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Exploring the Keyword Network Analysis and Research Trends for Sustainable Development of Paralympic Research: Based on Changes in Classification

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Abstract: This study aims to identify an overall keyword network by drawing on core keywords in Paralympic studies and analyzing the relationships. It also aims to provide information on the changes in Paralympic study trends through a time series analysis to understand change, according to the application of a new classification (evidence-based classification). This study made a bibliographic list of 1613 studies by collecting studies published between 2003 and 2022 using keyword network analysis (KNA). By refining to exclude unsuitable studies, 1404 studies and 6414 keywords were used for the analysis. As a result of analyzing entire Paralympic studies performed between 2003 and 2022, Paralympic studies were revealed to be on the rise. The entire Paralympic studies ascertained that the areas of study were mainstream and centered on the top three keywords: athlete; performance; and classification. Secondly, as a result of analyzing Paralympic study trends in a time series manner, based on 2017 when a new classification was applied, studies related to physical impairment centered on the top two keywords, athlete and performance, were mainstream in Section 1 (2003–2016). Olympic Games, performance, and wheelchairs formed detailed study areas. In the Paralympic studies in Section 2 (2017–2022), the relevant studies centered on the top two keywords, athletes and performance, were mainstream. Paraspport, disability, and classification were ascertained to form detailed study areas. Through all this, the changed trend in the keyword Paralympics was confirmed. The results of this study are meaningful in that they can contribute to the expansion of the Paralympic areas of study and invigoration by exploring core keywords and providing relevant information based on the significant change point in time, including entire Paralympic study trends.

Keywords: paralympic study; evidence-based classification; bibliometrics; keyword changes of paralympic research; keyword network analysis; trend analysis



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1. Introduction

The Paralympics is the largest mega event representing the sports field of disabled people, encouraging disabled people's sporting activities worldwide, and harmonizing nations through competitions in good faith beyond differences in cultures and nationalities. The Paralympics is contributing to positive change in disabled people's lives through sports and improving the global recognition of the disabled. The International Paralympic Committee (IPC) organizes Paralympic endeavors to expand the areas of the Paralympic Movement to encourage disabled people's sporting activities worldwide and inspire disabled people to embrace the world through sports [1]. The IPC delivers diverse programs to spread and develop the Paralympic Movement in international societies through exchanges between IPC member countries and in cooperation with various international organizations. As a result, outstanding achievements are being generated. Studies related to the Paralympics are being expanded to various areas through the VISTA Conference, held every two years to exchange the latest information, study and build expertise related to the Paralympics, and promote interactions between researchers [2,3]. Therefore, the international society is

developing a variety of knowledge through research relevant to diverse exchange activities, such as sports, cultures, and diplomacy between nations, centered on the Paralympics. Likewise, expanding Paralympic study areas positively affects policies and systems relevant to disabled people's sports environments. For disabled people's sports areas to be developed further, efforts to expand and invigorate Paralympic areas of study in various fields are essential.

Endeavors to expand areas of study in specific fields have been continuous. A study trend analysis is the most used method because it can confirm the characteristics of the fields concerned and ascertain study activities by checking entire studies, from the past to the present, to analyze areas or themes addressed in specific fields and to study paradigm changes [4]. For past study trend analyses, a content analysis method has been mainly used, but the possibility of interference due to the researcher's subjectivity is high; therefore, the method has a limitation in that objective grounds are lacking in terms of data collection, classification, and interpretation [5,6]. However, it has recently become common to supplement such a study with a keyword network analysis (KNA) [7–9]. KNA is a valuable technique used to identify areas of study and time series study trends, and it is being used considerably due to the advantage that KNA can visually express relationships between keywords used in studies. The KNA indicates a specific keyword as a node, demonstrates relevance between the core keywords as a link, and analyzes how each keyword is connected [10,11]. As keywords are the central concept of a study, they represent the study best. In the KNA, the keyword with the higher frequency of verb appearance emerges in the center, and mutual relevance is high. The keyword can be a leading concept, as its weight is high. A keyword with the most links is drawn as a core keyword. The links are connected more densely as the relationship is higher between the core keywords presented in each study [12,13].

Meanwhile, significant changes, such as the introduction of new regulations and the adoption of a system in the sports field, negatively affect not only the athletes' performance but the structure of the academic field. In the Paralympics, sports classification that considers disability type and physical capability is applied, and competitions are allowed so Para athletes (disabled athletes) with similar-level functions can fairly compete. Centered on classification in the Paralympics, a significant change has recently occurred in the disabled people's sporting world, and the change has generated problems in classification. For fairer games, the IPC has recently applied an evidence-based classification system starting with track and field games in 2017, based on data collection and scientific evidence [14]. Thus, many Para athletes were awarded a classification under the new regulations in major international competitions. As a result, many athletes' sports classification was adjusted [4,15]. An analysis of information collection, through which influences can be checked according to the adoption of the new classification (evidence-based classification) system, is required. For the disabled people's sporting environment, centered on the Paralympics, now is the time for an analytic approach, such as research of core keyword change and distribution, through which study trends can be comprehensively understood in order to further study based on the changes, and as Paralympic-related study increases by expanding Paralympic areas and fields of study.

This study used keyword network analysis (KNA) which aims to identify the overall keyword network by drawing on core keywords in the study of Paralympics. It also aims to analyze relationships and to provide information on the changes in Paralympic study trends through a bibliometrics analysis to check change, by comparing two periods based on the application of the classification.

2. Methods

2.1. Data Sources

To achieve its purpose, this study selected studies with the theme of Paralympics, and then chose the Web of Science and PubMed, the leading academic bibliographic databases in the sports field, as data sources. Figure 1 shows the research data collection procedure.

using PubMed and WoS for data collection, the conditions of the same query were used after setting the 'Publication Date' from 2003 to 2022. The following search terms were used: PubMed searched for the study by entering 'Paralympic' and 'Paralympic Games', 'Paralympics', 'Paralympics Game', and 'Paralympics Games' as OR conditions among the Boolean query box by setting Add terms to the query box. In WoS, 'All Fields' was set in Documents, and then 'Add row' was added to search under the same conditions [16].

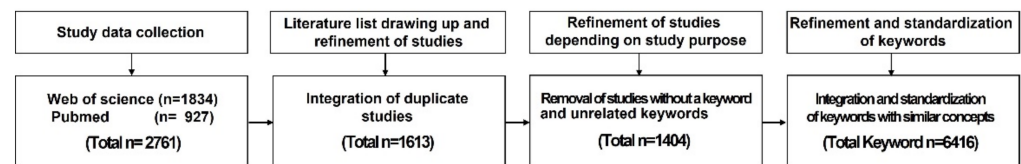


Figure 1. Study data collection.

The collected studies were limited from January 2003 to August 2022. In total, 1834 studies from the Web of Science and 927 from PubMed were collected. A literature list was made regarding bibliographic data, including publication year, author, and publishing journal. To prevent duplication and omission of the collected studies, duplication inspection was performed, bringing the number of studies collected to 1613. A process to remove unsuitable studies was then undertaken. The conditions for removal were: a study in which the keyword did not exist; and a study that has no keyword related to Paralympic. Following this, 1404 studies were ultimately selected. A refining process was applied to explore Paralympic-related study trends by collecting keywords containing the study theme, method, and subject. Regarding the main keywords of the collected studies, the words presented by each study were used as they were. Similar concepts or keywords indicating the same target, such as Olympic Games, Olympics and athletes, and players, were integrated into the Olympic Games and athlete, and were standardized. Following this procedure, 1404 studies on the Paralympics were included for analysis in this study, and 6416 keywords were used. To check how the Paralympic-related keyword network and trends, according to the new classification application, change from a time series perspective, the publication period was divided based on a 2017 study when the new classification was applied, and then the data was computerized with Excel.

2.2. Data Analysis Process

The data analysis method of this study was carried out using the following procedure: First, Paralympic study trends were illustrated by reporting the number of published studies by time periods. In addition, frequencies of top keywords were reported. The main keywords co-occurrence frequency (COF) and matrix were produced using the KrKwic 2.0 program. COF is the frequency of the simultaneous appearance of keywords that indicates the relationship between keywords. So, to prevent the distortion of analysis results, the data with less than five times COF were removed from the analysis. To analyze connectivity and relevance between keywords by visualizing them using the NetMiner 4 (Version 4.5.0, Cyram) program, a 1-mode network analysis was performed. In doing so, the COF and degree centrality (DC) were computed. DC is an indicator of how many keywords are connected (nodes) to specific keywords. As DC was higher, they were analyzed as core keywords indicating revealing nodes.

3. Results

3.1. Publication Status by Major Section Related to Paralympic Studies

This study collected the relevant studies centered on the Paralympics from the Web of Science and PubMed, which are academic databases. Through the process, unsuitable studies were excluded by collecting the studies published on the academic databases from 2003 to 2022. Therefore, 1613 studies were selected. A bibliographic list of publication year, title, author, and keyword was made, and it was used for analysis. To check the publication

status of Paralympic studies drawn through the process, the four-year section, including one Paralympic Summer Games and one Paralympic Winter Games since 2003, was set and analyzed. Figure 2 shows the results of analyzing the number of publications issued in the analyzed study by section.

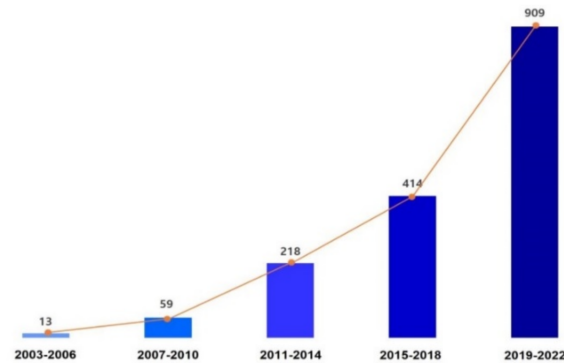


Figure 2. Number of published Paralympic studies in 2003–2022 (section from one year before the Paralympic Games to every two years after the Paralympic Games).

When looking at publication status by section, the Paralympic studies' publication frequency was on a steady rise from 2003 to 2022. After 13 studies in the 2003–2006 section, 59 studies were published in the 2007–2010 section. In the 2011–2014 section, 218 studies were published, or about 4-fold more than the entire section. In the 2015–2018 section, 414 studies were published, and 909 studies, about two times more than the entire previous section, were published in the 2019–2022 section. The result confirmed that the publication ratio continuously rose every four years, including the Summer and Winter Paralympics. As the Paralympics continued, it was ascertained that the relevant studies actively increased.

Figure 3 shows an analysis result of the top 30 keywords of the Paralympic studies performed between 2003 and 2022 to analyze the trends of Paralympic studies. A frequency analysis was conducted by producing 6416 keywords in 1404 studies used for the final analysis through a refinement process.

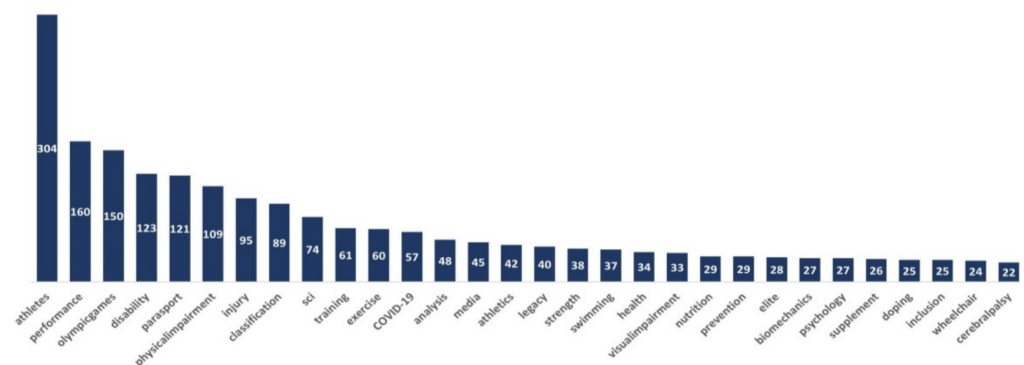


Figure 3. Number of duplicate frequencies of Top 30 keywords in Paralympic studies published from 2003 to 2022.

The analysis result is as follows: The sum of the top 30 main keywords in Figure 3 was 1982, indicating 31% of the 6,416 keywords. When looking at the top five keywords, indicating the highest frequency in the Paralympic studies, the athletes took up 4.7% at 304 times of frequency among all the keywords. The next one, performance, took up 2.5% at 160, and Olympic Games accounted for 2.3% at 150. Disability accounted for 2% at 123, and parasport took up 1.9% at 121.

3.2. Main Keywords Chart of the Entire Paralympic Studies

Table 1 and Figure 4 show the analysis results of main keywords with strong influence in the entire studies related to the Paralympics to confirm the characteristic of the Paralympic studies. After analyzing and selecting the data with five or more co-occurrence frequency (COF) using the KrKwic program, degree centrality (DC) was calculated with the Netminer program, and main keywords were produced.

Table 1. DC of 15 keywords of entire Paralympic studies.

Rank	Keywords	Degree Centrality
1	athlete	0.690
2	performance	0.655
3	classification	0.414
4	physical impairment	0.345
5	disability	0.310
6	sci	0.310
7	parasport	0.276
8	injury	0.276
9	wheelchair	0.276
10	olympic games	0.241
11	training	0.241
12	exercise	0.241
13	analysis	0.172
14	athletics	0.172
15	strength	0.172

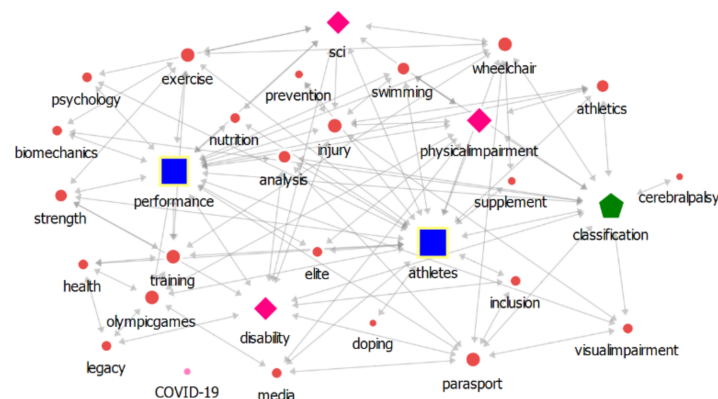


Figure 4. KNA chart of entire studies related to the Paralympics.

As a result of drawing the top 15 keywords in the Paralympic studies, the athlete's DC (0.690) was the highest, and the performance's DC (0.655) was the next highest. Classification (0.414) was relatively high, followed by physical impairment (0.345), disability (0.310), and SCI (0.310), and they were relatively higher among the top 15 keywords. It can be confirmed that study areas centered on the top three keywords, such as athlete, performance, and classification, constitute mainstream in the entire Paralympic studies performed from 2003 to 2022 through the network between main keywords, as shown in Figure 4 (among the top five key keywords: 0.6 or higher DC keyword shown by a blue square; 0.4 or more DC keywords shown by a green pentagon; 0.3 or more DC keywords shown by a pink diamond).

3.3. Analysis of Time Series Trends of Paralympic Studies

To check study trends according to the application of the new classification (evidence-based classification), a significant change in the Paralympics, this study analyzed the main keywords of each section by dividing the entire study period into Section 1 (2003–2016)

and Section 2 (2017–2022), based on 2017 when the classification system was applied, in a time series manner.

For the analysis of primary keywords by section, the COF was computed with the KrKwic program, and DC was drawn using the Netminer program. Table 2 and Figure 5 (among the top five key keywords: 0.6 or higher DC keyword shown by a blue square; 0.5 or more DC keywords shown by a purple diamond; 0.3 or more DC keywords shown by a pink pentagon) show the analysis results of the main keywords chart of the Paralympic studies in Section 1 (2003–2016). The number of studies used for the analysis was 378, and 2014 refined keywords were used to draw DS. As a result of drawing the main keywords in Section 1, athlete (0.690) and physical impairment (0.552) showed high levels of DC, followed by Olympic Games (0.414), performance (0.393), and wheelchair (0.379). In the Paralympic studies carried out from 2003 to 2016 through the network between main keywords shown in Figure 5, studies related to physical impairment, centered on top keywords athlete and performance, were mainstream. Olympic Games, performance, and wheelchair were confirmed to consist of detailed study areas. Table 2 and Figure 6 show the main keywords chart analysis results of Paralympic studies in Section 2 (2017–2022). The number of studies used for the analysis was 1026. The DC charts were drawn using 4402 refined keywords. As a result of drawing the main keywords in Section 2, athlete (0.724) showed the highest DC, performance (0.586) showed the second highest DC, followed by parasport (0.379), disability (0.379), and classification (0.345). Centered on the top two keywords, athlete and performance, the Paralympic studies were mainstream and carried out from 2017 to 2022 through the network between main keywords, as shown in Figure 6. Such keywords as parasport, disability, and classification were confirmed to consist of detailed study areas.

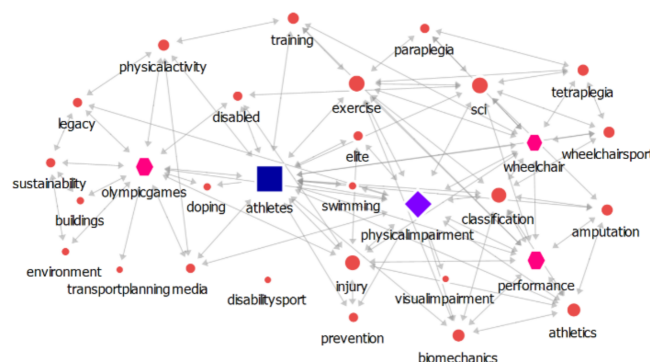


Figure 5. KNA chart of Paralympic studies in Section 1.

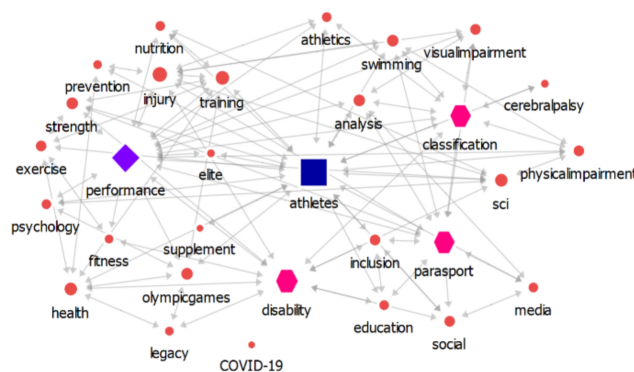


Figure 6. KNA chart of Paralympic studies in Section 2.

Table 2. DC of Top 15 keywords of Paralympic studies in Section 1 (2003–2016) and Section 2 (2017–2022).

Section 1 (2003–2016)			Section 2 (2017–2022)		
Rank	Keywords	Degree Centrality	Rank	Keywords	Degree Centrality
1	athlete	0.690	1	athlete	0.724
2	physical impairment	0.552	2	performance	0.586
3	olympic games	0.414	3	parasport	0.379
4	performance	0.393	4	disability	0.379
5	wheelchair	0.379	5	classification	0.345
6	sci	0.345	6	injury	0.310
7	exercise	0.345	7	training	0.276
8	injury	0.310	8	sci	0.241
9	classification	0.310	9	health	0.241
10	athletics	0.241	10	olympic games	0.207
11	biomechanics	0.207	11	analysis	0.207
12	amputation	0.172	12	strength	0.207
13	tetraplegia	0.172	13	swimming	0.207
14	training	0.172	14	exercise	0.172
15	physical activity	0.172	15	physical impairment	0.172

4. Discussion

This study conducted a bibliometrics analysis of the trend of Paralympic studies by identifying core keywords and analyzing the relationships among them. A bibliographic list of 1613 studies was compiled, covering publications from 2003 to 2022, using KNA. After refining unsuitable studies, 1404 studies and 6414 keywords were used for analysis.

The results showed that the number of published Paralympic studies steadily increased as the Summer and Winter Paralympics continued, with a significant increase observed between 2011 and 2015. This increase was likely influenced by the expansion of social science research following the 2015 VISTA Conference, as well as increased research on performance related to the International Paralympic Committee (IPC) and the London 2012 Paralympic Games.

The top five keywords used in the entire Paralympic studies were athlete, performance, Olympic Games, disability, and parasport. An analysis of core keywords with high DC in main areas of Paralympic studies, athlete, performance, and classification, showed high DC and constituted main study areas. Classification, physical impairment, and disability were connected with core keywords and constituted detailed study areas.

Over the ten-year period since the evidence-based classification was published, the IPC, para-sports coaches, and researchers have published research on the effective implementation and related issues of a new classification system that plays a crucial role in para-sports [17–20].

To grasp Paralympic study trends according to the application of the new classification (evidence-based classification), this study divided the study period into Section 1 (2003–2016) and Section 2 (2017–2022), produced core keywords with high DC, and analyzed keyword network in a time series manner. The Paralympic studies carried out in Section 1 (2003–2016) showed that physical impairment showed high DC, centered on the top two keywords, athlete and performance, and constituted the main study areas. Olympic Games, performance, and wheelchair showed a connection with highly related keywords and formed the detailed study areas. As for the structure of the Paralympic studies performed in Section 2 (2017–2022), the top two keywords, athlete and performance, revealed high DC and formed main study areas. Parasport, disability, and classification showed correlation with highly related keywords and formed detailed study areas. When comparing core keywords affecting keyword network the most, athlete and physical impairment were drawn in Section 1, and athlete and performance were drawn in Section 2. Regarding top-ranked keywords constituting detailed study areas, Olympic Games and performance

were produced in Section 1, and parasport, disability, and classification were produced in Section 2. In synthesizing, common things were shown: athlete was in the center of the keyword network in both sections, and performance-related, specific keywords were similarly included in the top keywords. Studies were vigorously performed by universities and state organizations in each country for athletic performance improvement to ensure competitiveness in the Paralympic Games, the largest international sporting event for disabled people. Consequently, athlete and performance indicate high DC and are judged to form the core study areas of Paralympic studies [21,22].

Meanwhile, the most significant difference between the two sections was that the Olympic Games keyword showed a separate study area with legacy, media, sustainability, and environment keywords having high relevance in Section 1. Recently, the international community is interested in how sporting events and related legacies can act as a platform for social change. In particular, the UN acknowledged that sports play an important role in supporting the UN 2030 agenda for sustainable development and the Olympic movement. Therefore, it is confirmed that a number of studies have been conducted focusing on creating the heritage of each competition with the theme of the Olympic and Paralympic Games [23,24]. According to the trend, as the IPC strives for related studies to be carried out with interest in such themes as tangible and intangible legacy creation, and environment shaping for sustainable development to realize the SDGs (Goal 3. Good health and Well-Being, Goal 4. Quality education, Goal 5. Gender Equality, Goal 10. Reduced Inequalities) announced by the UN in 2015, the study areas concerned have appeared [25]. The IPC is also the first to provide a platform for promoting SDGs at the Tokyo 2020 Paralympic Games, promoting efforts to encourage SDGs in conjunction with the IPC and the UN's SDGs agenda and Paralympic Movement [26]. In Section 2, parasport and disability keywords separate study areas from inclusion, society, and education with high relevance. Since it developed the parasport program in 2016, the IPC has endeavored to spread the Paralympic movement, aimed at education, equipment support, and athlete fostering for disabled people worldwide to participate in sports, and the IPC aims to make changes that help disabled people participate in sporting activities and develop their lives. Accordingly, 'We The 15', a global campaign to abolish discrimination against the disabled and realize equality of rights, has been actively promoted since the Tokyo 2020 Paralympic Games in August 2021. Also, the IPC announced further expansion plans in Paris in September 2022 to expand and disseminate the Para Sport movement worldwide [27–29]. This is judged to have affected the detailed study areas in Section 2. It was confirmed that classification (evidence-based classification) was included as the top-ranked keyword in Section 2, and detailed study areas were formed. This can be interpreted as applying the new classification in 2017 to the study areas in Section 2 [30–33]. In addition, COVID-19 appeared in Section 2. This directly affected the Paralympics, including the delay of the Tokyo 2020 Paralympic Games, and it can be interpreted as a result of an increase in relevant studies after a specific period.

5. Conclusions

As a result of analyzing entire Paralympic studies performed from 2003 to 2022, Paralympic studies were revealed to be on the rise. It was confirmed that the studies actively increase as the Paralympics continue. The entire Paralympic studies ascertained that the study areas were mainstream, centered on the top three keywords, athlete, performance, and classification. Second, as a result of analyzing Paralympic study trends in a time series manner, based on 2017 when the new classification (evidence-based classification) was applied, studies related to physical impairment, centered on the top two keywords, athlete and performance, were mainstream in Section 1 (2003–2016). Olympic Games, performance, and wheelchairs formed detailed study areas. In the Paralympic studies in Section 2 (2017–2022), the relevant studies centered on the top two keywords, athlete and performance, were mainstream. Parasport, disability, and classification were ascertained to

form detailed study areas. Through all this, the changed keyword network trend of the Paralympics was confirmed.

To better understand the starting point of the area of study and the relationship between sections, it is essential to monitor trends and pattern changes in diverse aspects over an extended period of time. This study conducted a time series analysis based on the Paralympic study trends and the application of the KNA classification at a specific point in time. The interpretation focused on the Paralympics and sporting activity arenas for people with disabilities.

Based on the limitations that emerged during the study's conduct, the following suggestions can be made: First, the study only considered the structure and trend of academic research at the Paralympics in Web of Science and PubMed, limiting the analysis of the keyword network and trends of Paralympic research. Second, the study selected keywords from various bibliographic information of academic research, so caution should be taken when interpreting the results. Furthermore, the keyword network was only explored based on keywords with more than five COF when analyzing the network, and only the connection centrality index was applied, so there are limitations in terms of calculating various information.

In future follow-up studies, it is expected that a wider range of information will be presented through analysis that includes bibliographic information, such as research titles and abstracts in addition to keywords. The scope of the investigation should be expanded and more comprehensive studies should be collected. Furthermore, a more segmented time series division should be applied to more accurately interpret Paralympic study trends and keyword network, and interpretation from various fields' perspectives beyond that of disabled people should be carried out. It would also be meaningful to compare and discuss the keyword network and research trends by dividing them between the field of physical education and other academic fields such as education and welfare.

Despite these limitations, this study is meaningful as it can contribute to the expansion and revitalization of the Paralympic study area by exploring core keywords and providing relevant information based on the significant change point in time, including the entire Paralympic study trend. It is hoped that this study will encourage related research on the Paralympics.

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