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Worldwide arthroplasty research productivity and contribution of Turkey

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ABSTRACT

Purpose: Bibliometrics is increasingly used to assess the quantity and quality of scientific research output in many research fields worldwide. However, to the best of our knowledge, no studies have documented the main characteristics of arthroplasty publications from different countries. This study aimed to evaluate the worldwide research productivity and status of Turkey in the field of arthroplasty using bibliometric methods and to provide an insight into the arthroplasty research for surgeons and researchers.

Methods: The Web of Science database was searched to identify arthroplasty articles published between 2006 and 2016. The contributions of countries were evaluated based on publication count, citation average, h-index and publication rate in the top 10 ranked journals. Each countries publication output was adjusted according to population size.

Results: A total of 26.167 articles were identified. World arthroplasty publications were increased significantly over time ($p < .005$). The United States was the most productive country with 9007 articles (34,4% of total) followed by England with 2939 articles (11,4 of total) and Germany with 1881 articles (7,1% of total). According to average citations per item, Scotland was in the first place followed by Denmark and Sweden, whereas in the first place according to publication output adjusted by population size was Switzerland followed by Denmark and Scotland. The United States was also in the first place according to h-index and publication rate in the top 10 ranked journals. Founding average was 28,8% (7539 of 26164) for the arthroplasty articles that were analyzed in the study.

Conclusion: There is a rapid increase in the number of articles in arthroplasty research from 2006 to 2016. The United States was the most productive country as measured by total publications in the arthroplasty field. However, some small European countries with high in-come have higher quality of articles and better productivity when adjusted for population. Gross domestic product (GDP) per capita and research foundation had positive affect on arthroplasty publications, both qualitatively and quantitatively.

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Introduction

The quality and level of scientific research is a well indicator of a country's developmental status.¹ Medical research with human subjects is often expensive and requires sophisticated

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instrumentation, biochemical measurements, and meticulous follow-up of subjects.^{2,3} Hence, scientific research has traditionally been dominated by the so-called "G5" countries: The United States of America, The United Kingdom, Japan, Germany and France.⁴

The word "bibliometrics" has been derived from the Latin and Greek words "biblio" and "metrics" which refer to the application of mathematics to the study of bibliography. Bibliometric analysis is useful in the evaluation of the quality of research in one field. Such studies may help to provide an insight into the dynamics of the field under consideration and this type of analysis provides useful indicators of scientific productivity. It is possible to indicate the quality and productivity in a specific field, in a country or region.

Moreover, it helps the academic society in identifying most productive authors, institutions and locations. The scientific papers promote the knowledge sharing and the advancement of arthroplasty research. However, the quality and quantity of research contributions varies between different countries, due to differences in economies, healthcare systems and medical research status.⁵ The number of articles published by a country is an indicator of its contributions to the creation of new knowledge, and bibliometric analysis is often used to investigate trends in scholarly publications and the relative importance of articles in a specific topic. Recently, a number of surveys of publication activity have been conducted to evaluate the contributions of different countries in various fields of medicine.^{6–8} Such articles also have been published in general orthopedics and its subspecialties.^{9–11}

To the best of our knowledge, no previous studies have reviewed global scientific productivity in the field of arthroplasty. The present study aimed to analyze the quantity and quality of worldwide publications, in order to determine the current status of global scientific productivity in the field of arthroplasty along with contribution of Turkey between 2006 and 2016.

Materials and method

36,052 articles were reviewed to analyze research volume and productivity in the field of arthroplasty between 2006 and 2016. Of those, 9,888 articles were excluded for the following reasons; different themes from orthopedic arthroplasty [temporomandibular surgery, spinal disc surgery, veterinary surgery, joint preserving surgery without prosthesis implantation, resection or interposition arthroplasty and osteoarthritis pathogenesis study without surgical intervention (n = 7,334)] and publication type [proceedings paper, meeting abstract, correction, reprint, retracted publication, book chapter, news item, biographical item and book review (n = 2,554)]. Finally, 26,167 articles were included in this study.

Science Citation Index Expanded (SCIE) database accessed through Web of Science (WoS) (Thomson Reuters, Philadelphia, PA, USA) was used for this study. The WoS is the world's leading database for citation and other academic impact information, which makes it widely used in the studies on scientific productivity.^{12–14} A computerized literature search was carried out using the database on December 20th, 2017. We used the following search terms: "Arthroplasty" as topic, "Name of Country" as address, and "2006–2016" as publication year among the English based literature. Top 25 countries were selected based on their publication records according to the literature search. The selected countries were as follows: The United States, England, Germany, Canada, Japan, China, Australia, the Netherlands, South Korea, Italy, Switzerland, Sweden, Spain, Denmark, Belgium, Scotland, Turkey, Taiwan, India, Austria, Norway, Finland, Singapore and Greece. Additionally, individual citation reports of the countries were analyzed. Average citations per item, number of publications per million population (PmP), h-index and percentage of funded study per countries were determined. The h-index is an author-level metric that attempts to measure both the productivity and citation impact of the publications of a scientist or scholar. h-index and average citations per item calculation was made by Web of Science database citation report chart. PmP was calculated by dividing the total number of publications by the population of each country. Gross domestic product (GDP) per capita of the countries were listed according to 2016 The World Bank data.¹⁵ Top 10 ranked orthopedic journals that publish arthroplasty articles were determined according to Journal Citation Reports (JCR) 2016 by Thomson-Reuters and countries number of publication in these journals were also listed. These journals were; Journal of

Arthroplasty, Clinical Orthopaedics and Related Research, Journal of Bone and Joint Surgery American Volume, Knee Surgery Sports Traumatology Arthroscopy, Journal of Bone and Joint Surgery British Volume, International Orthopaedics, Acta Orthopaedica (previously Acta Orthopaedica Scandinavica), Archives of Orthopaedic and Trauma Surgery, Journal of Orthopaedic Research and Osteoarthritis and Cartilage. The number of articles from Turkey, the year of publication, the journal which the article was published in, publishing institutions, level of study and type of study were recorded manually. The publishing institutions were determined according to the first author. The articles were divided in two groups regarding two equal time periods (01.01.2006–31.05.2011 and 01.06.2011–31.12.2016) to investigate the increase of quantity and quality of published articles over time.

Statistical analyses were performed by SPSS for Windows 15.0 software (SPSS Inc, Chicago, IL, USA). This study included all published articles and not merely a representative sample. Therefore, descriptive analysis was primarily used. Spearman rank correlation and Kolmogorov–Smirnov test was used to verify normal distribution and the homogeneity of variances of the scales used. To evaluate annual increases in the number of published articles and the correlation with the institutions, the linear regression analysis was performed. Statistical significance was set at $p < 0.05$.

Results

26,167 orthopedic arthroplasty papers were published in Science Citation Index Expanded (SCI-E) listed journals between 2006 and 2016. The United States was the most productive country with 9007 articles (34,4%) followed by England with 2939 articles (11,4%) and Germany with 1881 articles (7,1% of). Turkey was ranked 18th with 373 articles (1,4%). According to the publication records in the top 10 ranked journals (n = 9942), the United States was in the first place with 3770 articles (37,9%) and Turkey was 23rd with 86 articles (0,6%). The United States was also in the first place according to h-index with 120 points. According to average citations per item, Scotland was in the first place followed by Denmark and Sweden, whereas in the first place according to PmP was Switzerland followed by Denmark and Scotland. Turkey ranks last by the h-index and the average citations per item and 23rd according to PmP. 28,8% (7539 of 26,164) of arthroplasty articles were funded studies. Denmark was the first ranked country which 50,3% of the studies which were funded. Turkey was the last in the list with 8,8% funded publication. Details are given in Table 1.

PmP index was evaluated for quantitative assessment, average citations per item was evaluated for qualitative assessment of the publications. PmP was strongly correlated with rate of funded publication ($p = .007$) and GDP per capita ($p < .001$). Average citations per item was also strongly correlated with funded publication rate ($p = .006$) and GDP per capita ($p = .002$). Also the rate of funded studies in arthroplasty publications was correlated with GDP per capita ($p = .031$). In a multiple regression model, both GDP per capita ($R = 0.59$, $p < .001$) and the rate of funded publications ($R = 0.27$, $p = .007$) was independently associated with PmP index. GDP per capita ($R = 0.36$, $p = .002$) and the rate of funded publications ($R = 0.29$, $p = .006$) was also independently associated with average citations per item.

The most productive institution that published the highest number of articles worldwide is Mayo Clinic from the United States with 681 articles between this time periods. Istanbul University is the most productive institution in Turkey with 43 articles. The top 5 institutions that published the highest number of articles in the world and in Turkey are listed in Table 2. The Journal of Arthroplasty published the most arthroplasty articles in this period while Acta Orthopaedica et Traumatologica Turcica published the most

Table 1
The top 25 countries according to the number of arthroplasty publications.

Countries	Records	% of 26167	Percentage of funded studies (%)	Publication in Top 10 ranked journals (% of total publication of the country)	h-index	Average citations per item	Population	GDP per capita (US \$)	Number of publications per million (*10 ⁶)
USA	9007	34,426	33,1	3770 (41,9%)	120	17,56	310,232,863	57,638	29
ENGLAND	2939	11,233	29,8	1029 (35%)	87	17,5	61,284,806	40,341	48
GERMANY	1881	7190	32,3	726 (38,6%)	63	17,92	82,282,988	42,069	23
CANADA	1515	5791	39,7	482 (31,8%)	74	21,48	33,759,742	42,157	45
JAPAN	1376	5259	20,8	537 (39%)	42	10,58	126,804,433	38,900	11
CHINA	1271	4858	45,1	306 (24,1%)	40	7,7	1,354,040,000	8123	1
FRANCE	1109	4239	21,4	338 (30,5%)	58	18,99	40,548,753	36,855	27
AUSTRALIA	994	3799	34,9	390 (39,2%)	56	20,45	21,515,754	49,927	46
NETHERLANDS	945	3612	32,2	362 (38,3%)	48	16,32	16,783,092	45,669	56
SOUTH KOREA	880	3364	24,4	469 (53,3%)	37	10,26	48,636,068	27,538	18
ITALY	862	3295	18,7	264 (30,6%)	41	13,21	58,090,681	30,674	15
SWITZERLAND	806	3081	33,5	292 (36,2%)	57	17,91	7,997,000	79,890	101
SWEDEN	576	2202	39,8	314 (54,5%)	57	24,44	9,074,055	51,949	63
SPAIN	555	2121	26,3	195 (35,1%)	40	14,55	40,548,753	26,639	14
DENMARK	553	2114	50,3	231 (41,8%)	55	24,84	5,515,575	53,549	100
BELGIUM	428	1636	24,3	146 (34,1%)	40	16,47	10,423,493	41,236	41
SCOTLAND	418	1598	24,7	171 (40,9%)	41	26,38	5,228,000	34,608	80
TURKEY	373	1426	8,8	86 (23,1%)	17	4,09	75,627,384	10,862	5
TAIWAN	369	1410	30,6	93 (25,2%)	29	10,44	23,024,956	22,044	16
INDIA	350	1338	14	110 (31,4%)	24	8,53	1,236,686,732	1709	0,3
AUSTRIA	344	1315	23,3	168 (48,8%)	34	14,05	8,462,000	44,676	41
NORWAY	300	1147	32	153 (51%)	40	19,85	4,676,305	70,911	64
FINLAND	260	0,994	47,3	114 (43,85%)	33	15,51	5,255,068	43,402	49
SINGAPORE	193	0,738	20,2	72 (37,3%)	20	8,2	5,469,724	52,962	35
GREECE	187	0,715	11,7	76 (40,6%)	24	12,77	11,062,508	17,930	17

arthroplasty articles originated from Turkey. Top 5 journals which published the most articles are listed in Table 2. With regard to the authors, the author with the greatest number of arthroplasty publications was Javad Parvizi (n = 251) followed by Michael A. Mont (n = 225) and D.W. Murray (n = 146).

The number of the articles on arthroplasty increased from 1486 articles in 2006–3560 articles in 2016 $p < .005$ (Fig. 1). There was an increase of 140%, an average of 7% per year. The highest growth in the number of articles was recorded in 2011 with 17,8% growth rate and the increase in the number of publications continued throughout this time period. Whereas, the number of articles on arthroplasty published in Turkey increased from 10 articles in 8 journals in 2006 to 76 articles in 45 journals in 2016. Thus, there was an increase of 660%, an average of 30,5% per year. The highest

growth in the number of articles was recorded in 2010. This increase in the number of articles published was consistent except in 2009, 2011, and 2012 (Fig. 1).

Distribution of the publishing institutions from Turkey was found as following; universities 65,7% (n = 245), education and research hospitals 26,3% (n = 98), state hospitals 4,8% (n = 18) and private hospitals 3,2% (n = 12). The majority of publications were on knee arthroplasty (n = 185, 49,5%), then hip (n = 151, 40,5%), both hip and knee (n = 20, 5,3%) and the other joint arthroplasties (n = 17, 4,5%). 27% (n = 101) of the publications were retrospective studies, 23,6% (n = 88) were randomized prospective, 22,5% (n = 84) were non-randomized prospective, 12,6% (n = 47) were case reports, 3,7% (n = 14) were case series and 10,6% (n = 39) were other types studies (biomechanical or animal studies, letter to

Table 2
The distribution of the articles by institutions, authors and the journals.

WORLD			TURKEY		
Distribution of Publications by Institutions					
Institution	Record Count	% of 26167	Institution	Record Count	% of 373
Mayo Clinic	681	2.603%	Istanbul University (Çapa and Cerrahpaşa Medical Faculties)	43	11.528%
Harvard University	674	2.576%	Dokuz Eylül University	31	8.311%
University of California System	569	2.175%	Ankara Numune Education and Research Hospital	25	6.702%
Hosp Special Surg	559	2.137%	Ankara Atatürk Education and Research Hospital	20	5.362%
VA Boston Healthcare System	492	1.880%	Baskent University	20	5.362%
Distribution of Publications by Journals					
Journal	Record Count	% of 26167	Journal	Record Count	% of 373
Journal of Arthroplasty	3283	12.548%	Acta Orthopaedica Et Traumatologica Turcica	71	19.03%
Clinical Orthopaedics and Related Research	1372	5.244%	Eklem Hastalıkları ve Cerrahisi Joint Diseases and Related Surgery	30	8.04%
Journal of Bone and Joint Surgery American Volume	1014	3.876%	Knee Surgery Sports Traumatology Arthroscopy	25	6.7%
International Orthopaedics	886	3.386%	Journal of Arthroplasty	22	5.89%
Journal Of Shoulder and Elbow Surgery	768	2.935%	Archives of Orthopaedic and Trauma Surgery	20	5.36%

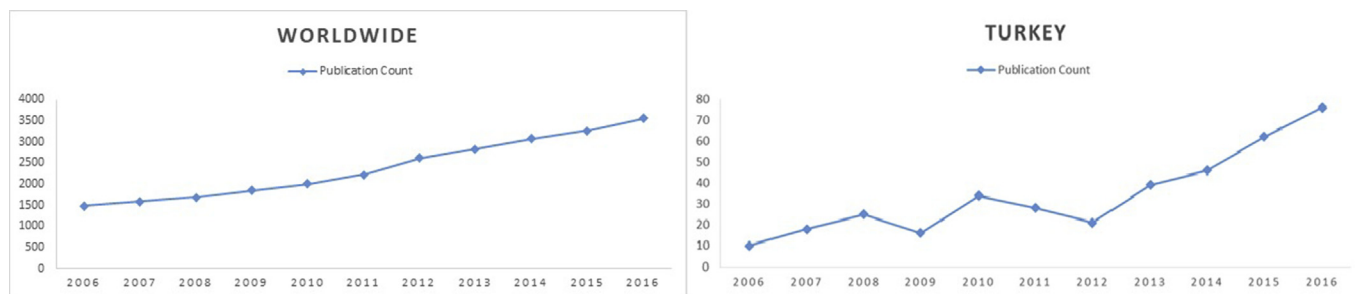


Fig. 1. Total number of arthroplasty articles by publication year.

editor and editorial materials). With regard to the time periods, the articles published between 01.01.2006 and 31.05.2011 were 115 and more than doubled to 258 between 01.06.2011 and 31.12.2016. Thirty six of 115 articles (31%) were published in the top 10 ranked journals between 2006 and 2011, whereas 50 of 258 articles (19%) were published in the top 10 ranked journals between 2011 and 2016.

Discussion

Bibliometrics is a set of methods to quantitatively analyze academic literature.^{16,17} It can be a yardstick to assess the academic achievements of a country, institutions as well as individuals and can be used as a measure for their appraisal.¹⁸ To assess the research contributions around the world, biomedical research publication has been used as an index for scientific research productivity.^{19–21} However, as far as we know, this study is the first bibliometric evaluation on worldwide productivity in the field of arthroplasty research.

Arthroplasty researches have shown a considerable progress in recent years. This study clearly demonstrated that there was a significant increase in the number of arthroplasty publications from 2006 to 2016. The authors in the United States published the largest number of arthroplasty papers than any other country in the world. Besides the United States, some small European countries, including Switzerland and Denmark, were more productive when the total number of articles was normalized by population size with PmP index. PmP index is one of the parameters used in the measurement of scientific productivity of a community.²² When the top 25 countries according to the publication records were ordered based on the PmP, Turkey ranked 23th, China and India with a population of over 1 billion, were naturally at the end of this ranking. Switzerland, Denmark and Scotland were the first three countries in PmP index ranking. Citation analysis is considered a quality indicator of articles and has been widely used to evaluate the academic significance of an article.^{12,23,24} The number of citations per paper is a useful measure of the impact of a nation's output.²⁵ In our study, the first three countries according to average citation per item ranking were Scotland, Denmark and Sweden (Table 1). According to our data, the qualitative and quantitative characteristics of countries' arthroplasty publications show a parallel course.

When we investigated why some countries were both more qualitatively and quantitatively ahead in the field of arthroplasty publication, we found several factors. As the main factor, GDP per capita was strongly correlated with both PmP index and average citation per item. According to our results, less populated and developed European countries with high GDP per capita, were found to be more productive with high quality publications in the field of arthroplasty. Similar findings are available in the literature. Man et al²² investigated the factors affecting national medical

publication output. They stated that northern European countries such as Denmark, the Netherlands, Switzerland, and Sweden had the highest standardized publication rate. In the study about international rank order of publications in major clinical orthopedic journals from 2000 to 2004, Bosker and Verheyen²⁶ stated smaller western European countries outrank the others according to publication output corrected for the size of population. Kennedy et al²⁷ investigated Ireland's contribution to orthopedic literature and they stated that small highly industrialized nations (the Netherlands, Sweden, Norway, Denmark and Finland) all ranked in the top in respect to both PmP and mean impact factor categories, and outperformed larger highly industrialized counterparts. Positive correlations between the number of publications and GDP per capita was also found in the study about worldwide productivity research in the field of arthroscopy.¹¹ GDP or high income of a country is directly related with better education system and higher share allocated to research. Thus, it is possible to conclude that the quality and the quantity of arthroplasty publications are associated with high GDP per capita similar with other scientific fields. According to our data, another factor that strongly correlated with both PmP index and average citation was rate of funded study in the arthroplasty publication. We also determinate that GDP per capita and the foundation of arthroplasty publications were correlated. To our data, northern European countries which leads PmP and citation average ranking also have high foundation rates in arthroplasty publications. Only exception of this situation was China with 45,1% funded study of total publication. It can explain why China has three times more publications than India, which has the similar population. The availability of funding has been shown to result in higher publication output.²⁸ Man et al²² stated that research funding levels may be directly responsible for increased publication output in high ranked journals. Lee et al²⁹ investigated characteristics and trends of orthopedic publications between 2000 and 2009 and they reported that 10.2% of published orthopedic articles declared grants as funding source. This study demonstrated that the funding rate was 28.8% among arthroplasty publication. This funding rates more than double in arthroplasty studies when compared with general orthopedic studies. This situation may be explained with higher cost of arthroplasty studies and more industrial interest in arthroplasty publications than general orthopedics.

Gürbüz et al³⁰ performed bibliometric analysis of orthopedic publications from Turkey. They stated that Turkey has ranked 14th regarding the number of orthopedic publications out of 122 countries and 26th out of 30 countries regarding the PmP index. In this study Turkey was 18th regarding the number of the articles but last according to average per item, h-index and rate of publication in top 10 ranked journals. First of all, the number of arthroplasty publications in the worldwide increased by 172% between 2006–2011 and 2011–2016, whereas the number of publications from Turkey increased by 123%. Despite quantitative increase of

arthroplasty publications in Turkey, the growth rate has fallen below the world average. The rate of publications in the top 10 ranked journals was also in a decrease trend over time. Multiple reasons for this situation can be listed. The main reason may be the fact that Turkey was the last according to funding rate among the top 25 countries that published the most number of arthroplasty articles. National funding capacity for research is an important determinant of publication output. In Turkey only 0,01% of total GDP spent for medical research whereas this ratio is 0,47% for Sweden.²² We believe that more financial support for medical research will increase the scientific output Turkey.

Turkish authors tend to publish their studies in national journals (27% of total). The most-cited articles are likely to be published in journals with high impact factors.³¹ National orthopaedics journals of Turkey have relatively lower impact factors. Thus, low average of per item citation of Turkish arthroplasty articles can be attributed to low publication rate in the top 10 ranked journals. To ensure a qualitative increase in arthroplasty publication of Turkey more studies should be published in the journals with high impact factors. Another reason for quantitatively and qualitatively backwardness in arthroplasty publications relatively with the other European Countries may be the late establishment of national registration system in Turkey. Since 2009 a national registry system covers all hospitals in Turkey.³² Whereas Sweden has arthroplasty registry system since 1979.³³ The use of registry system provides access to a large number of patients and gross data. This may have increased the number of publications in the field of arthroplasty.³⁴ And also, registry publications are more often cited.³³ We believe that the effective use of national registry system will affect positively on arthroplasty publication productivity of Turkey.

In the United States 21% of the orthopedic residents desire to pursue a fellowship in hip or knee arthroplasty, which represented the second most popular fellowship choice following sports medicine.³⁵ And also, the top ten adult reconstruction fellowship programs account for approximately two-thirds of all published arthroplasty research in the United States.³⁶ However, there is no official adult reconstruction fellowship programme for orthopedic residents in Turkey. We suggest that an adult reconstruction fellowship programme may increase arthroplasty publications in Turkey. Moreover, the results and the conclusions of this study may serve as a guide for orthopedic residents who pursue an academic career in the field of adult reconstruction and may help them to consider some of the most productive institutions in terms of arthroplasty publication.

Our study demonstrated that universities dominate the arthroplasty literature published from Turkey. This finding is consistent with the literature from other countries.³⁷ In most universities, the publications are the principal currency for academic recognition and promotion for researchers.³⁸ Despite more arthroplasty surgery is performed than university hospitals,³² the state education and training hospitals and other state hospitals are mainly concentrated on public service which may be considered for the reason of low publication rate. Scientific productivity may be rewarded for these institutions to promote publication rate.

There were several limitations in the present study. First, the WoS database was used to search for arthroplasty studies. Articles published in none WoS-cited journals were not included. This may be accepted as a shortcoming of this study. Citation analysis was used to evaluate quality of the articles and it is acknowledged that the number of citations are a proxy measure of influence reflecting the recognition and quality of the published research by its peers.³⁹ Nevertheless, over citation, biased citing, audience size, biased data, and ignorance of the literature are additional common criticisms of bibliometric studies.⁴⁰ Another potential limitation of this method is collecting data over a specific time period. These results will

almost certainly change if the time interval is either extended or shortened. And lastly, instead of using the PmP index, to normalize article number by the number of researchers in arthroplasty field in different countries might be more informative, but it is extremely difficult to get these data. However, given its broad nature and large numbers, this study still provides a comprehensive survey of arthroplasty research productivity, which may serve to track overall trends and identify topics of interest. To the best of our knowledge, the present study is the first bibliometric evaluation on the worldwide research productivity in the field of arthroplasty.

In conclusion, this study demonstrated that there is a rapid increase in the number of articles in arthroplasty research from 2006 to 2016. The United States was the most productive country as measured by total publications, but when adjusted for population, Switzerland published the highest number of articles, followed by Denmark and Scotland. GDP per capita and research foundation positively affect the quality and quantity of arthroplasty publications.

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