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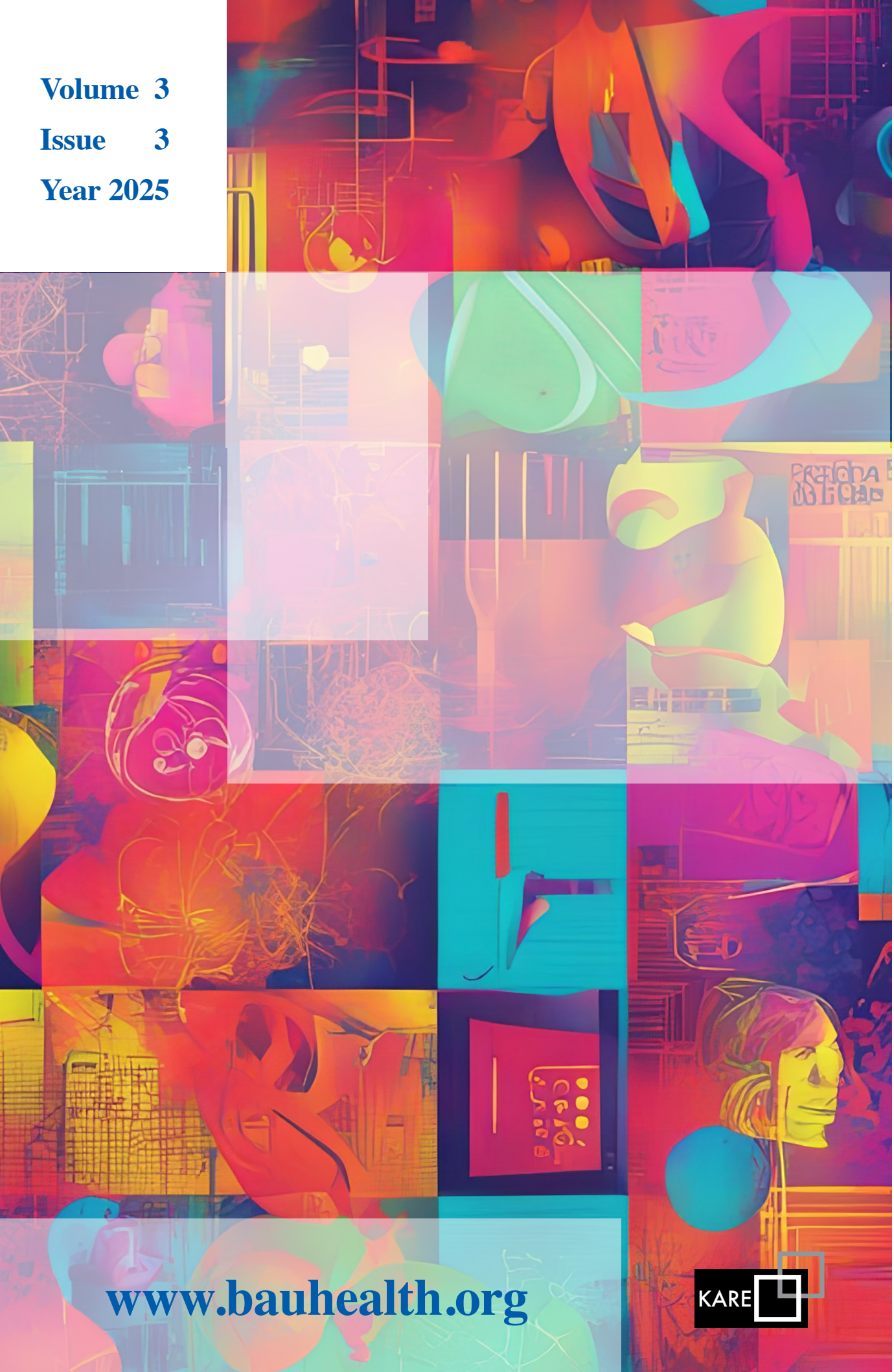

BAU HEALTH AND INNOVATION

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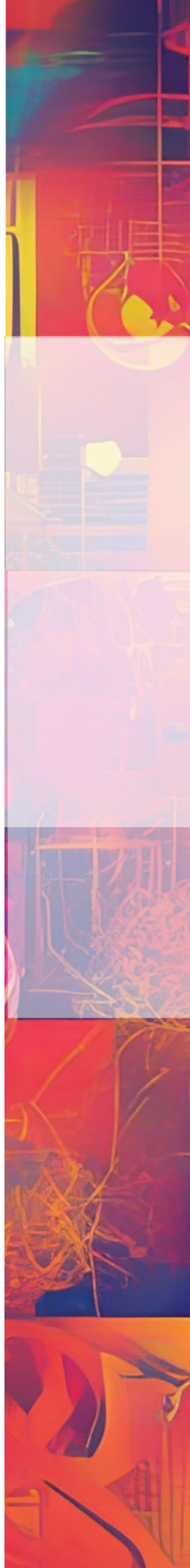

ABOUT THE JOURNAL

Current Name: The BAU Health and Innovation Journal

Abbreviation: BAU Health Innov

Publication Type: Periodical

Editor-in-Chief: Prof. Gökay Görmeli (e-mail: gokay.gormeli@bau.edu.tr)

Publisher: Kare Publishing (Kare Media)

Journal Description: The BAU Health and Innovation is supported by Bahçeşehir University Faculty of Health Sciences officially and is a blind peer-reviewed free open-access journal and three issues are released every year in April, August, and December.

Abstracting and Indexing: BAU Health and Innovation is indexed in EBSCO, DOAJ, Open Ukranian Citation Index, Scilit, İdealOnline, Asian Science Citation Index, Gale Cengage and Electronic Journals Library – EZB.

Start Year: 2023

Average Duration of the First Review Round: 2 months

Type of Publications: Original Article, Case Report, Review, Brief Report, Editorial Comments, Letter to the Editor.

Language of Publication: English

Frequency: Three issues per year April, August, and December.

Fee or Charges: This journal assesses NO submission fees, publication fees (article processing charges), or page charges.

AIM AND SCOPE

Aim

The BAU Health and Innovation is an international, scientific, open access periodical published in accordance with independent, unbiased, and double-blinded peer-review principles. The journal publishes original articles, reviews, case reports, and other commentary inaccordance with recognized ethical guidelines (https://bauhealth.org/policies) The journal is published every four months and three issues per year (April, August and December). The publication language of the journal is English.

The primary goal of The BAU Health and Innovation Journal is to contribute high-quality manuscripts from the field to the international literature. We are committed to fostering the global advancement of medical science, facilitating interdisciplinary dialogue, and promoting evidence-based clinical practices to improve patient care.

The editorial and publication processes of the journal are shaped in accordance with the guidelines of the International Committee of Medical Journal Editors (ICMJE), World Association of Medical Editors (WAME), Council of Science Editors (CSE), Committee on Publication Ethics (COPE), European Association of Science Editors (EASE), and National Information Standards Organization (NISO). The journal is in conformity with the Principles of Transparency and Best Practice in Scholarly Publishing (doaj.org/bestpractice).

All expenses of the journal are covered by the Bahçeşehir University Faculty of Health Sciences. Potential advertisers should contact the Editorial Office. Advertisement images are published only upon the Editor-in-Chief's approval.

Statements or opinions expressed in the manuscripts published in the journal reflect the views of the author(s) and not the opinions of the Bahçeşehir University Faculty of Health Sciences, editors, editorial board, and/or publisher; the editors, editorial board, and publisher disclaim any responsibility or liability for such materials.

All published content is available online, free of charge at https://bauhealth.org/. Printed copies of the journal are distributed internationally, free of charge.

Scope

The BAU Health and Innovation welcomes submissions in the following areas, but not limited to:

Clinical Research: Original research articles that contribute new knowledge to various medical specialties and sub-specialties.

Case Reports: Detailed reports of clinical cases that present unique or rare manifestations, challenges, or treatment approaches.

Review Articles: Comprehensive reviews on current topics, innovative treatments, or emerging technologies in the field of medicine.

Medical Education: Studies, reviews, and discussions concerning contemporary medical education practices, innovations, and challenges.

Medical Ethics and Medical Law: Articles addressing ethical dilemmas, discussions on medical law, and the integration of ethical practices in patient care.

Healthcare Management and Policies: Research and reviews on healthcare management, policies, system advancements, and patient safety protocols.

Interdisciplinary Medicine: Papers focusing on the intersection of different medical disciplines and the holistic approach to patient care.

Surgical and Medical Techniques: Detailed descriptions, evaluations, or innovations in surgical and medical procedures.

Technology in Medicine: Discussions, reviews, and original research on the impact, advancements, and challenges of technology in patient care, diagnosis, and treatment.

Global Health: Articles that address global health issues, international collaborations, and challenges in healthcare across different geographies.

Nutrition and Dietetics: Articles that address nutrition and dietetics issues, encompasses health, nutrition assessment, and dietary interventions.

Physiotherapy and Rehabilitation: Articles that address to enhance physical function, alleviate pain, and improve overall well-being through tailored therapeutic interventions and exercises.

Nursing: Articles that address Nursing encompasses the provision of holistic patient care, which includes health assessment, treatment planning, and compassionate support to promote well-being and recovery.

Language and Speech Therapy: Articles that address diagnosing and treating communication and speech disorders, helping individuals improve their communication skills.

Biomedical Engineering: Articles that application of engineering principles and techniques to solve problems in biology and medicine, such as designing medical devices, developing healthcare systems, and advancing medical imaging Technologies.

Manuscripts undergo a rigorous peer-review process to ensure that BAU Health and Innovation upholds the highest standards of medical scholarship and relevance. We value contributions from clinicians, researchers, educators, and medical professionals from around the world.

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Publications Coordinator: *Ece Hanne Şimşek*
Graphic Design: *Duygu Şimşek*

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Fax: *+90 216 550 61 12;* ***E-mail:*** *kare@karepb.com*

INSTRUCTIONS FOR AUTHORS

The BAU Health and Innovation is an international, scientific, open access periodical published in accordance with independent, unbiased, and double-blinded peer-review principles. The journal publishes original articles, reviews, case reports, and other commentary inaccordance with recognized ethical guidelines (https://bauhealth.org/policies) The journal is published every four months and three issues per year (April, August and December). The publication language of the journal is English.

Manuscript Preparation and Submission

Manuscripts should be prepared in accordance with the ICMJE-Recommendations for the Conduct, Reporting, Editing, and Publication of Scholarly Work in Medical Journals (updated in December 2015 - http://www.icmje.org/icmje-recommendations.pdf). Authors are required to prepare manuscripts in accordance with the Consolidated Standards of Reporting Trials (CONSORT) guidelines for randomized research studies, the STrengthening the Reporting of OBservational studies in Epidemiology (STROBE) guidelines for observational original research studies, the Standards for Reporting Diagnostic Accuracy (STARD) guidelines, the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines, the Animal Research: Reporting of In Vivo Experiments (ARRIVE) guidelines for experimental animal studies, and the Transparent Reporting of Evaluations with Non-randomised Designs (TREND) guidelines for non-randomized behavioral and public health evaluations.

Manuscripts may only be submitted through the journal's online manuscript submission and evaluation system, https://jag.journalagent.com/bauhi. Manuscripts submitted via any other medium will not be evaluated. Manuscripts should be submitted by one of the authors of the manuscript. Submissions by anyone other than one of the authors will not be accepted.

Artificial Intelligence (Ai)–Assisted Technology

At submission, the journal should require authors to disclose whether they used artificial intelligence (AI)– assisted technologies (such as Large Language Models [LLMs], chatbots, or image creators) in the production of submitted work. Authors who use such technology should describe, in both the cover letter and the submitted work, how they used it. Use of AI for writing assistance should be reported in the acknowledgment section. Authors who used AI technology to conduct the study should describe its use in the methods section in sufficient detail to enable replication to the approach, including the tool used, version, and prompts where applicable. Chatbots (such as ChatGPT) should not be listed as authors because they cannot be responsible for the accuracy, integrity, and originality of the work, and these responsibilities are required for authorship. Therefore, humans are responsible for any submitted material that included the use of AI-assisted technologies. Authors should carefully review and edit the result because AI can generate authoritative-sounding output that can be incorrect, incomplete, or biased. Authors should not list AI and AIassisted technologies as an author or co-author, nor cite AI as an author. Authors should be able to assert that there is no plagiarism in their paper, including in text and images produced by the AI. Humans must ensure there is appropriate attribution of all quoted material, including full citations.

Manuscripts will first be submitted to a technical evaluation process in which the editorial staff will ensure that the manuscript has been prepared and submitted in accordance with the journal's guidelines. Submissions that do not conform to the journal's guidelines will be returned to the author with requests for technical correction.

The quality and clarity of the language used in a manuscript is very important. The editors may request that authors have the manuscript professionally edited if the language of the submission does not conform to the journal standards. BAU Health and Innovation uses American English. Please submit text of a quality ready for publication. Information about language editing and copyediting services pre- and post-submission may contact Kare Media at kare@karepb.com. Please refer to specific formatting requirements noted in the submission checklist and elsewhere in this document.

Authors are required to prepare manuscripts in accordance with the international guidelines* below

* Enhancing the QUAlity and Transparency Of Health Research (equator network) (https://www.equator-network.org/)

** The BAU Health and Innovation encourages the registration of all clinical trials (randomized and non-randomized) via ClinicalTrials.gov (www.clinicaltrials.gov) or one of the registries of the WHO's International Clinical Trials Registry Platform (ICTRP: http://www.who.int/ictrp/network/primary/en/index.html). The name of the trial registry and the registration number together should be provided at the end of the abstract.

Manuscript Formating and Types

The manuscript should be typed in a Microsoft Word™ file, single-column format, double-spaced with 2.5 cm margins on each side, and 12-point type in Times New Roman font.

All abbreviations in the text must be defined the first time they are used (both in the abstract and the main text), and the abbreviations should be displayed in parentheses after the definition. Authors should avoid abbreviations in the title. Measurements should be reported using the metric system according to the International System of Units (SI). When a drug, product, hardware, or software mentioned within the main text product information, including the name of the product, producer of the product, city of the company and the country of the company should be provided in parenthesis.

Original article: It provides new information based on an original and novel research. It should contain a structured abstract of a maximum of 350 words with the following subheadings: Objective, Materials and Methods, Results, Conclusion. The main text of an original article should be structured with Introduction, Materials and Methods, Results, Discussion and Conclusion, References, Tables, and Figure Legends subheadings. Original articles are limited to 3500 words and 50 references.

Case report: Reports of rare cases or conditions that reflect challenges in diagnosis and treatment, or present something otherwise particularly interesting and educative will be accepted. It should contain an unstructured abstract of a maximum of 200 words and the text should be structured with subheadings of introduction, case report, and discussion. A case report is limited to 1200 words and 15 references.

Review article: Reviews prepared by authors who have extensive knowledge on a particular field and whose scientific background has been translated into a high volume of publications with a high citation potential are welcomed. These authors may even be invited by the journal. Reviews should describe, discuss, and evaluate the current level of knowledge of a topic in clinical practice and should guide future studies. The subheadings of the review articles should be planned by the authors. However, each review article should include an "Introduction" and a "Conclusion" section. Please check Table 1 for the limitations for Review Articles.

Brief report: A brief report conveys a focused message. Case series are also considered brief reports. These reports are restricted to a maximum of 1500 words, no more than 1 table and 3 figures, and 15 references. It should contain an unstructured abstract of a maximum of 150 words and the text should be structured with subheadings of introduction, methods, results, and discussion.

Editorial comment: Editorial comments provide a brief critical commentary by an invited experienced author in the topic of a research article previously published in the journal. The word count is limited to 1200 and 10 references may be included.

Type of manuscript	Word limit	Abstract word limit	Reference limit	Table limit	Figure limit
Original article	3500	350 (Structured)	50	6	6
Case report	1200	200 (Structured)	15	1	3
Review	5000	250	60	6	6
Brief report	1500	150	15	1	3
Editorial comments	1200	No abstract	15	No tables	No figures
Letter to the editor	500	No abstract	5	No tables	No figures

The submission should not include an abstract, keywords, tables, figures, and images.

Letter to the editor: This type of manuscript discusses important observations, ignored aspects, or details lacking in a previously published article. The article that is the subject of commentary must be properly cited within the manuscript. No abstract, keywords, tables, figures, images, or other media should be included. The text should be unstructured and is limited to 500 words. No more than 5 references will be accepted.

Cover letter: The cover letter should include the article name, article type, and the full name and address of the corresponding author. Corresponding author should declare the absence or presence of any conflict of interest in cover letter, and should affirm that the paper has not already been published, accepted, or is under simultaneous review for publication elsewhere in any language. For manuscripts that have been presented orally or as a poster, this must be stated on the title page with the date and the place of the presentation.

Title page: A title page should be submitted with all submissions and this page should include:

- The English full title of the manuscript no more than 150 characters and English short title (running head) of no more than 50 characters,
- Name, affiliation, ORCID ID number, e-mails and highest academic degree of the author(s),
- The statement of conflict of interest and funding information,
- Name, address, phone number(s), and email address of the corresponding author,
- Acknowledgment of the individuals who contributed to the preparation of the manuscript but who do not fulfill the authorship criteria.

Abstract: An English-language abstract is required with all submissions except editorial comments, images, and letters to the editor. Systematic reviews and original articles should contain a structured abstract of maximum 250 words with the subheadings of objective, materials and methods, results, and conclusion.

Keywords: Each submission must be accompanied by a minimum of three and a maximum of six keywords for subject indexing included at the end of the abstract. The keywords should be selected from the National Library of Medicine, Medical Subject Headings database (https://www.nlm.nih.gov/mesh/MBrowser.html).

Main document: Divide the text into the following sections: Introduction, Materials and Methods, Results, Discussion and Conclusion. for decimals (e.g. 12354.55).

- Statistical analysis should be conducted in accordance with the guidelines on reporting statistical data in medical journals [Altman DG, Gore SM, Gardner MJ, Pocock SJ. Statistical guidelines for contributors to medical journals. Br Med J 1983: 7; 1489-93 and Lang T, Altman D. Basic statistical reporting for articles published in clinical medical journals: the SAMPL Guidelines. In: Smart P, Maisonneuve H, Polderman A (editors). Science Editors' Handbook, European Association of Science Editors, 2013.]. The software used for statistical analysis must be described.
- All references, tables, and figures should be referred to within the main text, and they should be numbered consecutively in the order they are referred to within the main text. Limitations and drawbacks of original articles should be mentioned in the Discussion section before the conclusion paragraph.

Tables: Tables should be uploaded as separate files and not embedded in the main text. They should be numbered consecutively in the order they are referred to within the main text. A descriptive title must be placed above the tables. Abbreviations used in the tables should be defined below the table with footnotes, even if they are defined within the main text. The statistical method of significance value is calculated should be described in footnotes.

Figures and figure legends: Figures, graphics, and photographs should be submitted as separate files in TIFF or JPEG format through the article submission system. The files should not be embedded in a Word document or the main document. Thick and thin arrows, arrowheads, stars, asterisks, and similar marks can be used on the images to support figure legend. Any information within the images that may identify an individual or institution should be blinded. The minimum resolution of each submitted figure should be 300 DPI. Figure legends should be listed at the end of the main document.

References: Reference listings must be in accordance with ICMJE standards and numbered consecutively at the end of the manuscript in the order in which they are mentioned in the text. If an ahead of print publication is being cited the DOI number should be provided. Authors are responsible for the accuracy of references. Journal titles should be abbreviated in accordance with the journal abbreviations in Medline/PubMed (for journal abbreviations consult the List of Journals indexed for MEDLINE, published annually by NLM).

When there are 6 or less authors, all authors should be listed. If there are 7 or more authors the first 6 authors should be listed followed by "et al". In the main text of the manuscript, references should be cited using Arabic numbers in parentheses. The reference styles for different types of publications are presented in the following examples:

Journal article: Erdogan G, Unlu C, Gunay BO, Kardes E, Ergin A. Implantation of foldable posterior chamber intraocular lens in aphakic vitrectomized eyes without capsular support. Arq Bras Oftalmol 2016;79(1):159–62.

(more than six authors): Dahlmann-Noor AH, Comyn O, Kostakis V, Misra A, Gupta N, Heath J, et al. Plusoptix Vision Screener: the accuracy and repeatability of refractive measurements using a new autore fractor. Br J Ophthalmol 2009;93(1):346–9.

Epub ahead-of-print article: Miao Y, Wang X, Yin H, Han R. Effects of cavitation from extracorporeal shock wave combined with sulfur hexafluoride microbubble on myocardial ultrastructure in rats. Anatol J Cardiol 2023 Jun 7. doi: 10.14744/AnatolJCardiol.2023.2946. [Epub ahead of print].

Manuscript published in electronic format: T.C. Ministry of Health, General Directorate of Public Health. COVID-19 (SARS-CoV2 Infection) Guide (Science Board Study). Available from: www.hsgm.saglik.gov.tr. Accessed March 25, 2020.

Book section: Suh KN, Keystone JS. Malaria and babesiosis. Gorbach SL, Barlett JG, Blacklow NR, editors. Infectious Diseases. Philadelphia: Lippincott Williams; 2004. pp. 2290-308.

Conference proceedings: Bengisson S. Sothemin BG. Enforcement of data protection, privacy and security in medical informatics. In: Lun KC, Degoulet P, Piemme TE, Rienhoff O, editors. MEDINFO 92. Proceedings of the 7th World Congress on Medical Informatics; 1992 Sept 6-10; Geneva, Switzerland. Amsterdam: North-Holland; 1992. pp.1561-5.

Scientific or technical report: Cusick M, Chew EY, Hoogwerf B, Agrón E, Wu L, Lindley A, et al. Early Treatment Diabetic Retinopathy Study Research Group. Risk factors for renal replacement therapy in the Early Treatment Diabetic Retinopathy Study (ETDRS), Early Treatment Diabetic Retinopathy Study Kidney Int: 2004. Report No: 26.

Revisions

When submitting a revised version of a paper (include a clean copy and a highlighted copy), the author must submit a detailed "Response to reviewers" that replies to each issue point by point raised by the reviewers and indicates where changes can be found (each reviewer's comment, followed by the author's reply and line number where changes have been made). Revised manuscripts must be submitted within 30 days from the date of the decision letter. If the revised version of the manuscript is not submitted within the allocated time, the revision option will be automatically withdrawn. If the submitting author(s) believe that additional time is required, they should request this extension within the initial 30-day period.

Publication Process

Accepted manuscripts will be made available and citable online as rapidly as possible. The stages of publication are as follows:

Uncorrected publication: Accepted, The abstract will appear in journal web page under the "Accepted Articles" section. A DOI will be assigned to the article at this stage.

Ahead-of-print publication: After copy editing, typesetting, and review of the resulting proof, the final corrected version will be added online in the "Ahead-of-Print" section.

Final publication: The final, corrected version will appear in an issue of the journal and will be added to the journal website. To ensure rapid publication, we ask authors to provide their publication approval during the proofreading process as quickly as possible, and return corrections within 48 hours of receiving the proof.

Submission Checklist

Please use this list and the following explanations to prepare your manuscript and perform a final check before submission to ensure a timely review.

1. A cover letter containing;
   - The article title and type and the full name of the corresponding author,
   - A statement declaring the absence or presence of a conflict of interest,
   - Ethics approval and/or patient consent for publication,
   - The funding information,
   - The data availability a statement that the manuscript has not been previously published or accepted for publication and is not submitted or under simultaneous review for publication elsewhere.
2. A title page including;
   - The full title of the manuscript no more than 150 characters and a short title (running head) of no more than 50 characters,
   - Name, affiliation, ORCID ID number, e-mails and highest academic degree of the author(s),
   - The statement of conflict of interest and funding information,
   - Name, address, phone number(s), and email address of the corresponding author,
   - Acknowledgment of the individuals who contributed to the preparation of the manuscript but who do not fulfill the authorship criteria,
   - A statement of the date and place of the meeting where the manuscript was presented orally or as a poster, if necessary,
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ETHICS AND POLICIES

Authorship Policy

Each individual listed as an author should fulfill the authorship criteria recommended by the International Committee of Medical Journal Editors (ICMJE). The ICMJE recommends that authorship should be based on the following 4 criteria:

Substantial contributions to the conception or design of the work, or the acquisition, analysis, or interpretation of data for the work; AND

Drafting the work or revising it critically for important intellectual content; AND

Final approval of the version to be published; AND

Agreement to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

In addition to being accountable for their own work, authors should have confidence in the integrity of the contributions of their co-authors and each author should be able to identify which co-authors are responsible for other parts of the work.

All of those designated as authors should meet all four criteria for authorship, and all who meet the four criteria should be identified as authors. Those who provided a contribution but do not meet all four criteria should be recognized separately on the title page and in the Acknowledgements section at the conclusion of the manuscript.

The BAU Health and Innovation requires that corresponding authors submit a signed and scanned version of the authorship contribution form available for download through during the initial submission process in order to appropriately indicate and observe authorship rights and to prevent ghost or honorary authorship. Please note that the list of authors on the final manuscript will be presented in the order provided on this form. If the editorial board suspects a case of "gift authorship," the submission will be rejected without further review. As part of the submission of the manuscript, the corresponding author should also send a short statement declaring that they accept all responsibility for authorship during the submission and review stages of the manuscript.

Ethics Policy

The Editorial Board of the BAU Health and Innovation Journal and the Publisher adheres to the principles of the International Council of Medical Journal Editors (ICMJE), the World Association of Medical Editors (WAME), the Council of Science Editors (CSE), the Committee on Publication Ethics (COPE), the US National Library of Medicine (NLM), the World Medical Association (WMA) and the European Association of Science Editors (EASE).

In accordance with the journal's policy, an approval of research protocols by an ethics committee in accordance with international agreements "WMA Declaration of Helsinki - Ethical Principles for Medical Research Involving Human Subjects (last updated: October 2013, Fortaleza, Brazil)", "Guide for the care and use of laboratory animals (8th edition, 2011)" and/or "International Guiding Principles for Biomedical Research Involving Animals (2012)" is required for all research studies. If the submitted manuscript does not include ethics committee approval, it will be reviewed according to COPE's guideline (Guidance for Editors: Research, Audit and Service Evaluations). If the study should have ethical approval, authors will be asked to provide ethical approval in order to proceed the review process. If they cannot provide ethical approval, their manuscript will be rejected and also their institutions and when needed, the related bodies in their country will be informed that such studies must have ethics committee approval. If they provide approval, review of the manuscript will continue.

For articles concerning experimental research on humans, a statement should be included that shows informed consent of patients and volunteers was obtained following a detailed explanation of the procedures that they may undergo. The journal may request a copy of the Ethics Committee Approval received from the relevant authority. Informed consent must also be obtained for case reports and clinical images.

Studies using human or animal subjects should be approved by the appropriate institutional and local Ministry of Health ethics committees. Ethics approval of research protocols in accordance with international agreements is required for experimental, clinical, and drug studies, as well as for some case reports. Ethics committee reports or an equivalent official document may be requested from the authors. For manuscripts involving experimental research on humans, a statement should be included that shows that written, informed consent of patients and volunteers was obtained. For studies carried out on animals, the measures taken to prevent pain and suffering of the animals should be stated clearly. A statement regarding patient consent, and the name of the ethics committee, the ethics committee approval date, and number should be stated in the Materials and Methods section of the manuscript. It is the authors' responsibility to carefully protect patients' anonymity.

Plagiarism Policy

All submissions are screened using similarity detection software at least two times: on submission and after completing revisions. In the event of alleged or suspected research misconduct, e.g., plagiarism, citation manipulation, or data falsification/fabrication, the editorial board will follow and act in accordance with COPE guidelines. Plagiarism, including self-plagiarism, that is identified at any stage will result in rejection of the manuscript.

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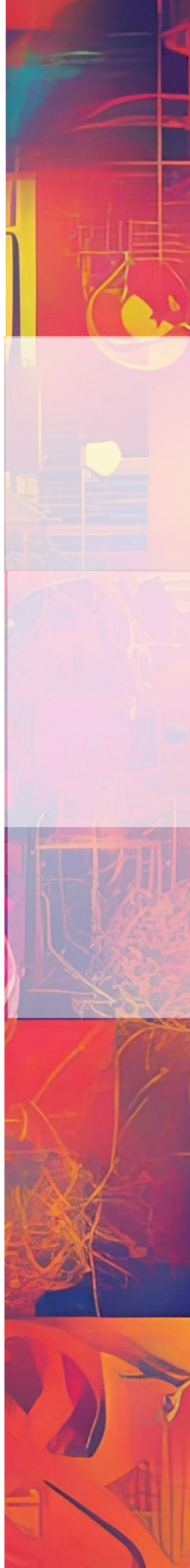

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Peer Review Policy

Only those manuscripts approved by its every individual author and that were not published before in or sent to another journal, are accepted for evaluation.

Submitted manuscripts that pass preliminary control are scanned for plagiarism using iThenticate software. After plagiarism check, the eligible ones are evaluated by Editor-in-Chief for their originality, methodology, the importance of the subject covered and compliance with the journal scope. Editor-in-Chief evaluates manuscripts for their scientific content without regard to ethnic origin, gender, sexual orientation, citizenship, religious belief or political philosophy of the authors and ensures a fair double-blind peer review of the selected manuscripts.

The selected manuscripts are sent to at least two national/international referees for evaluation and publication decision is given by Editor-in-Chief upon modification by the authors in accordance with the referees' claims.

Editor-in-Chief does not allow any conflicts of interest between the authors, editors and reviewers and is responsible for final decision for publication of the manuscripts in the Journal.

Reviewers' judgments must be objective. Reviewers' comments on the following aspects are expected while conducting the review.

- Does the manuscript contain new and significant information?
- Does the abstract clearly and accurately describe the content of the manuscript?
- Is the problem significant and concisely stated?
- Are the methods described comprehensively?
- Are the interpretations and consclusions justified by the results?
- Are adequate references made to other Works in the field?
- Is the language acceptable?

Reviewers must ensure that all the information related to submitted manuscripts is kept as confidential and must report to the editor if they are aware of copyright infringement and plagiarism on the author's side.

A reviewer who feels unqualified to review the topic of a manuscript or knows that its prompt review will be impossible should notify the editor and excuse himself from the review process.

The editor informs the reviewers that the manuscripts are confidential information and that this is a privileged interaction. The reviewers and editorial board cannot discuss the manuscripts with other persons. The anonymity of the referees is important.

Archiving Policy

The content published by the BAU Health and Innovation is electronically preserved by using Internet archive.

Fee Waiver Policy

There is no fee waiver.

Funding Sources Policy

All authors are required to declare what support they received to carry out their research. Declaring funding sources acknowledges funders' contributions, fulfills funding requirements, and promotes greater transparency in the research process.

Each author must individually declare all sources of funding received for the research submitted to the journal. This information includes the name of granting agencies, grant numbers, and a description of each funder's role. If the funder has played no role in the research, this must be stated as well.

Authors are not required to provide the complete list of every single grant that supports them if the grant is not related to the research published.

Publication Charges Policy

This BAU Health and Innovation assesses no submission fees, publication fees, or page charges.

Corrections Policy

If the editors or publisher learn from a third party that a published work contains a material error or inaccuracy, the authors must promptly correct or retract the article or provide the journal editors with evidence of the accuracy of the article.

Withdrawal Policy

The BAU Health and Innovation is committed to providing high quality articles and uphold the publication ethics to advance the intellectual agenda of science. We expect our authors to comply with, best practice in publication ethics as well as in quality of their articles.

Withdrawal of a manuscript will be permitted only for the most compelling and unavoidable reasons. For withdrawal of a manuscript authors need to submit an "Article withdrawal Form", signed by all authors mentioning the reason for withdrawal to the Editorial Office. The form is available from the web page of the journal. Authors must not assume that their manuscript has been withdrawn until they have received appropriate notification to this effect from the editorial office.

In a case where a manuscript has taken more than five months' time for review process, that allows the author to withdraw manuscript.

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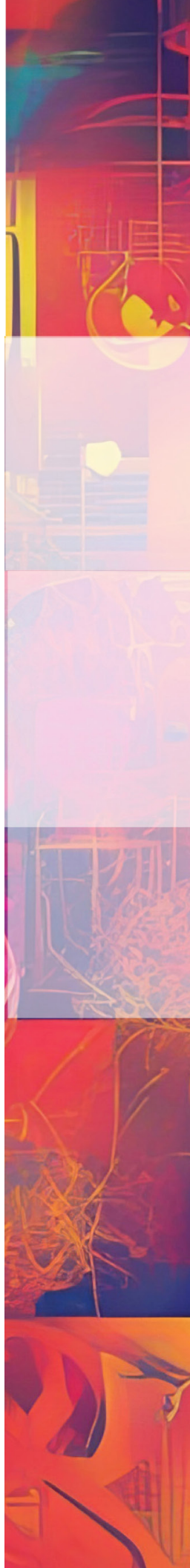

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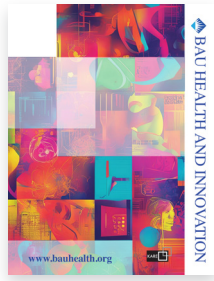

Original Article

Obesity Paradox and Long-term Cardiovascular Outcomes in Patients with Acute Coronary Syndrome Undergoing Percutaneous Coronary Intervention

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Abstract

Objectives: Obesity is a known modifiable risk factor for cardiovascular disease, and guidelines recommend maintaining a body mass index of 20–25 kg/m^2 to reduce cardiovascular risk. However, several studies have reported that obese patients with acute coronary syndrome (ACS) may have better short- and long-term survival than their normal-weight counterparts-a phenomenon known as the "obesity paradox." The effect of this paradox in ACS patients treated exclusively with percutaneous coronary intervention (PCI) remains unclear. This retrospective, two-center cohort study aimed to evaluate the impact of BMI on long-term mortality in ACS patients undergoing PCI, with a 3 years follow-up period.

Methods: A total of 1,198 patients were categorized according to BMI as normal weight (n=321), overweight (n=753), and obese (n=124). Survival across BMI categories was evaluated using Kaplan-Meier analysis with log-rank testing. Univariate and multivariable Cox proportional hazards regression models (backward likelihood ratio method) were performed to identify predictors of long-term mortality.

Results: In-hospital mortality was lowest among obese patients (2.2%) compared to overweight (2.8%) and normal-weight patients (7.4%) (χ^2=12.448; p=0.002). Over a 3 years follow-up, mortality remained significantly lower in the obese (6.5%) and overweight (8.5%) groups compared with the normal-weight group (20.1%) (χ^2=30.662; p<0.001). In multivariable analysis, smoking increased mortality risk by approximately 50% (Hazard ratio [HR]: 1.508; 95% confidence interval [CI]: 1.030–2.208; p=0.035), whereas obesity (HR: 0.297; 95% CI: 0.128–0.688; p=0.005) and overweight (HR: 0.404; 95% CI: 0.282–0.578; p<0.001) significantly reduced mortality risk.

Conclusion: Although obesity remains a significant risk factor for the development of cardiovascular disease, the present findings support the existence of an obesity paradox among ACS patients treated with PCI. Obese and overweight patients demonstrated a 60–70% lower risk of long-term mortality compared with normal-weight patients. These results highlight the need for a more nuanced approach to risk stratification and treatment planning in this patient group.

Keywords: Acute coronary syndrome, body mass index, obesity paradox, survival.

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Obesity is a well-recognized and modifiable risk factor for cardiovascular diseases, and it is commonly assessed through anthropometric measures, such as body mass index (BMI), waist circumference (WC), and waist-to-height ratio (WHtR). The presence of excess adipose tissue has been consistently linked with an increased

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risk of various metabolic and cardiovascular conditions, including type 2 diabetes mellitus, systemic hypertension, heart failure, and atrial fibrillation. Present international guidelines recommend maintaining a BMI between 20 and 25 kg/m^2 to lower cardiovascular risk and support long-term health.[1–3]

Interestingly, recent findings have described a counterintuitive observation known as the "obesity paradox," where individuals with obesity may experience more favorable clinical outcomes compared to their normal-weight counterparts after developing certain cardiovascular conditions. While the biological mechanisms behind this paradox are not yet fully understood, several hypotheses have been proposed. These include the protective role of higher lean body mass, reduced prevalence of malnutrition and cachexia, lower incidence of sarcopenia, and potentially greater metabolic and nutritional reserves in obese patients. In addition, differences in inflammatory and neurohormonal responses, as well as the potential effects of certain adipokines, have been suggested as contributing factors. It has been observed across different clinical groups, including patients with acute coronary syndrome – such as ST-segment elevation myocardial infarction (STEMI), non-ST-segment elevation myocardial infarction (NSTEMI), and unstable angina – as well as individuals with heart failure and certain malignancies.[4–7] In these cases, obese patients have often shown lower short-term and long-term mortality rates than non-obese individuals.

Standard treatment strategies for ACS involve pharmacological therapy, percutaneous coronary intervention, and coronary artery bypass grafting (CABG). Although previous studies on the obesity paradox have included patients receiving a combination of these treatments, only a limited number have focused specifically on those treated solely with PCI. Considering the widespread use of PCI as a primary revascularization approach, investigating the role of obesity in this patient population holds significant clinical relevance. This study aims to explore the existence and prognostic impact of the obesity paradox in patients diagnosed with ACS who underwent PCI during their initial hospitalization and were followed for up to 3 years.[1–8]

Materials and Methods

We designed a retrospective cohort study by reviewing medical records from two high-volume secondary and tertiary care centers to identify patients who underwent percutaneous coronary intervention for acute coronary syndrome between 2015 and 2018.

A total of 2,563 patients were screened, of whom 1,198 met the eligibility criteria and were included in the final analysis. Inclusion criteria were diagnosis of ACS (STEMI, NSTEMI, or unstable angina) and treatment with PCI during the index hospitalization. Exclusion criteria were ACS patients who did not receive PCI, alternative diagnoses, such as myocarditis, Takotsubo cardiomyopathy, pulmonary embolism, or myocardial infarction with non-obstructive coronary arteries, referral for coronary artery bypass grafting, severe comorbid illness predicting a life expectancy under 1 year, missing BMI data, or BMI values ≤18 or ≥40 at the time of admission (Fig. 1).

After applying these criteria, patients were grouped based on their BMI, which was calculated using the Quetelet formula: Weight (kg) divided by height squared (m^2). According to the World Health Organization classification, patients were categorized as normal (18.5–24.9 kg/m^2), overweight (25.0–29.9 kg/m^2), and obese (≥30.0 kg/m^2).

All patients included were followed for a period of 3 years. The primary outcome was all-cause mortality. Secondary outcomes included recurrent myocardial infarction, development of atrial fibrillation, and occurrence of stroke.

The study protocol was reviewed and approved by the Manisa Celal Bayar University Ethics Committee (Protocol No: V01, 03.11.2021-E.182270, date: 03.11.2021). All procedures were conducted in accordance with the ethical principles outlined in the Declaration of Helsinki.

Statistical Analysis

All statistical analyses were carried out using IBM Statistical Package for the Social Sciences Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY; Released 2017).

Descriptive data for continuous variables were summarized as means±standard deviations or medians with interquartile ranges (25th–75th percentile), depending on distribution.

For group comparisons, Student's t-test or the Mann-Whitney U test was applied, depending on the normality of the data. When comparing more than two independent groups, one-way Analysis of Variance or the Kruskal-Wallis test was used as appropriate, followed by Bonferroni or Dunn's test for post hoc comparisons.

Three-year survival outcomes were assessed using Kaplan-Meier analysis, stratified by BMI categories (normal weight, overweight, obese). The log-rank test was used to compare survival curves between groups. Univariate and multivariable Cox proportional hazard regression analyses were performed to identify predictors of long-term mortality. In the multivariable analysis, the backward

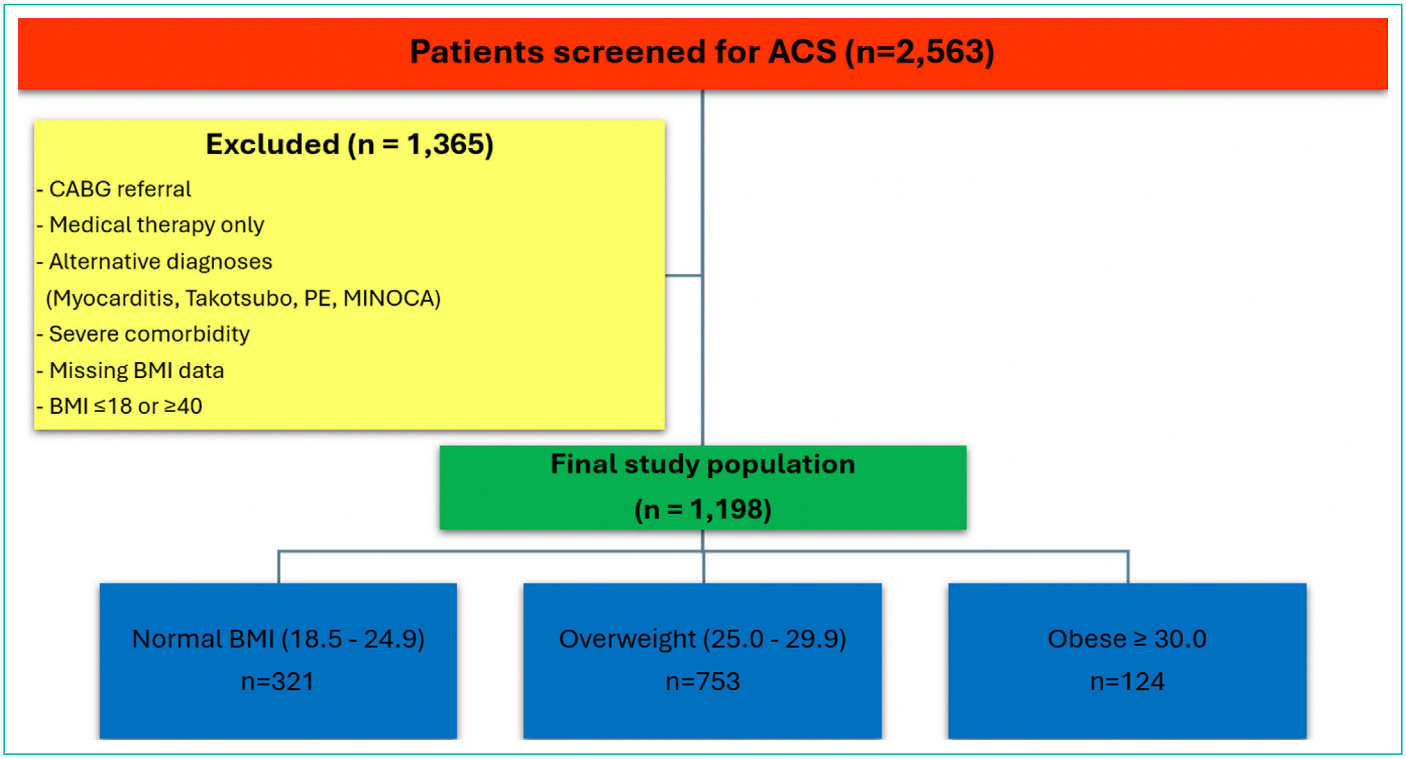

Figure 1. Flowchart of patient selection. A total of 2,563 patients with acute coronary syndrome were screened between 2015 and 2018. Of these, 1,365 were excluded due to referral for coronary artery bypass grafting, receipt of medical therapy only, alternative diagnoses (myocarditis, takotsubo cardiomyopathy, pulmonary embolism, myocardial infarction with non-obstructive coronary arteries), severe comorbid illness with life expectancy <1 year, missing body mass index [BMI] data, or BMI ≤18 or ≥40. The final study population included 1,198 patients treated with percutaneous coronary intervention, who were stratified by BMI categories into normal (n=321), overweight (n=753), and obese (n=124) groups.

likelihood ratio (LR) method was employed to construct the final model. A P-value below 0.05 was considered statistically significant throughout all analyses.

Results

A total of 2,563 patients diagnosed with acute coronary syndrome were screened. Among these, 1,365 patients were excluded due to reasons, such as referral for CABG, receiving conservative medical management, alternative diagnoses, missing BMI information, lack of adequate follow-up, or other clinical exclusions. The final study population consisted of 1,198 patients: 321 with normal BMI, 753 classified as overweight, and 124 identified as obese. Baseline demographic and clinical characteristics across BMI categories are presented in Table 1 (values reported as n [%] unless otherwise specified).

Compared to those with normal BMI, patients in the overweight and obese groups tended to be younger. The obese group also demonstrated a higher frequency of positive family history for cardiovascular risk factors. In terms of presentation, ST-elevation myocardial infarction was more commonly observed among obese patients. Laboratory parameters were largely similar between the groups, although levels of high-density lipoprotein cholesterol (HDL-C), high-sensitivity C-reactive protein (hs-CRP), and glomerular filtration rate (GFR) were significantly higher in the obese group (post hoc analyses are provided for each significant comparison in Table 1).

When comparing in-hospital mortality, the lowest rate was observed in the obese group (n=2; 2.2%), followed by the overweight group (n=19; 2.8%), and the highest rate was seen in the normal BMI group (n=24; 7.4%) (χ^2=12.448; p=0.002). All cell counts (n) are reported in Table 2.

Survival analysis over the 3 years follow-up period revealed that patients in the overweight and obese categories had significantly higher survival rates compared to those in the normal BMI group (mortality rates: 6.5%, 8.5%, and 20.1%, respectively; χ^2=30.662; p<0.001). The mean survival time was significantly longer in the overweight and obese groups compared to the normal BMI, with results expressed in months (Table 3). Kaplan–Meier survival curves (Fig. 2) further illustrate this difference, showing a clear separation of survival trajectories by BMI category, with overweight and obese patients demonstrating better outcomes.

Table 1. Baseline characteristics stratified by BMI categories

Number of patients	Normal weight n=321		Overweight n=753		Obese n=124		Test statistics; p	Post hoc comparisons
	n	%	n	%	n	%		
Age med [Q1–Q3]	63.5 [53.0–74.0]		62.0 [50.0–71.5]		60.0 [52.0–72.0]		**KW=6.813; 0.033**	**0–2: 0.035**
Sex male	214	28.6	466	62.4	67	9.0	χ^2=1.885	0.393
Sex female	110	32.5	202	59.8	26	7.7		
Family history, yes	57	47.1	58	47.9	6	5.0	**χ^2=19.749 <0.001**	
Diagnosis								
Non-ST MI	109	33.6	281	42.1	28	30.1	**χ^2=26.741 <0.001**	
ST elevation MI	90	27.8	203	30.4	45	48.4		
UAP	125	38.6	184	27.5	20	21.5		
Risk factors								
Smoking, yes	194	59.9	355	53.1	51	54.8	χ^2=4.010	0.135
Diabetes mellitus, yes	104	32.1	202	30.2	26	28.0	χ^2=0.690	0.708
Hypertension, yes	178	54.9	407	60.9	48	51.6	χ^2=5.115	0.077
Hyperlipidemia, yes	170	52.5	320	47.9	51	54.8	χ^2=2.826	0.243
CAD, yes	188	58.0	336	50.3	49	52.7	χ^2=5.225	0.074
CABG, yes	37	11.4	51	7.6	7	7.5	χ^2=4.105	0.128
hs-CRP med [Q1–Q3]	5.5 [3.1–8.1]		7.2 [4.5–9.6]		6 [4.6–7.9]		**KW=13.5; 0.001**	0–1; 0.020
Total cholesterol med [Q1–Q3]	197 [178.8–215]		208 [186–221.5]		200 [187.3–218]		KW=4.54; 0.103	
Triglyceride med [Q1–Q3]	168 [129–211.3]		186 [134.5–231]		183.5 [147–195]		KW=3.19; 0.202	
Laboratory								
Fasting glucose med [Q1–Q3]	131.5 [113.8–159]		129 [103.5–162]		120 [113–189.8]		KW=0.237; 0.888	
HDL med [Q1–Q3]	40 [35–51.3]		39 [35–47]		42 [40–47.3]		**KW=8.77; 0.012**	1–2: 0.014
LDL med [Q1–Q3]	114 [90.8–141]		125 [100.5–146]		126 [95–142.3]		KW=3.13; 0.209	
HbA1c med [Q1–Q3]	6.0 [5.5–6.5]		5.9 [5.6–6.7]		6.1 [5.3–7.3]		KW=3.64; 0.162	
GFr med [Q1–Q3]	68.6 [48.4–97.2]		89.0 [52.3–115]		94.4 [65.9–112.6]		**KW=28.0; <0.001**	0–1: <0.001 0–2: <0.001
Urea med [Q1–Q3]	38.5 [32–45.3]		32 [25–43]		37 [26.8–40]		**KW=13.4; 0.001**	0–1: <0.001
Creatinine med [Q1–Q3]	0.93 [0.8–1.1]		0.91 [0.8–1.2]		0.98 [0.8–1.1]		KW=0.925; 0.630	
EKG								
EKG AF	36	11.4	74	10.0	13	10.6	χ^2=0.450; 0.798	
EKG SR	281	88.6	667	90.0	110	89.4		
Drugs after discharge								
Acetyl salicylic acid	309	95.4	659	98.7	86	92.5	**χ^2=16.461; 0.129**	
Clopidogrel	166	51.2	429	64.2	65	69.9	**χ^2=18.950; <0.001**	
Ticagrelor	85	43.8	126	43.6	18	40.0	χ^2=0.230; 0.895	
Prasugrel	35	10.8	49	7.3	4	4.3	χ^2=5.500; 0.064	
Beta-blocker	142	43.8	374	56.0	62	66.7	**χ^2=20.293; <0.001**	
Ace inh/ARB	156	48.1	373	55.8	48	51.6	χ^2=5.282; 0.071	
Statin	278	85.8	499	74.7	85	91.4	**χ^2=25.36; <0.001**	
Coumadin	16	5.0	22	3.4	3	3.3	χ^2=1.614; 0.446	
NOAC	16	4.9	26	3.9	7	7.5	χ^2=2.692; 0.260	

χ^2: Chi-square test, KW: Kruskal Wallis test, BMI: Body mass index, MI: Myocardial infarction, ST elevation MI: ST-Segment elevation myocardial infarction, UAP: Unstable angina pectoris, CAD: Coronary artery disease, CABG: Coronary artery bypass grafting, hs-CRP: High-sensitivity C-reactive protein, HDL: High-density lipoprotein, LDL: Low-density lipoprotein, HbA1c: Hemoglobin A1c, GFR: Glomerular filtration rate, EKG: Electrocardiogram, AF: Atrial fibrillation, SR: Sinus rhythm, ACE inh: Angiotensin-converting enzyme inhibitor, ARB: Angiotensin II receptor blocker, NOAC: Non-Vitamin K antagonist oral anticoagulant, CVE: Cerebrovascular event, "Code: 0=Normal weight, 1=Overweight, 2=Obese", p<0.05 significance level.

Table 2. Endpoints according to BMI in the hospital and long-term

	Normal weight		Overweight		Obese		Test statistics; p
	n	%	n	%	n	%	
Death (overall)	65	20.1	57	8.5	6	6.5	χ^2=30.662; <0.001
Survived (overall)	256	79.9	696	91.5	118	93.5	
Death in Hospital	24	7.4	19	2.8	2	2.2	χ^2=12.448; 0.002
Alive at discharge	297	92.6	734	97.2	122	97.8	
Seconder endpoint							
MI_{have}	11	3.4	25	3.7	2	2.2	χ^2=0.628; 0.731
MI_{not}	310	96.6	728	96.3	122	97.8	
CVE_{have}	32	9.9	43	6.4	3	3.2	χ^2=6.263; 0.054
CVE_{not}	289	90.1	710	93.6	121	96.8	
AF development	33	10.2	72	10.8	3	3.2	χ^2=5.223; 0.073
AF_{not}	288	89.8	681	89.2	121	96.8	

χ^2: Chi-square test. BMI: Body mass index, AF: Atrial fibrillation, MI: Myocardial infarction, CVE: Cerebrovascular event, p<0.05 significance level.

Table 3. Kaplan Meier survival analysis of all-cause mortality in normal weight, overweight, and obese patients at 3-years follow-up

BMI (kg/m²)	Means for survival time (months)				Log rank (Mantel-Cox)		
	Estimate	SE	95% CI		Normal weight	Overweight	Obese
			Lower bound	Upper bound	Test statistics; p	Test statistics; p	Test statistics; p
Normal weight	31.892	0.613	30.690	33.094		**χ^2=27.427; <0.001**	**χ^2=9.053; 0.003**
Overweight	34.882	0.289	34.315	35.449	**χ^2=27.427; <0.001**		χ^2=0.454; 0.501
Obese	35.323	0.692	33.966	36.679	χ^2=9.053; 0.003	χ^2=0.454; 0.501	
Overall	34.027	0.266	33.506	34.547			

χ^2: Chi-square test, p<0.05 Significance level. BMI: Body mass index, SE: Standard error, CI: Confidence interval.

There were no statistically significant differences between BMI groups in secondary outcomes, such as recurrent myocardial infarction (χ^2=0.628; p=0.731), atrial fibrillation (χ^2=5.223; p=0.073), or stroke (χ^2=6.063; p=0.054), as displayed in Table 2.

In multivariable Cox regression analysis, factors, such as advanced age, NSTEMI presentation, and smoking status were associated with increased mortality risk. Conversely, both overweight and obesity were identified as protective factors. Specifically, smoking was associated with a ~50% increased mortality risk (Hazard ratio [HR]: 1.508; 95% confidence interval [CI]: 1.030–2.208; p=0.035), whereas overweight and obesity were associated with substantial reductions in mortality risk (overweight: HR 0.404; 95% CI 0.282–0.578; p<0.001, corresponding to ~60% risk reduction; obese: HR 0.297; 95% CI 0.128–0.688; p=0.005, corresponding to ~70% risk reduction). These findings, summarized in Table 4, remained significant after adjustment for potential confounders, such as age and comorbidities.

Discussion

This study investigated the impact of BMI on long-term outcomes in patients with acute coronary syndrome undergoing percutaneous coronary intervention. The analysis demonstrated that overweight and obese patients experienced significantly lower in-hospital and 3 years mortality compared with normal-weight individuals,

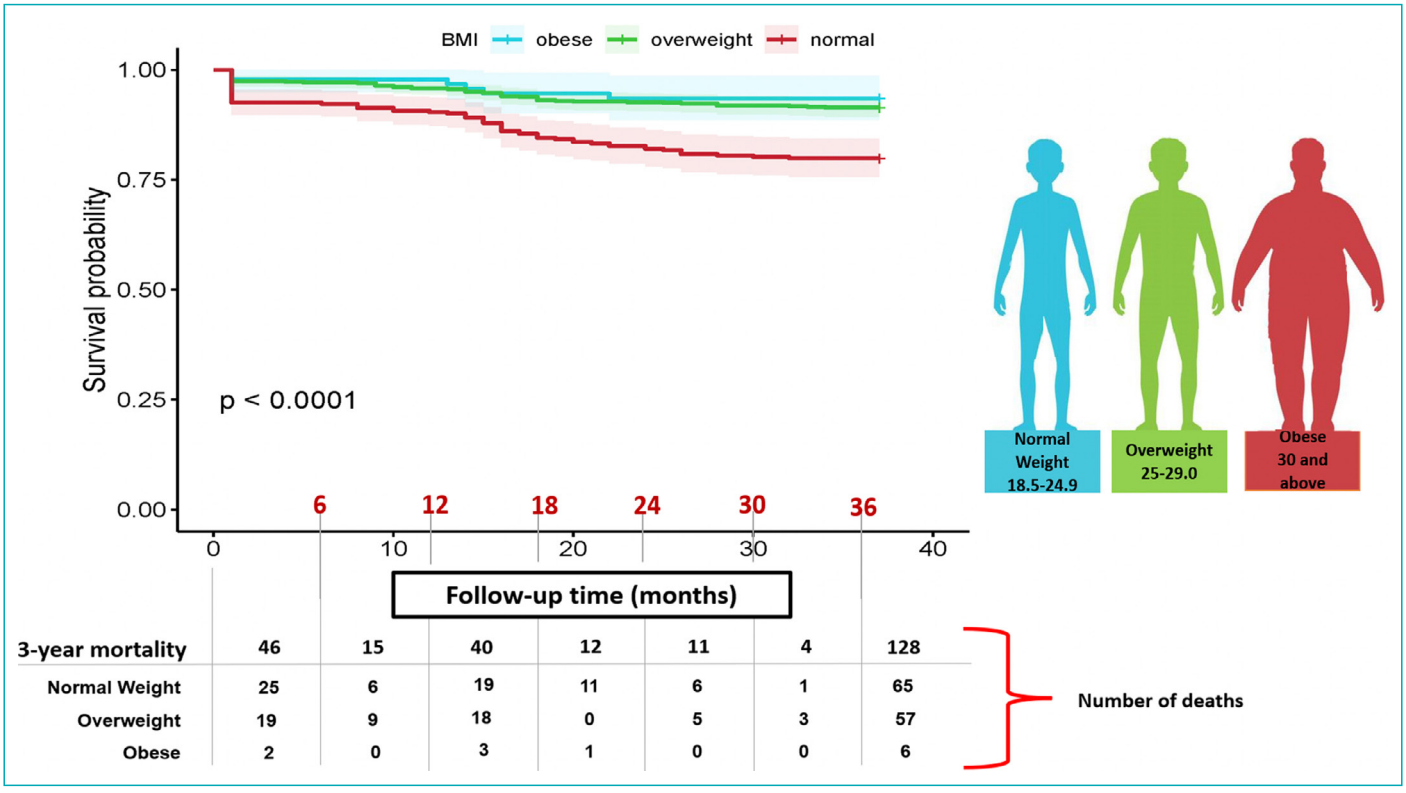

Figure 2. Survival analysis for all-cause mortality in normal weight, overweight, and obese patients at 3-year follow-up.

BMI: Body mass index.

Table 4. Univariate and multivariable predictors of long-term mortality

	Univariate analysis				Multivariable analysis			
	p	HR	95%CI for HR		p	HR	95%CI for HR	
			Lower bound	Upper bound			Lower bound	Upper bound
Age	**<0.001**	0.975	0.961	0.988	**0.001**	**0.976**	0.963	0.990
Diagnosis	**0.043**		**0.022**					
ST elevation MIUAP	0.088	0.692	0.453	1.057	0.718	1.086	0.693	1.702
Non-ST MI UAP	**0.016**	0.602	0.398	0.911	**0.011**	**1.726**	1.135	2.624
Diabetes, no	0.378	0.840	0.569	1.239				
Hypertension, no	0.740	1.061	0.746	1.510				
Hyperlipidemia, no	0.137	1.303	0.919	1.848				
Family history, no	0.749	0.914	0.515	1.622				
Smoking, no	**0.005**	1.698	1.174	2.456	**0.035**	**1.508**	1.030	2.208
CAD, no	0.122	1.321	0.929	1.880				
CABG, no	0.056	1.645	0.988	2.741				
BMI	<0.001		<0.001					
BMI obese	**0.005**	0.303	0.131	0.698	**0.005**	**0.297**	0.128	0.688
BMI overweight	**<0.001**	0.402	0.282	0.574	**<0.001**	**0.404**	0.282	0.578

Age: Continuous variable, Diagnosis: Acute MI: 0, UAP: 1, NSTEMI: 2, Diabetes: No: 0, Yes: 1, Hypertension: No: 0, Yes: 1, Hyperlipidemia: No: 0, Yes: 1, BMI: 25 and upper: 0, 18.5–24.9:1. HR: Hazard ratio, CI: Confidence interval, MI: Myocardial infarction, UAP: Unstable angina pectoris, NSTEMI: Non-ST Segment elevation myocardial infarction, CAD: Coronary artery disease, CABG: Coronary artery bypass grafting, BMI: Body mass index.

supporting the presence of an obesity paradox in this population. Specifically, overweight and obesity were associated with approximately 60% (HR 0.404; 95% CI 0.282–0.578) and 70% (HR 0.297; 95% CI 0.128–0.688) reductions in mortality risk, respectively, relative to normal BMI ($p<0.01$).

Low-grade chronic inflammation represents a biological link between excess adiposity and cardiovascular disease. Elevated high-sensitivity C-reactive protein levels in the overweight and obese groups in this study are consistent with large epidemiologic cohorts, such as NHANES III,[9] which also reported increased hs-CRP with rising BMI after controlling for confounders. Similarly, Festa et al.[10] and Pou et al.[11] demonstrated strong correlations between adiposity indices (BMI, waist circumference [WC]) and inflammatory biomarkers (CRP, interleukin-6), emphasizing the contribution of visceral fat to systemic inflammation. The persistence of elevated hs-CRP among overweight and obese patients in the present study may partly explain the earlier onset of ACS observed in these subgroups, as chronic inflammation accelerates atherosclerotic plaque formation.[12]

In addition to inflammatory markers, the study revealed higher glomerular filtration rate and unexpectedly elevated HDL-C levels in overweight and obese patients. Although obesity is known to be a risk factor for long-term kidney damage, elevated GFR may reflect early compensatory changes or measurement bias related to body size. In addition, the study revealed unexpectedly higher HDL levels in obese patients. The higher HDL-C values, which diverge from classical dyslipidemic profiles of obesity, might be attributed to metabolic alterations during the acute phase of ACS or variability in fasting status at the time of sampling.[13–15]

Multivariable Cox regression analysis identified age above 65 years, NSTEMI presentation, and smoking as independent predictors of long-term mortality, consistent with established risk factors in ACS populations. Smoking was associated with approximately a 50% higher risk of death (HR 1.51; 95% CI 1.03–2.21; $p=0.035$). In contrast, both overweight and obesity were independently linked to improved survival, in agreement with findings from previous studies.[16,17] The Kaplan–Meier survival curves clearly demonstrated this pattern, showing the best survival outcomes among obese patients and confirming an inverse association between BMI and mortality over the 3 years follow-up period.

A large meta-analysis by Lamelas et al.,[18] including more than 81,000 ACS patients, similarly found that underweight individuals had higher mortality than those of normal or slightly elevated BMI, while overweight and mildly obese patients had the best survival, with the lowest mortality near 30.9 kg/m^2. Gruber et al.[19] also reported better long-term outcomes after PCI among patients with higher BMI, identifying age, diabetes, and left-ventricular function as key predictors of mortality.

Several mechanisms may underline the apparent protective effect of higher BMI in ACS patients treated with PCI. Patients of normal weight are often older and have more comorbidities, whereas those who are overweight or mildly obese may possess greater physiological reserves, such as higher lean muscle mass, lower prevalence of sarcopenia, and reduced likelihood of malnutrition. These features could enhance tolerance to acute illness and recovery after PCI. Furthermore, BMI does not differentiate between fat and muscle tissue; therefore, individuals categorized as normal weight may include patients with low muscle mass or frailty, conditions known to worsen outcomes.[20,21]

From a clinical perspective, these findings suggest that weight-management strategies should be individualized rather than uniformly aggressive in ACS patients undergoing PCI. While excessive adiposity remains an established risk factor for developing coronary artery disease, once ACS occurs, modest overweight or mild obesity may not translate into poorer prognosis and could even be associated with better long-term survival. Incorporating other anthropometric and metabolic indicators – such as WC, visceral fat, and body composition – into clinical risk assessment may help refine prognostic evaluation beyond BMI alone.

Despite these findings, this study has several limitations. First, we relied exclusively on BMI for categorization, without including additional anthropometric measures, such as WC, WHtR, or direct assessments of visceral adiposity, which might provide stronger prognostic value. Second, although the study included a relatively large sample size and a 3 years follow-up, it was retrospective in design, and residual confounding by unmeasured variables, such as nutritional status, physical activity, and socioeconomic factors cannot be excluded. Third, we assessed all-cause mortality but did not differentiate between cardiac and non-cardiac deaths. Evaluating cause-specific mortality in future studies could offer greater insight into the prognostic relevance of BMI in acute coronary syndrome patients treated with percutaneous coronary intervention. Finally, while our findings are consistent with the obesity paradox described in previous studies, they may not be generalizable to populations treated with coronary artery bypass grafting or medical therapy alone, as our cohort included only patients who underwent percutaneous coronary intervention.

Conclusion

Obesity and being overweight are well-recognized risk factors for the development of cardiovascular disease. In this cohort of patients with acute coronary syndrome treated with percutaneous coronary intervention, however, both overweight and obesity were associated with lower long-term mortality, supporting the presence of an obesity paradox. These findings emphasize the need for more refined risk stratification in acute coronary syndrome, as BMI alone may not fully capture the prognostic impact of body composition. The results also suggest that aggressive weight-reduction strategies may not be universally beneficial in this population and should be carefully individualized. Further studies incorporating additional anthropometric and body-composition measures are warranted to improve clinical decision-making and guide secondary prevention strategies.

Disclosures

Ethics Committee Approval: The study was approved by the Manisa Celal Bayar University Ethics Committee (no: V01, 03.11.2021-E.182270, date: 03/11/2021).

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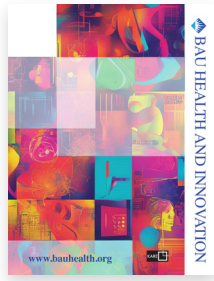

Original Article

The Effect of Breathing Exercises on Respiratory Function Test Parameters and Dyspnea in Patients with Chronic Obstructive Lung Disease and Asthma: A Retrospective Study

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Abstract

Objectives: Chronic lung diseases affect quality of life and are characterized by dyspnea and exacerbation. In addition to pharmacological treatments, pulmonary rehabilitation programs aim to reduce the impact of the disease. The aim of this study is to investigate the effectiveness of breathing exercises (BEs) on pulmonary function tests (PFTs) and dyspnea in patients with chronic obstructive pulmonary disease (COPD) or asthma.

Methods: In this retrospective study, a total of 60 patients diagnosed with COPD (n = 30) and asthma (n = 30) were included between August 2020 and March 2021. All participants performed BEs 4 days a week for 4 weeks, and their effects were evaluated. The functional status of the participants was evaluated with PFT (forced vital capacity [FVC], forced expiratory volume-1 (FEV1), FEV1/FVC, peak expiratory flow) parameters and dyspnea severity with the modified Borg scale. In addition, blood oxygen saturation and heart rate were also recorded and evaluated.

Results: After 4 weeks BEs program, it was observed that there was an increase in FEV1/FVC value among PFT parameters in patients diagnosed with asthma and no significant change in other values, while there was no change in pulmonary function parameters, blood oxygen saturation and heart rate results in patients diagnosed with COPD.

Conclusion: It was found that PFT parameters, blood oxygen saturation, and heart rate remained stable during the 4-week follow-up period in individuals with COPD and asthma who performed BE.

Keywords: Asthma, breathing exercises, chronic obstructive pulmonary disease, modified borg scale, pulmonary function test.

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Chronic obstructive pulmonary disease (COPD) is a chronic, progressive, irreversible lung disease characterized by airflow limitation. Airflow limitation in COPD develops as a result of parenchymal damage and inflammatory responses. While chronic inflammation causes remodeling, decreased elasticity of lung tissue, deterioration of its structure, and narrowing of the small airways, the decrease in elastic retraction force due to parenchymal damage makes it difficult to maintain airway strength and patency during expiration.[1] In reviewing the

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current classifications of COPD, an attempt has been made to divide it into two subcategories, with the predominant complaints being chronic bronchitis and emphysema. While chronic bronchitis reflects a clinical definition, emphysema includes a more pathological definition, and both definitions cause varying degrees of airflow limitation in patients. Chronic bronchitis is defined as the presence of complaints of cough and sputum production that persist for at least 3 months/year for at least 2 consecutive years, without causes such as tuberculosis, bronchiectasis, or lung abscess. Emphysema is defined as abnormal, permanent expansion and structural deterioration of the airways distal to the terminal bronchioles, together with tissue destruction, without significant fibrosis.[2] However, since this classification is distinguishable in very few patients with COPD and can be present at different rates, this distinction is no longer used.

People with COPD have muscle weakness in the diaphragm and other respiratory muscles. Respiratory muscle dysfunction is mainly due to mechanical effects caused by increased ventilation. Factors such as increased ventilation and airway resistance in COPD cause premature fatigue and weakness of the respiratory muscles. It is important to remove the chronic mucus produced in COPD from the lungs, maintain or increase limb muscle strength, and respiratory muscle strength to maintain quality of life in a patient with COPD. Therefore, respiratory muscle exercises are applied to this group of patients as part of respiratory rehabilitation.[3]

Asthma, a chronic and inflammatory airway hypersensitivity, is characterized by episodes of wheezing, dyspnea, and coughing. In asthma, the smooth muscles around the airways contract in response to triggers such as allergens, smoke, cold air, or exercise. In addition, the airways narrow due to increased mucus production. The causes of asthma may be genetic, working in jobs with inhaled dust and chemicals, exposure to allergens, or severe respiratory illness in infancy, maternal smoking, or exposure to cigarette smoke during pregnancy.[4] Breathing exercises (BEs) are a non-pharmacological treatment widely used around the world to treat people with asthma. The goal of BE is to control asthma symptoms and reduce the severity of attacks. BE can reduce dyspnea, improve ventilation, increase respiratory muscle strength and endurance, increase chest wall mobility, improve breathing patterns, and prevent atelectasis.[5]

Although there are studies investigating the effects of physical activity and BE in individuals with chronic lung diseases such as COPD and asthma, the evidence in the literature is insufficient. Furthermore, the timing, components, duration, and intensity of pulmonary rehabilitation are still unclear. The aim of this retrospective study was to evaluate the effectiveness of BE on parameters such as pulmonary function test (PFT), dyspnea, oxygen saturation, and heart rate in patients with COPD and asthma.

Materials and Methods

In this retrospective study, the data of patients admitted to the Respiratory Laboratory of the Chest Diseases Department of Istanbul Sisli Kolan Hospital were analyzed between August 2020 and March 2021. The inclusion criteria were as follows: having a diagnosis of COPD or asthma, being between 18 and 72 years of age, performing regular BE for 4 weeks (4 days/week) as prescribed by the physician, not changing the drug treatment program, being stable in terms of comorbidities and general health status, and having regular 4-week follow-up data. Exclusion criteria were as follows: COPD exacerbation or asthma attack in the previous 3 months, concomitant other respiratory diseases, and pregnancy. A total of 60 subjects were included in the study, including 30 patients with COPD and 30 patients with asthma who met the inclusion criteria. Ethics committee approval and study permission were obtained before data collection within the scope of the study in accordance with the Declaration of Helsinki (Date: April 07, 2021, Number: 2021-07/05). All parameters were evaluated twice, before and 1 month after BE.

Outcome Measures

Respiratory Function Test Parameters

The following PFT parameters were included and evaluated in the study. PFT was performed using the Masterscreen PFT device according to established standards.[6]

Forced vital capacity (FVC)

FVC is the volume of air that can be expelled with a rapid, forceful exhalation after a deep inhalation. Healthy people can usually exhale 80% of their lung volume in 4–6 s or less. In people with severe obstruction, the exhalation time can be as long as 20 s. FVC may be reduced in obstructive and restrictive diseases such as mucus plug, cystic fibrosis, bronchiectasis, asthma, chest wall deformities, and neuromuscular diseases.[7]

Forced expiratory volume-1 (FEV_1)

FVC is the volume of air exhaled in the 1st s from the start of the maneuver. It usually provides information about

large airway obstruction. A decrease in the FEV_1/FVC ratio indicates obstruction, and FEV_1 indicates the severity of the obstruction.[8]

FEV_1/FVC ratio

This is a parameter used to detect the presence of obstruction. It is low in obstructive diseases and normal or high in restrictive diseases.[8]

Peak expiratory flow (PEF)

It is measured by a maneuver of maximal inhalation followed by maximal exhalation. It provides information about obstruction in the large airways. It is usually correlated with FEV_1 measurements.[8]

Modified Borg Scale (MBS)

In addition to the PFT parameters mentioned above, the dyspnea level of the participants included in the study was evaluated using the MBS. The MBS is a scale between 0 and 10 and is a reliable tool in the evaluation of dyspnea in patients diagnosed with COPD and asthma.[9]

Heart Rate and Peripheral Oxygen Saturation

Participants' heart rate and blood oxygen saturation were evaluated using pulse oximetry.

BE Program

Patients were asked to perform the BE program 4 days a week for 4 weeks. The exercises were explained to the patients by physiotherapists and physicians trained in this field. Adherence to the program was monitored through weekly phone calls and verified based on documentation in the patient records. Only those patients who both reported and documented continued participation in the home-based program were included in the study. The details of the BE program for the patients included in this study are presented below.

Deep BE

This exercise was asked to be done while sitting in bed or on a chair. Patients were asked to take a deep breath through their nose and hold their breath for 3 s, and then exhale slowly through their mouth. A 30-s rest break was given after every 3 repetitions. This exercise was asked to be repeated 10 times, twice a day.[10]

Diaphragmatic BE

The patient is asked to lie supine with knees flexed 90°. The patient is asked to place one hand on the upper chest and the other hand on the abdomen just below the rib cage. It was explained that the patient should take the deepest breath possible through the nose slowly, while the hand on the chest should remain still and the hand on the abdomen should rise. In the exhalation phase, the patient was told to exhale slowly by tightening the abdominal muscles. This exercise was asked to be done in three sets of five repetitions, and 2 times a day. A rest period of 3 min was given between sets.[10]

Thoracic Expansion Exercises

With a belt-like object placed on the lower part of the costas, the patient is asked to breathe against the resistance while inhaling and to increase the mobility of the thoracic region by applying additional resistance while exhaling. This exercise is asked to be done 2 times a day, two sets of 5 times each.[11]

Statistical Analysis

IBM Statistical Package for the Social Sciences version 24.0 Software (IBM Corp., Armonk, NY, USA) was used for statistical evaluation. Destructive data were determined by the mean and standard deviation. Comparisons of these values before and after exercises were made with the Wilcoxon signed-rank test.

Results

A total of 60 patients with COPD (n=30) and asthma (n=30) were included in the study. Of the 30 patients with asthma included in the study, 16 were female and 14 were male. The ages of asthma patients in this group ranged between 18 and 41 years, with a mean age of 29±6.4 years. Eleven of the patients had a history of smoking, and 8 were active smokers. Of the 30 patients with COPD included in the study, 18 were female and 12 were male. The age range of the patients in this group was 44–72 years, with a mean age of 64±8.1 years. Four of the patients had no smoking history. The mean smoking history of patients in the COPD group was 62±18.5 pack-years.

In the participants in the COPD group, the mean FEV_1 value was 56.63±20.39 after exercises (p=0.410). The FVC value increased to 87.6±23.2, but this increase was not statistically significant (p=0.270). In addition, no significant difference was found in FEV_1/FVC value (p=0.840), PEF value (p=0.270), MBS values (p=0.700), blood oxygen saturation value (p=0.810), and heart rate values (p=0.750) (Table 1).

In the participants in the asthma group, the difference in the FEV_1/FVC ratio was found to be significant after exercise (p=0.027). However, the change in PEF value (p=0.390), FEV_1 value (p=0.100), MBS values (p=0.490), blood oxygen saturation value (p=0.720), and heart rate values (p=0.390) were not statistically significant (Table 1).

Table 1. Evaluation of participants before and after breathing exercise

Asthma (n=30)	Before exercise Mean±SD	After exercise Mean±SD	p
FEV_1	70.6±14.8	76.5±14.5	0.100
FVC	96.9±18.7	101±18.9	0.300
FEV_1/FVC	76.1±5.9	79.3±5.9	0.027
PEF	67.7±14.7	70.2±13.9	0.390
MBS	2.9±2.4	2.3±1.9	0.490
Saturation	98.1±1.4	98.3±1	0.720
Heart rate	80.6±3.3	81.2±3.2	0.390
COPD (n=30)			
FEV_1	53.7±18.7	56.6±20.4	0.410
FVC	82.1±21.8	87.6±23.2	0.270
FEV_1/FVC	66.7±12.8	67.2±13.8	0.840
PEF	49.6±17.3	52.7±15.9	0.270
MBS	4±2.6	3.7±2.4	0.700
Saturation	91±3.1	91.3±3.2	0.810
Heart rate	81.4±5.7	81.4±3.8	0.750

SD: Standard deviation, FEV_1: Forced expiratory volume 1, FVC: Forced vital capacity, PEF: Peak expiratory volume, MBS: Modified borg scale, COPD: Chronic obstructive pulmonary disease.

Discussion

In this retrospective study, BE were performed 4 times a week for 4 weeks in patients with COPD and asthma, and PFT parameters, dyspnea severity, heart rate, and blood oxygen saturation were evaluated. After the BE, a significant increase in FEV_1/FVC value was found only in the asthma group, while no significant change was found in the other values in both groups.

There are studies in the literature reporting strengthening in respiratory muscles after BE is applied in patients with COPD.[12,13] In this study, there was no worsening in PFTs and dyspnea severity as a result of BE in patients with COPD. Stable conditions in patients with COPD within 1 month may be related to the strengthening of respiratory muscles.

There are also studies indicating that BE applied to patients with COPD resulted in an increase in aerobic capacity assessed by the 6 m walk test in this patient group.[14] Factors such as decreased airway resistance, strengthening of respiratory muscles, and increased thoracic mobility play a role in the increase in aerobic capacity of patients.

Like the results of this study, in a meta-analysis examining the effects of BE applied to patients with COPD, it was found that there was no significant change in PFT parameters and dyspnea severity. It is thought that there is no significant change due to irreversible lung parenchymal and airway changes that occur in COPD disease.[3]

It has been reported that at least a 4-week exercise program should be implemented in patients with COPD for BE to lead to a statistically significant improvement in functional and clinical parameters.[15] In this study, a 4-week exercise program was applied, and if a longer program had been applied, significant differences could have been found in the clinical and functional parameters of the patients.

Respiratory muscles, such as other skeletal muscles, respond to muscle training and exercise according to certain principles. To obtain a response to inspiratory muscle training, the duration of inspiratory muscle training in most studies reported in respiratory patients is 8–12 weeks. However, structural changes in the inspiratory muscles are seen as early as 6 weeks. Inspiratory muscle training has a specific functional improvement in the inspiratory muscles and has been shown to produce adaptive positive changes in the structure of the intercostal muscles.[16] The lack of significant changes after BE in this study may be related to the short duration of the exercise program; therefore, it is recommended that longer exercise interventions should be performed in future studies. In addition, it is also important to evaluate the long-term effects of BE applied to individuals with chronic lung disease. Therefore, it is recommended to evaluate the long-term effects of BE in future studies.

There are studies showing a reduction in dyspnea severity, as measured by the MBS, as a result of BE in people with COPD.[17] In this study, although not statistically significant, there was a reduction in dyspnea severity as measured by the MBS. It is also thought that this may be related to the outbreak of COVID-19 during the period of data collection in the study. Factors such as a sedentary lifestyle and mask use may have had a negative impact on dyspnea.

BE is widely used in the treatment of asthma as an adjunct to pharmacologic therapy to reduce the symptoms of the disease. In addition to improving long-term respiratory function in asthma, BE can also produce positive improvements during attacks.[5] Therefore, BE has an important place for asthma patients. There are also studies that report an improvement in quality of life and a decrease in the frequency of medication use with the use of BE in patients with asthma.[18] Therefore, it is recommended that patients with asthma practice these exercises regularly.

In addition, there are publications showing a decrease in the frequency of acute exacerbations in asthma patients with a BE program of at least 8 weeks.[19] Based on this information, it is possible to say that BE is an effective and safe therapy modality in asthma.

Positive changes in asthma have been observed not only in the clinical setting but also in the home environment.

Therefore, after teaching BE to patients in the clinical setting under the supervision of a specialist or physiotherapist, it is recommended to apply it in the home environment as well.[20] In this study, patients were taught supervised BE in the clinical setting and then recommended to continue the program at home. Patients' adherence to the exercise program was monitored through weekly telephone interviews.

This study has some limitations. These limitations include the BE program being 4 weeks, not including long-term follow-up parameters, and not measuring quality of life. There is a need for future studies in which a longer BE intervention is performed, and the long-term effectiveness of BE is evaluated. However, the heterogeneity between both groups and the lack of baseline assessment are important limitations that prevent the generalization of the results. In future studies, it is recommended to be more careful in group selection and to give importance to homogeneity. In addition, due to the COVID-19 pandemic during the period of the study, factors such as mask use and sedentary lifestyle of the participants were not included in the study, which created uncertainty in the interpretation of the results.

Conclusion

In this study, no significant change was observed in FVC, FEV_1, PEF, MBS, SpO_2, and negative binomial (NB) results in asthma patients after BE, while a significant increase was found in FEV_1/FVC value. In COPD patients, data changes in FVC, FEV_1, FEV_1/FVC, PEF, MBS, SpO_2, and NB results were found to be insignificant. BE stabilized the respiratory functions and the dyspnea severity of the patients.

Disclosures

Ethics Committee Approval: The study was approved by the Bahçeşehir University Clinical Research Ethics Committee (no: 2021-07/05, date: 07/04/2021).

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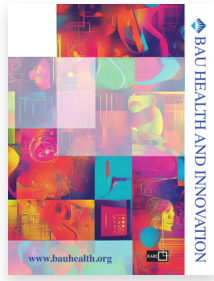

Original Article

Evaluation of Postpartum Women's Knowledge and Practice Regarding Traditional and Complementary Medicine After Cesarean Section

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Abstract

Objectives: This study aimed to evaluate the knowledge levels and experiences of women regarding traditional and complementary medicine (TCM) practices following cesarean delivery. With the increasing rates of cesarean sections, complications such as pain, infection, and prolonged recovery have become more common, leading women to seek supportive interventions during the postpartum period. However, research on this topic in Türkiye is limited.

Methods: This descriptive, cross-sectional study was conducted with 82 women who had undergone cesarean delivery at least 2 years prior. Participants were recruited using snowball and convenience sampling methods, and data were collected through an online survey between May and August 2025. The data collection tools included a "Descriptive Information Form" and the "Traditional and Complementary Medicine Attitude Scale (TCMAS)." Data analyses were performed using Statistical Package for the Social Sciences version 25.0.

Results: Of the participants, 68.2% had used at least one TCM method after cesarean delivery. The most commonly preferred practices were herbal teas/mixtures (30.5%), heat applications (11.0%), and massage (7.3%). Participants primarily learned about these practices through their own research (24.4%) and the Internet/social media (13.4%). The mean TCM attitude scale score was 111.26±21.12, indicating that women generally had a positive attitude toward TCM. A significant difference was found between women who considered TCM practices harmful and those who considered them harmless (p=0.027).

Conclusion: The findings indicate that women show interest in and have a positive attitude toward TCM practices after cesarean delivery. However, these practices are often applied irregularly and without sufficient knowledge. It is important for healthcare professionals to provide guidance and education on TCM during postpartum care.

Keywords: Cesarean section, health attitude, knowledge level, postpartum care, practice experience, traditional and complementary medicine.

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Cesarean section is one of the most frequently performed surgical procedures worldwide, and its increasing prevalence has been accompanied by complications such as post-operative pain, wound infection, hematoma, and delayed recovery. As a result, many women turn to traditional, complementary, and alternative medicine (TCAM) modalities, including herbal therapies, aromatherapy, massage, dietary supplements, acupuncture, and relaxation

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techniques, to support pain relief, enhance comfort, and promote overall postpartum recovery. The rising costs of healthcare services have also contributed to the growing preference for these modalities.[1–3]

TCAM methods are commonly used in the postpartum period to alleviate pain, reduce stress and anxiety, promote lactation, and improve maternal well-being. Evidence demonstrates that acupuncture may assist in managing post-operative pain and facilitating early mobilization after cesarean birth.[4] In addition, studies indicate that practices such as foot reflexology can support early physiological recovery and maternal comfort during the immediate post-cesarean period.[5,6]

Despite the widespread use of TCAM practices among postpartum women, research specifically focusing on attitudes toward and experiences with these modalities after cesarean section remains limited. Understanding women's perceptions, motivations, and patterns of use is essential for informing holistic, woman-centered postpartum care and for supporting safe clinical guidance in this period.[7]

Studies from various regions report differing levels of TCAM utilization among postpartum women. In Türkiye, for instance, Şimşek et al.[8] found that 60.5% of postpartum women used at least one TCAM method. Sociodemographic factors, including age, education level, and socioeconomic status, have been shown to influence TCAM use among postpartum populations.[9] Similarly, research from Malaysia highlights extensive use of traditional practices during the postpartum period, shaped by cultural norms and socioeconomic conditions.[10] A recent review from Türkiye further emphasizes the diversity of TCAM applications used during childbirth and the important role of midwives in guiding these practices.[11] However, studies focusing specifically on the post-cesarean period remain scarce.

Therefore, this study aimed to assess women's attitudes toward and practice experiences with traditional and complementary medicine (TCM) following cesarean delivery.

Materials and Methods

Study Design

This study was conducted as descriptive cross-sectional research.

Population and Sample

Data were collected through an online survey using popular instant messaging applications and social media platforms, leveraging the researchers' professional and personal networks. Snowball sampling was employed to reach women who had undergone cesarean delivery across Türkiye. In the initial phase, participants who responded to the form referred other eligible women living in different cities. Data collection was carried out between May 10, 2025, and August 10, 2025. A total of 82 women who met the inclusion criteria and completed the online survey were included in the study.

Inclusion Criteria

Participants were included if they:

- Had undergone cesarean delivery,
- Were at least 2 years postpartum,
- Were aged 18 years or older,
- Could read and write in Turkish, and,
- Voluntarily agreed to participate in the study.

Data Collection Instruments

The survey consisted of two sections as follows:

1. Descriptive ınformation form: Developed by the researchers based on the literature, this form included 18 questions covering demographic information (age, marital status, education, income) and TCM usage.[10–12]
2. TCM attitude scale (TCMAS): Developed by McFadden et al.[13] and adapted to Turkish by Köse, Ekerbiçer, and Erkorkmaz,[14] the scale is a 27-item Likert-type instrument (1=Strongly Disagree, 7=Strongly Agree). The scale does not have a cutoff score; higher scores indicate a more positive attitude toward TCM. It comprises three subscales: Cognitive Perspective on Complementary Medicine, Dissatisfaction with Modern Medicine, and Holistic View of Health. Twenty-two items are positively worded, and five items are negatively worded (reverse-scored during analysis). The Turkish adaptation reported a Cronbach's alpha of 0.80; in the present study, it was 0.84.

Data Collection Procedure

Data were collected online through Google Forms. Participants were recruited through social media (WhatsApp, Instagram, etc.,) and instant messaging platforms using snowball sampling, where respondents referred other eligible participants. The survey took approximately 10–15 min to complete. Participants were informed about the study's objectives and provided voluntary consent by selecting "I agree to participate in the study" at the beginning of the form. Permissions for the use of the scales in this study were obtained through email from the authors who conducted the Turkish validity and reliability studies.

Statistical Analysis

Data analysis was performed using IBM Statistical Package for the Social Sciences (SPSS) Statistics version 25.0 (IBM SPSS Statistics for Windows, Version 25. Armonk, IBM Corp, NY, USA). Descriptive analyses, including frequencies, percentages, means, and standard deviations, were used to summarize the data. The distribution of continuous variables was examined through the Skewness and Kurtosis coefficients and verified with the Shapiro–Wilk test. For variables that did not meet normality assumptions, comparisons between two groups were conducted using the Mann–Whitney U-test, whereas comparisons among three or more groups were made using the Kruskal–Wallis test. Statistical significance was determined at a p-value threshold of <0.05.

Ethical Considerations

The ethical approval was obtained from the KTO Karatay University Non-pharmaceutical and Medical Device Research Ethics Committee (Date: August 05, 2025/Decision No: 05). Participant rights were protected in accordance with the Helsinki Declaration. Participants were informed about the study, and voluntary consent was obtained online. Permissions for the use of the instruments were secured from the original authors of the Turkish validity and reliability studies through email.

Results

The mean age of participants was 32.77±5.64 years, and the mean time since their last delivery was 11.90±10.04 months. Among participants, 69.5% had a bachelor's degree, 8.5% had a postgraduate degree, and 61.0% were not employed. Regarding parity, 42.7% had one child and 46.3% had two children. In terms of birth order, 48.2% were primiparous. Cesarean delivery was chosen due to medical necessity in 54.9% of cases and due to previous births or cesarean history in 31.7%.

Of the participants, 68.2% reported using at least one TCM practice after cesarean delivery. The most frequently used methods were herbal teas/mixtures (30.5%), heat applications (11.0%), and massage (7.3%). Among TCM users, 24.4% reported choosing these methods based on their own research, while 13.4% learned about them through the Internet and social media. Approximately 40.2% perceived some benefit from the practices, and 14.6% reported significant benefits. A total of 61.0% expressed a desire for TCM practices to be supported in healthcare facilities (Table 1).

The mean TCMAS score was 111.26±21.12, indicating that participants had a generally positive attitude toward TCM after cesarean delivery. The internal consistency of the scale was high (Cronbach's alpha=0.84). No statistically significant differences in TCMAS scores were observed according to demographic variables such as education level, employment status, number of children, birth order, or reason for cesarean delivery (p>0.05). Variables such as TCM usage status, frequency, and source of recommendation also did not significantly affect attitude scores.

However, differences in TCMAS scores were observed based on perceived benefit and satisfaction from TCM, though these differences were not statistically significant (p>0.05). Participants who believed that TCM practices contributed to postpartum recovery had higher attitude scores, but this difference was not statistically significant (p=0.132). In contrast, a significant difference was found between women who considered TCM practices harmful and those who considered them harmless (p=0.027). According to Bonferroni post hoc tests, participants who perceived TCM practices as harmless had significantly higher attitude scores than those who perceived them as harmful (Table 2).

Discussion

This study examined women's attitudes and practice experiences regarding TCM during the postpartum period following cesarean delivery. Similar to our findings, global reports indicate that TCM use is widespread; the World Health Organization estimates that approximately 76% of the world population uses at least one traditional or complementary practice annually, and 88% of member countries utilize local traditional medicine or methods such as herbal therapy and acupuncture for health-related purposes.[15,16]

In Türkiye, national studies also report high rates of TCM use, with prevalence ranging between 60% and 70% depending on population characteristics.[17–19] Şimşek et al.[8] identified a 60.5% TCM utilization rate among Turkish women, while other studies have shown similarly high usage for managing maternal or familial health needs, including among mothers treating their children (76.9%).[19] These findings align with the 68% TCM use rate observed in our sample of post-cesarean women.[20]

In another study conducted at a family health center, it was observed that 53.2% of 400 people used Complementary and Alternative Medicine (CAM), and 88.7% of these people reported improvement.[21] Although many existing studies focus on different populations such as older adults, university students, or individuals managing chronic illness, they collectively highlight patterns relevant to postpartum women, particularly regarding commonly used methods. For example, herbal therapies,

Table 1. Sociodemographic characteristics of women (n=82)

Variables	Mean±SD (min-max)	
Age (years)	32.77±5.64 (18–43)	–
Time since last birth (months)	11.90±10.04 (1–48)	–
	n	**%**
Education level		
Primary education	3	3.7
Secondary education	15	18.3
Undergraduate	57	69.5
Graduate	7	8.5
Employment status		
Employed	32	39
Unemployed	50	61
Number of children		
1	35	42.7
2	38	46.3
3	9	11.0
Number of deliveries		
1	40	48.2
2	32	39.3
3	10	12.5
Reason for cesarean delivery		
Medical necessity	45	54.9
Previous births/cesarean history	26	31.7
Personal preference	11	13.4
T&CM use after cesarean		
Yes	56	68.2
No	26	31.8
Types of T&CM used		
Herbal tea/mixture	25	30.5
Massage	6	7.3
Aromatherapy	6	7.3
Yoga/Meditation	5	6.1
Heat therapy	9	11.0
Music therapy	5	6.1
Frequency of T&CM use		
Once a day	14	17.1
Several times a week	5	6.1
Only once	7	8.5
No regular pattern	17	20.7
Source of T&CM recommendation		
Family members	8	9.8
Healthcare personnel	9	11.0
Internet/social media	11	13.4
Neighbors/friends	7	8.5
Own research	20	24.4
Perceived benefit of T&CM		
Very beneficial	12	14.6
Somewhat beneficial	33	40.2
No effect	10	12.2
Desire for T&CM support in healthcare settings		
Yes	50	61.0
No	6	7.3
No opinion	26	31.7
Satisfaction with T&CM used		
Satisfied	12	14.6
Partially satisfied	29	35.4
Not satisfied	14	17.1
Perceived effect of T&CM on recovery		
Yes	10	12.2
Partially	27	32.9
No	17	20.7
Interest in learning more about T&CM		
Yes	50	61.0
Unsure	21	25.6
No	11	13.4
Desire for more guidance from healthcare professionals		
Yes	56	68.3
No opinion	18	22.0
No	8	9.8
Perception of T&CM harm after cesarean		
Yes	9	11.0
Unsure	37	45.1
No	36	43.9

SD: Standard deviation, Min: Minimum, Max: Maximum, TCM: Traditional and complementary medicine, T&CM: Traditional and complementary medicine

massage, vitamin supplements, music therapy, and heat applications are among the most frequently preferred approaches in various groups.[22–25] In our study, herbal applications were the most used method postpartum, although often inconsistently. Variations across studies likely reflect cultural norms, accessibility, and differing postpartum care expectations.

Participants' sources of information were also comparable to prior literature. Previous studies report that family members, social circles, and the Internet are major sources of TCM knowledge among women and young adults.[26–28] Similarly, in our study, women reported obtaining information primarily through their own Internet searches (24%) and social media (13%). These findings underscore

Table 2. Distribution of Women's (T&CMAS) scores by sociodemographic variables (n=82)

Variables	T&CMAS total score median (IQR) (minimum-maximum)	Test (X^2/z), p
Education level		1.087, 0.780
Primary education	109.00 (0.00) (81.0–120.0)	
Secondary education	110.00 (33.00) (81.0–144.0)	
Undergraduate	113.00 (25.50) (67.0–174.0)	
Graduate	105.00 (39.00) (79.0–154.0)	
Employment status		-1.307, 0.185
Employed	105.50 (31.75) (67.0–174.0)	
Unemployed	113.50 (20.75) (81.0–160.0)	
Number of children		1.571, 0.456
1	109.00 (30.00) (67.0–161.0)	
2	112.50 (22.25) (74.0–154.0)	
3	114.00 (32.00) (87.0–174.0)	
Number of deliveries		2.628, 0.269
1	108.00 (30.00) (74.0–161.0)	
2	115.00 (23.00) (81.0–154.0)	
3	110.00 (32.00) (67.0–174.0)	
Reason for cesarean delivery		1.091, 0.579
Medical necessity	109.00 (30.00) (74.0–174.0)	
Previous births/cesarean history	113.00 (27.50) (67.0–141.0)	
Personal preference	116.00 (47.00) (81.0–154.0)	
Post-cesarean T&CM use		-0.689, 0.491
Yes	115.00 (35.00) (67.0–161.0)	
No	109.00 (27.50) (74.0–174.0)	
Type of T&CM used		5.906, 0.316
Herbal tea/mixture	109.00 (24.50) (67.0–160.0)	
Massage	116.50 (17.50) (81.0–124.0)	
Aromatherapy	112.00 (31.75) (91.0–131.0)	
Yoga/Meditation	129.00 (55.00) (88.0–161.0)	
Heat therapy	121.00 (17.00) (106.0–140.0)	
Music therapy	114.00 (61.00) (81.0–152.0)	
Frequency of T&CM use		3.026, 0.388
Once a day	119.00 (17.25) (87.0–161.0)	
Several times a week	117.00 (28.00) (95.0–131.0)	
Only once	109.00 (29.00) (88.0–140.0)	
No regular pattern	107.00 (48.00) (67.0–160.0)	
Source of T&CM recommendation		2.606, 0.626
Family members	108.50 (22.75) (67.0–133.0)	
Healthcare personnel	116.00 (27.00) (81.0–130.0)	
Internet/social media	110.00 (36.00) (91.0–144.0)	
Neighbors/friends	121.00 (37.00) (85.0–152.0)	
Own research	116.50 (35.25) (82.0–161.0)	
Perceived benefit of T&CM		1.833, 0.400
Very beneficial	116.00 (13.00) (97.0–161.0)	
Somewhat beneficial	114.00 (34.50) (82.0–154.0)	
No effect	109.50 (38.75) (67.0–160.0)	
Support for T&CM in healthcare settings		3.073, 0.215
Yes	115.00 (24.50) (78.0–161.0)	
No	100.50 (60.00) (91.0–154.0)	

Table 2. Cont.

Variables	T&CMAS total score median (IQR) (minimum-maximum)	Test (X^2/z), p
No opinion	106.50 (23.75) (67.0–174.0)	
Satisfaction with T&CM		3.735, 0.155
Satisfied	116.50 (11.25) (95.0–161.0)	
Partially satisfied	114.00 (36.00) (82.0–154.0)	
Not satisfied	106.50 (26.00) (67.0–160.0)	
Perceived effect on recovery		4.050, 0.132
Yes	119.00 (12.25) (106.0–161.0)	
Partially	114.00 (32.00) (82.0–154.0)	
No	109.00 (28.50) (67.0–160.0)	
Interest in learning more about T&CM		1.700, 0.427
Yes	113.50 (20.75) (74.0–161.0)	
Unsure	108.00 (26.00) (67.0–174.0)	
No	97.00 (32.00) (82.0–152.0)	
Desire for more guidance from healthcare professionals		0.641, 0.726
Yes	112.50 (28.75) (67.0–161.0)	
No opinion	109.00 (40.25) (79.0–174.0)	
No	105.50 (28.50) (88.0–128.0)	
Perception of T&CM harm		7.230, 0.027*
Yes (a)	97.00 (30.50) (79.0–126.0)	
Unsure (b)	107.00 (29.00) (67.0–174.0)	
No (c)	116.00 (25.25) (78.0–161.0)	c>a
Total T&CMAS Score	111.26±21.12 (67.0–174.0)	Cronbach's α=0.84

z: Mann Whitney U-test, X2: Kruskal-Wallis test, a, b, c: Bonferroni Test istatistik, *p<0.05. T&CMAS: Traditional and complementary medicine attitude scale, TCM: Traditional and complementary medicine, IQR: Interquartile range, T&CM: Traditional and Complementary Medicine.

the importance of providing reliable, evidence-based information through health professionals, particularly considering that postpartum women frequently rely on non-professional sources.

Most of the women in this study perceived TCM methods as harmless. Comparable findings have been reported in different clinical contexts; for instance, Teng et al.[29] found that 71.7% of cancer patients believed they benefited from TCM practices, and Tan et al.[30] reported that 87% of participants expressed similar benefits. Although these studies involve distinct populations, they reflect a common belief in the safety and usefulness of TCM, an attitude also present among postpartum women in our study. Importantly, participants emphasized a desire for more structured information and institutional support regarding TCM use after cesarean delivery.

Overall, this study contributes to the limited body of knowledge on TCM use specifically in the post-cesarean population and highlights the need for postpartum-focused education and guidance regarding safe and effective use of these methods.

TCM practices, although widely perceived as harmless, may pose specific risks during the post-cesarean period. Herbal products can interact with analgesics, antibiotics, and anticoagulants commonly used after cesarean delivery, potentially altering drug metabolism or increasing adverse effects. Certain herbs, such as ginseng, ginger, ginkgo, and garlic, may increase bleeding risk, which is particularly relevant in women recovering from major abdominal surgery. Similarly, uterotonically active herbs such as sage, pennyroyal, or certain traditional postpartum mixtures may influence uterine contractility and pose risks if used unsupervised. Topical applications, including oils and heated compresses, may cause delayed wound healing or skin irritation near the incision site. Therefore, clinicians should provide postpartum women with evidence-based guidance on safe practice, and TCM use should be carefully evaluated when women are receiving post-operative medications or experiencing complications.[31,32]

Limitations

This study has several limitations. First, data were collected solely through online surveys, excluding individuals

without Internet access. Second, the sample was selected using non-probability sampling methods (snowball and convenience sampling), which limits generalizability. Self-reported data may also be subject to social desirability bias. Due to the cross-sectional design, causal relationships between variables could not be assessed. Finally, the study was conducted within a limited timeframe (May 10–August 10, 2025) and with a small sample size (n=82), which also restricts generalizability.

Conclusion

This study found that a significant proportion of women used TCM practices after cesarean delivery and that their attitudes toward these practices were generally positive. Information sources were primarily informal channels, such as social circles and social media. The findings align with existing literature indicating the widespread use of TCM in Türkiye and globally.

Herbal methods were among the most frequently used practices; however, these were often applied irregularly and without sufficient knowledge. Most of the women did not perceive TCM methods as harmful and emphasized the need for more information and institutional support regarding these practices.

Disclosures

Ethics Committee Approval: The study was approved by the KTO Karatay University Non-pharmaceutical and Medical Device Research Ethics Committee (no: 05, date: 05/08/2025).

Informed Consent: Obtained online from all participants.

Conflict of Interest Statement: All authors declared no conflict of interest.

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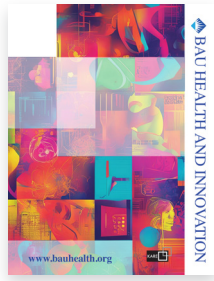

Original Article

Investigation of the effect of post-operative mobilization on bowel movements in neurosurgery patients; The case of Uludağ University faculty of medicine hospital

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Abstract

Objectives: Post-operative gastrointestinal dysfunction is common after neurosurgical procedures and may prolong hospitalization. Early mobilization is a key intervention in enhanced recovery after surgery-based nursing care to facilitate the timely return of bowel activity. Objective: The aim of the study was to examine the association between post-operative mobilization timing and recovery of bowel function (first bowel sound, first flatus, and first defecation) in neurosurgical patients.

Methods: This descriptive correlational study was conducted at a tertiary neurosurgical center between August 02, 2023, and February 02, 2024. A total of 178 adults who underwent brain or spinal surgery and met the inclusion criteria were included in the study. Data were collected using a semi-structured form covering demographics, perioperative variables, time to first mobilization, and bowel function indicators. Normality was assessed; due to non-normal distributions, Mann–Whitney U, Kruskal–Wallis, and Spearman correlation tests were used (IBM the Statistical Package for the Social Sciences 25.0). The significance level was set at $p<0.05$.

Results: The mean time to first mobilization was 18.94±19.09 h. The mean times to the first bowel sound, first flatus, and first defecation were 6.83±2.11 h, 13.30±7.21 h, and 34.30±20.67 h, respectively. Early mobilization was significantly associated with shorter bowel recovery times across outcomes ($p<0.001$ for all non-parametric comparisons). Correlation analyses confirmed significant associations between mobilization timing and each bowel function indicator.

Conclusion: The findings support the integration of structured early mobilization into routine post-operative nursing care for neurosurgical patients to accelerate gastrointestinal recovery and potentially reduce post-operative complications.

Keywords: Bowel movement, early mobilization, enhanced recovery after surgery, neurosurgery, nursing, post-operative.

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Post-operative gastrointestinal dysfunction is a common complication, especially in patients undergoing neurosurgery. This condition negatively affects patient comfort and prolongs the length of hospital stay required. Early mobilization, a key step in enhanced recovery after surgery (ERAS) protocols aimed at accelerating post-operative recovery, increases the effectiveness of the respiratory and circulatory systems and raises intra-

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abdominal pressure, stimulating the parasympathetic system and accelerating peristaltic movements.[1,2] In this context, many studies have indicated that early mobilization speeds up the onset of post-operative bowel movements and leads to earlier passage of gas and stools. Despite this, mobilization in neurosurgery patients is often delayed due to post-operative pain, changes in neurological status, or nurse shortages contribute to this situation. Prolonged immobility increases the risk of constipation and bowel inactivity, reduces patient comfort, and leads to complications.[1–3]

Early mobilization, defined as initiating movement within the first 24 h after surgery, tailored to the patient's physical and neurological status, is now considered a cornerstone of post-operative nursing care.[4,5] Moving soon after surgery benefits multiple systems: It improves respiratory and circulatory efficiency, stimulates peristaltic activity through abdominal pressure changes, and supports parasympathetic activation.[6,7] A consistent body of evidence suggests that patients who begin moving earlier tend to regain bowel sounds, pass flatus, and defecate sooner than those who experience delayed mobilization.[8–10]

Despite this evidence, mobilization is often postponed after neurosurgical operations. Factors such as pain, neurological instability, and lack of nursing personnel can contribute to this delay.[11] However, prolonged immobility may worsen constipation and other gastrointestinal disturbances, reducing comfort and slowing recovery.[12–14] Previous studies have reported that constipation affects 15–85% of neurosurgical patients, depending on factors such as age, comorbidities, and medication use.[15–17]

Because nurses spend the most time with post-operative patients, their role is vital in ensuring that mobilization occurs safely and effectively. Through regular assessments and encouragement, nurses help patients regain bowel activity and prevent related complications.[18,19] Incorporating evidence-based practices such as early mobilization has been shown to improve both physical recovery and emotional well-being, enhancing the overall quality of care.[20]

The present study investigated how the timing of post-operative mobilization relates to the recovery of bowel function in neurosurgical patients. By identifying these relationships, we aim to highlight the value of structured nursing interventions within ERAS-based post-operative care.

Materials and Methods

Study Design and Setting

This research was conducted as a descriptive and correlational study aimed at examining how early post-operative mobilization influences the recovery of bowel movements in patients who underwent brain or neurosurgical procedures. This study focused on evaluating the contribution of early mobilization to the normalization of gastrointestinal system function during the post-operative period. Data were collected at a tertiary health institution in Türkiye between August 02, 2023, and February 02, 2024.

Ethical Considerations

Ethical approval for this study was obtained from a university medical faculty ethics committee in Türkiye (Decision No: 2023-16/15, dated August 01, 2023). Written informed consent was obtained from all participants before data collection. This study was conducted in accordance with the principles of the Declaration of Helsinki.

Participants

The study population consisted of adult patients who underwent surgery at the neurosurgery clinic during the specified dates. As a result of the sample size calculation, at least 203 patients were determined; however, during the study period, 178 patients who met the inclusion criteria participated in the study. Participation was based on voluntariness, and individuals who were ≥18 years of age, had undergone brain or spinal cord surgery, did not have any gastrointestinal system diseases, and did not use laxatives were included in the study.

Although 203 patients initially met the eligibility criteria, 25 were excluded from the analysis. Of these, 11 declined to participate, five had incomplete post-operative bowel function records, four required reoperation during the post-operative period, and five developed complications that prevented safe mobilization. The final sample consisted of 178 patients who met all the inclusion criteria and completed the data collection process.

Data Collection

The data were collected using the "Patient Information Form" prepared by the researcher. This form included information such as demographic details, pre-operative and post-operative clinical data, time of first mobilization, first bowel sound, first passage of gas, and time of first defecation.

Early mobilization after surgery was initiated by explaining it to the patient before the procedure. Initially, patients were seated at the edge of the bed and then assisted to stand with the support of healthcare personnel. The duration and distance of mobilization were gradually increased according to the patient endurance. Mobilization was planned in 3-min intervals and implemented safely. In

the assessment of post-operative bowel function, the times of the first bowel sound, first passage of gas, and first bowel movement were recorded.

Early mobilization was planned in accordance with the ERAS recommendations for neurosurgical patients. The ERAS guidelines emphasize initiating mobilization within the first 24 h postoperatively, unless contraindicated. A progressive mobilization protocol was followed, beginning with sitting at the edge of the bed, followed by assisted standing and ambulating. This structured progression aligns with evidence-based ERAS practices aimed at improving post-operative gastrointestinal recovery outcomes.

The patient information form was developed by the researchers based on the ERAS guidelines, previous studies, and neurosurgical nursing practice standards. To ensure content validity, the form was reviewed by three experts in neurosurgical nursing and post-operative care, and minor revisions were made based on their feedback. Since the form consists of objective clinical variables rather than Likert-type scale items, internal consistency reliability analyses such as Cronbach's alpha were not applicable.

Statistical Analysis

IBM Statistical Package for the Social Sciences Statistics for Windows, Version 25.0 (IBM Corp., Armonk, NY, USA) software was used for data analysis. Descriptive statistics (mean, standard deviation, percentage, and frequency) were calculated, and the assumption of normal distribution was evaluated using the Shapiro–Wilk test. Since the data were found not to be normally distributed, Mann–Whitney U, Kruskal–Wallis, and Spearman correlation analyses were applied. The level of statistical significance was set at $p<0.05$.

Results

The data obtained from the study showed that 51.7% of the patients were female, 85.6% were married, and 88.6% had a high school education or below. The average age was 55.09 ± 14.74 years, and the average body mass index (BMI) was 29.53 ± 16.65. It was observed that 57.3% of the patients participating in the study had a chronic illness, and 56.7% regularly used medication. When patients were evaluated according to the type of surgery they underwent, 50.6% had spinal surgery and 98.3% had open surgical procedures (Table 1).

Before surgery, 57.9% of the patients reported regular daily bowel movements, whereas 33.7% defecated every 2–3 days. The mean pre-operative fasting time was 7.21±2.00 h, and the mean intravenous (IV) fluid administered preoperatively was 429.49±443.90 mL (Table 2).

Table 1. Demographic and clinical characteristics of the patients (n=178)

Variables	Categories	n (%)/mean±SD
Gender	Female/male	92 (51.7)/86 (48.3)
Marital status	Married/single	155 (85.6)/26 (14.4)
Education level	Illiterate/≤ High school/ ≥ University	6 (3.4)/152 (85.4)/ 20 (11.2)
Chronic disease	Yes/No	102 (57.3)/76 (42.7)
Regular medication	Yes/No	101 (56.7)/77 (43.3)
Type of surgery	Spinal/ıntracranial	90 (50.6)/88 (49.4)
Surgical method	Open/laparoscopic	175 (98.3)/3 (1.7)
Mean age (years)	—	55.09±14.74 (19–88)
BMI (kg/m^2)	—	29.53±16.65 (17–42)

SD: Standard deviation, BMI: Body mass index

Table 2. Pre-operative bowel habits and health characteristics (n=178)

Variables	Categories/ mean±SD	n (%)/range
Routine defecation	Daily	103 (57.9)
	Every 2–3 days	60 (33.7)
	Every 4–5 days	15 (8.4)
Pre-operative fasting time (h)	7.21±2.00	4–14
IV fluid before surgery (mL)	429.49±443.90	0–1500

SD: Standard deviation, IV: Intravenous

Table 3. Post-operative bowel function and mobilization data (n=178)

Variable	Mean±SD	Min-Max
IV fluid during surgery (mL)	1937.64±755.57	100–4000
Duration of surgery (h)	2.3±2.2	0.5–6
Time to first mobilization (h)	18.94±19.09	2–72
Time to first flatus (h)	13.30±7.21	3–40
Time to first bowel sound (h)	6.83±2.11	4–24
Time to first defecation (h)	34.30±20.67	4–96

SD: Standard deviation. All values are expressed as mean±SD (min–max). Lower values indicate a faster recovery

Post-operative Mobilization and Bowel Function Findings

The mean intraoperative IV fluid volume was 1937.64±755.57 mL, and the mean surgery duration was 2.3±2.2 h. Postoperatively, the mean time to first mobilization was 18.94±19.09 h, the first passage of flatus occurred at 13.30±7.21 h, the first bowel sound at 6.83±2.11 h, and the first defecation at 34.30±20.67 h (Table 3).

Table 4. Normality test results for mobilization time

Variable	Skewness	Kurtosis	Kolmogorov–Smirnov p
Time to first mobilization	1.394	1.418	<0.001

Interpretation: Data were non-normally distributed, and non-parametric tests were applied

Table 5. Comparison of mobilization time by flatus passage time (n=178)

Flatus passage time	n	Mean rank	p
≤12 h	105	75.09	<0.001
>12 h	73	110.23	

Spearman ρ=0.333, p<0.005 – weak positive correlation

Table 6. Relationship between mobilization time and bowel sound

Bowel sound time	Test statistic	p	Correlation (r)
≤6 h/7–12 h/≥12 h	χ^2=2.00	<0.001	–0.370

Spearman ρ=–0.370, p<0.005–moderate negative correlation

Table 7. Relationship between mobilization and defecation times

Variable	Correlation (r)	p
Mobilization ↔ defecation	0.779	<0.005

Spearman ρ=0.779, p<0.005–Strong positive correlation

Normality and Correlation Analysis

According to the Kolmogorov–Smirnov test and skewness–kurtosis values, the data were not normally distributed (p<0.001). Therefore, non-parametric analyses were performed (Table 4).

Relationship between Mobilization Time and Bowel Recovery

A statistically significant relationship was observed between mobilization time and all bowel function variables. Patients who were mobilized earlier experienced earlier gas passage, bowel sounds, and defecation.

A weak positive correlation was found between mobilization time and time to first flatus (r=0.333, p<0.005) (Table 5). Similarly, a significant relationship was identified between mobilization time and time to first bowel sound (p<0.001), with a moderate negative correlation (r=-0.370, p<0.005) (Table 6).

Finally, mobilization time was strongly positively correlated with time to the first defecation (r=0.779, p<0.005). Patients mobilized within the first 24 h after surgery achieved earlier defecation than those mobilized later (p<0.001) (Table 7).

Discussion

According to the findings of the study, the gender distribution of the participants was quite balanced (51.7% female, 48.3% male), with the majority being married (85.6) and having a high school education or lower (88.8%). The average age of the participants was determined to be 55.09±14.74 years, and their BMI was 29.53±16.65. It was found that 57.3% of the participants had a chronic illness, and 56.7% used medication regularly. These findings are consistent with previous studies reporting that surgical patients are typically middle-aged, have a higher BMI, and frequently present with chronic diseases.[5,9,11] Although chronic diseases are generally considered a factor that increases the risk of post-operative complications, this study found that they did not have a statistically significant effect on bowel functions. Durgun and Avcı (2020) also indicated that chronic diseases do not have a noticeable effect on bowel functions.[14] This finding shows that in parallel with the literature, the evaluation of bowel functions in terms of complications in individuals with chronic diseases is similar when early mobilization is applied.

Within the scope of the study, when the patients' pre-operative bowel habits were examined, it was found that the majority had a daily bowel movement (57.9%), the average pre-operative fasting period was 7.21±2.00 h, and the amount of IV fluid administered during surgery was 1937.64±755.57 mL. A significant relationship was found between the time to early post-operative mobilization and the time for bowel functions (first passage of gas, first bowel sound, and first defecation) to return. This finding is consistent with other studies in the literature. Kırtıl and Kanan (2021) stated that early mobilization stimulates gastrointestinal system functions and accelerates peristaltic movements.[9] Similarly, Terzioğlu (2013) demonstrated that early mobilization shortens the time to the first post-operative passage of gas and speeds up the patients' recovery process.[15]

In the study, a weak positive correlation was found between the time to first mobilization and the time to first passage of gas; a moderate negative correlation was found between the time to first mobilization and the time to first bowel sounds; and a strong positive correlation was found with the time to first defecation. These results are consistent with the findings of a study that reported that early mobilization increases bowel activity.[10] In another study, it was noted that patients mobilized within 4 h after surgery experienced earlier defecation and accelerated

gastrointestinal motility.[16,21] This indicates that early mobilization plays an important role in the normalization of post-operative bowel functions.

According to the results in the literature, early mobilization has been shown to not only improve physiological recovery but also enhance patient comfort and quality of care. Nurses play a key role in ensuring the safe implementation of early mobilization and motivating patients in the post-operative period.[5,16,19,20] Therefore, early mobilization should be planned as a standard nursing practice in the post-operative care of neurosurgery patients.

Limitations

Although the study was initially planned to include 203 participants, data could be collected from 178 individuals, which may have slightly reduced the statistical power of the findings. Since the study was conducted in a single center, the generalizability of the results is limited. Moreover, mobilization was evaluated as a single ERAS component; other multimodal interventions such as early oral hydration, chewing gum, or analgesia optimization were not assessed. The lack of a standardized institutional mobilization protocol may also have introduced variability in clinical practice. As this was a descriptive study, controlled or comparative analyses (e.g., ERAS vs. non-ERAS groups or early vs. delayed mobilization groups) could not be performed. Future randomized or controlled studies with standardized mobilization pathways and comprehensive ERAS components are recommended to better evaluate causal effects and to obtain more comparable post-operative outcomes. In addition, close monitoring of clinical indicators such as flatus, stool passage, defecation frequency, oral fluid intake, nausea, vomiting, and abdominal distension remains crucial for accurately supporting postoperative gastrointestinal recovery.

Conclusion

This research demonstrates that initiating mobilization soon after neurosurgical procedures significantly accelerates the return of bowel activity. The results emphasize that the timing of the first mobilization, rather than chronic comorbidities, is the primary factor affecting post-operative bowel recovery. Integrating structured early mobilization into nursing care not only promotes physiological recovery but also enhances patient comfort and reduces potential complications.

Based on the study findings, it is recommended that nurses assess patients' neurological and hemodynamic status early after surgery and initiate progressive mobilization within the first 24 h when clinically appropriate. Nurses should regularly monitor bowel sounds, flatus, abdominal distension, and fluid intake/output as indicators of gastrointestinal recovery. Mobilization should be individualized according to patient tolerance, and all sessions should be documented in a standardized manner. Providing patient education regarding the benefits of early mobilization and offering psychological support may also enhance adherence and improve postoperative outcomes.

Encouraging patients to ambulate as early as their clinical condition allows should be considered a standard component of postoperative nursing practice. Consistent implementation of ERAS-based mobilization protocols may shorten hospital stays, improve patient satisfaction, and contribute to safer and more effective surgical recovery.

Disclosures

Ethics Committee Approval: The study was approved by the Bursa Uludağ University Faculty of Medicine Ethics Committee (no: 2023-16/15, date: 01/08/2023).

Informed Consent: Written informed consent was obtained from all participants before data collection.

Conflict of Interest Statement: All authors declared no conflict of interest.

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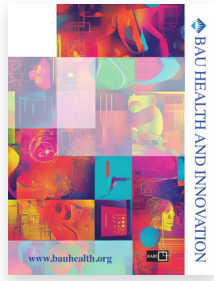

Invited Review

Orthopedic Problems and Fall Risk in Older Adults: Innovative Preventive Approaches

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Abstract

Falls are a significant health issue for older adults. They can lead to injuries, disabilities, loss of independence, and higher healthcare costs. Orthopedic issues such as osteoarthritis, osteoporosis, fractures, joint replacements, spinal deformities, and foot disorders significantly increase the risk of falling. These conditions can cause pain, limit mobility, reduce proprioception, and affect balance. This creates a cycle of immobility and repeated falls, which shows the need for effective prevention methods. Traditional approaches, including exercise programs, medication, nutritional support, environmental changes, and assistive devices, continue to be vital in preventing falls. However, new technology offers fresh ways to address the complex problem of falls in older adults. Wearable sensors with inertial measurement units can continuously track walking and balance. This allows for early detection of risks and timely preventive actions. Robotics and exoskeletons provide targeted training and support, especially after orthopedic surgeries. Virtual and augmented reality tools create engaging balance training that boosts motivation and lowers the fear of falling. Tele-rehabilitation and mobile health applications offer personalized care at home, while artificial intelligence and predictive analytics provide tailored risk assessments and proactive solutions. Smart home and assisted living technologies also help by reducing hazards and providing immediate fall alerts. Fall prevention can evolve from clinic-based methods to continuous, personalized, and technology-driven strategies. These combined approaches show great potential for lowering fall-related issues, supporting independence, and improving the quality of life for the growing elderly population.

Keywords: Accidental falls, orthopedic procedures, telemedicine, wearable electronic devices.

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The global population is aging quickly, creating challenges for healthcare systems worldwide.[1] Falls are one of the most serious health issues for older adults. They are a major cause of injuries, disabilities, loss of independence, and even death.[2] Studies show that about one in three people over 65 experiences at least one fall each year. A significant number of these falls result in hospitalization or a need for long-term care.[2,3] Beyond individual impacts, falls create substantial economic and social burdens for families and healthcare systems.[4] In the United States, healthcare costs linked to non-fatal falls among older adults reached around $80 billion in 2020. Between 2016 and 2018, there were nearly 922,000 hospital stays and 2.3 million emergency department visits due to falls.[4] In addition, falls lead to indirect societal burdens such as long-term care needs, strain on informal caregivers, loss of independence, and a decreased quality of life.[3,5] Beyond musculoskeletal conditions, other

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well-established risk factors such as multimorbidity and adverse drug interactions are also highly prevalent among older adults and further increase their vulnerability.[6] It is important to acknowledge that multimorbidity and drug interactions may also play a role in increasing fall risk and can indirectly worsen orthopedic outcomes in older adults. Orthopedic conditions significantly contribute to the risk of falls in older adults. Severe knee osteoarthritis can almost double the chance of falling due to pain, stiffness, limited mobility, and reduced proprioception.[7,8] Osteoporotic fractures, especially in the hip and spine, worsen disability and contribute to cycles of immobility and repeated falls.[9] Moreover, balance and walking problems following orthopedic surgery can extend rehabilitation and increase the risk of falls, highlighting the importance of orthopedic health in fall prevention.[10]

Given the multiple factors involved in falls, prevention strategies need to go beyond treating single issues. Evidence supports using comprehensive approaches, including exercise programs to improve strength and balance, medication and nutrition for osteoporosis, environmental adjustments, and assistive devices to reduce fall risk.[10,11] Recently, innovative methods such as wearable sensors, tele-rehabilitation, and robotic therapies have gained attention for their potential to enhance fall prevention for older adults with orthopedic disorders.[12] However, practical barriers such as high initial costs, limited accessibility in rural or resource-constrained areas, and usability challenges for older adults may limit the widespread adoption of these technologies in clinical practice.[13] In particular, low digital literacy has been identified as a major barrier, since many older adults face difficulties in operating digital devices, navigating applications, and maintaining confidence in technology use without additional support.[13] Physical limitations, lack of technical support, and affordability issues further restrict technology adoption in aging populations.[14] In addition, inequities in infrastructure and access have been reported as significant challenges in implementing telehealth and tele-rehabilitation services.[15] Addressing these issues is essential to ensure that innovative solutions can be effectively implemented alongside traditional strategies.

This review aims to summarize the current evidence on the link between orthopedic problems and fall risk in older adults while highlighting both traditional and innovative prevention strategies that can help reduce falls in this growing population. To ensure a broad and balanced overview, we searched PubMed, Scopus, and Web of Science for studies published in English up to 2025, using combinations of terms such as "falls," "older adults," "orthopedic problems," "wearable technologies," "tele-rehabilitation," "virtual reality," "exoskeletons," and "artificial intelligence." Additional relevant studies were identified by screening the reference lists of key articles.

Orthopedic Problems and Their Contribution to Fall Risk

Orthopedic issues are among the key contributors to falls in older adults. Osteoarthritis in the hip and knee can limit joint movement, change how a person walks, and increase instability due to pain, stiffness, and impaired proprioception.[7] Osteoporosis and fragility fractures, particularly in the hip and spine, worsen immobility and create a cycle of disability and repeated falls.[9] Surgical procedures such as total hip and knee replacements can restore function but may lead to muscle weakness, balance issues, and walking difficulties that keep the risk of falling high during recovery.[10] Similarly, spinal deformities such as kyphosis and scoliosis can affect posture and stability, while foot and ankle issues like hallux valgus or flatfoot can disrupt weight distribution and impair balance when walking.[16,17]

The reasons behind these associations are varied. Pain, stiffness, and restricted movement reduce mobility and independence, while issues with body awareness affect muscle control. In addition, loss of muscle mass or weakness can further reduce stability when moving. Changes in posture due to altered body mechanics and compensatory movements increase the likelihood of falling across different orthopedic conditions.[18] Together, these challenges show how crucial orthopedic health is in determining fall risk among older adults.

Innovative Preventive Strategies

Wearable Technologies and Sensor-Based Monitoring

Wearable technologies and sensor-based monitoring systems have become valuable tools for assessing and reducing fall risk in older adults. Devices equipped with inertial measurement units (IMUs), including accelerometers, gyroscopes, and magnetometers, can objectively quantify static and dynamic balance, gait speed, step length, and postural sway. Studies have demonstrated that smartphone-embedded IMUs and wearable sensors show moderate to strong correlate with gold standard laboratory systems, such as force plates and motion capture, in evaluating balance and mobility.[12]

In addition to smartphones, wearable sensors placed on the lower back, sternum, or within smart insoles have proven reliable for continuously monitoring walking and balance in everyday environments. These sensor-based systems are capable of capturing subtle spatiotemporal gait parameters such as stride variability, postural sway, and asymmetries that are often undetectable through conventional clinical assessments.[19,20] By detecting early deviations in mobility patterns, these technologies facilitate timely identification of older adults at increased risk of falls, allowing for preventive interventions before serious injuries occur.[21] Recent prospective study has further demonstrated the utility of wearable sensors in fall-risk prediction. Howcroft et al.[22] developed fall-risk classification models based on accelerometer and pressure insole data collected during single- and dual-task walking in 75 older adults and showed that multi-sensor neural network models could achieve moderate accuracy (57%) and specificity (65%) for predicting prospective falls. These findings highlight the feasibility of using wearable sensors for point-of-care fall-risk assessment in real-world clinical settings.

In addition to risk assessment, smart insoles and inertial sensors have been adapted for fall detection and alarm systems that can differentiate between actual falls and normal activities. They can send real-time alerts to caregivers or healthcare providers.[23] This integration of monitoring, prediction, and emergency response represents a significant shift in how to support the safety and independence of older adults living in the community. Overall, these advancements show how wearable sensors improve clinical evaluations and everyday fall prevention efforts for older populations.[12]

Importantly, sensor-based monitoring allows for longitudinal tracking of mobility, enabling clinicians to identify trends over time and tailor interventions accordingly. By changing fall risk assessment from clinic-based evaluations to continuous monitoring in real life, wearable technologies promise proactive and tailored fall prevention approaches. However, barriers such as device cost, the need for technical support, and limited digital literacy among older adults may restrict widespread use of wearable monitoring in daily practice.[14]

Robotics and Exoskeletons

Robotics and exoskeletons have become important tools for preventing falls in older adults, especially in relation to orthopedic disorders and age-related decline in function. Unlike typical physiotherapy, robotic-assisted gait training offers repetitive, specific movements that help with learning motor skills, strengthen the muscles in the lower limbs, and improve postural control.[24,25] Recent systematic reviews and clinical trials show that robotic rehabilitation can significantly improve walking speed, step length, gait symmetry, and balance in older people.[24,26] In particular, robotic exoskeletons have shown potential in speeding up recovery after hip and knee surgeries, where the risk of falling is high due to postoperative pain, limited mobility, and impaired proprioception.[27] Meta-analyses further support the use of wearable robotic devices such as hip-assist exoskeletons and motorized gait trainers in reducing energy expenditure during ambulation and enhancing long-term walking efficiency.[27,28] Overall, these findings suggest that robotics and exoskeletons are not only effective rehabilitation tools but also strategies to prevent falls, allowing older adults to maintain their independence and mobility while reducing orthopedic complications.

Exoskeletons and robotic orthoses provide external support that helps frail or sarcopenic individuals safely perform walking and balance exercises that might otherwise lead to falls.[24,29] These devices can help reduce compensatory movement patterns and support weight-bearing during ambulation, promoting safer and more efficient gait mechanics.[28] They have also proven especially useful for encouraging early mobilization after orthopedic surgeries like hip or knee arthroplasty, when the risk of falling is still elevated during recovery.[26,27] Importantly, robotic systems not only offer mechanical assistance but also provide objective feedback and real-time monitoring of gait parameters, allowing clinicians to use performance data in personalized rehabilitation plans.[30]

While cost and accessibility remain major challenges, progress in lightweight materials, portable exoskeletons, and at-home robotic training systems is making wider clinical use more feasible.[31,32] By enabling safe, intensive, and tailored rehabilitation, robotics and exoskeletons hold great promise for preventing falls and restoring mobility in older adults. Despite these benefits, the high initial costs of robotic systems and the complexity of their operation remain major barriers to adoption, particularly in resource-constrained settings.[15]

Virtual Reality (VR) and Augmented Reality (AR)

VR and AR technologies are increasingly being explored as innovative approaches to improve balance and reduce fall risk in older adults. Recent meta-analyses show that VR-based interventions can significantly enhance balance, walking performance, and mobility, even for community-dwelling older adults without neurological disorders.[33]

VR provides immersive and interactive environments that let individuals practice challenging balance and gait tasks safely, while also addressing fears of falling and improving reaction times.[34] AR interventions are gaining popularity as well; systematic reviews indicate that AR balance training effectively boosts mobility, postural stability, and reduces fall risk, providing a more engaging and accessible alternative to regular exercise programs.[35] By stimulating multisensory feedback and promoting motor learning through repetitive, game-like tasks, VR and AR enhance not just balance but also confidence and long-term independence in older adults.[36] Randomized controlled trials have shown that VR-based training improves balance and mobility in older adults at risk of falls, with significant gains in Berg Balance Scale and Timed Up and Go scores.[33] In individuals with knee osteoarthritis, VR exercise programs have been found to reduce pain and improve Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC) total and pain scores. They also enhance quadriceps and hamstring strength and support postural stability, although effects on stiffness and overall physical function remain inconsistent.[37]

The interactive and gamified features of VR and AR platforms boost patient engagement and adherence to rehabilitation programs, often exceeding traditional exercise methods in motivation and enjoyment.[38] Recent reviews highlight that gamification elements like performance feedback and rewards enhance motivation and compliance among older adults involved in fall-prevention programs.[39] Although there are still challenges around access, equipment costs, and the need for tailored program designs, VR and AR in fall-prevention strategies show great promise for improving functional outcomes and quality of life in older adults.[40] By combining engagement with clinical effectiveness, these technologies are paving the way for the integration of gamified interventions into mainstream fall-prevention strategies. Although challenges remain regarding accessibility, equipment costs, and the need for tailored program design, the integration of VR and AR into fall-prevention strategies represents a promising frontier for enhancing functional outcomes and quality of life in older adults.[41] These practical limitations, including usability issues and adaptation challenges in older adults, have been noted as important barriers to their widespread integration into rehabilitation programs.[42]

Tele-Rehabilitation and Mobile Health (mHealth) Applications

Tele-rehabilitation and mHealth applications have emerged as affordable and accessible options to support fall prevention in older adults.[43] Through video conferencing, smartphone apps, and remote monitoring systems, older individuals can engage in supervised exercise programs and get personalized feedback without frequent clinical visits.[44] This method is especially helpful for those with orthopedic conditions or limited mobility, as traveling to rehabilitation centers can be difficult or unsafe.[45]

mHealth platforms can record physical activity, gait data, and balance performance with built-in sensors while offering reminders, educational information, and progress monitoring.[46] Studies suggest that tele-rehabilitation methods, like remote-guided balance and strength training, work as effectively as traditional in-person therapy for improving functional outcomes and reducing fall risk.[44] In addition, mobile applications often use gamification and interactive features, which may increase patient engagement and adherence to prescribed exercises.[38]

By bridging the gap between clinical care and home practice, tele-rehabilitation and mHealth tools enable ongoing, personalized fall prevention strategies. Their scalability and ability to work with wearable or smart home technologies offer the potential for comprehensive and sustainable rehabilitation models for older adults at risk of falling.[43]

Evidence from clinical trials highlights the effectiveness of tele-rehabilitation in orthopedic populations. In a randomized controlled trial of patients with knee osteoarthritis, a 4-week program of remote physiotherapy sessions delivered 3 times/week produced outcomes comparable to conventional outpatient therapy, with significant reductions in pain, improvements in WOMAC scores, and better quality of life in several SF-36 domains (physical functioning, role limitation, energy, and pain) at 3-month follow-up.[47] These findings suggest that tele-rehabilitation can be safely and effectively incorporated alongside traditional therapy in managing knee osteoarthritis. Furthermore, a systematic review and meta-analysis including six randomized controlled trials (n=734) found that telerehabilitation strategies were more effective than usual care in reducing pain, although improvements in physical function were not statistically significant.[48] Collectively, these results indicate that while tele-rehabilitation consistently alleviates pain in knee osteoarthritis, its effects on physical function may vary depending on program design, duration, and patient characteristics. Although tele-rehabilitation increases accessibility, digital inequities, limited internet infrastructure, and ethical concerns about equitable access remain significant challenges for older adults.[15]

Table 1. Summary of innovative technologies for fall prevention in older adults

Technology	Reported benefits	Key limitations
Wearable sensors	Early fall risk detection, continuous monitoring, real-time alerts, objective gait/balance data[19–23]	Device cost, need for technical support, and limited digital literacy[14]
Robotics and exoskeletons	Improves gait speed, symmetry, postural control; supports early mobilization[24–28]	High cost, limited accessibility, complexity of use[15]
Virtual and augmented reality	Enhances balance, reduces fear of falling, and gamified training increases adherence[33–37]	Equipment cost, usability/adaptation issues in older adults[40–42]
Tele-rehabilitation and mHealth	Provides remote access, personalized feedback without clinical visits, improves pain and quality of life[43–48]	Internet access required, digital inequities, variable effects on function[15]
Artificial intelligence and predictive analytics	Personalized risk profiling, early identification of high-risk patients, tailored interventions[49–51]	Data privacy, integration challenges in clinical workflow[52]
Smart home and ambient assisted living systems	Fall detection and alerting reduce environmental hazards, support independence at home[53–56]	Cost, digital literacy, privacy concerns[56]

Artificial Intelligence (AI) and Predictive Analytics

AI and predictive analytics are increasingly being used in fall prevention, allowing for highly personalized and proactive care for older adults with orthopedic conditions. By examining large datasets from wearable sensors, gait assessments, electronic health records, and imaging studies, AI algorithms can identify subtle patterns that may precede falls and create individual risk profiles.[49] This helps clinicians detect high-risk patients sooner and apply targeted interventions to prevent falls. Machine learning models have shown good accuracy in predicting falls by combining factors like variability in gait, balance metrics, medication use, and other health issues.[50] For orthopedic patients, such as those with osteoarthritis or recovering from joint replacement surgery, AI systems can adjust predictions based on any changes in mobility or rehabilitation progress.[51] Predictive models also allow for remote monitoring and support, aiding healthcare providers in optimizing exercise plans, modifying medications, and efficiently allocating rehabilitation resources.[51]

Despite challenges around data privacy, algorithm transparency, and fitting into clinical workflows, AI-driven predictive analytics offer a groundbreaking way to prevent falls. By shifting focus from reactive to preventive care, these technologies have the potential to enhance safety, independence, and quality of life for older adults at risk of falling.[52]

Smart Home and Ambient Assisted Living (AAL) Technologies

Smart home systems and AAL technologies are becoming essential tools for preventing falls and improving safety for older adults. These systems use motion sensors, pressure mats, and video monitoring to identify unusual movement patterns or potential falls in the home. They automatically alert caregivers or healthcare providers to ensure timely help and minimize complications from delayed medical care.[53,54] In addition, smart home technologies help prevent falls by tackling environmental risks. Features such as automated lighting, obstacle detection, and voice-controlled assistants reduce common hazards such as poor visibility and cluttered pathways.[55] Integration with wearable devices and tele-rehabilitation platforms allows for ongoing monitoring of mobility and physical activity, offering a complete approach to fall prevention.

Importantly, AAL technologies focus on independence and quality of life. They enable older adults to stay safely in their homes while lowering the need for institutional care and easing the burden on caregivers.[31] However, barriers such as cost, digital literacy, and privacy concerns can slow down adoption. Advances in user-friendly design and affordability are making smart home solutions more available and acceptable to older populations.[56] A summary of the innovative technologies, their reported benefits, and limitations is provided in Table 1.

Limitations

This narrative review is not a systematic analysis, so some relevant studies may have been left out. Furthermore, much of the evidence on new technologies is still developing, with differences in study designs, populations, and outcomes. These factors may limit how broadly the findings can be applied, highlighting the need for more high-quality research.

Conclusion

Falls remain to be a major health issue for older adults. Orthopedic conditions such as osteoarthritis, osteoporosis, fractures, joint replacements, spinal deformities, and

foot disorders significantly increase vulnerability. These disorders result in pain, limited mobility, balance issues, and postural instability, creating a cycle of immobility and repeated falls. Traditional prevention strategies, such as exercise programs, medication management, and environmental changes, are still important but may not fully address the complexities of fall risk in this group.

Recent technological advancements, including wearable sensors, robotics, virtual and AR, tele-rehabilitation, AI, and smart home systems, show great potential for preventing falls among older adults. These tools allow for continuous monitoring, customized rehabilitation, engaging training, and safer home settings. By moving beyond traditional clinic-based methods, they provide new opportunities to promote independence, reduce injuries, and enhance quality of life for older populations.

Future Perspectives

The future of fall prevention for older adults relies on integrating innovative tools such as wearable sensors, AI, robotics, VR/AR, and smart home systems to provide ongoing monitoring and personalized care. Challenges such as cost, digital literacy, and privacy still need to be addressed. However, with user-focused design and robust clinical evidence, technology-driven, multidisciplinary approaches have great potential to lower fall risk and boost quality of life for aging populations.

In addition to the growing evidence of effectiveness, pilot applications and preliminary experiences suggest potential pathways for integrating these technologies into practice. For example, community-based VR programs may offer a feasible and engaging approach for older adults, while tele-rehabilitation models could provide accessible home-based care for conditions. Similarly, exoskeleton-assisted recovery after joint replacement has been explored as a way to support early mobilization. These emerging applications remain preliminary but point to possible directions for wider adoption, even in resource-constrained healthcare settings.

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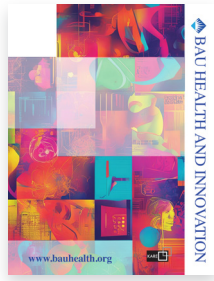

Review

Factors Affecting International Nurse Migration: A Systematic Review

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Abstract

This systematic review was planned to systematically examine the factors affecting international nurse migration. The study population consisted of 290 articles accessed by searching the cumulative index to nursing and allied health literature, PubMed, Cochrane, and Scopus databases between January 2019 and April 2024. Articles that were published between specified dates, whose publication language was Turkish or English, whose sample was nurses, and whose full text could be accessed were selected for sampling. The date of access to the data study was May 20, 2024. Three studies included in the study were cross-sectional, three were qualitative, and two were mixed-method. Nurse migration is caused by opportunities abroad, where 23.82% of participants expressed interest; job insecurity and escape from unemployment affect 8.68% of participants; economic factors also play an important role and affect a total of 8.43% of participants; and career advancement expectations affect 6.31% of participants. Findings of the study, which focused only on nursing professionals, shed light on the important factors that drive migration decisions in this demographic group. Main factors are the search for better career opportunities, living standards, and efforts to reduce job insecurity and unemployment. Economic concerns and desire for career advancement also emerged as noteworthy motivations.

Keywords: Brain drain, nurse immigrant, nurse migration, pushing and pulling force.

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Migration can be fundamentally defined as the movement of individuals from one place to another due to economic, social, or political reasons. Brain drain, however, typically entails migrating an educated, skilled, and qualified workforce from their places of origin to destinations offering better working and living conditions. While brain drain represents a significant loss of talent and knowledge for source countries, it can bring about knowledge and innovation for destination countries. Brain drain poses a considerable challenge for source countries, resulting in a depletion of the talent pool and knowledge scarcity. Conversely, it allows destination countries to harness new knowledge and innovation potential.[1] The migration rate has persisted throughout human history, albeit fluctuating at times due to various social factors. It has neither ceased nor disappeared completely, despite occasional increases or decreases influenced by historical events.[2]

The mobility of the workforce and international migration within the healthcare sector predominantly consists of educated nurses. Nurses often seek better working conditions and job opportunities, prompting them to

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move to other countries. In this context, an examination of preferred destination countries reveals that the United States holds a leading position, followed by the United Kingdom and Germany.[3]

Government policies play a significant role in shaping migration processes, so it's important to carefully assess how nurse workforce migration is managed. In this regard, an analysis of the Sustainable Development Goals shows that they seek to implement well-planned and well-managed migration policies, as well as to improve health financing and build up the health workforce in developing countries. In this context, nurse migration can lead to a loss of the healthcare workforce in source countries, negatively impacting the sustainability of health services. Therefore, policies and programs should be developed to mitigate the effects of nurse migration in source countries. This could involve promoting the education and development of the healthcare workforce, improving working conditions, and encouraging nurses to remain in their home countries.[4]

Based on a projection model developed to estimate the demand for doctors and nurses in 2030, taking into account factors such as per capita income, out-of-pocket health expenditures, and population aging, a shortage of approximately 2.5 million nurses is expected in 23 Organisation for Economic Co-operation and Development (OECD) countries.[5]

The phenomenon of international nurse migration has emerged as a significant aspect of the global health service workforce dynamics. Educated nurses often migrate from home to destination countries for better working conditions, labor market opportunities, and professional prospects.[6] This trend profoundly affects both source and destination countries as they grapple with resource and service shortages, ultimately impacting the delivery of health systems and essential services.

Source countries are typically characterized by resource and service inadequacies, and the migration of educated nurses exacerbates these existing challenges, creating gaps in healthcare services and hindering progress toward universal health coverage. Furthermore, the loss of healthcare professionals impedes the sustainability of healthcare services in underdeveloped regions with already limited access to quality care. Therefore, OECD countries have employed various strategies to attract internationally educated nurses for years, including active international recruitment campaigns, bilateral state agreements, favorable immigration regulations, and foreign qualification recognition policies aimed at successful integration.[7]

Government policies and international agreements play a critical role in shaping the dynamics of nurse migration. Efforts to regulate migration flows and address workforce imbalances necessitate a comprehensive understanding of the drivers and outcomes of nurse migration.[8]

Sustainable development goals underscore strengthening health systems and investment in the healthcare workforce to ensure equitable and sustainable provision of healthcare services worldwide.[9]

Given all these considerations, there is an urgent need for research and policy interventions to mitigate the negative impacts of nurse migration on source countries and to ensure ethical recruitment practices and fair distribution of healthcare professionals. By addressing the root causes of nurse migration and promoting collaboration between source and destination countries, it is possible to strengthen global health systems and advance the health and well-being of communities worldwide by harnessing the potential of international nurse migration.

Methods

Objective and Review Questions

The objective of this study is to consolidate the diverse reasons behind international nurse migration and their practical implications into a single document. By synthesizing this information, the study aims to propose actionable solutions to mitigate the adverse effects experienced by source countries. In doing so, it seeks to address a notable gap in the existing literature by providing concrete references to practical implications that can be adopted in the field. As a result of this systematic review, answers to the following three questions were sought;

- What factors influence international nurse migration?
- Do factors influencing international nurse migration vary across countries?
- What kinds of differences in factors affecting international nurse migration exist between countries?

Materials and Methods

Based on document analysis of articles, this systematic review encompasses studies published in national and international literature between January 2019 and April 2024. International literature recommends that systematic reviews (research report writing) adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement: Checklist of items to include when reporting a systematic review or meta-analysis. The researchers utilized the PRISMA statement checklist for their screening process.[10]

Screening Strategy

The literature search was conducted between January 2019 and April 2024. These dates were selected to include literature addressing the impacts of the pandemic that began in 2019. The first step of the research was to develop search terms to identify the critical variables related to the reasons for nurse migration. The keywords included "nursing emigration," "push and pull factors," and "brain drain," and searches were conducted using Boolean operators across PubMed, Scopus, Cumulative Index of Nursing and Allied Health Literature (CINAHL), and Cochrane databases.

To reduce the risk of potential bias in this systematic review, the obtained studies were reviewed at least twice, with titles and abstracts screened by two independent researchers. They evaluated, discussed, and reached a consensus on including studies. Full-text copies of the articles deemed suitable for inclusion were saved. After reassessing the full texts for inclusion criteria, an article selection form was completed, and a methodological quality assessment was conducted.

Selection Criteria and Study Selection

This systematic review formulated the research question within the PICO framework.[11]

Population: nurses, exposure: migration phenomenon, comparison: not mandatory (NONE), outcome: factors influencing migration, design: it has been determined that both qualitative and quantitative studies will be included in the analysis.

Inclusion Criteria

Research design is being qualitative and quantitative (including randomized controlled trials, quasi-experimental studies, and controlled descriptive studies) published in national and international peer-reviewed scientific journals.

- Published in Turkish or English
- Research published within the specified dates
- It was writing an original research article
- A sample consisting of nurses.

Exclusion Criteria

- Reviews
- Book chapters
- Unpublished thesis works
- Unpublished master's and doctoral theses were omitted and referred to as gray literature
- Studies where the sample consisted only of migrants, midwives, or nursing students.

Methodological Quality Assessment

The articles deemed eligible for inclusion were subjected to a Joanna Briggs Institute (JBI) quality appraisal.[12] By the findings, studies achieving ratings of "strong" and "moderate" on the scoring scale were deemed eligible for inclusion in the research.

The evaluation criteria used in the assessment tools are rated on a scale between 1 and 0 points. As the assessment score increases, it is accepted that the quality of the article increases.

The literature search yielded 290 studies (PubMed: 135, Cochrane: 16, CINAHL: 51, and Scopus: 88). These 290 studies were initially screened based on their titles, followed by screening based on their abstracts. Studies that did not meet the inclusion criteria and those that were duplicates were excluded, resulting in 56 studies for detailed examination. After this examination, 48 studies were excluded from the scope of the research for various reasons: not meeting the inclusion criteria (10 studies), receiving a "low" score in quality assessment (12 studies), not focusing on the migration factor in the outcome parameter (8 studies), not having a sample consisting of nurses (5 studies), and focusing on post-migration experiences (13 studies). The sample for the review consisted of eight studies. The PRISMA statement was used to create the research protocol and write the article in Figure 1.

Literature Search Tools

During the literature search, the "Research Article Selection Form" was utilized. This form includes the following fields: evaluating author, author of the article, journal name, date, title, participants, study design, final outcome, and notes (Appendix 1).

Statistical Analysis

Due to the lack of homogeneity in the obtained data, conducting a meta-analysis was not feasible. Instead, the data were presented in tabular form. However, combined calculations of common findings related to specific outcomes were performed as percentages in the studies included in the systematic review.

Ethical Approval

Since the study was conducted using openly accessible databases and search engines, it did not require ethical approval from an ethics committee. Our study was conducted using research and publication ethics.

Study Team

The study team comprises two academics with doctoral and specialization degrees in nursing management and

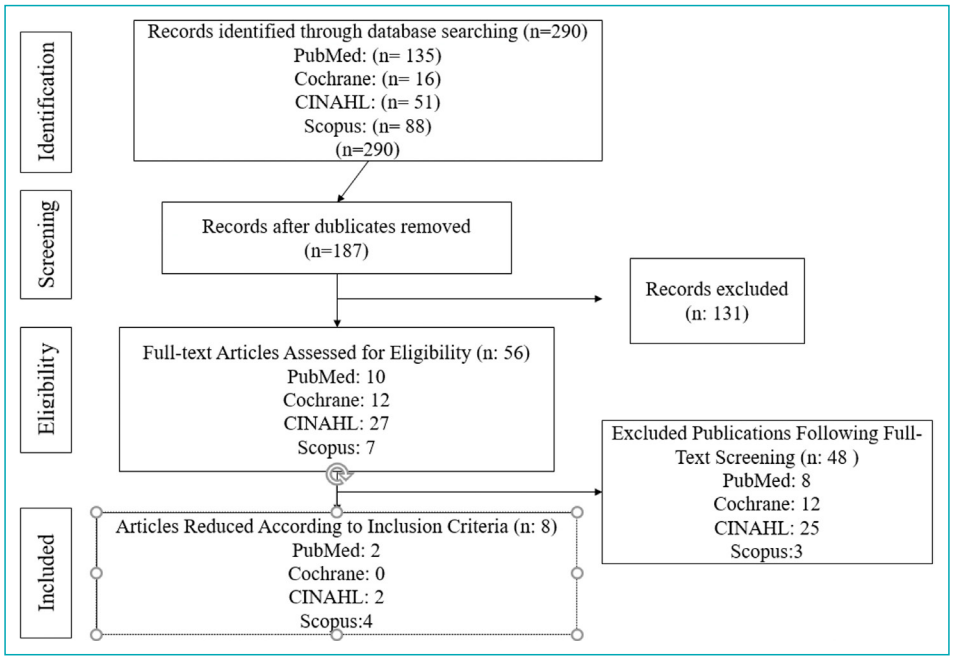

Figure 1. Flow diagram.

principles. The team, comprised of experts in the field, has previously published a report on a similar topic. The roles are divided into a literature search and review team.

Results

Features of the Studies

A comprehensive body of research spanning various regions delves into the multifaceted motivations driving nurses' migration patterns and their implications for source and destination countries' healthcare systems. In Indonesia, sociocultural determinants influencing Indonesian nurses' decisions to remain in their home country were explored.[13] They identified factors such as marital status, educational opportunities, career advancement prospects, and societal perceptions as pivotal considerations. Challenges emerged as significant influencers, including inadequate non-monetary support mechanisms in the workplace, a sense of disconnection, and spouses' overseas employment. In the UK, migration trends among Spanish nurses were examined, highlighting motivations such as escaping job insecurity, seeking professional validation, and pursuing enhanced life stability.[14]

Similarly, the impact of nurses on Nigeria's healthcare system was investigated, emphasizing factors such as career progression prospects, improved working conditions, and educational opportunities as key drivers for migration.[15] Delving into the experiences of Filipino nurses migrating to Norway, Nortvedt et al.[16] suggested that the selection of migration destinations is often influenced by chance and lucrative employment opportunities. Gea-Caballero et al.[17] explored Spanish nurses' migration motivations, revealing the significant roles played by employment uncertainty and aspirations for professional growth. Hashish and Ashour examined brain drain among Egyptian nurses in Spain, highlighting economic factors and workplace conditions as primary determinants.[18] Ulupinar et al.[19] investigated Turkish nurses' attitudes toward brain drain, emphasizing the allure of opportunities abroad and dissatisfaction with local working conditions. Finally, a study in Ghana underscored factors such as rising education costs, suboptimal healthcare systems, and institutional shortcomings as drivers of specialized nurses' migration intentions.[20] These studies provide critical insights into the nuanced interplay of economic, social, and professional factors shaping nurses' migration decisions globally, emphasizing the need for targeted interventions to address underlying issues and retain healthcare talent in source countries. The characteristics of the included studies are presented in Appendix 1.

Methodological Quality Assessment Results

Based on the JBI's evaluation tools, the methodological quality assessment results relied on ten references for observational reporting. Within this framework, three qualitative studies, five cross-sectional studies, and two mixed-method studies were evaluated. The qualitative studies received high scores, averaging 9 points out of

Table 1. Methodological quality table

Author	Criteria 1	Criteria 2	Criteria 3	Criteria 4	Criteria 5	Criteria 6	Criteria 7	Criteria 8	Criteria 9	Criteria 10	Criteria 11	Quality rating
Hamid et al. (2023)[13]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Rodriguez-Arrastia et al. (2021)[14]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	No	Yes	9
Olorunfemi et al. (2020)[15]	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	NA	NA	6
Nortvedt et al. (2020)[16]	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
Gea-Caballero et al. (2019)[17]	Yes	Yes	No	No	Unc	Unc	No	Unc	Yes	NA	NA	4
Hashish and Ashour (2020)[18]	Yes	Yes	Yes	Unc	Yes	Yes	Yes	Yes	Yes	Yes	Yes	10
(Qualitative criteria)												
(Cross-sectional criteria)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA	8
Ulupinar et al. (2024)[19]	Yes	Yes	Yes	Unc	Yes	Yes	Yes	Yes	Yes	Unc	Yes	10
(Qualitative criteria)												
(Cross-sectional criteria)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	NA	NA	8
Poku et al. (2021)[20]	No	Yes	Yes	Yes	Yes	No	Yes	Yes	NA	NA	NA	6

10 (10, 9, and 10). In contrast, the cross-sectional studies received moderate scores, averaging 5.3 points (6, 4, and 6). Studies utilizing mixed methods were scored based on cross-sectional and qualitative criteria, with an overall score of 20 considered high (18, 18). The methodological evaluation results of the studies are presented in Table 1.

Characteristics of Included Studies for Analysis

This systematic review included eight studies conducted between 2019 and 2024, covering the causes of nurse migration in Turkish and English. It was observed that three of the studies were cross-sectional, three were qualitative, and two utilized mixed methods. These studies collectively involved 2744 nurses and 52 managers, reaching 2796 participants. The distribution of these participants is as follows: 233 participants in the study conducted in Indonesia (52 managers and 181 nurses), 371 nurses in the study conducted in the UK, 270 nurses in the study conducted in Nigeria, 10 Filipino nurses in the study conducted in Norway, 172 nurses in the study conducted in Spain, 360 participants in the study conducted in Egypt (325 cross-sectional and 35 qualitative), 1018 nurses in the study conducted in Turkey, and 225 nurses in the study conducted in Ghana. The distribution of total participants by country is presented in Figure 2.

Implications for Factors Affecting Nurse Migration

Factors influencing nurse migration are diverse and often complex. Regarding motivations, 8.68% of participants (371 participants) preferred to migrate to the UK to escape job insecurity and unemployment, whereas 6.31% (270 participants) opted for Nigeria due to career advancement expectations. Only 0.23% (10 participants) chose Norway to seek better life stability, whereas 4.03% (172 participants) migrated to Spain due to employment insecurity or absence, and an equal percentage for professional development. 8.43% (360 participants) selected Egypt for economic reasons, whereas 23.82% (1018 participants) preferred Turkey for opportunities abroad. Finally, 5.27% (225 participants) chose to migrate from Ghana due to issues within the healthcare system and adverse patient health outcomes. The distribution of factors affecting nurse migration among participants is presented in Table 2.

Combined Distribution of Factors Influencing Nurse Migration

Factors influencing nurse migration were examined based on data obtained from various studies. One of the most significant factors affecting migration was opportunities abroad, accounting for 23.82% of total participants. The second most prevalent factor was escaping job insecurity

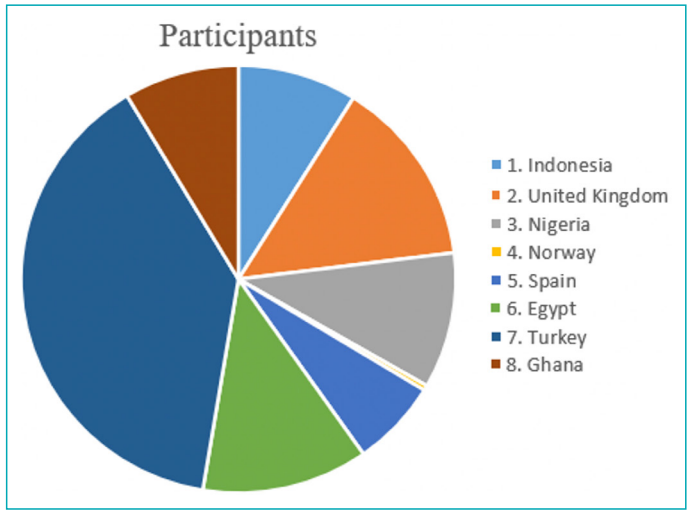

Figure 2. The distribution of total participants by country.

Table 2. Distribution of factors affecting nurse migration among participants

Distribution of factors affecting nurse migration	Participants
Escaping job insecurity and unemployment	371 (United Kingdom)
Career advancement expectations	270 (Nigeria)
Seeking better life stability	10 (Norway)
Employment insecurity or absence	172 (Spain)
Professional development:	172 (Spain)
Economic reasons	360 (Egypt)
Opportunities abroad	1018 (Turkiye)
Healthcare system challenges and adverse patient health outcomes	225 (Ghana)

Table 3. Combined distribution of factors influencing nurse migration

Factors affecting nurse migration	Combined %
Opportunities abroad	23.82 (1018/4271*100)
Escaping job insecurity and unemployment	8.68 (371/4271*100)
Economic reasons	8.43 (360/4271*100)
Expectation of career advancement	6.31 (270/4271*100)
Healthcare system and adverse health outcomes	5.27 (225/4271*100)
Lack of employment or insecure employment	4.03 (172/4271*100)
Professional development	4.03 (172/4271*100)
Pursuit of a better life stability	0.23 (10/4271*100)

and unemployment, affecting 8.68% of participants. Economic reasons were also a significant factor influencing migration decisions, affecting 8.43% of total participants. Career advancement expectations were another factor, influencing 6.31% of those considering migration. Healthcare system challenges and adverse patient health outcomes also had an impact, affecting 5.27% of participants. Other factors included employment insecurity or absence and professional development, both at 4.03%. Seeking better life stability was one of the least influential factors, affecting only 0.23% of participants. The combined distribution of factors influencing nurse migration is presented in Table 3.

Solution Suggestions Regarding Nurse Migration

According to the results of these studies, when we rank the recommendations regarding the factors influencing nurse migration by the number of studies, we reach the following findings:

In the study conducted in Turkey, the prominent recommendation is to support nurses who prefer migration due to opportunities abroad and to make structural improvements in the healthcare systems. In the study in the UK, it is recommended that support programs and guidance services be provided for nurses who prefer migration due to job insecurity and unemployment. In the research in Egypt, structural improvements in healthcare systems and increasing job satisfaction are recommended for nurses who choose to migrate for economic reasons. In Nigeria's study, providing professional development opportunities and international cooperation is essential for nurses who prefer migration due to career advancement expectations. In the research conducted in Spain, structural improvements in healthcare systems and the development of internationally standardized policies are recommended for nurses who prefer migration due to employment lack or precarious employment and professional development reasons. In the study in Norway, support programs and guidance services are recommended for nurses who prefer migration in search of better life stability. Finally, the recommendations highlighted in Indonesia, Ghana, and other studies can generally be summarized as structural improvements in healthcare systems, support programs, and international cooperation.

Discussion

Nurse migration is a global issue, requiring international cooperation and coordination to find solutions. This study examines factors influencing nurse migration by consolidating data from research conducted in different countries and discusses potential solutions.

In recent years, nurse migration has become a significant issue in many countries, leading to a shortage of nurses in source countries.[21] Research indicates various factors influence nurse migration in different countries, including active recruitment, post-graduation education, and financial gains. However, each factor appears to affect nurse migration to varying degrees. International nurse integration experiences support this study, showing differences based on source country experiences and the work environment they enter. Immigrant nurses' integration experiences vary depending on various factors such as cultural awareness, exposure to discrimination, English language and communication skills, social and professional support networks, social integration, and personal characteristics.[22] This review concludes that factors such as family unity and social image affect nurses in Indonesia, while economic reasons play a significant role in Egypt. In addition, in Nigeria, career advancement expectations and in Norway, the pursuit of a better quality of life and stability also influence migration decisions.

Economic factors such as low salaries and poor working conditions play a significant role in the international migration of nurses. Particularly in countries such as India, nurses in the private sector face low wages, which increases the tendency for international migration. India is one of the countries where economic reasons drive international nurse migration. The primary reasons for migration are notably low salaries and poorer working conditions, especially in the private sector. Given the competition among private hospitals, nurses often receive meager salaries. In January 2016, the Indian Supreme Court directed the central government to establish a committee to investigate the living conditions and salary structure of nurses in private hospitals.[23]

The respect and perception of the nursing profession also influence migration decisions. This study concludes that increasing job satisfaction is essential to reducing the desire of valuable healthcare personnel to leave their countries. Research conducted among nurses working in public hospitals in Tehran examined the relationship between job satisfaction and the desire to migrate, which was revealed through participant surveys, generally having high levels of migration desire and moderate levels of job satisfaction. The research identified a significant negative correlation between job satisfaction and the desire to migrate.[24]

In countries such as the Philippines, job dissatisfaction and lack of social support encourage international migration, leading to a shortage of experienced nurses in healthcare systems. Over the past decade, the Philippines has experienced significant nurse migration due to increasing demand for nurses in countries such as the Middle East, the United States, and the United Kingdom. Concerns influencing this migration include low salaries, lack of social support, high patient-nurse ratios, and limited opportunities for professional development.[25] This situation contributes to the loss of experienced nurses and increases workload in healthcare facilities, adversely affecting the quality of healthcare services. Another study addressing the deficiencies and current state of the global nursing workforce emphasizes the need to address the nursing shortage and focus on evidence-based policies and resource allocation at the national level.[26]

In a study investigating the prevalence of migration intentions among doctors, nurses, assistants, and medical students in Lithuania, it was found that 12% of nurses had decided to migrate within the next 2 years. Statistical analyses of survey data revealed that migration decisions were associated with sociodemographic factors, financial status, teamwork environment in the hospital, and perceived social value.[27] These findings provide an essential perspective for understanding migration tendencies among healthcare professionals and students and responding to threats affecting healthcare systems in source countries. They support the findings of this systematic review.

Another factor is career development and educational opportunities. In some countries, nurses may face limited career advancement and specialization opportunities, leading to increased international migration tendencies. Conversely, investments made in the nursing profession in various countries to improve the quality of healthcare services can reduce migration.

The increasing demand for nursing in the United States has significantly increased nursing registration and graduation in the Philippines. However, this surge has also expanded the supply of nursing programs, lowering nurses' quality. For every migrant nurse, nine more licenses are issued, and new graduate nurses have transitioned from other diploma types, contributing to the accumulation of human capital in the Philippines.[28]

Improving career opportunities and working conditions for nurses could be a significant step in reducing migration. A study providing a conceptual analysis to understand and define nurse retention identified four critical attributes of retaining nurses: Motivation, intention, and individual decision-making; strategy and intervention; geographical context; and job commitment. In addition, it elucidates the impacts of nurse retention on the healthcare system and individual nurses, emphasizing that international recruitment and retention of the nursing workforce are important priorities.[29]

Various solutions can be proposed to reduce nurse migration. First, each country must develop policies and programs tailored to its conditions.

Strengths and Limitations

This systematic review examines the factors affecting international nurse migration comprehensively and rigorously, offering detailed insights into the primary motivations behind nurses' migration decisions. Analyzing 290 studies employing different methodological approaches enriches the findings and provides a more comprehensive understanding. Reviewing data from various countries reflects the global dimensions of nurse migration and allows for comparing country-specific situations. Identifying the impact of economic factors, job security, and career progression on migration provides concrete data for policymakers and healthcare management.

The study is limited to articles published in Turkish and English, which may exclude studies in other languages, potentially omitting significant data. Restricting the analysis to publications between 2019 and 2024 might not fully reflect important research conducted earlier or changes in migration trends over time. Including only articles with full-text access might exclude significant findings due to access limitations. In addition, the focus solely on nurses means the results do not reflect the migration experiences of other healthcare professionals, limiting the generalizability of the findings.

Conclusion

There are various factors influencing nurses' migration decisions. Particularly, career opportunities abroad, job insecurity, economic reasons, expectations for career advancement, and issues related to the healthcare system play a decisive role in nurses' migration decisions. Various measures can be taken to reduce nurse migration. First, each country should improve the living conditions of migrant nurses, increase job security, and strengthen the healthcare system according to its conditions. Salaries should be offered reasonably, and economic stability should be ensured. In addition, healthcare systems should be restructured to address poor working conditions and inadequate healthcare infrastructure.

It is essential not only to provide career advancement and personal development opportunities for migrant nurses but also to strengthen their integration into society and social support systems. Moreover, ensuring a stable political environment and establishing justice are crucial. These recommendations can help address various factors related to nurse migration and contribute to resolving the issues at hand.

Disclosures

Online Appendix Files: https://jag.journalagent.com/bauhi/abs_files/BAUH-30075/BAUH-30075_(2)_BAUH-30075-Appendix_files.pdf

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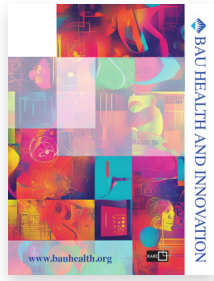

Review

Neurocognitive Changes and Advanced Testing Approaches in Anterior Cruciate Ligament Injuries: Review

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Abstract

Anterior cruciate ligament (ACL) injuries are one of the most common injuries experienced by athletes. ACL injuries not only have effects on the musculoskeletal system, but can also lead to significant changes in neurocognitive processes. This study examines 46 studies published between 2018 and 2024. Keywords such as sensorimotor dysfunction, visual reliance, return to play/sports, neuroscience, and neural plasticity/neuroplasticity were used in searches conducted on PubMed, Web of Science, Scopus, and Google Scholar. The review provides an in-depth analysis under the headings of ACL injuries, neurocognitive abilities, neural compensations, visual reliance, and the development of return-to-sport (RTS) tests. ACL injuries lead to neurocognitive changes that affect athletes' motor control, attention, and executive functions. Impairments in these functions can result in coordination deficits and increased injury risk. Visual reliance emerges as a compensatory mechanism used by the central nervous system (CNS) to address proprioceptive deficits following ACL injuries. However, heightened visual-cognitive demands may prolong decision-making times and reduce movement efficiency in athletes. Neural compensation processes involve neuroplasticity and adaptive changes to recover lost sensorimotor functions. During this process, the CNS requires increased brain activation to maintain motor control. Moreover, advanced RTS tests developed post-ACL injury aim to evaluate not only biomechanical performance but also neurocognitive functions. In conclusion, investigating neurocognitive changes following ACL injuries offers novel insights into rehabilitation strategies. Neurocognitive-enhanced RTS tests and rehabilitation programs to account for these changes can better support athletes' functional and cognitive recovery.

Keywords: Anterior cruciate ligament injuries, brain plasticity, return to sports, sensorimotor dysfunction.

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Anterior cruciate ligament (ACL) injuries are among the most common injuries encountered by athletes and typically occur during high-intensity activities.[1] These injuries not only adversely affect functional performance but also necessitate an extensive physical rehabilitation process.[2] However, the impact of ACL injuries extends beyond the musculoskeletal system, as they can also lead to significant alterations in neurocognitive processes. Athletes are often required to operate in dynamic and unpredictable environments, which challenge their sensitivity to environmental cues, motor planning abilities, and attentional focus.[3] These demands are particularly

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pronounced in team sports, where such factors can contribute to an increased risk of injury. Neurocognitive changes following ACL injury are thought to play a crucial role in understanding the mechanisms of injury and informing rehabilitation strategies.

The relationship between ACL injury and neurocognitive abilities is a key factor influencing an athlete's capacity to adapt to environmental cues. Neurocognitive components such as executive functions, working memory, and cognitive flexibility can significantly affect both performance and injury risk.[4–6] Following ACL injury, impairments in cognitive abilities, particularly attention and memory, can compromise motor control, potentially increasing the likelihood of subsequent injuries. Moreover, deficits in neurocognitive functioning can adversely affect an athlete's ability to coordinate movements effectively.[7]

Post-injury neural compensations are associated with the body's adaptations to compensate for the loss of sensory inputs. This process aims to restore motor control by enhancing the integration of visual and proprioceptive sensory information.[8] However, these neuroplastic changes may introduce new challenges in an athlete's movements and decision-making processes. For instance, a reliance on visual inputs post-ACL injury can disrupt the balance between mechanical and cognitive functionality.[9,10]

Finally, the development of return-to-sport (RTS) tests requires an integrated approach that considers not only biomechanical performance but also neurocognitive functions. Assessing an athlete's cognitive abilities – such as attention, memory, and motor planning – enables the evaluation of both physical and cognitive recovery. In this context, improved RTS tests can yield results more representative of real-game performance, promoting a safer and more comprehensive recovery process during the RTS phase.[11]

Materials and Methods

This study was conducted as part of the "FTR6024 Musculoskeletal Physiotherapy and Rehabilitation" course within the Doctoral Program of the Department of Physiotherapy and Rehabilitation at the Graduate School of Education, Bahçeşehir University, under the guidance of Dr. Berkay Eren Pehlivanoğlu. In our study, a systematic search was performed across the PubMed, Web of Science, Scopus, and Google Scholar databases. The search was limited to studies published between 2018 and 2024 and utilized the following keywords: ACL injury, sensorimotor dysfunction, visual reliance, return to play/sports, neuroscience, and neural plasticity/neuroplasticity. The inclusion criteria encompassed meta-analyses, systematic reviews, narrative reviews, and randomized controlled clinical trials relevant to the scope of this research. Following the screening process, a total of 46 studies were included in this review based on their relevance and alignment with the study's objectives.

Results

ACL Injury

ACL injuries are the most common type of injury encountered by athletes throughout their careers.[1] Approximately 70% of ACL injuries occur during non-contact situations, such as sudden changes in direction after landing on one leg.[2] These injuries are often associated with an increased risk of meniscal tears, osteochondral lesions, and early-onset knee osteoarthritis.[3] Non-contact ACL injuries are recognized in the literature as a type of injury primarily caused by sensorimotor errors, including weakened neuromuscular control and increased knee valgus.[4]

Researchers emphasize that the mechanisms of ACL injuries should not be analyzed solely within a biomechanical framework. Instead, they recommend considering the context of the sport, including the athlete's actions and those of their opponents. Particularly in team sports, athletes perform under time pressure in rapidly changing and unpredictable environments.[5] These conditions necessitate cognitive functions such as perceiving movements of both themselves and their opponents, as well as making appropriate action decisions accordingly. Deficiencies in perceptual or attentional processes can lead to coordination errors and risky knee movements, thereby increasing the likelihood of ACL injuries.[6]

ACL Injury and Neurocognitive Ability

Neurocognition refers to the understanding of cognitive functions in relation to the neural mechanisms in the brain. Higher-level neurocognitive functions, commonly known as executive functions, enable individuals to adapt to environmental cues by coordinating cognitive, emotional, and motor processes.[7] These functions consist of components such as working memory, inhibitory control, and cognitive flexibility. Traditionally considered distinct, cognitive constructs are now recognized as overlapping, spanning from fundamental sensory processes to executive control mechanisms.[6]

Sporting activities require continuous environmental monitoring, filtering out irrelevant information, and

executing complex motor programs simultaneously. While performing dynamic movements, athletes process various cognitive stimuli such as reacting to opponents, making decisions, and formulating strategies.[5] These cognitive abilities significantly influence neuromuscular control, biomechanical movement patterns, and injury risk.[5,7] Deficits in the ability to shift or sustain attention on a stimulus can lead to a loss of spatial awareness and impaired motor control.[6,8] Neuropsychological attributes such as situational awareness, motor planning, and coordination directly impact joint stiffness and injury prevention strategies. Studies have indicated an increased risk of non-contact ACL injuries in athletes with poor cognitive abilities. In addition, reduced reaction time has been linked to a higher risk of lower extremity injuries.[7]

In the mechanism of non-contact ACL injury, dynamic knee valgus during landing after a single-leg jump is the primary contributing factor.[1] However, in addition to increased knee valgus, diminished neurocognitive functions and altered neuromuscular characteristics are highlighted as potential risk factors, particularly in young female athletes.[5,8] Video analyses have revealed that during competitions, injured basketball players often shift their focus between the hoop, the opponent, and the ball. This divided attention reduces the athlete's focus on their own movements and limits the time available to correct actions, potentially triggering ACL injuries.[7,9]

Neural Compensations Following ACL Injury

Mechanical instability, pain, and subsequent kinesiophobia, along with muscle strength deficits, are among the challenges athletes face after an ACL injury.[1] These prolonged issues lead to somatosensory impairments and compensatory mechanisms,[8,10] which trigger central nervous system (CNS) adaptations.[11,12] Sensorimotor neuroplasticity following ACL injury begins with the abrupt loss of afferent feedback.[13,14] This loss, combined with pain and inflammatory responses, induces fundamental alterations in somatosensory feedback.[12] Impairments in gamma motor neuron function and reflex activity reflect changes in motor output, impacting the ability to maintain neuromuscular integrity.[14] The CNS compensates for diminished sensory feedback by employing additional mechanisms, such as visual feedback.[11] This process involves spinal and supraspinal pathways, leading to bilateral motor control and proprioceptive changes. Increased brain activation has been observed post-ACL injury, resulting in the recruitment of additional brain regions to support motor control.[9]

Neuroplasticity associated with ACL injury encompasses cross-modal neural activity involving changes in the parietal and occipital lobes, where visual and proprioceptive sensory information is processed.[15] This post-injury neuroplasticity alters motor output, joint stabilization mechanisms, and activity in regions associated with cognitive functions such as decision-making, executive function, and attentional focus within the frontal lobe.[11,15] Enhanced cognitive and cross-modal neural activities following ACL injury may provide sufficient joint stabilization, a critical factor during the RTS phase.[9]

Considering the neurocognitive changes observed in the CNS, it becomes evident that ACL injury should not be regarded merely as a musculoskeletal injury. Instead, its broader impact on sensory-motor integration and neuroplastic adaptations highlights its multifaceted nature.

Visual Reliance Following ACL Injury

The sensorimotor system plays a critical role in movement planning, execution, and maintaining postural control. The integration of somatosensory and visual information is essential for detecting movement deviations and adjusting motor responses. As movement complexity increases, sensorimotor demands also rise.[16] Following an ACL tear, the CNS may rely more heavily on alternative sensory inputs such as visual feedback and spatial awareness.[12] Figure 1 shows the relationship between the sensorimotor system and the motor control mechanism.

In individuals with ACL insufficiency, increased activation has been observed in brain regions such as the posterior inferior temporal gyrus (visual processing), pre-supplementary motor area (motor planning), and secondary somatosensory area (pain and sensory processing).[7,8] Studies have demonstrated greater neural activity during the processing of identical visual inputs in injured athletes compared to uninjured counterparts, supporting this hypothesis.[12,17] To compensate for altered somatosensory processing, athletes require greater reliance on visual input to maintain their performance levels.[9]

Visual cognition involves interpreting, integrating, and making sense of visual input. It also integrates spatial functions such as object recognition and depth perception.[16] Athletes who have sustained an ACL injury experience increased cognitive loads to process augmented visual input associated with their sports, often resulting in slowed reaction times.[18] A failure to balance cognitive and biomechanical functions adequately, coupled with delayed reaction times, renders these athletes more susceptible to secondary injuries.[13]

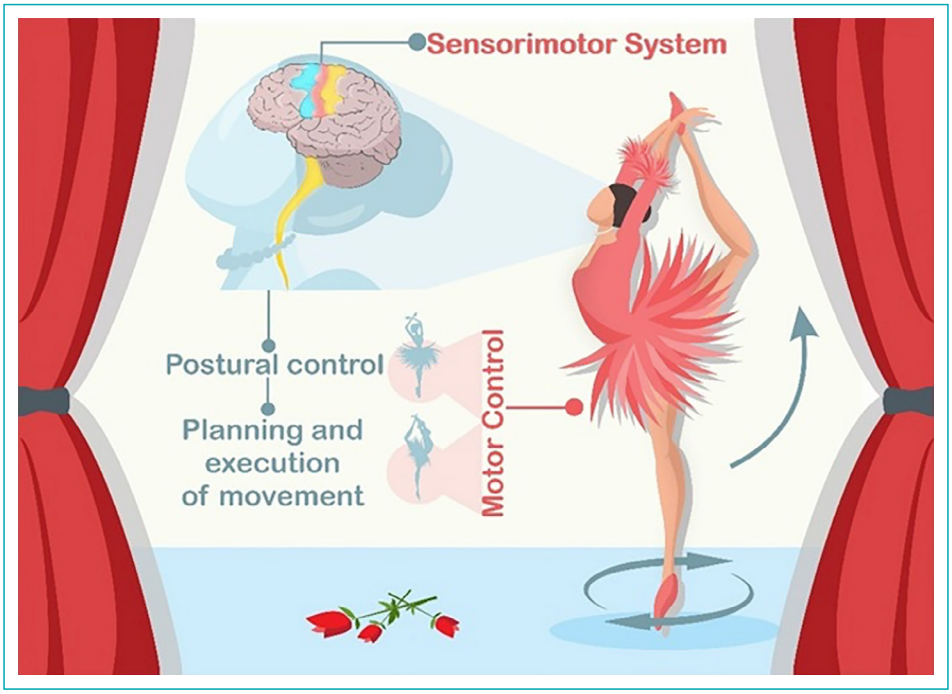

Figure 1. Relationship between sensorimotor system and motor control mechanism.[16]

These findings emphasize the need for rehabilitation programs to address the heightened visual reliance following ACL injuries, focusing on restoring the balance between visual and somatosensory systems to enhance motor control and reduce the risk of re-injury.

Developing RTS Tests Following ACL Injury

RTS criteria for athletes recovering from ACL injuries often focus on evaluating musculoskeletal functionality, such as agility, strength, and jumping performance. Test batteries that assess single-leg landing biomechanics and performance are commonly utilized as benchmarks for RTS.[19] However, reliance solely on tests that evaluate jumping performance and musculoskeletal systems often leads to suboptimal outcomes, such as failure to regain pre-injury performance levels and a heightened risk of secondary ACL injuries.[20] Athletic performance and injury risk are intricately linked to a complex integration of physical, cognitive, and visuospatial abilities. Therefore, incorporating visual and neurocognitive functional tests into the RTS criteria is of critical importance.[21] Neurocognitive-enhanced RTS tests should include components that assess both reactive movements and pre-planned agility maneuvers.

To evaluate the neurocognitive adaptations that occur after ACL injuries, many clinical test procedures can be modified. For example, adding a simple timed light sensor to traditional jump tests can measure visually mediated reaction times, offering a neurocognitive perspective on the athlete's readiness. Dual-task challenges that target cross-modal neural changes – requiring athletes to respond to specific cues while maintaining motor performance and stabilization – can further assess cognitive, proprioceptive, and visual capabilities.[15,21] Enhanced neurocognitive jump tests, incorporating stimuli such as lights, colors, or numbers, can evaluate not only movement initiation but also the cognitive and visual reliance during jumps.[9,15] In addition to integrating neurocognitive tasks into jump tests, agility tests measuring reaction time, linear speed, and sudden directional changes can also benefit from dual-task components. These modifications can provide insights into the compensatory strategies developed post-injury.[22] As an example test, Figure 2 shows the lateral slide test with light targets.

The addition of neurocognitive dual-task components to performance tests must minimize reliance on pre-planned agility maneuvers and reactive movements.[23] During sports competitions, athletes must respond to unpredictable conditions with automatic, spontaneous actions. Therefore, RTS assessments should simulate real-world scenarios encountered during competitive play. Incorporating neurocognitive components – such as executive function, attention, and memory – can create a more comprehensive evaluation framework, ensuring that athletes are better prepared for the demands of their sport.[23]

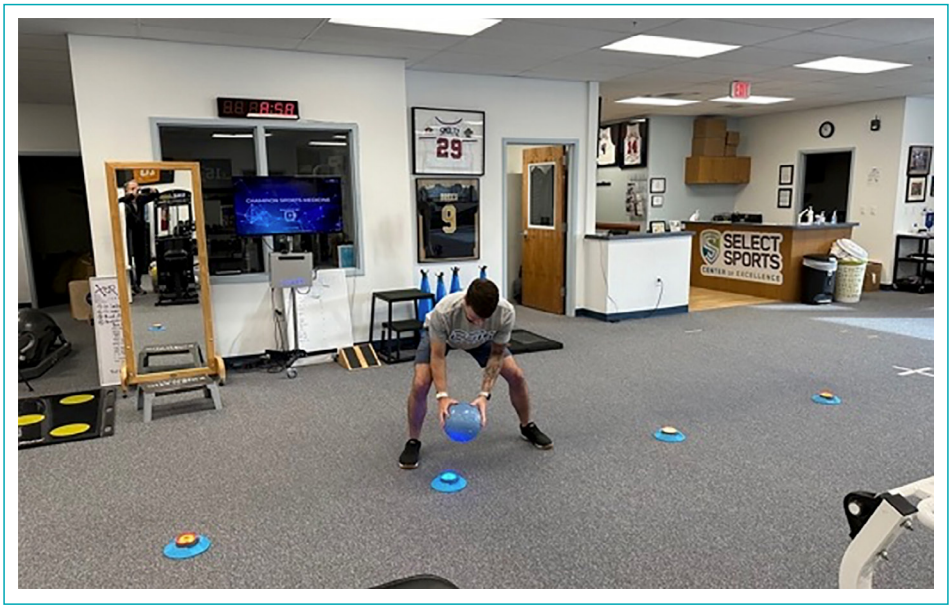

Figure 2. Lateral slide test with light targets. The lateral slide test involves an athlete shuffling laterally between four Blazepods, targeting the blue light while avoiding hopping or running. The athlete catches a soccer ball thrown to the target light, taps the light, and then tosses the ball back while moving to the next light. The goal is to tap as many lights as possible in 30 seconds, with total taps and average reaction time recorded and scored.[23]

Discussion

In this study, we focused on the impact of ACL injuries on neurocognitive changes and the significance of these changes in advanced test approaches. Specifically, we examined the effects of ACL injuries on motor control, neuromotor function, visuomotor integration, and the neurocognitive challenges encountered during the RTS process. This discussion highlights the nature of neurocognitive changes post-ACL injury and how these changes can be integrated into clinical assessments and rehabilitation strategies, supported by findings from various academic studies.

After ACL injuries, the CNS recruits additional brain regions to support motor control processes. Chaput et al.[9] demonstrated that the CNS allocates increased resources to maintain motor control, resulting in heightened brain activation following ACL injuries. This suggests that athletes rely more heavily on cognitive resources to coordinate movements and experience significant neurocognitive changes while regaining motor control. Similarly, Sherman et al.[13] found that individuals with ACL reconstruction (ACLR) exhibit greater motor planning and response inhibition compared to healthy controls. By examining electrocortical activities, the study revealed how neurocognitive adaptations influence motor planning and response selection, emphasizing their critical role in the RTS process.[13] Armitano-Lago et al.[24] also observed reduced performance in challenging postural tasks among individuals with ACLR compared to healthy controls, highlighting changes in motor function. These findings underline the need to consider brain activity alterations aimed at improving motor control when designing rehabilitation strategies.

The brain may develop new motor strategies post-injury to manage challenges, a phenomenon known as neurocognitive compensations. Criss et al.[25] reported increased activation in various brain regions, particularly the fronto-insular-temporal and sensorimotor areas, during a hip-knee movement paradigm in individuals with ACLR. These connections suggest that individuals rely on additional brain resources for visuospatial cognitive processes and motor control.[25] Similarly, Zarzycki et al.[26] identified variations in intracortical facilitation effects between limbs in ACLR patients and found that increased motor cortex inhibition could impair quadriceps strength. These findings underscore the importance of understanding neural adaptations in post-injury recovery. Lehmann et al.[17] observed enhanced functional connectivity in somatosensory and visual regions during postural control tasks in ACLR patients, suggesting the importance of neural compensation mechanisms during rehabilitation. These mechanisms are closely tied to physiological parameters such as muscle strength and postural stability.[17]

One notable finding is the increased reliance on visual inputs after ACL injuries. Miko et al.[27] (2021) showed that ACLR individuals experience greater instability during visual-motor dual tasks, impacting postural stability. This highlights the need for rehabilitation programs that address not only physical recovery but also visual-cognitive training.[27] Similarly, Wein et al.[28] demonstrated that ACLR patients become more dependent on visual feedback for postural control, emphasizing its critical role in rehabilitation.

ACLR individuals often exhibit reduced performance in tasks requiring visuomotor integration during RTS testing. Simon et al.[21] reported lower performance on neurocognitive jump tests compared to traditional tests, highlighting the importance of incorporating neurocognitive components into RTS criteria. Sports often demand rapid decision-making and increased motor control, reinforcing the need for neurocognitive testing in RTS assessments.[21] Brinkman et al.[29] evaluated the reliability of visuomotor reaction time and emphasized its importance as a critical parameter reflecting athletic performance. Similarly, Farraye et al.[30] validated a novel visuocognitive medial side-hop test, demonstrating its effectiveness in measuring both physical and cognitive loads during RTS.[30] These findings suggest that integrating neurocognitive tests into RTS assessments provides a more comprehensive evaluation than traditional tests. Simulating dual-task scenarios or situations requiring rapid decision-making may offer a more reliable means of assessing athletes' readiness to return to sport.

Limitations

A limitation of our study is that it is not a systematic review, which has led to a less comprehensive evaluation of the literature. However, the fact that this is a traditional review has allowed for greater attention to the subject matter. This review will provide valuable insights for future clinical studies.

Conclusion

The significance of neurocognitive changes and advanced test approaches in the RTS process following ACL injuries is unquestionable. High brain activation, visual input dependency, and changes in motor control processes are key factors shaping rehabilitation and testing approaches. It is clear that combining neurocognitive tests with traditional assessments will provide more reliable and functional RTS tests. These tests are expected to be an important tool for accelerating the return to sport and optimizing athlete performance.

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