

EVIDENCE PROVIDED BY THE LITERATURE ON THE USE OF CROSSFIT ELEMENTS IN SPORT

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Abstract: *In recent years, scientific literature has increasingly examined the use of CrossFit in various sports. This paper aims to analyze this literature through bibliometric methods. Searches in the Scopus database from 2000 to January 30, 2024, yielded 567 relevant results. The analysis identified publication dates, prominent authors, affiliations, and key publications, aligning findings with UN goals. Around 75% of articles were published in the last 5 years, indicating rising interest. Results were categorized into sports branches, performance measurement, injuries, nutrition, motivation, and benefits.*

Keywords: *CrossFit, training, workout, athletes, nutrition.*

1. INTRODUCTION

CrossFit is an international fitness program with more than 15,000 gyms [20] affiliated in more than 150 countries, being a form of high-intensity training that aims to develop several areas of fitness.

CrossFit is a program that involves a sense of community, and proper counseling. CrossFit leads to improved health, promotes healthy habits [16] and causes lifestyle changes [14]. CrossFit can be a supportive social environment for its members, providing them with social capital and support [16]. CrossFit workouts vary in mode, frequency, duration, rest intervals, and exercise variation [19]. This type of training is primarily aimed at achieving maximum performance [17]. CrossFit is a combination of aerobic, anaerobic and resistance training that improves cardiovascular function and body composition [21].

The aim of the paper is to do a systematic literature review to identify the most relevant results existing in scientific literature regarding to CrossFit topic.

2. MATERIALS AND METHODS

A systematic search was conducted in the Web of Science and Scopus databases on CrossFit. The search terms used was: CrossFit OR CrossFit training. The filters applied were: the period 2020 – 2024 (30 January); Web of Science categories researched: Sport Sciences; Hospitality and Leisure Sport Tourism; Public Environmental Occupational Health; Environmental Sciences; Multidisciplinary Sciences; Sociology; Education Educational Research; Social Sciences Interdisciplinarity; Health Care Sciences Services; articles or review papers; fitting into sustainable development objectives and the English language.

The bibliometric analysis allowed: the identification of the publication date of the articles, the identification of the most representative authors on this topic, the countries they come from and their affiliation; identifying the most relevant publications; framing the results in the sustainable development objectives provided by the UN. The obtained results were analyzed, systematized, processed by VOSviewer programme, and interpreted accordingly.

3. RESULTS AND DISCUSSIONS

3.1. Bibliometric analysis of selected papers on CrossFit

Of the total of 622 results downloaded from the Web of Science and Scopus databases, 567 were published in English. After applying the filters specified above, 296 papers were retained for analysis, of which 274 original articles, respectively, 22 review papers. They belong to the Web of Sciences domains: Sport Sciences (197 papers, 66.56%), Hospitality, Leisure Sport Tourism (44 papers, 14.86%); Public Environmental Occupational Health (31 papers, 10.48%); Environmental Sciences (24 papers, 8.10 %). The distribution of selected papers (on 30 January 2024) by year of publication is shown in Table 1.

The main fields of sustainable development to which they fall are: 05 Gender Equality (144); 03 Good Health and Well Being (71); 02 Zero Hunger (3); Quality Education (2).

Table 1 *Year of publication in WOS within analyzed period*

Source: Developed by authors, based on [28]

No	Publication Year	Frequency	Percentage of total sample
1	2024	6	2.02
2	2023	37	12.50
3	2022	45	15.20
4	2021	39	13.18
5	2020	53	17.90
6	2019	46	15.57
7	2018	22	7.43
8	2017	19	6.42
9	2016	11	3.72
10	2015	7	2.36
11	2014	7	2.36
12	2013	2	0.67
13	2012	2	0.67
	Total	296	100%

The 296 papers have 1140 authors, affiliated to 486 organizations. The most influential authors are: Ferito Yuri (20 papers and 327 citations); Mangine Gerald (15 papers and 174 citations); Heinrich Katie (15 papers and 287 citations); Tibana Ramires (7 papers and 142 citations); Box Allyson (5 papers and 85 citations); Petruzello Steven (5 papers and 72 citations). Figure 1 shows the most influential authors on CrossFit.

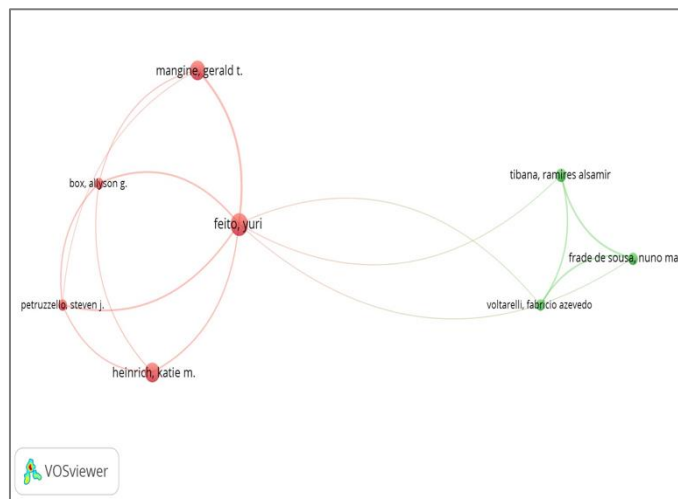


Figure 1. The most influential authors on CrossFit topics "caption"

Own processed data based on [23]. Regarding the distribution of the analyzed works according to the country of origin of the authors, it is noted that the most (118 papers with 2105 citations) were written by authors from the USA, 47 papers (554 citations) from Brazil, 35 papers (400 citations) from Spain, 18 papers (151 citations)

from Poland, 15 papers (197 citations) from the UK, 14 papers (426 citations) from Australia, while 49 papers have authors from 30 other countries.

Depending on the affiliation of the authors to different organizations it can be noted: Kennesaw State University (30 documents, 414 citations and 15 total link strength); Faculty Estacio Vitoria (6 documents, 138 citations and 8 total link strength); Univ. Catolica Brasilia (6 documents, 112 citations and 8 total link strength); University Illinois (6 documents, 72 citations and 8 total link strength); Kansas University (14 documents, 266 citations and 7 total link strength); Ponzan Univ. Phys. Education (7 documents, 90 citations and 6 total link strength); Univ. Brasilia (5 documents, 170 citations and 5 total link strength).

The 296 papers with the topic of CrossFit or CrossFit training were cited by articles from 102 journals, of which 11 contain at least 5 documents on this topic (Table 2).

Table 2. Journals and citations

Journal	Documents	Citations	Total link strenght
Sport	36	522	155
Journal of Sport Medicine and physical fitness	17	214	109
International Journal of Environment and Public Health	24	156	102
Orthopedic Journal of Sport Medicine	8	334	97
Plos one	7	146	69
Biology of Sport	5	121	59

The co-occurrence of all keywords identified in the selected articles (minimum 5 co-occurrence) was determined. (Figure 2). From the total of 1310 keywords identified, 96 have an occurrence of at least 5. They are grouped into 6 clusters.

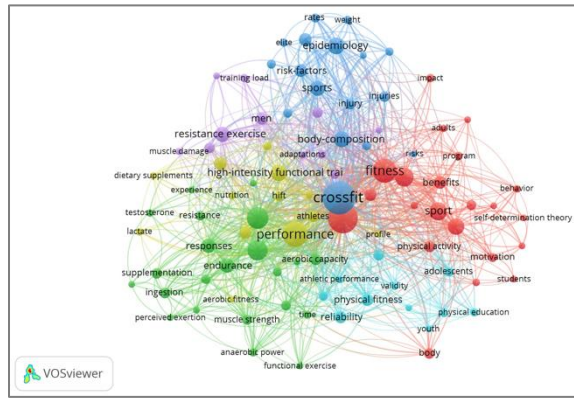


Figure 2. All key words occurrence in analyzed papers "caption". Source: Own processed data based on [23]

The keywords identified are grouped into six clusters: 1. Red, with 22 items (exercises, fitness, behaviour, motivation); 2. Green, with 22 items (aerobic capacity, anaerobic power, endurance, functional exercises); 3. Blue, with 17 items (body composition, CrossFit, elite, functional training, sports, weight, weightlifting); 4. Mustard, with 13 items (athletes, aerobic fitness, competition, performance, high-intensity functional); 5. Mauve, with 11 items (adaptation, blood lactate, crossfit, training load); 6. Blue, with 11 items (body composition, physical education, calidity, physical fitness, resistance training).

With the help of the Vosviewer program, 7,726 terms were extracted from the titles and summaries of the articles, of which 172 have an occurrence of at least 10. They are divided into 3 clusters, the most important terms selected per cluster being: cluster 1, 39 terms (red) – performance, effect, response, body mass, test; cluster 2, 38 terms (green) – participation, injury, crossfit training, training load, risk factor; cluster 3, 26 terms (blue) – sport, health, community, development, physical fitness, physical activity (Figure 3).

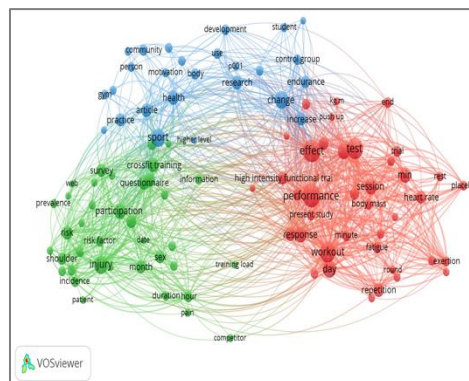


Figure 3. Key terms extracted from titles, and abstracts "caption". Source: Own processed data based on [23]

3.2. Obtained result from the systematic analysis of selected papers

The CrossFit training model includes physical skills and capabilities, cardiovascular, strength, endurance, flexibility, speed, power, balance [6], [7], coordination, precision and agility [8]. Each workout consists of a combination of Olympic gymnastics, weightlifting and aerobic exercises [3]. CrossFit combines intense training with resistance training. It contributes to increasing physical capacity, and has a technical component that includes elements from different sports branches [22].

In order to respond to multiple tasks that are performed against time, athletes must pay attention to resistance training [18]. In the case of CrossFit training, fatigue accumulates, often requiring more than 24 hours for recovery [27].

In planning workouts that use CrossFit elements, coaches should take into account body composition, body strength, and competition experience [20], and provide different strength loads for each workout [24]. A study published in 2023 demonstrated that each athlete has his own force-velocity profile and that CrossFit practitioners have a force-velocity profile more oriented toward speed than strength [25]. In the training of athletes advanced technology is used to optimize training, in parallel with the permanent monitoring of their health [1].

3.2.2. Nutrition in CrossFit

Performance in sports is influenced by eating habits. Nutrients and supplements play an important role in reducing fatigue and making recovery easier. Nutritional goals are underlying factors affecting eating behaviors in CrossFit participants.

The results of a study published in 2022 show the effect of the Mediterranean diet on the performance achieved by CrossFit practitioners. Its use allows maintaining body composition and improves general and CrossFit-specific performance [11]. CrossFit athletes must consume between 5 and 8 g/kg (body weight) of carbohydrates per day to restore liver and muscle glycogen, which is depleted due to the intensity of training.

CrossFit practitioners frequently seek nutritional help for improved athletic performance and easier recovery after exercise. Recent studies show that supplementation of their diet can be done with betaine (BET) [29], caffeine [12], [30], sodium bicarbonate and vitamin C [9], [30].

3.2.3. Injuries in CrossFit

CrossFit has a relatively low risk of injury. There are three important factors associated with injury incidence and injury incidence rates in CrossFit: 1) training frequency; 2) the athlete's experience; 3) competitive pressure. The injury rate in CrossFit is 3/1000 training hours [10]. The most common injuries affect the back, knees and ankles.

3.2.4. Types of CrossFit Reference Workouts

- The "Cindy" workout consists of 20 minutes of AMRAP of 5 pull-ups, 10 push-ups and 15 squats [15], [19].
- The "Fran" workout consists of FT of 21-15 -9 reps of thrusters and pull-ups. Severe post-exercise fatigue and decreased muscle function have been reported [19].
- The "Murph" workout consists of running 1 mile, 100 pull-ups, 200 push-ups, 300 squats [5].
- "Every minute on minute" (EMOM) training assigns a certain number of repetitions of an exercise to be completed in 1 minute and repeats this every minute for a predefined duration. The structure of the EMOM is flexible because intervals are not limited to just 1 minute [19].
- Tabata-style training is a subcategory of the "as many rounds as possible" (AMRAP) structure. A specific exercise is assigned to be completed for "as many repetitions as possible" within eight consecutive 20-second rounds. Rounds are separated by 10 second rest intervals for a total duration of 4 minutes.

CONCLUSIONS

The use of CrossFit elements in training in various sports effectively improves muscle strength, power, flexibility, sport-specific performance, and well-being of

athletes. Improving the endurance of athletes has a direct effect on the results obtained in competitions in various sports.

In addition to technical and tactical training, athletes must also benefit from psychological training that incorporates motivational techniques, goal setting, cognitive and emotional management, and mental focus techniques.

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