Heliyon 10 (2024) e24942

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Current situation and publication trends of skeletal muscle related research: A bibliometric analysis

Syed Sayeed Ahmad [a,b], Inho Choi [a,b,*]

[a] Department of Medical Biotechnology, Yeungnam University, Gyeongsan 38541, South Korea
[b] Research Institute of Cell Culture, Yeungnam University, Gyeongsan 38541, South Korea

ARTICLE INFO

Keywords:
Aging
Skeletal muscle
Myogenesis
Muscle satellite cell
Bibliometric analysis
Web of science

ABSTRACT

Skeletal muscle (SM) is a highly plastic and dynamic tissue of the body and is largely responsible for body maintenance. SM is primarily responsible for body balance, movement, postural support, thermogenesis, and blood glucose homeostasis. SM regeneration depends on the activation of muscle satellite (stem) cells (MSCs) under the regulation of several muscle regulatory factors that regulate myogenesis. Bibliometric analysis involves the quantitative and qualitative assessments of research and scientific progress that provides researchers access to recent publications, research directions, and thus generates ideas that can be implemented to guide future research. In this analysis, the Web of Science database was searched for articles using the search term "skeletal muscle AND myogenesis AND muscle satellite cell", and 1777 articles (original research/review articles) published from the year 1997 to June 2023 were retrieved. After applying several other exclusion and inclusion criteria, 129 articles were considered for analysis. Types of research, keywords, journals, authors, years, institutions, funding agencies, and average annual citations were analyzed. Muscle regeneration, satellite cell, and myogenesis were often used keywords and exhibited increasing trends in research articles over the decades. Some journals were found to strongly support research publications with high impact factors and citation scores. This study aimed to examine research ideas and growth in the skeletal muscle related field for atrophy and aging improvement.

1. Introduction

Skeletal muscle (SM) is a highly plastic and dynamic part of the human body that accounts for ~40 % of total body weight and ~50–75 % of body protein. The maintenance of SM depends upon protein synthesis and degradation, and the balance between these two factors is maintained by nutrition-rich food, hormones, and exercise. SM is primarily responsible for body balance, movement, postural support, thermogenesis, and blood glucose homeostasis [1,2] and can regenerate and repair injuries due to its diverse population of muscle stem (or satellite) cells (MSCs). These cells are responsible for postnatal growth and muscle regeneration [3,4] and are robustly activated after tissue injury to produce SM tissue through myogenesis, which involves MSC activation, leading to numerous proliferating myoblasts that later differentiate into mature myofibers under the direction of several muscle regulatory factors [5–7].

Various ECM components, such as fibromodulin (FMOD) [8–10], matrix gla protein (MGP) [11], dermatopontin (DPT) [12],

* Corresponding author. Department of Medical Biotechnology, Yeungnam University, Gyeongsan, 38541, South Korea.
E-mail address: inhochoi@ynu.ac.kr (I. Choi).

https://doi.org/10.1016/j.heliyon.2024.e24942
Received 26 September 2023; Received in revised form 16 January 2024; Accepted 17 January 2024
Available online 18 January 2024

IgLON4 (aids myogenesis via promoting cell adhesion and maintaining myotube orientation) [13], and IgLON5 (participates in myoblast adhesion and differentiation) [14] are crucial for regulating myogenesis and promoting SM regeneration. Muscle hypertrophy occurs when the overall rate of protein synthesis surpasses the rate of protein degradation, and protein synthesis is controlled by two major signalling pathways, namely, the IGF1-Akt-mTOR (positive regulator) and myostatin-Smad2/3 (negative regulator) pathways. MSC proliferation and fusion increase the number of myonuclei and may contribute to muscle growth during the early postnatal period but not during later stages [15].

An imbalance between protein synthesis and breakdown is the main cause of muscle atrophy and results in SM fibre size and mass reductions [16]. Furthermore, this imbalance is associated with several diseases and conditions, including myopathies, muscular dystrophies, aging, fasting, metabolic disorders, and cancers [17]. Proteolytic systems are activated in the background of muscle atrophy, and contractile proteins and organelles are depleted, resulting in muscle fibre shrinkage [18], an indicator of muscle atrophy. Activations of proteasomal and autophagic-lysosomal pathways are the main cause of muscle atrophy-induced muscle mass loss. Numerous atrophy-related genes (atrogenes) involved in these pathways are regulated by transcription factors, such as FoxO3, which is negatively regulated by Akt and NF–B in response to inflammatory cytokines [15]. Effective prevention and treatment strategies are crucial for SM-related disease management but remain inadequate. Although exercise is widely regarded as the most effective treatment for SM management, unfortunately, not all patients benefit. Several effective treatments for SM-related disorder management have been identified and subjected to clinical studies but have not yet been commercialized [19]. Some natural compounds [20], peptides [2] and extraxt [21] have been explored using in silico and in vivo study to manage the SM reletaed disorders management.

Bibliometric studies provide valuable insights into the popularity of topics within a given field. E Garfield conducted the first bibliometric study in 1987, using the top 100 cited articles in the Journal of the American Medical Association [22]. Bibliometric studies are being conducted in various fields of medicine [23–28] to identify the research trends and help emerging researchers choose research topics. Bibliometric analysis is a common method for determining the academic influence of any scientific article. Furthermore, SM-related studies have become a hot topic in recent years because several diseases, such as SM atrophy, cachexia, sarcopenia, diabetes, and other metabolic disorders, are associated with SM.

Many articles and reviews related to SM have been published, but research on global research trends related to SM disorders is lacking. Research articles provide meaningful indicators of the research contributions of countries or institutions [29]. Bibliometric analysis can provide information gleaned from databases to evaluate research trends quantitatively and qualitatively over specified periods and thus provide oversight of particular fields and a means of assessing the contributions of nations, journals, and institutes [30]. This study aimed to examine research trends on SM and myogenesis by focusing on the research performed by leading researchers. It is hoped that this article aids research topic decision-making by providing a summary of previous research on the identification of SM, myogenesis, and muscle satellite cell-related topics.

2. Materials and methods

2.1. Source of data

Web of Science core collection data was used in combination with selected indexes, viz., the Science Citation Index (SCI), the Science Citation Index Expanded (SCI-Expanded), the Social Sciences Citation Index (SSCI), and the Emerging Sources Citation Index (ESCI).

2.2. Search strategy/criterion

The main topic search term "skeletal muscle AND myogenesis AND muscle satellite cell" was used to search the Web of Science online database. Articles published from the year 1997 to June 23, 2023 were subjected to further screening using (TS (topic search) = (skeletal muscle) AND TS = (myogenesis) AND TS= (muscle satellite cell)). Literature types were defined as research or review articles. Relevant articles were exported and saved in plain. txt format (including full records and cited references) for analysis.

2.3. Data collection

Peer-reviewed articles, such as open access/early access/review articles (full/mini), on the mentioned topics (skeletal muscle, myogenesis, and muscle satellite cells) were retrieved from 1997 to June 23, 2023. Titles, authors' names, affiliations, keywords, publication years, and journal names were selected for study.

2.4. Inclusion and exclusion strategy/criterion

Peer-reviewed articles, such as open access/early access/review articles (full/mini) on Skeletal muscle AND myogenesis AND muscle satellite cell were included. On the other hand, conference/meeting abstracts, unpublished articles/reviews, repeated publications, editorials, letters, book chapters, and unrelated articles were excluded from the analysis.

2.5. Data analysis

VOSviewer (a freely available computer program) [31] and an online bibliometric website (https://bibliometric.com/) were used to visualize data. VOSviewer gives special consideration to the graphical portrayal of bibliometric maps, unlike the majority of computer programs used for bibliometric mapping. Large bibliometric maps can be easily understood when displayed using VOSviewer.

3. Results

3.1. Data collection

A total of 1777 articles published from 1997 to June 23, 2023 were retrieved from the Web of Science database. Of these articles, 1029 published during the last 10 years (2014–2023) were selected. Open access/early access/review articles (n = 132) were selected, and those in the English language (n = 129) were chosen because of their worldwide accessibility. Finally, these 129 articles (Fig. 1) were analyzed for keywords, authors, affiliations/organizations, citations, publishing journals, and funding agencies. A flowchart that summarizes this investigation, amount and pattern of yearly publications are seen in Fig. 1.

3.2. Keywords analysis

VOSviewer was employed to analyze the number of keywords closely related to the search terms used (skeletal muscle AND myogenesis AND muscle satellite cell). Co-occurrence analysis was performed for these keywords in all 129 selected articles. The 25 keywords obtained were divided into 3 clusters, viz. cluster 1(10 items), cluster 2 (10 items), and cluster 3(5 items) (Fig. 2 and Table 1). Keywords introduced annually are shown in Fig. 3. The resulting clusters indicated that satellite cells, myogenesis, skeletal muscle, and self-renewal are hot research topics.

3.3. Authors and citations analyses

The top 10 authors with a large total link strength and citations related to the selected topics the minimum number of documents by an author: 02 and minimum number of citations for an author: 02) were analyzed (Table 2). These authors contributed more to the skeletal muscle-related research, and details are provided in Fig. 4. Due to our interests in myogenesis, we explored the roles played by MSC activation, regeneration [10], extracellular matrix protein production [10], and natural compounds [20,21,32] in SM aging and related diseases. Our laboratory is devoted to the screening of natural compounds and designing peptides against selected targets responsible for SM degeneration. In this regard, we have published several articles related to myogenesis, which are cited in this manuscript.

3.4. University

The research related to selected topics was published by several organizations in the selected field. Out of the total participating organization with the minimum document (n = 02), only 14 organization was found to meet this threshold. The top institution was recognized as the University of Ottawa with the highest citation 641. The highest cited author Rudnicki, Michael A (total citation 606) belongs to the same place, the University of Ottawa. This information was shown in Tables 2 and 3. In this scenario, our group, Choi, Inho belongs to Yeungnam University is highly involved in this research (Table 3). Here, our research aims to explore more related to mentioned selected topic. There are different natural products [20,33] and designed peptides [2] have been explored to overcome SM-related disorders.

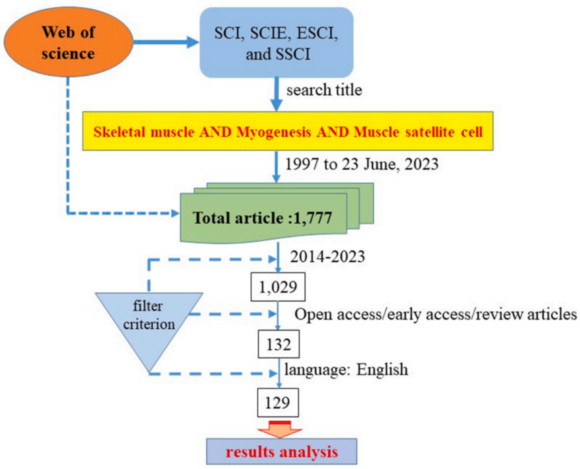

Fig. 1. Process of retrieving the data from Web of science database.

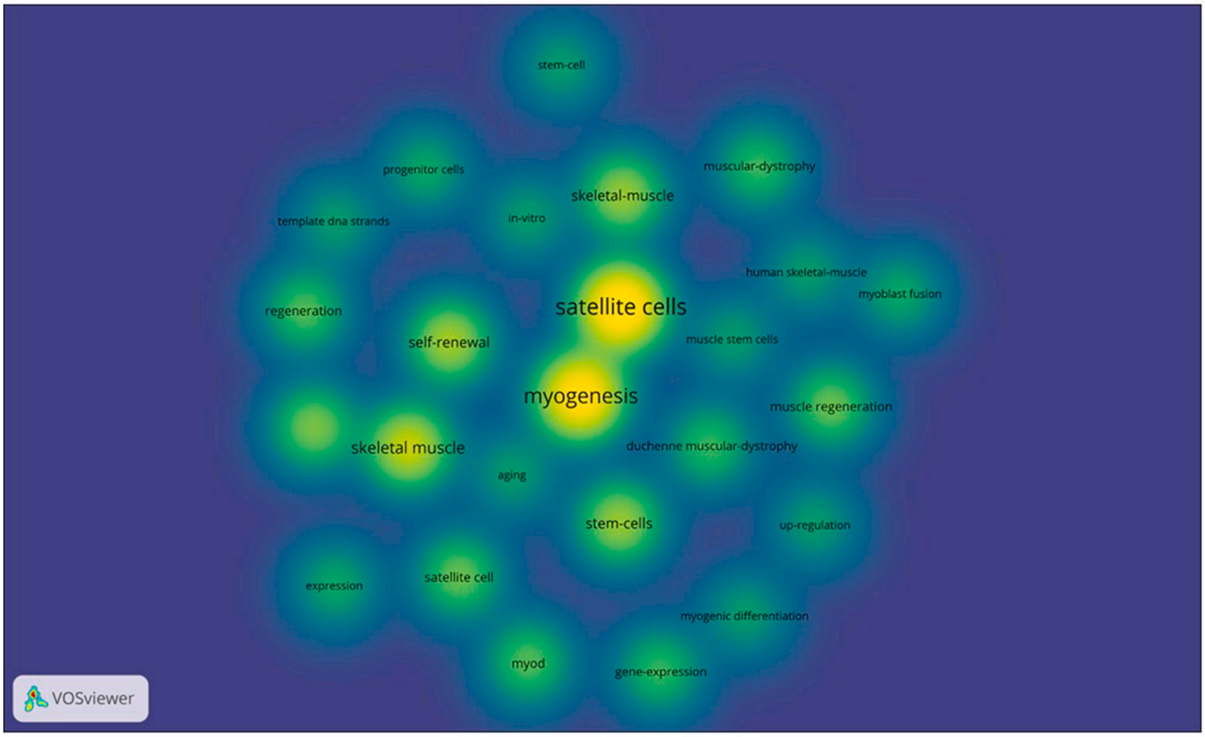

Fig. 2. The number of keywords used in skeletal muscle related research.

Table 1
Lists of keywords divided into three clusters.

ClustersAttributes	Keywords	occurrences	Total link strength
Cluster 1 (10 items)	Aging	5	22
	Differentiation	11	50
	Expression	6	22
	Myogenesis	29	134
	Progenitor cells	6	31
	Regeneration	9	45
	Self-renewal	14	79
	Skeletal muscle	17	86
	Stem-cells	13	54
	Template DNA strand	5	30
Cluster 2 (10 items)	Duchenne muscular dystrophy	8	34
	Human skeletal-muscle	5	18
	In-vitro	5	20
	Muscle regeneration	10	42
	Muscle stem cell	5	22
	Muscular-dystrophy	8	34
	Myoblast fusion	6	19
	Satellite cells	32	135
	Skeletal-muscle	13	58
	Stem-cell	5	18
Cluster 3 (5 items)	Gene-expression	8	38
	Myod	9	50
	Myogenic differentiation	5	26
	Satellite cell	10	60
	Up-regulation	5	25

3.5. Country

Researchers from several countries authored articles on skeletal muscle, myogenesis, and muscle satellite cells. The country with the largest number of publications was the USA (n = 42), followed by Italy (n = 16) and France (n = 14) (Table 4). Annual publications

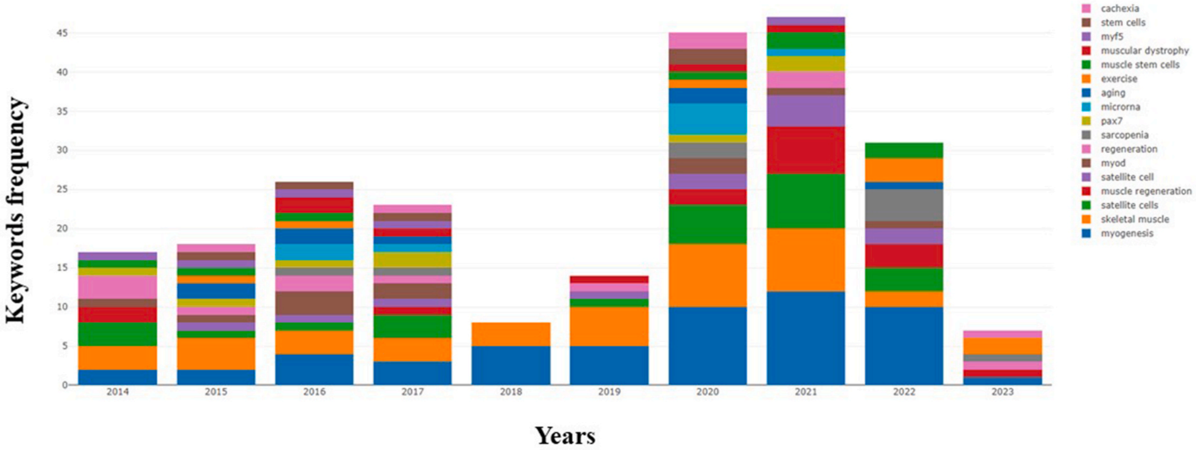

Fig. 3. The numbers of emerging keywords during last ten years.

Table 2
List of the top 10 cited authors in the selected topic.

No. of clusters	Name of authors	Citations	Total link strength
Cluster 1	Franco Diego	45	7
	Hernandez-torres Francisco	45	7
	Lozano-velasco Estefania	70	3
	Rodriguez-outeirino Lara	45	7
Cluster 2	Jin Jianjun	59	4
	Xu Zaiyan	59	4
	Zuo Bo	59	4
Cluster 3	Choi Inho	56	2
	Ahmad Khurshid	56	2
Cluster 4	Deng Shoulong	49	2
	Lian di	49	2
Cluster 5	Brun Caroline E	325	2
	Rudnicki Michael A	606	2
Cluster 6	Pourquie Olivier	384	0

during the last 10 years are shown in Fig. 5, and Fig. 6 depicts the relationships between publication trends in skeletal muscle research in various countries. We then assessed the quantity of institutional publications to see how institutions contribute to skeletal muscle related research.

3.6. Funding agencies

The top 10 funding agencies are listed in Table 5. The US National Institutes of Health NIH and the US Department of Health Human Services are at the top with 25 records count and contributed 19.23 % to total records funding. Funding is an important factor to conduct the research in detail with more deep knowledge. Requirment of funding is mostly based on the innovation in the research with new path and technology for human health and several other disease management.

3.7. Publications

The research trends in skeletal muscle-related research fluctuated over the 10-year period (2014–2023). The numbers of related publications by year are shown in Table 6. The highest number of publications was recorded in 2021 (27 articles). Publications with the highest citation records by year are shown in Fig. 7. The highest number of publications was recorded in 2021, while the highest citation number was recorded in 2022; citations obviously followed publications. Publication is the best way to show the research to the coming academic scholar for the related field to find a research oriented path for future direction.

3.8. Journals for publication

Several journals were found to publish work related to selected topics (Fig. 8). Journals found to frequently publish articles on selected topics are listed in Table 7. References for the publication of research findings can be found by journal analysis. Frontiers in

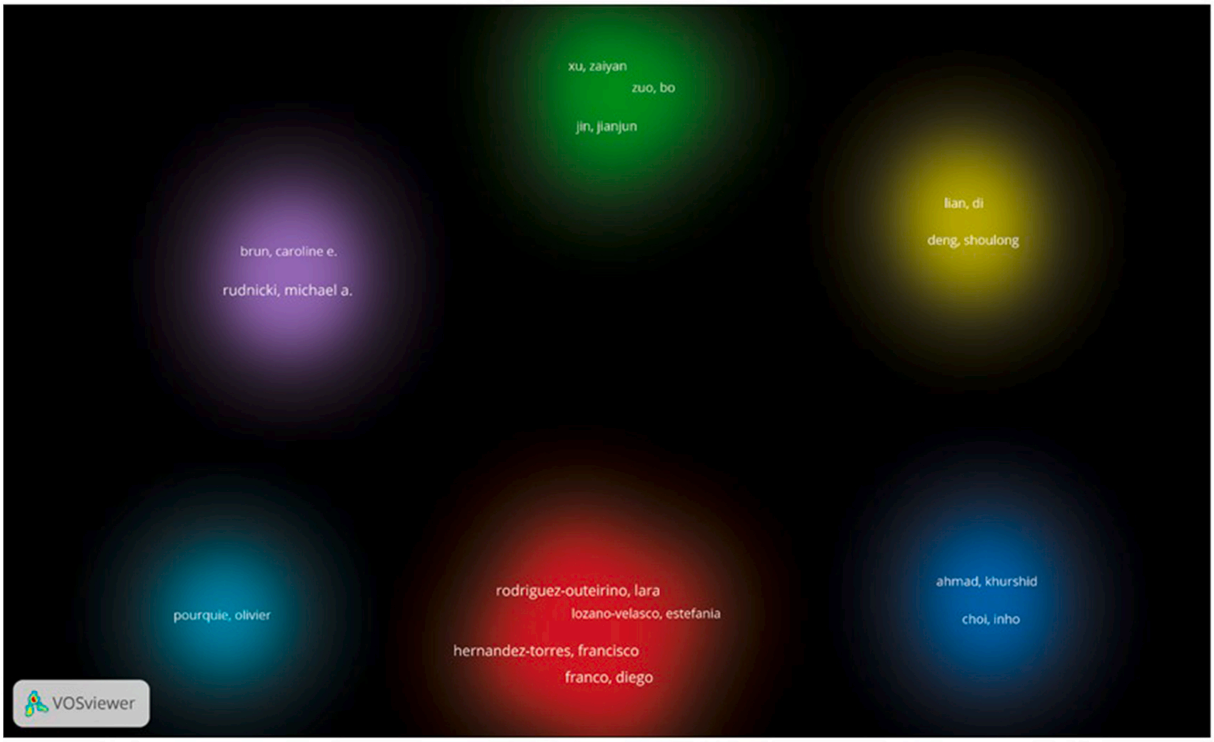

Fig. 4. The group of authors in a cluster involved in skeletal muscle related research.

Table 3
List of the top universities with the minimum number of 02 documents.

S.No.	Name of organization	Documents	Citations	Total link strength
1.	Brigham & Women's Hosp	2	384	4
2.	Harvard Med Sch	2	384	4
3.	Harvard Stem Cell instituted	2	384	4
4.	Medina Fdn	2	14	4
5.	Univ Granada	2	14	4
6.	Univ Jaen	3	45	4
7.	Univ Ottawa	4	641	3
8.	Cooperat innovat ctr sustainable pig produced	2	59	2
9.	Daegu Catholic Univ	2	56	2
10.	Huazhong Agr Univ	2	59	2
11.	Ottawa Hosp	2	359	2
12.	Yeungnam Univ	2	56	2
13.	Univ Alberta	2	42	1
14.	China Agr Univ	2	49	0

Table 4
List of numbers of publications by the top 10 countries.

S.No.	Country	Number of publications	% of contribution
1.	USA	42	32.30
2.	Italy	16	12.30
3.	France	14	10.76
4.	England	12	9.23
5.	Peoples R China	12	9.23
6.	Canada	11	8.46
7.	Spain	9	6.92
8.	South Korea	8	6.15
9.	India	4	3.07
10.	Japan	4	3.07

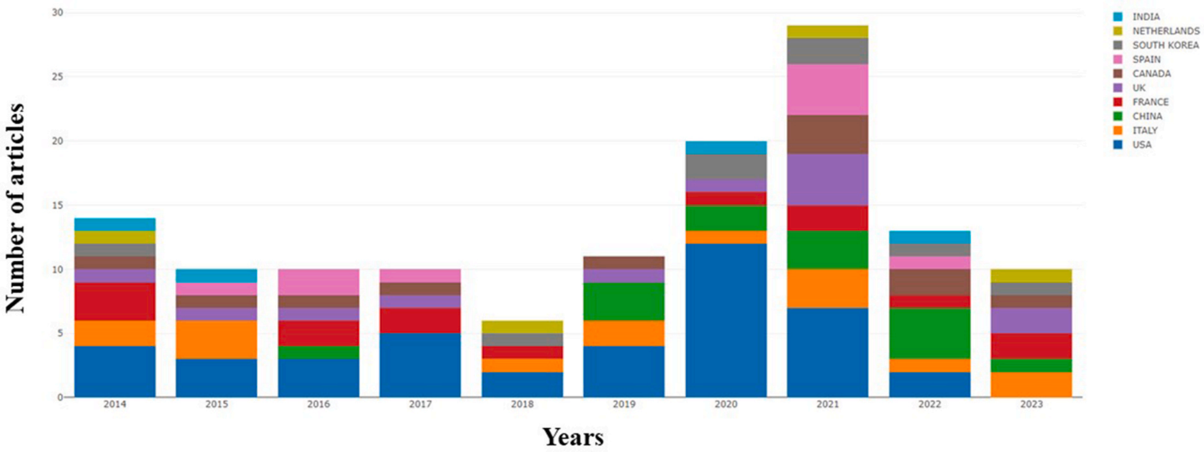

Fig. 5. The number of publication of articles by different countries.

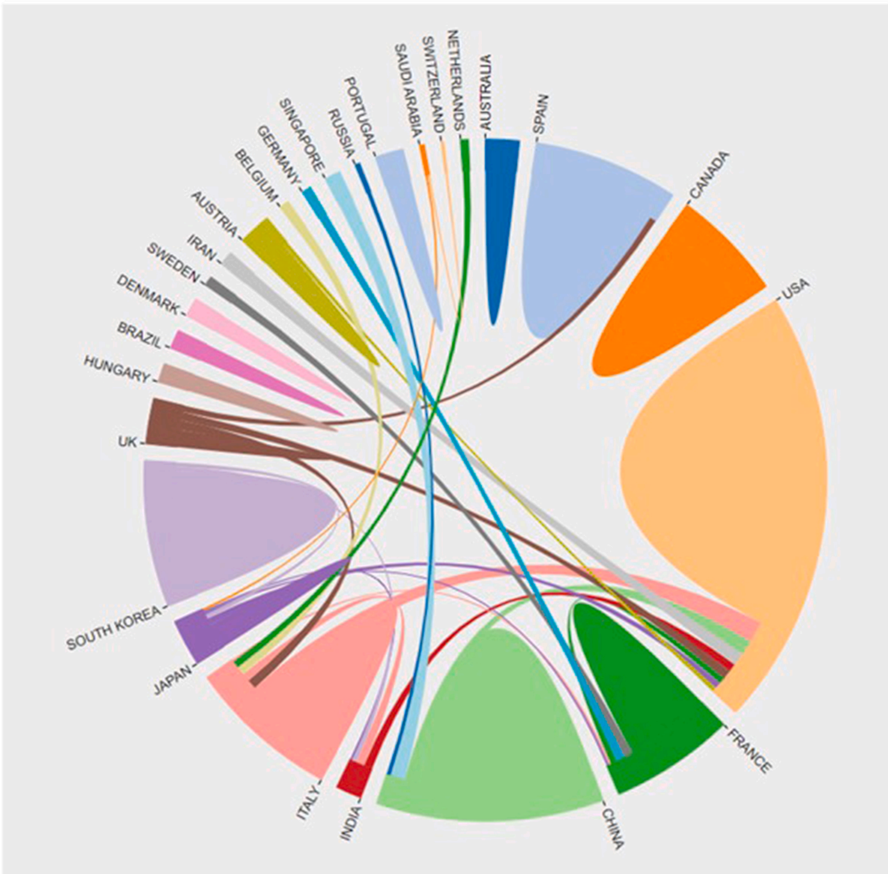

Fig. 6. The relationship between countries involved in skeletal muscle related research.

Cell and Developmental Biology, the International Journal of Molecular Sciences, Cells, Frontiers in Physiology, and Seminars in Cell & Developmental Biology were found to attract high-quality studies. A listing of professional journals on selected topics and the most popular journals in this field (Table 7), indicated researchers prefer to publish findings in professional journals because they have a larger worldwide readership than any subscription-based journals, and open-access journals can greatly enhance the number of times an article is cited. Nearly all of the top journals have open-access alternatives, which constitutes a new trend in research publishing.

Table 5
List of the top 10 funding agencies.

S. No.	Funding Agencies	Record count	% of sharing
1.	National Institutes of Health NIH USA	25	19.23 %
2.	United States Department of Health Human Services	25	19.23 %
3.	Association Francaise Contre Les Myopathies	11	8.46 %
4.	Canadian Institutes of Health Research Cihr	10	7.69 %
5.	Spanish Government	10	7.69 %
6.	European Commission	9	6.92 %
7.	French National Research Agency Anr	8	6.15 %
8.	Muscular Dystrophy Association	8	6.15 %
9.	National Natural Science Foundation of China Nsfc	7	5.38 %
10.	Natural Sciences and Engineering Research Council Of Canada Nserc	5	3.84 %

Table 6
Publication trends during the last 10 years.

Years	Number of publications	% of publications
2023	9	6.92
2022	16	12.30
2021	27	20.76
2020	22	16.92
2019	11	8.46
2018	7	5.38
2017	11	8.46
2016	10	7.69
2015	8	6.15
2014	9	6.92

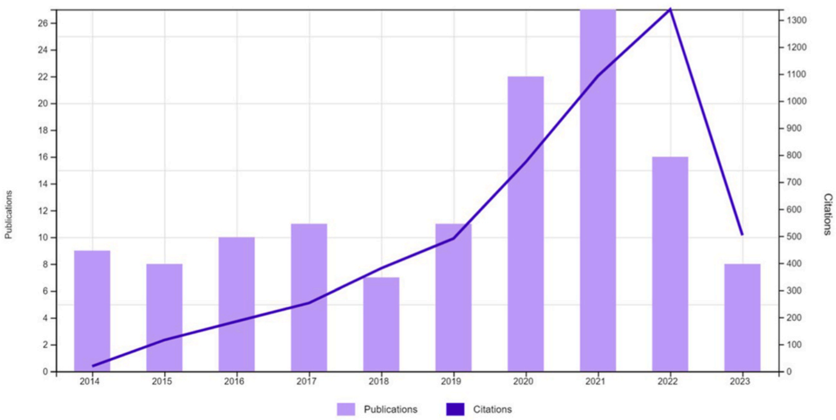

Fig. 7. The number of publications and their citations during last ten years.

4. Discussion

To our knowledge, this is the first bibliometric study conducted on skeletal muscle, myogenesis, and muscle satellite cells. We believe our findings will help researchers identify high-quality articles containing the most significant findings and reflecting trends in this research area. This study provides details of publication trends, research directions, funding agencies, and publishing journals. In this research, we applied a comprehensive bibliometric analysis from the Web of Science database. Articles published from the year 1997 to June 23, 2023 were subjected to further screening using (TS (topic search) = (skeletal muscle) AND TS = (myogenesis) AND TS= (muscle satellite cell)) incorporating 1777 articles from 1997 to June 23, 2023, in the research field of skeletal muscle. Analysis of journals can help researchers find intriguing topics and select proper journals when submitting the manuscript related to these selected keywords.

In bibliometric evaluations, research performance is assessed using techniques like citation analysis [34]. The citation data on the number of times an article has been cited are used to assess an article's impact over time, and bibliometric analysis can be used to find important articles that have influenced medical practice and initiated new ideas [35]. VOSviewer [31] is a distance-based bibliometric tool that enables the visualization of bibliometric networks [31]. In this study, VOSviewer was used to produce 1) a co-authorship

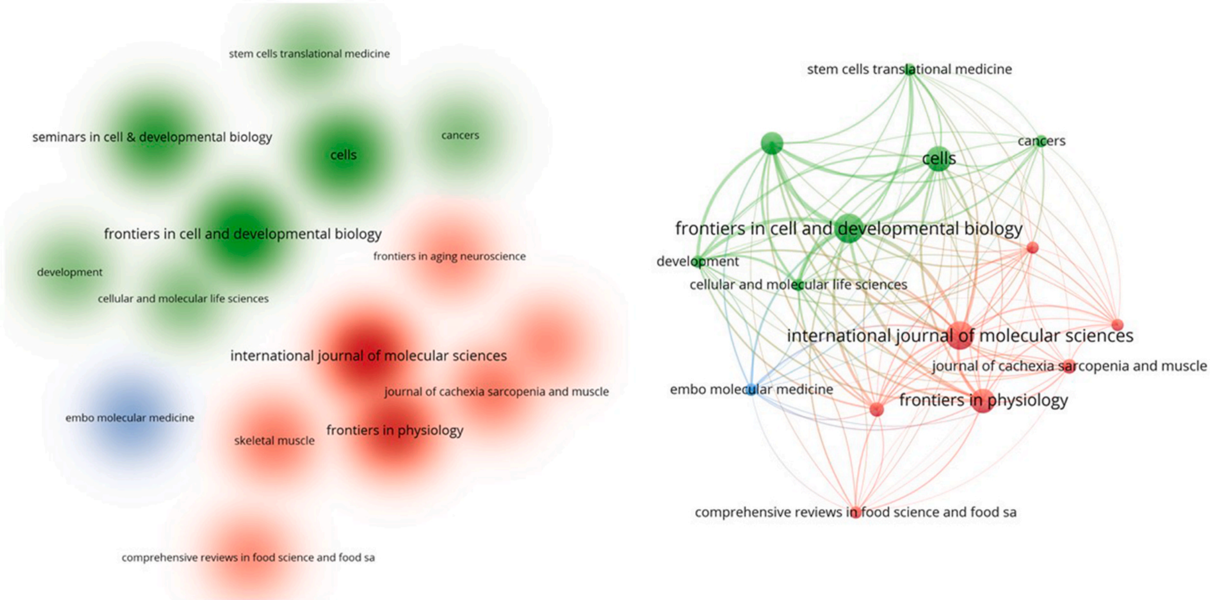

Fig. 8. Top list of journal with high-density publication (left) and link strength (right) related with in skeletal muscle research.

Table 7
List of the top selected journal for publication.

S.No.	Name of Journal	Impact factor	Access type
1.	Frontiers in Cell and Developmental Biology	6.08	Open access
2.	Seminars in Cell & Developmental Biology	7.49	Open access
3.	International Journal of Molecular Sciences	6.20	Open access
4.	Cellular and Molecular Life Sciences	9.23	Open access
5.	Cells	7.66	Open access
6.	Frontiers in Physiology	4.75	Open access
7.	Development	6.86	Open access
8.	Skeletal Muscle	5.06	Open access
9.	STEM CELLS Translational Medicine	7.65	Open access
10.	EMBO Molecular Medicine	14.00	Open access
11.	Frontiers in Aging Neuroscience	5.70	Open access
12.	Journal of Cachexia, Sarcopenia and Muscle	12.06	Open access
13.	Cancers	6.57	Open access
14.	Stem Cells International	5.13	Open access
15.	Comprehensive Reviews in Food Science and Food Safety	15.78	Open access

network of collaboration between authors and their institutions and 2) a co-occurrence network of relationships between authors' keywords. In addition, we used an online bibliometric website (https://bibliometric.com/) to visualize international collaborations.

Academic success is largely dependent on the productive authorship of highly cited articles, and in the present study, the number of research articles and reviews published was found to increase significantly. Bibliometric analysis of research can be used to display the status of research in specific fields and to predict future trends. SM-related research is certain to increase in parallel with societal aging, and therefore, more institutions will focus on SM-related research. Globally, population aging is a social issue of immense importance [36]. According to provisional estimates, in 2015, 26.7 %, 14 %, and 22 % of the populations of Japan, the United States, and Italy, respectively, were older than 65 [37], and 35.9 % of the population of South Korea will be older than 65 by 2050 [38].

Using bibliometric analysis, researchers can identify research original directions and focus on given research topics. Article keywords are most important when searching the literature; keywords related to skeletal muscle-related research are shown in Fig. 2. Divided these keywords into 3 clusters (Table 1) revealed research hot spots in this field. Furthermore, journals play an important role by publishing data with high impact and visibility in the right location. The SJR indicator helps researchers locate high-quality journals in their respective fields [39]. The SJR indicator and journal impact factors often exhibit positive relationships [40] and can be used to identify related high-impact journals. At last, it is quite important that the distribution pattern in the field of skeletal muscle has shown a huge expansion in the quantity of articles during recent years. However, it is significant to recognize that numerous of these recently published articles may not have received the attention they deserve, it is possibly due to their short citation rate.

Skeletal muscle, myogenesis, muscle satellite cells, self-renewal, regeneration, and aging are hot topics of research, and their use as keywords are going to increase. In terms of funding agencies, the National Institutes of Health NIH USA held the first position, and most articles were published in the English language in SCI/SCIE indexed journals. Societal aging is unavoidable, and researchers are paying more attention to delaying the aging process. Globally, skeletal muscle-related research increased rapidly from 1997 to 2023, especially during recent years.

The adult stem cells endure tissue homeostasis and regeneration and their functional decline is associated to aging. It is generally categorized by the progressive loss of physiological functions across multiple tissues and organs in the body. The resident MSC in SM are normally in quiescent form but activate upon tissue injury to reconstitute the damaged tissue. The SM regeneration through myogenesis are shown in Fig. 9. Overall SM mass and strength maintenance completely depends upon muscle satellite (stem) cells (MSCs) activity through myogenesis. Mature SM is formed by multinuclear cells (myofibers). The formation of myofibers depends on the proliferation, differentiation, and fusion of MSC during development and after injury [41] which is termed myogenesis. SM is composed of bundles of multinucleated muscle fibers. Each myofiber is formed by the fusion of mononucleated myoblasts. Following injury, the regeneration of SM occurs in different phases such as the destruction phase, repair phase, and remodeling phase. The secretion of cytokine occurs during destruction phase for regeneration which is facilitated by immune cells such as macrophages and neutrophils during the first week of injury [42]. In the repair phase activation, proliferation of MSC, and differentiation happens [43]. Finally, in the remodeling phase, TGF-β stimulates the synthesis of ECM molecules such as fibronectin (FN), collagens, and proteoglycans for SM regeneration [44]. Therefore, it is likely to be said that SM regeneration is an important parameter for healthy life. Here, with the help of this bibliometric analysis we can design new research path by concluding the current research scenario.

5. Conclusion

The adult stem cells endure tissue homeostasis and regeneration and their functional decline is associated to aging. Skeletal muscle, myogenesis, and muscle satellite cells are attractive research topics that are directly linked with aging. Researchers are attempting to delay rather than prevent aging by maintaining the health status of skeletal muscle. Studies on skeletal muscle will continue to focus on regeneration, muscle satellite cells, self-renewal, and related diseases and pathways with the aim of improving human lifestyles and the impacts of muscle-related diseases and aging.

Data availability statement

All data generated or analyzed during this study are included in this published article.

Ethical approval

Not applicable.

CRediT authorship contribution statement

Syed Sayeed Ahmad: Writing – original draft, Methodology, Data curation, Conceptualization. **Inho Choi:** Writing – review & editing, Funding acquisition.

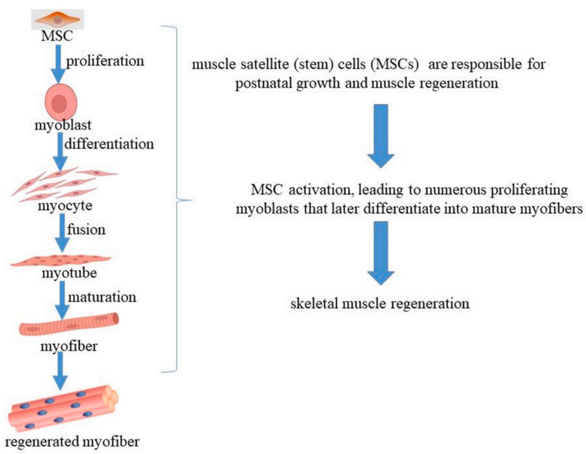

Fig. 9. The process of myogenesis for skeletal muscle regeneration.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

This research was supported by the Basic Science Research Program of the National Research Foundation of Korea (NRF), funded by the Ministry of Education (2020R1A6A1A03044512), the National Research Foundation of Korea (NRF), and the Korean government (NRF-2021R1A2C2004177). In addition, the study was supported by the Forestry (IPET) through High Value-added Food Technology Development Program of the Korea Institute of Planning and Evaluation for Technology in Food and Agriculture funded by the Ministry of Agriculture, Food, and Rural Affairs (MAFRA) (Grant nos. 321026-05 and 322008-5).

References

[1] W.R. Frontera, J. Ochala, Skeletal muscle: a brief review of structure and function, Calcif. Tissue Int. 96 (2015) 183–195, https://doi.org/10.1007/s00223-014-9915-y.

[2] E.J. Lee, S. Shaikh, M.H. Baig, S.Y. Park, J.H. Lim, S.S. Ahmad, S. Ali, K. Ahmad, I. Choi, MIF1 and MIF2 myostatin peptide inhibitors as potent muscle mass regulators, Int. J. Mol. Sci. 23 (2022), https://doi.org/10.3390/ijms23084222.

[3] K. Ahmad, E.J. Lee, J.S. Moon, S.Y. Park, I. Choi, Multifaceted interweaving between extracellular matrix, insulin resistance, and skeletal muscle, Cells 7 (2018), https://doi.org/10.3390/cells7100148.

[4] K. Ahmad, S. Shaikh, S.S. Ahmad, E.J. Lee, I. Choi, Cross-talk between extracellular matrix and skeletal muscle: implications for myopathies, Front. Pharmacol. 11 (2020) 142, https://doi.org/10.3389/fphar.2020.00142.

[5] S.S. Ahmad, K. Ahmad, E.J. Lee, Y.H. Lee, I. Choi, Implications of insulin-like growth factor-1 in skeletal muscle and various diseases, Cells 9 (2020), https://doi.org/10.3390/cells9081773.

[6] P. Sousa-Victor, L. García-Prat, P. Muñoz-Cánoves, Control of satellite cell function in muscle regeneration and its disruption in ageing, Nat. Rev. Mol. Cell Biol. 23 (2022) 204–226, https://doi.org/10.1038/s41580-021-00421-2.

[7] J. Chal, O. Pourquie, Making muscle: skeletal myogenesis in vivo and in vitro, Development 144 (2017) 2104–2122, https://doi.org/10.1242/dev.151035.

[8] E.J. Lee, A.T. Jan, M.H. Baig, J.M. Ashraf, S.S. Nahm, Y.W. Kim, S.Y. Park, I. Choi, Fibromodulin: a master regulator of myostatin controlling progression of satellite cells through a myogenic program, Faseb. J. 30 (2016) 2708–2719, https://doi.org/10.1096/fj.201500133R.

[9] E.J. Lee, A.T. Jan, M.H. Baig, K. Ahmad, A. Malik, G. Rabbani, T. Kim, I.K. Lee, Y.H. Lee, S.Y. Park, et al., Fibromodulin and regulation of the intricate balance between myoblast differentiation to myocytes or adipocyte-like cells, Faseb. J. 32 (2018) 768–781, https://doi.org/10.1096/fj.201700665R.

[10] E.J. Lee, S.S. Ahmad, J.H. Lim, K. Ahmad, S. Shaikh, Y.S. Lee, S.J. Park, J.O. Jin, Y.H. Lee, I. Choi, Interaction of fibromodulin and myostatin to regulate skeletal muscle aging: an opposite regulation in muscle aging, diabetes, and intracellular lipid accumulation, Cells 10 (2021), https://doi.org/10.3390/cells10082083.

[11] S. Ahmad, A.T. Jan, M.H. Baig, E.J. Lee, I. Choi, Matrix gla protein: an extracellular matrix protein regulates myostatin expression in the muscle developmental program, Life Sci. 172 (2017) 55–63, https://doi.org/10.1016/j.lfs.2016.12.011.

[12] T. Kim, K. Ahmad, S. Shaikh, A.T. Jan, M.G. Seo, E.J. Lee, I. Choi, Dermatopontin in skeletal muscle extracellular matrix regulates myogenesis, Cells 8 (2019), https://doi.org/10.3390/cells8040332.

[13] J.H. Lim, K. Ahmad, H.J. Chun, Y.C. Hwang, A.F. Qadri, S. Ali, S.S. Ahmad, S. Shaikh, J. Choi, J. Kim, et al., IgLON4 regulates myogenesis via promoting cell adhesion and maintaining myotube orientation, Cells 11 (2022), https://doi.org/10.3390/cells11203265.

[14] J.H. Lim, M.M.A. Beg, K. Ahmad, S. Shaikh, S.S. Ahmad, H.J. Chun, D. Choi, W.J. Lee, J.O. Jin, J. Kim, et al., IgLON5 regulates the adhesion and differentiation of myoblasts, Cells 10 (2021), https://doi.org/10.3390/cells10020417.

[15] S. Schiaffino, K.A. Dyar, S. Ciciliot, B. Blaauw, M. Sandri, Mechanisms regulating skeletal muscle growth and atrophy, FEBS J. 280 (2013) 4294–4314, https://doi.org/10.1111/febs.12253.

[16] M. Sandri, Protein breakdown in muscle wasting: role of autophagy-lysosome and ubiquitin-proteasome, Int. J. Biochem. Cell Biol. 45 (2013) 2121–2129, https://doi.org/10.1016/j.biocel.2013.04.023.

[17] R.R. Kalyani, M. Corriere, L. Ferrucci, Age-related and disease-related muscle loss: the effect of diabetes, obesity, and other diseases, Lancet Diabetes Endocrinol. 2 (2014) 819–829, https://doi.org/10.1016/s2213-8587(14)70034-8.

[18] P. Bonaldo, M. Sandri, Cellular and molecular mechanisms of muscle atrophy, Dis Model Mech 6 (2013) 25–39, https://doi.org/10.1242/dmm.010389.

[19] L. Yin, N. Li, W. Jia, N. Wang, M. Liang, X. Yang, G. Du, Skeletal muscle atrophy: from mechanisms to treatments, Pharmacol. Res. 172 (2021) 105807, https://doi.org/10.1016/j.phrs.2021.105807.

[20] S.S. Ahmad, K. Ahmad, E.J. Lee, S. Shaikh, I. Choi, Computational identification of dithymoquinone as a potential inhibitor of myostatin and regulator of muscle mass, Molecules 26 (2021), https://doi.org/10.3390/molecules26175407.

[21] E.J. Lee, S. Shaikh, K. Ahmad, S.S. Ahmad, J.H. Lim, S. Park, H.J. Yang, W.K. Cho, S.J. Park, Y.H. Lee, et al., Isolation and characterization of compounds from Glycyrrhiza uralensis as therapeutic agents for the muscle disorders, Int. J. Mol. Sci. (2021) 22, https://doi.org/10.3390/ijms22020876.

[22] E. Garfield, 100 citation classics from the journal of the American medical association, JAMA 257 (1987) 52–59.

[23] Y. Zhang, L. Quan, B. Xiao, L. Du, The 100 top-cited studies on vaccine: a bibliometric analysis, Hum. Vaccines Immunother. 15 (2019) 3024–3031, https://doi.org/10.1080/21645515.2019.1614398.

[24] A. Paniagua Cruz, K.Y. Zhu, C. Ellimoottil, C.A. Dauw, A. Sarma, T.A. Skolarus, Characterizing the benign prostatic hyperplasia literature: a bibliometric analysis, Urology 136 (2020) 202–211, https://doi.org/10.1016/j.urology.2019.11.033.

[25] E. Celik, M. Dokur, The most cited articles on cancer immunotherapy: an update study, J BUON 25 (2020) 1178–1192.

[26] N.S. Samanci, E. Celik, The top 100 cited articles in lung cancer - a bibliometric analysis, Contemp. Oncol. 24 (2020) 17–28, https://doi.org/10.5114/wo.2020.94725.

[27] V. Suzan, A.A. Suzan, A bibliometric analysis of sarcopenia: top 100 articles, Eur Geriatr Med 12 (2021) 185–191, https://doi.org/10.1007/s41999-020-00395-y.

[28] B. Borku Uysal, M.S. Islamoglu, S. Koc, M. Karadag, M. Dokur, Most notable 100 articles of COVID-19: an Altmetric study based on bibliometric analysis, Ir. J. Med. Sci. 190 (2021) 1335–1341, https://doi.org/10.1007/s11845-020-02460-8.

[29] K. Wang, D. Xing, S. Dong, J. Lin, The global state of research in nonsurgical treatment of knee osteoarthritis: a bibliometric and visualized study, BMC Muscoskel. Disord. 20 (2019) 407, https://doi.org/10.1186/s12891-019-2804-9.

[30] Q.H. Pu, Q.J. Lyu, H.Y. Su, Bibliometric analysis of scientific publications in transplantation journals from Mainland China, Japan, South Korea and Taiwan between 2006 and 2015, BMJ Open 6 (2016) e011623, https://doi.org/10.1136/bmjopen-2016-011623.

[31] N.J. van Eck, L. Waltman, Software survey: VOSviewer, a computer program for bibliometric mapping, Scientometrics 84 (2010) 523–538, https://doi.org/10.1007/s11192-009-0146-3.

[32] S. Ali, K. Ahmad, S. Shaikh, J.H. Lim, H.J. Chun, S.S. Ahmad, E.J. Lee, I. Choi, Identification and evaluation of traditional Chinese medicine natural compounds as potential myostatin inhibitors: an in silico approach, Molecules 27 (2022), https://doi.org/10.3390/molecules27134303.

[33] S. Shaikh, S. Ali, J.H. Lim, H.J. Chun, K. Ahmad, S.S. Ahmad, Y.C. Hwang, K.S. Han, N.R. Kim, E.J. Lee, et al., Dipeptidyl peptidase-4 inhibitory potentials of Glycyrrhiza uralensis and its bioactive compounds licochalcone A and licochalcone B: an in silico and in vitro study, Front. Mol. Biosci. 9 (2022) 1024764, https://doi.org/10.3389/fmolb.2022.1024764.
[34] I.D. Cooper, Bibliometrics basics, J. Med. Libr. Assoc. 103 (2015) 217–218, https://doi.org/10.3163/1536-5050.103.4.013.
[35] J.E. Hirsch, An index to quantify an individual's scientific research output, Proc. Natl. Acad. Sci. U. S. A. 102 (2005) 16569–16572, https://doi.org/10.1073/pnas.0507655102.
[36] M. Ciocca, S. Zaffina, A. Fernandez Salinas, C. Bocci, P. Palomba, M.G. Conti, S. Terreri, G. Frisullo, E. Giorda, M. Scarsella, et al., Evolution of human memory B cells from childhood to old age, Front. Immunol. 12 (2021) 690534, https://doi.org/10.3389/fimmu.2021.690534.
[37] G. Kojima, S. Iliffe, Y. Taniguchi, H. Shimada, H. Rakugi, K. Walters, Prevalence of frailty in Japan: a systematic review and meta-analysis, J. Epidemiol. 27 (2017) 347–353, https://doi.org/10.1016/j.je.2016.09.008.
[38] Y. Noh, Y. Yoon, Elderly road collision injury outcomes associated with seat positions and seatbelt use in a rapidly aging society-A case study in South Korea, PLoS One 12 (2017) e0183043, https://doi.org/10.1371/journal.pone.0183043.
[39] M.E. Falagas, V.D. Kouranos, R. Arencibia-Jorge, D.E. Karageorgopoulos, Comparison of SCImago journal rank indicator with journal impact factor, Faseb. J. 22 (2008) 2623–2628, https://doi.org/10.1096/fj.08-107938.
[40] J. Yuen, Comparison of impact factor, eigenfactor metrics, and SCImago journal rank indicator and h-index for neurosurgical and spinal surgical journals, World Neurosurg 119 (2018) e328–e337, https://doi.org/10.1016/j.wneu.2018.07.144.
[41] H. Yamakawa, D. Kusumoto, H. Hashimoto, S. Yuasa, Stem cell aging in skeletal muscle regeneration and disease, Int. J. Mol. Sci. (2020) 21, https://doi.org/10.3390/ijms21051830.
[42] J.M. Fishman, A. Tyraskis, P. Maghsoudlou, L. Urbani, G. Totonelli, M.A. Birchall, P. De Coppi, Skeletal muscle tissue engineering: which cell to use? Tissue Eng., Part B 19 (2013) 503–515, https://doi.org/10.1089/ten.TEB.2013.0120.
[43] J. Huard, A. Lu, X. Mu, P. Guo, Y. Li, Muscle injuries and repair: what's new on the horizon, Cells Tissues Organs 202 (2016) 227–236, https://doi.org/10.1159/000443926.
[44] R.A. Ignotz, J. Massague, Transforming growth factor-beta stimulates the expression of fibronectin and collagen and their incorporation into the extracellular matrix, J. Biol. Chem. 261 (1986) 4337–4345.