

Scientific mapping of somatotype research publications: A bibliometric analysis (1944–2023)

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ABSTRACT

The aim of this study was to map the global somatotype research trends using a bibliometric analysis. The method employed a bibliometric analysis of data sourced from the Scopus database, yielding 2,438 relevant studies authored by 7,609 individuals. To analyze these data, VOSviewer and Biblioshiny were employed to visualize publication trends, key authors, institutions, journals, and keywords. Key findings include a significant research focus in "Medicine" (39.6%) and "Health Professions" (13.1%), with emerging interdisciplinary opportunities in "Psychology" and "Engineering." Notable research themes include "somatotype components", "BMI", and "body image", with emerging studies focusing on 3D human models and artificial neural networks. Despite these advancements, international collaboration remains limited, mainly among industrialized nations. Additionally, the analysis highlights the critical role of somatotype in sports science for optimizing athlete performance and talent identification. Furthermore, new technologies, such as 3D scanning and machine learning, promise advancements in somatotype assessment. Future research should focus on enhancing validity and reliability by integrating advanced technologies and fostering international collaboration to overcome scientific isolation. In conclusion, somatotype research has significantly evolved, with concentrated efforts in medicine and health professions and expanding interdisciplinary collaborations. This study provides valuable insights, emphasizing the need for technological advancements and greater global collaboration.

KEYWORDS

Bibliometric Analysis; Body Assessment; Interdisciplinary Research; International Collaboration; Somatotype

1. INTRODUCTION

Somatotype represents an important classification system where the body's physical characteristics are quantitatively assessed through anthropometric measurements (Carter et al., 2005). It accounts for a significant portion, ranging from 25% to 60%, of the variance observed in physical fitness tests. Various methodologies exist for evaluating and expressing body shape, structure, and composition, with the Heath-Carter method standing out as the most widely utilized (Carter & Heath, 1990). Among these methods, the anthropometric approach holds prominence, involving measurements such as skin folds, bone dimensions, and other non-invasive field techniques that are cost-effective and widely applicable (Carter & Heath, 1990). This method calculates somatotype components—endomorph, mesomorph, and ectomorph—providing a comprehensive representation of body composition.

Somatotype significantly influences an individual's engagement in physical activities, optimizing performance outcomes when aligned appropriately with the demands of the activity (Gaurav et al., 2010; Ghozali et al., 2004). In sports science, somatotyping has been increasingly used to assess the suitability of athletes for specific sports, contributing to talent identification, training optimization, and injury prevention (Kolena et al., 2024; Baranauskas et al., 2024). Recent studies highlight how specific somatotypes correlate with superior performance in various disciplines, such as mesomorph being dominant among strength- and power-based athletes, ectomorph favouring endurance sports, and endomorph being associated with weight-classified sports (Ciftci & Kurtoglu, 2023; van der Zwaard et al., 2019). Additionally, research suggests that somatotype variations can influence biomechanical efficiency, recovery rates, and susceptibility to injuries, reinforcing its significance in athletic performance evaluation (Martínez-Mireles et al., 2025).

Beyond sports science, several studies have linked somatotypes with various medical conditions. Early investigations underscored the association between somatotype and certain behavioural and functional disorders, notably linking ectomorph and mesomorph to paranoid schizophrenia (Sheldon et al., 1969). Several studies have also investigated the correlation between somatotype components—endomorph, mesomorph, and ectomorph—and the prevalence of chronic diseases such as digestive system disorders, arterial hypertension, liver diseases, Alzheimer's disease, Type 2 diabetes, obstructive sleep apnea, chronic kidney disease, and ischemic heart disease (Koleva et al., 2002; Buffa et al., 2007; Baltadjiev, 2013; Toy et al., 2021; Ulubaba et al., 2023;

Valkov et al., 1996). These underscore the importance of considering human somatotypes in diagnosing, treating, and preventing various diseases.

Bibliometric analysis is a well-known method for mapping scientific research and identifying key trends and developments across different periods, contexts, and research fields (van Eck & Waltman, 2014). Despite the increasing interest in somatotype research across sports science, clinical medicine, and anthropology, no bibliometric study has comprehensively analyzed its evolution. One potential reason for this gap is that somatotype research has often been fragmented across multiple disciplines, with limited cross-disciplinary integration. This paper aims to fill that gap by analyzing global trends in somatotype research across multiple fields over the past 80 years, offering insights into the historical, current, and future landscape of this research area. Additionally, it presents a visual bibliometric mapping that focuses on publication trends, countries, institutions, authors, journals, citations, and keywords. This comprehensive analysis provides a snapshot of emerging research topics and potential future directions.

2. METHODS

2.1. Data Source and Search Strategy

The data for this study was sourced online from the Scopus database, one of the most extensive global repositories of publications, encompassing journals, books, and conferences and providing reliable scientific data. Scopus was selected as the primary database after being compared with other sources, such as ScienceDirect and PubMed, to assess coverage and relevance. It was chosen due to its extensive metadata compatibility with Biblioshiny software and its inclusion of a higher number of relevant publications on somatotypes compared to other databases. To mitigate bias from daily database updates, all searches were conducted on April 1st, 2024, using the keyword “somatotype.” The initial search yielded a total of 3,440 studies.

We limited the literature to English-language publications that had completed the publication process, as restricting our selection to English ensured that we could accurately interpret and analyze the findings without the risk of misrepresentation or misinterpretation due to language barriers. Our study included only articles, reviews, and conference papers, with journals as the source type. A total of 3,428 studies met these criteria. We then screened the titles and abstracts of these studies to exclude irrelevant ones. Irrelevant studies were identified as those that did not explicitly focus on somatotype assessment, classification, or its application. Eventually, 2,438 studies, authored by 7,609

individuals across 978 sources, were downloaded and analyzed. We extracted all metadata from each article, including authorship, journals, institutions, countries, and keywords.

2.2. Data Visualization and Analysis

The publication output was then analyzed using Scopus analysis tools, R package's bibliometrics (Biblioshiny) (Aria & Cuccurullo, 2017; Aria et al., 2022; Aria et al., 2020), and VOSviewer (version 1.6.18) (van Eck & Waltman, 2017; 2010). The downloaded data were examined using the literature analysis report from the Scopus database to describe fields, authors, institutions, countries, and journals.

VOSviewer, a bibliometric network analysis tool, was also employed to construct the visualizations. VOSviewer is a specialized software renowned for its outstanding capabilities in data visualization and cluster analysis. The results are depicted as nodes and links, illustrating the relationships within the bibliometric data. The size of each node corresponds to the frequency of its occurrence, while the distance between nodes indicates the strength of the association between the terms. Subsequently, Biblioshiny, which offers a wide range of tools that enable researchers to conduct thorough bibliometric studies, was also utilized in this study.

3. RESULTS

3.1. Field of Related Studies

Figure 1 provides a summary of the study field's characteristics, with the earliest publication in the "Medicine" category recorded in 1944.

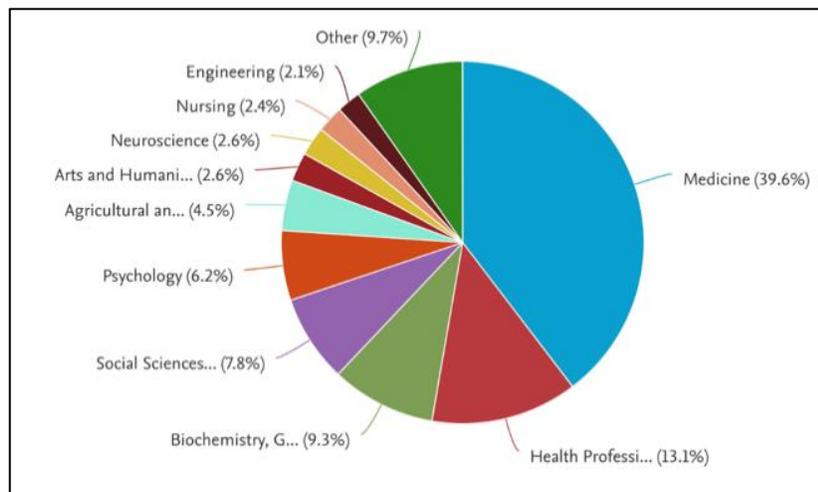


Figure 1. Pie diagram of the field of studies on somatotypes from 1944-2023

The database encompasses a wide range of articles spanning 27 research fields. The majority of somatotype-related articles were found in medicine (~39.6%), health professions (~13.1%), and biochemistry, genetics, and molecular biology (~9.3%).

3.2. Distribution of Annual Publications from 1944-2023

Research on somatotypes has shown steady growth over the past 80 years. The increasing number of publications and citations reflects growing interest in somatotype research across various fields. Figure 2 illustrates the annual number of publications in this field.

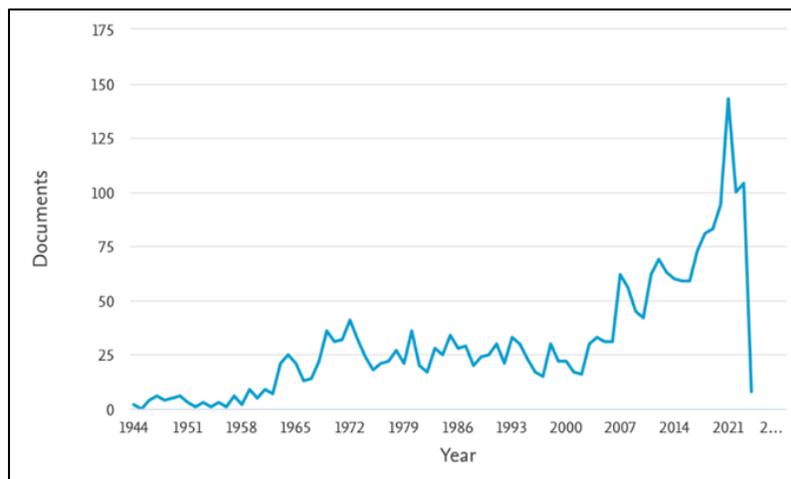


Figure 2. The trend of publications growth in somatotype study. Research output has steadily increased, peaking in 2021 before declining sharply

During the first decade (1944-1953), the growth was modest, with only 34 articles (1.39%) published. However, in 2021, a significant spike occurred, with 75 articles published in the "Medicine" field, contributing to a total of 142 publications that year, marking 2021 as the year with the highest number of publications.

3.3. Distribution of Authors with Most Publications and Collaboration

Below, Table 1 highlights the most influential authors in somatotype studies, as determined by the Scopus index metric. The total contribution of the top 10 from 7069 authors represents 5.95% of the total research production on somatotypes and is focused mainly in the field of "Medicine." Amongst 2,438 journals, 26 publications were made by Robert M. Malina. Ranked second and third are J. E. Lindsay Carter has 21 publications, and Gastón Prudence Beunen has 16. Besides publication count, authors are also ranked by their h-index, a metric that assesses impact based on the

number of articles and total citations. Robert M. Malina is also the top author with the highest h-index.

Table 1. Top 10 authors with the most publications in research of somatotype

Rank	Authors	h-index	Total Citation	Total Publication	First Publication	Main Field
1	Malina, Robert M.	78	805	26	1974	Medicine
2	Carter, J. E. Lindsay	18	1109	21	1966	Medicine
3	Beunen, Gastón Prudence	52	493	16	1980	Medicine
4	Claessens, Albrecht L.M.	42	574	16	1987	Medicine
5	Lefevre, Johan A.	53	451	12	1987	Medicine
6	Alacid, Fernando	21	105	11	2011	Medicine
7	Franchini, Emerson	54	725	11	2011	Medicine
8	Jürimäe, Toivo	38	102	11	1996	Medicine
9	Reilly, Thomas P.	75	1271	11	1979	Medicine
10	Bale, Peter	11	307	10	1980	Medicine

Collaboration patterns are critical to the knowledge structure of a field. The number of collaborations indicates concurrent support and interest in a research area. Determining the collaboration patterns was done by mapping co-authorship in VOSviewer. Links are created for each collaboration between researchers based on a fixed number of five collaborations and their extensive networks. Figure 3 shows a collaboration network with two clusters.

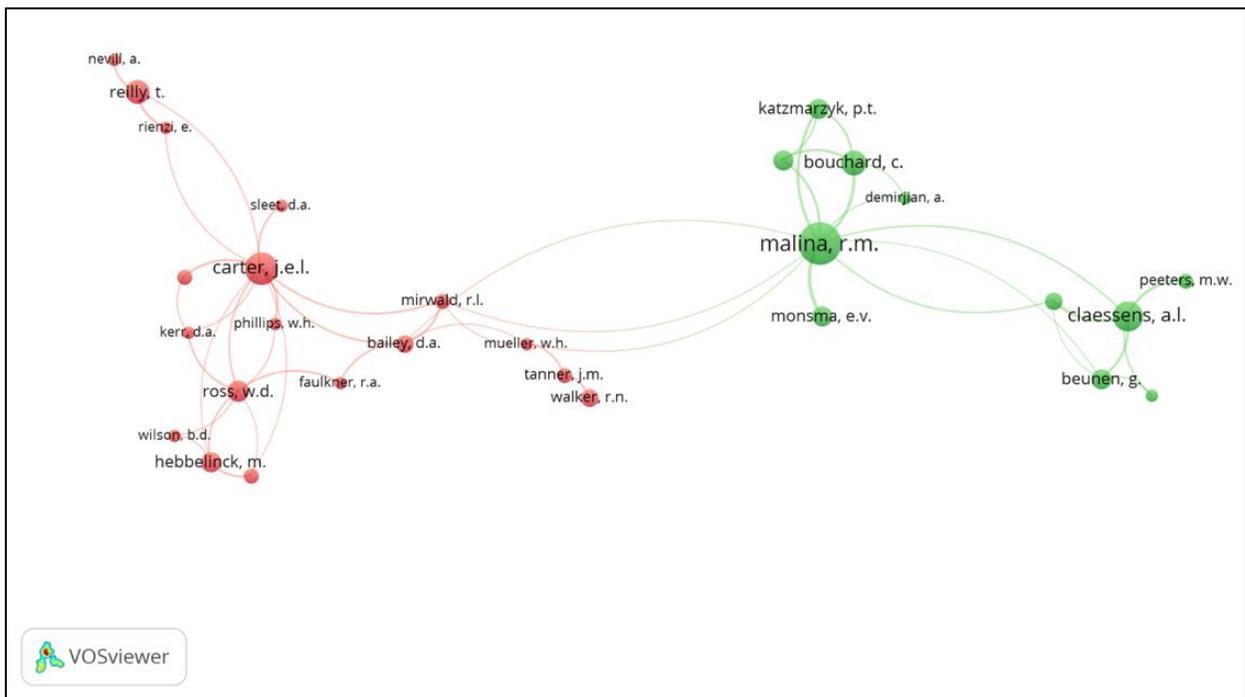


Figure 3. Collaboration network between researchers

Note. The strength (thickness) of a link indicates the frequency of collaboration between two authors. The node size and associated text size depend on the number of collaborations

The dominant collaboration is between the research fields of "Medicine" and "Health Professions." Of the top 30 collaborators, there are no collaboration clusters related to the research fields "Psychology" and "Engineering," indicating that not a single author in this field has a network of at least four additional collaborators or collaborative publications with other fields. This could be a potential for collaboration between new fields.

The limited collaboration between "Psychology" and "Engineering" in somatotype research may stem from its strong historical roots in medicine and health professions, where applications in sports science and disease risk assessment are well established. Psychology's role is emerging, focusing on body image and mental health, while engineering contributes through imaging technologies and AI-driven assessment tools. As advancements in 3D scanning, biomechanics, and machine learning progress, interdisciplinary collaboration is likely to increase. Encouraging cross-disciplinary partnerships, securing funding, and promoting open-access research could help integrate these fields with established medical domains.

3.4. Distribution of Countries with the Most Publications and Collaboration

Among the 94 countries, the top ten, primarily developed economies, contribute 71.78% of the total research publications on somatotype. Leading the list are the United States (28.26%), the United Kingdom (8.90%), Spain (8.01%), and Canada (4.81%), alongside rapidly growing economies such as China (3.92%). In terms of citation volume, the United States, the United Kingdom, and Spain are the most influential, collectively accounting for approximately 45% of the total citations. Table 2 shows a summary of country-level production ranked based on total publications, total citations, and multiple country publications (MCP).

Table 2. Country production and collaboration numbers in somatotype research

Rank	Journal	Total Publication	Total Citation	MCP	Collaboration Percentage
1	United States	635	24105	74	11.65%
2	United Kingdom	200	6952	27	13.5%
3	Spain	180	2853	35	19.44%
4	Canada	108	3158	14	12.96%
5	China	94	809	13	13.83%
6	Poland	88	1606	7	19.31%
7	Brazil	87	777	15	17.24%
8	Australia	83	2341	9	10.84%
9	Italy	77	3104	16	20.78%
10	Germany	61	1573	3	4.92%

Based on the affiliation of the corresponding author, we identified the percentage of collaboration among the most productive countries. Of the top 10 countries with the most total publications, Italy is the most collaborative country, with 20.78% of publications co-authored by at least one researcher from another country. Figure 4 shows an analysis of cross-country collaborative groups.

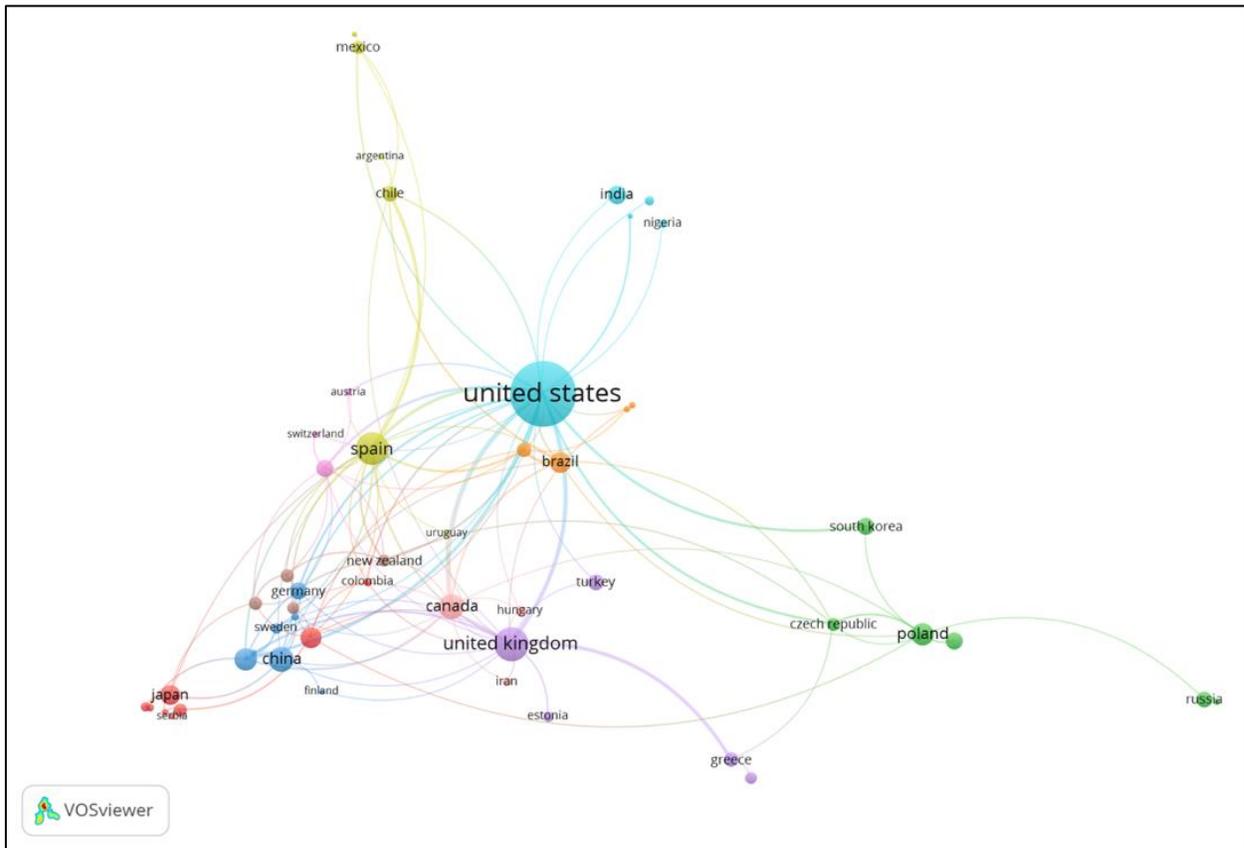


Figure 4. Collaboration network between countries

Note. The strength (thickness) of a link indicates the frequency of collaboration between two countries. The node size and associated text size depend on the number of collaborations

The United States leads with the largest collaboration network, producing 74 articles involving authors from 27 different countries. It is followed by England, which collaborates with 19 other countries on 27 articles, and Spain, which collaborates with 17 countries on 35 articles. To enhance the visualization of all countries, the link strength in the collaboration network is set at one co-author per document. Countries with the highest number of publications and collaborations are positioned at the centre of the network, while those with fewer collaborations and less influence are on the periphery. Among the top 50 countries, twelve have only one collaboration with another country: India, Ukraine, Bulgaria, Estonia, Israel, Nigeria, Norway, Serbia, Kyrgyzstan, Argentina,

Cuba, and Taiwan. Additionally, six countries do not collaborate with others: Ivory Coast, Algeria, Armenia, Honduras, Jordan, and Uzbekistan.

3.5. The Most Influential Journals

The most relevant journals publishing somatotype articles were ranked based on total publications and total citations. Table 3 shows that the "Journal of Sports Medicine and Physical Fitness" ranks first with 107 publications and 2,590 citations. The top 10 journals cover fields such as "Medicine," "Health Professions," "Social Sciences," "Psychology," "Neuroscience," "Arts and Humanities," and "Biochemistry, Genetics and Molecular Biology."

Table 3. The most influential publication journals

Rank	Journal (First Publication)	Cite Score 2023	Total Citation	Total Publication	Fields
1	Journal of Sports Medicine and Physical Fitness (1966)	2.8	2590	107	Health Professions: Physical Therapy, Sports Therapy and Rehabilitation. Medicine: Orthopedics and Sports Medicine
2	International Journal of Morphology (2008)	0.9	423	51	Medicine: Anatomy
3	American Journal of Physical Anthropology (1946)	4.8	1256	49	Social Sciences: Anthropology. Medicine: Anatomy
4	Journal of Sports Sciences (2021)	6.5	2282	47	Health Professions: Physical Therapy, Sports Therapy and Rehabilitation. Medicine: Orthopedics and Sports Medicine
5	Body Image (2007)	8.6	2252	43	Psychology: Social; General; Applied Psychology
6	Perceptual and Motor Skills (1964)	2.8	471	39	Psychology: Experimental and Cognitive Psychology. Neuroscience: Sensory Systems
7	Collegium Antropologicum (1979)	0.4	496	38	Arts and Humanities: Arts and Humanities (miscellaneous). Social Sciences: Anthropology
8	Annals of Human Biology (1974)	3.3	516	32	Medicine: Public Health, Environmental and Occupational Health; Epidemiology Biochemistry, Genetics and Molecular Biology; Genetics; Physiology; Aging
9	British Journal of Sports Medicine (1977)	26.9	842	26	Medicine: Orthopedics and Sports Medicine. Health Professions: Physical Therapy, Sports Therapy and Rehabilitation
10	Human Biology (1966)	2.1	479	26	Medicine: General Medicine

Similar to the list of top authors, the "Medicine" category dominates, with seven journals represented. The "International Journal of Morphology" ranks second with 51 publications and 423 citations, followed by the "American Journal of Physical Anthropology" with 49 publications and 1,256 citations.

3.6. Trending Topics

In VOSviewer, the network has a specific theme. Figure 5 identifies four clusters comprising the top 172 keywords used in somatotype research since 1944.

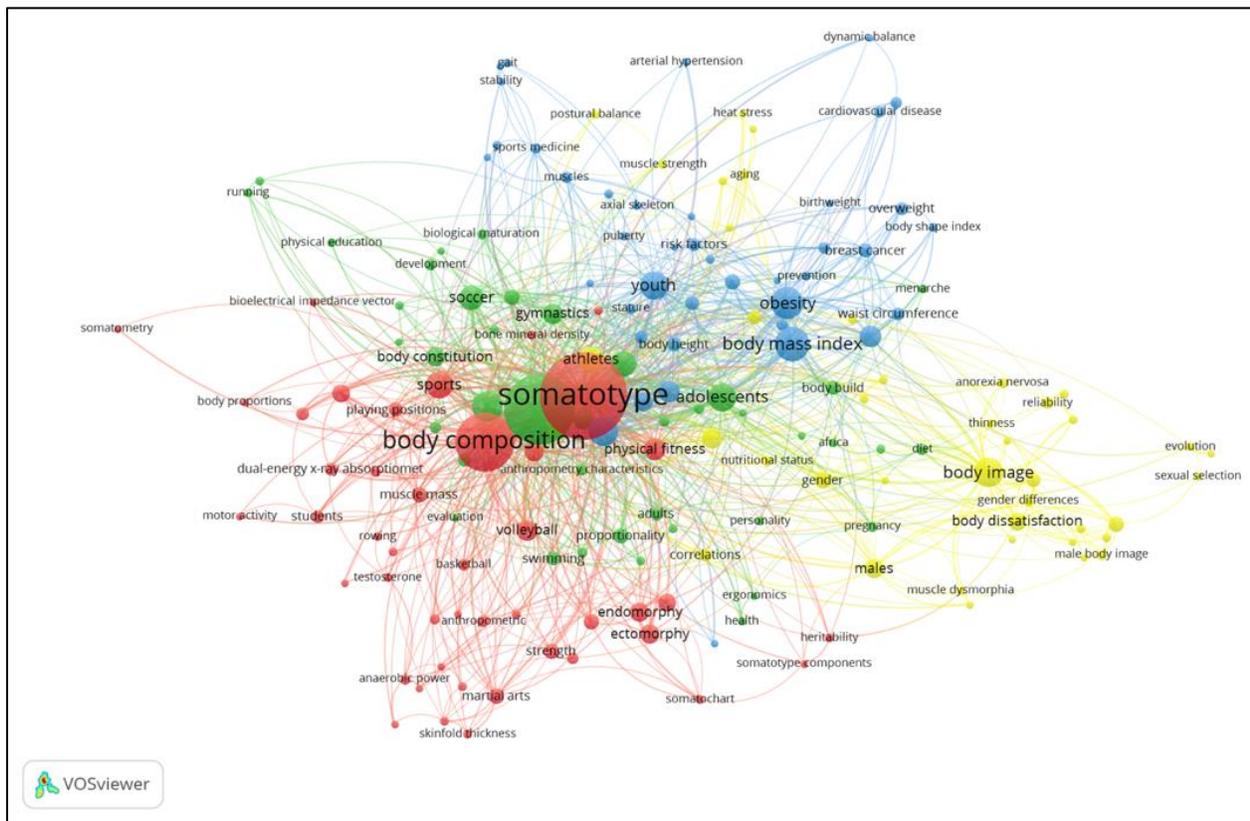


Figure 5. Key topics in somatotype research

Note. The size of each circle is proportional to the frequency of the keyword's occurrence—the larger the circle, the more frequently the keyword appears. Lines between items indicate relationships and the strength of these

The first cluster, coloured red, includes 45 keywords with "somatotype," "body composition," and "sports" as the primary keywords. The second cluster, green, contains 42 keywords, with "anthropometrics," "sports performance," and "adolescents" as the main keywords. The third cluster, blue, also consists of 41 keywords, with "body mass index," "obesity," and "body fat" as the main keywords. The fourth cluster, yellow, includes 41 keywords featuring "body image," "athlete," and "physique" as the main terms.

The keyword clusters provide insight into the cohesion and development of research themes in the field. To further understand the thematic structure of somatotype research, a thematic map of author keywords was created (Figure 6).

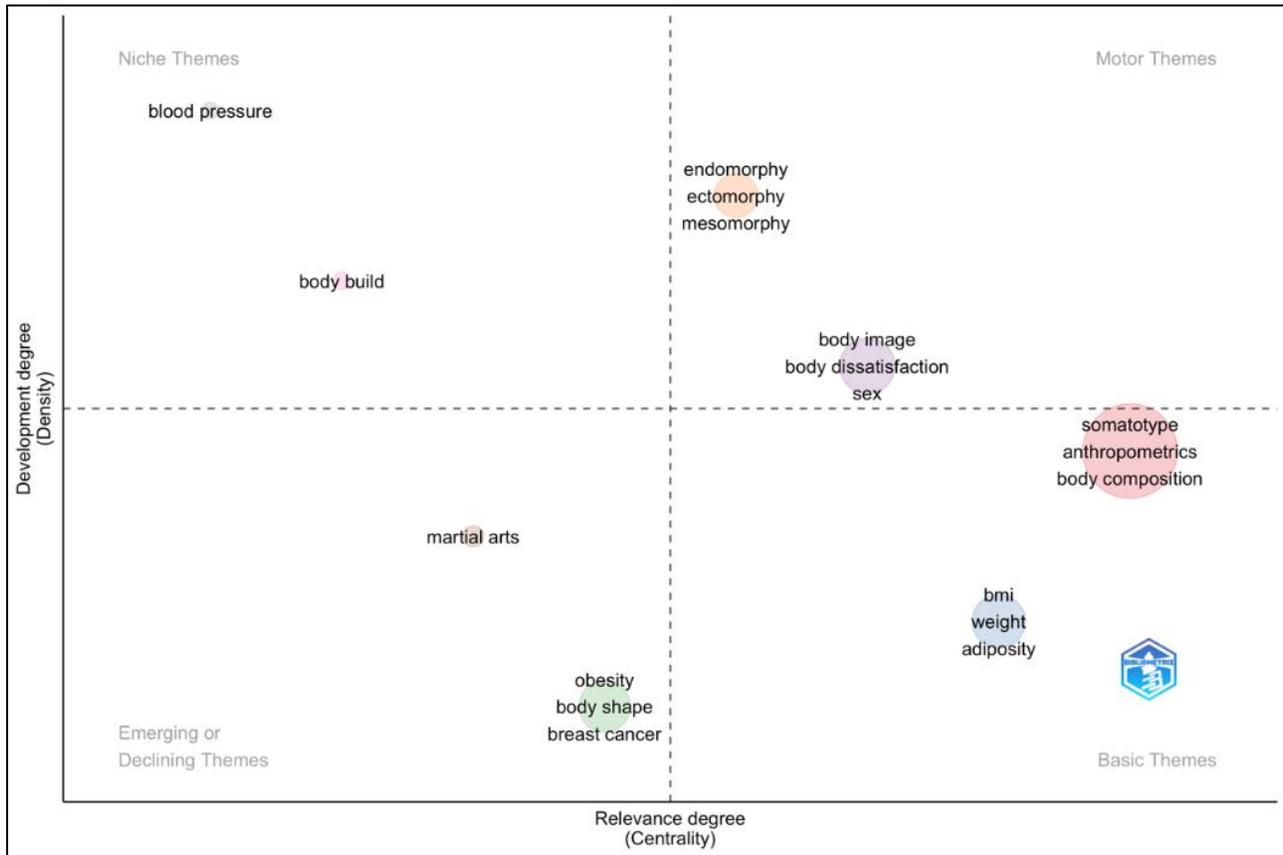


Figure 6. Thematic maps of author keywords

Thematic maps divide keywords into four quadrants based on their importance (centrality) and development (density) (Cobo et al., 2011; Janik et al., 2021). The upper right quadrant contains important and well-developed motor themes. The bottom right quadrant includes basic themes that are important but underdeveloped. The upper left quadrant consists of research themes that are well-developed in their appropriate context. The lower left quadrant includes themes that are less important and less developed, representing emerging topics in the field (Chen et al., 2019).

Keywords, including somatotype, anthropometrics, and body composition, are the most frequently occurring, with a frequency of 934, forming the red cluster. This cluster is located at the intersection of the lower right and upper right quadrants, indicating that these keywords are fundamental themes that are important but require further research. Keywords like BMI, weight, and

adiposity, with a frequency of 108 forming the blue cluster, are also situated in the lower right quadrant, signifying that they are basic yet underdeveloped themes. Obesity, body shape, and breast cancer, each with a frequency of 106, form another blue cluster in the lower left quadrant. The keyword "martial arts," with a frequency of 16, forms a brown cluster in the same lower left quadrant. These clusters indicate relatively low development and importance, suggesting a possible declining trend in somatotype research in these areas. In the upper left quadrant, there are two clusters: grey and pink. The grey cluster includes the keyword "blood pressure" with a frequency of 12, while the pink cluster includes "body build" with a frequency of 13. These clusters represent research themes that have developed appropriately within their context. In the upper right quadrant, two clusters, orange and purple, are present. The orange cluster comprises three keywords—ectomorphy, endomorphy, and mesomorphy (components of somatotype)—with a frequency of 66. The purple cluster includes three keywords—body image, body dissatisfaction, and sex. These clusters contain important and well-developed motor themes. Research on somatotypes has evolved significantly over the past decade, indicating a diversification of research topics across niche, motor, basic, and emerging areas. Strong motor themes, such as somatotype components, talent identification, volleyball, and combat sports, underscore the relevance of somatotypes in the sports industry. Basic themes, such as BMI, highlight the need for further development in somatotype research. Overall, the current research trends suggest an ongoing expansion and refinement of themes within the field.

4. DISCUSSION

This bibliometric analysis spans 80 years and includes 2,438 documents on somatotypes, revealing significant trends and the evolution of research across various disciplines. Research productivity has shown notable concentration in "Medicine" (39.6%), "Health Professions" (13.1%), and "Biochemistry, Genetics, and Molecular Biology" (9.3%). Despite concentrated research in these areas, thematic development also includes "Psychology" and "Engineering," which serve as potential bridges for cross-disciplinary collaboration. Expanding multidisciplinary collaboration may be fostered through joint research programs, interdisciplinary workshops, and targeted funding from major research organizations. Additionally, international conferences provide key networking opportunities to integrate expertise across various fields. Subsequently, by identifying the most influential sources and authors and mapping the evolution of somatotype research, the analysis highlights well-established motor and basic research themes, particularly in assessing "somatotype components," "BMI," and "body image." Emerging research addresses equity, diversity, and

technological innovations, like 3D human models and artificial neural networks. While fields like "Medicine" and "Health Professions" have advanced independently, the study underscores the need for international collaboration to overcome scientific isolation, promote a comprehensive understanding of somatotypes, and enhance the diversity and impact of research in this area.

Research on somatotypes continues to play a pivotal role in advancing human knowledge and practice across various disciplines. This is evidenced by the growing body of research and practical applications in fields such as "Medicine," "Health Professions," "Biochemistry," "Genetics and Molecular Biology," "Psychology," "Engineering," and "Multidisciplinary" studies. Anthropometric measurements, crucial in the selection of athletes and performance criteria in sports, are integral to somatotype assessment, which categorizes physical attributes based on body shape and composition (Vucetić et al., 2008; Ryan-Stewart et al., 2018). Somatotype is particularly relevant in sports where body biomechanics significantly impact performance (Massidda et al., 2013; Çınarlı & Kafkas, 2019), helping to understand and optimize the motor performance requirements unique to each sport (Gutnik et al., 2015).

Evaluating somatotype and body composition is essential for selecting appropriate sports activities and understanding the development dynamics of elite athletes during training and competition (Gutnik et al., 2015; Hermassi et al., 2020; Marta et al., 2013; Noh et al., 2015). Both exercise and diet are influential in shaping an individual's somatotype (Lindsay et al., 1969). Beyond sports, somatotype characteristics are extensively researched to explore their relationship with obesity and specific nutritional traits (Koleva et al., 2000; Das et al., 2021). Subsequently, somatotype classification can serve as a predictive parameter for disease predisposition (Katzmarzyk et al., 1999), highlighting its potential as a predictor for various diseases.

Analysis of somatotype research shows its origins in the field of "Medicine" and its rapid expansion into "Health Professions," "Biochemistry, Genetics and Molecular Biology," "Psychology," and "Engineering." Over 2,000 journals have published articles on somatotypes, with the top 10 journals collectively accounting for 458 (18.79%) publications from 1944 to 2023. Leading journals in this domain include the "Journal of Sports Medicine and Physical Fitness," the "International Journal of Morphology," the "American Journal of Physical Anthropology," the "Journal of Sports Sciences," and "Body Image." These journals have a higher number of scientific publications compared to multidisciplinary journals like PLOS ONE, which ranks 22nd with 23 publications.

The most prolific researchers are primarily within the field of "Medicine," supported by the fact that eight of the ten most cited publications on somatotype from 1944-2023 are from journals in this field. For instance, the article "Indices of Relative Weight and Obesity" by Keys et al. (1972), published in the *Journal of Chronic Diseases*, holds the highest citation count at 1,474 [39]. This article highlights the significant role of somatotype research in "Medicine" and its connections to other fields like "Health Professions" (67 citations), "Biochemistry, Genetics, and Molecular Biology" (267 citations), and "Psychology" (126 citations). The study by Keys et al. reports on the correlation between body height and subcutaneous fat thickness, expressed as relative weight percentages at certain heights, weight/height ratio, weight/height squared, and the ponderal index (cube root of weight divided by height) in 7,424 men across 12 groups in five countries. It also examines the relationship between relative weight indicators and body density in 180 young men and 248 men aged 49-59 years. The study concludes that the body mass index (BMI) is preferable to other relative weight indices due to its simplicity and applicability to the entire population.

The second most cited article, "Generalized Equations for Predicting Body Density of Women" by Jackson et al. (1980), published in *Medicine and Science in Sports and Exercise*, has 1,473 citations. This research underscores the importance of somatotype studies in "Medicine" and their connections to "Health Professions" (536 citations), "Psychology" (64 citations), and "Engineering" (20 citations). The study aimed to develop generalized equations for predicting body density in women of varying ages and body compositions using hydrostatic methods, skinfold fat measurements, gluteal circumference, and age as independent variables. The resulting equations demonstrated strong correlations and were cross-validated on a separate sample of women. These findings emphasize the vital role of somatotype research in multiple fields and the necessity of advancing measurement methods. With the rise of technologies such as 3D reconstruction techniques, it is crucial to enhance somatotype examination methods to ensure accuracy and reliability.

The publication by Reilly et al. (2000), titled "A Multidisciplinary Approach to Talent Identification in Soccer," published in the *Journal of Sports Sciences Medicine*, is the most cited article in the field of "Health Professions," with 689 citations. This study has implications for other research fields, such as "Medicine" with 469 citations, "Psychology" with 80 citations, and "Social Sciences" with 113 citations. The research investigates the multifactorial requirements of football and uses multivariate analysis to differentiate the characteristics of elite players. The study involved 31 youth players (16 elite, 15 sub-elite), matched by age (15–16 years) and body size. Test questions

included anthropometric, physiological, psychological, and soccer-specific skills. Key discriminating measures were agility, running time, ego orientation, and anticipation skills. Elite players were significantly leaner, had greater aerobic power (9.0 ± 1.7 vs. 55.5 ± 3.8 ml/kg-1/min-1), and showed higher fatigue tolerance ($p < 0.05$). They also excelled in dribbling but not in shooting. The study concludes that these tests can establish baseline reference data for young players selected for special development programs.

In the field of "Psychology," the notable publication is a meta-analysis by Thomas & French (1985) titled "Gender Differences Across Age in Motor Performance. A Meta Analysis," published in *Psychological Bulletin*. This paper, ranked 9th with 432 citations, analyzed gender differences in motor performance across ages but initially did not index each motor task to its reference. This work lists 20 motor tasks and their references, covering fundamental movements (e.g., catching, jumping, running, throwing), motor fitness (e.g., agility, arm hang, balance, grip strength), and perceptual-motor abilities (e.g., anticipation timing, fine eye-motor coordination, pursuit-rotor tracking, reaction time). The arms hang appeared in the fewest papers ($n = 2$), while the dash and long jump were most frequently referenced ($n = 21$). This meta-analysis contributes significantly to understanding gender differences in motor performance across different ages.

The contributions highlighted above facilitate productive researchers in "Medicine," "Health Professions," "Biochemistry, Genetics, Molecular Biology," "Psychology," and "Engineering" to establish future cross-field collaborative research projects, aiming to pioneer and develop new themes, both basic and advanced, in somatotype research. While journals and authors continue to solidify the knowledge base of somatotype research, there is still significant room for improvement in the global application of this research. Most bibliometric analyses consider country-level article production as a measure of scientific contribution. We acknowledge the challenges faced by researchers in developing countries and institutions where limited resources and policies impact scientific productivity. Furthermore, major publication venues are often located in industrialized countries, creating access barriers such as journal database paywalls or language issues.

Despite the high productivity in somatotype research, international collaboration remains limited. Collaborative efforts are predominantly seen among industrialized countries, with 12 countries having only one international collaboration and six countries having none at all. The analysis underscores the progress and productivity in developed countries but also highlights the scientific isolation in other regions, a common theme across all research fields. Cross-national and interdisciplinary collaboration are encouraged to enhance knowledge production, innovation, and

diversity in somatotype research. Promoting the open production and exchange of knowledge across geographic boundaries and disciplines is crucial for a comprehensive understanding of human phenomena, advancing science, and improving technology globally (Lin & Li, 2023). This approach ensures the cross-fertilization of ideas and addresses gaps from a global and multidisciplinary perspective.

4.1. Future Directions

As research on somatotypes continues to develop, open debates persist in challenging its progress. Thematic evolution relates to changes in an author's keywords over time. To examine changes in emergent, specific, basic, and motor research themes regarding somatotypes, time slices for keyword cluster analysis were generated across four periods: (a) 1944–1983, marking the initial 40 years of slow growth; (b) 1984–2003, a period of increased research activity and thematic diversity; (c) 2004–2013, a time of consolidation of accumulated research; and (d) 2014–2023, reflecting trends in the most recent decade.

In the first 40 years of research on somatotype, there were 599 (24.57%) articles published, with somatotype becoming a central keyword, predominantly in Medicine (49.6%), Health Professions (9.7%), and Biochemistry, Genetics, and Molecular Biology (8.9%). From 1984 to 2003, interest in somatotypes remained steady, with 491 articles (20.14%) introducing new keywords like soccer, child development, training, obesity, and growth. Medicine (42.5%), Health Professions (16.6%), and Biochemistry, Genetics, and Molecular Biology (10.7%) continued to dominate. The 2004-2013 period saw a rise in research, with 494 (20.27%) articles incorporating new keywords such as body image and muscle. Research themes were prominent in Medicine (36.8%), Health Professions (11.7%), and Psychology (10.7%). From 2014 to 2023, research surged with 854 (35.02%) articles featuring new keywords like epidemiology and talent identification. The main fields were Medicine (36.8%), Health Professions (11.7%), and Psychology (10.7%).

Despite the diversification of somatotype research across fields, some collaborations remain limited. Researchers advocate for integrating conceptual foundations across disciplines to enhance the cross-pollination of ideas and practices. Given the crucial role of somatotype, several considerations are necessary, particularly regarding measurement methods. Most research still employs manual measurements (the anthropometric method) using the Heath-Carter formula. The advent of new 3D reconstruction techniques using low-cost depth cameras for 3D human models (Newcombe et al., 2011) necessitates advancements in somatotype examination methods. Chiu et al.

(2022) suggested a machine-learning model for the automatic estimation of Heath-Carter somatotypes using a single-camera 3D scanning system. Their evaluation showed that 3D scanning allows accurate (mean error <0.5 ; intraclass correlation coefficient >0.8) and precise (retest root mean error <0.5 ; intraclass correlation coefficient >0.8) somatotype predictions. This study indicates that 3D scanning methods could serve as a viable alternative to traditional somatotyping approaches, pending improvements with large datasets. However, though 3D scanning presents a promising alternative to traditional methods, challenges remain in terms of affordability, accessibility, and real-time data processing, particularly in low-resource settings. Future research should focus on developing cost-effective 3D scanning solutions, enhancing machine learning algorithms for better generalizability across diverse populations, and improving integration with wearable technologies for continuous monitoring.

Several commercial solutions have developed automated body measurement techniques that extract anthropometric data without the need for technical expertise in manual data post-processing (Ng et al., 2016). Drywien et al. (2021) explored alternatives to the commonly used bioelectrical impedance analysis for somatotype evaluation, though the accuracy of their proposed formula remains debatable. The research investigated the potential of using artificial neural networks to create a formula for determining somatotypes using height, weight, and bioelectrical impedance data in young women. This study demonstrated the successful application of an artificial neural network-based model in predicting somatotypes in adolescent girls, suggesting future practical use in bioelectrical impedance analysis devices. However, limited evidence regarding the validity and reliability of these methods highlights the need for technological advancements in somatotype research. Promoting multidisciplinary research on somatotypes worldwide could help foster consensus and signal promising progress in the field.

5. LIMITATIONS

Several limitations must be noted. First, our results and conclusions are confined to the articles and authors included in this database. Although Scopus is extensive, not all relevant articles on somatotypes are indexed, and items prior to 1991 may lack essential metadata such as keywords, DOI, and titles. This inconsistency in high-quality indexing practices affects the comprehensiveness of bibliometric analyses. Publication bias may also exist, as certain journals and countries could dominate the field, influencing citation trends. Second, we included only articles in English to cover the widest collection of international items. This may overlook valuable non-English research, and future studies could incorporate multilingual datasets or translation tools for a more global

perspective. Finally, while Scopus includes all articles containing the terms somatotype and its proxies, our study focused only on titles, abstracts, and keywords. Consequently, other relevant literature that conceptualizes somatotypes differently may have been omitted from our analysis.

6. CONCLUSIONS

This study examined global research on somatotypes over the past 80 years, highlighting key patterns of productivity, collaboration, and knowledge structures. Concentrated primarily in the fields of “Medicine”, “Health Professions”, and “Biochemistry, Genetics, and Molecular Biology”, somatotype research has evolved to include themes like "somatotype components", "BMI", and "body image" with emerging focuses on equity, diversity, and technology-based innovation. Thematic evolution analysis shows robust motor and basic research themes, with sports science emphasizing "talent identification." Despite progress, international collaboration remains limited, and debates about somatotype definitions and assessments persist. To advance the field, researchers may prioritize interdisciplinary collaboration between various disciplines. Additionally, policymakers should support funding initiatives for affordable 3D scanning and AI-driven analysis to enhance accessibility and application in diverse populations, which may bridge research gaps and drive innovation in somatotype assessment.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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