BIBLIOMETRIC STUDY (1922-2009) ON RUGBY ARTICLES IN RESEARCH JOURNALS

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ABSTRACT

The purpose of this research was to perform a bibliometric analysis of research journals containing scientific articles on the sport of rugby from 1922 to 2009. In this field 2057 articles were selected from major databases. The journals, authors and contents published were selected by taking into account the year of publication, thematic areas and modalities of rugby among other variables. A steady increase in production was found in the period considered, with a maximum of 174 articles published in 2007. The articles were written by an average of 2.5 authors and most of them (80.9%) only participated in one. The data showed a utility loss of 7.5% of the total items each year. The thematic areas and most influential journals on rugby had been identified. Finally, limited support has been found for attempting to adjust the bibliometric data by applying the laws of Lotka and Price with respect to the authors, and Bradford's law regarding scientific journals.

Key words: Rugby; Bibliometric study; Scientific literature; Bibliometric laws of Lotka and Price; Law of Obsolescence in scientific literature; Bradford's law.

INTRODUCTION

Since the birth of rugby in the 19th century in England, it has been steadily increasing its number of practitioners, today becoming one of the major team sports in the world. Rugby or rugby football (when referring to it generically), has been a sport subject to, like any other human activity, the vicissitudes of history. In this way there have been several methods that have evolved at different times. One example was the first differentiation that occurred with the clash between supporters of the defence of amateurism and supporters of accepting financial compensation. This resulted in the division of Rugby football into two codes: XV Rugby or Rugby Union and XIII Rugby or Rugby League, which have since been separated organisationally (Sheard, 1997).

The body responsible for the Rugby Union is the International Rugby Board (IRB) with an estimated three million members in its sport federations belonging to 98 federation members and 18 federation associates (IRB, 2009). During 2009, it received a new impetus with the inclusion of 'Sevens' as a new Olympic sport. Rugby was already an Olympic sport, but in the form of XV Rugby at the games held in London (1908), Antwerp (1920) and Paris (1924). Other important milestones that can be considered momentous in the development of the sport have been the first Rugby World Cup that took place in New Zealand in 1987 and the recognition of rugby's professional sport status in 1995 (McMillan, 2006; Williams, 2008).

Rugby League is played in countries like Australia, New Zealand, France, Russia, Wales, Scotland, Ireland, England, Papua New Guinea, Fiji, Samoa and South Africa. In 2008, the latest edition of the Rugby League World Cup was held in Australia, and its next edition is scheduled for 2013 in the UK. The other most widespread form of rugby is Sevens. This variant originated in Melrose (Scotland) in 1883, but did not become popular until the 1920's of the 20th century. Sevens had a major boost in the 1990's with the birth of the World Series and now with its inclusion in the 2016 Olympics to be held in Rio de Janeiro. With the approval of the International Olympic Committee (IOC), since the Athens Paralympics in 2002, Quad Rugby (wheelchair rugby) has been developed, which had its origins in Canada in 1976.

There are other types with more applicable functions in the fields of recreation and education, such as tag rugby (or flag rugby), touch rugby, beach rugby and underwater rugby, amongst others. However, this social development has not had an equal impact on research into sport (Mellalieu *et al.*, 2008). According to these authors, there are some articles that deal with the rugby union in scientific literature, mainly from the medical perspective of injuries, rather than epidemiological studies or case studies. These authors also classified the remaining articles into four major areas: performance; physiology; psychology; and biomechanics.

Gabbett (2005) completed a review of rugby league and scientific research. The areas highlighted were anthropometry and physiology, psychology, epidemiology of injury, training and strength and performance analysis. Several scientific articles have included bibliometric studies in the field of sport and physical activity.

Bibliometrics is the name given by library and information science to the study of patterns of publications (Hawkins, 1977; Diodato, 1994). Bibliometrics is used to examine scientific productivity as classified by author, journal, discipline, affiliation, etc. A bibliometric researcher is able to identify the attributes that make a specific body of literature unique from others. Bibliometrics dates back to the 1900s (Cole & Eales, 1917), and is governed by several laws and principles (Bradford's law of scattering and Lotka's or Price's law relating to patterns of citation).

At first, Lidor *et al.* (1999) studied whether there was an increase in the number of scientific publications related to aging and physical activity in adults. Based on data collected from *Sport Discus* and *MEDLINE* from 1973 to 1997, comparisons were made of publications focusing on aging and physical activity in relation to publications in the area of physical activity along with the published totals. This relationship was likewise studied in six

scientific journals, which concluded that the interest of researchers in sport science and exercise does not correspond with increases produced in this period in society regarding the adult population.

The second bibliometric study was undertaken by O'Connor *et al*. (2001), which focused on the teaching area of adapted physical activity (APA). A sample of 770 articles from 259 scientific journals was researched from 1988 until 1998 by accessing *Article First, ERIC, MEDLINE* and *Sport Discus* databases. The results indicated that 1 720 authors, of whom only 11 contributed four or more articles, submitted publications. They also investigated the adjustment of the data by applying different bibliometric laws, such as Bradford's law, Lotka's law or Price's law. Bradford's law states that journals' research articles can be grouped in different categories according to the number of publications in this area.

In the current study, the literature on APA pedagogy was distributed in four areas, with 4, 15, 64 and 176 journal articles in each of these areas respectively. This was approximately the same amount of articles, which supports Bradford's law. Lotka's law and Price's law allows relating the number of articles to the number of authors. For example, it can be calculated by a formula where 50% of the papers published during a given period will be produced by 10% of the active publishing scientists. However, there was no evidence in favour of Price's law, since most authors only contributed one article. They also highlighted the four publications that have made the most contributions in this area and form the important core of the creating articles on APA pedagogy.

In the field of sport psychology, Baker *et al*. (2003) published an investigation that examined whether the research articles published in the field of sport psychology followed the law of Lotka and Price. They studied the authors who had published articles in five journals in sport psychology from 1970 to 2000. The results provide some support for the bibliometric laws studied. However, they deducted that the field of sport psychology is less elitist than other disciplines because there is a greater dispersion in the number of authors who have access to publish in scientific journals. Finally, in the related area of athletic training, Delwiche and Hall (2007) identified the major databases and journals in this field by studying the references of the three major journals in the area between 2002 and 2004. After applying Bradford's law, they identified six primary journals and 40 at a more secondary level.

Bibliometric articles have also been written about scientific journals in the area of sport like those published by Heinemann and Preuss (1990) in the *International Review for the Sociology of Sport*, Reid and Broadhead (1995) in the *Adapted Physical Activity Quarterly*, Thompson (1996) in the *British Journal of Sports Medicine*, Ward and Ko (2006) in the *Journal of Teaching in Physical Education* and recently, Arbinaga *et al*. (2010) in the *Journal of Sport Psychology*. Other bibliometric studies on sport, although about other types of publications, have been of, for example, doctoral dissertations on sports science in Turkey (Yaman & Atay, 2007), or on martial arts case studies published in Spain (Perez & Gutierrez, 2008).

PURPOSE OF THE STUDY

The objective of this research was to conduct a bibliometric analysis of research journals containing scientific papers on rugby from 1922 to 2009. This analysis involves studying the journals, authors and content of articles taking into account the years of publication, thematic areas and modalities of rugby, among other variables. It also seeks to establish whether the bibliometric laws of Lotka and Price are fulfilled in this area with respect to the authors' obsolescence in relation to the years of publication and Bradford's laws in relation to the journals where the articles were published. Thus, this article attempts to provide an overview of the scientific production of articles on the sport of rugby.

METHODOLOGY

The first step in a bibliometric analysis is to select the key word or words for the search (Lidor *et al*., 1999; O'Connor *et al*., 2001). In this study it was accepted that the word 'rugby' designates a set of modalities of sport or sports (Rugby Union, Rugby League, Rugby Seven, Quad Rugby, etc.), and that it is spelled the same in the main languages in which the major research journals are written.

The search was restricted to articles in scientific journals (including research and review articles and editorial statements), compared to other types of publications that were rejected (books, Internet-based resources, symposia, presidential addresses, abstracts associated with conference proceedings, unpublished reports, theses, dissertations, conference proceedings, poster presentations, book/video reviews, government documents including federal and state laws, interviews, emails, patents, and other items).

The search was conducted in 3 databases: Scopus, ISI Web of Knowledge (MEDLINE is included) and Sports Discus. Sport Discus and ISI Web of Knowledge were selected because they have been used in all previous studies on sport bibliometrics. Scopus were added as the current largest database of abstracts of the world, with 13 450 publications from more than 4 000 international publishers. The fields in which the search was delimited included the article title, the summary and key words. In the ISI Web of Knowledge database there were 1 395 references, in Scopus, 1 586 and Sports Discus, 1 830 under these criteria. In each of these, the references were exported and then imported to the RefWorks program (Refworks-ProQuest, version 2008).

A total the 4 811 references were stored in a folder and filtered. Firstly, duplicate references were removed, as well as those that did not have at least one identifiable author. After this initial filter there were 2 911 references. Subsequently, each reference was individually studied, citing the word 'rugby' (referring to the sport) in the title, key words or abstracts. After this second filter, 2 057 articles were selected that constitute the sample for this bibliometric study. References from RefWorks were exported to enter the data into Excel and SPSS programs that performed statistical calculations and produced the graphics.

RESULTS

Study of the authors

The 5 186 authors wrote 2 057 articles so that each article was written on average by 2.5 researchers. The place of writing of each author was not taken into account. A total of 3 604 authors were included and the distribution of their contribution to scientific knowledge of rugby is shown in Table 1. It is noteworthy that 80.9% of the authors contributed only one article and 10.8% contributed only two.

TABLE 1: **PRODUCTIVITY OF THE AUTHORS**

Number of articles	*Number of authors*	*Number of contributions*	*% Number authors*
1	2916	2916	80.91%
2	389	778	10.79%
3	138	414	3.83%
4	57	228	1.58%
5	33	165	0.92%
6	21	126	0.58%
7	12	84	0.33%
8	7	56	0.19%
9	3	27	0.08%
10	5	50	0.14%
11	3	33	0.08%
12	6	72	0.17%
13	4	52	0.11%
14	1	14	0.03%
15	3	45	0.08%
16	2	32	0.06%
17	1	17	0.03%
18	1	18	0.03%
22	1	22	0.03%
37	1	37	0.03%
Total	3604	5186	100%

It can be seen that the 10 most prolific authors have written more than 14 articles each, possibly highlighting the rugby code in which they research, the years in which they were published and the affiliation of the author (Table 2). For a further analysis of the authors in a study area, the bibliometric laws of Price and Lotka were applied.

Price's law indicates that success leads to success, in terms of productivity in the number of articles by several authors (Price, 1963). It was also Price who concluded that half of the

literature produced in a given field will be carried out by the square root of the total number of authors publishing in that field. In this study, the square root of 3 604 is 60.03 authors that have generated a maximum of 619 articles. This result differs from that established by Price's law, which would be half of those studied: 2 057/2=1 028.5.

TABLE 2: **MOST PRODUCTIVE AUTHORS**

Author	No. articles	Type	Year of publication	Affiliation
Gabbett, Tim J.	37	RL	2000-2009	Queensland Academy of Sport, AU
Chalmers, David J.	22	RU	1991-2009	Dept. of Preventive and Social Medicine, Univ. of Otago, NZ
Noakes, Timothy D.	18	RU	1983-2008	Dept. of Human Biology, Univ. of Cape Town, Sports Science Inst. of South Africa, RSA
Lac, Gerard	17	RU	2000-2008	Laboratoire de physiologie de la performance motrice, FR
Quarrie, Ken L.	16	RU	1995-2009	NZ Rugby Union, Inst. of Sport & Recreation Research, AUT Univ., NZ
Scher, A.T.	16	RU	1981-1998	Dept. of Radiology, Tygerberg Hospital & Univ. of Stellenbosch, RSA
Hopkins, Will G.	15	RU	2005-2009	Auckland Univ. of Technology, Inst. of Sport & Recreation Research, NZ
Kemp, Simon P.T.	15	RU	1999-2008	Rugby Football Union, Twickenham, UK.
Nauright, John	15	RU & RL	1990-2007	Dept. of Human Movement Studies, Univ. of Queensland, AU
Brooks, John H.M.	14	RU	2005-2008	Rugby Football Union, Twickenham, UK.

RL = Rugby League   RU = Rugby Union
AU = Australia   FR = France   NZ = New Zealand   RSA = Rep. of South Africa   UK = United Kingdom

For its part, Lotka's law (Lotka, 1926), established a relationship between authorship and the number of publications. Thus, the relationship between the frequency of a group of people (y) who carry out a number of defined contributions (x) is constant according to the equation:

$$y_x = c * x^{-n}$$

In the current study and after following the proposed methodology for calculating the n and c constants of the previous equation (Pao, 1985; Nicholls, 1986; Pulgarín & Gil-Leiva, 2004), the result would be:

$$y_x = 0{,}7711 * x^{-2{,}6123}$$

110

Having established the parameters of the equation, it can be determined if the theoretical data predicted in it, fit the empirical data and then it can be decided whether the set of publications in Rugby followed the Law provided by Lotka. To study the adjustment of the empirical to the theoretical distribution, the Kolmogorov-Smirnov test was performed (Pao, 1985). To do this, the maximum difference among the differences in observed and predicted accumulated observations were compared with the critical value. Here the maximum difference was 0.0380, which was higher than critical value of 0.0272, indicating significant differences (p= 0.01) between the two distributions.

Study descriptors and themes

Study descriptors (key words for each article) can also be investigated. Of the 2 057 articles studied, key words were registered in only 1 371. The most utilised were rugby football, wounds and injuries and rugby union football (Table 3).

TABLE 3: **MOST FREQUENT DESCRIPTORS**

Descriptors	Frequency
Rugby football	483
Wounds & injuries	345
Rugby Union football	336
Rugby	297
Rugby League football	169
Sports	159
Athletes	135
Males	127
Rugby football players	115
New Zealand	104
History	100

However, these descriptors do not give a clear picture of the contents. In order to explain this idea, the analysis was based on a set of terms in major fields of the records in each group for all the articles. In principle, the rules or terms relating to rugby was analysed. It was found that the term 'rugby' appeared in 2 012 articles (97.8%), Rugby Union in 542 (26.4%), Rugby League in 297 (14.4%) and both terms were found in 60 (2.9 %). Other modalities have been studied, namely wheelchair rugby or quad rugby (25; 1.2%), Rugby Sevens (3; 0.2%) or Underwater Rugby (2; 0.1%).

With the analysis of the topics, the most discussed topics concerns injuries (727; 35.2%) followed by those dealing with training (318; 15.5%), performance (314; 15.3%), history (247; 12.0%), strength (160; 7.8%), psychology (130; 6.3%), management (121; 5.9%), anthropometry (109; 5.3%), physiology (107; 5.2%), sociology (72; 3.5%) and biomechanics (45; 2.2%). Regarding the countries, the most productive country is Australia (185; 9.0%), followed by New Zealand (174; 8.5%), England (116; 5.6%), South Africa (84; 4.1%), Wales

(43; 2.1%), Japan (36; 1.8%), United States (30; 1.5%), France (29; 1.4%), Ireland (19; 0.9%) and Scotland (16; 0.8%).

Study of the publication years

The publication of rugby articles in scientific journals has had a steady increase since it was launched in the 1960's. Thus, in the decades of the 1920's, 30's, 40's and 50's, the averages were 0.4, 0.1, 0.3 or 0.4 respectively. An increase occurred in the decades of the 1960's through to 2000, with an average of 1.5, 9.1, 30.7, 50.6 and 112.6. This pattern may be observed in Figure 1.
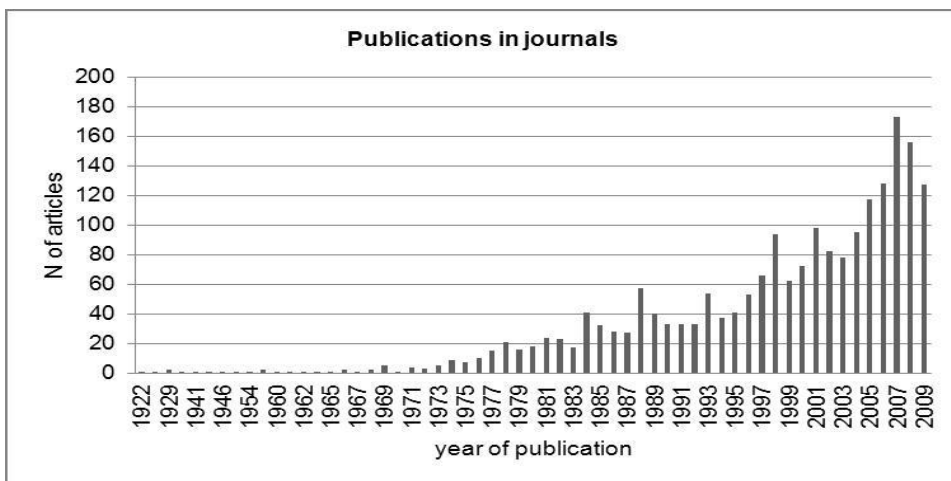

FIGURE 1: PUBLICATIONS BY YEAR OF RUGBY ARTICLES IN SCIENTIFIC JOURNALS

The obsolescence or disuse of a group of articles was also studied. Obsolescence means the temporary decline in value of a measure or validity of information. Burton and Kebler (1960) introduced the concept of 'half-life' into the field of information science, finding that the half-life of the references in the journals of various sciences depends on the topical area concerned. Brookes (1970) established a mathematical law to measure the temporary loss of use of a set of documents from the average life (h). The Brookes equation states:

$$a = e^{(\ln 0,5)/h}$$

From the data of this study, the value can be estimated of **h**= 8.8 and thus the value of **a** (annual age factor) will be:

$$a = e^{(\ln 0,5)/8,8362} = 0,9246$$

So the annual aging factor is 92.5% or, expressed in another way, a current annual loss of 7.5%. It can also be stated that every 9 years (approximately 8.8362) the usefulness of the publications is reduced by 50%.

Study of scientific journals

The 2 057 articles dealing with rugby have been published in 631 journals, of which 421 have only published 1 article on this subject. Bradford (1934,1948), proposed a law to describe the distribution of a subject in a set of scientific journals. According to this author, the journals could be divided into 3 zones, each with the same number of articles, and the number of journals and the number that increased geometrically. Also, the distribution of journals according to their productivity presented a different model of concentration and dispersion when it was represented as a statistical distribution, with a larger group forming a long tail of less productive journals.

Several authors have expressed these ideas mathematically (Leimkuhler, 1967; Brookes, 1969; Rousseau & Leimkuhler, 1987; Egghe, 1990; Rousseau 1994). Thus, to determine and verify the number of zones, the Bradford multiplier **k** needs to be calculated:

$$k = (e^{\gamma} \, Y_m)^{1/P}$$

Here γ is Euler's number (0.5772) and Y_m is the number of articles published in the most productive journals. Thus:

$$k = (1{,}781 * 175)^{1/3} = 6{,}78$$

The average of **k** is equal to 6.19 which are similar to that obtained in the equation. This is similar with each value of **k**, showing a distribution in the 3 zones (Table 4).

TABLE 4: ZONES PROPOSED BY BRADFORD'S LAW

Zone	No. of Journals	No. of Articles	k
1	14	677	
2	83	692	83/14 = 5.93
3	534	688	535/83 = 6.45
TOTAL	631	2,057	

The similarity of the different values of **k** and differences between these and the calculated Bradford multiplier k (6.78), clearly shows that the distribution fits a 3-zone of Bradford's law. Likewise, the equation established by Bradford is:

$$R(r) = a \ln(1 + br)$$

Here **R(r)** is the cumulative number of articles produced by the journals of rank *1; 2; 3,* where *r,* y *a,* y *b* are constants. Following the methodology proposed by Pulgarín and Gil-Leiva (2004), for the data in this study, the equation would have the following values:

$$R(r) = 359,456 \ln(1 + 0,151\, r)$$

TABLE 5: JOURNALS AND ARTICLES OF ZONE 1 OR CORE

	JOURNAL NAME	Published articles
1.	British Journal of Sports Medicine	175
2.	Journal of Sports Sciences	84
3.	Journal of Strength & Conditioning Research	61
4.	International Journal of the History of Sport	55
5.	Journal of Science & Medicine in Sport	41
6.	American Journal of Sports Medicine	33
7.	Sports Medicine	33
8.	Italian Journal of Sports Traumatology	30
9.	Science & Sports	30
10.	South African Medical Journal	30
11.	Sporting Traditions	30
12.	Clinical Journal of Sport Medicine	27
13.	International Review for the Sociology of Sport	25
14.	Journal of Sports Medicine & Physical Fitness	25

Using Lotka's law, one can check whether the empirical data matches the data proposed by the theoretical equation to determine if there is a good fit between the two. To check whether the data conforms to Bradford's law, several tests have been proposed. First, it must be confirmed that A/m>z/2, where A/m is the number of articles in the nucleus and z is the number of journals contributing only one article. In this study, A/m is 679 and z = 175. The inequality is obviously demonstrated in the data.

Another possibility to apply to check the fit is the Kolmogorov-Smirnov test. The maximum difference among the differences in the observed and predicted accumulated observations, were compared with the critical value. The maximum difference was 0.2585, which was greater than the critical value of 0.0300. There was a significant difference (p=0.01) between the two distributions. According to this test, the empirical data does not follow Bradford's law.

DISCUSSION

This study was conducted to determine the current status of research through the analysis of scientific articles related to a global sport, namely rugby. This study covers a larger number of references (2 057) than most of the bibliometric studies published. Baker *et al*. (2003) worked on a similar study with 2 417 articles, but it was limited to one type of publication, similar to the studies of Lidor *et al*. (1999), O'Connor *et al*. (2001) and Valcarcel *et al*. (2010). The sources of information in which the searches have been carried out were by

means of the databases used by, for example, Lidor *et al*. (1999), Reid and Prupas, (1998), O'Connor *et al*. (2001) and Yaman and Atay (2007).

As for the topic, the study is the only one that has focused on scientific articles in a particular sport. Other authors have made bibliometric studies on other topics, such as physical activity and aging (Lidor *et al*., 1999), sport disability (Reid & Prupas, 1998), adapted physical activity (O'Connor *et al*., 2001), sport psychology (Baker *et al*., 2003), a scientific journal about a specific area (Heinemann & Preuss, 1990; Thompson, 1996, Ward & Ko, 2006) or a topic such as athletic training (Delwiche & Hall, 2007).

Concerning the number of authors, there was an average of 2.54 signatures per article, similar to the 2.53 found by Arbinaga *et al*. (2010) and the 2.5 of Valcarcel *et al*. (2010), and similar to the average values between 1.91 and 2.54 obtained in the six journals that Baker *et al*. (2003) investigated. To this effect, other studies have reported that the number of articles with one author has changed from the majority (O'Connor *et al*., 2001), 51% (Reid & Broadhead, 1995) or 75% (Heinemann & Preuss, 1990).

In terms of scientific productivity per author in a certain area, it was found that most authors only contributed one article. In this investigation, 80.9% of the authors only made one contribution of all the articles surveyed. These results are similar to those found by Baker *et al*. (2003), who found in the six journals studied, a percentage between 71.6 and 81.9% of the authors with a single contribution, which is below the 86% found by Thomson (1996).

Another way to evaluate the productivity of authors in a given field of study is to divide them into three groups and estimate the percentage in each of them. Baker *et al*. (2003) estimated that producers could be classified into three categories: high, if they produce more than 10 articles; medium, three to nine; and low, if they produce one or two articles. The data found by Baker *et al*. (2003) indicates percentages of 2.7%, 13.5% and 83.8% for high, medium and low, respectively. In the current study the percentages were 0.8%, 7.5% and 91.7%.

The lack of support for Price's law is consistent with those found by O'Connor *et al*. (2001). In both cases the square root of the total number of authors has failed to generate half of the scientific productions, since in the case of the current study, a maximum of 30.1% was generated. This is in agreement with the data found by Baker *et al*. (2003). In another formulation of Price's law, Baker *et al*. (2003) found that 10% of the authors only generated 44% of the scientific productions, which is less than half. The current data indicates that 10% of the authors (36) generated a maximum of 22.3% of the publications.

No evidence was found to support the adjustment of the data in the current study for Lotka's law based on the calculation proposed by Pao (1985), Nicholls (1986) and Pulgarín and Gil-Leiva (2004). Thus, this field is less elitist than other areas of knowledge. Topics included in these research papers have been varied and although difficult to structure the topic from the key words, it was more enlightening when the search included words in the articles (in the title, key words or abstract). As has been already noted in the review of rugby union by Mellalieu *et al*. (2008) and rugby league by Gabbett (2005), most literature has addressed or is related to the study of injuries, probably because sport medicine literature has traditionally been dominant. Other issues have also been widely documented: training, performance,

history, strength, psychology, management, anthropometry, physiology, sociology and biomechanics.

Considering that rugby is a global sport with different codes, most of the scientific articles are focused on rugby union, followed by rugby league. In terms of the rugby codes, as often happens in a global sport, rugby union is the one that has occupied more articles followed by rugby league. It is noteworthy that a significant number of articles (60) included both types. The other variants of rugby have had little or sparse dissemination in scientific literature, with particular emphasis on the few studies related to 'Sevens'.

As for the countries represented by the authors of the articles, they coincide with those in which rugby is strongly entrenched since the late 19th and early 20th centuries. Specifically confined to Anglo-Saxon countries together with France and others in which, despite rugby being played less, there is a high scientific development and they have many publications, such as the US or Japan.

Focusing on the years of publication of the articles studied, its growth has been steady, with 2007 being the year that reached the maximum number of publications, with 173 articles. As far as the aging factor and average life, other studies were not found that address the area of Physical Education and sport. In other areas, several authors have found aging factors ranging from 0.9 in Sociology, 0.981 in History (Sangam, 1999), the 0.95 automatic indexing of the literature (Pulgarín & Gil-Leiva, 2004); and as for the average life values, between three for genetics and 6.6 in sociology, to 36 in music theory and 37 in history (Diodato & Smith, 1993; Sangam, 1999).

Finally, the study of the journals in which the articles have been published has enabled establishing, under Bradford's law, three zones that include every publication, including the main zone to the 14 most important journals (representing a total of 2.22% of the journals studied), that publishes scientific articles related to rugby. O'Connor *et al*. (2001) in the area of adapted physical training identified four zones and the main zone included four journals (1.54%). For its part, Delwiche and Hall (2007) divided the articles in their study of athletic training into three zones and found six journals in the main zone (0.6% total). Of the 14 journals included in zone 1, seven had ratings above the average impact of all the journals in the area of sports science in 2006, where the ratings ranged between 3504 and 1212 (Tsigilis *et al*., 2010).

The adjustment to Bradford's law has been limited. Thus, the value adopted by the constant *k* of Bradford, supports an adjustment to this law. However, data from this study did not conform to this equation, as shown by the Kolmogorov-Smirnov test.

In summary, it can be concluded that the articles published on Rugby are written by an average of 2.5 authors and that only 8.3% of them have written more than two articles in this field. This supports the idea that there are a limited number of authors who published a number of articles and the majority published only on one or two occasions. However, the data findings did not provide support for Price and Lotka's laws. Gabbett in Rugby League and Chalmers in Rugby Union were found to be the most prolific authors, the descriptors of Rugby football and wounds and injuries were the topics most addressed, and Australia, New

Zealand, England and South Africa as the countries represented by the publications. Regarding publication years, there has been an increase since 1922, and most articles were published in 2007. A study of obsolescence established that every nine years or so, 50% become outdated. Finally, applying Bradford's law, 14 journals were identified where more has been published about Rugby, which can be considered as the core. The journal that has published the most scientific articles about Rugby is the British Journal of Sports Medicine.

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