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BIBLIOMETRIC INDICATORS IN PHYSICAL EDUCATION RESEARCH: BRAZIL IN COMPARISON

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Dissertação apresentada à Faculdade de Educação Física da Universidade de Brasília, como requisito parcial para obtenção do título de Mestre em Educação Física.

Orientador:

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BRASÍLIA, 21 de Junho de 2022

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Glossary

Citation Impact - Number of citations per document

CNCI - Category Normalized Citation Impact of a document is calculated by dividing the actual count of citing items by the expected citation rate for documents with the same document type, year of publication and subject area.

DocCit – Number of documents in the database in the period studied that had at least one citation in the database

Highly cited – Papers that perform in the top 1% based on the number of citations received when compared to other papers published in the same field in the same year.

IND- papers published with Industry Collaboration

JNCI - The Journal Normalized Citation Impact indicator is a similar indicator to the Normalized Citation Impact, but instead of normalising per subject area or field, it normalises the citation rate for the journal in which the document is publishing.

OA - Open Access - is a set of principles and a range of practices through which research outputs are distributed online, free of cost to the reader or other access barrier

Publications in Top Journal Percentiles - indicates the extent to which an entity's outputs are present in the most-cited journals in a database source. This metric calculates how many publications, as an absolute count or a percentage, are in the top 1%, 5%, 10% or 25% of the most-cited journals indexed by the database source. An entity can be an institution, a research group or an individual researcher. In this paper we used %Top1% and %Top10%.

Q1, Q2, Q3, Q4 - Quartile rankings are therefore derived for each journal in each of its subject categories according to which quartile of the IF distribution the journal occupies for that subject category. Q1 denotes the top 25% of the IF distribution, Q2 for middle-high position (between top 50% and top 25%), Q3 middle-low position (top 75% to top 50%), and Q4 the lowest position (bottom 25% of the IF distribution). In this paper we used %Q1 and %Q2.

WoS – Web of Science is a website which provides subscription-based access to multiple databases that provide comprehensive citation data for many different academic disciplines. It was originally owned by the Institute for Scientific Information (ISI) and is currently maintained by Clarivate Analytics (previously the Intellectual Property and Science business of Thomson Reuters

Resumo

Os artigos em InCites ® baseados em Web of Science ® para Educação Física foram avaliados em todo o mundo e no Brasil. As análises incluíram Cluster, Discriminante, Canonical e Análise Fatorial, para diferenciar entre países do mundo e universidades no Brasil. Os temas mais comuns estudados no Brasil e no mundo também foram pesquisados. A maioria dos documentos a nível mundial é publicada nos EUA (46%) e Inglaterra (26%), seguidos por três outras nações europeias, sendo o Brasil o 6º maior país editor (1,7%). Em contraste, os autores brasileiros tendem a publicar mais dentro do seu próprio país (40%). Há uma tendência para que os países com maior percentagem de documentos nas revistas do primeiro quartil tenham também uma percentagem mais elevada de 10% dos documentos citados (R2=0,73 para todos os documentos e 0,92 para acesso livre). Ao comparar todos os documentos com os de acesso aberto, a maioria dos países aumenta a sua pontuação dos 10% mais citados, enquanto que o Brasil diminui 1%. As variáveis que diferenciam entre os grupos de países incluem % documentos em revistas do primeiro quartil, % Colaboração internacional, % Acesso Aberto, Impacto da Citação (número de citações por artigo) e % Documentos no Top 10%. A correlação entre o número de publicações por tópico a nível mundial e o Brasil é de 0,79. O aumento da publicação em revistas do Q1, bem como maior colaboração internacional e com indústria são indicados para aumentar o impacto das publicações de autores brasileiros na educação física. Deve ser concedido financiamento para ajudar no pagamento de taxas de processamento de artigos em revistas de grande impacto de Acesso Aberto.

Abstract

Papers in InCites ® based on Web of Science ® for Physical Education were evaluated worldwide and in Brazil. Analyses included Cluster, Discriminant, Canonical and Factorial Analyses, to differentiate between countries worldwide and universities in Brazil. Most common topics studied in Brazil and worldwide were also researched. Most documents worldwide are published in the USA (46%) and England (26%), followed by three other European nations, with Brazil being the 6th largest publishing country (1.7%). In contrast, Brazilian authors tend to publish more within their own country (40%). There is a tendency for the countries with higher percentage of documents in Q1 journals to also have higher percentage of top 10% cited documents (R^2=0.73 for all documents and 0.92 for open access). When comparing all documents with those in open access, most countries increase their Top 10% score, while Brazil decreases by 1%. The variables that differentiate between country clusters include % documents in Q1 journals, % International collaboration, % Open Access, Citation Impact (number of Citations per paper) and % Document sin Top 10%. The correlation between number of publications per topic worldwide and Brazil is 0.79. Increases in publishing in Q1 journals, as well as more industry and international collaboration are indicated for increasing impact of publications by Brazilian authors in physical education. Funding should be provided to help with the payment of Article Processing Charges in high impact Open Access journals.

Keywords: Impact; Collaboration; Industry; International; Open Access

Introduction

Physical education (PE) is often advocated as a lifelong process, with physical activity is universally acknowledged to be an important part of healthy functioning and well-being (Cope & Parnell, 2015). These authors recognise its impacts in several domains such as Emotional, Financial, Individual, Intellectual, Physical, and Social. Themes also include holistic well-being and alternative leisure activities (yoga, meditation – Gerdin & Pringle, 2017), as well as nutritional and health benefits (Boguszewski et al., 2014). These themes researched in PE have changed over time (Enright & O'Sullivan, 2012a; Bracht et al., 2011) and may be contradicting (Devecioglu et al., 2012). Changes may involve the use of digital technologies (Bodsworth & Goodyear, 2016), attitudes towards physical education and how meaningful it is (Ennis, 2000; Wilhelmsen & Sørensen, 2017; Enright & O'Sullivan, 2012b), autonomy-supportive climates (Hastie et al., 2013), public health (Pate et al., 2011) and disabilities (Tant & Watelain, 2016; Cervantes & Taylor, 2011), among others.

Professionals in this area work in schools, sports clubs, or community centres (Nahas & Garcia, 2010) as well as in private facilities. Studies in physical education have been increasing (Hastie et al., 2011). These range from primary school (Andrieieva et al., 2017), adolescents (Diamant et al., 2011; Dalen et al., 2016), to adults (Loprinzi et al., 2015) and geriatrics (Arai et al., 2011; Kosse et al., 2013), sports (Petrovska et al., 2020; Harmandeep et al., 2015) as well as factors such as how the sports industry interacts with an active economy (Solntsev, 2012) and investment opportunities (Letiagina et al., 2019, Sorokin et al., 2018).

Scientometrics was defined by Nalimov (1971) as the use of quantitative methods of research on the development of science as an informational process. The researcher, their group, institution or area of knowledge can use the scientometric approach to evaluate and manage research performance (Bornmann & Leydesdorff, 2014) as well as the prominence of research topics, taking into account inter- and trans-disciplinary studies (Mingers & Leydesdorff, 2015).

Bibliometric analyses are useful for useful for identifying interconnections between research articles, topics, gaps and resources (Xu et al., 2022), understanding citations.

Tahamtan et al. (2016) found three general categories (paper related, journal related and author-related) and twenty-eight factors associated with the number of citations. The use of citation impact factors has become common in evaluating scientific research, including individual publications, researchers, research groups, research institutions, countries, or journals (Waltman, 2016) and used to measure quality (Moed, 2005). Increasing citation impact can be due to several factors, such as international or industry collaboration, publishing open access (OA) in high impact journals, country wealth (King, 2004), or English as a country's official language (Bornmann & Leydesdorff, 2013).

This paper aimed to examine the quantity and performance of publishing in physical education and related areas worldwide and compare with Brazilian practices. This can help in constructing policies for improving physical education in Brazil and aid in identifying where improvements can be made in this area within the country.

Material and Methods

Data worldwide and from Brazil were collected from InCites® from Clarivate Analytics based on Web of Science from 2005 – 2020. This was limited to Physical Education (PE) as defined in the database, from the Coordenação de Aperfeiçoamento de Pessoal do Nivel Superior (CAPES – Brazilian Ministry of Education) area of knowledge. Only organizations with more than 10 publications per year were included in the analysis. This left 2536 of the 11482 organizations for initial analyses. Data were then limited to the top 15 countries as these represented 77.5% of all publications in the period. The final data set had 1809 institutions and 32384 researchers.

Quantitative, structural and performance information was collected (see Glossary for definitions).

Quantitative and Structural: Total number of Papers, % Documents Cited, Citation Impact (CI), Times Cited, % papers in 1st, 2nd, 3rd and 4th Quartile journals (%Q1, %Q2, %Q3, %Q4), Average Percentile, publication location, and cited funding agencies. For universities, information was also available on % 1st Author, % Last Author, and % Corresponding author from the institutions. Word Clouds for created for the 500 most prominent topics (SciVal®) using wordart.com.

Performance: % Papers in Top 1% and Top 10% of citations, Impact Relative to the World (IRW), Category Normalised Citation Impact (CNCI) and Journal Normalised Citation Impact (JNCI), % Hot Papers, and % Highly Cited Papers.

Statistical analyses included correlation (PROC CORR), regression (PROC REG) and principal component/factor (PROC FACTOR) to assess the relationship between quantity and performance indicators, as well as cluster analyses (PROC FASTCLUS) to group countries and universities according to their production and impact. A MANOVA test (PROC GLM) was carried out followed by a Dunnett test to compare other countries with Brazil. To evaluate the factors affecting CNCI, a multiple regression was carried out including a Variance Inflation Factor (VIF). Variables with VIF greater than 10 were deleted from the analysis.

Results

There were a total of 882,171 papers published in this time in Incites, in 2,559 journals, of which 1,920 published less than 50 papers. It should be noted that the same papers, with multiple authors, may appear for several countries, so individual countries cannot be summed. Those that published most papers were Medicine and Science in Sports and Exercise, American Journal of Tropical Medicine and Hygiene, and International Journal of Environmental Research and Public Health. The first Brazilian Journal is in 32nd in terms of number of papers published (Ciência & Saúde Coletiva). Brazilian authors published 33,126 papers in 608 journals with 509 with less than 50 papers. Other Brazilian journals with high number of papers include Cadernos de Saúde Pública, Revista de Saúde Pública and Saúde e Sociedade. Papers published in Brazil were 100% OA, compared with 33% in the USA, 24 % in the Netherlands or 54 % in England. Supplementary Table 1 shows the % OA and CNCI by publishing country and journal quartile, worldwide (A) and Brazilian papers (B).

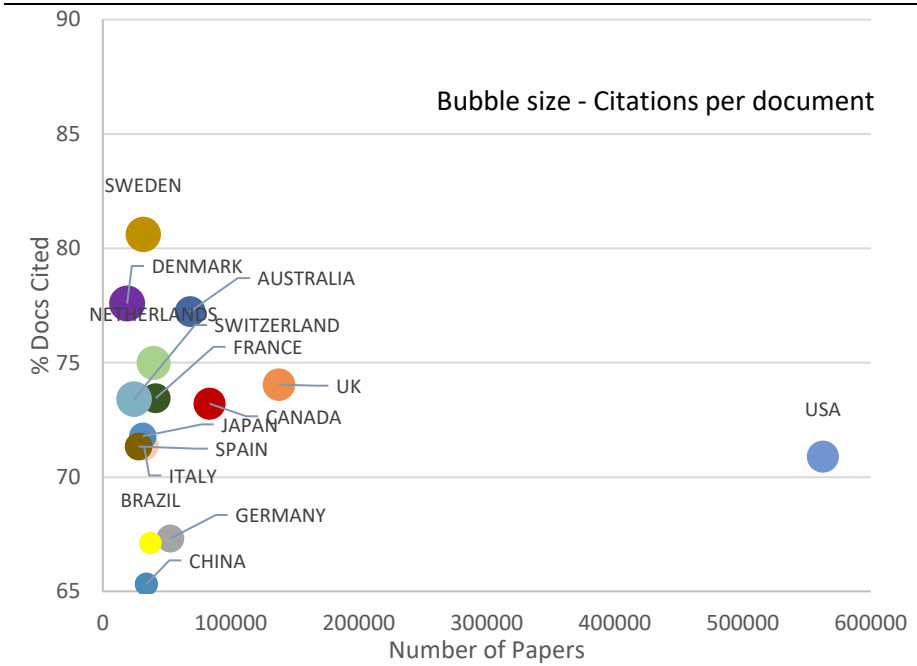
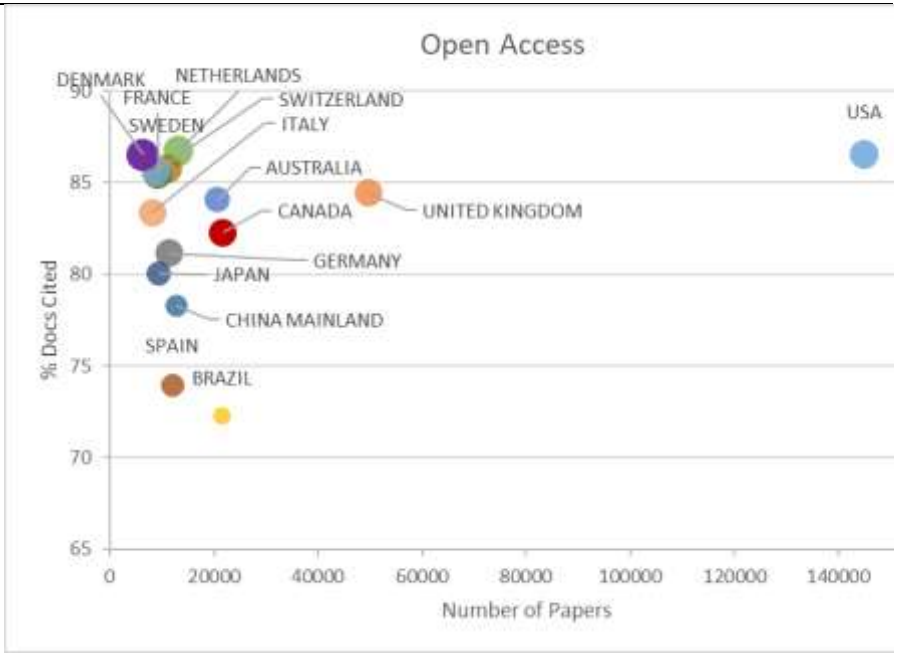
The correlation worldwide between % OA and CNCI was 0.23 (P<0.01) (overall) and 0.09 (P>0.05) for Brazil. Worldwide, the correlation between CNCI and % documents in Q1 journals was 0.11 (P<0.01), 0.00 (P>0.05; Q2), -0.06 (P<0.01; Q3), and -0.13 (P<0.01; Q4), showing that an decrease in journal quartile had tendency to decrease CNCI. For papers with at least one Brazilian author this was -0.09 (P>0.05) (overall), 0.22 (P<0.01; Q1), -0.02(P>0.05; Q2), -0.35 (P<0.01; Q3), and -0.19 (P<0.01; Q4). More open access in Q1 journals led to higher CNCI for Brazilian authors but in the other quartiles an increase in OA had no effect on CNCI (Table 1).

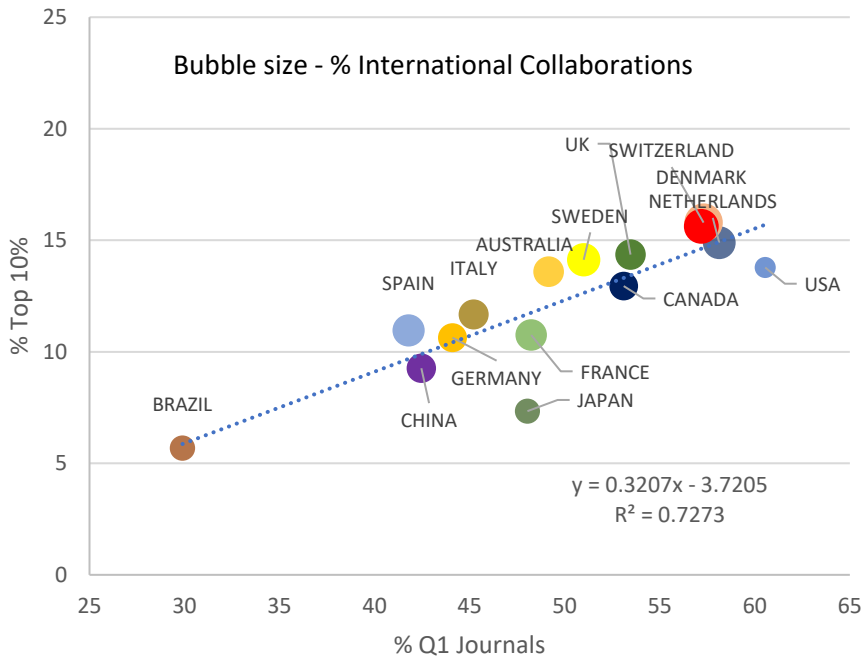
Table 1 Relationship between Open Access publishing and CNCI for Brazilian authors

Quartile	Equation	Significance
Q1	CNCI = 1.437+0.016*%OA	P<0.01
Q2	CNCI = 0.823+0.001*%OA	Ns
Q3	CNCI = 0.484+0.001*%OA	ns
Q4	CNCI = 0.432-0.001*%OA	ns

Higher percentages of documents were cited when published in Q1 ($P<0.01$), open access journals ($P<0.01$) across major publishing countries (Figure 1). Although some of them have higher increases when comparing all publishing to only open access (i.e. USA +15% ; Germany +14% ; China +13%), Brazil only goes up by 5% and Spain by 2.5%. There is a tendency for the countries with higher percentage of documents in Q1 journals to also have higher percentage of top 10% cited documents ($R^2=0.73$ for all documents and 0.92 for open access). When comparing all documents with those in open access, most countries increase their Top 10% score, while Brazil decreases by 1%. Brazil also shows a lower % of their documents having international collaboration (20%) than other major publishing counties ($\mu=52\%$) when looking only at open access articles ($P<0.01$). Major impact in publishing is mostly in European countries. The USA shows, by far, the largest number of papers but with an average number of these being cited (71% vs 77% for Australia or 81% for Japan).

The lowest % international collaborations are seen with Brazilian (27%) and USA (19%) papers ($P<0.01$; Figure 2). China (13.8) and Spain (15.9) also show low citation impact. These countries also show the lowest % papers in Q1 journals and % of Top 10% cited papers ($P<0.01$)

All	Open Access
	



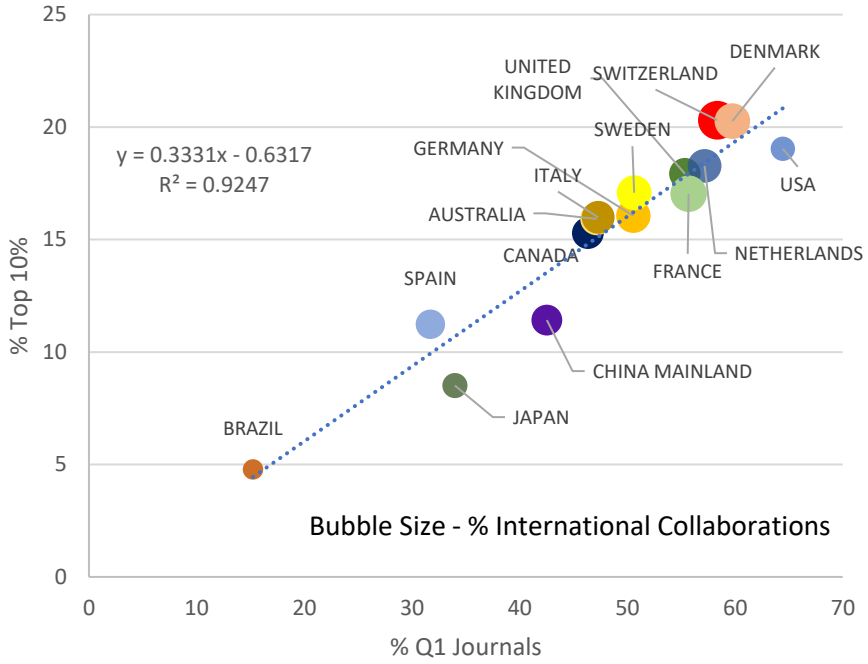
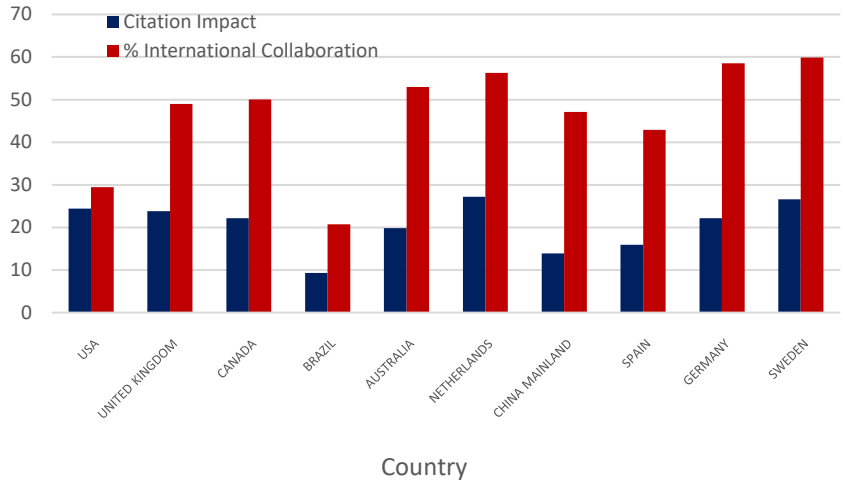


Figure 1. Impact and number of papers for major publishing countries worldwide for all types of publication (A) and only Open Access (B) in Physical education (InCites®).



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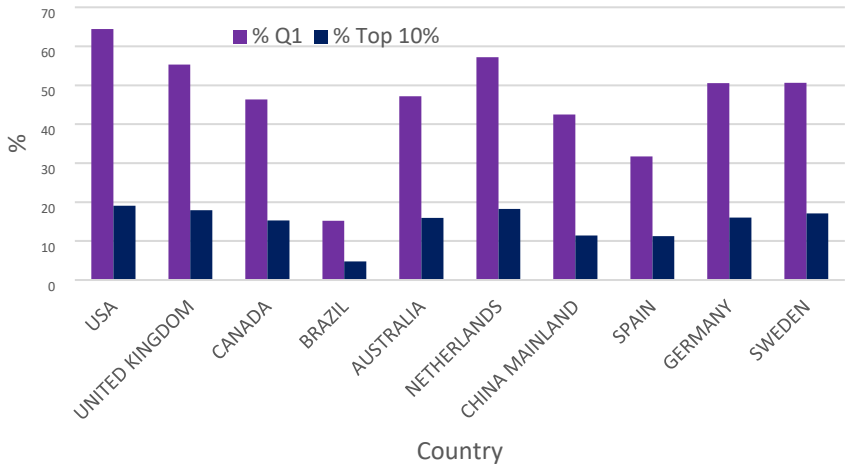
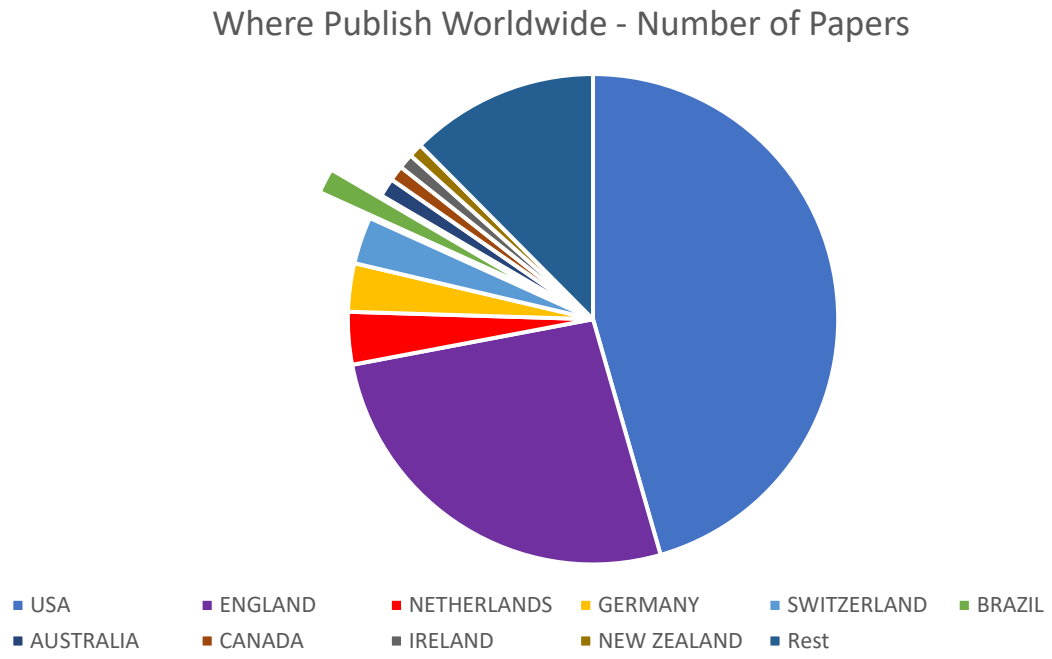


B

166 Figure 2. Performance indicators for Open Access Publishing in Physical Education by top 10 Author Countries (InCites®) including A) Citation Impact, %
167 International Collaboration and B) percentage of papers in Q1 and Top 10 % of cited papers.

Publishing

Most documents worldwide (Figure 3) are published in the USA (46%) and England (26%), followed by three other European nations, with Brazil being the 6th largest publishing country (1.7%). In contrast, Brazilian authors tend to publish more within their own country (40%).



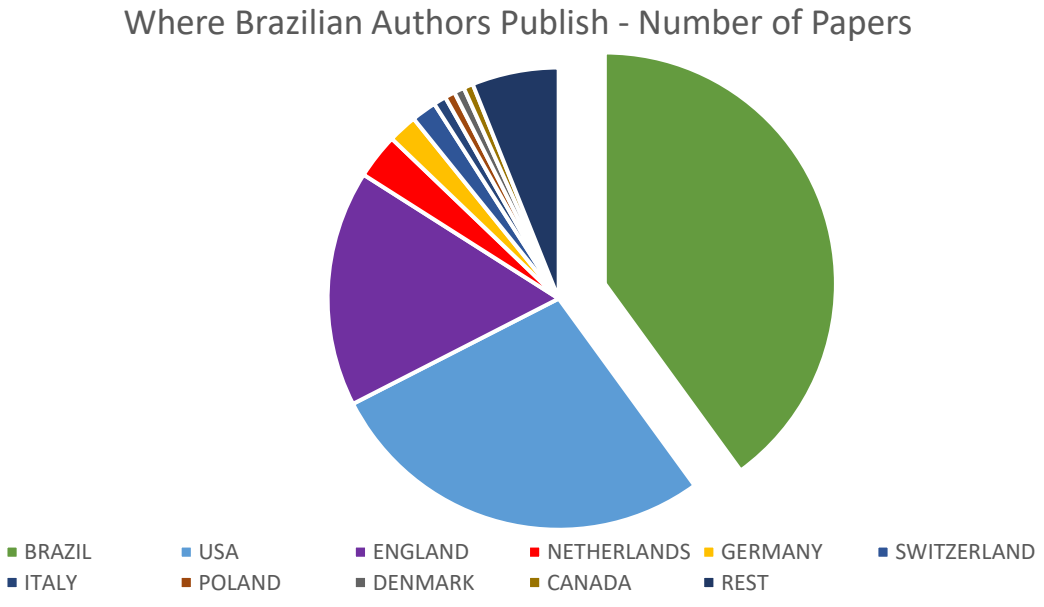
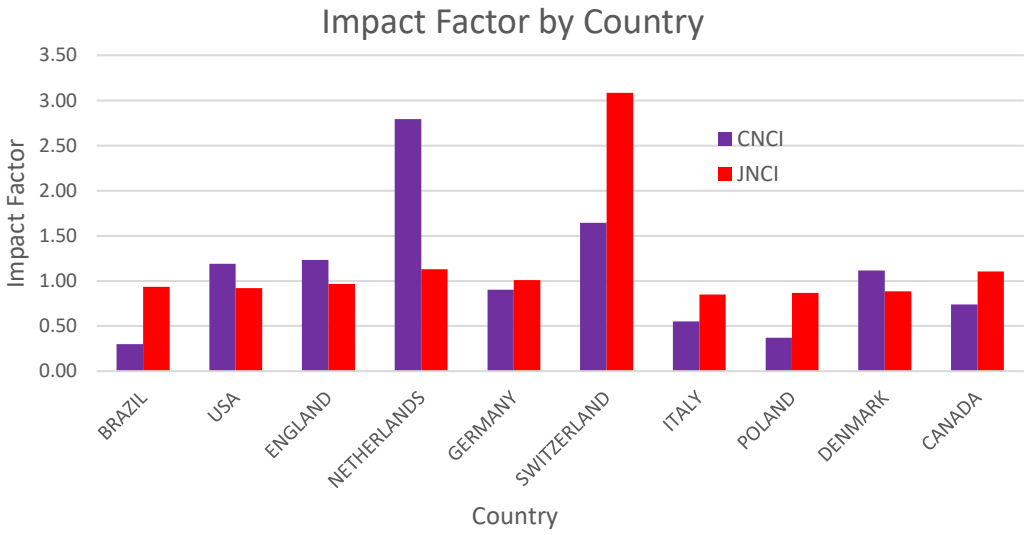


Figure 3. Publishing Localities in Physical Education (A) Worldwide authors and (B) Brazilian authors (InCites®)

Even though Brazil publishes the vast majority of their documents in open access journals, the average citation impact factor of them pale in comparison to those of other large publishing nations (Figure 4). Publishing Brazilian papers in Italy and Poland also show low CNCI (One is the world mean). The Journal Impact factors do not show large variations between countries, except for Switzerland. When Brazilian authors publish in Brazil and Poland, they tend to publish a high percentage of their papers in Open Access. When publishing in countries such as Denmark and Canada they tend to have very low Open Access publishing rates. This does not affect the percentage of papers cited.



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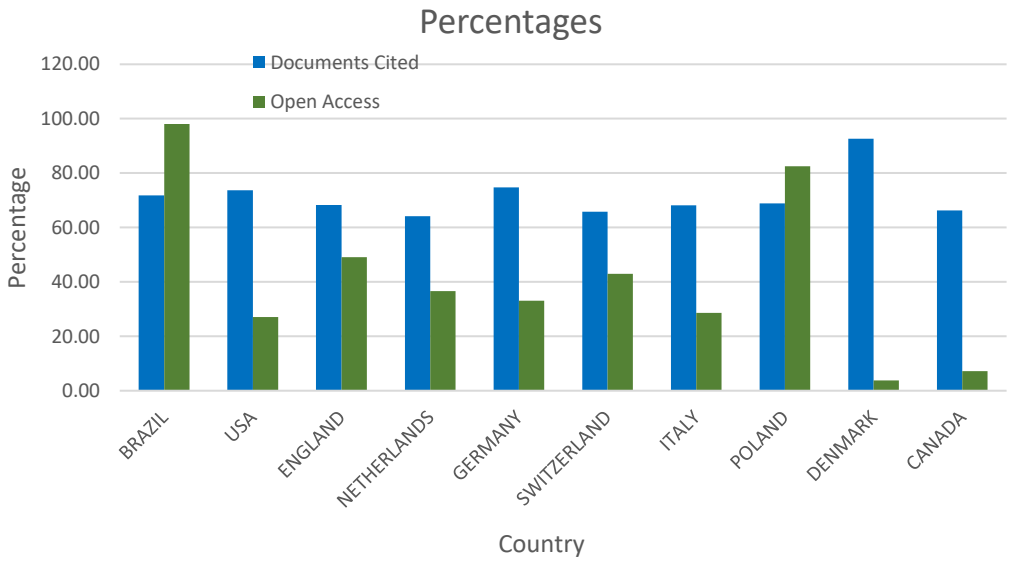

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Figure 4. Journal and Citation impact factors (A) and percentages of cited documents and open access papers (B) by journal country (InCities®) for Physical Education papers from Brazil

Brazil does not follow the same pattern (Figure 5) compared to other countries. Without Brazil the regression is CNCI = 0.144(%OA)+0.790 (R^2 = 0.19; P<0.01). Although R^2 is low it is still significant. With Brazil it is CNCI = -0.003(%OA)+1.306 (R^2 = 0.01; P>0.05).

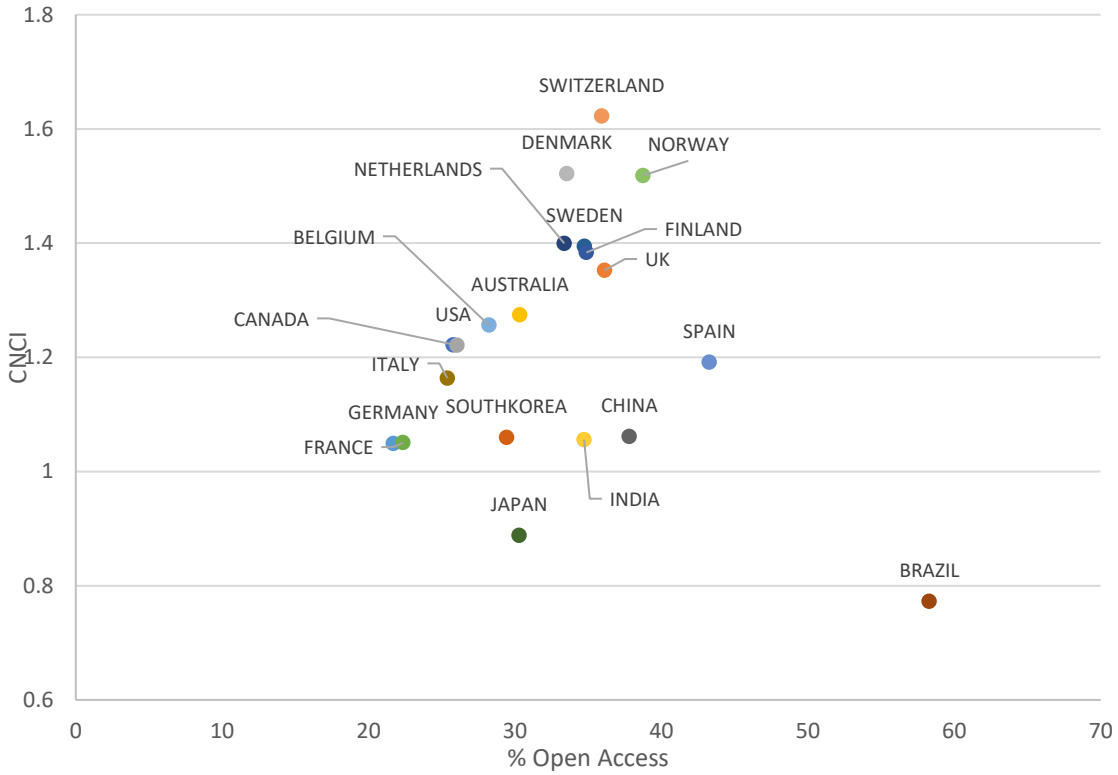
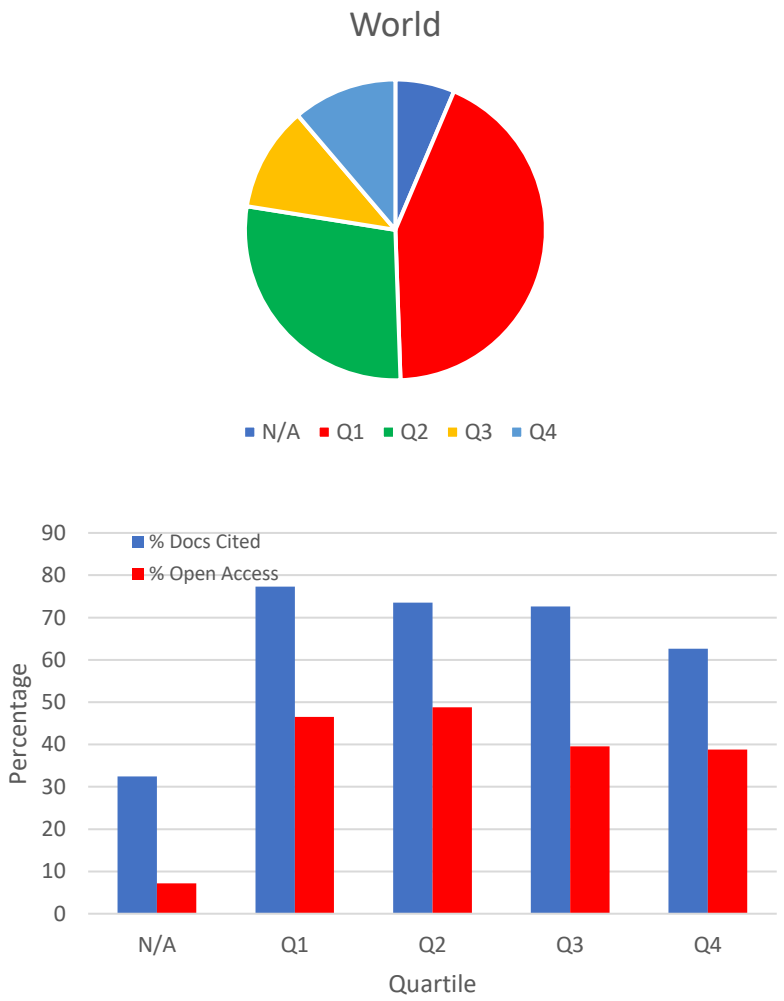
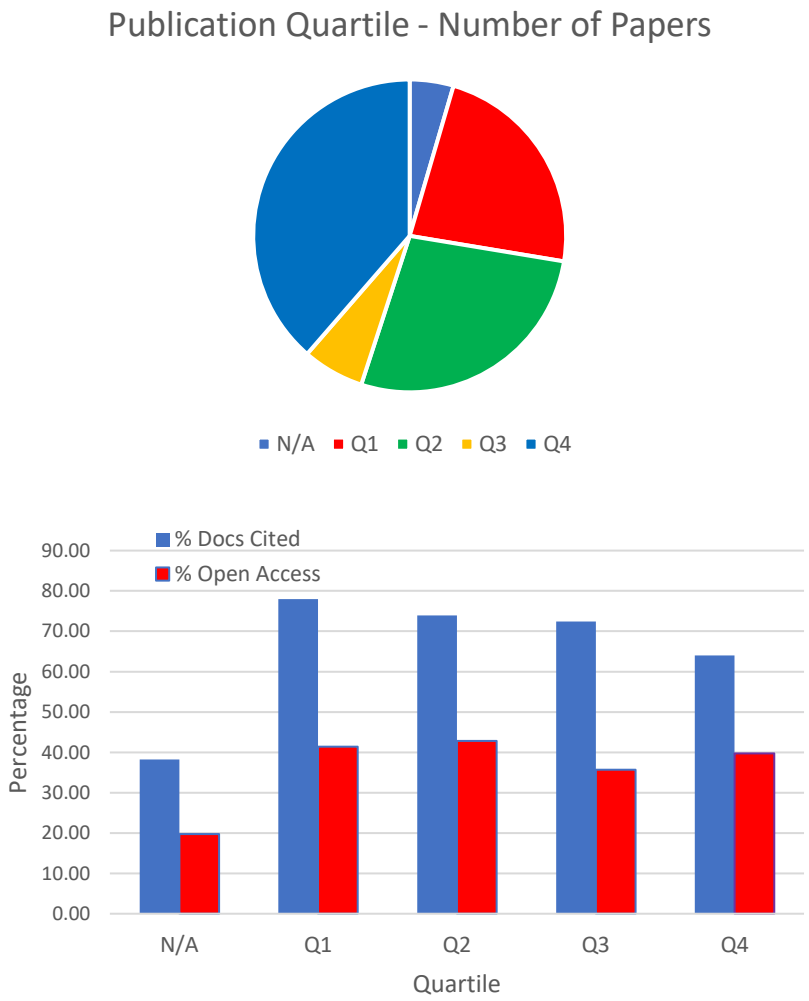


Figure 5. Effect of % Open Access Papers on Category Normalised Citation Impact (CNCI) for Physical Education for the top 20 publishing countries (InCites ®)

The worldwide tendency is to publish more papers in Q1 (43%), followed by Q2 (28%), Q3 ((11%) and Q4 (11%)journals, respectively (Figure 6). In Brazil the sequence is Q4 (39%), Q2 (27%), Q1 (23%)and Q3 (6%). When comparing Brazil to the rest of the world, the documents published in each journal category follow the same overall pattern in % Documents Cited, % Open Access and Impact Factor. In all cases, papers in Q1 show highest citation rates and impact factors, with a higher percentage of cited documents. When Brazilian researchers publish in Q1 journals, their impact tends to be higher than the worldwide average for the area.

World	Brazil





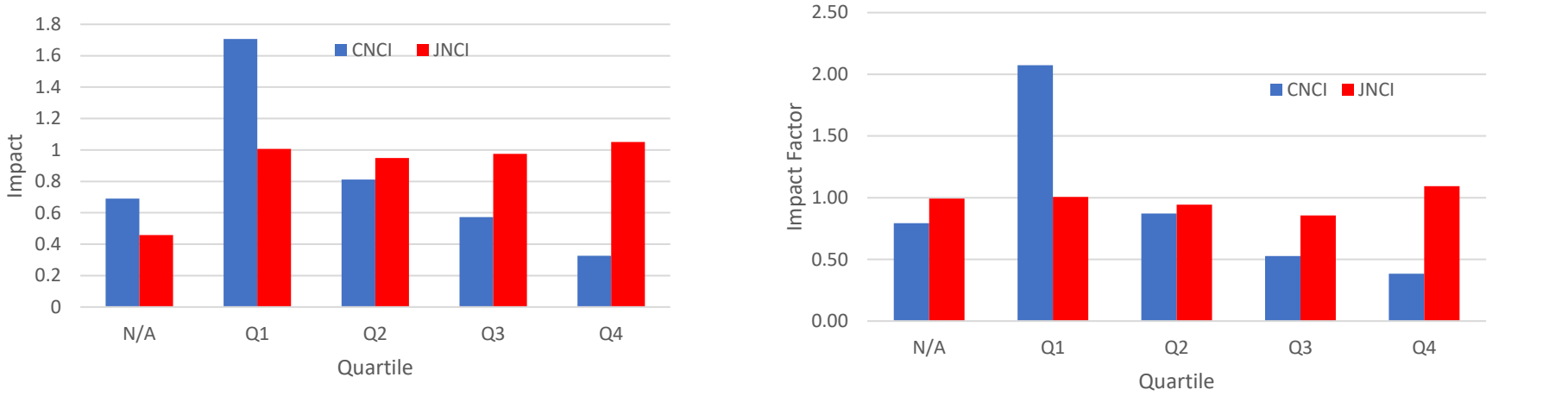


Figure 6. Effect of Journal Quartile on Quality Indicators in Physical Education worldwide (Column A) and in Brazil (Column B) (IncItes ®). Q1, Q2, Q3, Q4 are publishing quartiles while N/A refers to books and congress proceedings.

Path Analysis and Multiple Regressions

For Brazilian (-0.40) and worldwide (-0.36) authors, the % of OA documents led to a decrease in the % of documents in Q1 journals (Figure 7; Table 2), but the percentage of papers in collaboration with international authors led to an increase of % in Q1 (0.47 and 0.11, respectively). The increase in international collaborations led to a decrease in % OA publishing (-0.28 and -0.24 worldwide and Brazil, respectively), with a corresponding increase in Q4 (0.24 and 0.43, respectively). This may be related to the increase in Q1 documents for which APCs are higher. Publishing in Q4 was seen to decrease % Documents cited, which increased opportunities to be within the top 10% cited, increasing citation index and therefore CNCI. For Brazilian authors, their place on the author list (first, last or corresponding did not affect CNCI).

Table 2. Paths for Impact for Brazilian and Worldwide Authors

		Standardised Estimate	
From	To	Worldwide	Brazil
WoS	% International	-0.34**	0.05
WoS	% Industry	0.07	-0.01
WoS	% OA	-0.03	0.03
% Industry	% OA	0.24*	0.02
% International	% OA	-0.28*	-0.24**
% OA	% Q1	-0.36**	-0.40***
% OA	% Q4	0.28*	0.43***
% International	% Q1	0.47***	0.13*
% International	% Q4	-0.34**	-0.20*
% Industry	% Q1	0.38**	-0.11*
% Industry	% Q4	-0.35*	0.03
% Q4	% Docs Cited	-0.48**	-0.24**
% Q1	% Docs Cited	0.08	-0.09*
% Docs Cited	CI	0.53**	0.21**
% Q1	CI	0.75***	0.05
% Q4	CI	0.38*	-0.05
% Docs Cited	% Top 10%	0.31*	0.22**

% Docs Cited	% Top 1 %	0.31*	0.11*
% Q1	% Top 10%	0.80***	0.09*
% Q1	% Top 1 %	0.72***	0.13*
% Q4	% Top 10%	0.19*	-0.02
% Q4	% Top 1 %	0.34**	0.01
CI	CNCI	0.26**	0.89***
% Top 10 %	CNCI	0.08	0.09*
% Top 1%	CNCI	0.65**	0.28*
% Corresp. Author	CNCI		0.00
% First Author	CNCI		0.03
% Last Author	CNCI		0.00

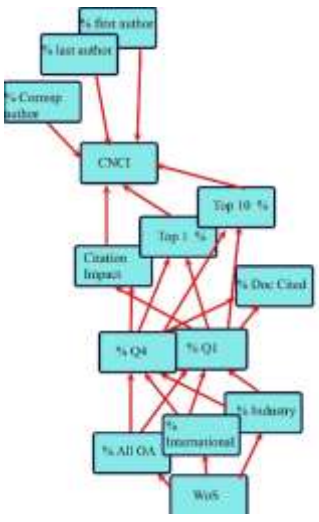
*P<0.05; **P<0.01; ***P<0.001

An increase in %Q1 journals, led to more cited documents, which in turn led to an increase in the percentage of documents in Top 10 %, Top 1 % and Citation Impact, thereby increasing the CNCI. The number of papers in WoS was related to % international papers.

Full Model

Significant Model

Brazil



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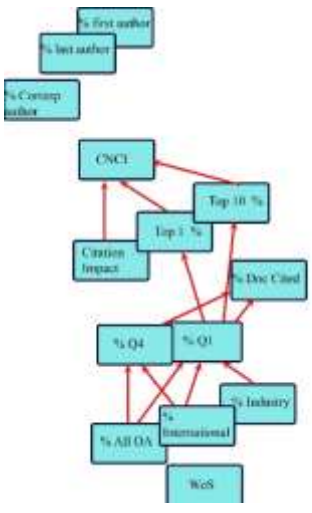

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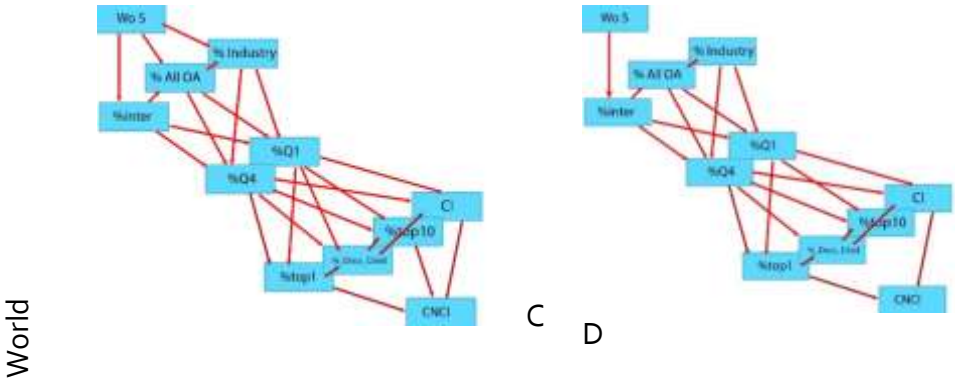

Figure7. Paths to Citation Impact tested and significant for A) and B) Brazilian and C) and D) worldwide authors in Physical Education (Incites®), in line with Table 2. A and C reflect the full model tested while B and D reflect the significant (P<0.05) paths. Abbreviations in Material and Methods

Multiple regression of Brazil's path analysis (Table 3) shows that the only variable that influence impact factor (CNCI) is where it is being publishes (JNCI), although the determination coefficient (r^2=0.22) shows this does not explain the situation completely (probably other undetermined variables play a role). Worldwide the impact factor is influenced by % of international collaboration, % of papers published in Q1 journals and % of documents cited.

Table 3. Multiple regression for impact factor in Brazilian universities and Worldwide

Brazil	**Worldwide**
CNCI = -0.299 + 0.949*JNCI	CNCI = -0.537 + 0.007*%Inter + 0.008*%Q1 +0.015*%DocCited
R^2=0.22	**R^2=0.67**

Discussion

Measuring research quality has been widely discussed in the literature. Tijssen and Kraemer-Mbula (2018) state that, to be excellent, research should be: 1) visible and recognizable; 2) attributable; 3) comparable; and 4) categorized in terms of quality judgement. Limitations in the use of metrics are well known. For example, Aksnes et al. (2019) suggest that citation metrics are not suitable for evaluating the plausibility, originality and societal value of research. Nevertheless, they can function as proxies for scientific relevance and scientific impact, rather than as a direct indicator of quality (Hicks et al., 2015; Wildsdon et al., 2015).

Most research in Brazil is produced in higher education institutions (HEIs), and many institutions have more than one program. At present there are 81 physical education postgraduate programs in Brazil[1] (36 academic masters, 4 professional masters, 40 academic masters and doctorates and one professional masters and doctorate). The major knowledge areas for physical education in Brazil include physical education (39 programs), physical and occupational therapy (30) as well as speech therapy (12).

In general, an increase in % of papers published in Open Access journals leads to an increase in Citation Impact, except for Brazil. The lower percentage of increase in citations from Brazilian Open Access publishing compared with worldwide authors (Figure 1 and 5) may be a reflection of publishing in journals registered in platforms such as Scielo (scielo.org - Scientific Electronic Library Online) and Redalyc https://www.redalyc.org/ (Sistema de Información Científica Redalyc Red de Revistas Científicas). Both register open access journals and these journals tend to be younger than more established data bases such as Scopus and Web of Science. Nevertheless, numbers of Scielo and Redalyc journals in international databases have been increasing in recent years (McManus et al., 2020, 2021).

[1]https://sucupira.capes.gov.br/sucupira/public/consultas/coleta/programa/quantitativos/quantitativoAreaConhecimento.jsf?areaAvaliacao=21

Other factors may influence this result such as i) failure to publish in high impact journals; ii) lack of resources to pay expensive open access (OA) costs abroad preferring lower OA costs in Brazil; iii) lack of policies in funding agencies for publishing; iv) the themes studied and v) publishing in Portuguese in Brazil. While there may be a perceived lower quality of research from Brazilian researchers, as seen here, when Brazilian researchers publish in Q1 journals, their impact tends to be higher than the worldwide average for the area.

The preference for publishing in Brazilian journals is seen, in line with other areas in Brazil (McManus et al., 2021b). While abroad, open access tends to show higher impact than closed access, most Brazilian authors publish in Brazilian journals, which, although Open Access, show low impact. This was seen in Kokubun (2003) looking at CAPES data. With Iranian publications (Rajabi et al., 2021), these authors also found that most papers are published in domestic journals in the Web of Science Emerging List, as with Brazilian papers. Looking at education journals, Repiso et al. (2017) show that Scielo (125) and Redalyc (99) have a significantly higher number than Scopus (66) and Social Sciences Citation Index (9). This may indicate that international databases probably do not capture their citations. At the same time, Van Leeuwen et al. (2001) and Van Raan et al. (2011) show that fewer citations are received by non-English language publications This can create a bias due to language deficiencies (Waltman, 2016), with most local journals being invisible internationally (Tijssen et al., 2006; Li & Yang, 2020).

The number of papers in the most popular themes studied worldwide and in Brazil showed a correlation of 0.79, indicating similarity between the two datasets. Nevertheless, papers published in journals not registered in Scopus and Web of Science were not included in this analysis and a significant fraction of the "topics" defined by SciVal does not perfectly fit the article's field (Zanotto & Carvalho, 2021) which may lead to bias. Nascimento (2010), in a survey of thesis themes in physical education found that the main areas of research were Physical/Sports Training (12.9%). Biomechanics (8.7%). Physical Activity/Sports in special groups (8.4%); Teacher Training/Physical Education and curriculum (8.1%); Physiology (7.5%); Sociology (6.6%) and Physical Education/sports in schools (6.3). This author showed a

large amount of research lines with low production indices. On the other hand, Manoel & Carvalho (2011) showed concentration in biodynamics, in detriment of sociocultural and pedagogical areas of research, while Lazzarotti Filho et al. (2012) noticed wide dispersion in the themes studied.

In the present study (Supplementary Table 2) questions linked to older ages such as osteoarthritis, knee, *Medialis oblique,* bone density, frailty (elderly, phenotype), Alzheimer's, as well as life style such as diabetes remission, body mass index, behaviour and prolonged sitting etc are also more prevalent and showed significant growth in recent years. This is in line with Formica (2002) and Green et al. (2006) who showed a move away from studies with children in school towards more adult physical education and life-style choices. Important research areas centre around conditions such as aging (Osteoarthritis, fragility), lifestyle (diabetes, body mass index (BMI), hypertension, obesity) and illnesses (such as cancer, diabetes, hypertension etc). Given the effect that earlier experiences with physical education have on adult physical activity and life style choices (Ladwig et al., 2018), these authors suggest that research efforts should include how childhood memories affect physical activity and health in terms of attitude, intention and sedentary behaviour in adulthood. Balwan & Kour (2021) state that Lifestyle Disease are a major health problem worldwide, with cardiovascular, cancers, respiratory and diabetes linked diseases accounting for over 80% of non-communicable disease deaths (WHO, 2017). Many of the most prevalent techniques seen in Supplementary Table 2 have been used in the control of these conditions. Quennerstedt (2019) argues for the use of health in physical education, and the themes studied here confirm this tendency, through promoting activities and behaviour that reduce the risk of disease, at present or in the future.

International and industry collaboration in Brazilian physical education is low (Figure 2) which may affect impact (Figure 7). Other studies (McManus et al., 2020; McManus & Baeta Neves, 2021) have shown the importance of these sectors in improving citation impact, through improving quality, competition, knowledge and resource transfer, among others (Boekholt et al., 2009). Rosa & Leta (2010, 2011) concluded that research in PE in Brazil has low visibility, based on studies in physiology. Nevertheless, other areas such as Sociology and Psychology as well as biophysics

were also predominant. Part of this lack of visibility may be due to the fact that Brazilian authors tend to show low international collaboration compared with other countries (Figure 2), although Brazil still being within the top ten publishing countries in physical education. This may be because this area is a relatively new in Brazil. Motta et al. (2018) looks at ways of increasing linkages between physical education sectors in industry and academy, but identified resistance on both parts.

Brazilian authors tend to publish more in Q4 journals (Fig 6), so efforts should be made to publish in Q1 journals and increase industry relations (Figure 10). This obviously is impacted by the quality of the research being carried out. Changes in public policies can change this, as was seen with the Russian Project 5-100 (Matveeva & Ferligoj, 2020), and increasing international collaborations. The number of papers and impact (Figure 1) is in line with general statistics on Brazilian publishing (McManus et al., 2020), especially with the domination of the USA. Brazil's location in this analysis is also in line with the general evaluation. The low number of papers in Q1 and high impact open access journals may be because of the lack of financial resources (Pavan & Barbosa, 2018) to pay Article Processing Charges (APCs).

Several recent papers have discussed the impact of research in Brazil relative to its social and cultural relevance, other than scientific (McManus & Baeta Neves, 2021). According to Vitor-Costa et al. (2012), bibliographic measures are more suitable to measure production in the basic and not professional sciences, such as physical education. Lazzarotti Filho et al. (2012) also noticed a mixture of themes related to the soft and hard sciences in physical education journals in Brazil, and Hallal & Melo (2016) indicate that research in physical education has a tendency to be more interdisciplinary than other areas, but consider "over-fragmentation" may be a problem in the future, thereby making it an appendix of other more consolidated areas.

Conclusions

To increase impact, Brazilian authors in physical education should aim to increase the number of papers published abroad, in high impact open access Q1 journals. As a large portion (>60%) of Brazilian papers in Q1 journals are published closed access

there needs to be financial resources to pay Article Processing Charges. Increases in publishing in collaboration with industry and internationally are indicated for increasing impact of publications by Brazilian authors in physical education.

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Conflict of Interest

The authors declare no conflict of interest.

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557 Supplementary Table 1. Percentage Open Access and CNCI by Journal Quartile and Publishing Country in Physical Education.

	Mean % Open Access					Mean CNCI				
Journal publishing country	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Mean
Worldwide publishing in physical education										
Argentina				100.00	100.00				0.22	0.22
Australia	20.30	46.21	13.69	51.86	35.64	1.22	0.69	0.51	0.48	0.66
Austria			15.49		15.49			0.41		0.41
Bangladesh			36.78		36.78			0.64		0.64
Brazil		100.00	100.00	100.00	100.00		0.52	0.47	0.17	0.33
Bulgaria				0.00	0.00				0.09	0.09
Canada	49.82	22.76	51.43	10.16	36.88	1.24	0.77	0.64	0.40	0.81
Chile				78.09	78.09				0.26	0.26
China Mainland	100.00	50.12	100.00	86.92	81.19	1.85	0.59	0.47	0.47	0.97
Colombia			100.00		100.00			0.18		0.18
Croatia			100.00	100.00	100.00			0.56	0.23	0.48
Czech Republic				79.74	79.74				0.32	0.32
Denmark	19.04	16.48		0.00	13.64	1.42	1.16		0.33	1.08
Egypt	100.00			60.16	80.08	0.23			0.30	0.27
England	57.29	57.81	45.71	41.44	53.88	1.86	0.92	0.67	0.46	1.14
Ethiopia				1.84	1.84				0.27	0.27
Finland	78.25				78.25	1.29				1.29
France		100.00	1.47	14.30	22.40		0.46	0.21	0.22	0.24
Germany (Fed Rep Ger)	39.69	12.63	20.29	8.23	21.46	1.12	0.77	0.64	0.24	0.69
Greece				0.00	0.00				0.53	0.53
Hong Kong			100.00		100.00			0.21		0.21
Hungary				54.05	54.05				0.13	0.13
Iceland				100.00	100.00				0.19	0.19
India		92.30	50.00	31.76	45.62		0.53	0.20	0.20	0.25
Iran		38.96	3.76	84.35	43.04		0.36	0.57	0.35	0.44

Ireland	22.37	15.59	7.79		15.25	1.03	1.10	0.61		0.91
Israel		100.00		0.00	50.00		2.15		0.37	1.26
Italy	0.00	23.33	0.00	25.09	18.67	0.09	1.01	0.13	0.51	0.45
Jamaica				30.23	30.23				0.19	0.19
Japan	100.00	97.20	96.73	100.00	98.27	0.97	1.13	0.49	0.00	0.74
Kuwait			100.00	0.00	50.00			0.44	0.03	0.24
Lithuania			98.68		98.68			0.37		0.37
Malawi				86.88	86.88				0.33	0.33
Malaysia			15.09	46.67	30.88			0.44	0.11	0.28
Mexico			52.00	18.75	40.92			0.36	0.12	0.28
Nepal				100.00	100.00				0.09	0.09
Netherlands	29.09	20.37	16.52	21.61	24.35	1.57	0.99	0.56	0.46	1.16
New Zealand	16.85	100.00	25.00	100.00	59.78	1.29	0.73	0.58	0.40	0.84
Nigeria				4.57	4.57				0.25	0.25
Norway		19.27		9.86	14.56		1.05		0.35	0.70
Pakistan				52.78	52.78				0.26	0.26
Poland		88.89	76.92	80.64	81.73		1.10	0.61	0.29	0.70
Portugal				100.00	100.00				0.35	0.35
Romania			0.00		0.00			0.00		0.00
Russia				66.67	66.67				0.08	0.08
Saudi Arabia		100.00	50.00	94.29	73.57		0.00	0.36	0.28	0.25
Scotland	100.00			22.22	61.11	0.96			0.17	0.56
Serbia				100.00	100.00				0.14	0.14
Singapore			20.41		20.41			0.69		0.69
Slovakia			46.15		46.15			0.12		0.12
Slovenia				91.14	91.14				0.23	0.23
South Africa			92.42	16.15	73.35			0.47	0.36	0.44
South Korea		100.00			100.00		0.63			0.63
Spain			34.36	92.44	63.40			0.49	0.18	0.33

Sri Lanka				25.00	25.00				0.25	0.25
Sweden	33.33	97.50	15.34		60.92	1.68	0.67	0.58		0.90
Switzerland	92.40	68.05	35.66	37.37	73.98	1.39	0.85	0.56	0.49	1.03
Taiwan		60.75			60.75		0.68			0.68
Thailand				50.00	50.00				0.17	0.17
Turkey			100.00	52.00	84.00			0.49	0.20	0.39
Uganda				67.01	67.01				0.68	0.68
Usa	40.75	34.12	28.11	19.98	32.68	1.88	0.90	0.58	0.47	1.11
Wales			5.65		5.65			0.47		0.47
Total	48.08	51.35	42.47	40.62	45.82	1.72	0.88	0.55	0.34	0.91

B) Brazilian Authors

	% OA					**CNCI**				
	Q1	Q2	Q3	Q4	Total	Q1	Q2	Q3	Q4	Mean
Argentina				100.00	100.00				0.16	0.16
Australia	7.69	0.00	56.94	50.00	39.79	1.14	0.32	0.24	0.57	0.48
Bangladesh			21.74		21.74			0.65		0.65
Brazil		100.00	100.00	100.00	100.00		0.56	0.48	0.18	0.34
Canada		16.31	0.00	0.00	8.16		0.54	0.23	1.66	0.74
Chile				100.00	100.00				0.64	0.64
China Mainland	100.00	50.00		88.24	72.06	2.35	0.94		0.24	1.12
Colombia			100.00		100.00			0.20		0.20
Croatia			100.00		100.00			0.38		0.38
Denmark	4.04	6.11			4.73	1.15	1.35			1.21
England	52.26	52.23	37.42	44.79	48.85	2.24	0.88	0.69	0.32	1.27
Finland	83.33				83.33	3.21				3.21
France		100.00		32.43	49.33		0.31		0.16	0.20
Germany (Fed Rep Ger)	22.35	23.05	20.00	0.00	20.08	1.29	0.65	0.64	0.00	0.88
India		94.12			94.12		0.62			0.62
Iran		0.00	0.00	100.00	33.33		0.08	0.32	1.12	0.51

Ireland	22.22	12.36			17.29	1.04	0.93			0.99
Israel		100.00		0.00	50.00		0.00		1.11	0.56
Italy				28.57	28.57				0.53	0.53
Jamaica				100.00	100.00				0.00	0.00
Japan	100.00	88.89	100.00		96.30	0.66	0.46	0.65		0.59
Lithuania			100.00		100.00			0.41		0.41
Malawi				100.00	100.00				0.00	0.00
Mexico			100.00		100.00			0.33		0.33
Netherlands	33.96	20.69	20.00	83.71	31.41	0.97	1.01	0.58	0.14	0.88
New Zealand	10.78	100.00		100.00	64.31	1.13	0.78		0.25	0.81
Norway		25.00		0.00	12.50		1.23		0.26	0.74
Poland		100.00	70.83	100.00	82.50		0.48	0.36	0.39	0.39
Portugal				100.00	100.00				0.89	0.89
Scotland	100.00				100.00	0.73				0.73
Singapore			0.00		0.00			0.65		0.65
Slovakia			100.00		100.00			0.15		0.15
South Africa				0.00	0.00				0.28	0.28
South Korea		100.00			100.00		0.24			0.24
Spain			100.00	97.44	98.08			0.37	0.12	0.18
Sweden		100.00	16.67		58.33		0.87	0.72		0.79
Switzerland	98.19	61.53	22.22	27.66	67.65	1.58	0.76	0.46	0.27	0.97
Thailand				0.00	0.00				0.18	0.18
Turkey			100.00		100.00			0.75		0.75
USA	36.94	30.80	18.55	26.80	29.48	2.31	0.83	0.56	0.46	1.27
Wales			8.57		8.57			0.72		0.72
Mean	43.53	45.26	36.72	45.95	42.88	2.10	0.81	0.56	0.40	1.09

Supplementary Table 2. Growth, Impact and Prominence of Topics by Brazilian authors with more than 100 papers sorted by growth of topic (Scival® 2015 – 2020)

	Scholarly Output	Growth (%)	Field-Weighted Citation Impact	Prominence percentile
Resistance Training	505	222.34	1.01	82.35
Plyometric training	122	218.70	1.14	98.41
Moderate-intensity continuous	133	216.10	1.09	98.74
Carcinoma, Papillary	108	196.28	2.43	92.02
Osteoarthritis, Knee	134	137.12	1.13	94.34
Vitamin D Deficiency	225	98.88	1.34	96.56
Bone Density	154	77.79	1.16	84.72
Medialis oblique	112	72.40	1.06	94.61
Behavior	102	54.60	3.44	99.48
Prolonged sitting	102	54.60	3.44	99.48
Thyroid Neoplasms	258	53.63	1.91	86.97
Diabetes remission	124	49.40	1.14	99.03
Body Mass Index	193	48.70	1.03	94.22
Frail Elderly	198	36.30	1.22	99.73
Frailty phenotype	198	36.30	1.22	99.73
Training RT	216	17.00	1.26	95.93
Arcuate nucleus	100	15.60	1.04	99.26
Hypothalamus	100	15.60	1.04	99.26
BFR exercise	108	13.90	1.29	92.86
Health	222	8.93	8.86	68.52
Muscle index	235	4.20	1.67	99.78
Sarcopenia	236	4.20	1.20	86.33
Inactivation PDI	409	1.80	1.17	98.92
Peptidyl-Dipeptidase A	163	0.50	1.12	95.49
Receptor axis	163	0.50	1.12	95.49
Adipose Tissue, Brown	104	0.25	1.00	93.58
Hypertension	257	-0.92	0.99	73.62
Photosensitizing Agents	495	-2.25	1.20	86.53
Metagenome	208	-5.20	1.59	99.99
Microbial composition	208	-5.20	1.59	99.99
Adipose Tissue	108	-15.43	1.05	58.69
Osteoporosis	341	-15.77	1.03	81.64
MPS IIIA	180	-17.20	1.14	96.09
Muco-polysaccharidoses	180	-17.20	1.14	96.09
Foot	105	-19.30	1.06	78.81
Mutation	107	-21.87	1.31	85.65
Photochemotherapy	540	-26.13	1.35	68.33
Alzheimer Disease	414	-28.38	1.16	76.57
Diet, High-Fat	192	-28.50	1.17	96.13
Weight Loss	170	-31.03	0.99	89.31
Rehabilitation	144	-32.86	5.80	64.60
Mitochondria	106	-38.38	1.79	79.14
Neoplasms	147	-45.44	1.05	66.49
Intercellular Signaling Peptides & Proteins	118	-48.90	1.19	98.89
Risk	201	-59.50	1.28	74.05
Diabetes Mellitus, Type2	206	-66.04	4.32	86.30
Periodicals Topic	245	-81.96	3.80	59.65
Blood Platelets	129	-82.97	1.14	77.01