Asian Journal of Medicine & Health Sciences Vol 9 Issue 1, June 2026

REVIEW ARTICLE

Exercise and Physical Fitness Interventions in Stroke Rehabilitation: A Bibliometric and Thematic Review of Research Trends and Outcomes.

Rasydan Ramlan[1], Haidzir Manaf[2*], Azliyana Azizan[2], Saiful Adli Bukry[2], Zulaikha Zainuddin[2], Hafifi Hisham[3], Zulaikha Karim[4], Nazrin Mazehi[5], Zainizam Rasid[5], Hanan[6], Izzati Aznan Azzman[7], Hizami Mustafa[8], Murtadha Ramly[1]

[1]Physiotherapy Programme, Faculty of Pharmacy and Health Sciences, Universiti Kuala Lumpur, Royal College of Medicine, Perak, Malaysia
[2]Centre for Physiotherapy Studies, Faculty of Health Sciences, Universiti Teknologi MARA, Puncak Alam Campus, 42300, Selangor, Malaysia
[3]Physiotherapy Program, Center for Rehabilitation and Special Needs Studies, Faculty of Health Sciences, Universiti Kebangsaan Malaysia, 50586 Kuala Lumpur.
[4]Department of Rehabilitation Medicine, Hospital Al-Sultan Abdullah, Universiti Teknologi MARA, 42300, Selangor, Malaysia
[5]Rehabilitation Department, Pusat Rehabilitasi PERKESO Tun Abdul Razak, Lot PT7263,[H.S (D) 18923],Bandar Hijau,Hang Tuah Jaya,75450,Melaka,Malaysia
[6]Department of Rehabilitation Medicine, Hospital Sultan Abdul Aziz Shah, Universiti Putra Malaysia, 43400 Serdang, Selangor, Malaysia
[7]Physiotherapy Unit, Department of Rehabilitation Medicine, Hospital Sultan Idris Shah Serdang, 43000, Kajang, Selangor, Malaysia

Corresponding Author
Haidzir Manaf
Centre for Physiotherapy Studies, Faculty of Health Sciences, Universiti Teknologi MARA (UiTM), Puncak Alam Campus, 42300 Puncak Alam, Selangor, Malaysia
ORCID: 0000-0003-0342-8136
Email: haidzir5894@uitm.edu.my
DOI: https://doi.org/10.70672/egcrkh17

Received: 06/01/2026. Revised: 02/04/2026. Accepted: 03/05/2026. Published online: 01/06/2026.

Abstract

Stroke is a leading cause of death and long-term disability worldwide, placing major physical, psychological, and socioeconomic burdens on patients, families, and healthcare systems. In this bibliometric review with thematic analysis, we examined the trends in research on exercise and physical fitness interventions for stroke rehabilitation. A literature search was conducted in the Web of Science Core Collection on 22 December 2025, including English-language articles and review articles published between 2015 and 2025. Title-based search terms combined stroke-related and physical fitness–related concepts. Publication output and citation patterns were analysed, and keyword co-occurrence analysis was performed to identify dominant research themes. The findings revealed a steady increase in publication volume over the past decade, with accelerated growth after 2020, indicating rising scholarly interest in exercise-based stroke rehabilitation. In contrast, citation counts declined in recent years, likely reflecting citation lag associated with newly published studies. Three major thematic clusters were identified: functional performance and mobility-oriented rehabilitation, physical activity and health-related quality of life, and cardiorespiratory fitness with an emphasis on exercise prescription and clinical translation. These findings indicate a shift from primarily function-focused research toward more comprehensive, health-oriented, and clinically translational approaches. While functional mobility remains a central research priority, increasing attention to quality of life and cardiorespiratory fitness reflects a broader conceptualisation of post-stroke recovery. This review highlights the need for standardised outcome measures, clearer exercise prescription parameters, and stronger integration of evidence into clinical practice to advance exercise-based stroke rehabilitation.

Keywords: *Cerebrovascular accident, physical endurance, physical fitness, stroke.*

Introduction

Stroke remains a leading cause of mortality and chronic disability worldwide, imposing significant physical, psychological, and socioeconomic burdens on patients, their families, and health systems [1]. Survivors often suffer lasting impairments in motor control, muscle strength, balance, and cardiovascular endurance, which limit their functional independence and participation in daily activities. Improvements in acute stroke care have increased survival rates, leading to a larger population living with stroke impairments (2). This trend underscores the urgent need for effective, evidence-based rehabilitation strategies to optimize recovery and long-term health outcomes after stroke.

Exercise and physical fitness interventions are recognized as essential components of stroke rehabilitation, especially within physiotherapy practice. After a stroke, reduced physical activity and deconditioning commonly worsen deficits in aerobic capacity, muscle strength, and endurance, thereby raising the risk of secondary complications such as cardiovascular diseases and recurrent stroke (3). Exercise-based rehabilitation programs, including aerobic training, resistance exercises, task-specific practice, and combined fitness regimens, aim not only to restore movement but also to enhance overall fitness and health. A growing body of evidence indicates that such interventions can enhance functional recovery, mobility, and community participation, underscoring their pivotal role in contemporary stroke rehabilitation. Assessing rehabilitation's effectiveness depends critically on the choice of outcome measures. Stroke rehabilitation studies frequently evaluate outcomes like cardiovascular fitness, mobility, activities of daily living, and health-related quality of life. However, the literature shows substantial variability in which outcomes are

chosen. This heterogeneity complicates the comparison and synthesis of findings across studies. It highlights the need for a clearer picture of which outcome domain has been most frequently examined, how focus areas have changed over time, and how they align with current rehabilitation priorities.

Research on exercise-based interventions in stroke rehabilitation has evolved markedly over the past two decades. Early studies in the 2000s primarily asked whether structured exercise could improve basic mobility and function after stroke, often with limited detail on intervention or outcome specifics [4,5]. In the 2010s, the field shifted to more systematic, theory-driven investigations, including rigorous systematic reviews and meta-analyses that evaluated intervention efficacy, dosing, and study quality [6,7]. More recently, technology-assisted therapies (e.g. robotics, virtual reality, exergaming) have been integrated with conventional exercise paradigms, reflecting a trend toward innovative, multimodal, and patient-centered rehabilitation strategies (8–10).

Throughout this evolution, certain outcome domains have remained consistently prominent. Improvements in walking speed, balance, and functional mobility are frequently measured using standardized tools such as the 10-Meter Walk Test, Timed Up and Go, and Berg Balance Scale, highlighting the importance of fitness interventions in regaining movement capacity (7,9). At the same time, there is growing attention to cognition, daily living activities, and quality of life, recognizing that stroke recovery is multidimensional. Cognitive function is often assessed, for example, via the Montreal Cognitive Assessment in combined physical-cognitive programs (4,6). Measures of independence and participation such as the Barthel Index, Functional Independence Measure, and stroke-specific quality-of-life scales are also common, and evidence suggests both traditional and technology-enhanced exercises can improve these broader outcomes (11–13).

Despite the large and growing literature, there has been limited synthesis of how exercise interventions, outcome domains, and research emphases have changed over time. Bibliometric and thematic analysis provide a systematic way to map publication trends, highlight key themes, and identify gaps. This review, therefore, aims to comprehensively examine research trends, intervention features, and outcome domains in exercise-focused stroke rehabilitation, offering an integrated perspective to guide future research and practice.

Method

A bibliometric study with thematic analysis was conducted using the Web of Science (WoS) Core Collection database (search date: 22 December 2025). Bibliometric mapping and visualization were performed using VOSviewer software, which is widely used for constructing and visualizing bibliometric networks, including keywords co-occurrence, co-authorship, and citation relationships (14). WoS was chosen for its extensive coverage of high-quality, peer-reviewed journals and its robust citation data. Our search targeted studies on exercise and physical fitness interventions in stroke rehabilitation by performing a title-field search. This ensured that the main concepts of stroke and physical fitness were central to each retrieved article. The combined search terms included the following Boolean operators and keywords:

- **Stroke-related term: "***cerebrovascular accident" OR "stroke" OR "cerebral infarction" OR "ischemic stroke" OR "haemorrhagic stroke"*
- **Physical fitness term:** *"physical fitness" OR "exercise" OR "exercise therapy" OR "aerobic capacity" OR "muscle strength" OR "physical endurance"*

In addition to the title keywords, we applied filters to restrict the results to English-language publications, document type of Article or Review, and the publication years 2015 to 2025. These inclusion criteria captured both original research

and reviews. The final set of records was exported for detailed trend and thematic analysis.

The retrieved records were exported in plain text format, including full records and cited references, and subsequently imported into VOSviewer for analysis. Co-occurrence analysis of author keywords was conducted to identify major research themes, with a minimum keyword occurrence threshold of more than 5 applied to ensure meaningful network connections. VOSviewer was used to generate network visualisation maps, where nodes represent keywords and links indicate co-occurrence relationships, and link strength reflects the frequency of keyword co-occurrence. Clustering was performed using VOSviewer algorithm to group related keywords into thematic clusters. Additionally, publication output and citation trends were analysed using WoS tools to examine temporal patterns.

Results

Publication output and citation trends

As shown in Figure 1, the annual number of publications on exercise-based stroke rehabilitation grew over the study period. After 81 papers in 2015, output dipped briefly in 2016 with 56 papers but then rose steadily. A notable increase occurred from 2020 onward. For instance, there were 90 papers in 2020, 116 in 2021, and 121 in 2022. Output momentarily fell to 90 in 2023 but then rebounded, reaching 104 in 2024 and peaking at 129 in 2025. Overall, this upward trajectory reflects sustained and accelerating research activity in the latter half of the decade.

In contrast, total citation counts declined over the same period. Early in the decade, annual citations were high, with 2,385 in 2015 and 2,291 in 2016, but fell in subsequent years. For instance, citations dropped to 1,641 in 2018 before briefly rising again in 2019–2020 (1,905 in 2019, and 2,318 in 2020). From 2021 onward, however, citations fell sharply to 1,500 in 2021, 764 in 2023, and only 121 by 2025. This divergence between increasing publications and declining citations likely reflects a citation-lag effect, meaning that newer studies have simply had less time to accumulate citations. In other words, foundational earlier papers continue to gather citations, while recent articles have not yet reached comparable citation levels.

Keyword co-occurrence and thematic structure

The keyword co-occurrence analysis (Figure 2) revealed three main thematic clusters in the literature.

The first cluster (red) centers on functional performance and mobility. Keywords like *gait*, *walking, balance, mobility*, *strength, recovery*, and *rehabilitation* co-occur frequently, indicating a dominant focus on restoring movement capacity after stroke. This cluster's prominence is supported by evidence that exercise and cardiorespiratory training improve gait speed, balance control, and functional ambulation in stroke survivors (15–17). The co-occurrence of measurement-related terms such as *reliability*, *validity*, and *scale* within this cluster underscores the importance placed on standardized, psychometrically sound outcome measures for evaluating rehabilitation effectiveness (18,19).

The second cluster (green) reflects a broader health-oriented theme linking physical activity to overall well-being, participation, and quality of life. Key terms include *physical activity*, *aerobic exercise, health, quality of life, older adults*, *impairment*, and *randomised controlled trials*. This suggests growing interest in how exercise affects long-term health outcomes and life participation, especially in older stroke survivors. Studies in this cluster commonly use rigorous trial designs to examine how regular exercise programs influence health-related quality of life and functional independence (16,20,21). The frequent link to randomised controlled trials highlights the emphasis on high-quality evidence in this research area.

The third cluster (blue) is characterized by terms related to cardiorespiratory fitness and exercise prescription, such as *cardiorespiratory fitness,*

aerobic capacity, intensity, treadmill exercise, subacute stroke, survivors, recommendations, and *statement*. This cluster represents an expanding body of work on optimal exercise dosing and modality. Research in this area shows that structured cardiorespiratory exercise, for example, treadmill or aerobic training during rehabilitation, is associated with improvements in functional independence, mobility, and aerobic capacity, particularly in the subacute recovery phase (17,22). The prominence of guideline-related keywords suggests an increasing effort to translate these findings into clinical practice recommendations for stroke rehab.

Emerging trends and research directions in rehabitation

The co-occurrence network (Figure 3) further clarifies how these themes are interconnected and highlights emerging directions. The term "rehabilitation" appears as a central hub, linking core functional keywords such as balance, gait, and strength with measurement terms such as *reliability* and *validity*. This confirms that restoring function through evidence-based assessment remains foundational. Simultaneously, "*rehabilitation*" is strongly linked with keywords like *physical activity, health, quality of life, older adults*, and *randomised controlled trial*, indicating a broader shift toward patient-centred and population-relevant outcomes. Clinical studies show that structured exercise programs can improve independence, walking ability, and quality of life for stroke survivors, especially among older adults (16–19). In sum, functional recovery remains at the core, but there is growing embedding of research rigour and health-related outcomes in rehabilitation frameworks.

Beyond these established themes, the network reveals new emphases. Keywords such as *cardiorespiratory fitness, aerobic exercise, intensity, capacity, treadmill exercise, recommendations*, and *statement* suggest a growing focus on exercise dosage, intensity, and translation of evidence into practice. Recent studies emphasize that aerobic and treadmill training during subacute and chronic phases can significantly boost aerobic capacity, functional independence, and participation (15,17). Additionally, the co-occurrence of mechanistic terms like brain and neurotrophic factor with exercise-related keywords indicates rising interest in the biological pathways of recovery. Translational research suggests exercise may promote neuroplasticity and neuroprotection after stroke (23,24). Collectively, these patterns point toward future rehabilitation models that integrate functional training, cardiovascular conditioning, mechanistic insights, and evidence-based guidelines to optimize stroke recovery. Figure 3 illustrates the central nodes of this network.

Discussion

This review used bibliometric and thematic indicators and keyword analyses to interpret how research on exercise-based stroke rehabilitation has evolved. By examining publication trends, citation patterns, thematic clusters, and keyword networks together, we gain insights into the field's growth trajectory and intellectual structure. Rather than simply recapping the results, we focus on what these patterns imply about the maturation and emerging directions of the research landscape.

Publication output grew markedly over the past decade, especially after 2020, indicating sustained and rising interest in exercise as a core component of stroke recovery. In contrast, citation counts declined in recent years. We interpret this as a citation-lag effect rather than a drop in research impact: foundational early papers continue to accrue citations, while newer studies have not yet had the time to reach similar citation levels. Similar dynamics have been observed in other rapidly expanding fields (16,17). The keyword analysis clarifies how the literature is conceptually organized. The dominance of the cluster on functional mobility emphasizes the enduring priority of restoring gait, balance, strength, and independence after stroke. This emphasis is consistent with strong evidence that

exercise and cardiorespiratory training improve ambulation and motor recovery (15–17). The focus on measurement terms like *reliability* and *validity* further highlights the field's commitment to standardized, clinically meaningful outcomes (18,19).

In contrast, the cluster on physical activity, health, and quality of life reflects a broader shift toward patient-centred outcomes. This theme goes beyond motor function to encompass participation, well-being, and long-term health. Studies in this cluster often use randomized trials and target older adults to evaluate how exercise interventions influence life participation and quality of life (16,20,21). This shift aligns with contemporary rehabilitation frameworks that prioritize life engagement and quality of life alongside physical recovery.

The third cluster highlights growing attention to cardiorespiratory fitness and exercise prescription. Unlike the first cluster's focus on mobility or the second on holistic outcomes, this theme emphasizes exercise dose, intensity, and modality. Evidence suggests structured aerobic training, such as treadmill or cycling, significantly improves cardiovascular fitness, mobility, and independence, especially in the subacute phase (17,22). The frequent mention of guidelines and recommendations indicates the field's progress toward translating evidence into practical exercise prescriptions for clinical use.

Taken together, these clusters show both continuity and progression in the literature. Improving functional mobility remains a foundational research goal, but there is clear expansion toward health-related quality of life and cardiorespiratory outcomes. This evolution reflects broader trends in rehabilitation science, including more rigorous study designs such as RCTs, a more holistic view of recovery, and stronger efforts to integrate research into practice. Nevertheless, challenges remain. Heterogeneity in intervention protocols and outcome measures is still common, making cross-study comparisons and the synthesis of evidence difficult.

Nevertheless, this study has several limitations that should be considered. First, the analysis was limited to WoS, which may have excluded relevant studies from other databases. Second, only English-language publications were included, potentially introducing language bias. Third, the use of title-based search terms may have excluded relevant studies where key concepts were not clearly stated in the title. Fourth, the minimum keyword occurrence threshold may have excluded less frequent but potentially emerging topics. Finally, citation-based analysis may underestimate the influence of more recent publications due to citation lag.

From a clinical and research perspective, our findings have several implications. The enduring dominance of mobility-focused outcomes underscores their relevance in practice. Meanwhile, the growing emphasis on quality of life and cardiovascular fitness suggests that comprehensive, multimodal exercise programs should be integrated into stroke rehabilitation. Future research should aim to harmonize outcome measures, clearly define optimal exercise dosage and intensity, and bridge gaps between evidence and clinical guidelines. By mapping these research trends and themes, this review provides an integrated overview of the evolving evidence base, which can guide future studies and inform evidence-based practice in exercise-based stroke rehabilitation.

Authors' Contribution

R.R - contributed to the conceptualisation, study design, data analysis, data collection, and manuscript drafting. H.M - contributed to study design, validation, and project administration. A.A - contributed to the validation of the study. S.A.B, H.H, Z.K, and M.R - contributed to manuscript review and editing. All authors critically reviewed and approved the final version of the manuscript.

Funding: This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Acknowledgement: The authors would like to thank the Faculty of Health Sciences, especially the Centre for Physiotherapy Studies, UiTM Puncak Alam, for their support.

Conflict of Interest: The authors declare that they have no conflict of interest

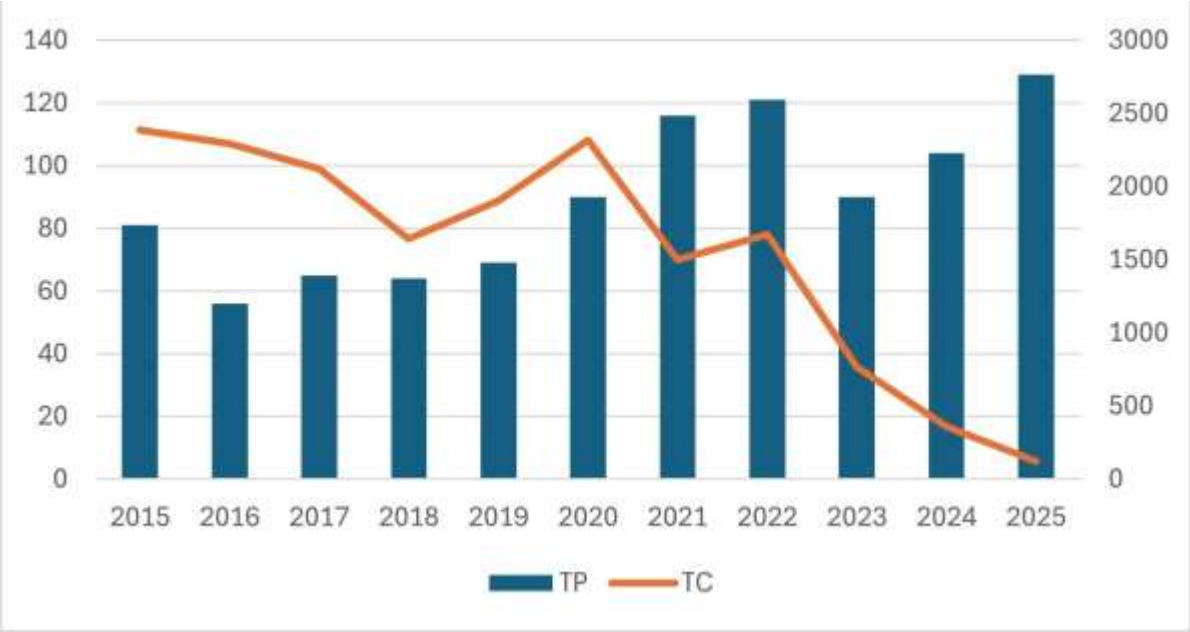

Figure 1. Annual Trends in Publication Output and Citation Counts in Exercise-Based Stroke Rehabilitation (2015-2025).

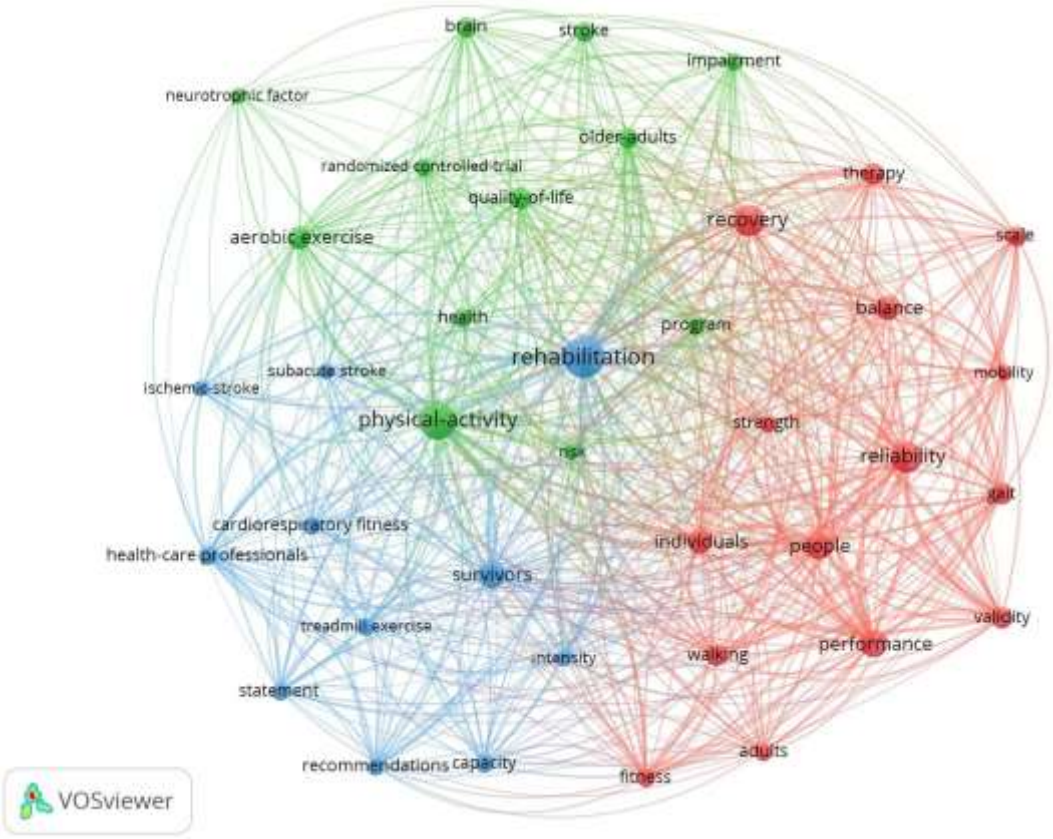

Figure 2. Keywords Co-occurrence Network Showing Thematic Clusters in Exercise-Based Stroke Rehabilitation

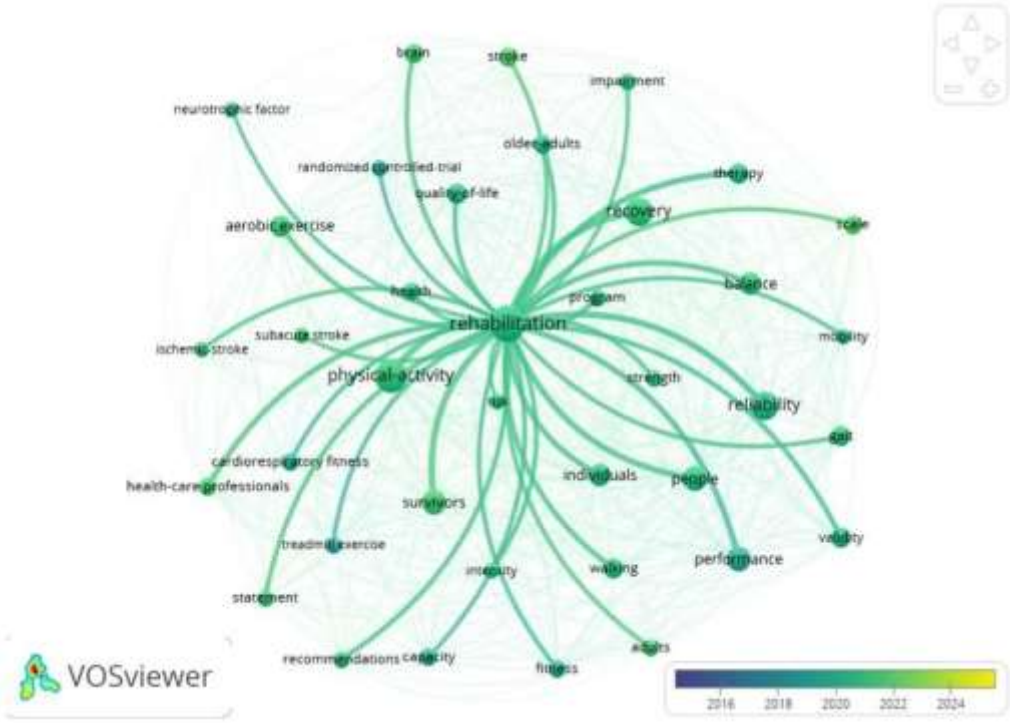

Figure 3. Central Keyword Network Highlighting Core Research Themes and Linkages

References

[1]. Katan M, Luft A. Global Burden of Stroke. Semin Neurol. 2018 Apr 1;38(2):208–11. doi:10.1055/S-0038-1649503 PubMed PMID: 29791947.

[2]. Chen CH, Chang TY, Sung PS, Su HC, Chou CH, Tung H, et al. An overview of post-stroke disability. Journal of the Formosan Medical Association. 2025 Nov 6. doi:10.1016/J.JFMA.2025.10.038

[3]. Blokland IJ, Groot FP, Logt NHG, van Bennekom CAM, de Koning JJ, van Dieen JH, et al. Cardiorespiratory Fitness in Individuals Post-stroke: Reference Values and Determinants. Arch Phys Med Rehabil. 2023 Oct 1;104(10):1612–9. doi:10.1016/J.APMR.2023.03.035 PubMed PMID: 37172675.

[4]. Oremus M, Santaguida P, Walker K, Wishart LR, Siegel KL, Raina P. Studies of stroke rehabilitation therapies should report blinding and rationalize use of outcome measurement instruments. J Clin Epidemiol. 2012;65(4):368–74. doi:10.1016/j.jclinepi.2011.10.013

[5]. Saunders DH, Greig CA, Young A, Mead GE. Physical fitness training for stroke patients. Cochrane database of systematic reviews (Online) [Internet]. 2004;(1):CD003316.

Available from: https://www.scopus.com/inward/record.uri?eid=2-s2.0-2942752063&partnerID=40&md5=753a33abb9530ad92d9cf85cb5f831e7

[6]. McGlinchey MP, James J, McKevitt C, Douiri A, Sackley C. The effect of rehabilitation interventions on physical function and immobility-related complications in severe stroke: A systematic review. BMJ Open. 2020;10(2). doi:10.1136/bmjopen-2019-033642

[7]. Pollock A, Baer G, Campbell P, Choo PL, Forster A, Morris J, et al. Physical rehabilitation approaches for the recovery of function and mobility following stroke. Cochrane Database of Systematic Reviews. 2014;2014(4). doi:10.1002/14651858.CD001920.pub3

[8]. Basagni B, Malloggi S, Polito C, Pellicciari L, Campagnini S, Pancani S, et al. MoCA Domain-Specific Pattern of Cognitive Impairment in Stroke Patients Attending Intensive Inpatient Rehabilitation: A Prospective Study. Behavioral Sciences. 2024;14(1). doi:10.3390/bs14010042

[9]. Ramstrand N, Stevens PM. Clinical outcome measures to evaluate the effects of orthotic management post-stroke: a systematic review. Disabil Rehabil. 2022;44(13):3019–38. doi:10.1080/09638288.2020.1859630

[10]. Rizvi MR, Sharma A, Malki A, Sami W. Enhancing Cardiovascular Health and Functional Recovery in Stroke Survivors: A Randomized Controlled Trial of Stroke-Specific and Cardiac Rehabilitation Protocols for Optimized Rehabilitation. J Clin Med. 2023;12(20). doi:10.3390/jcm12206589

[11]. Akkara Y, Afreen R, Lemonick M, Paz SG, Rifi Z, Tosto J, et al. Standardizing Domains and Metrics of Stroke Recovery: A Systematic Review. Brain Sci. 2024;14(12). doi:10.3390/brainsci14121267

[12]. Du M, Chen L, Li Y, Xia L, Liu Y, Guo M, et al. Effect of exercise-based interventions on stroke rehabilitation: an umbrella review of systematic reviews and meta-analyses. J Neuroeng Rehabil. 2025;22(1). doi:10.1186/s12984-025-01781-y

[13]. Li X, Li Z, Wang H. Bibliometric analysis of traditional Chinese exercises in stroke rehabilitation from 2003 to 2022 using CiteSpace. Front Neurol. 2024;15. doi:10.3389/fneur.2024.1260643

[14]. van Eck NJ, Waltman L. Software survey: VOSviewer, a computer program for bibliometric mapping. Scientometrics. 2010;84(2):523–38. doi:10.1007/S11192-009-0146-3 PubMed PMID: 20585380.

[15]. Billinger SA. Physical activity and exercise recommendations for stroke survivors. Stroke. 2014. doi:10.1161/STR.0000000000000022

[16]. Saunders DH et al. Physical fitness training for stroke patients. Cochrane Database of Systematic Reviews. 2016 Mar 24;3(3):CD003316. doi:10.1002/14651858.CD003316.pub6

[17]. Thompson S, Devasahayam AJ, Danells CJ, Jagroop D, Inness EL, Mansfield A. Cardiorespiratory exercise during rehabilitation is associated with improved functional recovery early post-stroke: A cohort study. Ann Phys Rehabil Med. 2025;68(8):102006. doi: 10.1016/j.rehab.2025.102006.

[18]. Eng JJ, Dawson AS, Chu KS. Submaximal exercise in persons with stroke: test-retest reliability and concurrent validity with maximal oxygen consumption. Arch Phys Med Rehabil. 2004;85(1):113–118. doi:10.1016/S0003-9993(03)00436-2. .

[19]. Martins JC, Teixeira-Salmela LF, Souza LAC, Aguiar LT, Lara EM, Moura JB, Faria CDCM. Reliability and validity of the modified sphygmomanometer test for the assessment of strength of upper limb muscles after stroke. J Rehabil Med. 2015;47(8):—. doi:10.2340/16501977-1978.

[20]. Polese JC, Ribeiro-Samora GA, Lana RC, et al. Physical activity and quality of life after stroke: a systematic review. Braz J Phys Ther. 2017;21(6):387–394. doi:10.1016/j.bjpt.2016.11.006.

[21]. Tielemans NS, Visser-Meily JMA, Schepers VPM, Passier PE, van de Port IGL, Vloothuis JDM, Struyf PAA, van Heugten CM. Effectiveness of the Restore4Stroke self-management intervention “Plan Ahead!”: a randomized controlled trial in stroke patients and partners. J Rehabil Med. 2015;47(10):901–909. doi:10.2340/16501977-2020.

[22]. Billinger SA, Boyne P, Coughenour E, Dunning K, Mattlage A. Does aerobic exercise and the FITT principle fit into stroke recovery? Curr Neurol Neurosci Rep. 2015 Feb;15(2):519. doi: 10.1007/s11910-014-0519-8

[23]. Alcantara CC, García-Salazar LF, Silva-Couto MA, Santos GL, Russo TL. Post-stroke BDNF concentration changes following physical exercise: a systematic review. Front Neurol. 2018;9:637. doi:10.3389/fneur.2018.00637.

[24]. Penna LG, Pinheiro JP, Ramalho SHR, Ribeiro CF. Effects of aerobic physical exercise on neuroplasticity after stroke: systematic review. Arq Neuropsiquiatr. 2021;79(9):832–843. doi:10.1590/0004-282x-anp-2020-0551