that judokas do is perceived differently by athletes. Thus, an experiment tested the perception of athletes after two weeks of two types of training: traditional training (TT) and functional unit training (FUT). Indicators such as: motivation, pleasure, fatigue, understanding, competitive specifics, physical condition, tactical-technical training, variability of scores, creativity, problem solving and general evolution were analyzed. An interview conducted with the athletes at the end of the two weeks shows that the participants felt that FUT was more effective in the following categories: motivation; pleasure; understanding; competitive specificity; technical-tactical training, randomness variability; creativity; problem solving and general development. TT was perceived as superior in the other two analyzed categories: fatigue and physical condition. According to the results, the study participants found FUT to be the most effective judo training model (Olivio Junior et al., 2018).

A recent study aimed to verify whether athletes' mental fatigue influences the performance and physiological and perceptual responses of judokas subjected to a high-intensity intermittent test specifically designed and validated for this sport. Thus, mentally fatigued athletes are shown to exhibit impaired aerobic performance, reduced strength endurance, and manual dexterity, despite no changes in anaerobic performance and maximal muscle strength and power. Physical performance measured during a judoka-specific test is not affected by a prior 30-minute cognitive task that causes mental fatigue. Furthermore, this cognitive task did not influence the physiological changes induced by the specific physical test (Campos et al., 2022).

Some authors show that judo is a multifactorial sport in which many variables or key performance indicators (CPIs) such as force-speed profile, bioenergetic capacity, technical and tactical skills, and cognitive and emotional competence play a role and influence the final result. Motivation is usually intrinsic to the athlete and must be maintained at a high level, not only during tournaments, but also during daily training and lifestyle activities.

To improve the performance of judokas, it is recommended that they receive professional psychological support during daily training sessions, and coaches should encourage sports internships (Uriarte Marcos et al., 2021). Thus, the psychologist's role is to benefit the athletes they work with by targeting approaches to the judo athletes' physical self-concept.

Also in judo, another study had as its main objective to identify the possible differences in the level of motivation, self-confidence and anxiety depending on the gender and the competitive level of two groups of judoka (High Performance Group and Specialization Group). The results revealed differences in the level of somatic anxiety (intensity), higher values being observed in women than in men. Significant differences were also found in the self-confidence variable (intensity), showing that the judokas of the national team present higher values than those of the specialization group. No differences were found in the variables of motivation and self-confidence according to gender, nor in the variables of motivation and anxiety in the comparison between both groups (Pulido et al., 2021). A study conducted among members of the Turkish national judo team analyzed the value of the mental toughness of the athletes. The concept of mental toughness, which is one of the psychological characteristics, is an important factor in the success of elite athletes. Mental toughness contains four critical traits, which are motivation, pressure management, focus and confidence. In elite high-performance sports, there are few factors as important as mental toughness in achieving competitive advantage and success (Yasar & Turgut, 2020). Another study that highlighted mental toughness in judoka shows that some characteristics of perfectionism may be trainable (Ernesto Suarez Cadenas et al., 2016). Authors such as Wolska et al. highlighted that Brazilian Judo and Jiu-Jitsu training provides practitioners with a sense of health, fitness and independence (Wolska et al., 2022).

CrossFit® is a training program characterized by high-intensity stimuli with constantly varied and multifunctional movements that induce a significant range of physiological, hemodynamic and biochemical responses. CrossFit has been around for over three decades and is more popular than ever. Its popularity is due to its short and intense workouts. The WOD (workout of the day) usually tends to be load or time sensitive: "Do this workout as fast as you can" or "as much as you can do in this time frame." Both methods require high intensity, but rest is kept to a minimum due to the purpose of each workout Crossfit involves working with 10 general physical skills: strength, power, endurance, flexibility, speed, accuracy, balance, coordination, agility and cardiovascular endurance, which must be trained (Celebration crossfit, 2018). Heart rate variability (HRV) can be used to measure how individuals respond to physiological stress and fatigue. Thus, the acute responses of HRV and blood pressure during and after Crossfit® sessions can be checked (Barreto et al., 2023). Some authors show that CrossFit practitioners subjected to periods of competition have changes in their mood profile and stress levels compared to non-competitive individuals subjected to

the same training routines (D'alpino et al., 2022). Judo coaches offer various strength training protocols to improve the performance of judo athletes. A high level of special physical condition is required to achieve high results in combat sports (martial arts) (A. Y. , Osipov et al., 2020). Osipov et al. shows that there is a certain lack of significant scientific research into the use of CrossFit training in the practice of pre-competitive and competitive training of judoka at various levels (Osipov A.Y. et al., 2019). Avetisyan et al. conducted a pilot study to examine the effectiveness of a CrossFit-based training program to improve general and sport-specific fitness in 10–12-year-old judokas. The authors designed a pedagogical research experiment designed as a complete, annual macrocycle (September-June). Thus, the target group used was 24 boys (3 years of sports experience on average; age = 11 ± 0.64 years) who were randomly assigned to one of two groups: CrossFit-based training (experimental , n = 10) and traditional training (control, n = 10). Initial testing included tests of motor skills and general physical fitness domains, including sit-ups, push-ups, long jumps, squats, shuttle runs, and forward rolls. Judo-specific tests included O Soto Gari and O Goshi throws. CrossFit-based training was implemented twice a week for 15-20 minutes in the experimental group after regular training. The control group completed traditional judoka fitness training methods with the same training load in terms of time. It was observed that the training of participants in the experimental group improved significantly in terms of leg raises ($p < 0.01$), push-ups ($p < 0.05$) and shuttle running ($p < 0.001$). Also, the O Soto Gari ($p < 0.01$) and O Goshi ($p < 0.05$) throws improved in the experimental group. The results showed that the use of CrossFit-based training had a positive effect on 10-12-year-old judokas' speed-strength skills, speed-strength endurance and muscle strength (Avetisyan et al., 2022).

Another study by Osipov et al. investigated the impact of different strength interventions in the pre-competitive training process of elite junior male judokas. The target group was represented by 53 elite judoka (age: 17.22±1.37 years, height: 176.34±5.47 cm, body weight: 78.46±6.22 kg, judo training experience : 4.52±0.89 years), who performed two different 8-week strength training interventions: group 1 (n=27) performed the "strength" intervention, group 2 (n=26) performed the "CrossFit®" approximately 5.3-6.0 hours per week. The obtained results demonstrated that 8 weeks of different strength training interventions are not equally effective to increase the performance of junior male judokas in specific strength tests. The final decision for a specific strength training intervention ("strength" or "CrossFit®") can be made depending on a judoka's individual challenges during the competitive season (A. Osipov et al., 2022). The same authors showed that 12 weeks of different strength training protocols: resistance training and mixed training (CrossFit + resistance), are more effective to increase some strength and sports performance of junior male judokas (A. Osipov et al., 2021).

Accurately quantifying the workload and difficulty of CrossFit workouts provides coaches, athletes, and sports scientists with a practical measure to relate to any observed (or perceived) physiological response to training. Without such a measure, any changes in programming cannot be clearly documented as small or large in a positive or negative direction, nor can different workouts be adequately compared. Thus, to date, only a few practical methods have been suggested for quantifying CF training performance (Mangine & Seay, 2022). A recently published study shows that video analysis is a universal method that can be used to calculate total training repetition completion rates and training components, the number and durations of breaks and transitions, the number of failed repetitions, and subjective (or objective) assessments of technique. These values can be further evaluated using a variety of additional calculations (e.g., by calculating means, SDs, etc.) to describe their nature throughout the training. Although more tedious than other methods, especially when multiple athletes need to be observed, this method provides the most information with the least amount of error, is inexpensive in monetary terms, and is available to anyone with access to a video recording device. Coaches and athletes are encouraged to use the most accurate and efficient timing method available to properly monitor training and make appropriate adjustments.

Conclusions

Some authors address the topic of CrossFit practitioner injuries. Thus, a descriptive epidemiological study carried out by Kempler E. et al. based on a survey of 494 Dutch fitness participants aged ≥ 18 years (mean 38.9; 59% male) who had sustained a fitness-related injury in the previous 12 months, shows that most injuries had place during strength training, individual cardio, yoga/Pilates, group cardio and CrossFit. Study findings highlight that most self-reported injuries related to gym fitness occur during strength training and individual cardio exercises (Kemler et al., 2022). Other authors have reported that the shoulder joint is the most commonly injured joint in CrossFit practitioners, due to the high intensity and loads associated with this sport (Silva et al., 2022).

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