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Bibliometric Analysis of Fitness Equipment: How Scientific Focuses Affect Life-Cycle Approaches and Sustainable Ways of Development

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Received: 6 September 2019; Accepted: 14 October 2019; Published: 16 October 2019

Abstract: *Research Question*: Although *fitness equipment* is recognised worldwide as a tool for physical activities and a sustainable result in optimizing human movements within a wide range of environments, the state of the art and scientific advances have not been analysed from a bibliometric point of view. *Research Methods*: Using descriptive bibliometric software, this study examined the scientific production, and the most prolific authors, articles, and institutions. Bibliometric maps were used to visualise the content of published articles and to determine the most prolific terms, co-citation, and co-authorship. *Results and Findings*: A total of 678 original papers were retrieved from 447 journals in *Web of Science®*. *The Journal of Strength and Conditioning Research* had the highest number of articles (25), while the *American Journal of Preventive Medicine* the highest number of global citations (656). Citation and co-authorship networks were defined. *Implications*: Research on *fitness equipment* is still in an early maturation stage with 30 years of scientific development in its timeline. Fitness equipment and its related fields of application could represent a real step into a more sustainable balance between the economic, environmental, and social spheres.

Keywords: bibliometrics; culture; fitness equipment; life-cycle behaviours; product sustainability

1. Background

Fitness equipment is an important part of a fitness routine and has become an unescapable trend due to the rapid development of electronic and information technologies [1]. A fitness brand is not only the physical or incorporeal product, but also the knowledge that the equipment has been well researched by the manufacturers; it is the best option for any group of final users that needs to face with it at any level [2]. Bi-directional cooperation between academic and for-profit corporate settings has barely been practiced, even though it has been proved to work efficiently. This fact is confirmed by the reduced number of scientific contributions in the last 30 years, since the end of the 1980s (formally known as the real starting point of the fitness industry). Changes are due to developments in environments and markets, in addition to the concrete modification and application of new scientific principles in the most investigated product related areas. Currently, there is an evident lack of international scientific congresses that could bring together knowledge of this fitness industry sub-field.

Despite the various approaches to the fitness equipment areas, a search in Web of Science® (WoS), one of the main scientific databases, revealed that articles have been published in high-ranked peer-reviewed journals. However, a closer look confirms the multi-disciplinary focuses of original contributions (in detail specified along next subparagraph entitled 'Related works'). This situation could also be affected by the lack of specific studies on the selected topic by sports science papers. It seems clear that difficulties could exist in understanding the general state of research on fitness equipment. For this reason, it might be useful to apply bibliometric methods, which refers to mathematical and statistical analyses of scientific publications [3]. This method enables the identification of papers that deal with a specific focus and the logical and social relationships among the main interpreters involved in a particular science's branch. According to Broadus [4], bibliometrics means the use of statistical methods in the analysis of a body of literature to reveal the historical development of subject fields and patterns of authorship, publication, and use. Researchers may use bibliometric methods of evaluation to determine the influence of a single writer, or to describe the existing relationship between two or more writers or works [5].

To the best of the provided knowledge, there has been no previous bibliometric analysis of fitness equipment. As a research topic, evaluating strength and weaknesses, this complex task has been performed to identify all the information available. Therefore, the aim of the present paper is to determine the status of scientific production, collaboration, and impact of scientific articles on fitness equipment, as well as the most active research groups working in this direction. In parallel, to the planned scientific assessment provided, the reader could interpret the most common ways in which product life-cycle development is related with the sustainable processes offered by the peer-reviewed literature until now.

Related Works

As a worldwide phenomenon, societies tend to divide fitness equipment into various categories which partially changed over decades. Weight or oxygen training equipment and aerobic training equipment are the conventional areas of fitness industry products [1,6]. Nowadays, there are also 'unconventional' methods, techniques, and equipment for strength and conditioning that emerged from the normal schemes and could be tracked back to combat sports [7]. Examples include barbells, bands, dumbbells, heavy-medicine balls, heavy bars, kettlebells, large tires, pulleys, rocks, sandbags, and sleds.

Fitness equipment should be user-friendly [8], safe, effective, and produce real changes and improvements [2]. It needs to be up-to-date, based on the time and context in which it is purchased, and foster creativity [7]. Even the price, features, warranty, and brand reputation (knowledge of producers) need to cope with other qualities, such as the real performances (as marketed), functionality, reliability, and convenience [9]. Yet, specific demanded levels of 'immersion' (engagement) for customers during training could create positive effects on both motivation and attendance [10]. Additionally, dynamic performances and mechanical characteristics [11] cover the risk that one product should be labelled as unsuitable or inappropriate [12]. In the literature, scientific studies embrace their topics in the most varied quality arguments directly correlated to fitness equipment.

Some articles have deeply developed the methodologies of work through which it is possible to exploit and evaluate a single physical amenity [13]. Burgess et al. [12] defined the eight areas for the final aim of 'what you want the equipment to do?': (1) technical requirements; (2) environmental considerations; (3) sample presentation; (4) data acquisition needs; (5) operability factors; (6) health and safety issues; (7) integration with other equipment or interface with computer application where specified; and (8) cost–benefit analysis. At the same time, holistic [12] and heuristic [14] approaches have been applied to the analysed product areas.

In this respect, all pragmatic stages of creating a specific apparatus started from the definition of the four basic elements (4Q discipline) of the qualification [12]: (1) specification of what exactly the analytical scientist requires the equipment to do (design); (2) 'does the instrument work to the manufacturer's

specification?' (installation); (3) 'does the instrument work the way the analytical scientist wants it to?' (operational); and (4) 'does it continue to operate within the parameters monitored?' (performance). In unison the eight main areas to be addressed for laboratory certification are (a) management systems; (b) operating procedures; (c) personnel training; (d) data accountability; (e) method validation; (f) equipment; (g) facilities; and (h) certification documentation. For computerized devices there is an additional stage defined as (i) no on-going assessment of system performance (IT validation). Another relevant sub-topic, and still related to the working process, is the welding phase [15–17]: from the occupational exposure (metals, oxidative, and telomeres), through the specific environmental particle sizes, until the hypothetical future defect cases (reducing down and non-productive times, number of unscheduled shutdowns, etc.). The corrosion and erosion processes, based on apparatus thickness, have also been evaluated [18].

Another investigated sub-theme is the one directly connected with physiological indexes, in relation to the exercise devices, and takes into account variables such as cardiorespiratory (hearth rate and oxygen uptake or consumption) and neuromuscular responses, hyperthermia, hypohydration, perceived exertion, skin temperature, and thermal sensation [19,20]. In connection with this branch there are articles related to the aetiology and frequency of injuries on equipments with different evaluated areas, such as age distribution, diagnosis, localisation, and risk of injury [21]. A minor sub-field investigated is the connection with bacterial and viral contamination from the product surfaces [6]. Normally, these kinds of studies assess the benign bacterial species (coagulase-negative staphylococci, diphtheroids, etc.) during pre and post-exercise phases.

Among the interesting topics studied in the literature is the gender difference in utilisation of fitness products. Males clearly prefer strength equipment or free weights, whereas females tend to opt for cardiovascular or 'selectorised' (specific strength muscular focus) physical amenities [22]. Additional sex information has also been structured in relation to the interaction styles of employees as components of the organisation's structure [23]. Connected to the final consumer, the aim of sector professionals is to embrace the upgrading of health facilities with the maintenance of existing equipment as well as new purchases to keep ahead of the competition while maintaining high delivery of quality in relation to the programmes which requires thoughtful evaluation [9]. The physical 'resources' allocation, such as apparatus and member recruiting, is evaluated in order to improve revenues, enhance the corporate image, and determine the expected sales numbers [14]. Limited financial resources often restrict all the required actions for the proper use of the apparatus in possession such as modifications (up-to-date), calibrations, and overall procedures [8]. 'Incredible' claims tend to be used for the launch of new exercise products by manufacturers [24]. The author recommends planning the choices on exercise physiology milestones, evidence, and peer-reviewed scientific literature to assess the ad's claims.

Even if not revealed in these publications it seems that the lowest common denominator which unites all these fitness equipment sub-topics is the conscious search for an optimized final results, aiming at the overall sustainability at all levels of product life-cycle processes and final usability. There is a direct connection between the areas of sports, physical culture (in this case related to the physical activity devices), and the environment (society's actual applications) that intersects the economic, planet/environmental, and sociological aspects of this slice of science [25].

Sustainable products normally follow six main features [26]: consumer satisfaction (profiled behaviors), dual focus significance (ecological and social), total life-cycle orientation, significant improvements (problems vs performances), continuous improvements (variations), and competing offers (mostly benchmark). In this case changes could directly affect the original providers which are the sectoral firms who produce and manufacture these kind of amenities available inside international society.

2. Material and Methods

2.1. Data Collection

The papers for the study were extracted from the Science Citation Index (SCI) and Social Science Citation Index (SSCI), which were evaluated via WoS (Thomson Reuters, New York, USA). The decision to keep valid only the WoS® Core Collection databases is due to the results incongruencies in terms of language, overall contents, and mostly trackable papers information. For this reason six sub-libraries such as (order of appearance in the website): Current Contents Connect, Derwent Innovations Index, Korean Journal Database (KCI), Medline®, Russian Science Citation Index, and SciELO Citation Index have been excluded from the bibliometric analysis.

The search strategy utilised the general term 'fitness' united by a Boolean logic (*AND*) to 'equip*', and the second word was voluntarily truncated (with '*') to create inclusion possibilities such as 'equipment'/'equipments'/'equipamiento' (Spanish), which are the most common ways to define fitness products by means of scientific articles.

'Fitness equipment' is a widely accepted and used term in most of the languages represented in the above-mentioned databases. Consequently, any search about this area will use 'fitness equipment' in any of the fields involved with the meta-field topic. For this reason, synonyms of the selected keywords such as (alphabetical order) 'exercise-health-rehab' instead of 'Fitness', and 'accessory-device-good-instrument-item-hardware-service amenity-machinery-machine-object-quality physical material-product-system-tool' instead of 'Equipment' have been assessed during the prior analysis, but excluded to better focus on the criteria-rationale of the final selection provided. For example, the specific case of 'exercise equipment' has been discarded due to the focuses offered by scientific contributions: since the bibliometric analysis has been founded on product life-cycle processes and sustainable ways of development (in creation/featuring/exploitation phases, etc.) most of these publications embrace topics such as purely medicine-surgery/rehabilitation protocols, or applied sports physiology and overall experiments/tests which could not lead to actual evaluation usefulness.

The analysis was limited to research articles in a strict sense, including literature reviews, meta-analyses, and original papers. The following typologies were excluded: bibliographic articles and chapters, meeting abstracts, editorial and news articles, sectoral letters. No boundaries of time, geographical areas, or original language (when additional translation to English has been performed) have been adopted.

The search was performed on 7 November 2017. There were no limits on language or publication year. The initial search retrieved 678 items, and all records were stored on hard disk in plain text format for further analyses.

2.2. Bibliometric Analysis and Construction of a Scientific and Citation Network

Duplicate records were checked before performing the bibliometric criteria. Additionally, for possible misspellings of authors' names and initials, we performed a standardisation in the database for the data extraction. However, due to a lack of this option in the WoS database (no co-author addresses), we resolved homonymy or synonymy phenomena always for authors' name controlling, through the analysis of extended papers when not completely clarified from the plain database [27]. To better organise and define the names of the authors' affiliated institutions, we selected the one found in the complete article. When multiple affiliations were identified, the most recent was chosen. Examples of these could be homonymy or synonymy phenomena between authors, not complete name-surname(s) in Spanish speakers contributors (the second surname was not always written), latest or main University affiliation, etc.

Two software programmes were utilised to create a citation network for the bibliometric analysis: HistCite (version 12.03.17; HistCite Software LLC, New York, USA), and Bibexcel (version 02.20.2016.; Olle Persson, Umeå University, Umeå, Sweden). Two phases defined the analysis: (a) calculate the

basic bibliometric indicators and variables; (b) establish the existent relationships among authors and citations in the scientific journals and perform a co-occurrence analysis.

The following three categories of indicators were calculated for the articles related to fitness equipment: (1) scientific productivity ranking and patterns of author collaborations (number of published documents, number of published documents per year, number of authors, citation analysis, collaboration index or average number per paper, number of collaborators); (2) analysis of the most productive journals (number of published documents, number of citations within the journal collection—*Total Local Citation Score* (TLCS), total citations in WoS to papers in the journal within the journal collection—*Total Global Citation Score* (TGCS); and (3) analysis of the most common words (number of words in the title and abstract fields).

Subsequently, we conducted a structural analysis in which we established the networks. For each paper, all co-authorships (combination of pairs of authors) were identified for all possibilities between authors ('A with B, A with C, B with C' logic), except when there were only single authors. In addition, encompassing the listed references for each document, a citation map was generated to show the citation relationships among various articles.

2.3. Representation of the Scientific and Citation Networks

To represent the citation and scientific networks obtained, we utilised the programme Pajek (version 5.04; Batagelj and Mrvar, University of Ljubljana, Slovenia). The number of co-occurrences between authors and between citations was high, which made graphic representation difficult. For this reason, we provided a simplified representation of the network (admitting only those that reached a minimum intensity between the relationships). The figures show only clusters that contained at least two members of the scientific network of references for the citation network: this selection criteria, or threshold, has been adopted in this way to create a better version of clusters readability, with the final logic of simplifying and optimizing the schemes only focused to the most relevant groups revealed.

In addition to the network maps, we generated a density map of citations with VOSviewer (version 1.6.8; Nees Jan van Eck and Ludo Waltman, Leiden University, Leiden and Erasmus University, Rotterdam, Netherlands). Colors of each point in the map depended on the density of items at that specific point (i.e., red color means greater density, while blue color refers to lower density). The calculation of the density of the points on the map was calculated using the number of neighbouring items and the weight of the same using the Gaussian kernel function [28]. The larger the number of items in the neighbourhood of a point and the higher the weights of the items, the closer the colour of the point was red (conversely, a smaller amount of items and lower weights were represented with the colour blue). In those cases where the subject allowed it, the maps were depicted in areas of the institutional affiliation of each author.

3. Results

3.1. General Data

The search in the WoS database retrieved 678 articles; this number corresponds to the total number of papers analysed in the study. Of these, 643 (94.84%) are original articles and the remaining 35 (5.16%) are proceedings papers (academic field, learned society, and academic conference). The first original contribution on fitness equipment that was indexed in the database dates to 1987 [21], although most of the papers have been published since 2006 (Figure 1). Effectively, more than three quarters (524 papers, 77.29%) of the entire sample was published in the last 12 years of the bibliometric analysis [29]. Only the first five years of the current century (2000–2005) do not maintain a relevant level of obtained forecasts.

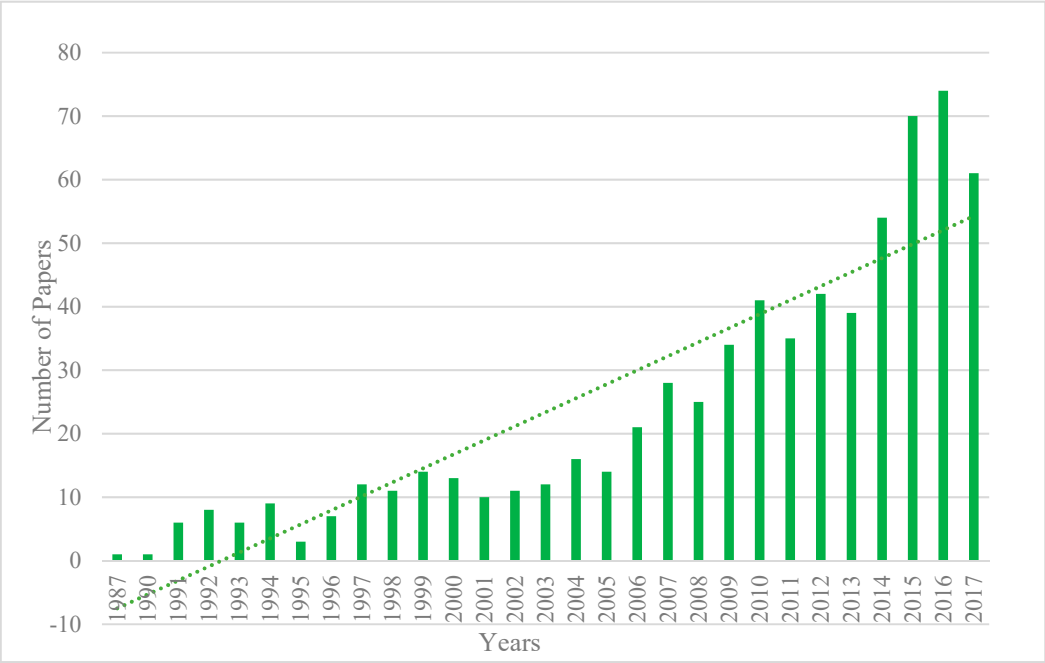

Figure 1. Number of articles published on fitness equipment in the Science Citation Index (SCI) and Social Science Citation Index (SSCI) from 1987 to 2017. The bars represent the number of papers published for each year, and the diagonal function defines the adjusted publication trend line emerging from the series.

The most common language is English (94.54%), followed by German (1.92%), Spanish (0.88%), and nine other languages, including Portuguese and Russian (when a translation from, e.g., Cyrillic has been provided). The five most productive countries in order are as follows: the USA, the UK, Canada, Australia, and China. A total of 60 nations were detected.

The 678 articles were published in 447 journals (Table 2) and received a total of 9736 citations (TGCS).

3.2. Analysis of Productivity, Collaboration Patterns, and Citations Received by the Authors

The articles retrieved in our search were produced by 2455 authors, although only 12 of them produced greater than or equal to four (≥4) (Table 1). It should be noted that 93.36% (2292 individual investigators) of the sample contributed only a single paper on the analysed topic.

Table 1. Most productive authors (≥4 papers), with actualised institutional affiliations.

Author	Papers	TLCS	TGCS	Institutional Affiliation
Lubans, David R.	6	6	109	*School of Education (Faculty of Education and Arts), Priority Research Centre in Physical Activity and Nutrition, University of Newcastle, Callaghan, New South Wales, Australia*
Morgan, Philip J.	6	6	93	
Plotnikoff, Ronald C.	5	5	98	
Rimmer, James H.	5	8	419	*School of Health Professions, University of Alabama at Birmingham, Birmingham, US*
Trost, Stewart G.	5	5	579	*QLD Center for Children's Health Research, Queensland University of Technology, Brisbane, Australia*
Alexander, Kisha	4	0	91	*Healthcare Inc. (accountable), University of Phoenix, Phoenix, US*

Table 1. *Cont.*

Author	Papers	TLCS	TGCS	Institutional Affiliation
Oka, Koichiro	4	0	64	*Faculty of Sport Sciences, Waseda University, Saitama, Japan*
Pate, Russell R.	4	5	543	*Children's Physical Activity Research Group, Arnold School of Public Health, University of South Carolina, Columbus, US*
Shibata, Ai	4	0	64	*Faculty of Sport Sciences, Waseda University, Saitama, Japan*
Smith, Jordan J.	4	6	75	*School of Education (Faculty of Education and Arts), Priority Research Centre in Physical Activity and Nutrition, University of Newcastle, Callaghan, New South Wales, Australia*
Stopka, Christine B. Tillman, Mark D.	4 4	2 2	15 92	*College of Health and Human Performance, Living Well (formerly named O'Connell) Fitness Center, University of Florida, Gainesville, US*
27 authors with 3 publications	81	-	-	
124 authors with 2 publications	248	-	-	
2292 with 1 publication	2292	-	-	

TLCS-Total Local Citation Score, TGCS-Total Global Citation Score.

It is relevant to highlight how the top three most productive authors come from the same research group (Priority Research Centre in Physical Activity and Nutrition, University of Newcastle, Australia); they are, in descending order, Lubans, D.R.; Morgan, P.J.; and Plotnikoff, R.C. The top three most cited (TGCS) researchers are, in descending order, Trost, S.G. (Queensland University of Technology, ranked fifth in quantity production) with 579 citations for his five articles; Pate, R.R. (University of South Carolina, eighth position) with 543 citations for his four papers (these first two authors also cooperated); and Rimmer, J.H. (University of Alabama at Birmingham, fourth position) with 419 citations for his five sectoral contributions.

The most cited article was written by Trost et al. [30] and has been referenced 343 times. This contribution was published in the *International Journal of Obesity* (ISSN 0307-0565) and reports all those variables (determinants or not) related to physical activity during developmental age, especially among children (mean age of 11.4 ± 0.6). In relation to the topic of the current paper, and with differentiation between obese and non-obese subjects, we evaluated the effective access to sporting and/or fitness equipment in a domestic context (home, preferably), and fitness equipment has been listed among the 'environmental' variables.

3.3. Analysis of Most Representative Journals and Citation Received

Among all the journals (447) that published articles containing the term 'fitness equipment', only 10 had published more than five (≥6) articles in this field (Table 2). The *Journal of Strength and Conditioning Research* has the maximal number of related contributions with 25 items.

This academic paper focuses on strength and conditioning in the sport and exercise field and evaluates strength and conditioning as two separate areas, in contrast to the average definitions affirmed among fitness industry product practitioners. The journal was founded in 1987, the year in which sectoral publications appear in this bibliometric analysis [21]. In the specific case of this leading journal, the first paper on the selected topic, was published 10 years after the foundation and written by Fratangelo and McNaughton [31]. This contribution examined the exercise choices of a retired Australian weightlifter. In this stage of historical development of the industry, for the defined 'weight training', ex-athletes preferred free weights against 'machine' weights (average 51%, up to 74% in some sub-categories, of the studied sample). Still talking about the efficacy of the same journal, it has been detected that, only in the last 10 years of analysis (2008–2017), it had nearly double the publications of

the other second-ranked journals evidenced (19 publications versus 10 each), occupied respectively by Ergonomics and the Journal of Pressure Vessel Technology. In conclusion, the American Journal of Preventive Medicine (ISSN 0749-3797), with its four targeted contributions, totalise 656 TGCS, of which the most (with 298 TGCS) came from the article of Rimmer et al. [32].

Table 2. Source journals for the articles and citations.

ISSN	Journal	Original Articles	TLCS	TGCS
1533-4287	*Journal of Strength and Conditioning Research*	25	9	347
0014-0139	*Ergonomics*	10	17	203
0094-9930	*Journal of Pressure Vessel Technology-transactions of the ASME*	10	0	16
1471-2458	*BMC Public Health*	9	0	72
0195-9131	*Medicine and Science in Sports and Exercise*	9	3	254
0264-0414	*Journal of Sports Sciences*	8	1	269
(eISSN)1932-6203	*Plos One*	8	0	33
0026-4075	*Military Medicine*	7	2	47
0095-6562	*Aviation Space and Environmental Medicine*	6	4	136
1479-5868	*International Journal of Behavioral Nutrition and Physical Activity*	6	0	105
	5 journals with 5 publications	25	-	-
	9 journals with 4 publications	36	-	-
	22 journals with 3 publications	66	-	-
	52 journals with 2 publications	104	-	-
	349 journals with 1 publication	349	-	-
	Total	**678**		

3.4. Analysis of Most Topical Words and Relations among Them

The topical words in relation to the selected topical area include a total of 2660 usages; these are the ones provided inside the field named 'title' of contribution, and are not related to the indexing data obtainable from the same database assessed (Table 3). The search also retrieved the article keywords (fitness, equipment). The only word found in 100 papers was 'fitness', followed by 'physical' (92), 'exercise' (59), and 'activity' (53). 'Equipment', in seventh position, had a total of 41 papers and 707 TGCS.

To understand the real orientation of the publications, it is necessary to perform another classification step (50> and ≥25): there are words oriented to sports physiology (based, effects, analysis), to the overall product usability (health, performance, using), and in relation to gender and other classification types (children, training, women).

Table 3. Most topical words (≥25 appearances) among title, abstract, and keywords variables (the utilised key-word combination for the WoS search is included and underlined in the scheme).

Common Words (in Order of Descending Number of Papers for Each Category)	Papers	TLCS	TGCS
fitness	≥100	21	1451
physical, exercise, activity	100> and ≥50	59	5704
training, effects, equipment, using, based, analysis, performance, children, health, women	50> and ≥25	58	5706
72 words	25> and ≥10	-	-
164 words	10> and ≥5	-	-
280 words	5> and ≥3	-	-
2130 words	≤2	-	-
Total	**2660**		

We also extracted the relationship map of the most utilised words in the sample (Figure 2). It is possible to see how the three fulcrums, differentiated by the colors, are connected. The logic is that when a single point appears bigger, it includes a great number of relations among the proximal (or less) near points.

For example, the main points are the words 'exercise' and 'participation' for the green area, 'system' and 'paper' for the red area, and 'intervention' and 'physical activity' for the blue area. Following this logic, it is interesting to observe how any single usage is divided and located in each of the three research macro-areas. When researchers adopt a specific channel of investigation, this could mean a great probability that findings reveal information on these single topics, or nothing much, in relation to the closest ones.

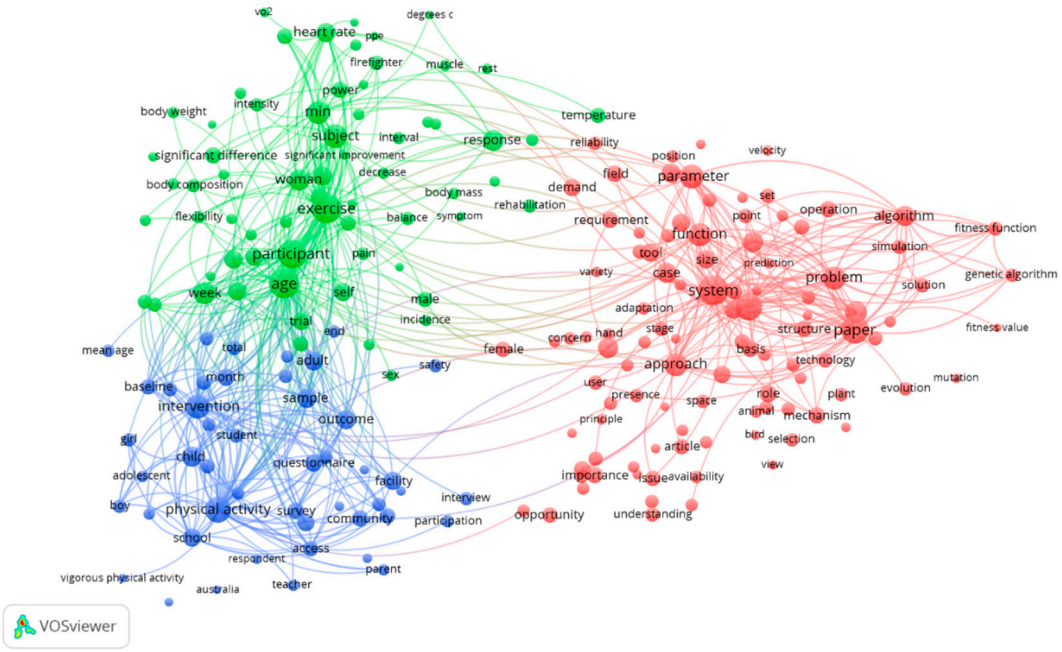

Figure 2. Co-word relationship map.

3.5. Scientific and Citation Network (Co-Authoring and Co-Citation)

To represent the co-author network, we established a threshold of two or more (≥2) citations written in collaboration. Utilising this criterion, 34 authors were identified. The authors were gathered into 11 clusters and/or research groups (Figure 3). The largest group had seven members; in this case, Morgan was placed in a central position in his respective cluster due to the most collaborative level obtained among all. For example, the latest contribution he co-authored [33], focuses on the exploration of young men's motivators and barriers to engage in physical activity. The cluster's logic and positioning, both for citation and density maps, is defined according to the closeness (or less) of a single author / investigation group to the others displayed. Variables such as the oldness (or less) of a specific contribution is not measured in these kind of analyses and by the selected software.

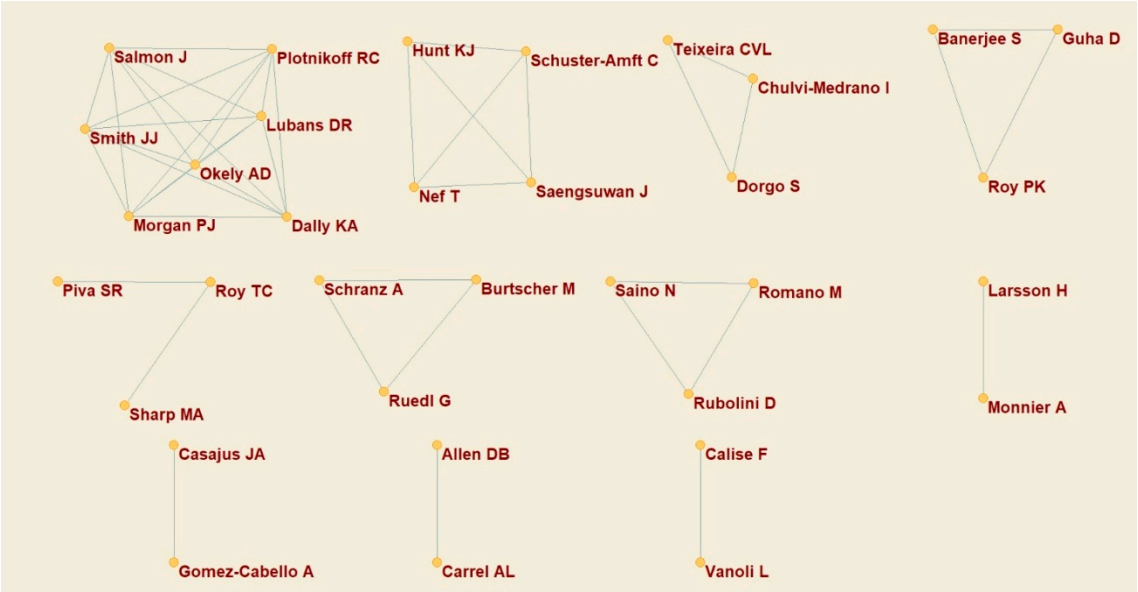

Figure 3. Citation map of the published articles in the search (≥2).

Despite the high number of authors and works assessed in the study, the citation relationships among the works are inconsistent (Figure 4). Moreover, the network comprised 70 authors (or work teams), with a single 'major centre' of citation represented by Gledhill [34].

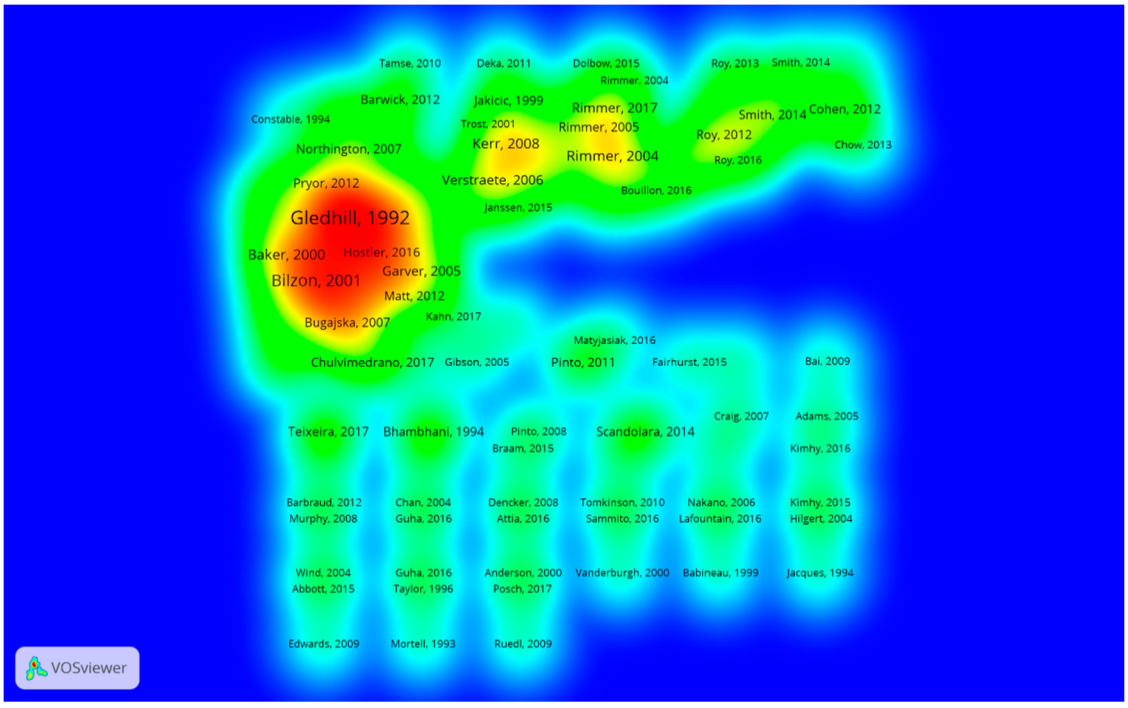

Figure 4. Density citation map of the article published on fitness equipment.

This article evaluated the physical demands required by firefighting, evaluating the equipment useful for the strength and endurance of this specific job category. An additional version of the citation map is provided to highlight any relations (Figure 5).

Figure 5. Citation map of the articles published on fitness equipment.

Additionally, using the same procedure, we evaluated the co-citation network of our sample (Figure 6). Eight relevant (red color density in the figure for the most co-cited) fulcrums emerged, and the distances between each of them represent the close (or far) relation between the single fulcrums.

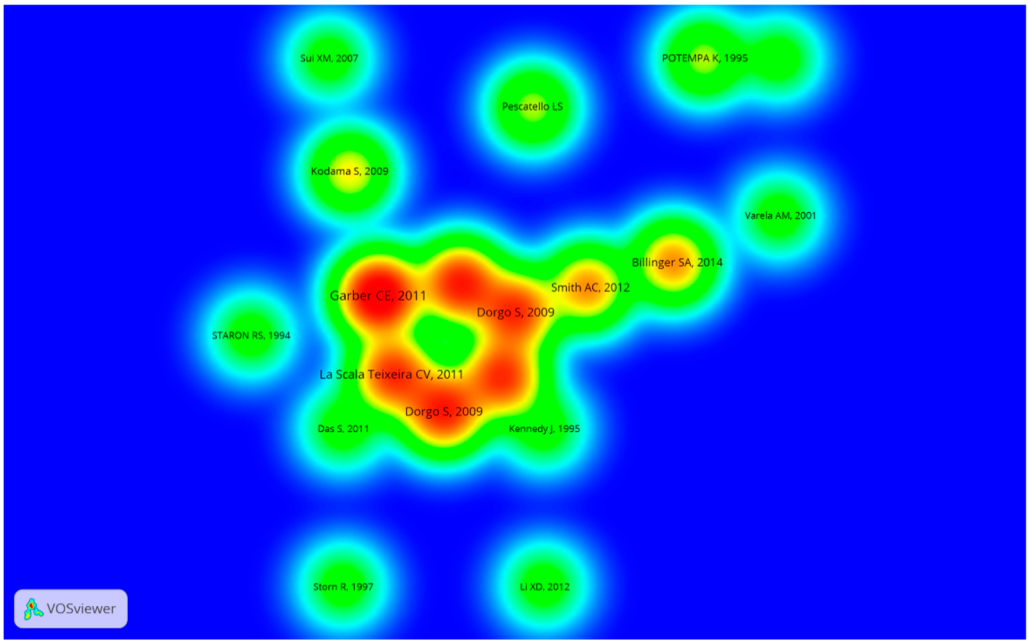

Figure 6. Density co-citation map of the articles published on fitness equipment.

4. Discussion

The present paper shows that research on *fitness equipment* is still in its early-mid stage, with less than 50 years since its beginning. In quantitative terms, the results show a 'just sufficient' number of documents and citations to affirm apparent and complete knowledge of the sector. Even the qualitative analysis, regarding the relationships among researchers, revealed little interaction among groups compared for example to other sports science or general fitness areas, for example.

4.1. Scientific Contribution

The first issue to discuss is in relation to the absolute number of papers published on fitness equipment (678 articles). During the same period examined, in the 'real-world timeline', the importance and presence of these amenities or apparatuses have increased exponentially worldwide in many physical activity routines. Nevertheless, at the academic level, not only in corporate and private settings, until recently (in the last decade analysed, 2006–2017) there was not much interest from the scientific community in developing this targeted theme. In this direction, the interests in financial and competitive facets of the market slices indirectly selected could be relevant. For example, every manufacturer wants to stand out among others of the same segment (and not only) by keeping information only through for-profit realities; for this reason, most contributions have probably remained private without enriching the broader scientific knowledge.

4.2. Languages and Geographical Areas

Regarding the language in which the articles were written, the most common language was English, coming mostly from (top three) North America (Canada and USA) and Europe (UK) and found its support also in the latest report version released from one of the main sectoral associations [35]. In these areas, manufacturers used to set up their own headquarters, and in terms of revenue and consumption, these regions lead over other areas. Moreover, the input of emerging areas such as Oceania (Australia) and the Far East is confirmed in the same investigation and reflected in the findings of this article. Outcomes of this bibliometric analysis demonstrate how variables such as amount of contributions encountered, languages/geographical most interested areas, and variety of authors/co-authors extractions bring to an holistic approach to the selected topic.

4.3. Most Productive Authors and Journals

We detected no authors who reached 10 publications on the selected topic, but there is a large spread of production sources. In terms of citation values, there is no correlation between TLCS and TGCS, where the global citations are greater than the local citations. Among the 678 contributions retrieved, we detected 116 TLCS, against the greater 9673 TGCS. The majority of journals (51.47%) published only one article; few journals (2.06%) contributed 5–10 articles, and only one published most of the papers in the field of interest (*Journal of Strength and Conditioning Research*, with 25 publications and 3.69% of the total). This broad range of journals reflects how the researchers on *fitness equipment* cannot reliably identify the core journals for their field of study, or simply adapt their productions in order to obtain valid contributions to the nearest sectors [36]. Contrary to what may be expected, the most productive journal is not the most cited (TGCS). This could also suggest that the knowledge accumulated by the most representative journal is not always the most widely recognised by practitioners of the same field. As already stated, this could also be due to the spread outputs that a single investigation reaches in terms of areas of interest. Even coming from the sports science sector, there is a lack of journals that cover fitness equipment as the only or principal aim.

4.4. Co-Authorships

Correlated to the relationships established by the authors with their co-authors, we found clusters composed of one or two universities and countries. The maximal distance corresponds to the number of 'hops' that have to be performed to join most separated authors of each network. Additionally, the results confirmed that most of the co-authorships were not centralised (positive only in the greater cluster obtained), with no lead authorship. Moreover, the citation maps presented herein confirm that there was no relevant coherence between the published works and how citations and authors are related.

4.5. Strengths and Limitations

Although the number of articles published on *fitness equipment* is quite low, one of the strengths of the current article is that the number of journals is unusually high (in comparison to other parallel research areas seen in literature, for e.g.,), being a sub-field of fitness scientific area. Moreover, the variety of associated sectors (categories) shows a wide range of knowledge and different approaches to analysis of the topic. Furthermore, the replicable procedure revealed that some authors or papers were not retrieved or were underestimated.

The first limitation is the utilisation of only one database. This was done to simplify the technical aspects of the analysis. In this way, it was possible to standardized all authors or publication information, delete duplicate records, and manage all the material through similar flat archives sources.

The lack of similar studies is one of the main limitations of the results obtained in the present article. Bibliometric procedures have rarely been applied to the sports science and sustainability fields; hence, several statements in the discussion are also based on other (well-founded information) knowledge statements of the assessed theme of investigation by the same authors. For the same reason, the absence of previous studies that include collaboration networks makes additional comparisons with other results difficult.

The search profile used should be one of the most complex themes of the investigation. The single-word search term improved the relation of the articles and the same topic. However, if we had used the word without truncation ('fitness(AND)equipment' instead of 'fitness(AND)equip*'), the results would have been different. Additionally, the sample used is not as large as complete statistical bibliometric techniques require (originally created for giant groups).

5. Conclusions

Ultimately, global research on *fitness equipment* has been quite prolific in comparison to the existence of products or services within international societies. Yet, the article underlined how interest has increased exponentially in recent years and in numerous related and derived sub-fields of investigation.

The most productive work teams came mainly from Australia and the USA. These are geographical regions in which these types of resources have already been welcomed in the mayor percentage of environments and social classes. Additionally, for reflection, academics chosen to focus their attentions on their applicability and usability facets. Nowadays, citation networks are partially 'skinnies', but the evolution trends promise a continuous expansion for the ever-growing world of the fitness industry.

To better understand the findings of this paper, it is important to note that the selected topic is still an emerging area of interest (researchers should represent an 'early adopter' audience for marketing prospects due to the industry's 'early maturation stage'), this is even clearer observing the variety of journals addressing the topic (fitness, nutrition, medicine, militaries, physical activity, physiology, etc.).

It has been assessed that, more in general, physical activities since scholar stages could have a positive impact on overall healthy behaviors, from choice to innate patterns generated [37]. All social (gender, age, etc.), ethnic, and economical categories are involved in this life procedure. This life-long process leads to reflection on how this organization (mostly manufacturers of this field) could bring and transmit sustainable practices and lifestyles useful for most of society's categories. Hence, embracing various and different worldwide environments, under the same lower denominator (fitness equipment) is natural to find environmental issues and differences in relation to organizational (personnel and practices) forms already assumed [38]. This could be defined as a cross-cultural context in which it is necessary to examine collaborative efforts (at all sustainable levels, including 'external' stakeholders) to address, or re-address, environmental issues or non-positive trends. The case of life-cycle process mostly consists in developing strategies to conserve and deploy various tangible (products) and intangible (services) resources [39].

The ultimate goal, even for this sector, is undoubtedly to reduce the ecological footprint and use sports as a means to raise environmental awareness [40]. Normally this could be achieved by adopting lower energy usage, sourcing products from fair-trade organizations (now corporates give

more attention to these facets), and ensuring that their physical waste, in all process procedures, is disposed to save earth energies (wind, hydro, solar, etc.) and raise environmental awareness. Current sustainability topics focus on meeting the needs of the present without compromising the ability of future generations to meet their next requirements. Scientists and manufacturers of the field know perfectly that their efforts are precursors of the following forward steps because nowadays, more in general, investors can be wary of companies who don't commit to sustainability, worry about sectoral realities being transparent with their earning results (words or incredible claims not always correspond to short- medium-term goals).

With the final aim create fresh approaches to the topic (e.g., organisation, management, and marketing themes), further interventions need to be planned with relevant potentiality or originality to reveal investigations based on newly sports science sustainable 'facades', also taking into consideration the relation with the current author's background. At a statistical level, future studies should also better quantify assumptions on bibliometric search logics (Booleans, truncations, or word combinations) or the effective publication 'profiles' in which the topic is usually named.

Author Contributions: Conceptualization: S.A.; Data Curation-Addolorato, S.A., V.P.-G.; Formal Analysis: V.P.-G.; Investigation: S.A.; Methodology: F.C.; Project Administration: S.A.; Resources: F.C.; Software: V.P.-G.; Supervision: F.C., L.G., J.G.-U.; Validation: F.C.; Visualization: S.A., J.G.-U.; Writing (original draft): S.A.; Writing (review and editing): S.A.

Funding: This research received no external funding.

Conflicts of Interest: The authors declare no conflict of interest.

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