

Review of Research Trends in Publications from Korean Journal of Sport Biomechanics using Topic Modeling Analysis

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Objective: Biomechanics is a research field focused on human movement, with broad applications in sports science and physical health. This study aims to synthesize previous publications in the field using a text-mining approach to identify key research trends.

Method: Dirichlet Multinomial Regression topic modeling was applied to 1,233 research papers published in the Korean Journal of Sport Biomechanics between 1994 and 2024. To enhance the model's accuracy, we excluded the top three most frequent terms and trained the model over 2,000 iterations. Publication year data was also used to analyze temporal trends across topics.

Results: Topic modeling identified 15 key research topics in biomechanics, covering both experimental and review studies across various sports and health-related fields. The analysis revealed growth in research on 'Functional Movement' and 'Clinical Biomechanics', while 'Sports Biomechanics' showed a decline. Other topics displayed mixed trends, with some maintaining steady interest over time.

Conclusion: This study provides a comprehensive overview of historical research trends in biomechanics within Korea. By identifying key topics such as motion, movement, and sports, it offers valuable insights into the evolution of the field and suggests future research directions.

Keywords: Big data, Text mining, Topic modeling, Biomechanics, KJSB

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INTRODUCTION

As an applied science, biomechanics is dedicated to the quantitative and objective exploration of human movement, with particular focus on applications in sports science and physical health. Over the past 30 years, biomechanics research in Korea has witnessed considerable growth and transformation. Since the first issue of the Korean Journal of Sport Biomechanics (KJSB) in 1992, a wide range of research topics and methodologies have been introduced by numerous scholars, contributing to both academic and research achievements and

the development of the Korean society in biomechanics.

Initially, biomechanics focused on studying the phenomena of movement itself, seeking to measure and analyze these movements mathematically and mechanically (Lee, 2002). Over time, the field expanded its scope to include not only sports but also clinical areas, shifting its attention from the phenomena of movement to the functional mechanisms inherent in movement itself (Choi et al., 2012; Park & Kim, 2008). This evolution gave rise to studies focused on optimizing movement, rationalizing movement, and creating effective and normal movements, leading to research on the effects of various in-

terventions such as exercise, cognitive or biofeedback related training (Byun, Han, Bhang, Seo & Lee, 2020; Kim, Lee & Jung, 2009; Yang & Lee, 2021).

The evolution of research interests and trends in biomechanics has thus expanded the field from a focus on human movement alone to a holistic study of applied health sciences, integrating health-oriented applications. Particularly, recent research has tried to integrate cutting-edge technologies such as wearable devices, exoskeletons, and various sensor-based rehabilitation aids (Chae & Jung, 2021; de Miguel-Fernández, Lobo-Prat, Prinsen, Font-Llagunes & Marchal-Crespo, 2023; Yao et al., 2024). Further, the rise of artificial intelligence, including machine learning and deep learning models, has propelled biomechanics research as an applied science, facilitating predictive modeling through big data analysis (Kim, Cho, Jung & Lee, 2022; Lee, Ryou & Kang, 2021). These advancements have enabled biomechanics to offer innovative solutions, not only for performance enhancement and injury prevention but also for personalized health monitoring and rehabilitation. As above, the study of biomechanics in Korea has undergone continuous evolution and development over time through diverse approaches and technologies, providing not only research insights but also meaningful messages for practical applications to training and rehabilitative purposes.

This study aims to analyze the historical and current trends in Korean biomechanics research, particularly by applying topic modeling to identify key themes within publications of KJSB. We expect that this analysis will provide a structured overview of the research trajectory in Korea, revealing shifts in focus areas and the adoption of new methodologies. By gaining an understanding of the overall state of our biomechanics research, we propose future research directions through comparisons with global research trends.

METHODS

1. Data collection and preparation

To collect articles published by KJSB, we utilized the Korean studies Information Service System and KoreaScience databases. Excluding the Spring Conference Proceedings and Fall Conference Proceedings, our collection focused on research articles published in KJSB from 1994 through August 2024. Using Python 3.9.13 in Jupyter Notebook with the Selenium library, we conducted dynamic web scraping to collect infor-

mation such as English and Korean titles, publication year, journal name, volume and issue, English and Korean abstracts, and keywords. In total, all information from 1,253 articles were stored as a CSV file.

To perform a more objective topic modeling process, a total of 20 publications written only in Korean were excluded from the analysis, because if the papers were arbitrarily translated by others, there could be an unforeseen risk of altering the original intent of the original authors. Furthermore, since keywords set by the authors were often commonly used words within the titles and abstracts possibly hindering meaningful differentiation between topics, we excluded keywords from the analysis. Finally, we could prepare a corpus of 1,233 publications from KJSB for the comprehensive topic modeling.

2. Data preprocessing

The first step in data preprocessing for topic modeling analysis was to convert the corpus to lowercase, followed by tokenization using the NLTK package. Part-of-speech tagging was also performed by using the Penn Treebank POS Tag Set. These POS tags were then converted to WordNet POS tags (e.g., POS tags starting with 'V' were unified as 'V') for lemmatization.

Second, as a few Korean words were occasionally found in the preprocessed corpus, a general process of removing Korean text was performed, along with the removal of numbers and special characters (non-alphabet words).

Third, the stopword list was organized into three categories, and all items were removed as follows: a) The Long Stopword List provided by Rank NL (Ranks NL, n.d.) with a total of 667 items, b) A custom list of 57 items deemed removable based on qualitative evaluation by the researcher, and c) A list of 263 items including meaningless two-letter units and typos (with exceptions such as 'ai').

Finally, for consistency in meaning, words with suffixes were standardized to their base form, while maintaining their unique meanings. For instance, 'walked', 'walking', and 'walker' were unified as 'walk' due to their core meaning. However, we did not standardize words that would alter their inherent meaning after being converted to a base form. For example, words like 'arch' (meaning a curved shape) and 'archer' (meaning a person who shoots arrows) maintained their specific meanings by keeping their own forms.

3. Topic modeling

Topic modeling is an algorithm designed to figure out key topics within large document collections (Blei, 2012; Blei, Ng & Jordan, 2003). It allows for the categorizing or grouping of documents by topic, making it highly useful for researchers in automatically organizing and exploring large datasets. One of main techniques of topic modeling is Latent Dirichlet Allocation (LDA) based on the assumption that each document is a mixture of various topics, and each topic is described by a probability distribution over specific word (Blei et al., 2003). By estimating the topic distribution within documents and the word distribution within each topic, LDA enables the analysis of thematic similarity across documents and the discovery of hidden topic structures. Probabilistic models like LDA are widely used because they are easy to implement and intuitively understandable. However, since this model bases its topic distribution estimations solely on the words within a document, it is hard to incorporate meta information such as author, publisher, or publication date (Mimno & McCallum, 2012). Therefore, in this study, we used Dirichlet Multinomial Regression (DMR) which is an extension of LDA, to analyze patterns in topic changes over time.

DMR is a protocol to model the topic distribution of a document conditioned on external attributes (Mimno & McCallum, 2012). By associating textual data within documents with meta information, DMR allows for the integration of additional information. Incorporating the meta information enables a more precise estimation of topic distribution, enhancing the accuracy of topic analysis in documents. It also helps clarify relationships between topics and associated external characteristics, making DMR adaptable for various types of textual data and analysis objectives.

4. Application of DMR

We implemented the DMR model with the Tomotopy package, a Python extension of the topic modeling tool, which provides various types of topic modeling and functions. Tomotopy is powerful, providing faster execution time with stable and consistent results than the natural language processing library Gensim (Bab2min, n.d.).

After conducting the DMR model with the number of latent topics ranging from 10 to 20. We selected 15 as the optimal number of topics because this number provided the most

concise and meaningful interpretability (Chang, Gerrish, Wang, Boyd-Graber & Blei, 2009). Additionally, during model training, the top three frequently appearing terms were removed to reduce their impact on model learning. This step allows the model to focus on more significant terms, thereby improving both accuracy and efficiency. The publication year was used as meta information to examine trends in each topic over time. The final model was trained over 2,000 iterations on the entire dataset.

RESULTS

1. Results of topic modeling

In this study, we categorized the main topics of biomechanics research into five classifications including 'Functional Movement', 'Methodology', 'Clinical Biomechanics', 'Lower Extremity', 'Sports Biomechanics' based on the topic modeling results. This classification aims to analyze the trends of the publications through topic modeling and understand the changes according to each topic's trend. Each topic comprises thematically related topics based on the study's objective, methodology, and application area, reflecting the trends relevant to core areas in the field.

The first category of 'Functional Movement' includes research topics including 'Gait' and 'Postural Stability', focusing on fundamental abilities that enable us to effectively move in daily life. Basically, research in this area involves analyzing changes in gait and posture due to aging, physical injuries or movement disabilities such as Parkinson's disease and stroke. Further, this area involves assessing gait patterns and posture control abilities to support the recovery and enhancement of physical functions.

The second category of 'Methodology' represents a foundational element for all other studies, encompassing the collection, analysis, and interpretation of biomechanical data. Over time, various methodologies have been proposed in the field of biomechanics, highlighting its significance as a key factor determining the quality of biomechanical research.

'Clinical Biomechanics' includes 'Rehabilitation', 'Spine Biomechanics', and 'Muscular Function', aiming to optimize overall physical function. This area focuses on studying methods to restore and strengthen muscle function, maintain the structural stability of the spine, design effective rehabilitation programs, and promote physical stability in diverse activities.

Table 1. 15 Topics from the Topic Modeling Results of KJSB

Topic #	Topic 1	Topic 2	Topic 3	Topic 4	Topic 5	Topic 6	Topic 7	Topic 8	Topic 9	Topic 10	Topic 11	Topic 12	Topic 13	Topic 14	Topic 15
Main Theme	Functional Movement		Methodology	Clinical Biomechanics			Lower Extremity			Sports Biomechanics					
Title	Gait	Postural Stability	Methodology	Rehabilitation	Spine Biomechanics	Muscular Function	Kinetics	Foot	Angular Motion	Performance Enhancement	Track and Field	Taekwondo	Gymnastics	Golf	Racket Sports
Proportion	0.0568	0.0548	0.0781	0.0594	0.0269	0.067	0.145	0.0636	0.0458	0.0386	0.0425	0.1106	0.0957	0.0595	0.0556
1	Walk	Elderly	System	Exercise	Posture	Muscle	Force	Shoe	Rotation	Skill	Hurdle	Kick	Bar	Golf	Tennis
2	Gait	Balance	Model	Train	Neck	Activity	Moment	Foot	Energy	Ski	Javelin	Type	Horizontal	Swing	Stroke
3	Length	COP	Error	Strength	Cervical	EMG	Jump	Pressure	Speed	Start	Athlete	Taekwondo	Body	Ball	Racket
4	Speed	Postural	Data	Muscle	Feedback	Femoris	Reaction	Plantar	Acceleration	Unskill	Pole	Side	Velocity	Club	Attack
5	Step	Control	Coordinate	Program	Offer	Activation	Knee	Insole	Internal	Skate	Release	Velocity	Jerk	Drive	Stance
6	Limb	Stability	Develop	Pain	Row	Biceps	Landing	Arch	Stope	Turn	Championship	Dance	Vault	Head	Wrist
7	Stride	CAI	Sensor	Torque	Pressure	Gastrocnemius	Ankle	Type	Impact	Player	Record	Left	Time	Shot	Player
8	Obstacle	Woman	Marker	Lumbar	Body	Rectus	GRF	Forefoot	Peak	Block	IAAF	Hip	Center	Impact	Angular
9	Level	Dynamic	Sport	Treatment	Scoliosis	Squat	Height	Distribution	External	Swim	Velocity	Movement	Horse	Grip	Shoulder
10	Width	Healthy	Image	Extension	Load	Vastus	Ground	Area	Tibia	Sprint	Class	Difference	Vertical	Putter	Forehand

Note. GRF: Ground Reaction Force; IAAF: International Association of Athletics Federations; COP: Center of Pressure; CAI: Chronic Ankle Instability; EMG: Electromyography

'Lower Extremity' focuses on 'Kinetics', 'Foot', and 'Angular Motion', centering on the biomechanics of the lower limbs. These topics mainly analyze kinetics (forces) applied to the foot and lower extremities and provide valuable insights for functional assessment through angular movements of the lower limbs.

Finally, 'Sports Biomechanics' includes various topics such as 'Performance Enhancement', 'Track and Field', 'Taekwondo', 'Gymnastics', 'Golf', and 'Racket Sports'. This category aims to enhance performance and prevent injuries by analyzing dynamic movement or performance skills in each sport, sharing a common goal of analyzing and optimizing efficient movement and skill execution.

The topic proportions indicate the frequency of each topic's appearance in the entire data set, with tokens in each topic ordered by their frequency in descending order (Table 1).

2. Trends by themes and topics

Figure 1 shows the total number of papers published in KJSB from 1992 to August 2024, providing an overview of research trends. The number of publications in KJSB surged after 2000, with the highest number of papers published in 2007. However, since 2010, there has been a gradual decline

in the number of publications. The average annual number of publications from 1992 to 1999 was 8.5, which increased nearly eightfold to an annual average of 64.8 in the 2000s. In the 2010s, the average annual number of publications decreased to 53, and this downward trend has continued into the 2020s.



Figure 1. The number of publications in KJSB from 1992 to 2024

Since 2010, although the number of papers published in KJSB has decreased, there have been various changes in the relative proportions of topics within each publication. In 2021, there was a temporary increase in the number of papers, with a total of 41 publications, where topics 2, 4, and 5 showed a significant upward trend. In contrast, topics 6, 7, 10, 12, and

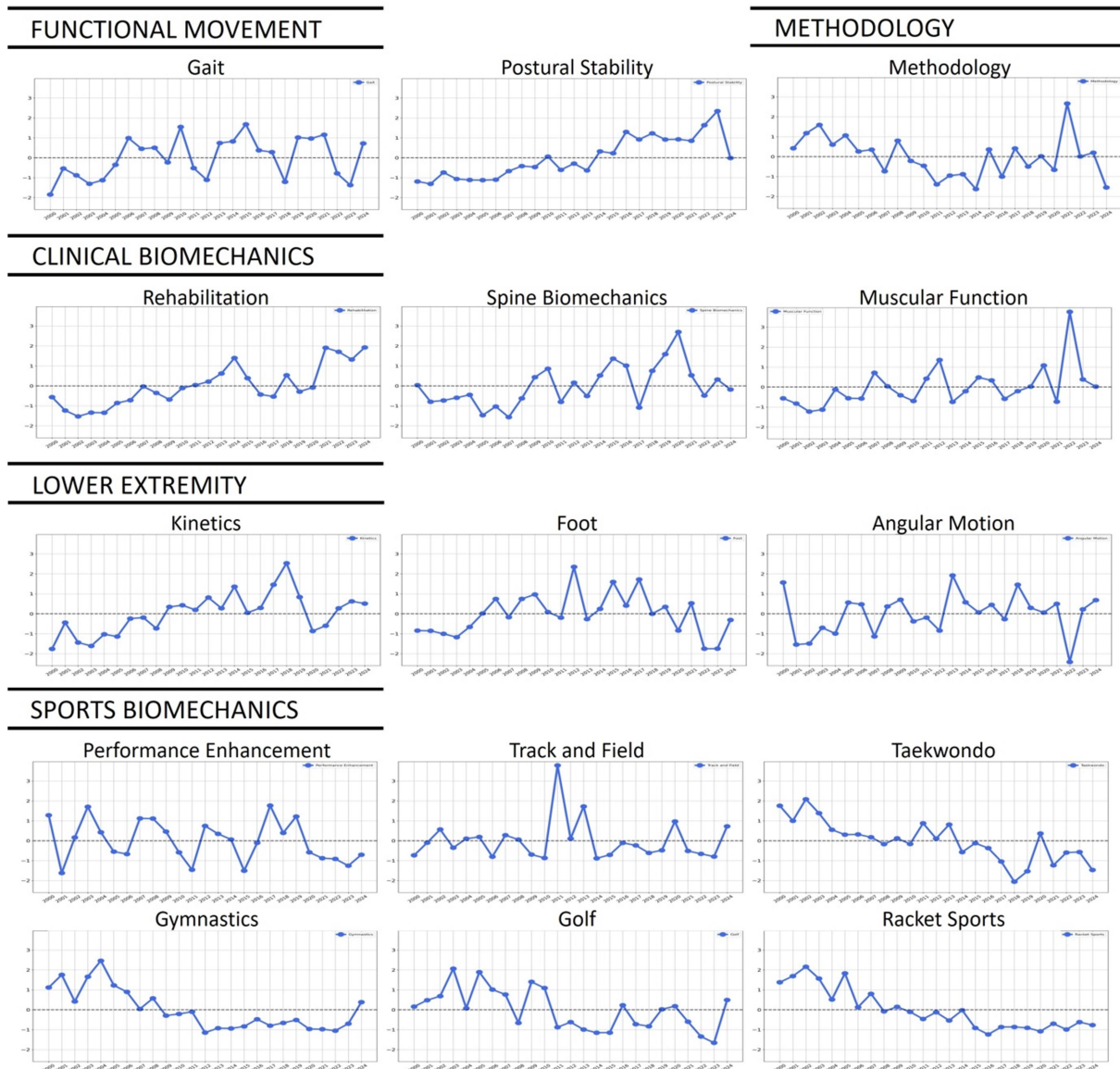


Figure 2. Yearly trend graphs for each topic from 2000 to 2024

14 experienced a notable decline, while topics 1, 3, 8, 9, 11, 13, and 15 remained relatively stable (Figure 2). These changes appear to be related to an increase in papers on topics such as Foot, Methodology, and Rehabilitation.

From the trend analysis, we primarily used data from after 2000, when there were more than 20 papers annually. Data from before 2000 was excluded, as the relatively small number of publications could introduce noise into the analysis, allowing for clearer and more consistent trend results. The five major themes identified were categorized as increasing,

decreasing, or with no distinctive trend. During this process, we calculated the mean proportion of each topic's distribution probability. After standardizing these values, we derived regression coefficients (slopes, β) through a linear regression model. A slope greater than 0.1 was classified as an increasing trend, less than -0.1 as a decreasing trend, and values between these showing no distinct trend (Figure 3).

The trend analysis by year revealed that each major theme exhibited distinct patterns of change (Figure 4). Firstly, the Sports Biomechanics theme showed an overall declining trend.

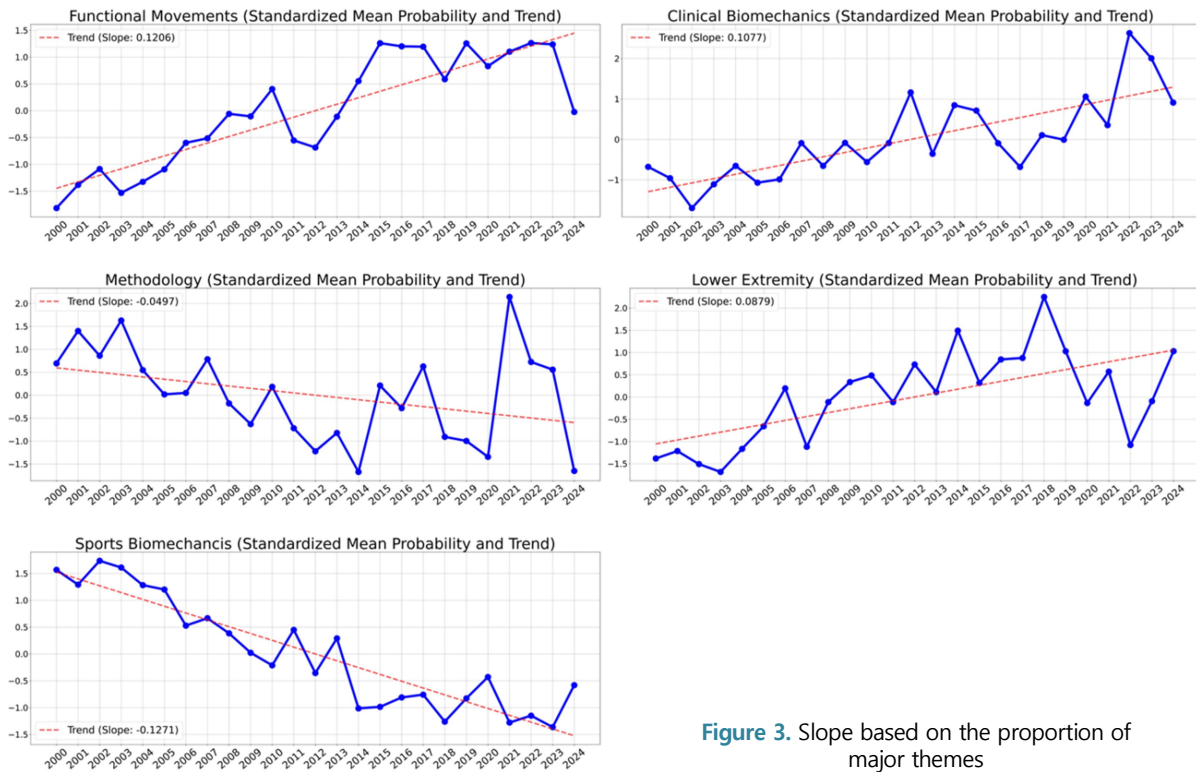


Figure 3. Slope based on the proportion of major themes

This theme peaked in the early 2000s, particularly in 2003, but began to decrease gradually afterward. Although there was a temporary increase in 2011, it has maintained a steady decline since then. This overall downward trend aligns with research patterns in Taekwondo, Gymnastics, Golf, and Racket Sports, while Performance Enhancement showed the most irregular variations.

On the other hand, two major themes demonstrated an upward trend. Functional Movement saw a sharp increase in 2010, paused briefly, and then resumed an upward trend. Notably, 2010 had higher proportions of Gait and Postural Stability compared to other periods. While Gait saw a few years of temporary decline, it has remained a consistent area of research. In contrast to Gait, which has been steadily studied since the early 2000s, Postural Stability has shown a clear upward trend since the early 2010s, peaking notably in 2023.

Another rising theme, Clinical Biomechanics, continued to grow, reaching its highest proportion in 2022. Research on Rehabilitation and Muscular Function also recorded high proportions, with Muscular Function research experiencing a sharp increase in 2022, and Rehabilitation showing a marked rise since 2021. Conversely, Spine Biomechanics has been on

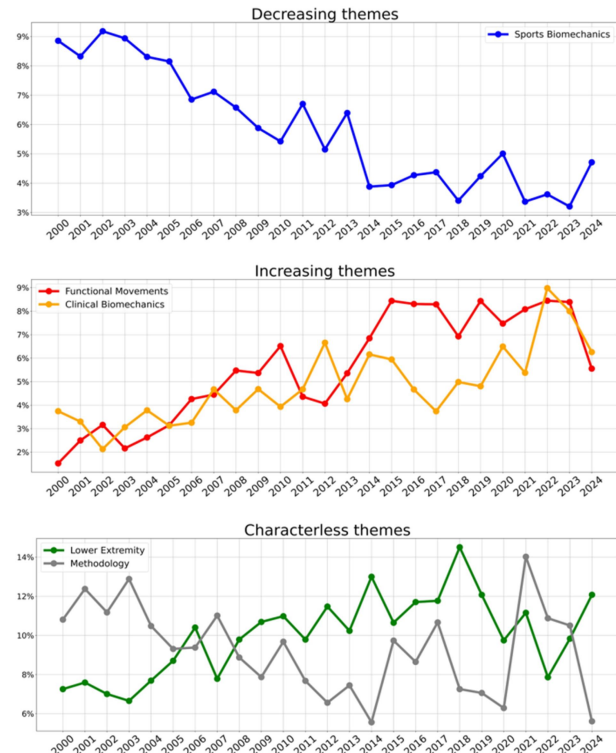


Figure 4. The average proportion of major Themes by trend

the decline since 2020.

The remaining themes showed no distinct trends but had somewhat different patterns. Methodology steadily declined until 2015, after which it gradually increased, reaching its highest proportion in 2021. Meanwhile, Lower Extremity saw positive growth after 2003 but began to decline after reaching its peak in 2018. Within this theme, Foot research was particularly active in the 2010s, and Angular Motion experienced yearly fluctuations. However, both topics dropped sharply after 2021. Kinetics consistently increased until 2018, when it peaked, followed by a decline.

DISCUSSION

The number of papers published in KJSB increased rapidly after 2000 but has shown a decreasing trend since 2010. The increased publications in the 2000s may indicate a broadening of academic interest in sports biomechanics, reflecting the growth of the field and a wide range of actively researched topics. However, the decreased publications after 2010 may be due to diverse factors such as changes in research topics, or limited research resources. Furthermore, the awareness of Korean biomechanists has recently grown that international journals can bring higher citation indices and global recognition. Thus, the researcher's preference for publishing research in international journals rather than KJSB has also influenced the decreased publication tendency.

The topic modeling results provided important insights into the research trends and topic-specific changes in the Korean Society of Sports Biomechanics (KSSB). Research regarding Sports Biomechanics has generally shown a downward trend, especially in areas such as Track and Field, Taekwondo, Gymnastics, Golf, and Racket Sports. This decrease in research focus within Sports Biomechanics may be attributed to temporary interest and resource allocation due to international sports events. For example, the 2011 Daegu World Championships in Athletics which is one of the large-scale sporting events might stimulated research activity (Ryu et al., 2011; Oh et al., 2011; Woo et al., 2011), but a lack of sustained follow-up studies led to a decline. Additionally, resource allocation changes may have had an impact, especially as new scientific and health-related fields emerged, potentially reducing resources allocated to sports science research. To reverse this trend, there needs to be an environment that supports continuous development in sports research through long-term funding and follow-up

studies, rather than relying on one-time events.

On the other hand, Functional Movement and Clinical Biomechanics have shown consistent growth, with particular interest in Postural Stability and Rehabilitation over the past three years. This reflects the increasing need for fall prevention and functional stability research due to the aging population and the associated decline in physical abilities. Gait research has also remained a key area, as gait is an important factor in both physical function and various sports, and has thus attracted sustained interest from researchers, especially given its association with diverse motor mechanisms seen in neurological disorders such as Parkinson's disease or stroke.

Research regarding themes of Lower Extremity and Methodology, though lacking distinct trends, has maintained high average proportions within research topics in KJSB. Research on lower limb joints and movement (Park, Kim & Yoon, 2023) remains fundamental to understanding human movement and is expected to continue as a major research area. Furthermore, advancements in biomechanical methodologies, such as enhanced motion capture systems and computational modeling, are increasing the precision and applicability of these studies (Werling et al., 2023). These developments provide a solid foundation for integrating advanced technologies into the biomechanics field.

Currently, the use of wearable devices and artificial intelligence technologies leveraging big data is becoming increasingly important for rehabilitation and injury prevention (Morouço, 2024; Reis, Alaiti, Vallio & Hespanhol, 2024). These technologies enable personalized health management and diversified rehabilitation methods, providing new insights in areas such as gait pattern analysis and fall risk assessment. For instance, wearable devices are used to monitor gait patterns in real time, assess fall risk through biomechanical analysis, and develop models to predict fall risk in older adults using machine learning algorithms (Speiser et al., 2021). Additionally, machine learning is used in sports environments to predict athletic performance or aid in training adaptations, such as analyzing athlete load data to offer personalized training and feedback (Rebelo, Martinho, Valente-dos-Santos, Coelho-e-Silva & Teixeira, 2023) or analyzing past data to predict injury risk and optimize training and game strategies (Claudino et al., 2019). These systems support injury prevention, enhancing athletes' safety and improving training efficiency to boost performance.

This study analyzed research trends in KJSB through topic

modeling. As this topic modeling analysis does not fully explain global trends in sports biomechanics research, it would be valuable to conduct topic modeling on international journals in the future. This could allow for a comparative analysis of domestic and international interests in sports biomechanics research. Additionally, a thorough analysis of global trends could provide comprehensive insights into how wearables, big data, and AI technologies are being applied and transforming sports biomechanics research. This would clarify the research direction of the sports biomechanics field in Korea.

CONCLUSION

With a concentrated focus on certain research areas, the themes and directions of research in sports biomechanics are evolving. To reflect these changes, the Korean Society of Sports Biomechanics must consider readers' interests and identify globally recognized research topics to set future research directions. In collaboration with researchers, it is essential to actively incorporate the latest trends in domestic and international research, exploring diverse topics to support the advancement of the society. This foundation can position the society's journal as an attractive platform for researchers and drive the academic growth of the sports biomechanics field.

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