THE EVOLUTION OF NORDIC WALKING RESEARCH: A BIBLIOMETRIC ANALYSIS

LA EVOLUCIÓN DE LA INVESTIGACIÓN SOBRE LA MARCHA NÓRDICA: UN ANÁLISIS BIBLIOMÉTRICO

A EVOLUÇÃO DA PESQUISA SOBRE A MARCHA NÓRDICA: UMA ANÁLISE BIBLIOMÉTRICA

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ABSTRACT

Nordic Walking has expanded from a sport-specific method to a widely used physical activity and therapeutic strategy, generating a rapidly growing body of literature. This study aimed to conduct a comprehensive bibliometric analysis of Nordic Walking research from 1996 to 2024. A bibliometric analysis was performed using Scopus. Peer-reviewed journal articles and reviews published between 1996 and 2024 were included. Performance indicators and science-mapping analyses were conducted using Biblioshiny. A total of 331 documents were analysed. The field showed consistent growth, with an annual growth rate of 12.18%, and 39.27% of publications occurring in the last five years (2020–2024). Poland was the leading country in research output (20.8% of publications), followed by Italy (11.6%) and Spain (6.4%). Co-occurrence network analysis revealed three main research clusters centred on physiology, human walking, and exercise therapy. Topic trend analysis identified “Nordic walking,” “physical activity,” “exercise,” and “walking” as dominant themes. International collaboration

networks showed strong links among European countries, particularly Italy and Poland. This study provides insights into the evolution and current state of Nordic Walking research, highlighting its growing relevance in health and exercise science and supporting future agenda setting and targeted international collaboration.

Keywords: physical activity, exercise, scientific production, health, science development.

RESUMEN

La marcha nórdica ha pasado de ser un método específico del ámbito deportivo a convertirse en una estrategia ampliamente utilizada de actividad física y terapéutica, generando un cuerpo de literatura en rápido crecimiento. Este estudio tuvo como objetivo realizar un análisis bibliométrico integral de la investigación sobre marcha nórdica entre 1996 y 2024. Se llevó a cabo un análisis bibliométrico utilizando Scopus. Se incluyeron artículos de revistas revisadas por pares y revisiones publicados entre 1996 y 2024. Los indicadores de rendimiento y los análisis de mapeo científico se realizaron mediante Biblioshiny. Se analizaron un total de 331 documentos. El campo mostró un crecimiento constante, con una tasa anual del 12,18%, y el 39,27% de las publicaciones se concentró en los últimos cinco años (2020–2024). Polonia fue el país líder en producción científica (20,8% de las publicaciones), seguido de Italia (11,6%) y España (6,4%). El análisis de redes de coocurrencia reveló tres clústeres principales de investigación centrados en la fisiología, la marcha humana y la terapia mediante ejercicio. El análisis de tendencias temáticas identificó “marcha nórdica”, “actividad física”, “ejercicio” y “caminar” como los temas dominantes. Las redes de colaboración internacional mostraron fuertes vínculos entre países europeos, especialmente Italia y Polonia. Este estudio aporta información sobre la evolución y el estado actual de la investigación en marcha nórdica, destacando su creciente relevancia en las ciencias de la salud y del ejercicio, y apoyando la definición de agendas futuras y la colaboración internacional focalizada.

Palabras clave: actividad física, ejercicio, producción científica, salud, desarrollo de la ciencia.

RESUMO

A marcha nórdica evoluiu de um método específico do desporto para uma estratégia amplamente utilizada de atividade física e terapêutica, gerando um corpo de literatura em rápido crescimento. Este estudo teve como objetivo realizar uma análise bibliométrica abrangente da investigação sobre marcha nórdica entre 1996 e 2024. Foi realizada uma análise bibliométrica utilizando a Scopus. Foram incluídos artigos e revisões publicados em revistas com revisão por pares entre 1996 e 2024. Os indicadores de desempenho e as

análises de mapeamento científico foram conduzidos com o Biblioshiny. Foram analisados 331 documentos. O campo apresentou crescimento consistente, com uma taxa anual de 12,18%, e 39,27% das publicações ocorreu nos últimos cinco anos (2020–2024). A Polónia destacou-se como o país líder na produção científica (20,8% das publicações), seguida pela Itália (11,6%) e pela Espanha (6,4%). A análise de redes de coocorrência revelou três principais clusters de investigação centrados na fisiologia, na marcha humana e na terapia por exercício. A análise de tendências temáticas identificou “marcha nórdica”, “atividade física”, “exercício” e “caminhada” como temas dominantes. As redes de colaboração internacional mostraram ligações fortes entre países europeus, particularmente entre a Itália e a Polónia. Este estudo fornece insights sobre a evolução e o estado atual da investigação em marcha nórdica, destacando a sua crescente relevância nas ciências da saúde e do exercício, e apoiando a definição de agendas futuras e a colaboração internacional direcionada.

Palavras-chave: atividade física, exercício, produção científica, saúde, desenvolvimento da ciência.

INTRODUCTION

Nordic Walking (NW), initially developed in Finland as a summer training method for cross-country skiers, has evolved into a popular form of physical activity practised worldwide (Shove & Pantzar, 2005). This exercise modality involves walking with specially designed poles, which engages upper and lower body muscles in a coordinated movement pattern (Church et al., 2002). The distinctive feature of NW lies in its ability to combine the natural movement of walking with the active use of poles, resulting in increased energy expenditure and enhanced physical engagement compared to conventional walking (Tschentscher et al., 2013).

Over the past three decades, NW has garnered significant attention from practitioners and researchers, primarily due to its versatility and health benefits. Systematic reviews have established comprehensive advantages over conventional walking regarding physiological responses and biomechanical patterns (Pérez-Soriano et al., 2014). These benefits include enhanced energy expenditure through upper body engagement, improved gait mechanics, and increased cardiovascular responses (Church et al., 2002; Willson et al., 2001). The evidence base has expanded from initial physiological studies to more specialised clinical applications, demonstrating NW's effectiveness across various populations, from healthy adults to individuals with chronic conditions such as Parkinson's disease (Cugusi et al., 2015), chronic obstructive pulmonary disease (Breyer et al., 2010), and cardiovascular disorders (Piotrowicz et al., 2015). The growing body of evidence supporting NW's therapeutic applications has

incorporated it into rehabilitation programs and health promotion initiatives worldwide (Fritschi et al., 2012).

Expanding NW from a specialised training technique to a widely adopted form of physical activity represents a unique case of practice innovation and knowledge dissemination in exercise science (Pantza & Shove, 2010). This systematic accumulation of evidence has validated NW as an effective exercise modality and sparked diverse research directions in rehabilitation, performance analysis, and public health promotion (Shove & Pantzar, 2005). However, despite the growing academic interest in NW, there has been no comprehensive bibliometric analysis of the literature that systematically maps the development and current state of research in this field.

Bibliometric analysis provides valuable insights into the structure and evolution of scientific fields by examining publication patterns, research impact, and collaboration networks (Donthu et al., 2021). This methodological approach has been successfully employed to analyse research trends in various areas of physical activity and health science (Memon et al., 2020). By applying bibliometric techniques to the NW literature, it is possible to identify key research themes, influential works, and patterns of scientific collaboration. Moreover, because NW research is dispersed across sport, clinical, and public health outlets, a bibliometric analysis is important to provide an integrated overview of the field.

Therefore, this study aims to conduct a comprehensive bibliometric analysis of NW research from 1996 to 2024, with the following specific objectives: (1) to analyse the temporal evolution of scientific production in NW research; (2) to identify the most influential authors, institutions, and countries contributing to the field; (3) to examine collaboration patterns and research networks; and (4) to map the thematic development and emerging research trends. This analysis will provide valuable insights for researchers, practitioners, and policymakers interested in NW while highlighting potential areas for future investigation.

MATERIALS AND METHODS

Data Collection and Search Strategies

This study is a bibliometric analysis using performance analysis and scientific mapping to characterise the evolution and structure of NW research. Bibliometric analysis is considered a suitable approach to comprehensively examine the current state of research on a specific topic (Ellegaard & Wallin, 2015). Furthermore, ensuring the reliability and validity of such an analysis requires adherence to established guidelines and methodologies (Donthu et al., 2021).

A systematic search was performed in the Scopus database, covering its inception through January 5, 2025. This decision was adopted because Scopus has a broader coverage of journals compared to Web of Science and other databases (Singh et al., 2021). In addition,

it is a commonly used database in bibliometric analysis conducted in the field of Sport Sciences (Cherappurath et al., 2024; González-Devesa, 2026). On the other hand, as the study was conducted while 2025 was still in progress, publications from 2025 were excluded. This decision was made to ensure the validity of the findings, as the absence of data from an entire semester would have rendered the outcomes for 2025 incomplete and unreliable. The careful selection of keywords is a pivotal aspect of bibliometric analysis, as it directly influences the accuracy and relevance of the results (Memon et al., 2020).

Keywords were determined after thoroughly reviewing the previous literature on Nordic Walking. The specific strategies were as follows: TITLE ((“Nordic walking" OR "Pole walking" OR "Pole striding" OR "Walking poles" OR "Polestriding”)). Using title-based keyword searches minimises false-positive results and ensures that unrelated articles are kept within acceptable limits, aligning with methodologies employed in prior bibliometric analysis (Feng et al., 2022; Memon et al., 2020).

To ensure the inclusion of scholarly sources with the highest methodological rigor, we applied predefined filters in Scopus and retained only peer-reviewed records indexed as journal articles or reviews. All other document types (e.g., books, book chapters, conference papers/proceedings, editorials, letters, notes, and errata) were excluded. Consequently, the final dataset comprised peer-reviewed journal articles and reviews (regardless of study design) that met the predefined inclusion criteria (see Figure 1). No language restrictions were applied.

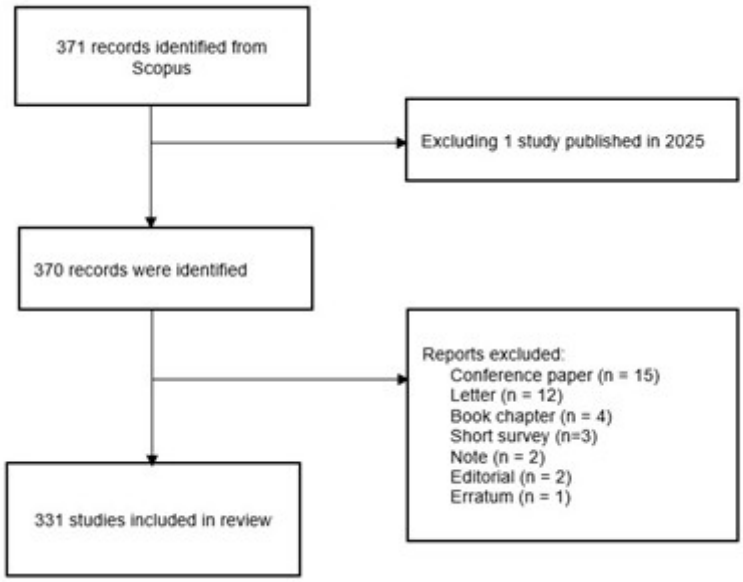


Figure 1. Flow chart of the article selection. Source: the authors.

Bibliometric Analysis

Bibliometric analysis is broadly categorised into two principal tecniques: (1) performance analysis and (2) scientific mapping.

Performance analysis evaluates publication-related metrics, including total publications, annual publication trends, the most-cited articles, influential journals and authors, collaboration networks, and the leading institutions and countries contributing to the field. Performance analysis evaluates a field's output and impact through Publication-related metrics (total publications, number of contributing authors, sole-authored publications, number of active years of publication, and productivity per year of publication), as well as Citation-related metrics. This workflow enabled the application of Bradford's Law to identify core journals and facilitated the exploration of prevailing thematic clusters and emerging research trends within the domain.

In contrast, Science mapping examines research domain's structural and evolutionary dynamics by modelling relationships in the literature via citation analysis, co-citation analysis, bibliographic coupling, co-word analysis, and co-authorship analysis. This approach typically divides the study period into two phases: the first, often the longest, identifies major research themes or "fronts," while the second highlights emerging or diminishing themes, providing insights into the field's future trajectory (Donthu et al., 2021).

Data extraction and analysis were conducted using the Bibliometrix R-package (v. 4.3.0) within the R environment (v. 4.4.2) (Aria & Cuccurullo, 2017). Bibliographic records were retrieved from Scopus, exported in BibTeX format, and subsequently analysed using Biblioshiny, the web-based interface of Bibliometrix. No other software was used.

RESULTS

The search yielded a total of 371 documents. Among these, one study was excluded for being published in 2025, and 39 records were removed for not being classified as articles or reviews. Consequently, 331 studies were included in the final analysis (Figure 1). Among these, 303 were articles, and 24 were reviews.

Performance Analysis

The first publication on this topic, authored by Walter et al. (1996), was titled "Acute Responses to Using Walking Poles in Patients With Coronary Artery Disease" and appeared in the Journal of Cardiopulmonary Rehabilitation. No publications were recorded in 1997, 1998, 1999, or 2000. From 2001 onwards, research output showed consistent growth, albeit slow in its initial phase. The peak in publication volume occurred in 2020 (n = 30), followed by 2017 (n = 29), and 2015 and 2023 (n = 27 each). Remarkably, the literature published in the last five years (2020–2024) represents 39.27% (n = 130) of the total contributions to this field. The annual growth rate was 12.18 %.

Most prolific authors, institutions, and countries: Table 1 shows that the researchers Woźniewski M. and Ziemann E. secured the top position with the highest number of

publications (n = 12), followed by Pellegrini B. (n = 10) and Schena F. (n = 9). Additionally, it is worth noting that only 20 out of the 1,377 authors included in this review contributed to five or more studies. Ziemann E. and Pellegrini B. achieved the highest productivity metrics (index = 8), followed by Cugusi L. and Prusik K. (index = 7).

Table 1.

Most prolific authors on research about Nordic Walking from 1996 to 2024.

Author	Total Publications	Total Citations	index	Publication starting year
Woźniewski Marek	12	126	6	2010
Ziemann Ewa	12	149	8	2015
Pellegrini Barbara	10	244	8	2014
Schena Federico	9	214	6	2014
Cugusi Lucia	8	288	7	2015
Prusik Katarzyna	8	131	7	2011
Di Blasio Andrea	7	216	5	2015
Jasiński Ryszard	7	78	4	2015
Kortas Jakub	7	118	6	2015
Peyré-Tartaruga Leonardo Alexandre	7	147	4	2015
Pilch Wanda	7	71	6	2017
Prusik Krzysztof	7	129	7	2011

Source: the authors.

The universities with the highest research output on NW from 1996 to 2024 were the Gdansk University of Physical Education and Sport, Poland (n = 50), the Poznan University of Physical Education, Poland (n = 35), and the University of Verona, Italy (n = 27). Concerning the most productive countries, Poland ranked first with sixty-eight publications (20.8% of the total articles), followed by Italy with thirty-eight publications (11.6% of the total articles) and Spain with twenty-one publications (6.4% of the total articles).

Most relevant journals: Table 2 shows that the International Journal of Environmental Research and Public Health maintained the top position of journals on the topic (n = 10), followed by the Journal of Physical Therapy Science (n = 8) and Plos One (n = 7). Notably, nine of the ten journals with the highest number of publications on NW were indexed in the 2024 SCImago Journal & Country Rank (SJR), with five of them ranked in Q1 within their respective categories. The Journal of Physical Therapy Science was the only journal not

indexed in SJR in 2024; however, it was indexed in the Journal Citation Reports (JCR) in 2014 and in SJR until 2019.

Table 2.

The most relevant sources are several publications about Nordic Walking.

Sources	Nº of articles	Journal's SJR	Quartile	Category	Publisher
International Journal of Environmental Research and Public Health	10	0.919	Q2	Public Health, Environmental and Occupational Health	MDPI
Journal of Physical Therapy Science	8	0.392‡	Q4‡	Rehabilitation‡	Soc Physical Therapy Science
Plos One	7	0.803	Q1	Multidisciplinary	Public Library Science
Journal of Functional Morphology and Kinesiology	6	0.804	Q1	Physical Therapy, Sports Therapy and Rehabilitation	MDPI
Scandinavian Journal of Medicine and Science in Sports	6	1.494	Q1	Sports Science	Wiley
Clinical Interventions in Aging	5	1.117	Q1	Medicine (miscellaneous)	Dove Medical Press Ltd
Healthcare (Switzerland)	5	0.754	Q2	Health Policy	MDPI
Journal of Aging and Physical Activity	5	0.684	Q2	Rehabilitation	Human Kinetics Publ Inc
Journal of Clinical Medicine	5	0.919	Q1	Medicine (miscellaneous)	MDPI
Teoriya I Praktika Fizicheskoy Kultury	5	0.194	Q4	Physical Therapy, Sports Therapy and Rehabilitation	CPCS of the Council of Ministers of the USSR
International Journal of Environmental Research and Public Health	10	0.919	Q2	Public Health, Environmental and Occupational Health	MDPI

Note. The journal's SJR, quartile, and subject category are based on the 2024 edition of the SCImago Journal & Country Rank (SJR). Data from the 2014 edition of JCR, marked with (‡), are included for journals not indexed in the SJR 2024. Source: the authors.

Most cited articles: The ten most-cited studies were published between 2001 and 2015, as shown in Table 3. The two studies with the highest citation counts were Shove & Pantzar (2005) and Pantza & Shove (2010), with 708 and 170 citations, respectively, focusing on the

NW practice analysis. The remaining eight studies on the list of most-cited documents primarily examined the effects of NW on health-related variables.

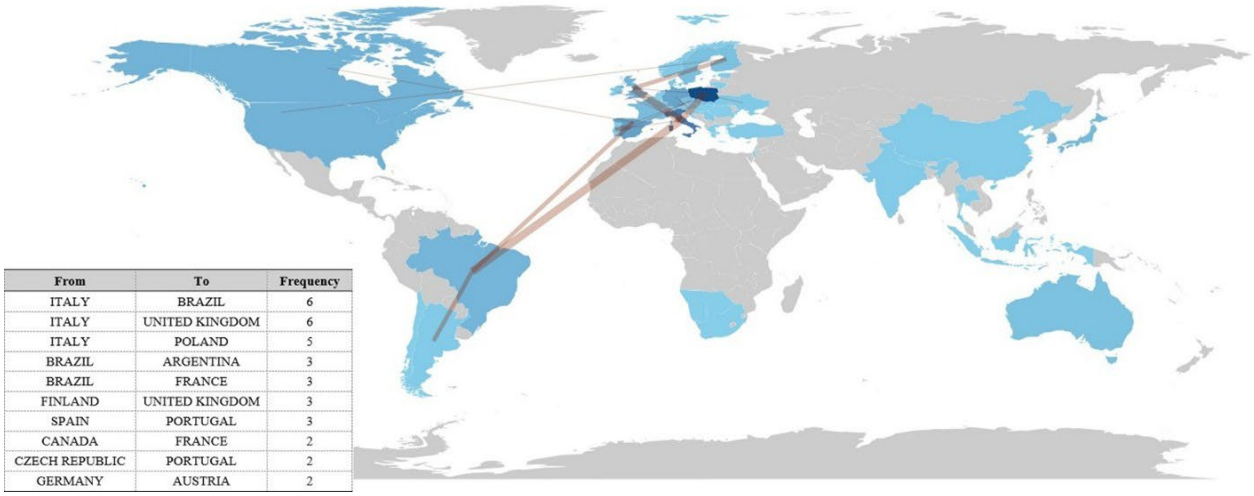
Table 3.

Most globally cited documents related to Nordic Walking.

Author/s	Title	Total Citations
Shove & Pantzar (2005)	Consumers, Producers and Practices: Understanding the invention and reinvention of Nordic walking	708
Pantza & Shove (2010)	Understanding Innovation in Practice: A Discussion of the production and reproduction of Nordic Walking	170
Tschentscher et al. (2013)	Health Benefits of Nordic Walking	170
Church et al. (2002)	Field Testing of Physiological Responses Associated with Nordic Walking	158
Breyer et al. (2010)	Nordic Walking improves daily physical activities in COPD: a randomised controlled trial	140
Reuter et al. (2011)	Effects of a flexibility and relaxation programme, walking, and Nordic walking on Parkinson's disease	139
Piotrowicz et al. (2015)	Home-based telemonitored Nordic walking training is well accepted, safe, effective and has high adherence among heart failure patients, including those with cardiovascular implantable electronic devices: a randomised controlled study	130
Cugusi et al. (2015)	Effects of a Nordic Walking Program on motor and non-motor Symptoms, functional performance and Body Composition in patients with Parkinson's Disease	109
Willson et al. (2001)	Effects of walking poles on lower extremity gait mechanics	109
van Eijkeren et al. (2008)	Nordic walking improves mobility in Parkinson's disease	99

Source: the authors

Collaboration networks: Figure 2 highlights Italy as the leading country in collaborative research, frequently partnering with Brazil, UK, Ireland, Spain, Poland, among others. Poland is ranked as the second most collaborative country, engaging in joint research efforts with Italy, Slovakia, the UK, Ukraine, among others.



From	To	Frequency
ITALY	BRAZIL	6
ITALY	UNITED KINGDOM	6
ITALY	POLAND	5
BRAZIL	ARGENTINA	3
BRAZIL	FRANCE	3
FINLAND	UNITED KINGDOM	3
SPAIN	PORTUGAL	3
CANADA	FRANCE	2
CZECH REPUBLIC	PORTUGAL	2
GERMANY	AUSTRIA	2

Figure 2. The most common patterns of international collaboration in Nordic Walking research. Source: the authors.

Scientific mapping

Thematic evolution of author's keywords: The evolution of the author's keywords and keywords plus is divided into two dis-tinct phases: 1996–2018 and 2018–2022. The size of the vertical bars represents the frequency of keyword usage, while the flow between the bars indicates the progression of these keywords over time (Figure 3).

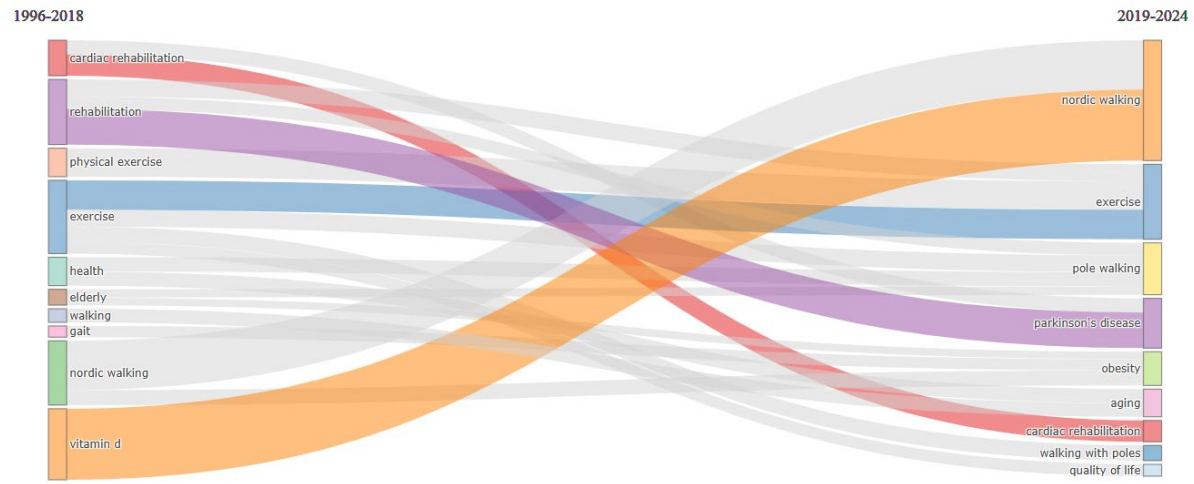


Figure 3. Thematic evolution of author's keywords of publications on Nordic Walking. Source: the authors.

Co-occurrence network of keywords plus: Three clusters of keywords plus were identified (Figure 4). The size of each circle indicates the frequency of the keyword, while the thickness of the connecting lines reflects the strength of their associations. The red cluster consisted of twelve keywords, with "physiology" as the most prominent, demonstrating a link

strength of 1.584, which reflects its frequent co-occurrence with other keywords. The second cluster, represented in dark blue, comprised twenty-three keywords, with “human” and “walking” being the most frequently used. These keywords exhibited total link strengths of 7.718 and 5.471, respectively. The third cluster, shown in green, included fourteen keywords, with “exercise therapy” being the most frequently used. This keyword demonstrated a total link strength of 0.603.

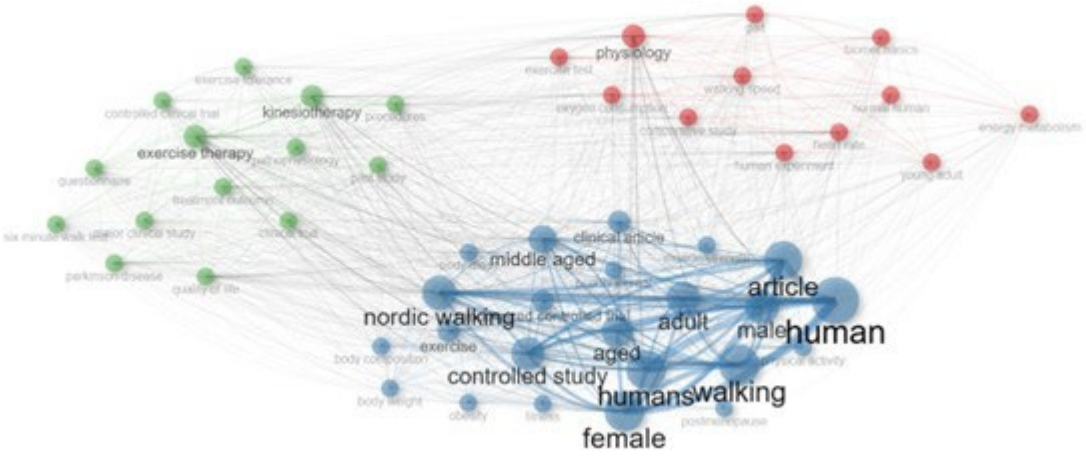


Figure 4. Co-occurrence of keywords plus related to Nordic Walking. Source: the authors

Trend topics: Figure 5 highlights the trending topics analysed through author-supplied keywords using the following parameters: 1) Minimum Word Frequency = 6 and 2) Number of Words per Year = 3. Among the fifteen identified terms, the most prominent topics were “Nordic walking,” “physical activity,” “exercise,” and “walking.”

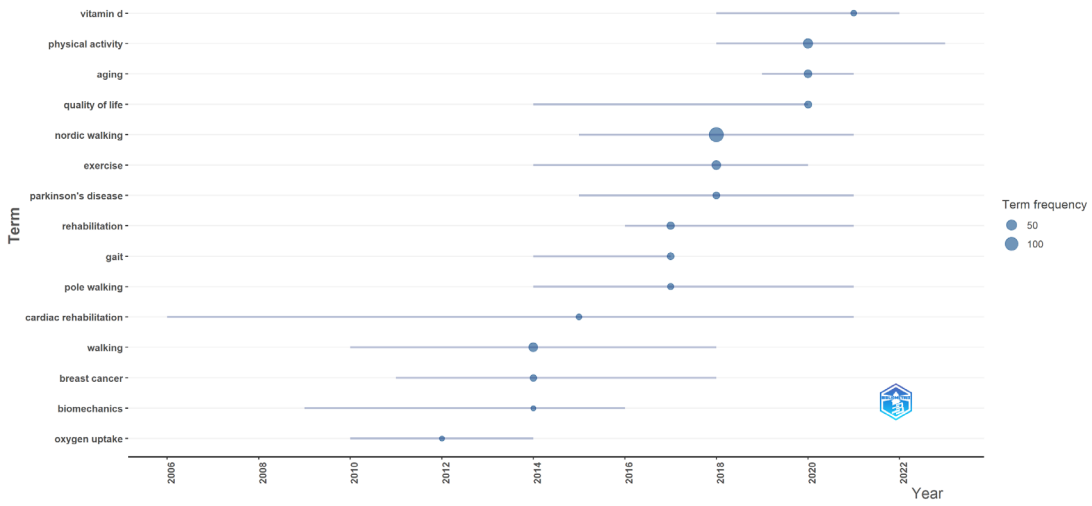


Figure 5. Trend topics in research on Nordic Walking from 1996 to 2024. Source: the authors.

DISCUSSION

This bibliometric analysis provides comprehensive insights into the evolution and current state of NW research from 1996 to 2024. The findings reveal significant growth in research output, geographical distribution patterns, and thematic developments that merit detailed discussion.

The temporal analysis of publications demonstrates a consistent growth pattern, with an annual growth rate of 12.18% and nearly 40% of all publications occurring in the last five years (2020-2024). This acceleration in research output coincides with the growing recognition of NW as a therapeutic modality and health-promoting physical activity. The surge in publications post-2020 may be partially attributed to increased interest in outdoor physical activities during the COVID-19 pandemic, as outdoor exercise was identified as a safer alternative (Ding et al., 2020; Filgueira et al., 2021). Studies have shown that the pandemic significantly influenced exercise behaviours, with many individuals turning to outdoor activities to maintain physical and mental health (Lesser & Nienhuis, 2020; Sallis et al., 2021). This trend aligns with systematic reviews highlighting NW's effectiveness across various populations and conditions (Bullo et al., 2018; Salse-Batán et al., 2022; Skórkowska-Telichowska et al., 2016), including, for example, older adults and individuals with Parkinson's disease, among others.

The geographical analysis reveals a strong European dominance in NW research, with Poland and Italy emerging as the leading contributors. This research concentration in European countries, particularly Poland (20.8% of publications), reflects the historical roots of NW in Northern Europe and its subsequent spread across the continent. The prominence of Polish institutions, notably the Gdansk University of Physical Education and Sport and the Poznan University of Physical Education, suggests a strategic focus on NW research within the Polish academic system. This geographical pattern is consistent with the historical development of NW as described in previous studies (Pantza & Shove, 2010; Shove & Pantzar, 2005) and its widespread adoption in European healthcare systems (Golledge et al., 2018; Torri et al., 2024).

The analysis of collaboration networks reveals strong international cooperation between European institutions (Figure 2). The robust collaboration between Italian and Polish researchers is especially noteworthy, suggesting a productive exchange of expertise and resources (Cugusi et al., 2017; Piotrowicz et al., 2010). This pattern of international collaboration has likely contributed to the rapid development of the field and the diversification of research approaches, as evidenced in recent systematic reviews (González-Devesa et al., 2024; Saller et al., 2023). The growing international networks have facilitated the exchange of methodological approaches and clinical applications, enriching the field's development.

The thematic analysis identified three main research clusters centred around physiology, human walking, and exercise therapy, indicating a well-balanced distribution of research focus.

The prominence of physiological studies aligns with the findings of recent meta-analyses demonstrating NW's superior effects on cardiovascular parameters compared to conventional walking (Schiffer et al., 2011; Wiacek et al., 2023). The emphasis on exercise therapy in the keyword analysis reflects the growing application of NW in clinical settings, supported by evidence from randomised controlled trials showing its effectiveness in various patient populations (Breyer et al., 2010; Granziera et al., 2020; Mannerkorpi et al., 2010).

Recent studies have particularly highlighted NW's effectiveness in improving functional capacity and quality of life in older adults (Rodrigues et al., 2021), patients with chronic conditions (Girold et al., 2017), and individuals with neurological disorders (Cugusi et al., 2015; Salse-Batán et al., 2022). The evolution of research themes from 1996-2018 to 2018-2024 shows a progression from basic physiological studies to more specialised clinical applications. Citation analysis reveals that the most influential papers span theoretical frameworks (Shove & Pantzar, 2005) and clinical applications (Tschentscher et al., 2013). This dual emphasis on theoretical understanding and practical application has contributed to the field's development as both an academic discipline and a therapeutic modality. The high citation counts of papers focusing on specific clinical populations, particularly those with Parkinson's disease and cardiovascular conditions, underscore the clinical relevance of NW research (Cugusi et al., 2015; Girold et al., 2017).

The journal analysis shows diverse publication venues, with a notable presence in high-impact journals across multiple disciplines. The prominence of the International Journal of Environmental Research and Public Health and other Q1-ranked journals suggests growing recognition of NW research within the broader scientific community. This wide distribution across journals indicates the multidisciplinary nature of NW research, spanning exercise science, rehabilitation, and public health domains (González-Devesa et al., 2024). However, none of the ten most-cited papers were published in the top eleven most productive journals.

Recent studies have continued to expand the evidence base for NW, particularly in the context of emerging health challenges. For example, research has explored the role of NW in post-COVID rehabilitation programs, highlighting its potential to improve respiratory function and overall physical fitness in patients recovering from the virus (Cano-de-la-Cuerda et al., 2024). Additionally, studies have begun to investigate the mental health benefits of NW, with preliminary findings suggesting that it may reduce symptoms of anxiety and depression (Liu et al., 2022). These developments underscore the adaptability of NW research and its relevance in addressing contemporary health concerns.

While this study provides a comprehensive overview of NW research, it is important to acknowledge certain limitations. First, the analysis was conducted using only the Scopus database, which may introduce biases due to its coverage of predominantly English-language publications. Future bibliometric studies could benefit from including additional databases,

such as Web of Science or PubMed, to ensure a more comprehensive field representation. Additionally, excluding non-English publications may have omitted relevant studies, particularly from non-European countries where NW is gaining popularity. These limitations highlight the need for more inclusive bibliometric analyses in the future.

Finally, several promising research directions emerge from this analysis. First, there is significant potential for expanding NW research in non-European countries, particularly in regions where NW is gaining traction as a form of physical activity. Second, the growing interest in technological applications, such as wearable devices and remote monitoring systems, offers exciting opportunities for innovation in NW instruction and performance tracking (Adesida et al., 2019). For example, integrating NW with digital health platforms could enable real-time feedback on technique and physiological responses, enhancing clinical and recreational applications. Moreover, integrating NW into preventive healthcare programs represents a promising avenue for future research. Studies could explore the long-term benefits of NW in reducing the risk of chronic diseases, such as cardiovascular disease and diabetes, particularly in at-risk populations.

In addition to these broader directions, the analysis highlights specific gaps that remain insufficiently addressed. Notably, evidence on Nordic Walking in children and adolescents is scarce, despite its potential relevance for promoting physical activity and healthy behaviours across developmental stages. Moreover, additional studies are required to examine the feasibility, acceptability, and implementation of Nordic Walking within commercial fitness programmes, including its perceived attractiveness as a contemporary fitness modality.

CONCLUSIONS

Offering a comprehensive view of the development and state of NW research from 1996 to 2024, this bibliometric analysis highlights a sustained increment in scientific output by about 12.18% per year, with almost 40% of the publications in the last 5 years (2020-2024). Such growth reflects people's awareness regarding NW as a widespread and useful form of physical activity, especially in health promotion and rehabilitation. Geo-graphically, European countries dominate NW research; Poland and Italy are the top contributory nations, responsible for 20.8% and 11.6% of the publications, respectively. Collaboration networks remain stronger among European institutions, with Italy and Poland often joining forces to conduct impactful studies. Thematic analyses isolated three main clusters of research: physiology, human walking, and exercise therapy, demonstrating that NW research is multidisciplinary and applicable to various populations, including older adults and individuals with chronic diseases such as Parkinson's and cardiovascular disorders. The major journals, including the International Journal of Environmental Research and Public Health, show how the field is embedded in general health and exercise science disciplines. The study provides an in-depth

map of the NW research landscape, emphasizing the growth, thematic focus, and collaborative networks over three decades.

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