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TÜRK FİZYOTERAPİ VE REHABİLİTASYON DERGİSİ

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FUNCTIONAL PERFORMANCE OF GERIATRIC INDIVIDUALS: A BIBLIOMETRIC OVERVIEW

ABSTRACT

Purpose: Functional performance reflects older adults' ability to perform work and daily living activities. The aim of this study is to analyze the articles on functional performance in older adults.

Methods: The Web of Science database was searched for the titles of English-language articles including "functional performance" and ("geriatric" OR "elderly" OR "aging" OR "older" OR "old age") words. Biblioshiny and VOSviewer software were used to present the thematic structure and mapping of analysis.

Results: A total of 154 English-articles published between the years 1995 and 2023 were included. The average citation per document was 31.47. The peak of the total citation count over years was seen in 1998 (9.4 citations). The year with the lowest average citation was 2003. The year with the highest number of publications was 2021. Brazil and the United States of America (USA) were the most productive and cited countries. The USA was the most relevant country, but only 5.13% of the publications were with multiple countries. Cress ME was the most relevant author. The most highly cited source was "Journal of the American Geriatrics Society". The most frequent word was "strength".

Conclusion: The results of this study provide important clues about the leading researchers and countries, and publication and citation potentials of studies regarding the functional performance of older individuals. The findings emphasize the significant deficiency in international cooperation; and provide the authors with valuable clues in determining original and specific goals for their future work on the subject and in realizing collaboration opportunities.

Keywords: Bibliometric analysis, Exercise, Functional status, Muscle strength, Old age

GERİATRİK BİREYLERİN FONKSİYONEL PERFORMANSI: BİBLİYOMETRİK BİR BAKIŞ

ÖZ

Amaç: Fonksiyonel performans, yaşlı yetişkinlerin iş ve günlük yaşam aktivitelerini gerçekleştirme becerilerini yansıtır. Bu çalışmanın amacı yaşlı yetişkinlerde fonksiyonel performansla ilgili makaleleri analiz etmektir.

Yöntem: Web of Science veri tabanında "functional performance" ve ("geriatric" OR "elderly" OR "aging" OR "older" OR "old age") kelimelerini içeren İngilizce makalelerin başlıkları arandı. Analizin tematik yapısını ve haritalamasını sunmak için Biblioshiny ve VOSviewer yazılımı kullanıldı.

Bulgular: 1995-2023 yılları arasında yayınlanan toplam 154 İngilizce makale çalışmaya dahil edildi. Belge başına ortalama atıf sayısı 31,47'dir. Yıllara göre toplam atıf sayısının zirvesi 1998 yılında görüldü (9,4 atıf). Ortalama atıf sayısının en düşük olduğu yıl 2003'tür. En fazla yayının yapıldığı yıl 2021'dir. Brezilya ve Amerika Birleşik Devletleri (ABD) en üretken ve en çok atıf alan ülkelerdi. Konuyla en ilgili yazarın Cress ME, ülkenin ise ABD olduğu, yayınların sadece %5,13'ünün farklı ülkelerle işbirliği ürünü olduğu görüldü. Konuya ilişkin yayınlarda en çok "Journal of the American Geriatrics Society"ye atıf yapıldığı ve yayınlarda en sık kullanılan kelimenin "strength (kuvvet)" olduğu saptandı.

Sonuç: Bu çalışmanın sonuçları, yaşlı bireylerde fonksiyonel performansa yönelik literatür örneklerinde ele alınan konular, önde gelen araştırmacılar, ülkeler ve de konuyla ilgili çalışmaların yayımlanma ve atıf alma potansiyeli konusunda önemli ipuçları sunmaktadır. Bulgular, uluslararası işbirliğindeki önemli eksikliği vurgulamakta olup yazarlara, konuya ilişkin gelecekteki çalışmaları için orijinal ve belirli hedefler belirlemede ve işbirliği fırsatlarının farkına varmada değerli ipuçları sağlamaktadır.

Anahtar Kelimeler: Bibliyometrik analiz, Egzersiz, Fonksiyonel durum, Kas kuvveti, Yaşlı

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INTRODUCTION

Functional performance reflects an individual's ability to perform work (1) and is an important determinant of older adults' ability to perform basic and instrumental activities of daily living (1,2). Assessment of functional performance in older adults generally involves assessment of changes in functional capacity (1).

Aging is a process associated with the deterioration of various physiological capacities such as muscle strength, aerobic capacity, neuro-motor coordination, and flexibility (3). These physiological impairments in turn, may predispose a range of functional limitations in older people (4), and aging is an independent risk factor for deterioration in functional capacity (5). As people grow older, changes in health status and an increasing prevalence of chronic diseases, may lead to difficulties in performing daily activities such as self-care, household maintenance, shopping, and other community activities, voluntary or work pursuits, and recreation and leisure activities (1). Assessment of functional performance is important for physiotherapists and other clinicians since it is an indicator of the mobility, lower and upper limb function, and competency in activities of daily living in older adults (1).

Health research, especially in the fields of geriatrics and gerontology, requires the analysis of complex biological, psychological, and social situations with advanced statistical tools (6). Professionals and scientists need various theoretical and practical tools to measure data. Bibliometrics is an important tool for assessing and analyzing the output of scientists, collaboration among universities, the impact of government science funding on national research, development performance, and educational effectiveness (7). Bibliometric analysis provides a quantitative examination of the literature (8), and network analysis describes multifactorial conditions and multiple variables considering a complex data structure (7). As highlighted in recent studies, bibliometric analysis allows researchers to track publications, funders, journals, and conceptual structures, offering a solution to the limitations of traditional methods in the face of exponential data growth (7,9).

Bibliometric analysis studies in the geriatrics and gerontology field are limited with the topics of physical activity, sarcopenia, Alzhemier's disease, dementia, and cardiac aging in the current literature (10-15). Although there are systematic review studies about functional performance in older adults in the literature (16-20) no bibliometric and network analysis studies exist, and there is a lack of knowledge about prominent researchers, institutions, and countries in this field.

This study aimed to analyze the studies related with the functional performance of older people from a bibliometric perspective, and to guide further clinical practice and research collaborations worldwide. The results of this study may help to guide future studies by showing out the properties and scope details of the most cited literature samples, presenting the issue trends, and therefore, may contribute to expanding and producing new knowledge regarding the subject.

METHOD

Study Design

This study has a bibliometric analysis design that reveals the bibliometric and intellectual structure by analyzing the social and structural relationships between different research parameters. The parameters analyzed in this research are publication outputs, research fields, authors, country-specific analysis, citation analysis and words.

Data Acquisition and Search Strategy

This study is based on the Web of Science (WoS) database that developed by Thomson Reuters (1990), is a platform based on web technology (21). The WoS database is almost one of the best standardized indices of research performance in different disciplines. It provides better graphics and more detailed citation analysis than other databases such as Scopus, PubMed, etc. (21). In this study, it was the preferred database in the analysis because it provides comprehensive data in terms of bibliometric information.

The keywords "functional performance" and ("geriatric" OR "elderly" OR "aging" OR "older" OR "old age") were searched On September 13, 2023.

A total of 258 publications were found. When only English language articles as document type were included, and other source types such as conference papers, reviews, data papers, editorial materials, and retracted papers were excluded, a total of 154 articles were found to be eligible for the data analysis.

After the first search, the literature was checked by two researchers (S.Y. and İ.Ç.K.) independently.

Analysis Tool and Data Analysis

The Bibliometrix package of R studio version (2023.06.1+524) was used for the bibliometric analysis (22). Biblioshiny - a web interface for bibliometrix is a Java software developed by Massimo Aria from the University of Naples Federico II (Italy) in 2019 (7). Biblioshiny combines the functionality of the bibliometrix package with the easy use of web apps through the Shiny package environment and is recommended to researchers who do not use codes for analysis (7). The analysis options are subdivided into seven categories as overview, sources, authors, documents, conceptual structures, intellectual structure, and social structure (7).

VOSviewer (The Centre for Science and Technology Studies, CWTS, Leiden, The Netherlands) (version 1.6.19) (23), a freely available software was used to run the analysis and mapping. VOSviewer analysis and visualized maps that can be connected based on co-authorship relations, co-occurrence citation, or co-citation link (23). The records of the search results were exported in plain text format for VOSviewer.

RESULTS

Publication Outputs

One hundred fifty-four English articles published between the years 1995 and 2023 were included in the study.

The number of relevant publications range from 1 to 15 per year, being the lowest in the years 1995, 1998, 2000, and 2003; and the highest in the year 2021.

The local-impact sources were measured using the high citation count (h-index), which was proposed by Jorge E Hirsch of the University of California, San Diego, USA, in 2005. It is a mixed quantitative metric used to assess the scholarly achievement of researchers. The higher the h-index, the greater the academic impact. The h-index indicates that a person has "h" papers, each of which has been cited at least "h" times in a given period (24). The average h-index of all articles was 38 based on the WoS database.

According to the local source impact analysis, *Archives of Gerontology and Geriatrics* (185 total citations in 2002), and *Archives of Physical Medicine and Rehabilitation* (with 326 total citations in 1996) were the journals with the highest h-index value (h-index: 5). *Age and Ageing, Journal of Strength and Conditioning Research,* and *Journal of the American Geriatrics Society* ranked third through fifth, with h-index of 4, and total citations of 406, 123 and 463, respectively.

The average citation per document was 31.47 between 1995 and 2023, and average citations per year was the highest in 1998 (9.4 citations), and the lowest in 2003 (0.1 citation).

Research Fields

The most productive research field was "Geriatrics-Gerontology" with 54 articles, followed by "Rehabilitation" with 32 articles. Gerontology and Sport Sciences with 30 articles, rank third and fourth. Orthopedics, Medicine General Internal, Public Environmental Occupational Health, Neurosciences, Nutrition Dietetics, Physiology, and Psychology are the other most productive research areas, respectively.

Authors

The number of publications of an author on a specific subject is considered an indicator of his/her scientific activity in this field. Biblioshiny-R output showed that Cress ME and Buchner DM were the first authors in this field by their publications in 1996. Cress ME, a well-known author who has published five articles on functional performance in geriatric individuals, can be considered as one of the most influential authors in this field, having contributed strongly to the academic literature on functional performance in older people. It can be seen that, the number of authors reached maximum between 2008 and 2016, and Bezerra ES, who began publishing in the relevant field in 2018 is the top author currently. Another finding of this study is that the average number of co-authors per document related with the functional performance of geriatric individuals is 5.38, and only 20.13% of the articles had international co-authorship (Figure 1).

The Most Relevant Authors, Journals, and Affiliations

Table 1 presents the most relevant authors, journals, and affiliations about functional performance of geriatric individuals. According to the number of relevant articles and citations, *Archives of Gerontology and Geriatrics* seems to be the most influential journal, and The Federal University of Minas Gerais in Brazil seems to be the most relevant institution in this field (Table 1).

Country-Specific Analysis

The top 10 most productive and cited countries are shown in Table 2. The most productive country was Brazil with 173 publications followed by the USA which was the most cited country with 2125 citations in this research field (Table 2).

The analysis of corresponding authors by countries is shown in Figure 2. Single Country Publications (SCP) show the number of the articles published by the authors from the same country, and Multiple Country Publications (MCP) indicate the articles published by the collaboration with other researchers from different countries. According to Figure 2, the USA is the most productive country with the highest number of corresponding authors in 39 articles (SCP: 37, and MCP: 2), followed by Brazil with 38 articles. While the publications of corresponding authors from China and Japan are all SCP, Brazil is the country with the highest number of MCPs (n=8). However, when the ratio of MCP over total number of publications is considered, Australia and Canada seem to be the countries with the highest collaboration of authors from different countries (Figure 2).

Citation Analysis

The most highly cited paper was written by Hurley et al. (25), in 1998 with 244 citations, and published in the "*Age and Ageing*" journal (Table 3). The functional performance of older people was assessed by timed up & go test, and stair ascent & descent tests, and was compared with those of healthy young and middle-aged subjects in this study (25).

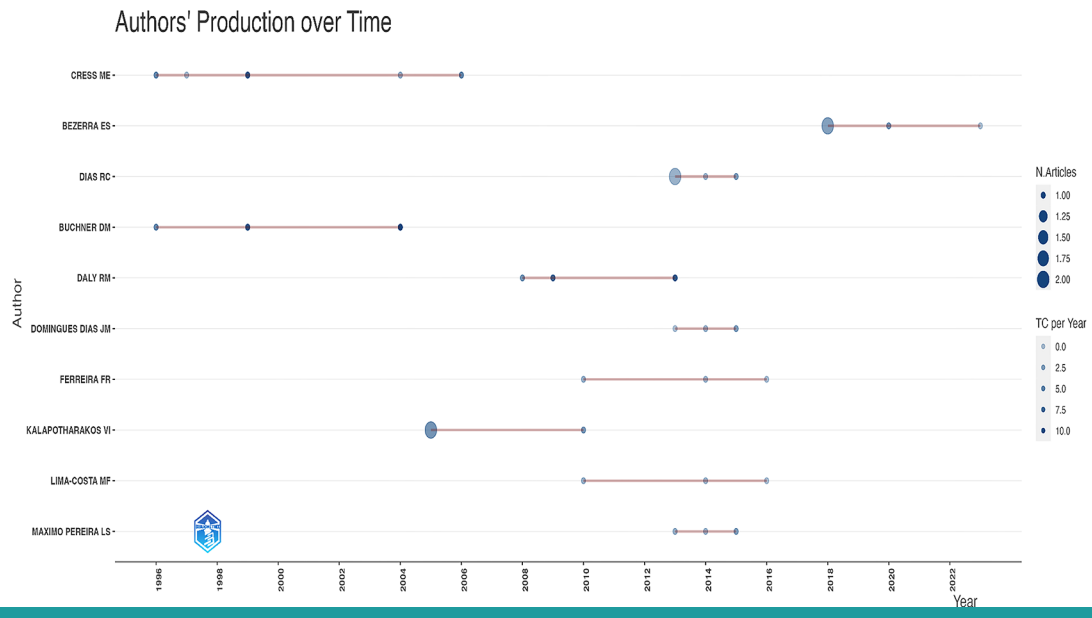

Figure 1. Authors' production over time.

Table 1. The top 10 most relevant authors, journals, and affiliations

	Author	Number of documents	Journal	Number of documents	Affiliation	Number of documents
1	Cress ME	5	Archives of Gerontology and Geriatrics	6	Univ Fed Minas Gerais	29
2	Bezerra ES	4	Archives of Physical Medicine and Rehabilitation	5	Univ Sao Paulo	19
3	Dias RC	4	Journal of Strength and Conditioning Research	5	Katholieke Univ Leuven	11
4	Bunchner DM	3	Age and Ageing	4	Vrije Univ Amsterdam	10
5	Daly RM	3	BMC Geriatrics	4	Univ Melbourne	9
6	Domingues Dias JM	3	Journal of Aging and Physical Activity	4	Univ Copenhagen	8
7	Ferreira FR	3	Journal of The American Geriatrics Society	4	Copenhagen Univ Hosp	7
8	Kalapotharakos VI	3	Topics in Geriatric Rehabilitation	4	Univ Georgia	7
9	Lima-Costa MF	3	Aging Clinical and Experimental Research	3	Univ Vienna	7
10	Maximo Pereirals	3	American Journal of Physical Medicine & Rehabilitation	3	Univ Washington	7

Words

The word cloud displays words in different sizes depending on how often they occur. The placement of the words is somewhat random, with dominant words placed in the center to make them more visible given the larger its size (26). A word cloud was created with Biblioshiny (R) to show the frequency of the keywords which occurred more than 10 times. It was found that "strength" (34 occurrences), "exercise" (33 occurrences), and "disability" (32 occurrences) were the most frequent words (Figure 3A).

Among the 366 keywords, 20 met the threshold of a minimum of 5 occurrences for mapping in VOSviewer. For each of the 20 keywords, the total strength of the co-occurrence links with other keywords was analyzed. As shown in Figure 3B, the most frequent keywords fall into four clusters.

Cluster 1 was the largest cluster, with eight keywords marked in red circle, mainly related to "muscle strength", "balance", "elderly", and "functional performance", "gait", "physical function", "sarcopenia", and "strength training" (Figure 3B).

Cluster 2 was marked in green circles and included six keywords: "aged", "cognition", "physical fitness", "physical functional performance", "rehabilitation", and "resistance training" (Figure 3B).

Cluster 3 with three keywords was marked in blue circles, including "aging", "exercise", and "strength" (Figure 3B).

Table 2. The top 10 most productive and cited countries

	Most productive countries	Frequency	Most cited countries	Number
1	Brazil	173	USA	2125
2	USA	166	Brazil	792
3	Denmark	43	Australia	459
4	China	38	United Kingdom	281
5	Australia	36	Netherlands	174
6	Netherlands	31	Canada	147
7	Spain	26	Belgium	136
8	Canada	19	Finland	128
9	Belgium	18	Denmark	114
10	Japan	14	Greece	114

USA: United States of America.

Cluster 4 consists of three keywords marked in a yellow circle. The keywords included "activities of daily living", "older adults", and "physical activity" (Figure 3B).

The term "aging" occurred 27 times and had 28 total link strength in the blue circle. The term "functional performance" occurred 20 times (10 link, 17 total link strength), and "muscle strength" occurred 19 times (14 links, 29 total link strength) (Figure 3B).

DISCUSSION

The analysis of the literature shows that the publications related with functional performance in older people, fluctuated at low levels during the initial periods of 1995. However, the number of publications increased rapidly between 2017 and 2021, reaching the highest level in 2021 with only 15 articles. A number as low as 15, even in the highest period, suggests that there is not enough interest in this field or that sufficient publication conditions have not been achieved by the researchers.

Geriatrics and Gerontology is the most productive research field, and followed by *Rehabilitation* in present study. Functional performance is important not only for determining functional status, but also for monitoring the overall clinical development of older adults (27). In the context of rehabilitation strategies, it is important in the older population to assess and reach the optimal level of functional performance, as this predicts falls, adverse health events and deaths (27,28). From this point of view, it is thought that *Geriatrics and Gerontology* rank first,

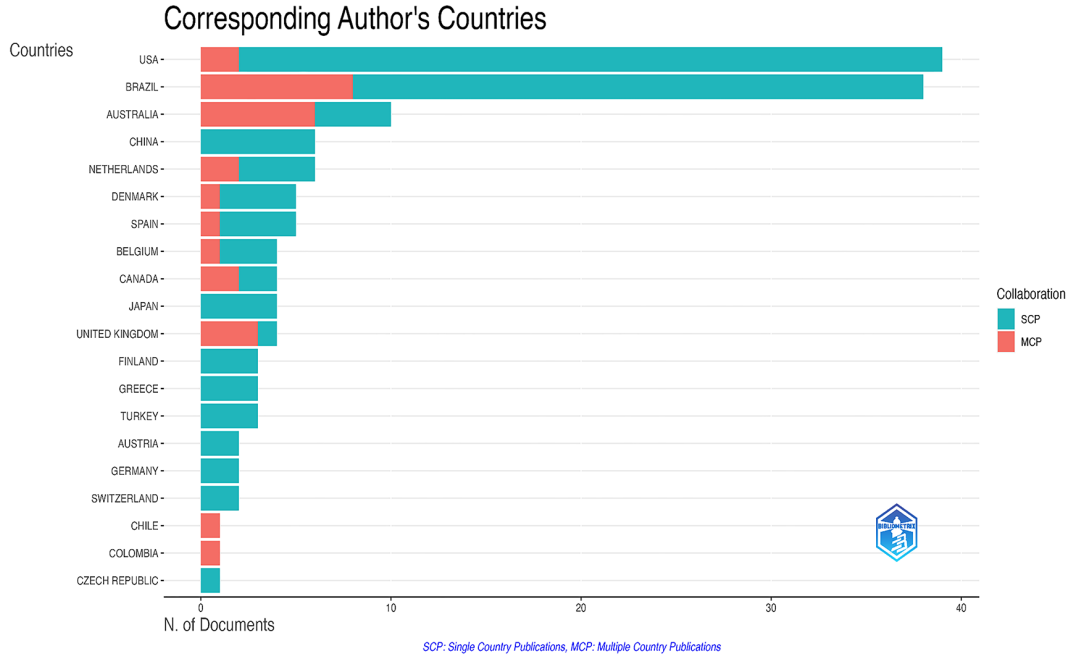

Figure 2. Corresponding authors' countries analysis.

Table 3. The 10 most cited papers

	Title	First author	Journal	Year	Total Citation	Journal Citation Indicator™ (2023)	Quartile
1	Quadriceps function, proprioceptive acuity and functional performance in healthy young, middle-aged and elderly subjects	Hurley MV	Age and Ageing	1998	244	1.42	Q1 (GERIATRICS & GERONTOLOGY in SCIE edition)
2	Muscle power of the ankle flexors predicts functional performance in community-dwelling older women	Suzuki T	J Am Geriatr Soc	2001	236	1.31	Q1 (GERIATRICS & GERONTOLOGY in SCIE; and GERONTOLOGY in SSCI edition)
3	Exercise: effects on physical functional performance in independent older adults	Cress ME	J Gerontol A Biol Sci Med Sci	1999	230	1.39	Q2 (GERIATRICS & GERONTOLOGY in SCIE edition) Q1 (GERONTOLOGY in SSCI edition)
4	The effects of multidimensional home-based exercise on functional performance in elderly people	Nelson Me	J Gerontol A Biol Sci Med Sci	2004	214	1.39	Q2 (GERIATRICS & GERONTOLOGY in SCIE edition) Q1 (GERONTOLOGY in SSCI edition)
5	Effect of high versus low-velocity resistance training on muscular fitness and functional performance in older men	Bottaro M	Eur J Apple Physıol	2007	199	0.96	Q2 (PHYSIOLOGY in SCIE edition, and SPORT SCIENCES in SCIE edition)
6	Association between executive attention and physical functional performance in community-dwelling older women	Carlson MC	J Gerontol B Psychol Sci Soc Sci	1999	154	1.79	Q1 (GERIATRICS & GERONTOLOGY in SCIE edition) (GERONTOLOGY in SSCI edition)
7	Impaired aerobic capacity and physical functional performance in older heart failure patients with preserved ejection fraction: role of lean body mass	Haykowsky MJ	J Gerontol A Biol Sci Med Sci	2013	128	1.39	Q2 (GERIATRICS & GERONTOLOGY in SCIE edition) Q1 (GERONTOLOGY in SSCI edition)
8	Continuous-scale physical functional performance in healthy older adults: a validation study	Cress ME	Arch Phys Med Rehabil	1996	123	1.63	Q1 (REHABILITATION in SCIE edition) (SPORT SCIENCES in SCIE edition)
9	Cognitive correlates of functional performance in older adults: comparison of self-report, direct observation, and performance-based measures	Schmitter-Edgecombe M	J Int Neuropsychol Soc	2011	112	0.84	Q2 (PSYCHOLOGY in SCIE edition) Q3 (PSYCHOLOGY, CLINICAL in SSCI edition)
10	Effects of resistance exercise and fortified milk on skeletal muscle mass, muscle size, and functional performance in middle-aged and older men: an 18-mo randomized controlled trial	Kukuljan S	J Appl Physiol	2009	109	1.27	Q2 (PHYSIOLOGY in SCIE edition, and SPORT SCIENCES in SCIE edition)

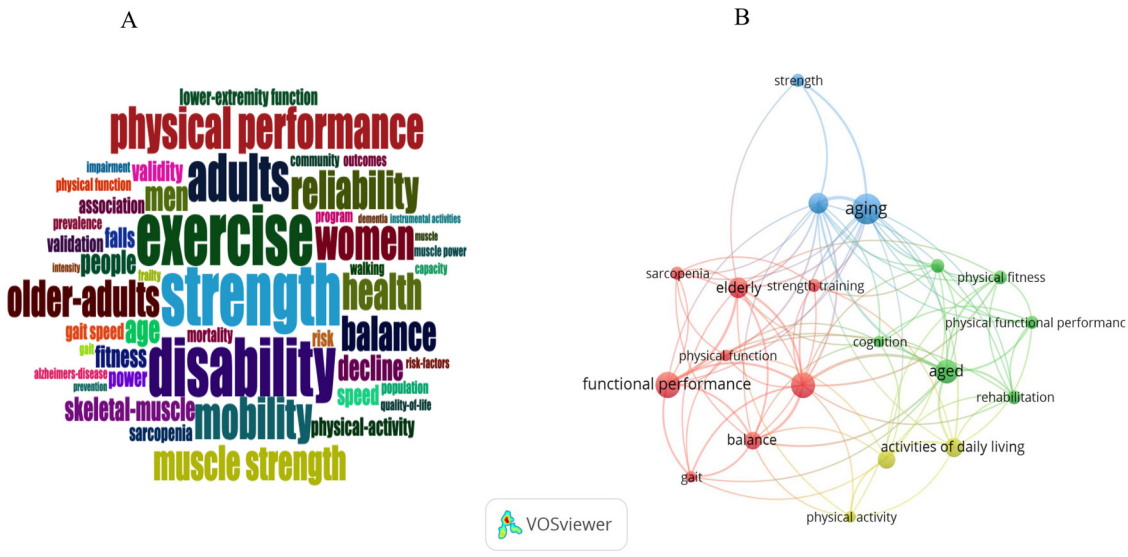

Figure 3. (A) Word cloud of keywords. (B) Co-occurrence of keywords.

and *Rehabilitation* is in second place in WoS categories on functional performance.

The most productive authors are Cress ME, Bezerra ES and Dias RC from the USA, and Brazil respectively. The findings of bibliometric analysis from a country perspective indicated that the most productive and relevant countries were Brazil and the USA. The authors most relevant to this field and their countries are complementary to these findings. In terms of institutes, the Federal University of Minas Gerais in Brazil has the highest number of publications. Citation of countries analysis showed the USA has the highest total link strength and followed by Brazil. In the light of these consistent findings, it is clear that Brazil and the USA have researchers and opportunities who are interested in this field in terms of publication, as leading countries. Although the USA was the most relevant country, only 5.13% of the publications were with multiple countries; and although Brazil was in the first rank, only 21.05% of publications were with multiple countries. Science can be an important component that connects different national innovation systems and enables growth through international knowledge flows (29). As an important part of rapidly changing research systems, international research collaboration is also recognized as an indicator of high quality research. International research collaboration provides opportunities for health researchers to share experiences, data and methods that can form the basis for new and important insights into current practice (30). Although international collaboration in science has increased rapidly in recent years (31), findings of this study indicate the need for international collaboration in this field.

The most highly cited papers were published in Q1/Q2-rated (quartile 1 and 2 – the top quarter based on ranking) journals according to the Journal Citation Reports. This can be explained by the fact that researchers have submitted their articles with a higher citation potential to higher-ranking journals. On the other hand, it is thought that factors related to good management of the publication process, such as some high-ranking journals keeping the publication process short, may be effective in revealing this result.

Keywords reflect the authors' focus, the trend of publications' research topics, with the most used keywords indicating the most researched topics (32). The analysis of keywords showed that the four cluster keywords focus on muscle strength and exercise areas in this study. The relationships between keywords make it easier to understand the key concepts and topics of a field. Through keywords, the focus areas of authors and publications can be assessed. The results of this analysis indicate that studies about functional performance in older adults are more related to muscle strength and exercise. The findings of keyword analysis are consistent with the most cited articles in this field. The top 3 most-cited articles were about aging, muscle strength, disability, and exercise.

The most cited study published by Hurley et al. (25) found that age-related deterioration in the sensorimotor function of the muscle may lead to increased fear and the frequency of falls in older people, thus decreasing independence. The findings indicate that combined exercise programs that increase muscle strength, postural stability, balance and proprioception should be implemented to reduce the fear, risk and frequency of falls and related trauma in older adults.

In addition, based on these findings, addressing many factors related to muscle function and functional independence of older people may be a reason why this study is the most cited publication. In addition, it is evident that studies investigating muscle function and its related factors have an important role for other studies about functional performance in older adults.

There are systematic review studies about functional performance in older adults in the literature (16-20). Eccentric exercise (17), high-velocity power training (HVPT) and traditional resistance training (TRT) (18), interventions were investigated in older adults. The functional performance was assessed with walking tests such as maximal walking speed, and timed up and go test, Short physical performance battery performance, stair climb test, chair stand time, sit to stand tests, and usual and fast gait speed tests (7,10,12). These studies showed eccentric exercise, resistance training improved functional performance (7,12), and the effectiveness of HVPT may be equivalent to TRT protocols in terms of functional performance in older adults (10).

However, there was no bibliometric analysis study in this field worldwide. Bibliometric analysis studies differ from systematic reviews, but are complementary, as they consider the research from a holistic perspective and map the general knowledge. It is recommended that some of the sub-topics highlighted in this study be analyzed more deeply through a systematic review in future studies.

Strength and Limitations

Being the first bibliometric analysis study which was analyzed with Biblioshiny-R and VOSviewer on functional performance in geriatric individuals is the main strength of this study. This study has a more comprehensive perspective and important data for sources, authors, countries, documents, words than studies in the literature. The co-occurrence cluster and network analysis provide information in terms of both the number of times that the terms co-occurred and knowledge about the relationships between the terms.

The present study also has some limitations. The bibliometric analysis includes only English-language papers and articles document type in the WoS database. Research in other languages and document types were excluded in data collection.

The comprehensive findings of the WoS database point out that the number of publications about functional performance of geriatric individuals has decreased rapidly in recent years. Although the average citation rate increased rapidly after 1995 and reached its highest level in 1998, this rate has decreased and reached its initial level in recent years. The results suggest that, although the USA was the most relevant country, only 5.13% of the publications were with multiple countries. Brazil had the highest number of publications with multiple countries with only 21.05% of publications, indicating a significant lack of international collaboration. Future research should include analysis of scientific databases such as Scopus and PubMed.

CONCLUSION

In conclusion, the USA stands out as the most productive, cited and relevant country in this study. The Journal of the American Geriatrics Society, also published in the USA, was the most cited source. Cress ME from the USA was the most relevant author. Despite the USA being the most relevant country, only 5.13% of publications were with more than one country, indicating a significant lack of international collaboration. This study, which shows there is a significant deficiency in international cooperation in terms of research on functional performance in the geriatric population, provides guidance to physiotherapist clinicians and researchers in terms of countries, authors and institutions that could potentially collaborate. In addition, the analysis of the most cited publications and keywords can shed light on the idea and design of physical and functional performance studies.

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