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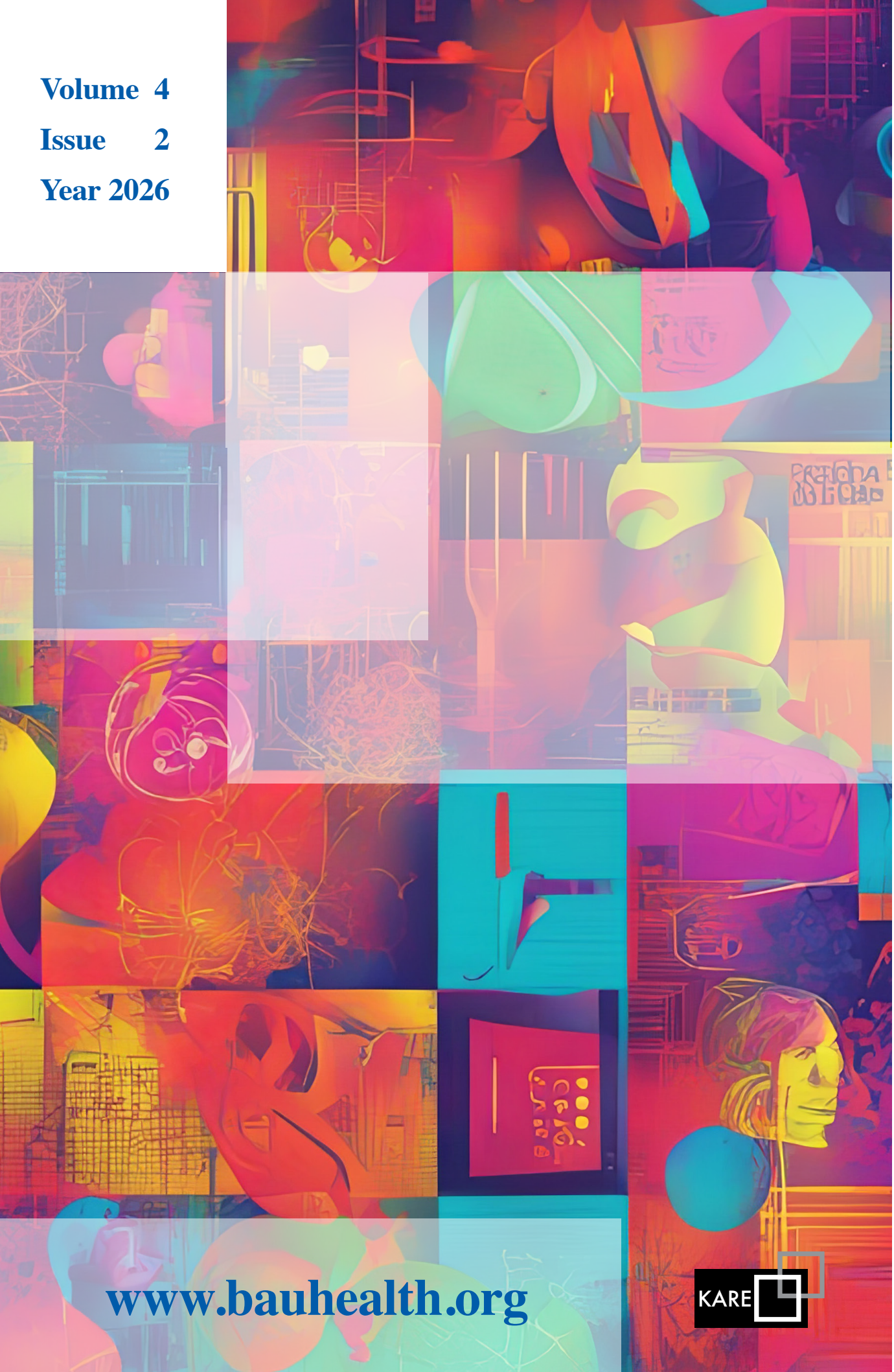

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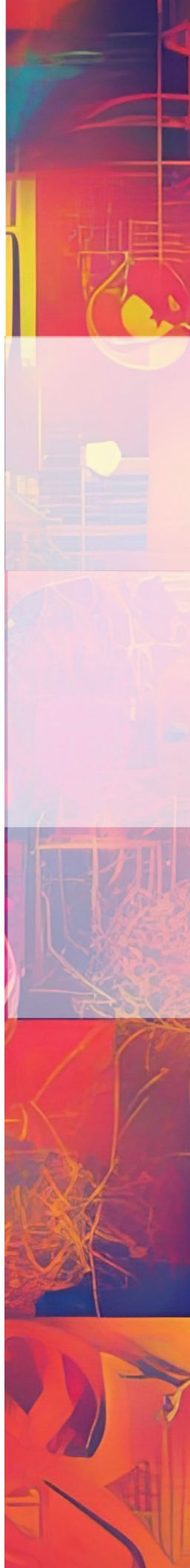

ABOUT THE JOURNAL

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, Electronic Journals Library – EZB and Embase.

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.

Publishing House: *KARE Media*
Publications Coordinator: *Eda Kolukısa Doğru*
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,
3. Abstract and the main text,
4. Tables uploaded as a separate file,
5. All Figures have been uploaded and appear correctly,
6. The Author Contribution, Conflict of Interest statement (ICJME) and Copyright Transfer forms,
7. Ethics Comittee Report, if necessary,
8. Permission for reprinted figures, tables, materials or photographs, if necessary.

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.

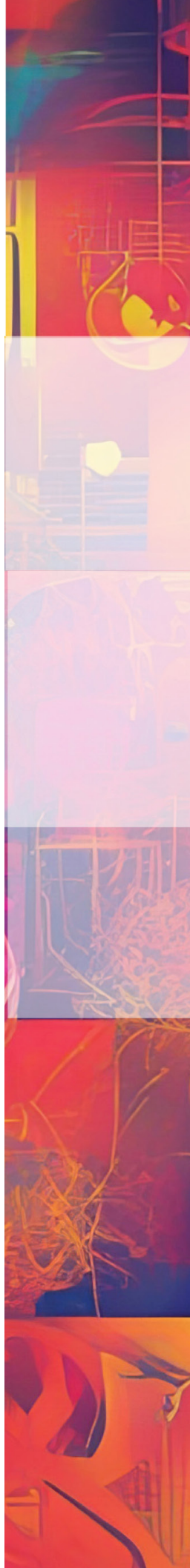
Studies using human or animal subjects should be approved by the appropriate institutional and local Ministry of Health ethics committees. Ethics approval of research protocols in accordance with international agreements is required for experimental, clinical, and drug studies, as well as for some case 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.

Open Access Policy

The BAU Health and Innovation supports the Budapest Open Access Initiative statement of principles that promotes free access to research literature. The declaration defines open access to academic literature as free availability on the internet, permitting users to read, record, copy, print, search, or link to the full text, examine them for indexing, use them as data for software or other lawful purposes without financial, legal, or technical barriers. Information sharing represents a public good, and is essential to the advancement of science. Therefore, articles published in this journal are available for use by researchers and other readers without permission from the author or the publisher provided that the author and the original source are cited. The articles in BAU Health and Innovation are accessible through search engines, websites, blogs, and other digital platforms. Additional details on the Budapest Open Access Initiative and their guidelines are available at https://www.budapestopenaccessinitiative.org/



Open Access Statement

Licenses and Copyright Policy

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.

Manuscript withdrawal penalty: After receiving the Article withdrawal Form, BAU Health and Innovation Editorial Board will investigate the reason of withdrawal.

If the reason finds to be acceptable, the author is allowed to withdraw the manuscript without paying any withdrawal penalty. If not BAU Health and Innovation will not accept any manuscripts from the same author for one year.

Important notes: Manuscripts may be withdrawn at any stage of review and publication process by submitting a request to the editorial office. Manuscript withdrawal will be permitted after submission only for the most compelling and unavoidable reasons.

If the author wants to withdraw a manuscript, the author needs to submit a completed "Article withdrawal Form", signed by all authors of the manuscript stating the reasons for manuscript withdrawal.

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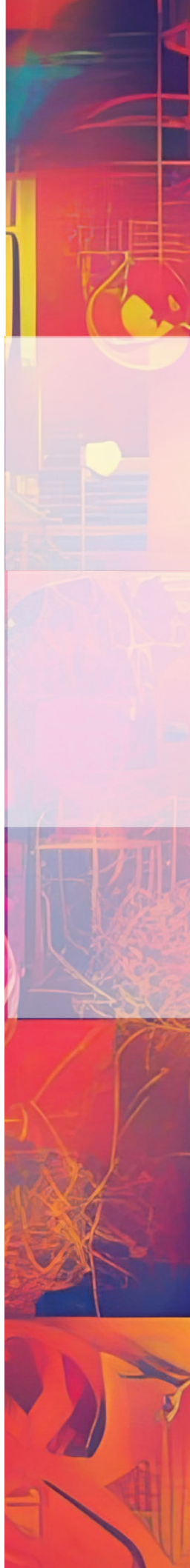

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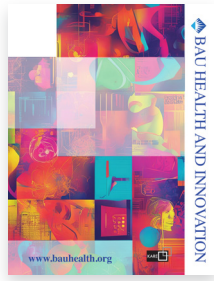

Original Article

Comparison of Two Different Rehabilitation Approaches Applied Following Anterior Cruciate Ligament Reconstruction: A Randomized Controlled Trial

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Abstract

Objectives: This study was to investigate and analyze the effects on pain, range of motion (ROM), functional status, balance, quality of life (QOL), and kinesiophobia between a rehabilitation program including traditional physiotherapy and dual-task exercises (CP + DT) and another rehabilitation program including foam roller application in addition to traditional physiotherapy and dual-task exercises (CP+DT+FR) in patients undergoing anterior cruciate ligament reconstruction (ACL-R).

Methods: A total of 28 patients who underwent unilateral arthroscopic anterior cruciate ligament (ACL) reconstruction using hamstring tendon graft were included in this randomized controlled study. Patients who underwent ACL reconstruction for the 1st time, were in the post-operative rehabilitation phase, and were still participating in the study up to 1 year, were eligible for inclusion. Individuals with bilateral ACL injury, concomitant ligament injuries, previous knee surgery, or neurologic disorders affecting balance were excluded. Participants were divided into two groups using the randomization method, which was created by randomly drawing the group names we wrote on the papers according to their order of arrival: Traditional physiotherapy plus dual-tasking exercise group (CP+DT; n=14; mean age: 27.64 ± 6.51 years; 14 males) and traditional physiotherapy, dual-tasking and foam roller exercise group (CP+DT+FR; n=14; mean age: 23.07±3.97 years; 11 males and 3 females). All participants attended supervised rehabilitation sessions 3 times a week for a total of 8 weeks. Outcome measures were assessed at baseline and at the end of the 8-week intervention period and included measures of pain intensity, knee ROM, functional status, balance performance, QOL, and kinesiophobia.

Results: Both rehabilitation groups demonstrated statistically significant improvements in pain intensity, knee ROM, functional status, balance performance, QOL, and kinesiophobia from baseline to the end of the 8-week intervention period ($p < 0.05$). However, when between-group comparisons were performed, no statistically significant differences were observed between the CP+DT and CP+DT+FR groups for any of the outcome measures ($p>0.05$). These findings indicate that while both rehabilitation protocols were effective in improving clinical and functional outcomes following ACL reconstruction, the addition of foam roller exercises did not confer a statistically superior benefit compared with conventional physiotherapy combined with dual-task training.

Conclusion: The findings of the present study indicate that an 8-week intervention comprising conventional physiotherapy and dual-task exercises leads to significant improvements in clinical outcomes. Nevertheless, incorporating foam roller exercises into this rehabilitation protocol does not provide additional advantages with respect to pain, ROM, functionality, balance, QOL, or kinesiophobia. These results suggest that the inclusion of foam roller exercises does not appear to enhance clinical outcomes beyond those achieved with conventional physiotherapy and dual-task training within the study period.

Keywords: Anterior cruciate ligament reconstruction, exercise, outcomes, rehabilitation.

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This study was produced from a master's thesis conducted at Marmara University Institute of Health Sciences. The present study was orally presented at the 19th Congress on Developments in Physiotherapy on April 09, 2025, and its abstract was included in the abstract book of the congress.

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Each year, anterior cruciate ligament (ACL) injuries occur in approximately 3% of sedentary individuals and amateur athletes; however, the incidence increases markedly, reaching up to 15% among elite athletes.[1] Notably, ACL injuries remain highly prevalent in contact sports, and despite considerable advances in research and prevention strategies, their occurrence has not significantly declined.[2]

The ACL plays an important role in the stability of the knee joint.[3] Total rupture of the ACL is considered an indication for surgery and ACL reconstruction aims to restore the joint. This goal is also shaped by the communication between the surgeon and the physiotherapist and requires the cooperation of the post-operative team because physiotherapy is the most important step for post-operative pain, swelling, loss of muscle strength, quality of life (QOL), and kinesiophobia.[4] There are also many rehabilitation methods to reduce the amount of negative effects that may occur. Some of these are cold applications, open-closed kinetic chain exercises, electrotherapy, double duty exercises, foam roller, and blood flow restriction exercises, which can be used from the 1st day.[5]

Furthermore, ACL injuries usually occur when athletes are given a second task (motor or cognitive) while they are mostly engaged in motor activity, such as landing quickly after a jump or making a difficult pass while dribbling, where decision-making is involved and creates extra load on the athlete, which can lead to an ACL tear if they are not used to it.[6] ACL tear is a knee pathology that has effects on the central nervous system's flexibility. People who have undergone ACL reconstruction (ACL-R) use cross-modal brain regions to perform knee-related movements, and their physical performance is reduced when faced with cognitive-motor dual tasks in sports or daily life. Moreover, research has shown that people who have undergone ACL-R have increased visual-cognitive neural processes to achieve motor control.[7]

Previous studies have investigated the effects of including dual-task exercises in traditional rehabilitation programs after ACL-R. In one such study, static balance performance and disability levels were assessed in individuals undergoing ACL-R, and the addition of dual-task training resulted in significant improvements in static balance.[8] While the beneficial effects of dual-task interventions have been well documented in a variety of populations, including individuals with Parkinson's disease, stroke survivors, and the elderly, evidence for their effectiveness in individuals with ACL-R remains limited. This highlights the need for further research to clarify the role of dual-task training in rehabilitation after ACL reconstruction.[9,10]

A wide range of rehabilitation modalities is continuously being introduced to facilitate return to sport following ACL injury and to reduce the risk of re-injury. Persistent deficits in muscle strength relative to pre-injury levels, along with incomplete joint range of motion (ROM), residual swelling, and pain, are among the primary factors contributing to re-injury risk.[11] In this context, foam roller application has gained increasing attention in clinical practice and has recently emerged as a popular recovery modality. Furthermore, the effects of foam roller interventions on recovery processes, physical performance, and various physiological and functional parameters have been extensively investigated in both athletic and healthy populations.[12,13]

For instance, Hajouj et al.[14] investigated the effects of adjunct rehabilitation modalities in individuals following ACL-R. In their study, one group received conventional physiotherapy alone, while the other group underwent conventional physiotherapy combined with hydrotherapy and foam roller interventions. The authors reported significant improvements in proprioceptive efficiency and neuromuscular coordination in the group receiving the combined treatment compared with conventional physiotherapy alone.[14]

However, the foam roller remains a commonly used physiotherapy modality following ACL-R and is less well documented in the literature than its clinical use. Although ACL-R rehabilitation is primarily based on traditional therapeutic approaches, the widespread clinical use of the foam roller makes it both important and necessary to investigate its effects in a structured research setting, particularly in terms of optimizing healing. However, although the acute effects of foam roller application are well known, its long-term effects have not been adequately investigated, which constitutes a limitation of the current study design.[15]

Based on the current evidence, we designed a study that integrates dual-task training with foam roller interventions in the post-operative rehabilitation period following ACL-R. The primary objective of this study is to determine whether the addition of foam roller applications to a conventional physiotherapy program combined with dual-task protocols during gait and balance training yields superior outcomes in pain modulation, joint ROM, functional performance, postural stability, QOL, and kinesiophobia when compared to a conventional rehabilitation program incorporating dual-task training alone.

Materials and Methods

Participants

This study was conducted at a private clinical center. A total of thirty-two patients who underwent unilateral arthroscopic ACL-R using a hamstring tendon autograft were included in the study.

Inclusion criteria comprised individuals aged between 18 and 40 years who had undergone unilateral ACL reconstruction and had no previous injury or surgery affecting the contralateral lower extremity.

Exclusion criteria included the presence of cardiovascular disease; a history of additional lower extremity injuries or surgeries (including revision ACL reconstruction or other knee surgeries); chronic pain requiring medication; neurological disorders that could influence balance (such as epilepsy); and concomitant posterior cruciate ligament rupture associated with the ACL injury.

Randomization

Participants were randomly assigned to one of two rehabilitation groups using a simple randomization method with sealed envelopes. A random allocation sequence was generated by preparing fourteen slips of paper labeled "CT + DT" and fourteen labeled "CT + DT + FR." These slips were randomly placed into 28 sealed and consecutively numbered envelopes by a project manager who was not involved in participant recruitment, assessment, or intervention delivery.

Participants were assigned envelope numbers from 1 to 28 according to the order in which they presented to the clinic, and group allocation was determined by opening the corresponding sealed envelope.

The first group was the conventional therapy plus dual-task group (CT + DT; n=14; age: 27.64±6.51 years; body weight: 85.50±13.72 kg), which received conventional therapy based on the accelerated rehabilitation protocol.[16] The second group was the conventional therapy, dual-task, and foam rolling group (CT + DT + FR; n=14; age: 23.07±3.97 years; body weight: 75.45±11.29 kg), which received foam rolling training in addition to the conventional rehabilitation protocol. The two groups were comparable in terms of demographic characteristics (Table 1).

Ethics Statement

All patients were informed about the research before participating in the study, and written informed consent was obtained. The ethical approval was obtained from Marmara University Faculty of Medicine Ethics Committee for Clinical Research (Protocol Number: 09.2024.370). This study was prospectively registered on Clinicaltrials.gov (NCT06831279). The study was conducted in accordance with the principles of the Declaration of Helsinki.

Table 1. Participants' characteristics

Variables	CT+DT group (n=14) Mean±SD	CT+DT+FR group (n=14) Mean±SD	p
Weight (kg)	85.50±13.72	75.45±11.29	0.068
Height (cm)	179.92±4.54	174.92±9.65	**0.036**
Age (years)	27.64±6.51	23.07±3.97	**0.036**
BMI (kg/m^2)	26.12±4.30	24.61±2.79	0.280

SD: Standard deviation, BMI: Body mass index, CT+DT: Conventional therapy+dual task, CT+DT+FR: Conventional therapy+dual task+foam roller.

Table 2. Information on gender, operative limb, dominant limb, and type of injury

Variables	Category	CT+DT group (n=14%)	CT+DT+FR group (n=14%)	p
Gender	Female	0 (0.0)	3 (21.4)	0.22
	Man	14 (100.0)	11 (78.6)	
Operative limb	Left	7 (50.0)	7 (50.0)	1.00
	Right	7 (50.0)	7 (50.0)	
Dominant limb	Left	1 (7.1)	0 (0.0)	1.00
	Right	13 (92.9)	14 (100.0)	
Mode of injury	Contact	2 (14.3)	7 (50.0)	0.08
	Non-contact	12 (85.7)	7 (50.0)	
Type of injury	Sports competition	13 (92.9)	11 (78.6)	0.60
	Other	1 (7.1)	3 (21.4)	

CT+DT: Conventional therapy+dual task, CT+DT+FR: Conventional therapy+dual task+foam roller.

Outcome Measures and Testing Protocols

Demographics of the patients such as medical history, age, gender, height, weight, and body mass index (BMI) were recorded. In addition, information regarding gender, operative limb, dominant limb, and type of injury was also collected (Table 2). The following were measured: Kinesiophobia, soreness, equilibrium, activity level, knee function, and QOL throughout the evaluation.

Pain Level

Visual Analog Scale (VAS) is a psychometric measurement tools that allow the severity of a subjectively experienced symptom in an individual to be quantified.[17] A 100 mm paper was given for pain assessment. One end of the paper was labeled "no pain-0," and the other end was

labeled "the most severe pain possible-100." The patient was asked to mark a point on the line according to their current pain level.[18]

Activity Level

The Tegner Activity Score was used to measure the activity level of patients. The range was measured numerically related to physical activity. It is classified from 0 to 10. The lower points figure shows bad activity owing to injury, while the higher points figure shows a good activity level.[19]

Knee Function

The Lysholm Knee Scoring Scale was used to measure the functionality of the knee of patients. It consists of questions asked specifically of the patient with pain and instability. Lysholm's knee scale consists of eight items. This range scopes between 0 and 100 points. The higher the points are the far better the knee functions.[20] Out of 100 points, 95–100 points are considered excellent, 84–94 points are considered good, 65–83 points are considered average, and <65 points are considered bad.[19] The Turkish validity and cultural adaptation of the Lysholm knee score was provided by Celik et al.[20]

Balance Assessment (Star Excursion Test)

Athletes reached with their feet to the star-shaped directions drawn on the ground at a 45° angle, totaling 8 directions, and the distance they could reach was noted in cm. Balance score was measured with the formula "distance/leg length × 100."[17]

QOL

The ACL-QOL survey was used to measure the QOL. The ACL-QOL range represents subjective, patient-based, and disease-related questions. The scale includes five different items, and the higher the scores are, the better the QOL is.[19] ACL-QOL; These 5 items are in the field of symptoms and physical complaints, and also work-related. It is a scale specific to ACL injuries that examine 5 main topics with 32 questions: 4 questions in the field of concerns, 12 questions in the field of hobbies, sports, or participation in competitions, 6 questions in the lifestyle field, and 5 questions in the social and emotional field. The Turkish validity and reliability were determined by Kinikli et al.[21]

Kinesiophobia

Kinesiophobia (fear of movement) was observed by using the Tampa Scale of Kinesiophobia. Accordingly, the overall score can be scoped from 17 to 68 points. A higher score holds out higher perceived levels of kinesiophobia while lower score exhibits lower fear of mobility.[22] The scale utilizes a 4-point Likert scale (1=I completely disagree, 4=I completely agree). A total score is measured after reversing items 4, 8, 12, and 16. Its validity and reliability in Turkish were conducted on MS patients and it is still a widely used scale today. TSK is a 17-question checklist and is utilized in acute and chronic low back pain, fibromyalgia, musculoskeletal injuries, and whiplash-related diseases.[23]

Treatments

All patients underwent a pre-test, an 8-week rehabilitation exercise program, and post-test. Pre-test was performed by the physiotherapist and the doctor, after the ACL surgery was performed. At the beginning of treatment, subjects were assigned to two different groups according to their order of arrival. The CT + DT group continued to receive conventional rehabilitation, including walking, strengthening with a dual task balance exercise (60–75 min). Each conventional therapy session consisted of ROM exercise, closed kinetic chain exercise, open kinetic chain exercise, weight-bearing exercise, and dual task exercise. Elevation, cold application, ankle pump exercise, patellar mobilization, and bandaging were performed to reduce inflammation in the early post-operative period. Ice was applied 3 times daily for 30 min each application. Ankle pumping exercise was performed 5 times a day with 3 sets of 10 repetitions. Patellar mobilization was performed 3 times a day, 2 sets of 10 repetitions, superior and inferior starting from the 1st week after surgery. The ROM exercise is aimed at gaining full ROM in 8 weeks and accelerating recovery.

The 1st week was designed to increase ROM to 90°. Flexion was performed while lying down or sitting. At the end of the 4th week, flexion progressed from 90° to 130°. By the completion of the 8th week, flexion was completed to 130°. All ROM exercises were performed 3 times a day with 2 sets of 10 repetitions. Neuromuscular Electrical Stimulation (NMES) was started on the 1st post-operative day for quadriceps inhibition. NMES was given together with the straight leg raising exercise and terminal knee extension. NMES was performed at 2500 Hz in each session. It was applied with the patient lying supine for 10 s/50 s of extension and 10 s of contraction. The consistency of the stimulation was adjusted by the physiotherapist as to the patient's tolerance in each session, aiming to maximize the distribution of the motor unit. Voluntary participation was encouraged to activate their quadriceps muscles throughout the process, and the maximum limit was 120 mA. All patients showed compatibility during the sessions in the past 4th week. Hence, quadriceps strength was completed, and electrotherapy stopped in the 4th

Figure 1. Rehabilitation Exercise Program. (1) Neuromuscular electrical stimulation therapy, (2) Q-set exercise, (3) Foam roller exercise, (4) Straight leg raise, (5) Bridge exercise, (6) Stretching (hamstring femoris), (7) Heal side, (8) Lunge, (9) Clamshell exercise, (10) Patellar mobilization.

week. Strengthening exercises started on the 1st day after the surgery. In this process, which started with isometric exercises, closed kinetic chain exercises started when the muscles reactivated. After strengthening the muscles with closed kinetic chain exercises for 4 weeks, open kinetic chain exercises increased.

All strength exercises were performed 3 times a day, 2 sets of 10 repetitions. Dual-task exercises started on the 1st day after surgery. In the 1st week, while using crutches or a walker, the patient was asked to describe daily events, pictures placed in front of them, count rhythmically, and spell words. These exercises were performed on a stable surface in the 1st weeks, but after week 4, patients were asked to perform them on unstable ground or during balance exercises. The dual-task exercise was incorporated into the walking and balance exercises and practiced three times a week for approximately 15–20 min.

The CT + DT + FR group received the same traditional and dual-task rehabilitation in addition to foam roller training. All patients in this group received treatment using the foam roller used in the study. With the patient sitting upright in bed, the foam roller was placed just above the hip joint (above the ischial tuberosity). The patient lifted their hips with the help of their hands, and the foam roller was rolled up to just above the knee joint. After this stage, the rolling was continued back to the starting point. Rolling was performed at a frequency of 5 cycles/min in week 1, with each roll lasting 1.5 s. The number of cycles was increased by 10 repetitions each week. Rounding times were monitored with a cell phone stopwatch. The exercises were performed under the supervision of a physiotherapist to prevent loss of balance during the movement (Fig. 1). Dual-task exercises; in the first stage, the number recorded during walking was asked to be said again after a certain period of time. Sometimes, they were asked to count rhythmically, perform an auditory Stroop test, and sometimes to talk about daily life. The above-mentioned was started with a fixed floor and then switched to a moving floor as the weeks progressed. The progression of the traditional training protocol is presented in Table 3.

Statistical Analysis

The analysis was conducted using IBM Statistical Package for the Social Sciences Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA). All data are presented as mean and standard deviation. Qualitative variables were stated from the perspective of proportions and the contrast between two proportions was tested with the Chi-square or Fisher's exact test, relying on applicability. The normality of

Table 3. Conventional physiotherapy and dual-task exercises

Clinical physiotherapy	
0–4 weeks	4–8 weeks
1. Ice (3 times* 30 min) and elevation	1. Closed kinetic chain (squat, squat with Wall)
2. Ankle pump exercise	2. Straight leg raise with resistance
3. Range of motion (0–90°)	3. Range of motion (0–130°)
4. Stretching (hamstring femoris and quadriceps muscle)	4. Leg curl (non-weight and also weight)
5. Weight shifting	5. Lunge exercise and side lunge exercise
6. Muscle strength (Q-set, straight leg raise, leg extension)	6. Bridge exercise
7. Close kinetic chain (heel raise, gait retraining)	7. Clamshell exercise
Dual Task (0–4 weeks)	Dual Task (4–8 weeks)
8. While performing walking exercises on a stable surface with crutches, the patient was asked to say the color written in a circle (Auditory Stroop test) in front of the visuals shown.	8. The patient was asked to repeat the numbers and letters that were said after a certain period of time. (movable surface)
9. The patient was asked to repeat the numbers and letters said after a certain period of time.	9. The patient was asked to spell the words, describe a picture shown, count numbers rhythmically, etc. (movable surface)
10. The patient was asked to spell words and count numbers rhythmically.	10. The patient was asked to say words that started with the specified letter, such as a city, animal, plant, object (movable surface)
11. The patient was asked to narrate his daily routine and interpret a simple daily event	11. The patient was asked to narrate his daily routine and to interpret a simple daily event. (movable surface)

distribution of all outcome variables was using the Shapiro–Wilk test. Mann–Whitney U test was used to compare quantitative variables. All statistical analyses were two-sided and carried out at a significance level of alpha =0.05.

Results

A total of 32 patients were screened in the first phase. However, three patients did not meet the criteria to continue treatment, and as a result, twenty-nine screened patients were randomized into two groups. After this process, one patient from the CT + DT group was excluded from the study because they did not attend the control examinations. Thus, the study ended with fourteen patients in the CT + DT group and fourteen patients in the CT + DT + FR group. Furthermore, the flowchart showing the criteria, excluded patients, and the groups in which the information was presented is presented in Figure 2. In addition to the flowchart, the table above showing the anthropometric characteristics (i.e., age, height, weight) of the subjects can be seen in Table 1.

In both treatment groups, there were significant differences ($p<0.05$) in VAS, ROM (flexion, extension), Lysholm score, Star movement test score, QOL, and kinesiophobia before and after the intervention. There was a significant difference in Tegner score before and after treatment in the first group, while no significant difference was observed between before and after treatment in the second group ($p=0.390$) (Table 4).

The recovery VAS ($p=0.489$), extension gain ($p=0.582$), and star movement test score of the second group (CT + DT + FR) were slightly higher than those of the first group (Fig. 3). However, this difference was not statistically significant. In contrast, the flexion degree gain, Tegner score, and QOL were slightly higher in the first group than in the second group. However, this difference was again not statistically significant (Table 4). In summary, no significant difference was observed between the two groups in all variables ($p>0.05$).

Discussion

The aim of this study was to comparatively examine the effects of dual-task exercise training during gait and balance exercises in addition to the traditional rehabilitation protocol on pain, ROM, functionality, QOL, and fear of movement in individuals with ACL-R.

The primary hypothesis of the study was that the use of foam rollers as an innovative approach would be more effective compared to the group without foam rollers. Accordingly, the study evaluated an effective exercise program and innovative approaches aimed at accelerating the healing process and increasing functional gains in ACL injuries, one of the most common injuries of the knee joint.

The findings showed that there was no statistically significant difference between the group using foam rollers and the group not using foam rollers. In other words, improvement was observed in both groups; however, the

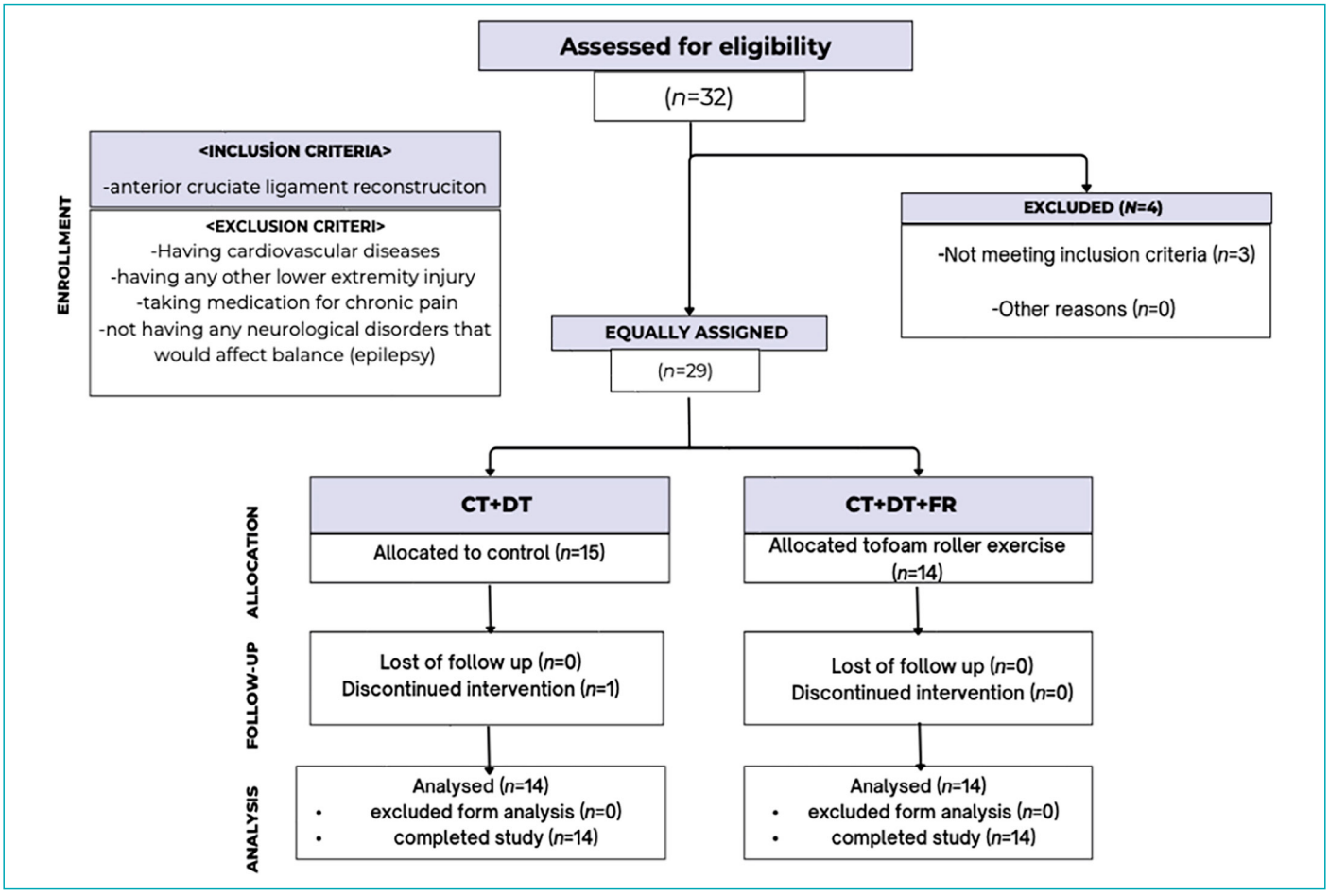

Figure 2. CONSORT flowchart.

CT+DT: Conventional and dual task rehabilitation exercise group, CT+DT+FR: Conventional rehabilitation program, dual task rehabilitation exercise, and foam roller treatment group.

innovative approach involving the use of foam rollers was not superior between the groups.

This result is in accordance with some studies in the literature. Indeed, there are studies demonstrating the effectiveness of dual-task exercises on balance and motor control.[24] In addition, in a study in which foam rollers were used during hydrotherapy, the main aim of the program was to increase neuromuscular control and reduce pain, and it was reported that this approach applied in addition to the traditional physiotherapy program increased proprioceptive efficiency.[14]

However, findings regarding the effects of myofascial release techniques such as foam rolling on short-term performance are inconsistent in the literature. Some studies report that these techniques reduce pain, increase muscle length, and ROM in the acute period.[25] On the other hand, some studies suggest that such interventions do not provide a significant advantage in long-term functional outcomes.

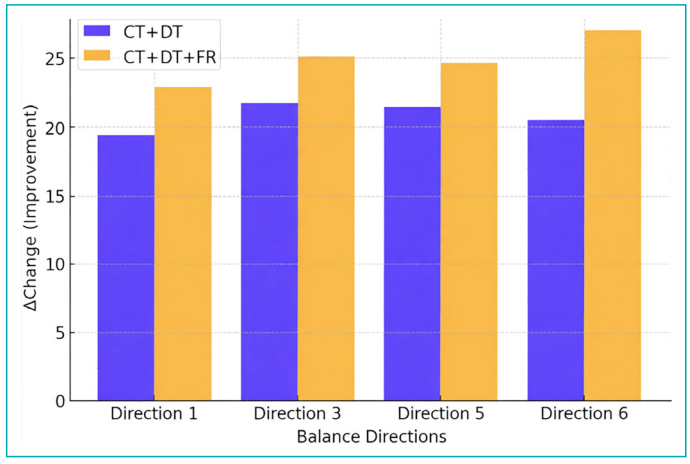

Figure 3. Star excursion balance test improvement comparison.

In this study, significant improvements in balance parameters were observed in both groups. Dual-task exercises are thought to improve adaptive responses by simultaneously challenging balance and activating the

Table 4. Change in the pain, range of motion, functionality, quality of life, and kinesiophobia score through 8-week rehabilitation intervention in each group

Variable pain (score)	Baseline, Mean±SD	8th week±SD	p_1	Δchange	p_2
CP+DT	86.92±17.40	18.35±13.95	**0.001**	-68.57±21.52	0.489
CP+DT+FR	87.14±17.17	16.78±18.35	**0.001**	-70.35±21.87	
Range of motion – Flexion (value)					
CP+DT	73.42±27.44	115.50±8.20	**0.001**	42.07±23.53	0.782
CP+DT+FR	79.28±24.87	115.21±13.62	**0.001**	35.92±17.23	
Range of motion –Extension (value)					
CP+DT	-6.57±7.79	-2.50±2.59	**0.027**	4.07±5.66	0.582
CP+DT+FR	-7.28±8.09	-1.42±3.05	**0.017**	5.85±7.40	
Functionality – Tegner (score)					
CP+DT	0.78±1.88	2.35±0.92	**0.015**	1.57±2.10	0.077
CP+DT+FR	2.35±0.92	2.00±0.78	0.390	-0.21±3.62	
Functionality – Lysholm (score)					
CT+DM	26.50±13.29	62.78±9.64	**0.001**	36.28±10.99	0.872
CT+DM+FM	28.50±19.81	61.07±12.24	**0.002**	32.57±19.96	
Quality of Life (score)					
CP+DT	12.83 ±12.10	66.55±17.96	**0.001**	53.72±18.04	0.073
CP+DT+FR	18.07±18.38	63.14±19.15	**0.001**	45.07±11.43	
Kinesiophobia (value)					
CP+DT	47±8.18	34.71±5.34	**0.001**	-12.28±4.95	0.489
CP+DT+FR	45.57±10.36	37.00±5.06	**0.016**	-8.57±10.27	

p_1: Values indicate within-group pre- and post-intervention comparisons performed using the Wilcoxon Signed-rank Test, p_2: Values indicate between-group comparisons performed using the Mann–Whitney U Test. CT+DT+FR: Conventional therapy+dual task+foam roller.

executive functions of the brain. This may contribute to the formation of a more effective and efficient postural control mechanism. Indeed, there are studies in the literature supporting that dual-task exercises positively affect balance performance in ACL-R.[26]

Recent studies have shown that psychological factors complicate the return to sports in ACL injuries and that gait and postural strategies adopted by individuals with a protective instinct may negatively affect knee joint biomechanics. In this study, a significant decrease in kinesiophobia levels was found in both groups.[27]

It is thought that foam roller applications may have reduced the perceived threat level by providing physical relaxation through muscle relaxation and proprioceptive stimulation. In addition, it can be said that dual-task exercises contribute to the suppression of fear-related responses by distracting attention from physical symptoms and thus help to reduce the fear of movement.

A statistically significant decrease in pain levels was observed in both groups. This finding is thought to be related to the analgesic and healing effects of traditional physiotherapy approaches. Although foam roller applications had pain-reducing effects in the acute period, this effect was not statistically significant in group comparisons.

The increase in ROM values indicates that muscle activation improved in both groups. It was determined that dual-task exercises supported motor control, and foam roller applications supported the flexibility of the musculoskeletal system.

After rehabilitation, an increase in the level of participation in activities of daily living was observed. It was determined that the improvement in functionality was especially associated with an increase in mobility. However, there was no statistically significant difference between the groups in terms of these parameters.

Limitations of the study include the small sample size and the single-center design, which restrict the generalizability of the findings. Although baseline differences in certain physical parameters (such as weight and BMI) were not statistically significant, they may still have influenced treatment responses. The relatively short duration of the intervention and potential variability in the standardization of foam roller application (pressure, duration, and frequency) further limit the interpretation of long-term

effects. Larger multicenter studies with extended follow-up periods are needed to validate these results.

The main strengths of this study include the fact that the interventions were implemented under controlled conditions and that all rehabilitation processes were conducted by the same therapist/team. This approach increased the consistency of the intervention and contributed to the reduction of intervention-related variability.

In the study, multidimensional assessments covering physical, functional, and psychological domains were performed, and clinically important parameters such as pain, ROM, balance, functionality, QOL, and kinesiophobia were considered together. This comprehensive assessment approach reveals not only the physical but also the psychological and functional aspects of the rehabilitation process in a holistic manner.

In addition, the dual-task exercise approach, which has been addressed in a limited number of studies in the literature on ACL rehabilitation, was integrated into the traditional rehabilitation protocol. In addition, the evaluation of foam roller application in addition to dual-task exercises offers an innovative approach that is rare in the existing literature. In particular, the comprehensive examination of parameters such as kinesiophobia, balance, functionality, and QOL with dual-task exercises and foam roller application shows that the study makes a unique contribution to the literature.

The findings of this study revealed that the traditional rehabilitation program and dual-tasking exercise approach did not provide any additional superiority in terms of pain, ROM, functionality, balance, QOL, and kinesiophobia compared to foam roller therapy applied in addition to the same interventions in individuals with ACL-R.

In the existing literature, there is no consistent consensus on the effectiveness of both dual-task exercises and foam roller applications. In this context, the addition of supportive approaches such as dual-tasking exercises or foam rolling to rehabilitation programs should be planned in line with the clinical characteristics, functional requirements, and treatment goals of individuals.

It is suggested that further studies with larger sample sizes and longer follow-up periods are needed to increase the generalizability of the findings and to demonstrate the long-term effects more clearly.

Conclusion

Dual-task exercises are preferred as a complementary rehabilitation method to traditional physical therapy approaches after ACL-R, due to the decrease in proprioceptive and kinesthetic functions and increased reliance on visual feedback in the operated limb compared to the contralateral healthy limb.

This study was designed to evaluate the effects of dual-task exercises and foam rolling intervention, applied in addition to traditional physical therapy, on pain, ROM, functionality, balance, QOL, and kinesiophobia.

The study results showed statistically significant improvements between pre- and post-intervention measurements in both regular exercise groups; however, no significant difference was found, indicating the superiority of one approach over the other when comparing the groups.

Disclosures

Ethics Committee Approval: The study was approved by the Marmara University Faculty of Medicine Clinical Research Ethics Committee (no: 09.2024.370, date: 25/05/2024).

Informed Consent: Written informed consents were obtained from patients who participated in this study.

Conflict of Interest Statement: The authors declare that there is no conflict of interest.

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References

1. Moses B, Orchard J, Orchard J. Systematic review: Annual incidence of ACL injury and surgery in various populations. Res Sports Med 2012;20(3-4):157–79.
2. Jiménez-Martínez J, Gutiérrez-Capote A, Alarcón-López F, Leicht A, Cárdenas-Vélez D. Relationship between cognitive demands and biomechanical indicators associated with anterior cruciate ligament injury: a systematic review. Sports Med 2025;55(1):145–65.
3. Diermeier T, Rothrauff BB, Engebretsen L, Lynch AD, Ayeni OR, Paterno MV, et al. Treatment after anterior cruciate ligament injury: Panther Symposium ACL Treatment Consensus Group. Knee Surg Sports Traumatol Arthrosc 2020;28(8):2390–402.
4. Czamara A, Krzemińska K, Widuchowski W, Dragan SL. The muscle strength of the knee joint after acl reconstruction depends on the number and frequency of supervised

physiotherapy visits. Int J Environ Res Public Health 2021;18(20):10588.
5. Demirci S. Effect of plyometric training with blood flow restriction on muscle strength and function after anterior cruciate ligament reconstruction [doctoral thesis]. Ankara: Hacettepe University Institute of Health Sciences; 2019.
6. Saadat S, Bricarell KM, Gillette JC. Dual tasking increases kinematic and kinetic risk factors of ACL injury. Sports Biomech 2025;24(5):1400–13.
7. Chaput M, Simon JE, Taberner M, Grooms DR. From control to chaos: visual-cognitive progression during recovery from ACL reconstruction. J Orthop Sports Phys Ther 2024;54:431–9.
8. Hallaj Mazidluie M, Ahadi J, Oraei Eslami F, Ghanavati T, Moradi A. Comparison of the effects of cognitive dual-task and single-task balance exercises on static balance among people with anterior cruciate ligament reconstruction: a randomized controlled trial. Arch Bone Jt Surg 2024;12(5):349–56.
9. Gaßner H, Trutt E, Seifferth S, Friedrich J, Zucker D, Salhani Z, et al. Treadmill training and physiotherapy similarly improve dual task gait performance: a randomized-controlled trial in Parkinson's disease. J Neural Transm (Vienna) 2022;129(9):1189–200.
10. Ahmed U, Karimi H, Amir S, Ahmed A. Effects of intensive multiplanar trunk training coupled with dual-task exercises on balance, mobility, and fall risk in patients with stroke: a randomized controlled trial. J Int Med Res 2021;49(11):3000605211059413.
11. Konrad A, Nakamura M, Tilp M, Donti O, Behm DG. Foam rolling training effects on range of motion: a systematic review and meta-analysis. Sports Med 2022;52(10):2523–35.
12. Macdonald GZ, Button DC, Drinkwater EJ, Behm DG. Foam rolling as a recovery tool after an intense bout of physical activity. Med Sci Sports Exerc 2014;46(1):131–42.
13. Habscheid C, Szikszay TM, Luedtke K. The effect of foam rolling on local and distant pain sensitivity assessed with pressure pain thresholds in healthy participants and musculoskeletal pain patients: A systematic review. J Bodyw Mov Ther 2024;40:786–96.
14. Hajouj E, Hadian MR, Mir SM, Talebian S, Ghazi S. Effects of innovative aquatic proprioceptive training on knee proprioception in athletes with anterior cruciate ligament reconstruction: a randomized controlled trial. Arch Bone Jt Surg 2021;9(5):519–26.
15. Cheatham SW, Stull KR. Roller massage: Comparison of three different surface type pattern foam rollers on passive knee range of motion and pain perception. J Bodyw Mov Ther 2019;23(3):555–60.
16. van Grinsven S, van Cingel RE, Holla CJ, van Loon CJ. Evidence-based rehabilitation following anterior cruciate ligament reconstruction. Knee Surg Sports Traumatol Arthrosc 2010;18(8):1128–44.
17. Gribble PA, Hertel J, Plisky P. Using the Star Excursion Balance Test to assess dynamic postural-control deficits and outcomes in lower extremity injury: a literature and systematic review. J Athl Train 2012;47(3):339–57.
18. Eliöz M, Sitti S, Koç M, Murt Z, Koç H. A study on static balance performance of healthy and hearing-impaired football players. Eur J Appl Sci 2013;5(1):25–8.
19. Briggs KK, Kocher MS, Rodkey WG, Steadman JR. Reliability, validity, and responsiveness of the Lysholm knee score and Tegner activity scale for patients with meniscal injury of the knee. J Bone Joint Surg Am 2006;88(4):698–705.
20. Celik D, Coşkunsu D, Kiliçoğlu O. Translation and cultural adaptation of the Turkish Lysholm knee scale: ease of use, validity, and reliability. Clin Orthop Relat Res 2013;471(8):2602–10.
21. Kinikli GI, Celik D, Yuksel I, Atay OA. Turkish version of the Anterior Cruciate Ligament Quality of Life questionnaire. Knee Surg Sports Traumatol Arthrosc 2015;23(8):2367–75.
22. Huang H, Nagao M, Arita H, Shiozawa J, Nishio H, Kobayashi Y, et al. Reproducibility, responsiveness and validation of the Tampa Scale for Kinesiophobia in patients with ACL injuries. Health Qual Life Outcomes 2019;17(1):150.
23. Kese B, Salcı Y, Yılmaz ÖT. Validity and reliability of the Tampa Kinesiophobia-Fatigue Scale in patients with multiple sclerosis. Ir J Med Sci 2023;192(1):285–90.
24. Maden C, Turhan B, Sarı EO, Bayramlar K. Comparison of physical activity, dual-task performance, and cognitive skills between problematic video game players and control subjects. Cureus 2022;14(11):e31073.
25. MacDonald GZ, Penney MD, Mullaley ME, Cuconato AL, Drake CD, Behm DG, et al. An acute bout of self-myofascial release increases range of motion without a subsequent decrease in muscle activation or force. J Strength Cond Res 2013;27(3):812–21.
26. Grooms D, Appelbaum G, Onate J. Neuroplasticity following anterior cruciate ligament injury: a framework for visual-motor training approaches in rehabilitation. J Orthop Sports Phys Ther 2015;45(5):381–93.
27. Nedder VJ, Raju AG, Moyal AJ, Calcei JG, Voos JE. Impact of psychological factors on rehabilitation after anterior cruciate ligament reconstruction: a systematic review. Sports Health 2025;17(2):291–8.

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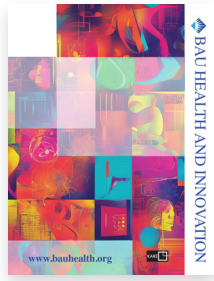

Original Article

Psychometric Properties of the Perceived Ageism Questionnaire in Turkish Older Adults

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Abstract

Objectives: Perceived ageism has been shown to play an important role in older adults' health and well-being; however, brief measures assessing both negative and positive age-related experiences require robust psychometric evidence across different languages and contexts. This study provides psychometric evidence for the Perceived Ageism Questionnaire (PAQ-8) in Turkish community-dwelling older adults.

Methods: This study used a methodological design and included 101 adults aged 55 years and older. After translation and expert appraisal, content validity was examined using item- and scale-level indices. Evidence for construct validity was obtained through exploratory and confirmatory factor analyses. Reliability was evaluated by assessing internal consistency and short-term stability in a subsample. Statistical analyses were performed using the Statistical Package for the Social Sciences 27 and R (lavaan package).

Results: In the present sample, participants' mean age was 61.46±5.88 years. Content validity was excellent (Item content validity index=1.00). Sampling adequacy was supported (Kaiser-Meyer-Olkin=0.747), and Bartlett's test indicated suitability for factor analysis ($p<0.001$). Exploratory factor analysis supported a two-factor structure (negative and positive perceived ageism) explaining 49.62% of the total variance. Confirmatory factor analysis confirmed the two-factor model with excellent fit. The total scale and both subscales showed satisfactory internal consistency coefficients (total $\alpha=0.81$, $\omega=0.85$; negative $\alpha=0.80$, $\omega=0.81$; positive $\alpha=0.75$, $\omega=0.76$).

Conclusion: The Turkish PAQ-8 demonstrated excellent content validity, a stable two-factor structure, satisfactory internal consistency, and excellent test–retest reliability. It appears to be a brief and reliable instrument for assessing perceived negative and positive ageism among older adults in Türkiye.

Keywords: Ageism, cross-cultural adaptation, older adults, perceived ageism, psychometrics, reliability, validity.

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Population ageing is accelerating worldwide, making healthy ageing a central public health and policy priority. Yet older adults continue to face ageism – stereotyping, prejudice, and discrimination directed at people because of their age – which can occur at interpersonal, institutional, and societal levels.[1] The World Health Organization (WHO's) global report on ageism emphasizes that ageism is widespread and consequential, shaping participation, access to resources, and experiences within health and social care systems.[1] Recent syntheses further indicate that ageism is expressed within health services through both interpersonal interactions and organizational practices, potentially influencing older adults' experiences across care pathways and contributing to inequities in access and treatment.[2,3]

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A growing body of evidence indicates that ageism is not only a social justice issue but also a measurable risk factor for health. In a major synthesis, Chang et al.[4] concluded that ageism is associated with worse health outcomes across multiple domains. Mechanistically, ageism can operate through psychosocial and behavioral pathways, including stress, reduced help-seeking, poorer adherence, and internalization of negative age stereotypes.[5] Stereotype Embodiment Theory posits that age stereotypes internalized across the life course can become self-relevant in later life and influence cognition, affect, behavior, and physiological responses.[5] Accordingly, older adults' subjective experiences of being treated differently because of age may contribute to poorer quality of life and mental well-being, and may also relate to physical health through stress-related processes and health behaviors.[1,5]

Given these implications, robust measurement of ageism – particularly as experienced by older adults themselves – is essential for epidemiological surveillance, cross-cultural comparisons, and evaluation of interventions aiming to reduce ageism. However, many available tools focus on attitudes toward older people or capture limited facets of discrimination, which can constrain comparability across studies and settings.[1] To address the need for brief, theory-informed assessment of perceived ageism, Brinkhof et al.[6] developed the Perceived Ageism Questionnaire (PAQ), including an 8-item version (PAQ-8), to capture older adults' subjective experiences of ageism. The PAQ-8 reflects both negative and positive perceived ageism and showed meaningful associations with self-perceptions of ageing and mental health indicators in the original validation study.[6] A concise instrument is particularly advantageous in psychogeriatric and community research, where respondent burden is a practical concern and integration into broader assessments is often required.

Against this background, establishing a robust measurement of perceived ageism in Turkish is important. In Türkiye, existing ageism measures and validations provide a useful starting point, yet additional work is warranted to strengthen the measurement of older adults' perceived ageism across diverse samples and settings.[7–11] Because cross-cultural measurement requires conceptual and contextual equivalence beyond literal translation, further psychometric evidence for Turkish instruments remains important for high-quality national research and international comparability.[12,13] Recently, a Turkish adaptation of the PAQ-8 (PAQ-TR) was published, confirming the two-factor structure in a different sample context.[8] However, that study reported comparatively lower reliability for the positive ageism subscale and did not examine short-term temporal stability. In addition, methodological differences – such as administration mode and sample characteristics—may influence factorial structure and subscale performance. Therefore, further psychometric evaluation in independent Turkish samples remains important to assess the robustness, stability, and contextual sensitivity of the PAQ-8 structure. In this context, the aim of the present study was to provide psychometric evidence for a Turkish version of the PAQ-8 in a community-based sample of adults aged 55 years and older, focusing on its factor structure and reliability.

Materials and Methods

Study Design

This study adopted a methodological approach to perform the Turkish cultural adaptation and psychometric assessment of the 8-item PAQ. Reporting of this study followed the "International Test Commission (ITC) Guidelines for Translating and Adapting Tests" to ensure linguistic, cultural, and psychometric equivalence.[14]

Setting and Participants

Data were collected online in Türkiye using a snowball sampling approach. Individuals aged 55 years or older who were able to read and understand Turkish and had basic smartphone literacy sufficient to complete an online questionnaire were eligible to participate. Individuals younger than 55 years and those with a reported diagnosis of intellectual disability were excluded. A total of 101 community-dwelling older adults were included in the main analyses. For test–retest reliability, 30 participants completed the PAQ-8-T a 2nd time 2 weeks after the initial administration.

In scale adaptation studies, sample size is commonly determined using the rule of recruiting approximately 5–10 participants per item.[14,15] Given the eight-item structure of the PAQ-8 and commonly cited participant-to-item ratios in scale adaptation studies, the sample size (n=101) may be considered minimally acceptable for exploratory and confirmatory factor analyses.

Measurement Instruments

Sociodemographic Information Form

A researcher-developed sociodemographic form was used to collect basic participant characteristics (age, gender, marital status, education, living arrangements, and employment status).

PAQ-8

The PAQ was developed by Brinkhof et al.[6] to assess perceived ageism among adults aged 55 years and older. The PAQ-8 consists of eight items and includes two subscales: Perceived negative ageism (NEG; 5 items-1,2,4,6,7) and perceived positive ageism (POS; 3 items-3,5,8). NEG subscale captures experiences of negative ageism (e.g., perceiving age-related stereotypes, prejudice, or discriminatory treatment), whereas the POS subscale reflects perceived positive/benevolent ageism experiences (e.g., being treated more positively because of one's age). Participants indicate how often they experienced each situation over the previous 12 months using a 5-point Likert-type scale ranging from "1=never" to "5=very often". Subscale scores are computed by summing the relevant items; higher scores indicate more frequent perceived ageism experiences within that domain. In the original study of PAQ-8, Cronbach's alpha was reported as 0.67 for total, 0.79 for the NEG subscale, and 0.71 for the POS subscale.[6]

Translation and Cultural Adaptation Procedures

Before the adaptation process, written permission to translate and use the PAQ-8 was obtained from the corresponding author of the original scale. The translation and cross-cultural adaptation procedures were conducted in line with internationally recognized recommendations for test adaptation, including the International Test Commission guidelines[14] and the WHO translation and adaptation process.[16]

Step I – Forward Translation

To achieve semantic accuracy and preserve the intended meaning of the items, the scale was translated from English into Turkish independently by two bilingual translators. Translators were instructed to prioritize conceptual meaning and clarity over literal word-by-word translation, and to consider Turkish cultural usage when selecting expressions for potentially sensitive or context-dependent items.

Step II – Reconciliation and Synthesis

The two Turkish drafts were compared item-by-item by the researcher. Discrepancies in wording, tone, and meaning were discussed until a single reconciled Turkish version was created. Special attention was paid to maintaining the time frame ("past year") and response anchors (5-point frequency format) consistent with the original instrument.

Step III – Back Translation

The reconciled Turkish version was independently back-translated into English by two translators who were blinded to the original scale. The goal of back translation was to check whether the Turkish items preserved the original meaning and intent. The back-translated version was then compared with the original PAQ-8, and items showing potential conceptual drift were reviewed and refined.

Step IV – Expert Panel Review and Content Validity

An expert panel consisting of five specialists working in public health, geriatric health, and psychiatry evaluated the Turkish version for semantic clarity, cultural appropriateness, and content representativeness. Content validity was assessed using the Davis technique.[17] Experts rated each item on a four-point relevance scale (1=not relevant, 2=somewhat relevant, 3=relevant with minor revisions, 4=highly relevant). Ratings of 3 or 4 were considered acceptable. Based on expert feedback, minor wording adjustments were made to improve comprehensibility and to ensure consistency in terminology across items.

Step V – Pilot Testing

Following the expert review, the pre-final Turkish form was pilot-tested with 20 older adults from the target population to evaluate item comprehensibility, response process, and feasibility of the online administration format. Participants were asked to comment on unclear words or expressions, and the approximate completion time was recorded. The pilot feedback indicated that the items were understandable, and no major revisions were required. Data obtained during the pilot were used only to confirm clarity and feasibility and were not included in the psychometric analyses.

Step VI – Finalization and Documentation

After incorporating minor expert-driven edits and confirming clarity through pilot testing, the final PAQ-8-T version was established. All steps of the adaptation process – including translation notes, reconciliation decisions, expert recommendations, and pilot feedback – were documented to support methodological transparency and reproducibility.

Step VII –Final Study

Following the adaptation process, the finalized PAQ-8-T was administered to the main sample for psychometric evaluation.

Data Collection

Data were collected online using Google Forms and a snowball sampling approach. The survey link was initially shared with eligible individuals and disseminated

through participants' networks. Eligibility was confirmed through self-report screening items. Before accessing the questionnaire, participants were presented with a brief study information screen outlining the aim of the research, data collection procedures, conditions of voluntary participation, data privacy safeguards, and the option to discontinue participation at any stage without consequences; consent was provided electronically by indicating agreement to take part.

To protect confidentiality, no personally identifying information was collected within the main survey responses (e.g., name or national ID number), and data were stored in a secure, password-protected account accessible only to the researcher. Following consent, participants completed the sociodemographic information form and the PAQ-8-T.

For temporal stability (test–retest reliability), participants were informed that they might be invited to complete the questionnaire again 2 weeks later. Those who voluntarily agreed to participate in the retest provided a contact detail solely for scheduling the second administration (phone number or e-mail). Contact details were collected separately from survey responses and were not linked to questionnaire data. After 2 weeks, the PAQ-8-T was re-administered to the same 30 participants via the online form, and test–retest analyses were conducted using these matched responses. Contact information was used only for re-invitation purposes and was deleted after completion of the retest.

Ethical Considerations

Approval for the study was granted by the Van Yüzüncü Yıl University Non-interventional Clinical Research Ethics Committee (Date: February 04, 2025; No: 2025/01–16). Authorization to translate and apply the PAQ-8 was obtained from the scale's original authors. Participation was entirely voluntary, and consent was provided electronically before respondents proceeded to the survey. Before participation, individuals were informed about how the study would be carried out, how their data would be handled, and their option to discontinue participation at any stage. All procedures were performed in line with internationally accepted ethical standards, including the Declaration of Helsinki.

Data Analysis

Data were analysed in a stepwise manner. Descriptive statistics were used to summarize participant characteristics and item responses. Evidence for validity was examined through content and construct validity procedures. Content validity was evaluated based on expert judgments using the Davis method.[17] Before factor analyses, data suitability was checked using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test.

Exploratory factor analysis (EFA) was performed with Principal Axis Factoring (PAF) and oblique rotation, allowing correlations between factors. The number of factors was determined using eigenvalues, explained variance, and visual inspection of the scree plot. The factor solution was interpreted based on factor loadings and communalities. The proposed factor structure was subsequently tested using confirmatory factor analysis with an estimator appropriate for ordinal data.

Reliability was assessed by examining internal consistency coefficients and short-term stability. Internal consistency was evaluated using Cronbach's alpha and McDonald's omega, while test–retest reliability was examined using intraclass correlation coefficients (ICC). All statistical analyses were conducted using the Statistical Package for the Social Sciences version 27.0 (IBM, New York, USA) and R (version 4.5.2; RStudio; lavaan package).

Results

Sample Characteristics

A total of 101 participants were included. Ages ranged from 55 to 80 years, with a mean age of 61.46±6.88. Overall, 55.4% of participants were women (n=56). Most were married (n=84, 83.2%). Regarding education, the largest group had middle school education (n=32, 31.7%). The vast majority lived with family (n=96, 95.0%). Finally, 77.2% were not working (n=78) (Table 1).

Validity

The item-level CVI (I-CVI) of PAQ-8-T was 1.00 for all items, and the scale-level CVI (S-CVI/Ave) was 1.00 (Table 2). An EFA was conducted to assess construct validity. The KMO value was 0.747 for sampling adequacy, and Bartlett's test was significant ($\chi^2[28]=273.747$, $p<0.001$), indicating that the data were suitable for factor analysis. An EFA was conducted using PAF with Direct Oblimin rotation (allowing correlated factors). Based on the eigenvalues (>1) and the scree plot, a two-factor solution was retained (Fig. 1). The two factors explained 49.62% of the total variance (Factor 1: 37.59%; Factor 2: 12.03%). The pattern matrix showed that five items loaded on the perceived negative ageism subscale (NEG) factor (N1, N2, N4, N6, N7; loadings 0.620–0.733) and three items loaded on the POS (perceived positive ageism subscale) factor (P3, P5, P8; loadings 0.595–0.909) (Table 3).

Table 1. Sociodemographic characteristics of the participants (n=101)

	Min–Max	Mean±SD
Age (years)	55–80	61.46±5.888
	n	**%**
Gender		
Female	56	55.4
Male	45	44.6
Marital status		
Married	84	83.2
Single/Widowed	17	16.8
Education level		
Literate	6	5.9
Primary school	27	26.7
Middle school	32	31.7
High school	24	23.8
University	12	11.9
Living arrangement		
Alone	4	4.0
Family	96	95.0
Relatives	1	1.0
Employment status		
Employed	23	22.8
Unemployed/Not working	78	77.2

SD: Standard deviation, Min: Minimum, Max: Maximum.

Table 2. Item-level and scale-level CVI results for the PAQ-8-T

Item	Expert agreement (3 or 4 ratings)	I-CVI
N1	5/5	1.00
N2	5/5	1.00
P3	5/5	1.00
N4	5/5	1.00
P5	5/5	1.00
N6	5/5	1.00
N7	5/5	1.00
P8	5/5	1.00
S-CVI/Ave	—	1.00

I-CVI: Item content validity index, S-CVI/Ave: Scale content validity index (average method), PAQ: Perceived ageism questionnaire. Experts rated each item on a 4-point relevance scale; ratings of 3 or 4 were considered acceptable.

Table 3. Exploratory factor analysis (EFA) results of the PAQ-8-T

	NEG (Factor 1)	POS (Factor 2)
N2	0.733	—
N1	0.695	—
N6	0.628	—
N7	0.627	—
N4	0.620	—
P3	—	0.909
P8	—	0.619
P5	—	0.595
Eigenvalue (Initial)	3.500	1.422
Explained variance (%)	37.586	12.033
Cumulative variance (%)	37.586	49.618

NEG: Perceived negative ageism subscale, POS: Perceived positive ageism subscale, PAQ: Perceived ageism questionnaire. Extraction method: Principal axis factoring (PAF), Rotation method: Direct Oblimin (δ=0) with Kaiser normalization. Factor loadings <0.30 are suppressed.

Confirmatory factor analysis (CFA) was conducted to test the hypothesized two-factor structure of the PAQ-8-T, consisting of NEG (N1, N2, N4, N6, N7) and POS (P3, P5, P8). The initial two-factor model demonstrated acceptable-to-good fit (χ^2/df=25.907/19=1.36, comparative fit ındex [CFI]=0.994, Tucker-Lewis Index [TLI] = 0.991, root mean square error of approximation [RMSEA]=0.060, standardized root mean square residual [SRMR]=0.070). Based on both theoretical considerations and modification indices, a residual covariance was specified between items N1 and N2 (Model 2). These two items both reflect interpersonal experiences of age-based devaluation in communication contexts – specifically, being treated as if one were a child and not being taken seriously due to age. Because both items capture closely related aspects of paternalistic or infantilizing ageism, it was theoretically plausible that they share variance beyond the underlying NEG factor. Allowing their residuals to correlate, therefore, reflects overlapping content rather than model overfitting. The revised model showed improved fit (χ^2/df=20.137/18=1.12, CFI=0.998, TLI=0.997, RMSEA=0.034, SRMR=0.064) (Table 4). Figure 2 presents the final two-factor CFA model of the PAQ-8-T. All standardized factor loadings were statistically significant (p<0.001) and ranged from 0.65 to 0.90 for NEG and from 0.68 to 0.82 for POS (Fig. 2). The correlation between NEG and POS was moderate and negative (r=−0.59, p<0.001). A residual covariance between N1 and N2 was added based on modification indices (N1~~N2).

Reliability

Internal consistency of the PAQ-8-T was examined using Cronbach's alpha and McDonald's omega. The total score showed good internal consistency (α=0.81, ω=0.85). For the subscales, reliability coefficients were acceptable: The perceived NEG yielded α=0.80 and ω=0.81, while the POS yielded α=0.75 and ω=0.76 (Table 5). Overall, the coefficients were at or above commonly recommended

Table 4. Model fit indices for competing CFA models of the PAQ-8-T

Criterion	Fit ranges		Model 1: Two-factor (initial)	Model 2: Two-factor (revised; N1 ~~ N2)
	Good	Acceptable		
χ^2/df	$0 \leq \chi^2/df \leq 2$	$2 \leq \chi^2/df \leq 5$	25.907/19=1.36	20.137/18=1.12
CFI	0.95≤CFI≤1	0.90≤CFI≤0.95	0.994	0.998
TLI	0.95≤NNF≤1	0.90≤NNFI≤0.95	0.991	0.997
RMSEA	0<RMSEA<0.05	0.05≤RMSEA≤0.10	0.060	0.034
SRMR	0≤SRMR≤0.05	0.05≤SRMR≤0.10	0.070	0.064

χ^2: Chi-square, df: Degrees of freedom, CFI: Comparative fit index, TLI: Tucker–Lewis index, RMSEA: Root mean square error of approximation, SRMR: Standardized root mean square residual.[18–22] PAQ: Perceived ageism questionnaire. Estimator: WLSMV. Model 2 includes a residual covariance between N1 and N2 (N1~~N2).

thresholds (≥0.70), supporting internal consistency for the scale and its subscales. Corrected item–total correlations ranged from 0.552 to 0.655 for the negative subscale and from 0.536 to 0.639 for the positive subscale, indicating adequate item discrimination and internal consistency (Table 5).

The ICC for the total instrument score was 0.95 (95% confidence interval [CI], 0.467–0.986; p<0.001), the NEG subscale was 0.95 (95% CI, 0.452–0.972; p<0.001), and the POS subscale was 0.94 (95% CI, 0.732–0.973; p<0.001) between the two administrations. The ICC values ranged from 0.94 to 0.95 and were statistically significant, indicating high test–retest stability.

Discussion

This study provides psychometric evidence for a Turkish version of the 8-item PAQ-8 in an online community sample of adults aged 55 years and older. Overall, the findings support the structural validity and reliability of the PAQ-8-T and indicate that the measure can be used to assess perceived negative and positive ageism experiences among older adults in Türkiye.

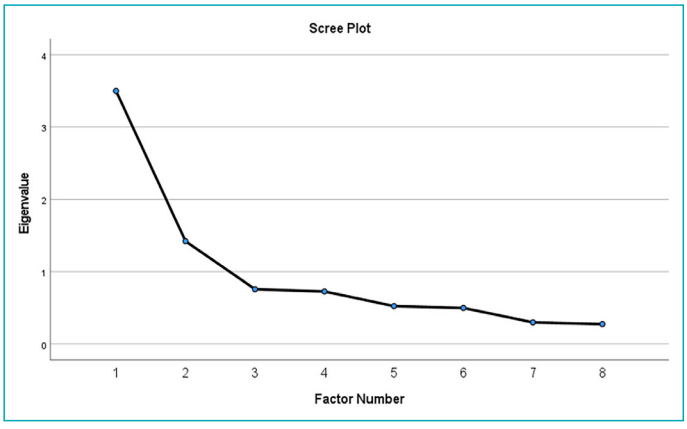

Figure 1. Scree plot of eigenvalues across factors.

Table 5. Item–total correlations, Cronbach's α, and McDonald's ω for the PAQ-8-T

	Number of items	Corrected item–total correlation	Cronbach's α	McDonald's ω
NEG (N1, N2, N4, N6, N7)	5	0.552–0.655	0.80	0.81
POS (P3, P5, P8)	3	0.536–0.639	0.75	0.76
Total instrument	8		0.81	0.81

NEG: Perceived negative ageism subscale, POS: Perceived positive ageism subscale, PAQ: Perceived ageism questionnaire. Positively worded items (P3, P5, P8) were reverse-coded before computing the total score so that higher total scores indicate greater perceived negative ageism.

Consistent with the original development and validation of the PAQ-8, both EFA and CFA in the present study supported a two-factor structure comprising perceived negative ageism (NEG; five items) and perceived positive ageism (POS; three items).[6] In our sample, the two-factor solution demonstrated adequate explained variance and salient item loadings in EFA, and CFA corroborated this structure with excellent fit using Weighted Least Squares

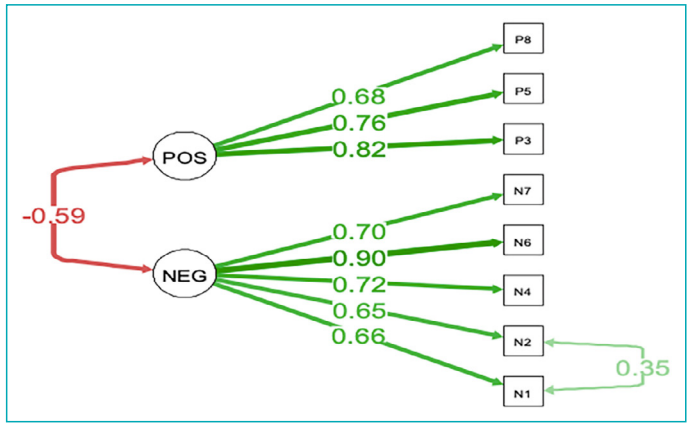

Figure 2. Confirmatory factor analysis of the perceived ageism questionnaire-8-T.

Means and Variance adjusted estimation (e.g., CFI=0.998; RMSEA=0.034). These results align with prior cross-cultural evidence. For example, the recently published Turkish adaptation (PAQ-TR) likewise confirmed the two-factor model with good fit indices,[8] and preliminary evidence from the Portuguese version also supported the same two-dimensional structure.[23] Taken together, the convergence of factorial findings across the original and translated versions supports the structural validity and cross-cultural robustness of the PAQ-8.

Reliability analyses indicated that the Turkish PAQ-8 has satisfactory internal consistency and high short-term temporal stability. Internal consistency coefficients were acceptable[24] for the total score and for both subscales (total α=0.81, ω=0.85; NEG α=0.80, ω=0.81; POS α=0.75, ω=0.76). These values are comparable to those reported in the original validation and consistent with Portuguese findings indicating acceptable reliability for NEG and POS.[6,23] Importantly, while the Turkish PAQ-TR study reported strong reliability for NEG but comparatively lower reliability for POS, suggesting potential contextual sensitivity of the positive dimension,[8] POS reliability in our sample was higher. This discrepancy may reflect differences in sample composition, administration context, or interpretation of benevolent/positive ageism items. Finally, test–retest reliability over a two-week interval was excellent (ICC=0.94–0.95), supporting the stability of PAQ-8-T scores. Finally, although point estimates of the ICC were high (0.94–0.95), the relatively wide confidence intervals, likely attributable to the modest retest sample size (n=30), suggest that temporal stability should be interpreted with caution. Nonetheless, the findings indicate satisfactory short-term stability of PAQ-8-T scores.

Regarding associations between subscales, NEG and POS were moderately and inversely related in our CFA (r=-0.59). This pattern is conceptually plausible: individuals who more frequently perceive negative, demeaning, or discriminatory age-based experiences may be less likely to interpret age-related interactions as positive or supportive. Evidence on the NEG–POS association appears to vary across samples and contexts. In the original PAQ-8 study, the correlation between the two factors was small and non-significant in one sample (r=0.08), suggesting that the dimensions may operate relatively independently under some conditions.[6] In contrast, the Turkish PAQ-TR validation reported a strong negative association between the latent factors (r=−0.75), which is directionally consistent with our finding but suggests that the magnitude of the relationship may differ across Turkish samples.[8] The Portuguese validation, however, reported a small positive association (ρ≈0.15), indicating that the direction and magnitude of the relationship may depend on population characteristics and measurement context.[23] Future studies should clarify how NEG and POS relate across populations by testing measurement invariance and replicating factor correlations in larger, diverse samples.

From a clinical and research perspective, a brief, psychometrically supported Turkish measure of perceived ageism may facilitate routine assessment of both negative and positive ageism experiences in psychogeriatric research and practice. Such measurement can support monitoring efforts in community and clinical settings and inform evaluations of interventions aimed at reducing ageism.

The inclusion of individuals aged 55 years and older follows the original PAQ-8 development study.[6] Ageism is increasingly conceptualized as a life-course phenomenon rather than a construct limited to traditional old age.[1] Consistent with stereotype embodiment theory, age stereotypes are internalized across the life span and may become self-relevant before conventional old-age thresholds are reached.[5] Thus, the 55+ criterion is conceptually defensible, although future research may explore differences across narrower age groups.

Strengths

This study has several strengths. The adaptation process followed internationally recognized guidelines for test translation and cultural adaptation. Both exploratory and confirmatory factor analyses were conducted to examine internal structure, and internal consistency was evaluated using both Cronbach's alpha and McDonald's omega. In addition, short-term test–retest reliability was assessed, providing evidence regarding temporal stability of the PAQ-8-T. These methodological features contribute to the robustness of the psychometric evaluation.

Study Limitations

These findings should be interpreted in light of several limitations. First, validity evidence in this study was primarily limited to content validity and internal structure (EFA/CFA); future studies should examine convergent, discriminant, and criterion-related validity using external measures and outcomes. Second, more advanced psychometric testing (e.g., measurement invariance across key demographic groups) was not conducted and should be evaluated in larger samples. Third, data were collected online using a snowball sampling approach. This recruitment strategy may have favored older adults with greater digital access

and smartphone literacy, potentially excluding individuals with limited technological skills and thereby restricting representativeness. Furthermore, the sample was relatively homogeneous in certain sociodemographic characteristics (e.g., marital status and living arrangements), which may restrict generalizability to more diverse older populations. Finally, although the sample size may be considered minimally acceptable for factor analysis given the eight-item structure, more advanced psychometric testing (e.g., measurement invariance across key demographic groups) and replication in larger and more heterogeneous samples are warranted.

Conclusion

The Turkish PAQ-8 demonstrated excellent content validity, a stable two-factor structure supported by both EFA and CFA, satisfactory internal consistency, and high test–retest reliability over 2 weeks. These findings indicate that the PAQ-8-T is a brief, reliable, and valid instrument for assessing perceived negative and positive ageism among older adults in Türkiye. The scale may facilitate psychogeriatric research, support monitoring of ageism in community and clinical settings, and enable cross-cultural comparisons in studies examining the health and well-being correlates of perceived ageism.

Disclosures

Ethics Committee Approval: The study was approved by the Van Yüzüncü Yıl University Non-interventional Clinical Research Ethics Committee (no: 2025/01–16, date: 04/02/2025).

Informed Consent: Informed consent was obtained from all participants.

Conflict of Interest Statement: The author declare that there is no conflict of interest.

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References

1. World Health Organization. Global report on ageism. Geneva: World Health Organization; 2021. Available at: https://www.who.int/publications/i/item/9789240016866. Accessed June 23, 2026.
2. Araújo PO, Soares IMSC, Vale PRLFD, Sousa AR, Aparicio EC, Carvalho ESS. Ageism directed to older adults in health services: A scoping review. Rev Lat Am Enfermagem 2023;31:e4019.
3. Jeyasingam N, McLean L, Mitchell L, Wand APF. Attitudes to ageing amongst health care professionals: a qualitative systematic review. Eur Geriatr Med 2023;14(5):889–908.
4. Chang ES, Kannoth S, Levy S, Wang SY, Lee JE, Levy BR. Global reach of ageism on older persons' health: A systematic review. PLoS One 2020;15(1):e0220857.
5. Levy B. Stereotype embodiment: a psychosocial approach to aging. Curr Dir Psychol Sci 2009;18(6):332–6.
6. Brinkhof LP, de Wit S, Murre JMJ, Krugers HJ, Ridderinkhof KR. The subjective experience of ageism: The Perceived Ageism Questionnaire (PAQ). Int J Environ Res Public Health 2022;19(14):8792.
7. Çapa BE, Ekşi H. Yaşlılık Ayrımcılığı Ölçeği'nin Türkçeye uyarlanması: Geçerlilik ve güvenirlik çalışması. In: Şahin Eİ, Amanzholova A, editors. 6th Baskent International Conference on Multidisciplinary Studies Proceedings Book. Ankara: Iksad Publications; 2024. p. 535-544.
8. Doğan M, Doğan ÖE. Cross-cultural adaptation and psychometric evaluation of the Turkish Perceived Ageism Questionnaire (PAQ-TR). Healthcare (Basel) 2025;13(22):2844.
9. Erol S, Ergun A, Kadıoglu H, Gur K, Albayrak S, Şişman FN, et al. The psychometric features of the Turkish version of the Ageism Survey and the frequency of ageism. International Journal of Gerontology 2016;10(3):170–4.
10. Kutlu Y, Kucuk L, Yildiz Findik U. Psychometric properties of the Turkish version of the Fraboni Scale of Ageism. Nurs Health Sci 2012;14(4):464–71.
11. Yurttaş S, Sarıkoca E. Positive and Negative Ageism Scale (PNAS) A validity and reliability study. ATASOBED 2018;22:1977–91.
12. Beaton DE, Bombardier C, Guillemin F, Ferraz MB. Guidelines for the process of cross-cultural adaptation of self-report measures. Spine (Phila Pa 1976) 2000;25(24):3186–91.
13. Güngör D. Psikolojide ölçme araçlarının geliştirilmesi ve uyarlanması kılavuzu. Türk Psikoloji Yazıları 2016;19(38):104–12. [Article in Turkish]
14. International Test Commission. The ITC Guidelines for Translating and Adapting Tests (Second edition). Available at: https://www.intestcom.org/files/guideline_test_adaptation_2ed.pdf. Accessed June 23, 2026.
15. Boateng GO, Neilands TB, Frongillo EA, Melgar-Quiñonez HR, Young SL. Best practices for developing and validating scales for health, social, and behavioral research: a primer. Front Public Health 2018;6:149.
16. World Health Organization. Process of translation and adaptation of instruments; 2007. Available at: http://www.who.int/substance_abuse/research_tools/translation/en/. Accessed June 23, 2026.
17. Davis LL. Instrument review: Getting the most from a panel of experts. Appl Nurs Res 1992;5(4):194–7.

18. Tabachnick BG, Fidell LS. Using multivariate statistics. 7th ed. Boston: Allyn & Bacon/Pearson Education; 2019.
19. Hu L, Bentler PM. Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. Structural Equation Modeling: A Multidisciplinary Journal 1999;6(1):1–55.
20. MacCallum RC, Browne MW, Sugawara HM. Power analysis and determination of sample size for covariance structure modeling. Psychological Methods 1996;1(2):130–49.
21. Hooper D, Coughlan J, Mullen MR. Structural equation modelling: Guidelines for determining model fit. Electron J Bus Res Methods 2008;6(1):53–60.
22. Kline RB. Principles and practice of structural equation modeling. 5th ed. New York: Guilford Publications; 2023.
23. Miguel I, Pedroso Chaparro MdelS. Preliminary analysis of the psychometric properties of the Portuguese Perceived Ageism Questionnaire (PAQ). Aging Ment Health 2025;29(12):2255–62.
24. Hussey I, Alsalti T, Bosco F, Elson M, Arslan R. An aberrant abundance of Cronbach's alpha values at .70. Adv Methods Pract Psychol Sci 2025;8:1–18.

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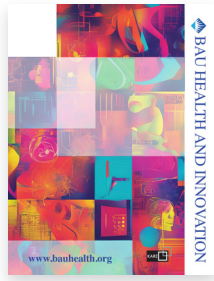

Original Article

Cognitive Function and Left/Right Judgment Performance in Individuals with Chronic Neck Pain: A Cross-sectional Comparative Study

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Abstract

Objectives: Neck pain (NP) is associated with impaired cognitive function and altered neck awareness; however, its impact on implicit motor imagery performance, assessed by the left/right judgment task (LRJT), remains unclear. This study compared LRJT performance, cognitive function, and neck awareness between patients with NP and pain-free controls.

Methods: This cross-sectional comparative study included 35 patients with NP and 35 matched pain-free controls. Cognitive function was assessed using the Montreal Cognitive Assessment (MoCA), neck awareness using the Fremantle Neck Awareness Questionnaire (FreNAQ), pain levels by the Visual Analog Scale, and LRJT performance using the Recognize® application.

Results: Patients with NP had significantly lower MoCA scores and higher FreNAQ scores compared to controls ($p<0.05$). LRJT accuracy and right response time did not differ between groups; however, left response time was significantly shorter in patients with NP ($p<0.05$). A significant negative correlation was observed between MoCA scores and left response time in patients with NP ($r=-0.391$, $p=0.020$).

Conclusion: These results indicate that chronic NP is associated with reduced cognitive function and altered neck awareness, while overall LRJT performance may remain preserved. The observed association between cognitive function and response time suggests that cognitive capacity may influence lateralized motor judgment processes in individuals with chronic NP. Consideration of cognitive function may therefore be important when interpreting LRJT outcomes in this population.

Keywords: Cognitive performance, implicit motor imagery, left-right judgment task, neck pain.

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Neck pain (NP) is one of the most common musculoskeletal disorders, with an average prevalence of 23.1%, and negatively affects quality of life. The Global Burden of Disease study reports NP as the second most common musculoskeletal disease and the third cause of shortened life expectancy.[1,2] People with NP have activation disorders in the neck muscles compared to people without pain. Neuromotor control disorder[3] and disorders in head-and-neck position sense[4] compared to those in individuals without pain.

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Brain imaging studies in NP patients have shown that both structural and functional changes occur in brain regions involved in the cognitive and emotional modulation of pain.[5,6] Studies have shown that individuals with NP perform worse than healthy controls in tasks requiring attention, concentration, and working memory.[7,8] Furthermore, a recent study highlights additional impairments in executive functions, language, abstraction, visuospatial skills, calculation, and orientation.[9]

The left/right judgment task (LRJT) is a well-established method for evaluating implicit motor imagery, as it requires judgments of body part laterality (left vs. right) that draw upon cortical body schema in the sensorimotor cortex[10–12] from LRJT performance provides meaningful information about both cortical proprioceptive representations and efficiency of body-related information processing.[13–15]

Impairments in implicit motor imagery have previously been demonstrated in different studies examining pain in the body.[10,16–20] Impairments in LRJT performance have also been reported in patients with chronic NP.[13,21] Previous studies have shown that NP patients achieve lower scores on LRJT performance; however, these findings have not been examined in relation to cognitive performance. Furthermore, the interaction between cognitive function and LRJT performance has not been fully clarified.

NP is not only a physical problem, but also a condition that can profoundly affect cognitive functions.[7] However, there is limited information on the extent of these effects and their relationship to specific cognitive functions.[13,22] In particular, studies examining the interaction between implicit motor imagery and cognitive functions are quite rare.[21,23] This gap constitutes an obstacle to the development of more targeted treatment approaches for patients experiencing pain.

Although research has been conducted on the cognitive effects of NP, the relationship between these effects and implicit motor imagery LRJT has not been sufficiently investigated. There is limited evidence regarding how LRJT performance changes in individuals with NP and how it relates to cognitive function. Therefore, the primary aim of this study was to investigate LRJT performance in individuals with NP compared to pain-free controls. A secondary aim was to examine the relationships between LRJT performance, cognitive functions, and neck awareness.

Materials and Methods

Study Design, Sample Size, and Blind Design

This study was designed as a cross-sectional comparative study including individuals with NP and pain-free controls. The study was executed at the Istanbul FSM Medical Center Physical Therapy Clinic between May and November 2023. Participants provided written permission before study entry. Ethical approval was obtained from the Bahçeşehir University Non-invasive Research Ethics Committee (Approval No. 2022/09, 26.10.2022). The study was registered at ClinicalTrials.gov (NCT05750472).

The sample size of the study was calculated using G*Power 3.1.9.2 software. LRJT accuracy performance was determined by comparing the sample size with the standard deviation obtained from Elsig et al.'s[21] study for differences in mean values and primary results between groups. An effect size of 0.71, a power of 85%, and an alpha level of 0.05 for the laterality accuracy performance of the patients with NP compared with the healthy controls were obtained for 60 participants (30/group). A total of 80 participants were assessed for eligibility, of whom 10 were excluded due to not meeting the inclusion criteria or declining to participate. A total of 70 participants completed the study and were included in the final analysis (Fig. 1).

Participants, including individuals with NP and a pain-free control group, were given general information about the study but were not informed about the specific purpose of the questionnaires. The physiotherapist who administered the assessments was blinded to the study aims and hypotheses, ensuring an assessor-blinded design.

Participants

According to the NP task force (NPTF) classification,[24] all participants were evaluated by a physical therapist and diagnosed with Grade 2 or 3 nonspecific chronic NP before inclusion in the study. Individuals with chronic NP for at least 3 months were subjected to all measurements and tests by a physiotherapist after a physician examination. Participants who were between the ages of 18 and 65 years, had Grade 2 or 3 pain according to the NPTF classification, had a Visual Analog Scale (VAS) score of at least 30 mm, and were able to use a telephone and computer were enrolled in the study.

Individuals with a history of cancer within the last 5 years, previous neck surgery, visual or hearing impairment, suspected malignant or systemic disease, rheumatologic, psychiatric, or neurologic disease, and treatment for NP within the past 6 months were excluded.[21]

The control group consisted of asymptomatic and pain-free healthy individuals matched for age (±2 years) and gender. These individuals had no history of neck or back pain that limited their daily activities or pain that led to incapacity for work, and had not received any previous medical intervention or treatment for NP.

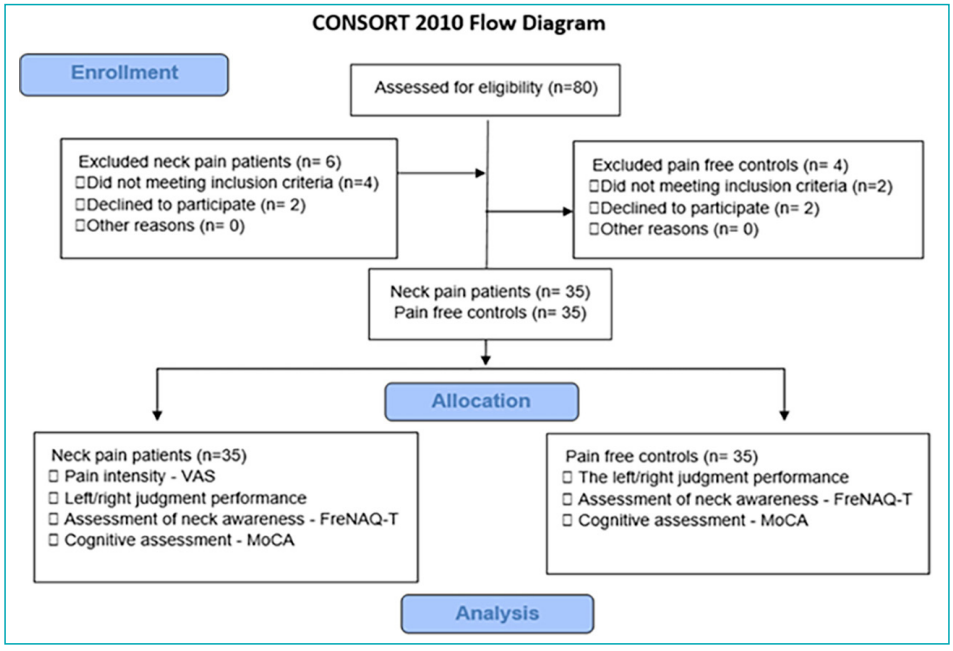

Figure 1. Flow chart of the study.

MoCA: Montreal cognitive assessment, VAS: Visual analog scale, FreNAQ: Fremantle Neck Awareness Questionnaire.

Outcome Measure

Pain Intensity

Participants' current NP intensity was subjectively assessed using the VAS. This scale consists of a 100 mm linear line. The starting point of the line is 0, representing no pain, and the ending point is 100, representing the most severe pain experienced. In the present study, participants were asked to mark the point on the line corresponding to their pain.[25]

LRJT Performance

In a previous study with individuals with NP, participants reported their performance on an LRJT task using neck images. In the current study, neck images from Recognize Online (NOI Group, Adelaide, Australia) were used to assess left/right neck judgment task performance.[26] Each experimental block in Recognize Online consisted of 20 neck images. Participants were asked to respond as quickly as possible, without guessing whether the head of the model in each image turned left or right relative to the shoulders. Each image was seen on the screen for a maximum of 5 s. Before the application started, two training images were presented to the participants, and then the test phase started. The difficulty level of the task was set as "Vanilla." The outcome variables were the accuracy rate, calculated as the percentage of correct responses, and the response time measured in seconds.[10,26]

Assessment of Neck Awareness

Neck awareness was assessed using the FreNAQ. The Turkish version of the scale FreNAQ-T was developed by Onan et al.,[27] and its validity and reliability for the Turkish population have been proven. The FreNAQ-T consists of 9 items related to NP, attention, and proprioceptive awareness. Each item is scored between 0-4, and the total score ranges from 0 to 36. High scores indicate low neck awareness.[27]

Cognitive Assessment

Cognitive functions were assessed using the MoCA scale. The MoCA is a widely performed cognitive screening tool developed by Nasreddine et al.[28] for the detection of mild cognitive impairments. In this study, the Turkish version adapted to the cultural and linguistic characteristics of the participants was used. The MoCA assesses eight cognitive domains: Visuospatial/managerial functions, naming, memory, attention, language, abstraction, delayed recall, and orientation. The total score range is 0–30; scores of 26 and above indicate normal cognitive performance.[28]

Statistical Analysis

All statistical analyses were conducted using IBM Statistical Package for the Social Sciences Statistics 22.0 (IBM Corp., Armonk, NY, USA). Statistical significance level was accepted as $p<0.05$. Continuous variables were reported as mean±standard deviation, and categorical variables were reported as number and percentage (%). Distributional characteristics of the data were evaluated by Shapiro–Wilk test. Group differences between demographic variables were evaluated by an

Table 1. Demographic and clinical data of the participants

Variables	Patients with NP (n=35)	Pain-free controls (n=35)	p
Age (years), Mean±SD	38.89±11.72	36.63±11.03	0.438[a]
Body mass index (kg\m^2), Mean±SD	23.94±3.53	22.96±3.28	0.184[a]
Gender, n (%)			0.806[b]
Female	22 (62.9)	21 (60)	
Male	13 (37.1)	14 (40)	
Education level, n (%)			
Primary school	7 (20)	5 (14.3)	
Secondary school	2 (5.7)	3 (8.6)	
High school	7 (20)	5 (14.3)	
Bachelor's degree	19 (54.3)	21 (60)	
NP duration, n (%)			
3–6 months	8 (22.9)		
6–12 months	9 (25.7)		
More than 12 months	18 (51.4)		
NPTF, n (%)			
Grade 2	23 (65.7)		
Grade 3	12 (34.3)		
Visual Analog Scale (0–100), mean±SD	79.06±12.45		
MoCA (0–30), mean±SD	24.89±2.83	26.74±2.16	**0.006**[c]
MoCA sub-test scores, mean±SD			
Visuospatial/Executive	3.74±1.09	4.54±0.61	**0.000**[c]
Attention	4.57±1.46	5.06±1.11	0.122[c]
Language	2.31±0.79	2.49±0.65	0.399[c]
Abstraction	1.57±0.55	1.80±0.47	**0.042**[c]
Delayed recall	3.74±1.01	3.89±1.38	0.624[c]
Orientation	6	6	
FreNAQ-T	5.66±3.58	1.34±1.13	**0.000**[c]
Smoking history, n (%)			
Yes	17 (48.6)	21 (40)	
No	18 (51.4)	14 (60)	
Alcohol history, n (%)			
Yes	6 (17.1)	8 (22.9)	
No	29 (82.9)	27 (77.1)	

[a]: Independent samples t-test; [b]: Chi-square, [c]: Mann–Whitney U test. Bold values indicated significant differences. NP: Neck pain, SD: Standard deviation, MoCA: Montreal cognitive assessment, FreNAQ-T: Fremantle neck awareness questionnaire Turkish, NPFT: The Neck Pain Task Force.

independent sample t-test for continuous variables and Chi-square test for categorical variables. When the data were not normally distributed, nonparametric tests were used in the analyses. As the variables were not normally distributed (Shapiro-Wilk test, $p<0.05$), correlations were analyzed using Spearman's rank correlation coefficient. In addition, Cohen's d effect size was calculated; 0.20–0.49 was interpreted as a small effect, 0.50–0.79 as medium effect, and 0.80 and above as large effect.

Results

Sociodemographic Characteristics of the Participants

Thirty-five patients with NP and 35 age- and sex-matched controls were included. No significant differences were found between groups in demographic characteristics ($p>0.05$, Table 1). Pain intensity in patients with NP was 79.06 mm (95% confidence interval [CI]: 75.12–82.97).

Table 2. MoCA total and domain/sub-test scores according to NPFT in patients with NP

NP patients (n=35)	Grade 2 (n=23) (Mean±SD)	Grade 3 (n=12) (Mean±SD)	Between-group p[b]
MoCA	25.22±2.50	24.25±3.41	0.449
Visuospatial/Executive	4.00±0.95	3.25±1.21	0.034
Attention	4.35±1.55	5±1.20	0.222
Language	2.26±0.81	2.42±0.79	0.542
Abstraction	1.61±0.49	1.50±0.67	0.745
Delayed recall	3.91±0.90	3.42±1.16	0.230
Orientation	6	6	1.000

[b]: Mann–Whitney U test. Bold values indicated a significant difference. NPFT: The neck pain task force; Grade 2 and Grade 3; NP: Neck pain; MoCA: Montreal cognitive assessment; SD: Standard deviation.

Table 3. Correlation coefficient between MoCA and LRJT task in patients with NP and pain-free controls

MoCA	Patients with NP (n=35)		Pain-free controls (n=35)	
	Correlation coefficient (r)	p	Correlation coefficient (r)	p
Response time				
RRT	-0.187	0.283	-0.281	0.102
LRT	-0.391	**0.020**[c]	-0.176	0.311
Recognition accuracy (ACC, %)				
RACC	-0.028	0.873	0.087	0.619
LACC	0.172	0.323	-0.287	0.095

[c]: Correlation is significant at the 0.05 level (2-tailed). Bold values indicated significant difference. RRT: Right response time, LRT: Left response time, RACC: Right accuracy in %, LACC: Left accuracy in %, MoCA: Montreal cognitive assessment, LRJT: Left/right judgement task, NP: Neck pain.

Neck Awareness Levels of Participants

FreNAQ-T scores were significantly higher in individuals with NP compared to pain-free controls ($p<0.05$, Table 1). Mean scores were 5.66 (95% CI: 4.54–6.91) in patients with NP and 1.34 (95% CI: 0.97–1.77) in pain-free controls.

Cognitive Levels of the Participants

MoCA total scores were significantly lower in patients with NP compared to pain-free controls ($p=0.006$, Table 1). Among MoCA subdomains, visuospatial/executive function ($p<0.001$) and abstraction ($p=0.042$) differed significantly between groups, while no significant differences were observed in attention, language, delayed recall, or orientation.

No significant differences were observed in total MoCA scores between NPTF Grade 2 and Grade 3 ($p=0.449$, Table 2). However, visuospatial/executive scores were significantly lower in individuals with Grade 3 compared to Grade 2 ($p=0.034$, Table 2).

According to Spearman's correlation analysis, there was no significant correlation between MoCA score and LRJT performance in the pain-free controls (Table 3). In individuals with NP, a significant negative correlation was observed between MoCA score and left response time ($r=-0.391$, $p=0.020$, Table 3).

Multivariable linear regression analysis was performed with left response time as the dependent variable and MoCA score, age, education level, and pain intensity as predictors. MoCA score was at the threshold of statistical significance ($\beta=-0.353$, $p=0.050$), while the overall model was not statistically significant ($p=0.254$).

LRJT

No significant differences were observed between individuals with NP and pain-free controls in LRJT accuracy or right response time ($p>0.05$, Table 4). However, left response time was significantly shorter in individuals with NP compared to controls ($p=0.039$, Table 4).

Table 4. Comparison of LRJT task results in patients with NP and pain-free controls

LRJT	Patients with NP (n=35)	Pain-free controls (n=35)	Between-group p[a]	Effect size (Cohen's d)
Response time, Mean±SD				
RRT	1.79±0.43	2.04±0.61	0.088	0.47
LRT	1.91±0.42	2.14±0.54	**0.039**	0.47
Recognition accuracy (ACC, %), Mean±SD				
RACC	67.43±21.73	68.57±22.89	0.769	0.05
LACC	60.29±21.75	62.86±24.80	0.626	0.11

[a]: Mann–Whitney U test. Bold values indicated significant difference. RRT: Right response time, LRT: Left response time, RACC: Right accuracy in %, LACC: Left accuracy in %, SD: Standard deviation, LRJT: Left/right judgement task, NP: Neck pain.

Discussion

In the current study, we compared MoCA scores, neck awareness, and neck LRJT performance between patients with NP and pain-free controls. We also investigated the relationships between LRJT performance and MoCA score. The patients with NP had lower MoCA scores and neck awareness scores than the controls. LRJT accuracy and right response time did not differ between groups, whereas left response time was significantly shorter in patients with NP. in addition, a negative correlation was found between MoCA scores and left response time in the patients with NP, suggesting a potential link between cognitive function and motor imagery performance in these patients.

LRJT

In the current study, no significant difference was found between patients with NP and pain-free controls in terms of LRJT accuracy. Several systematic reviews have reported that individuals with chronic musculoskeletal pain tend to show reduced accuracy and prolonged response times in LRJT when identifying images of painful body parts.[29,30] These findings have been interpreted as impairments in body schema and impaired cortical proprioceptive representations. However, the study's findings do not fully align with those of studies conducted in patients with NP.[13,21] Knee pain,[31] and low back pain[20,32] reporting impaired LRJT performance. However, these results are consistent with earlier studies that also reported no impairments in LRJT performance among the NP population.[20,33] The inconsistency between these findings may be due to variability in sample characteristics, particularly pain severity, chronicity, or NPTF classification levels. Differences in cortical involvement or impairment of proprioceptive feedback may become apparent only at higher levels of dysfunction or in more severe clinical subgroups (e.g., Grade 3 vs. Grade 2). in addition, the sample size and subgroup distribution in the current study may not have been sufficient to detect subtle differences in performance, especially when stratified by gender or severity.

In the current study, in terms of response time, patients with NP demonstrated shorter left response times compared to pain-free controls, while no significant differences were observed for other response time parameters. This finding was unexpected. In studies comparing individuals with chronic musculoskeletal pain and healthy controls, contradictory results were found in the literature. It was reported that there was an increase in response time in individuals with han[34] and knee osteoarthritis,[31] no difference in response time in individuals with chronic pelvic pain[35] or leg or foot pain,[16] while there was a difference in response time in individuals with neck,[13] low back pain,[20] and shoulder pain.[36] As previous research has frequently shown delayed response times in individuals with chronic pain, often interpreted as a reflection of disrupted sensorimotor processing or increased cognitive load.[19,30,37] However, this faster response in the current study may indicate an impulsive or less attentive response pattern, potentially related to reduced attentional capacity in the patients with NP - an interpretation supported by the significantly lower attention subscores in MoCA among these individuals. Furthermore, the significant negative correlation between the MoCA score and left side response time adds further meaning to this interpretation. In particular, poorer cognitive performance was associated with faster left side responses, which likely reflects a compensatory or maladaptive strategy (e.g., "guessing" or "responding hastily") in the context of impaired cognitive function, particularly in attentional or visuospatial/executive domains. The lateralized nature of this correlation (only on the left side) could also hint at asymmetrical processing

mechanisms or hemispheric dominance effects, although further neurophysiological research would be required to clarify this. Overall, these findings suggest that LRJT response time and accuracy may be influenced not only by pain-related changes in body schema but also by cognitive function, particularly attention and executive control. This is the first study to analyze MoCA-assessed cognitive domains and LRJT performance together in NP. The study's results highlight the importance of incorporating cognitive assessment into sensorimotor assessments and suggest that cognitive status should be taken into account when interpreting LRJT performance in chronic pain populations.

Cognitive Function, Pain, and LRJT

Previous studies have consistently reported that individuals with chronic pain exhibit poorer cognitive performance, particularly in domains such as visuospatial/executive function, attention, memory, and abstraction.[7,9] In the current study, patients with chronic NP exhibited significantly lower MoCA scores compared with pain-free controls, particularly in the visuospatial/executive and abstraction subdomains. These findings are consistent with increasing evidence that chronic musculoskeletal pain may negatively impact cognitive function due to neuroplastic changes and pain modulation in brain regions involved in sensory and motor processing.[8]

One of the main findings of the present study was a significant negative correlation between MoCA score and left response time in patients with NP. This indicates that higher global cognitive performance was associated with shorter (i.e., faster) left response times. This finding suggests that intact cognitive processes, particularly those related to visuospatial and executive functioning, may facilitate performance in implicit motor imagery tasks such as the LRJT. This may reflect potential lateralized processing differences or increased cognitive demand when evaluating less dominant directional stimuli, particularly in predominantly right-handed individuals. However, this association should be interpreted with caution, as it was not supported by the regression analysis. Nevertheless, the results highlight the potential relevance of cognitive functioning in sensorimotor task performance. Future studies are needed to clarify the underlying mechanisms and to determine whether specific cognitive deficits contribute to altered implicit motor processing in this population.

Neck Awareness

The present study showed that patients with NP demonstrated significantly lower levels of neck awareness compared to pain-free controls. This finding supports previous research indicating that chronic pain can disrupt cortically maintained body schema and lead to altered perception of the size, shape, or position of the affected body part.[19] The decreased neck awareness shown in the current study may be related to dysfunction in the deep cervical muscles and impaired proprioceptive feedback mechanisms.[38] These impairments may affect joint position sense and sensorimotor control, as shown in previous studies.[27,39] Given that the body schema is constantly associated with proprioceptive and sensorimotor input, persistent nociceptive signaling in chronic NP may interfere with accurate internal representations of the neck region. In summary, the study's findings add to the growing evidence suggesting that chronic NP is associated with impaired body perception and reduced sensorimotor awareness, and that this is mediated by central nervous system changes. These changes should be considered in the assessment and rehabilitation planning of patients with NP.

Study Limitations

There are some limitations in this study. First, the limited sample size and imbalances between subgroups (e.g., NPTF grades or gender distribution) may have reduced statistical power. Furthermore, it is possible that cognitive functioning may have been affected by uncontrolled variables such as sleep patterns, stress levels, or medication use. Furthermore, individual differences such as hand dominance were not taken into account in the analyses.

Conclusion

One of the main findings of the current study is that individuals with NP exhibited impairments in cognitive function and neck awareness. Overall, LRJT accuracy and right response time did not differ significantly between groups; however, left response time was significantly shorter in individuals with NP compared to pain-free controls. Another finding was a significant negative correlation between MoCA scores and left reaction time in individuals with NP, suggesting that reduced cognitive function, particularly in the visuospatial and executive domains, may affect motor imagery processes. These findings emphasize the importance of considering cognitive status when interpreting LRJT performance in patients with NP and suggest that motor-cognitive interactions may play a role. Further studies are needed to examine these relationships more comprehensively.

Disclosures

Ethics Committee Approval: The study was approved by the Bahçeşehir University Non-invasive Research Ethics Committee (no: 2022/09, date: 26/10/2022).

Informed Consent: Written informed consents were obtained from patients who participated in this study.

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References

1. Kazeminasab S, Nejadghaderi SA, Amiri P, Pourfathi H, Araj-Khodaei M, Sullman MJM, et al. Neck pain: global epidemiology, trends and risk factors. BMC Musculoskelet Disord 2022;23(1):26.
2. GBD 2019 Diseases and Injuries Collaborators. Global burden of 369 diseases and injuries in 204 countries and territories, 1990-2019: a systematic analysis for the Global Burden of Disease Study 2019. Lancet 2020;396(10258):1204–22.
3. Falla D, Bilenkij G, Jull G. Patients with chronic neck pain demonstrate altered patterns of muscle activation during performance of a functional upper limb task. Spine (Phila Pa 1976) 2004;29(13):1436–40.
4. Armstrong B, McNair P, Taylor D. Head and neck position sense. Sports Med 2008;38(2):101–17.
5. DePauw R, Coppieters I, Meeus M, Caeyenberghs K, Danneels L, Cagnie B. Is traumatic and non-traumatic neck pain associated with brain alterations? - a systematic review. Pain Physician 2017;20(4):245–60.
6. Yang S, Chang MC. Chronic pain: structural and functional changes in brain structures and associated negative affective states. Int J Mol Sci 2019;20(13):3130.
7. Coppieters I, De Pauw R, Kregel J, Malfliet A, Goubert D, Lenoir D, et al. Differences between women with traumatic and idiopathic chronic neck pain and women without neck pain: interrelationships among disability, cognitive deficits, and central sensitization. Phys Ther 2017;97(3):338–53.
8. Coppieters I, De Pauw R, Caeyenberghs K, Lenoir D, DeBlaere K, Genbrugge E, et al. Differences in white matter structure and cortical thickness between patients with traumatic and idiopathic chronic neck pain: Associations with cognition and pain modulation? Hum Brain Mapp 2018;39(4):1721–42.
9. Oz M, Ozel Asliyuce Y, Demirel A, Cetin H, Ulger O. Determination of cognitive status and influencing variables in patients with chronic neck pain: A cross-sectional study. Appl Neuropsychol Adult 2023;30(6):764–71.
10. Moseley GL. Why do people with complex regional pain syndrome take longer to recognize their affected hand? Neurology 2004;62(12):2182–6.
11. Parsons LM. Integrating cognitive psychology, neurology and neuroimaging. Acta Psychol (Amst) 2001;107(1-3):155–81.
12. Osuagwu BA, Vuckovic A. Similarities between explicit and implicit motor imagery in mental rotation of hands: an EEG study. Neuropsychologia 2014;65:197–210.
13. Wallwork SB, Leake HB, Peek AL, Moseley GL, Stanton TR. Implicit motor imagery performance is impaired in people with chronic, but not acute, neck pain. PeerJ 2020;8:e8553.
14. Hyde C, Wilmut K, Fuelscher I, Williams J. Does implicit motor imagery ability predict reaching correction efficiency? A test of recent models of human motor control. J Mot Behav 2013;45(3):259–69.
15. Hudson ML, McCormick K, Zalucki N, Moseley GL. Expectation of pain affects laterality recognition. Eur J Pain 2006;10(3):219–24.
16. Coslett HB, Medina J, Kliot D, Burkey A. Mental motor imagery and chronic pain: the foot laterality task. J Int Neuropsychol Soc 2010;16(4):603–12.
17. Reinersmann A, Haarmeyer GS, Blankenburg M, Frettlöh J, Krumova EK, Ocklenburg S, et al. Left is where the L is right. Significantly delayed reaction time in limb laterality recognition in both CRPS and phantom limb pain patients. Neurosci Lett 2010;486(3):240–5.
18. Schmid AB, Coppieters MW. Left/right judgment of body parts is selectively impaired in patients with unilateral carpal tunnel syndrome. Clin J Pain 2012;28(7):615–22.
19. Bray H, Moseley GL. Disrupted working body schema of the trunk in people with back pain. Br J Sports Med 2011;45(3):168–73.
20. Bowering KJ, Butler DS, Fulton IJ, Moseley GL. Motor imagery in people with a history of back pain, current back pain, both, or neither. Clin J Pain 2014;30(12):1070–5.
21. Elsig S, Luomajoki H, Sattelmayer M, Taeymans J, Tal-Akabi A, Hilfiker R. Sensorimotor tests in neck pain. Man Ther 2014;19(6):555–61.
22. Thompson DP, Urmston M, Oldham JA, Woby SR. The association between cognitive factors, pain and disability in

patients with idiopathic chronic neck pain. Disabil Rehabil 2010;32(21):1758–67.
23. Dere T, Yurdakul G, Buğra Kılınç S, Alemdaroğlu-Gürbüz İ. Association between motor imagery ability and pain, functional status, neck awareness, and depression in individuals with chronic neck pain. Altern Ther Health Med 2025;31(2):23–9.
24. Haldeman S, Carroll L, Cassidy JD, Schubert J, Nygren A; Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. The bone and joint decade 2000-2010 task force on neck pain and its associated disorders: executive summary. Spine (Phila Pa 1976) 2008;33(4 Suppl):S5–7.
25. Downie WW, Leatham PA, Rhind VM, Wright V, Branco JA, Anderson JA. Studies with pain rating scales. Ann Rheum Dis 1978;37(4):378–81.
26. Wallwork SB, Butler DS, Fulton I, Stewart H, Darmawan I, Moseley GL. Left/right neck rotation judgments are affected by age, gender, handedness and image rotation. Man Ther 2013;18(3):225–30.
27. Onan D, Gokmen D, Ulger O. The fremantle neck awareness questionnaire in chronic neck pain patients: turkish version, validity and reliability study. Spine (Phila Pa 1976) 2020;45(3):E163–9.
28. Nasreddine ZS, Phillips NA, Bédirian V, Charbonneau S, Whitehead V, Collin I, et al. The Montreal Cognitive Assessment, MoCA: a brief screening tool for mild cognitive impairment. J Am Geriatr Soc 2005;53(4):695–9.
29. Ravat S PT, MSc, Olivier B PT, PhD, Gillion N PT, MSc, et al. Laterality judgment performance between people with chronic pain and pain-free individuals. A systematic review and meta-analysis. Physiother Theory Pract 2020;36(12):1279–99.
30. Breckenridge JD, Ginn KA, Wallwork SB, McAuley JH. Do people with chronic musculoskeletal pain have impaired motor imagery? a meta-analytical systematic review of the left/right judgment task. J Pain 2019;20(2):119–32.
31. Özgül S, Öztürk Ö, Gülkesen A. Tactile acuity and left/right judgment performance in patients with knee osteoarthritis: A cross-sectional study. Musculoskelet Sci Pract 2023;64:102747.
32. Linder M, Michaelson P, Röijezon U. Laterality judgments in people with low back pain--A cross-sectional observational and test-retest reliability study. Man Ther 2016;21:128–33.
33. Pedler A, Motlagh H, Sterling M. Laterality judgments are not impaired in patients with chronic whiplash associated disorders. Man Ther 2013;18(1):72–6.
34. Magni NE, McNair PJ, Rice DA. Sensorimotor performance and function in people with osteoarthritis of the hand: A case-control comparison. Semin Arthritis Rheum 2018;47(5):676–82.
35. Díaz-Mohedo E, González-Roldán G, Muñoz-Gámez I, Padilla-Romero V, Castro-Martín E, Cabrera-Martos I, et al. Implicit motor imagery for chronic pelvic pain: a cross-sectional case-control study. J Clin Med 2023;12(14):4738.
36. Breckenridge JD, McAuley JH, Moseley GL, Ginn KA. Is implicit motor imagery altered in people with shoulder pain? The shoulder left/right judgement task. Musculoskelet Sci Pract 2020;48:102159.
37. Romano RR, Anderson AR, Failla MD, Dietrich MS, Atalla S, Carter MA, et al. Sex differences in associations of cognitive function with perceptions of pain in older adults. J Alzheimers Dis 2019;70(3):715–22.
38. Boyd-Clark LC, Briggs CA, Galea MP. Muscle spindle distribution, morphology, and density in longus colli and multifidus muscles of the cervical spine. Spine (Phila Pa 1976) 2002;27(7):694–701.
39. Rix GD, Bagust J. Cervicocephalic kinesthetic sensibility in patients with chronic, nontraumatic cervical spine pain. Arch Phys Med Rehabil 2001;82(7):911–9.

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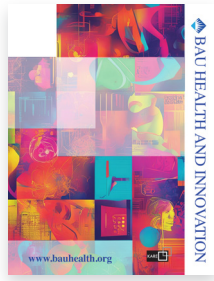

Original Article

Examination of the Relationship Between Archers' Attention Levels and Nutritional Intakes: A Pilot Study

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Abstract

Objectives: Archery performance relies heavily on sustained attention and concentration. This pilot study examined the relationships between attention level, concentration performance (CP), and dietary intakes in adolescent and young adult archers.

Methods: The sample comprised 27 active archers from Istanbul Anka Sports Club (mean age 17.3±3.2 years). Nutritional intake was assessed using a 3-day food consumption record. Attention was evaluated with the d2 Test of Attention, and concentration-related indices were derived. Body composition was estimated by measuring skinfold thickness at three sites (triceps, subscapular, and abdominal), and body fat percentage was calculated accordingly. Data were analyzed using the Statistical Package for the Social Sciences 20.0.

Results: Regarding the general nutritional status of the archers, it was observed that total energy and fluid intakes were generally below the recommended levels for their age groups. A significant negative association was found between attention consistency (FR) and body fat percentage (r=-0.507, p=0.043). Processing speed (TN-E) scores were negatively correlated with protein intake (g/kg) (p=0.035). CP showed significant positive relationships with carbohydrate intake (g/kg) and fiber intake (g) (p<0.05). Vitamin C intake was negatively associated with attention consistency (FR) and specific learning difficulty (E2) (p<0.05).

Conclusion: The findings indicate that nutritional factors and body composition are meaningfully related to attention and concentration metrics in archers. Appropriate, balanced nutrition strategies, particularly regarding macronutrient distribution and fiber intake, may support concentration continuity, whereas higher body fat percentage may be linked to reduced sustained attention. These results offer practical insights for sports nutrition and cognitive performance interventions in archery.

Keywords: Archery, athlete health, attention, cognitive performance, nutrition.

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Archery is a sport that requires a high level of attention, concentration, and fine motor skills. One of the most critical factors determining an athlete's performance is the ability to focus on the target and sustain concentration.[1,2] During shooting, the athlete's capacity to manage psychological pressure, maintain visual-motor coordination, and resist environmental distractions directly influences performance.[3,4] Therefore, attention and concentration are regarded not only as cognitive functions but also as integral components of athletic success.[5]

Sports nutrition plays a crucial role in both the physical and cognitive dimensions of performance. Carbohydrates,

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as the primary energy source for the brain, are key determinants in sustaining attention and concentration. Proteins and fats are essential for muscle health, energy metabolism, and neurological function.[6,7] Moreover, vitamins and minerals, particularly antioxidant nutrients such as Vitamins C and E, have been reported to influence mental fatigue and the continuity of attention.[8,9] However, excessive antioxidant supplementation may suppress exercise-induced adaptive processes.[10]

Hydration is another critical factor for cognitive performance. Even mild dehydration has been shown to impair attention, decision-making, and reaction time.[11,12] Savvides et al.[13] emphasized that dehydration negatively affects both performance and subjective perceptions in archery, whereas Esen et al.[14] demonstrated that fluid balance and sleep quality play a decisive role in the performance of elite archers. Such physiological demands and recovery needs may differ between genders; for instance, Esen et al.[14] reported significant sex differences in energy intake, sweating rates, and electrolyte losses among archers. These findings suggest that a sex-specific approach is necessary when evaluating the interplay between nutrition and cognitive performance.

Recent studies have highlighted the close relationship between dietary habits, performance, and attentional processes among archers. For instance, Günay et al.[15] observed improvements in hematological parameters and performance indicators among archers who received nutrition education. Shaari et al.[16] found that competitive anxiety negatively affected attention processes, indicating that psychological variables, along with nutrition, play a substantial role in performance. Despite these insights, the specific relationship between daily dietary intakes, anthropometric characteristics, and attentional processes among young athletes remains insufficiently explored in the literature. Most existing research focuses on elite adult populations, leaving a gap in understanding how spontaneous nutritional choices and body composition relate to cognitive metrics in developing athletes.

In this context, the present study aims to investigate the relationship between attention levels, CP, dietary intake, and anthropometric profiles in young archers. Furthermore, aligned with the need for individualized sports nutrition, this study explicitly aims to evaluate whether these parameters and their relationships exhibit significant sex-based differences. The findings are expected to contribute to the existing literature on sports nutrition and cognitive performance and to provide guidance for developing effective sex-based nutritional strategies for archers in practice.

Materials and Methods

Sample

The study employed a pilot study design using a convenience sampling approach, targeting all active athletes training at the Istanbul Anka Sports Club during the data collection phase. Inclusion criteria required participants to be active licensed archers with a minimum of 1 year of regular training experience and a willingness to participate voluntarily. Conversely, exclusion criteria were defined as having any diagnosed neurological or psychiatric disorders, utilizing medications that might influence cognitive functions or attention levels, or providing incomplete dietary records. Based on these criteria, the final study sample comprised 27 athletes (20 females and 7 males) aged between 13 and 21 years.

Ethical approval was obtained from the Non-interventional Clinical Research Ethics Committee of İstanbul Beykent University (Approval No: E-45778635–050.99–180002; Date: February 27, 2025). Written informed consent was obtained from all participants and, for those under 18 years of age, from their legal guardians. The study was carried out in accordance with the principles of the Declaration of Helsinki.

Data Collection Process

The research was conducted between February and April 2025, corresponding to the active competition season for the athletes. At the beginning of the study, participants' age was recorded, and height and body weight were measured. Each athlete completed a personal information form and a voluntary participation consent form. To assess dietary habits, a 3-day food consumption record (2 weekdays and 1 weekend day) was collected from each participant. Attention levels were measured using the d2 Test of Attention. All measurements and assessments were conducted at the facilities of the Istanbul Anka Archery Club.

Data Collection Instruments

Anthropometric Measurements

Participants' height (cm) was measured using a stadiometer (SECA, Germany), and body weight (kg) was measured with a digital scale (Tanita BC730, Japan). Body mass index was calculated using the formula (kg/m^2). Skinfold thickness was measured at the triceps, subscapular, and abdominal sites using a Holtain skinfold caliper to estimate body composition. Body fat percentage was estimated using the Lohman (1981) equation, which is appropriate for this age group.[17] Waist and hip circumferences were measured with a non-elastic measuring tape. All anthropometric measurements

were conducted by the primary researcher before the start of daily training sessions to ensure standardized conditions.

Assessment of Attention Level (d2 Test)

To measure participants' selective attention and concentration levels, the d2 Test of Attention,[18] originally developed by Brickenkamp and Zillmer and whose Turkish validity and reliability study was previously conducted,[19] was administered to the athletes. The test was conducted in a quiet environment under standardized instructions, and a stopwatch was used to ensure timing accuracy. The test consists of 14 lines, each containing the letters "p" and "d." Participants were given 20 s to complete each line.

The scores obtained from the test reflect both quantitative and qualitative aspects of attention performance. The total number of processed items (TN) represents the total number of items marked and indicates psychomotor speed. Total errors (E) include both incorrectly marked items (E2) and omitted correct items (E1). The error percentage (%E) expresses the ratio of errors within the total number of processed items; a lower error rate reflects higher accuracy and quality of attention. The total performance score (TN-E) is calculated by subtracting the total number of errors from the total number of processed items, representing both speed and accuracy components of attention performance. This score highlights the quantitative aspect of performance and typically follows a normal distribution. Concentration performance (CP) is calculated by subtracting E2 from the correctly marked target items and is largely independent of random marking or skipped lines. The attention consistency (FR) indicates the difference between the line with the highest and lowest number of processed items; higher FR values are associated with inconsistency in processing speed or reduced motivation. The TN-E scores were used to determine the overall level of attention performance, classified as follows: 50–60% (low), 60–70% (moderate), 70–85% (normal), and above 85% (very good).[20]

Assessment of Nutritional Habits

To evaluate the nutritional status of the athletes, 3-day dietary intake records (2 weekdays and 1 weekend day) coinciding with the athletes' active training days were collected. Total daily fluid intake was calculated based on these records; however, physiological fluid losses during training or competition (e.g., sweat rate) were not objectively measured. Before the recording period, participants and their guardians were provided with detailed oral and written instructions by the researchers on accurate food recording. Portion sizes were estimated using a standardized photographic food atlas to minimize reporting errors. Participants recorded all foods and beverages consumed, categorized by meal, and the records were reviewed together with the researchers to ensure accuracy. The data were analyzed using the Nutrition Information System (BeBiS) software to determine daily energy intake as well as macro- and micronutrient consumption.[21] In addition, total fluid intake and meal frequency patterns were evaluated. It is important to note that these dietary records are intended to reflect intake patterns and are not, by themselves, sufficient to define the participants' overall nutritional status. The analysis specifically focused on omega-3 fatty acids, tryptophan, and caffeine due to their established roles in neurological function, neurotransmitter synthesis, and the regulation of alertness and attention, which are critical for archery performance. Meal frequency was not included in the final analysis to maintain focus on nutrient density and its relationship with cognitive metrics.

Statistical Analysis

Data obtained from the study were analyzed using the Statistical Package for the Social Sciences version 20.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were presented as mean±standard deviation and minimum-maximum values. The normality of data distribution was assessed using the Shapiro–Wilk test. For group comparisons based on sex, the independent sample t-test was used for normally distributed data, whereas the Mann–Whitney U test was applied for variables showing non-normal distribution. Relationships between variables were analyzed using Spearman's correlation test. A significance level of $p<0.05$ was adopted for all statistical analyses.

Results

The mean age of the participants was 16.3±2.0 years. The mean age of female athletes was 16.1±1.7 years, whereas that of male athletes was 17.3±3.2 years; the difference was not statistically significant ($p=0.345$). The participants had a mean sports experience of 3.2±1.1 years. The athletes followed a structured training program consisting of an average of 12±2.5 h of practice per week.

The anthropometric characteristics and demographic data of the archers are presented in Table 1. While most parameters showed no significant differences between sexes, males exhibited significantly higher values in height ($p<0.001$), waist circumference ($p=0.001$), and biceps circumference ($p=0.043$) compared to females. Despite these physical differences, body fat percentage was found to be similar across both groups ($p=0.676$).

Table 1. Anthropometric and demographic characteristics of archers according to sex

Variables	Total (n=27) Mean±SD (Min-Max)	Female (n=20) Mean±SD (Min-Max)	Male (n=7) Mean±SD (Min-Max)	p
Age (years)	16.3±2.0 (13.0-21.0)	16.1±1.7 (13.0–20.0)	17.3±3.2 (14.0–21.0)	0.345
Experience (years)	3.2±1.1 (1.0–5.0)	3.1±1.0 (1.0–5.0)	3.5±1.4 (2.0–5.0)	0.420
Body weight (kg)	56.3±9.6 (42.3–82.4)	53.7±6.7 (42.3–68.8)	70.4±11.4 (59.8–82.4)	0.258
Height (cm)	164.9±9.2 (154.0–187.0)	161.7±4.7 (154.0–170.0)	182.3±8.1 (173.0–187.0)	0.000**
Waist circumference (cm)	70.4±7.9 (60.0–91.0)	68.2±5.6 (60.0–80.0)	82.7±8.0 (75.0–91.0)	0.001**
Hip circumference (cm)	94.6±5.3 (82.8–106.0)	93.8±4.9 (82.8–102.0)	99.2±6.0 (95.0–106.0)	0.108
Biceps circumference (cm)	26.1±2.1 (23.0–30.5)	25.7±1.9 (23.0–29.0)	28.3±2.0 (26.5–30.5)	0.043*
Calf circumference (cm)	32.0±2.7 (28.0–40.0)	31.9±2.9 (28.0–40.0)	32.3±1.5 (31.0–34.0)	0.826
Subscapular skinfold (mm)	13.0±3.4 (7.8–21.8)	12.7±2.8 (7.8–18.2)	14.7±6.3 (10.0–21.8)	0.380
Triceps skinfold (mm)	14.0±3.6 (8.8–17.6)	16.8±3.2 (12.0–23.6)	14.1±4.7 (8.8–17.6)	0.232
Abdominal skinfold (mm)	13.8±4.1 (7.8–21.8)	13.3±4.1 (7.8–21.8)	16.3±4.2 (11.6–19.8)	0.258
Body fat percentage (%)	15.4±2.4 (11.6–19.0)	15.3±2.2 (12.6–18.9)	16.0±3.9 (11.6–19.0)	0.676

Independent Samples t–test was used. *: p<0.05, **: p<0.01. SD: Standard deviation, Min: Minimum, Max: Maximum.

Analysis of energy and nutrient intakes revealed that male athletes had significantly higher intakes of Vitamin A, carotene, Vitamin K, calcium, and iron compared with females (p<0.05). Although water intake was higher among males, the difference was not statistically significant (p=0.056). When assessed against age- and sex-specific recommended daily allowances (RDA) for the 13–21 age range, it was determined that the majority of both male and female athletes had suboptimal total energy and fluid intakes. This observation suggests a general trend of inadequate dietary consumption regardless of the specific developmental stage within the sample (Table 2).

Attention levels were evaluated using the d2 Test of Attention. The results indicated no statistically significant sex differences in TN, E1, E2, TN-E, CP, or FR (p>0.05). Although the CP scores of male athletes were notably higher than those of female athletes, the difference did not reach statistical significance (Table 3).

A significant negative correlation was found between FR and body fat percentage (r=-0.507; p=0.043). No significant correlations were observed between other attention parameters and anthropometric measurements (Table 4).

A significant negative correlation was found between TN-E and protein intake (g/kg) (p=0.035). CP showed a positive relationship with carbohydrate intake (g/kg) (p=0.023) and fiber intake (g) (p=0.009). No other significant relationships were found between energy or macronutrient intake and attention parameters (Table 5).

Regarding micronutrient intake, a significant negative correlation was found between Vitamin C intake and both FR and E2 (p=0.034). This finding suggests that higher Vitamin C intake may be associated with fluctuations in attention performance within this specific sample (Table 6).

Discussion

This pilot study utilized an in-person, cross-sectional design to investigate the potential relationships between dietary intakes, anthropometric characteristics, and attention levels in young archers. The findings revealed that athletic performance in archery is closely associated not only with physical but also with cognitive factors. The results of this study indicate that a significant proportion of the archers in our sample do not meet their required energy and nutrient targets. A critical finding is the widespread suboptimal dietary intake observed across the participants when compared to the age- and sex-specific RDA. Specifically, the mean energy intake (1593.3±359.2 kcal) was notably lower than the metabolic requirements for active adolescents and young adults, who face high demands to support both physical growth and intensive training loads. This persistent energy deficit, particularly during training seasons, was not limited to macronutrients; micronutrient intakes, most notably calcium and iron in female archers, were also found to be below the recommended thresholds. Such nutritional deficiencies are particularly concerning, as they may potentially impact not only physical development and physiological recovery but also cognitive functions and overall athletic performance. Consequently, these data suggest that the archers' current dietary patterns may not fully support the high cognitive demands of their sport, providing a solid, evidence-based foundation for the observed associations between nutritional factors and attention metrics.

Table 2. Energy, nutrient, and caffeine intakes of archers according to sex

Variables	Total (n=27) Mean±SD (Min–Max)	Female (n=20) Mean±SD (Min–Max)	Male (n=7) Mean±SD (Min–Max)	p
Energy (kcal)	1593.3±359.2 (1093.1–2545.1)	1545.6±372.8 (1093.1–2545.1)	1847.9±56.2 (1815.5–1912.9)	0.188
Water (mL)	891.3±319.5 (458.2–1505.7)	831.4±294.2 (458.2–1505.7)	1210.9±296.1 (869.0–1381.8)	0.056
Protein (g)	64.1±13.5 (46.1–83.9)	62.8±14.2 (46.1–83.9)	70.9±7.5 (62.3–75.2)	0.308
Protein (% energy)	17.0±3.9 (12.0–28.0)	17.2±4.3 (12.0–28.0)	16.0±1.7 (14.0–17.0)	0.647
Protein (g/kg)	1.2±0.3 (0.7–1.8)	1.2±0.3 (0.7–1.8)	1.0±0.1 (0.9–1.1)	0.372
Carbohydrate (g)	180.4±65.5 (110.1–408.2)	176.6±71.0 (110.1–408.2)	201.2±4.7 (195.8–203.9)	0.565
Carbohydrate (% energy)	46.1±9.1 (30.0–66.0)	46.3±10.0 (30.0–66.0)	45.0±1.7 (43.0–46.0)	0.827
Carbohydrate (g/kg)	3.2±1.3 (1.6–7.6)	3.4±1.4 (1.6–7.6)	2.9±0.4 (2.5–3.3)	0.599
Fat (g)	66.5±21.9 (34.9–104.8)	63.8±22.7 (34.9–104.8)	80.8±8.8 (75.7–90.9)	0.228
Fat (% energy)	37.0±8.8 (21.0–52.0)	36.6±9.5 (21.0–52.0)	39.0±3.5 (37.0–43.0)	0.681
Fiber (g)	16.5±6.5 (9.7–36.5)	15.8±6.7 (9.7–36.5)	19.8±5.4 (13.8–22.9)	0.352
Vitamin A (µg RE)	881.7±453.9 (111.8–1781.2)	774.7±412.1 (111.8–1781.2)	1452.6±9.3 (1447.2–1463.4)	0.013*
Carotene (mg)	2.0±1.3 (0.2–4.6)	1.7±1.0 (0.2–4.1)	3.7±1.6 (1.8–4.6)	0.013*
Vitamin D (µg)	3.3±3.7 (0.2–12.0)	2.6±3.5 (0.2–12.0)	6.7±3.6 (2.6–8.8)	0.081
Vitamin E (mg)	13.1±6.7 (3.2–28.5)	12.6±7.1 (3.2–28.5)	16.1±2.8 (14.4–19.4)	0.426
Vitamin K (µg)	302.4±126.0 (123.0–584.1)	266.4±84.1 (123.0–455.7)	494.5±155.3 (315.2–584.1)	0.001**
Vitamin B1 (mg)	0.7±0.2 (0.4–1.2)	0.6±0.2 (0.4–1.2)	0.7±0.1 (0.5–0.8)	0.866
Vitamin B2 (mg)	0.9±0.3 (0.6–1.5)	0.9±0.3 (0.6–1.5)	1.1±0.2 (0.9–1.2)	0.448
Vitamin B3 (mg)	11.0±3.5 (5.6–17.9)	10.8±3.7 (5.6–17.9)	12.5±1.4 (10.9–13.3)	0.450
Vitamin B6 (mg)	1.1±0.2 (0.6–1.5)	1.1±0.2 (0.6–1.5)	1.2±0.0 (1.2–1.3)	0.240
Folate (µg)	86.9±28.8 (25.4–157.5)	84.6±30.4 (25.4–157.5)	99.2±16.0 (80.7–108.4)	0.436
Vitamin B12 (µg)	3.2±1.6 (0.6–6.5)	3.3±1.7 (0.6–6.5)	2.4±0.1 (2.4–2.6)	0.416
Vitamin C (mg)	71.5±35.4 (4.2–125.6)	66.5±34.1 (4.2–125.6)	98.0±36.3 (56.1–118.9)	0.163
Sodium (mg)	3344.7±1125.8 (1534.3–5585.8)	3098.4±875.7 (1534.3–5419.5)	4658.1±1606.8 (2802.8–5585.8)	0.023*
Potassium (mg)	1837.5±439.4 (1059.9–2901.2)	1785.7±445.8 (1059.9–2901.2)	2113.7±332.2 (1728.9–2306.1)	0.246
Calcium (mg)	609.6±365.7 (151.2–1326.6)	516.1±287.0 (151.2–1292.5)	1108.4±377.9 (619.7–1326.6)	0.006**
Magnesium (mg)	220.9±56.2 (124.9–327.4)	215.6±55.4 (124.9–327.4)	249.2±63.0 (176.4–285.6)	0.356
Iron (mg)	10.5±3.6 (6.5–17.5)	9.7±2.7 (6.5–16.7)	14.4±5.4 (8.2–17.5)	0.030*
Zinc (mg)	7.7±2.0 (4.7–12.3)	7.7±2.1 (4.7–12.3)	8.1±1.4 (6.5–8.9)	0.724
Omega-3 (g)	2.0±1.3 (0.5–5.7)	1.9±1.4 (0.5–5.7)	2.1±0.8 (1.7–3.0)	0.828
Tryptophan (mg)	709.0±145.4 (468.0–947.1)	694.8±153.4 (468.0–947.1)	784.9±59.7 (716.0–819.3)	0.339
Caffeine (mg)	14.6±26.2 (0–93.3)	16.9±28.0 (0–93.3)	2.2±3.9 (0–6.7)	0.388

An independent samples t-test was used. *: p<0.05, **: p<0.01. SD: Standard deviation, Min: Minimum, Max: Maximum.

Table 3. Evaluation of D2 attention test results of archers according to sex

Variables	Total (n=27) Mean±SD (Min-Max)	Female (n=20) Mean±SD (Min-Max)	Male (n=7) Mean±SD (Min-Max)	p
TN	456.7±86.8 (309.0–596.0)	462.4±90.5 (309.0–596.0)	426.3±68.7 (364.0–500.0)	0.524
E1	58.6±36.7 (5.0–126.0)	62.3±37.4 (5.0–126.0)	39.3±30.9 (6.0–67.0)	0.335
E2	12.2±12.4 (0.0–52.0)	13.1±13.3 (0.0–52.0)	7.0±2.6 (5.0–10.0)	0.447
E (%)	15.1±9.2 (3.0–37.4)	14.2±9.0 (3.0–37.4)	19.6±10.6 (12.6–31.8)	0.370
TN-E	385.9±76.9 (248.0–569.0)	387.1±81.6 (248.0–569.0)	380.0±56.6 (342.0–445.0)	0.889
CP	119.8±43.7 (21.0–237.0)	116.1±46.1 (21.0–237.0)	139.3±23.6 (121.0–166.0)	0.414
FR	17.7±12.6 (3.0–55.0)	19.0±13.1 (4.4–55.0)	10.5±7.3 (3.0–17.6)	0.299

SD: Standard deviation, Min: Minimum, Max: Maximum, TN: Psychomotor speed, E1: Selective attention, E2: Specific learning difficulty, E (%): Error percentage, TN-E: Processing speed, CP: Concentration performance, FR: Attention consistency.

Table 4. Relationship between D2 test subdimensions and anthropometric characteristics

Variables	Body weight	Waist circumference	Body fat percentage
TN	r=0.165 p=0.499	r=0.125 p=0.609	r=-0.009 p=0.972
E1	r=-0.201 p=0.388	r=-0.104 p=0.673	r=-0.271 p=0.263
E2	r=-0.182 p=0.456	r=-0.367 p=0.122	r=-0.005 p=0.982
TN-E	r=0.316 p=0.188	r=0.250 p=0.302	r=0.124 p=0.614
CP	r=0.136 p=0.578	r=0.217 p=0.372	r=-0.076 p=0.759
FR	r=-0.409 p=0.082	r=-0.403 p=0.087	r=-0.507 p=0.043*

Spearman correlation coefficient (r). *: p<0.05 indicates statistical significance. TN: Psychomotor speed, E1: Selective attention, E2: Specific learning difficulty, E (%): Error percentage, TN-E: Processing speed, CP: Concentration performance, FR: Attention consistency.

The negative correlation observed between FR and body fat percentage (r=-0.507, p=0.043) represents a moderate-to-strong effect size. This finding suggests that body composition may be a factor in explaining a portion of the variance in attentional consistency among archers. Similarly, the positive correlations found between CP and carbohydrate intake (r=0.519) and fiber intake (r=0.581) also reflect moderate effect sizes. These values indicate that dietary intake appeared to have a meaningful association with cognitive stability during performance. By focusing on these effect sizes rather than just statistical significance, it becomes clearer that dietary interventions targeting macronutrient balance could offer tangible benefits for an archer's mental focus. Similarly, Ates et al.[22] reported that a lower fat percentage was associated with better attention performance in physically active children. Considering that performance accuracy in archery can depend on millimeters, it may be inferred that

Table 5. Relationship between D2 attention test subdimensions and nutritional intakes

Variables	Energy (kcal)	Protein (g/kg)	Carbohydrate (g/kg)	Fiber (g)	Omega-3 (g)	Water (mL)	Caffeine (mg)	Tryptophan (mg)
TN	r=0.266 p=0.271	r=-0.205 p=0.399	r=0.217 p=0.371	r=0.064 p=0.795	r=0.199 p=0.413	r=-0.283 p=0.240	r=-0.283 p=0.241	r=-0.124 p=0.613
E1	r=0.311 p=0.195	r=0.422 p=0.072	r=0.397 p=0.092	r=0.12 p=0.616	r=0.236 p=0.330	r=-0.121 p=0.623	r=0.063 p=0.797	r=0.281 p=0.243
E2	r=0.015 p=0.951	r=0.327 p=0.172	r=0.010 p=0.968	r=-0.212 p=0.384	r=0.367 p=0.123	r=-0.399 p=0.091	r=-0.004 p=0.986	r=0.269 p=0.265
TN-E	r=0.149 p=0.542	r=-0.485 p=0.035*	r=0.054 p=0.826	r=0.047 p=0.847	r=0.053 p=0.829	r=-0.198 p=0.417	r=-0.348 p=0.144	r=-0.317 p=0.186
CP	r=0.149 p=0.542	r=-0.046 p=0.852	r=0.519 p=0.023*	r=0.581 p=0.009*	r=0.045 p=0.855	r=0.174 p=0.475	r=-0.015 p=0.951	r=0.020 p=0.935
FR	r=-0.164 p=0.502	r=0.372 p=0.117	r=0.126 p=0.607	r=-0.065 p=0.790	r=-0.019 p=0.938	r=-0.213 p=0.381	r=0.108 p=0.661	r=0.124 p=0.612

Spearman correlation coefficient (r). *: p<0.05 indicates statistical significance.

Table 6. Relationship between D2 test subdimensions and selected micronutrient intakes

Variables	Magnesium	Iron	Vitamin C	Vitamin A	Vitamin E	Vitamin B6	Folate	Vitamin B12
TN	r=0.067 p=0.784	r=0.032 p=0.895	r=-0.082 p=0.738	r=-0.231 p=0.340	r=0.025 p=0.918	r=0.019 p=0.938	r=-0.083 p=0.735	r=-0.015 p=0.952
E1	r=0.297 p=0.217	r=0.243 p=0.316	r=-0.443 p=0.058	r=-0.138 p=0.573	r=-0.122 p=0.619	r=0.074 p=0.762	r=0.023 p=0.925	r=0.161 p=0.509
E2	r=0.097 p=0.694	r=-0.104 p=0.673	r=-0.488 p=0.034*	r=-0.181 p=0.458	r=0.421 p=0.073	r=0.002 p=0.994	r=-0.235 p=0.333	r=0.133 p=0.587
TN-E	r=-0.081 p=0.740	r=-0.063 p=0.799	r=0.197 p=0.419	r=-0.166 p=0.497	r=0.019 p=0.939	r=-0.014 p=0.955	r=-0.067 p=0.955	r=-0.115 p=0.639
CP	r=0.306 p=0.202	r=0.299 p=0.213	r=0.027 p=0.913	r=-0.119 p=0.628	r=0.385 p=0.103	r=0.401 p=0.089	r=-0.031 p=0.899	r=-0.442 p=0.058
FR	r=-0.033 p=0.893	r=-0.117 p=0.633	r=-0.488 p=0.034*	r=-0.162 p=0.507	r=-0.224 p=0.356	r=-0.141 p=0.565	r=-0.235 p=0.334	r=0.184 p=0.452

Spearman correlation coefficient (r). *: p<0.05 indicates statistical significance.

body fat percentage is critical not only for physical agility but also for mental stability.

Regarding the sex-based differences found in our results, males exhibited significantly higher intakes of certain micronutrients and different anthropometric profiles compared to females. To our knowledge, these findings represent a novel contribution, as sex-specific dietary patterns in young archers are rarely addressed in the literature. These differences highlight the need for sex-based nutritional strategies even when cognitive outputs remain similar between sexes.

The negative correlation found between TN-E and protein intake represents a rare and noteworthy finding in the existing literature. While protein intake is well known to play an essential role in maintaining muscle function, supporting recovery processes, and preserving immune function,[6,23] this inverse association appeared to be linked to an imbalance in overall energy consumption within our sample. Specifically, reduced carbohydrate intake may be associated with fluctuations in the brain's primary energy source, which could indirectly relate to cognitive functioning. Thus, the observed relationship is more likely a reflection of an imbalance between macronutrients rather than a direct negative effect of protein. Esen et al.[14] similarly emphasized that disproportionate macronutrient consumption may be associated with fluctuations in cognitive performance. Nevertheless, some studies have proposed that high-quality protein intake can enhance attention and cognitive performance.[8] Therefore, the timing and quality of protein intake may also play a crucial role in sustaining optimal attention levels.

The positive correlations observed between CP and both carbohydrate and fiber intake further support this interpretation. Carbohydrates are the brain's principal energy substrate, and insufficient intake has been linked to reduced concentration and mental fatigue.[7,24] Fiber intake, on the other hand, is potentially related to cognitive stability by improving glycemic control and may support brain function via the gut–brain axis.[9]

The negative associations between Vitamin C intake and both FR and specific learning difficulty indicate that antioxidant intake does not necessarily enhance performance. High levels of antioxidant supplementation may suppress exercise-induced oxidative stress and consequently hinder adaptive physiological processes.[10,25] Therefore, in young athletes, the indiscriminate use of vitamin and mineral supplements should be approached cautiously, as excessive intake may be counterproductive. This outcome underscores the importance of "balance" and "individualized supplementation" principles in sports nutrition. Although no significant associations were found between omega-3 fatty acid or water intake and attention parameters, certain trends were observed. Previous studies have consistently demonstrated that hydration plays a crucial role in cognitive performance.[11,12] Savvides et al.[13] reported that dehydration negatively affects archery performance, whereas Esen et al.[14] identified fluid intake during competition as a key determinant of elite archers' performance. Moreover, Esen and Goodall[14] documented sex-based differences in sweating rate and electrolyte loss, highlighting the need for individualized hydration strategies among athletes. Omega-3 fatty acids have also been associated with cognitive function and attention in previous research.[9,26] However, the absence of significant findings in the present study may be attributable to both the small sample size and the generally low omega-3 intake among young athletes.

The psychological dimension of these findings requires cautious interpretation. While our results appear to align with studies by Shaari et al.[16] and Wang et al.,[4] who linked attention to anxiety and resilience, it must be clarified that our study did not directly measure psychological processes. Therefore, the suggestion that nutrition-supported attention serves as a mechanism for psychological regulation remains a tentative interpretation and should be viewed as a hypothesis for future research.

Overall, this research indicates that cognitive performance in archers is closely linked to the triad of balanced nutrition, adequate hydration, and optimal body composition. The findings are consistent with the recommendations of Thomas et al.[6] and the most recent position stand of the International Society of Sports Nutrition regarding exercise and sports nutrition.[7]

Study Limitations

This study possesses a novel focus as a pilot investigation into the diet-cognition relationship specifically within the under-researched population of young archers, providing practical insights for individualized coaching. However, several limitations must be acknowledged. First, the relatively small sample size of 27 athletes restricts the generalizability of the findings. Since the research was conducted exclusively with archers from the Istanbul Anka Sports Club, the results may not be directly applicable to different age groups, sports disciplines, or larger athletic populations. Furthermore, there is a notable sex imbalance in the sample (n=20 females vs. n=7 males), which makes the sex-based comparisons less robust.

Second, the assessment of dietary intake was based on a 3-day food record. While this method is valuable for reflecting short-term energy and nutrient intake, it may not fully represent participants' long-term dietary habits. The short recording period also introduces potential variability due to day-to-day differences in food consumption. Furthermore, while fluid intake was recorded, the absence of objective measurements for fluid losses (e.g., sweat rate) limits the assessment of the participants' overall hydration dynamics during high-intensity archery training.

Finally, the study employed a cross-sectional design. Although it identified associations between nutritional status and attention performance, causal inferences cannot be drawn. Future studies using longitudinal or experimental designs are needed to establish the direction and mechanisms of these relationships.

Conclusion

This pilot study highlights that nutritional intake and body composition are meaningfully associated with cognitive performance metrics in young archers. The findings suggest that higher carbohydrate and fiber intakes are linked to better concentration performance, while a lower body fat percentage appears to be related to greater attention consistency. However, it is essential to interpret these findings with caution, as a cross-sectional study, these results indicate correlations rather than definitive causal or adverse effects. For instance, the observed negative associations involving protein and Vitamin C intake should be viewed as indicators of potential macronutrient imbalances within this specific sample rather than direct negative impacts on focus. Given the prevalent dietary inadequacies identified relative to RDA standards, developing individualized nutrition strategies that ensure energy balance and nutrient density may serve as a supportive tool for optimizing the cognitive demands of archery. Future longitudinal research is needed to clarify further the physiological mechanisms underlying these associations.

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References

1. Açıkada C, Hazır T, Asçı A, Aytar SH, Tınazcı C. Effect of heart rate on shooting performance in elite archers. Heliyon 2019;5(3):e01428.
2. Ulukan M, Özdemir N. An investigation of attention and performance in archers. J Hist Sch 2021;54:3637–57.
3. Türker Ü. The effect of basic archery training on attention and concentration ability. Gümüşhane University Journal of Health Sciences 2022;11(4):1491–506.
4. Wang D, Hu T, Luo R, Shen Q, Wang Y, Li X, et al. Effect of cognitive reappraisal on archery performance of elite athletes: the mediating effects of sport-confidence and attention. Front Psychol 2022;13:860817.
5. İbiş S, Kutlu Z, Aka H, Aktuğ ZB. Sport and attention: attention tests used in sports. In: Her Yönüyle Spor Bilimleri. Ankara: Akademisyen Kitabevi; 2022. p. 124.
6. Thomas DT, Erdman KA, Burke LM. Position of the academy of nutrition and dietetics, dietitians of canada, and the American College of Sports Medicine: nutrition and athletic performance. J Acad Nutr Diet 2016;116(3):501–28.
7. Kerksick CM, Wilborn CD, Roberts MD, Smith-Ryan A, Kleiner SM, Jäger R, et al. ISSN exercise & sports nutrition review update: research & recommendations. J Int Soc Sports Nutr 2018;15(1):38.
8. Meeusen R, Decroix L. Nutritional supplements and the brain. International Journal of Sport Nutrition and Exercise Metabolism 2018;28(2):200–11.
9. Puri S, Shaheen M, Grover B. Nutrition and cognitive health: A life course approach. Front Public Health 2023;11:1023907.
10. Li S, Fasipe B, Laher I. Potential harms of supplementation with high doses of antioxidants in athletes. J Exerc Sci Fit 2022;20(4):269–75.
11. Ganio MS, Armstrong LE, Casa DJ, McDermott BP, Lee EC, Yamamoto LM, et al. Mild dehydration impairs cognitive performance and mood of men. Br J Nutr 2011;106(10):1535–43.
12. Cheuvront SN, Kenefick RW. Dehydration: physiology, assessment, and performance effects. Compr Physiol 2014;4(1):257–85.

13. Savvides A, Giannaki CD, Vlahoyiannis A, Stavrinou PS, Aphamis G. Effects of dehydration on archery performance, subjective feelings and heart rate during a competition simulation. J Funct Morphol Kinesiol 2020;5(3):67.
14. Esen O, Walshe I, Goodall S. Energy intake, hydration status, and sleep of world-class male archers during competition. J Int Soc Sports Nutr 2024;21(1):2345358.
15. Günay Derebaşı D, Asal C, Yüceloğlu Keskin DÖ, Elmacıoğlu F, Ağaoğlu SA. Evaluation of hematological findings and performance in archers after nutrition education. Manas Journal of Social Studies 2016;5(1):257–67. [Article in Turkish]
16. Shaari JS, Nizam NFDM, Nor MAM, Halim NAA, Aiman S, Prasetyo Y. Relationship between competitive anxiety and performance: a study of archers at the national competition. In: Proceedings of the 8th ACPES International Conference; 2022. ASEAN Council of Physical Education and Sport.
17. Lohman TG. Skinfolds and body density and their relation to body fatness: a review. Hum Biol 1981;53(2):181–225.
18. Brickenkamp R, Zillmer E. Test d2: concentration-endurance test. Göttingen: C.J. Hogrefe; 1998.
19. Çağlar E, Koruç Z. Reliability and validity of the D2 attention test among athletes. Hacettepe J. of Sport Sciences 2006;17(2):58–80.
20. İbiş S, Aka H, Kurt S, Aktuğ ZB. Çocuklarda fiziksel aktivite seviyesi motor beceri ve dikkat düzeylerinin incelenmesine yönelik bir araştırma. MJSS 2021;4:210–20. [Article in Turkish]
21. Pasifik Software. BeBiS: Nutrition Information System (Version 9.0) [computer software]. Istanbul (TR): Pasifik Software; 2025.
22. Ates B, Tanir H, Akinci Y. Body composition, cardiovascular fitness and attention of school-aged male children practicing sports club activities: A cross-sectional. J Educ Health Promot 2024;13:262.
23. Kerksick CM. Requirements of proteins, carbohydrates, and fats for athletes. In: Debasis Bagchi, Sreejayan Nair, Chandan K. Sen, editors. Nutrition and Enhanced Sports Performance. 2nd ed. London: Elsevier; 2019. p. 443–59.
24. Payne J, Welshans M, Seeland S, Nielsen M. Nutritional considerations for the power athlete. Curr Sports Med Rep 2022;21(7):224–31.
25. de Sousa CV, Sales MM, Rosa TS, Lewis JE, de Andrade RV, Simões HG. The antioxidant effect of exercise: a systematic review and meta-analysis. Sports Med 2017;47(2):277–93.
26. O' Donovan F, Carney S, Kennedy J, Hayes H, Pender N, Boland F, et al. Associations and effects of omega-3 polyunsaturated fatty acids on cognitive function and mood in healthy adults: a protocol for a systematic review of observational and interventional studies. BMJ Open 2019;9(6):e027167.

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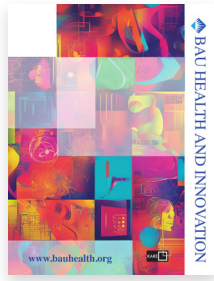

Review

Effect of Climate Change on Foods, Health, and Eating Habits

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Abstract

Climate change (CC) is reshaping our world in profound ways, particularly impacting our food systems, health, and daily eating habits. As global temperatures rise and weather patterns become more unpredictable, farming is facing significant challenges. Crops that once thrived are now struggling, leading to reduced yields and heightened food insecurity. Extreme weather events, such as droughts and floods, further disrupt food production and distribution, causing widespread hunger and malnutrition. These environmental changes threaten food production, quality, prices, and distribution systems on a global scale. Recent studies suggest that adopting plant-based diets can significantly reduce greenhouse gas emissions. In addition, plant-based foods generally use less energy, land, and water, and have lower greenhouse gas intensities than animal-based foods. CC may influence the prevalence of seasonal affective disorder, affecting eating habits and potentially leading to overeating or unhealthy food choices. The economic impacts of CC are vast, affecting agriculture, food security, and health systems, potentially leading to increased poverty and inequality, further impacting food access and health outcomes. In summary, CC profoundly affects food systems, health, and eating habits through complex interactions that influence food availability, quality, and consumption patterns, with significant implications for global health and well-being.

Keywords: Climate, climate change, eating habits, food, health.

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Climate change (CC) refers to long-term changes in temperature and weather patterns that are having far-reaching impacts on the planet and human society. This phenomenon of climate alteration is influencing nearly all facets of existence, from the natural environment to human health and economic systems. On a global scale, we are witnessing escalating temperatures, alterations in rainfall distribution, and a surge in the severity of heatwaves, along with more frequent occurrences of severe weather conditions such as droughts, floods, and storms. These changes are detrimentally impacting numerous systems that are essential for maintaining adequate nutrition and food security.[1,2] The environmental emergency created by CC is escalating more rapidly than earlier forecasts had anticipated. A range of projections now foresee alarming and potentially devastating consequences of this ecological crisis on human populations and natural habitats around the world.[3] The Earth's temperature has already risen by 1.2°C compared to pre-industrial times, and the past several years have seen some of the hottest years on record globally. The anticipated hazards to human health and the incidence of malnutrition are projected to be more severe with a 2°C increase in global average temperature compared to a 1.5°C rise. Specifically, it is estimated that the number of people facing hunger globally could increase to between 530–550 million at 1.5°C and 540–590 million at 2°C of warming.[4] Biodiversity loss in agriculture is another consequence, reducing the ability of food systems to respond to shocks

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and stresses. These changes are expected to drive up food prices globally, which could increase by between 31% and 106% by 2050.[5,6] Such price fluctuations negatively affect household food availability, nutritional quality, and access to social and health services. These impacts particularly affect children under the age of five and can have long-term consequences, such as impaired cognitive functioning and future income potential. Furthermore, CC has been shown to have detrimental effects on maternal health and birth outcomes, contributing to the intergenerational transmission of malnutrition.[7]

Effects of a Changing Climate

The phenomenon of CC poses a significant and multifaceted threat to reproductive health, particularly impacting the most vulnerable and marginalized populations. The risks are especially acute in areas with low income and high urban density, where communities may face greater exposure to environmental hazards and have limited access to resources for adaptation or mitigation.[8] Expectant mothers and young children are particularly vulnerable to the health impacts of CC. They face both immediate and long-term risks from factors such as extreme temperatures, severe weather events, and air pollution, which can affect their health through various direct and indirect pathways.[9] One of the key pathways is the impact of CC on food production and distribution. Human-caused CC is expected to affect the quality and quantity of food produced, as well as the ability to distribute it equitably. Disruptions to agriculture, fisheries, and livestock, which are crucial for food production, can lead to food insecurity and malnutrition, with significant consequences for maternal and child health.[10] Furthermore, the health impacts of CC are multifaceted and intersecting. Extreme heat, air pollution, and increasing allergens can exacerbate a range of health issues, including heat-related illnesses, cardiovascular problems, and respiratory conditions. These factors can affect water and food quality, leading to the spread of waterborne diseases such as cryptosporidiosis, as well as increasing the risk of malnutrition. Cryptosporidiosis can exacerbate malnutrition by causing severe diarrhea that leads to nutrient loss and dehydration, particularly in vulnerable populations such as children, creating a cycle where malnutrition increases susceptibility to infections and those infections further worsen nutritional status.[11,12] Beyond these direct health impacts, CC can also contribute to indirect effects, such as forced migration, mental health issues, and the rise of vector-borne diseases due to ecological shifts. These complex and far-reaching consequences underscore the urgent need to address the climate crisis and its disproportionate impact on vulnerable populations, including expectant mothers and young children.[13] In summary, the connection between CC and reproductive health is multifaceted and deeply concerning. The risks span from immediate health impacts to long-term, systemic challenges that require comprehensive, multisectoral solutions to protect the well-being of those most vulnerable to the effects of a changing climate.

CC and Food Systems

CC has multifaceted effects on food systems. Agricultural production faces challenges due to increased temperatures, water stress, and elevated CO2 levels, potentially reducing crop yields. In addition, elevated atmospheric CO2 concentrations impact nutrient content in crops, affecting overall food quality. Ocean warming and acidification, linked to CC, can reduce fish catch potential and alter nutrient content in seafood. These combined effects pose risks to global food security, potentially disrupting the supply of nutritious foods and leading to increased insecurity.[14] Studies indicate that higher CO2 levels can decrease essential micronutrients such as zinc, iron, and protein, particularly in crops such as wheat, rice, and soybeans. These crops, which follow the C3 photosynthesis pathway, may see protein reductions of 7–15% under elevated CO2. Legumes and C4 crops experience smaller reductions. In addition to protein, CO2 increases can also lower concentrations of zinc, iron, and other nutrients such as phosphorus, calcium, and magnesium. By 2050, global nutrient availability is expected to decline by 19.5% for protein, 13.6% for iron, and 14.6% for zinc.[7,15,16]

CC affects various properties of crops, such as fruits, vegetables, and other plants, such as nutrients, secondary metabolites, and sensory properties. Increased temperature affects properties such as antioxidant content, sugar content, nutrient content, texture, and color in fruits and tends to reduce the vitamin content in certain types of fruits.[17] Research has shown that elevated carbon dioxide (CO2) levels can positively impact fruit crops by increasing yield, flavor, and nutritional content. For instance, tomatoes grown under elevated CO2 concentrations have demonstrated yield increases of up to 80%. While nutrients such as fructose, glucose, total soluble sugars, total antioxidant capacity, total phenols, and ascorbic acid tend to increase, protein, nitrate, magnesium, iron, and zinc concentrations in the edible portions of vegetables may decrease. Specific effects can vary depending on the crop and nutrient, and other factors such as temperature also play a role in nutrient availability.[18]

Obesity and CC

The first systematic review on the relationship between global warming and the obesity epidemic aimed to determine if these two factors share common determinants and pathways. The authors proposed a conceptual model linking global warming and obesity, focusing on land use, urbanization, motorized transportation, agricultural productivity, population growth, industrialization, and the fossil fuel economy.[19] Global warming influences obesity by affecting food supply, prices, and adaptive thermogenesis, while also contributing to CC through higher energy consumption. Mild-to-moderate food insecurity, coupled with the availability of cheap, processed foods, is linked to higher obesity rates. Rising temperatures, reduced physical activity, and food price volatility may increase reliance on processed foods, further driving obesity. This creates a cycle where global warming leads to higher obesity rates, which in turn contribute to greater greenhouse gas emissions.[19,20]

The Lancet Commission on Obesity's 2019 report on the Global Syndemic of Obesity, Undernutrition, and CC identifies CC as a pandemic due to its widespread impact on health.[21] Obesity, undernutrition, and CC are interconnected, with obesity, stunting, and food insecurity occurring in the same children and population. The agricultural system contributes to greenhouse gas emissions, with cattle production generating methane, contributing to obesity, colon cancer, and cardiovascular disease.[21,22] CC also increases atmospheric water uptake, leading to severe hurricanes, flooding rains, fires, and droughts. Increased atmospheric CO2 decreases crop yields and increases ocean acidification, disproportionately impacting poor populations, especially in the global south. Fossil fuel use for transportation also increases greenhouse gas emissions, obesity rates, and health issues. Poor air quality is associated with obesity in children and adults and may contribute to asthma.[23]

Seasonal Affective Disorder (SAD) and Eating Habits

SAD is a cyclical mood disorder that typically occurs during the autumn and winter seasons and gradually improves in the subsequent spring and summer seasons.[24] This condition is characterized by a recurrent pattern of depression that coincides with the changing of the seasons. The onset of SAD is often gradual, with symptoms gradually worsening as the days become shorter and the weather becomes colder and darker. One of the hallmark features of SAD is the presence of atypical vegetative symptoms, which refer to changes in appetite, sleep, and energy levels. In contrast to typical depression, where individuals often experience a loss of appetite and insomnia, individuals with SAD more commonly exhibit hyperphagia (increased appetite and food consumption) and carbohydrate cravings.[25] This increased appetite and carbohydrate intake during the winter depressive episodes may involve discrete binge-eating episodes, where the individual consumes large amounts of food accompanied by a sense of loss of control over their eating.[26] The underlying mechanisms behind these atypical vegetative symptoms in SAD are not fully understood, but they are thought to be related to the body's biological response to the changing seasons. The reduced exposure to sunlight during the winter months can disrupt the body's circadian rhythms and hormone regulation, leading to changes in appetite, sleep, and energy levels.[27] Recent research has also highlighted the potential role of nutrition and dietary factors in the development and management of major depressive disorders, including SAD. A systematic review of 31,424 participants found that Vitamin D supplementation may help to mitigate depression symptoms.[28] Other essential nutrients, such as B Vitamins, omega-3 polyunsaturated fatty acids, zinc, and antioxidants, have also been implicated in the pathogenesis of depression, as deficiencies in these nutrients can lead to memory function, cognitive impairment, and depression.[29,30] Healthy dietary patterns, such as the Mediterranean and Dietary Approaches to Stop Hypertension diets, are linked to a reduced risk of depression due to their focus on whole, unprocessed foods such as fruits, vegetables, whole grains, lean proteins, and healthy fats. While much research has examined nutrient deficiencies and general depression, there is a need for further investigation into how these dietary factors specifically affect SAD. This research could lead to more targeted dietary interventions for those experiencing this seasonal type of depression.

Impact of Climate on Eating Disorders

Research has explored the complex relationship between climate and eating disorder pathology. While various biological, psychological, and sociocultural factors come into play, the climatic conditions of a region may have a significant influence on the risk of developing eating disorders. A growing body of evidence suggests that warm-weather climates, in particular, may heighten the risk factors associated with disordered eating.

A study comparing female college students from warm, southeastern regions of the United States to those in

colder, northeastern regions found distinct differences in eating behaviors and body image concerns. Women residing in warmer climates had significantly lower body weight, more frequent episodes of bulimic behaviors such as binge eating and purging, and greater preoccupation with body shape and size. These findings indicate that living in a warm weather environment may exacerbate the social and cultural pressures surrounding thinness and appearance, ultimately increasing the vulnerability to developing clinical or subclinical eating disorders.[31] Furthermore, eating patterns and food consumption can be directly influenced by seasonal fluctuations in temperature and climate. Individuals living in cold-weather climates have been observed to alter their dietary intake and food preferences when transitioning to hot, humid environments, potentially as an adaptive response. Climatic parameters, such as latitude and average temperatures, may also play a role in the occurrence and prevalence of specific eating disorder diagnoses, such as anorexia nervosa.[32] Understanding the complex interplay between environmental factors, such as climate, and the development and maintenance of eating disorder pathology is crucial for informing prevention and treatment strategies. Further research is needed to explore these connections more comprehensively and elucidate the multifaceted mechanisms by which climatic conditions may influence disordered eating attitudes and behaviors across diverse populations.[33]

Global CC and the Global Economy

Global CC is one of the greatest environmental and economic threats the world has faced in recent decades. The increase in greenhouse gas concentrations in the atmosphere leads to an increase in temperatures worldwide and significant changes in climate patterns. These changes have both direct and indirect impacts on human health and also deeply affect the global economy.[34] Global agriculture, responsible for 30–40% of greenhouse gas emissions, is significantly impacted by CC.[35] Precipitation extremes, such as floods, forest fires, and droughts, significantly impact agricultural productivity.[36] The dependency on non-renewable resources also contributes to deforestation, affecting food and water supplies. Agriculture is an essential part of the economy, especially in developing countries, and its decline challenges farmers' quality of life and contributes to poverty.[37] The Intergovernmental Panel on Climate Change (IPCC) reports increased greenhouse gas concentrations in the air, with global temperatures predicted to rise from 1°C to 3.7°C by the end of the century.[35]

Tourism is a commercial activity with multiple dimensions, including job generation, revenue creation, foreign exchange, cross-cultural promotion, and business benefits.[38] However, CC is a significant threat to the industry, as the climate is essential for tourism. Variations in weather patterns, such as those in the IPCC report, can lead to challenges for local economies and the global tourism industry, such as the decline of ski seasons.[39] CC threatens socioagricultural, socioeconomic, and physical systems, impacting psychological well-being and affecting human and environmental health sustainability. Food security is also a concern, with compromised quality, higher prices, and inadequate distribution systems. Global forests face challenges from various climatic factors, and adaptation measures are crucial for decision-making. Rapid CCs make it harder to survive and adjust, requiring immediate attention at all levels. Policy implications can help mitigate the consequences of CC, especially in the agriculture sector.[35]

CC and Famines

The following 10 specific CCs affect food security: 1-Rising Temperatures, 2-Rising CO2 Levels, 3-Rising Temperature Extremes, 4-Rising Drought, 5-Intense Rainfall, Floods, and Tropical Storms, 6-Melting Glaciers and Changing River Flows, 7-Rising Sea Levels, 8-Pests and Diseases, 9-Weeds, 10-Rising Ozone. Extreme weather events can destroy the food system, disrupting food processing, packaging, and storage facilities, and affecting food prices. Rising temperatures and changing rainfall patterns can alter the distribution of animal diseases, which can reduce production. Fisheries are also expected to decline by 40% in the tropics. With the global population expected to reach 9 billion by 2050, total food production needs to increase by 70% from 2005–2007 levels. However, a 5°F to 9°F increase in the global average temperature could reduce cereal yields by 30% to 50% and further reduce the global food supply. This combination of reduced food production and increased food demand could lead to widespread social unrest and hunger, and potentially catastrophic global famine. To rewrite the future, we must create solutions such as efficiency and renewable energy to reduce greenhouse gas emissions by 80% by 2050.[40] By 2030, the combination of CC and poverty is estimated to affect between 35 million and 122 million people. Food, water, sanitation, and shelter are essential for human survival, but they are becoming harder to access for low-income communities in developing countries due to CC and institutional failure. Asia has the largest population in the world, and natural disasters have affected lower-

income communities the most.[41] Developing countries are facing increasing mortality due to climate-related heat, with increased diarrhea, malaria, undernutrition, dengue, and coastal flooding. To address these challenges, many developing countries have introduced schemes to help end hunger and improve nutrition.[42]

Opportunities to Strengthen Linkages between Nutrition and CC

The World Health Organization emphasizes the need to strengthen the connections between nutrition and CC. Key opportunities include integrating nutrition into global climate frameworks, promoting gender equality, and adopting multisectoral approaches that address both issues, especially for vulnerable populations. The nutrition sector should focus on ensuring access to diverse, sustainable, and high-quality diets, shifting from traditional definitions to more holistic, systems-oriented strategies. Governments and partners are encouraged to transition from reactive responses to proactive preparedness in nutrition. Community engagement is vital for creating culturally appropriate solutions, and increased support is necessary to help communities adapt to climate-related risks. In addition, developing cross-sectoral indicators, such as resilience scales, would aid in integrated planning and monitoring progress.[43]

Climate Benefits of Changing Diet

Public health and the environment are deeply interconnected through the lens of food systems. Every stage of the food lifecycle – production, processing, distribution, and consumption – has substantial impacts on both human well-being and the planet.[44] Food systems contribute significantly to environmental challenges, including greenhouse gas emissions, excessive water use, and hazardous waste generation.[45] A critical aspect of this relationship lies in the contrast between animal-based and plant-based foods. Animal-based products, such as meat and dairy, require considerably more land, water, and energy than plant-based alternatives.[46] This is largely due to the resource-intensive nature of livestock production, which involves rearing, feeding, and processing animals. In contrast, plant-based foods – such as fruits, vegetables, and grains – generally have a much lower environmental footprint. Sustainable dietary patterns, such as the Mediterranean diet, offer a promising solution to reduce the environmental burden of food systems.[46] Characterized by a high intake of plant-based foods, limited red meat consumption, olive oil as the primary fat source, and moderate wine intake, the Mediterranean diet significantly lessens dependence on animal-based foods – the major contributors to greenhouse gas emissions and land degradation.[47,48]

Adopting the Mediterranean diet or similar plant-centric dietary approaches can lead to meaningful environmental benefits. Research suggests that a 40% reduction in meat and dairy consumption could result in a 20–30% decrease in greenhouse gas emissions.[46] In this way, shifting toward plant-based diets not only supports CC mitigation but also enhances personal health. Ultimately, the strong link between public health and the environmental impact of food systems highlights the urgency of adopting sustainable eating habits. Reducing the consumption of animal-based foods and embracing plant-based alternatives can significantly lower greenhouse gas emissions, conserve water, and reduce other environmental pressures associated with food production, benefiting both people and the planet.

Conclusion

The impacts of CC on the global food system, human health, and eating behaviors are significant and wide-ranging. Rising temperatures, shifting precipitation patterns, and extreme weather events are disrupting agricultural production, food distribution, and food access around the world. This is leading to reduced food security, nutritional deficiencies, and increases in diet-related illnesses such as obesity and malnutrition.

CC is also directly influencing human health and eating habits through pathways such as SAD, which can drive changes in appetite and food preferences. The mental health impacts of CC, including anxiety about food availability and safety, are also affecting how people approach their diets and eating routines.

At the same time, shifts in global food systems and individual dietary choices have the potential to mitigate CC through reduced greenhouse gas emissions. Transitioning to more plant-based, sustainable, and locally-sourced foods can lower the carbon footprint of our food systems.

As the effects of CC continue to escalate, it is crucial that we take comprehensive action to build climate resilience in food production, distribution, and consumption. This will require collaboration between policymakers, agricultural producers, food industry stakeholders, public health experts, and individual consumers. Only by addressing the intersections between climate, food, and health can we create a more sustainable, equitable, and nourishing global food system for the future.

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References

1. Al-Jawaldeh A, Nabhani M, Taktouk M, Nasreddine L. Climate change and nutrition: implications for the eastern mediterranean region. Int J Environ Res Public Health 2022;19(24):17086.
2. World Health Organization. Initiative on Climate Action and Nutrition (I-CAN); Geneva, Switzerland, 2022; Available at https://www.gainhealth.org/resources/reports-and-publications/initiative-climate-action-and-nutrition-i-can. Accessed November 8, 2022.
3. Macdiarmid JI, Whybrow S. Nutrition from a climate change perspective. Proc Nutr Soc 2019;78(3):380–7.
4. Ebi KL, Hasegawa T, Hayes K, Monaghan AJ, Paz S, Berry P. (). Health risks of warming of 1.5 °c, 2 °c, and higher, above pre-industrial temperatures. Environmental Research Letters 2018;13(6):063007
5. Nelson G, Bogard J, Lividini K, Arsenault J, Riley M, Sulser T, et al. Income growth and climate change effects on global nutrition security to mid-century. Nature Sustainability 2018;1:773–81.
6. Nelson GC, Rosegrant MW, Palazzo A, Gray I, Ingersoll C, Robertson R, et al. Food security, farming, and climate change to 2050: scenarios, results, policy options. Washington (DC): International Food Policy Research Institute; 2010.
7. Owino VO, Kumwenda C, Ekesa B, Parker ME, Ewoldt L, Roos N, et al. The impact of climate change on food systems, diet quality, nutrition, and health outcomes: a narrative review. Front Clim 2022;4:941842.
8. Smith GS, Anjum E, Francis C, Deanes L, Acey C. Climate change, environmental disasters, and health inequities: the underlying role of structural inequalities. Curr Environ Health Rep 2022;9(1):80–9.
9. Chalupka SM, Latter A, Trombley J. Climate and environmental change: a generation at risk. MCN Am J Matern Child Nurs 2023;48(4):181–7.
10. Segal TR, Giudice LC. Systematic review of climate change effects on reproductive health. Fertility and sterility 2022;118(2):215–23.
11. Karl TR, Melillo JM, Peterson TC, editors. Global climate change impacts in the United States: a state of knowledge report. New York (NY): Cambridge University Press; 2009.
12. CCSP. Analyses of the effects of global change on human health and welfare and human systems. Gamble JL, Ebi KL, Sussman FG, Wilbanks TJ, editors. Washington (DC): U.S. Environmental Protection Agency; 2008.
13. Centers for Disease Control and Prevention. (n.d.). Impact of climate change on human health. Available at: https://www.cdc.gov/climateandhealth/effects/default.htm. Accessed April 27, 2022.
14. Myers SS, Smith MR, Guth S, Golden CD, Vaitla B, Mueller ND, et al. Climate change and global food systems: potential impacts on food security and undernutrition. Annu Rev Public Health 2017;38:259–77.
15. Myers SS, Zanobetti A, Kloog I, Huybers P, Leakey AD, Bloom AJ, et al. Increasing CO2 threatens human nutrition. Nature 2014;510(7503):139–42.
16. Beach RH, Sulser TB, Crimmins A, Cenacchi N, Cole J, Fukagawa NK, et al. Combining the effects of increased atmospheric carbon dioxide on protein, iron, and zinc availability and projected climate change on global diets: a modelling study. Lancet Planet Health 2019;3(7):e307–17.
17. Rasheed M, Liu J. Unraveling the environmental Kuznets curve: interplay between [Formula: see text] emissions, economic development, and energy consumption. Environ Sci Pollut Res Int 2024;31(9):13372–91.
18. Stewart AL, Ahmed S. Effects of climate change on fruit nutrition. In: Fruit crops: diagnosis and management of nutrient constraints. 2020. p. 77–93.
19. An R, Ji M, Zhang S. Global warming and obesity: a systematic review. Obes Rev 2018;19(2):150–63.
20. Kanazawa S. Does global warming contribute to the obesity epidemic? Environ Res 2020;182:108962.
21. Swinburn BA, Kraak VI, Allender S, Atkins VJ, Baker PI, Bogard JR, et al. The global syndemic of obesity, undernutrition, and climate change: The Lancet Commission report. Lancet 2019;393(10173):791–846.
22. Vermeulen SJ, Campbell BM, Ingram JSI. Climate change and food systems. Annual Review of Environment and Resources 2012;37:195–222.
23. Dietz WH, Pryor S. How can we act to mitigate the global syndemic of obesity, undernutrition, and climate change? Curr Obes Rep 2022;11(3):61–9.
24. Chen ZW, Zhang XF, Tu ZM. Treatment measures for seasonal affective disorder: A network meta-analysis. J Affect Disord 2024;350:531–6.
25. Rosenthal NE, Genhart M, Jacobsen FM, Skwerer RG, Wehr TA. Disturbances of appetite and weight regulation in seasonal affective disorder. Annals of the New York Academy of Sciences 1987;499:216–30.

26. Levitan RD, Masellis M, Basile VS, Lam RW, Kaplan AS, Davis C, et al. The dopamine-4 receptor gene associated with binge eating and weight gain in women with seasonal affective disorder: an evolutionary perspective. Biol Psychiatry 2004;56(9):665–9.
27. Opie RS, O'Neil A, Jacka FN, Pizzinga J, Itsiopoulos C. A modified Mediterranean dietary intervention for adults with major depression: Dietary protocol and feasibility data from the SMILES trial. Nutr Neurosci 2018;21(7):487–501.
28. Anglin RE, Samaan Z, Walter SD, McDonald SD. Vitamin D deficiency and depression in adults: systematic review and meta-analysis. Br J Psychiatry 2013;202:100–7.
29. Khayyatzadeh SS, Mehramiz M, Mirmousavi SJ, Mazidi M, Ziaee A, Kazemi-Bajestani SMR, et al. Adherence to a Dash-style diet in relation to depression and aggression in adolescent girls. Psychiatry Res 2018;259:104–9.
30. Yang Y, Zhang S, Zhang X, Xu Y, Cheng J, Yang X. The role of diet, eating behavior, and nutrition intervention in seasonal affective disorder: a systematic review. Front Psychol 2020;11:1451.
31. Sloan DM. Does warm weather climate affect eating disorder pathology? Int J Eat Disord 2002;32(2):240–4.
32. Halawa, A. Effects of subjective feeling of environmental temperature on appetite and food intake in Chinese sociodemographic and ethnic groups. Journal of Ethnic Foods 2019;6:1–11.
33. Vazquez R, Carrera O, Birmingham L, Gutierrez E. Exploring the association between anorexia nervosa and geographical latitude. Eat Weight Disord 2006;11(1):e1–8.
34. Watts N, Amann M, Arnell N, Ayeb-Karlsson S, Beagley J, Belesova K, et al. The 2020 report of The Lancet Countdown on health and climate change: responding to converging crises. Lancet 2021;397(10269):129–70.
35. Abbass K, Qasim MZ, Song H, Murshed M, Mahmood H, Younis I. A review of the global climate change impacts, adaptation, and sustainable mitigation measures. Environ Sci Pollut Res Int 2022;29(28):42539–59.
36. Chen C, Chaudhary A, Mathys A. Dietary change scenarios and implications for environmental, nutrition, human health and economic dimensions of food sustainability. Nutrients 2019;11(4):856.
37. Schlenker W, Roberts MJ. Nonlinear temperature effects indicate severe damages to U.S. crop yields under climate change. Proc Natl Acad Sci U S A 2009;106(37):15594–8.
38. Scott D. Sustainable tourism and the grand challenge of climate change. Sustainability 2021;13(4):1966.
39. Bujosa A, Riera A, Torres CM. Valuing tourism demand attributes to guide climate change adaptation measures efficiently: the case of the Spanish domestic travel market. Tour Manag 2015;47:233–9.
40. Moeller N. The First Intermediate Period: a time of famine and climate change? Ägypten Levante 2005;15:153–67.
41. Hallegatte S, Rozenberg J. Climate change through a poverty lens. Nature Climate Change 2017;7(4):250–6.
42. World Health Organization. Quantitative risk assessment of the effects of climate change on selected causes of death, 2030s and 2050s. Geneva: World Health Organization; 2014. Available at: https://www.who.int/publications/i/item/9789241507691. Accessed June 23, 2026.
43. Bush A, Wrottesley S, Mates E, Fenn B. Nutrition and climate change—current state of play: scoping review. Oxfordshire (UK): Emergency Nutrition Network; 2022.
44. Sáez-Almendros S, Obrador B, Bach-Faig A, Serra-Majem L. Environmental footprints of Mediterranean versus Western dietary patterns: beyond the health benefits of the Mediterranean diet. Environ Health 2013;12:118.
45. Nemecek T, Jungbluth N, i Canals LM, Schenck R. Environmental impacts of food consumption and nutrition: where are we and what is next?. The International Journal of Life Cycle Assessment 2016;21:607–20.
46. Metin ZE, Çelik ÖM, Koç N. Relationship between adherence to the Mediterranean diet, sustainable and healthy eating behaviors, and climate change awareness: A cross-sectional study from Turkey. Nutrition 2024;118:112266.
47. Tepper S, Kissinger M, Avital K, Shahar DR. The Environmental footprint associated with the Mediterranean diet, EAT-Lancet diet, and the Sustainable Healthy Diet Index: A population-based study. Front Nutr 2022;9:870883.
48. Sanz-Cobena A, Lassaletta L, Aguilera E, del Prado A, Garnier J, Billen G, et al. Strategies for greenhouse gas emissions mitigation in Mediterranean agriculture: A review. Agriculture, ecosystems & environment 2017;238:5–24.

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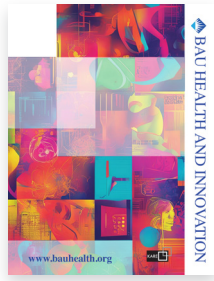

Review

The Role of Dynamic Neuromuscular Stabilization Exercises in the Rehabilitation Process: A Traditional Review

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Abstract

Dynamic neuromuscular stabilization (DNS) is an approach based on developmental kinesiology and aims to optimize postural control, movement patterns, and musculoskeletal functions. DNS focuses on the synchronized activation of the pelvic floor, diaphragm, transversus abdominis, and multifidus muscles to provide spinal stabilization. In the literature, DNS has been shown to be an effective method for improving postural control, pain management, and motor functions in orthopedic, sports, pediatric, and neurological rehabilitation. From a developmental kinesiology perspective, DNS addresses motor control levels at spinal, subcortical, and cortical levels. Based on the developmental patterns of motor functions in early childhood, it works on the correct activation and coordination of the muscles that stabilize the spine. This provides a basis for developing postural control and motor skills in children, and for reorganizing movement patterns in neurological disorders. In orthopedic rehabilitation, DNS improves movement patterns by addressing problems such as muscle weakness and postural disorders. In sports rehabilitation, DNS reduces injury risks by increasing core stabilization and optimizing athletic performance. In pediatric rehabilitation, DNS supports children's motor control and postural stability, contributing to their social, cognitive, and emotional development. It has been reported that DNS improves musculoskeletal system functions and increases quality of life, especially in children with neurological developmental delays. In neurological rehabilitation, DNS is used to improve balance, postural control, and functional independence in neurological disorders. In conclusion, DNS exercises are a holistic approach that addresses not only the symptoms but also the root causes of movement disorders in rehabilitation processes.

Keywords: Core stabilization, developmental kinesiology, dynamic neuromuscular stabilization, rehabilitation.

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Dynamic neuromuscular stabilization (DNS), developed by Professor Pavel Kolar, is a therapeutic approach based on the foundations of developmental kinesiology.[1] All movements work with the integration of the locomotor system, and are strengthened subcortically with spinal segmental activities to ensure postural stabilization. This system, which is based on the stable movement of the spine, focuses on coordination and power.[2] This system, which uses synkinetic and subconscious activation of the pelvic floor, multifidus, transversus abdominis, and diaphragm to provide stability of the spine and create optimal intra-abdominal pressure, is rapidly gaining acceptance in musculoskeletal rehabilitation and injury prevention.[1,3]

The word core is defined in the literature as the center of the body.[4] The concept of core, which has different definitions, has been defined as a powerhouse by

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Akuthota and Nadler[5] and as a box or double-layered cylinder by Richardson et al.[6] The core region is a region consisting of 29 pairs of muscles that stabilize the pelvis and spine during movements, consisting of the abdominal muscles in the front, the gluteals and paraspinals in the back, the diaphragm above, and the hip and pelvic floor muscles below. Without the core region and the muscles located here, the spine cannot maintain its stability against resistance.[7]

Core stabilization training is a method designed to increase the strength of the core muscles and improve body balance.[8] Core stabilization training consists of two main components: static and dynamic movements.[9] Dynamic exercises increase the ability to maintain stability during position changes, resistance changes, or rotations, whereas static exercises focus on maintaining posture under resistance.[10] Golsefidi et al.[11] proved in their study that lumbopelvic stabilization increases with regularly performed core stabilization exercises, thus reducing stress on the spine and reducing the risk of injury to the lumbar muscles. Neuromuscular disorders occurring in the core region can trigger unstable behaviors and injuries at all levels of the kinetic chain.[12] Devlin[13] reported in the study that muscle fatigue occurring in the abdominal muscles causes hamstring injuries. While adequate core stabilization plays a role in maintaining balance, core strength and correct posture are very important for balance ability. In a body supported by proper posture alignment and sufficient core strength, core strength and correct posture play a therapeutic role in chronic low back pain.[14]

The aim of this study is to explain the DNS method and to contribute to future studies based on the DNS exercise studies in the literature. There is no study in the literature investigating the effects of DNS exercises in different rehabilitation areas. Our study aims to fill this gap in the literature, and it is important to shed light on future studies.

Materials and Methods

The keywords in our study were searched using Google Scholar, PubMed, and MEDLINE databases. The keywords used were DNS, developmental kinesiology, core stabilization, and rehabilitation. Our study is a review, and therefore, appropriate evidence was selected and compiled according to the flow of the study. This review was created within the scope of the Musculoskeletal Rehabilitation course of the Physiotherapy and Rehabilitation Doctorate program of Bahcesehir University Graduate Education Institute.

Research Results and Findings

Developmental Kinesiology

Developmental kinesiology is based on the fact that the development of motor functions occurs in early childhood. DNS addresses and treats the harmonious functioning of joints, posture, and respiration.[15] The foundations of developmental kinesiology are based on sensorimotor control at three levels: the spinal level, the subcortical level, and the cortical motor control level.[1] Sharma and Yadav[16] reported that while general movements occur at the spinal level, at the subcortical level, the synergistic activation of the pelvic floor, diaphragm, abdominal wall, and spinal extensors occurs before the extremity movements. At the cortical motor control level, the development of the movement pattern occurs.[16] Genetically determined motor functions present a predictable pattern in early childhood in humans. The movement pattern, which changes and develops with the development of the central nervous system, continues to form. In this way, the baby is allowed to control their posture, maintain their verticalization against gravity, and use their necessary muscles in the best way for all these purposes.[16]

DNS Exercises in Orthopedic Rehabilitation

Mascal et al.[17] reported in their study that strengthened core muscles in individuals with patellofemoral pain syndrome showed significant improvements in lower extremity functions.

Shin et al.[18] investigated the effects of isometric chin-tuck exercise and dynamic neuromuscular exercise method on muscle tension of neck flexors and posture during sitting in people with forward head posture, and as a result of the study, they proved that the group doing DNS exercises had better results. Ross[19] investigated the effects of a 12-week DNS exercise program in a case study conducted on a person with chronic low back pain. He reported that DNS exercises provided stabilization with the increase in intra-abdominal pressure and thus protected the spine with the reduced load of the lumbar region.

Cha et al.[20] investigated the effects of the DNS method on core instability with bilateral straight leg tests in young people with core instability. As a result of this study conducted with 20 people, it was proven that the tests performed at the end of the study yielded more successful results than at the beginning.[20]

DNS exercises stand out as an effective approach in orthopedic rehabilitation in terms of providing postural control, improving musculoskeletal functions, and pain management. While orthopedic problems are associated with muscle weakness, posture disorders, and instability,

DNS aims to reorganize movement patterns by getting to the root of these problems. Studies by Mascal et al.[17] on patellofemoral pain syndrome have shown that strengthened core muscles provide significant improvements in lower extremity functions. These findings emphasize the critical role of core stabilization in lower extremity control and biomechanical load distribution.[17]

As a result, DNS exercises stand out as an effective and holistic intervention method in orthopedic rehabilitation processes. Core stabilization, reducing the load on the joints, and optimizing posture are among the main goals of DNS. This method provides long-term improvement by addressing not only the symptoms but also the origin of movement disorders in the treatment of musculoskeletal disorders. DNS increases the effectiveness of orthopedic rehabilitation programs by offering a personalized and functional approach, and allows individuals to move more independently and painlessly in their daily life activities.

Neuromuscular Stabilization Exercises in Athlete Rehabilitation

Core stabilization is very important for maintaining or increasing athletic performance at an optimum level.[21] In the literature, core stabilization has been defined as the dynamic control of the hip-lumbopelvic complex, which provides torque and momentum transfer to the upper and lower extremities in movements requiring gross motor skills in daily life, sports, and during exercise. During functional tasks, the core muscles are activated before the activation of the extremities to create a stable foundation in the extremities. In addition, studies have shown that the strength of the core muscles is effective in reducing the loads on the joints and controlling the direction in the lower extremities.[22] Larwa et al.[23] reported in their systematic review that weak core stabilization, weak hip abduction, increased knee valgus, and landing on the heels may increase the risk of anterior cruciate ligament injury in young athletes.[23]

Core muscles are at the base of all kinetic chains in the body and have an impact on physical performance as they are responsible for the generation and transmission of force throughout the body. Yörükoğlu et al.[24] stated in their study that adding core stabilization exercises to rehabilitation programs can yield effective results. In addition, current publications have mentioned the importance of increasing core stability in preventing shoulder injuries, and that core stabilization is one of the factors involved in shoulder kinematics.[25,26]

In a study conducted by Jebovy et al.[27] with 20 female futsal players in sports rehabilitation, the effects of core strengthening exercises and DNS exercises were investigated, and as a result of the 6-week study, significant results were obtained in the side plank, intra-abdominal pressure, and trunk flexion measurements of DNS exercises compared to the core strengthening group.[27] In a study conducted with elite rowing athletes, it was shown that 6 weeks of DNS training caused significant increases in rowing power.[28] In another study conducted with elite baseball players, 12 weeks of DNS exercises and TheraBand exercises were examined in shoulder joint range of motion, shoulder strength, and ball throwing speed, and positive effects were observed in the ball throwing speed, shoulder internal and external joint range of motion, and shoulder internal and external muscle strength of the participants in the DNS exercises group.[29]

DNS exercises stand out as an effective approach for sports rehabilitation and performance development. Core stabilization plays a vital role in generating and transmitting force by forming the foundation of the body's kinetic chain. Strengthening the core muscles is of critical importance in optimizing athletes' performance and minimizing injury risks. It has been emphasized in the literature that core stabilization increases movement efficiency in a wide range of daily life activities to high-level athletic performance to playing an important role in transferring torque and momentum to the extremities. It has also been stated that core stabilization reduces the loads on the joints and improves directional control in the lower extremities. Weak core stabilization and biomechanical problems, especially in young athletes, can lead to serious athletic injuries such as anterior cruciate ligament injuries.

DNS exercises have been shown to be superior to traditional core strengthening programs in studies across a variety of sports. In female soccer players, DNS provided significant improvements in parameters such as side plank performance, intra-abdominal pressure, and trunk flexion strength. Similarly, in elite rowers, 6 weeks of DNS training resulted in significant increases in rowing power. In a study of elite baseball players, DNS exercises demonstrated positive effects on shoulder strength, range of motion, and ball velocity.

In conclusion, DNS is an important tool in both injury prevention and athletic performance improvement by increasing core stabilization in the sports rehabilitation process. The holistic approach of DNS not only retrains the athlete's movement patterns but also optimizes performance, providing an advantage on the field. The adaptability of these exercises to different sports branches shows that DNS has a wide range of applications and is considered an indispensable method in sports rehabilitation.

DNS Exercises in Pediatric Rehabilitation

Pediatric rehabilitation increases motor performance and provides support and development of children in terms of social, cognitive, and emotional aspects.[30] In newborns, the diaphragm plays the role of the respiratory muscle in the early postural development period.[31] As the central nervous system develops, the sagittal stabilization of the spine, pelvis, and chest matures in 4.5 months, and frontal and transverse stabilization comes next, and movements such as rolling, turning, creeping, and crawling are observed.[32] At approximately 6 months of age, the diaphragm fully fulfills its dual function of postural stabilization and respiratory muscle in coordination with abdominal breathing and the chest. In this way, upright postural stabilization is achieved, and standing, sitting, and walking occur.[33]

DNS is a holistic approach used in pediatric rehabilitation to support the child's motor skills as well as social, cognitive, and emotional development. Early motor skills of children are shaped by the harmonious interaction between the central nervous system and the musculoskeletal system. In this process, it is observed that the diaphragm in newborns plays a role not only in respiratory function but also as a basic component of postural stabilization. With the maturation of the central nervous system, the spine, pelvis, and chest area are stabilized in the sagittal plane, followed by stabilization in the frontal and transverse planes. These stages enable the emergence of motor skills such as rolling, turning, creeping, and crawling.

At approximately 6 months of age, the diaphragm's coordination of both respiratory and postural stabilization functions forms the basis for upright posture. This coordination plays a critical role in achieving developmental milestones such as sitting, standing, and walking. The primary goal of DNS is to optimize the child's motor control and postural stability by reactivating these natural developmental movement patterns. DNS stands out as an effective intervention method for improving musculoskeletal functions, especially in children with neurological or motor developmental delays.

In conclusion, DNS in pediatric rehabilitation is a comprehensive method that responds to the general developmental needs of the child as well as the acquisition of motor skills. Supporting the movement patterns acquired by the child in the early period prepares the ground for skills such as postural control, balance, and functional independence in later ages. When DNS is applied with individualized approaches, it provides a holistic effect that positively affects not only the physical rehabilitation processes but also the child's quality of life. DNS, which is approached from a multidisciplinary perspective, continues to be one of the cornerstones of pediatric rehabilitation.

DNS Exercises in Neurological Rehabilitation

Cerebrovascular diseases are the most important cause of mortality worldwide after cancer and cardiovascular diseases.[34] Stroke and cerebrovascular diseases are the third leading cause of mortality worldwide, affecting approximately 17 million people annually, and have been reported to result in the death of 6 million people.[35] Strokes cause the most functional losses and a decrease in quality of life in individuals worldwide.[36] In the literature, stroke is explained as a neurological syndrome that occurs suddenly with the cessation or decrease in blood flow to a certain area of the brain.[34] It has been observed that individuals who have had a stroke have very poor exercise capacity. The decrease in exercise capacity, together with already reduced mobility, triggers secondary immobility.[37]

In individuals who have had a stroke, balance, body movements, and muscle control are often asymmetrical due to the decreased function of the core region.[38] In these individuals, stabilization is reduced, and decreased joint range of motion, muscle strength, sensation, coordination, cognitive functions, and abnormal muscle tone lead to balance problems.[39]

In stroke patients, the better the trunk supports, the fewer abnormalities in other parts of the body. The trunk acts as a dynamic stabilizer in task-related functions, and since it is effective in contact with the support surface both while sitting and standing, trunk control is very important.[40] The transversus abdominis, multifidus, internal and external obliques, and rectus abdominus are the most important trunk muscles, but the transversus abdominis provides trunk stabilization by working together with the neural system.[41]

The DNS approach has an important place in neurological rehabilitation. While stroke and other cerebrovascular diseases can cause serious loss of motor skills and functional abilities in individuals, DNS stands out as an effective method to reduce these losses. Weak core muscle function, balance problems, and asymmetric movement patterns, which are frequently seen in individuals after stroke, are the basic problems that should be taken into the center of the physical rehabilitation process. Trunk stability and control are necessary for many functions, from daily living activities to advanced motor skills. DNS aims for the trunk stabilizer muscles, especially muscles such as the transversus abdominis and multifidus, to work in integration with the neurological system.

The DNS approach treats the body as a functional whole, based on human developmental movement patterns. This

Table 1. Studies in the field of DNS

Studies	Aim	Number of participants	Participant characteristics	Exercise attempt	Conclusion
Davidek et al.,[28] 2018	To examine the effect of DNS exercise on maximum rowing force and shoulder pain perception	20 male rowers	Elite rowers	30 min of DNS exercises daily, 5 days a week, for 6 weeks	A significant increase in rowing strength was observed after pre-, mid-, and post-tests.
Jebavy et al.,[27] 2020	Comparison of DNS and traditional core strength exercises	20 female futsal athletes	Elite futsal athletes	25 traditional core strength exercises and 6 DNS exercises	After the DNS exercise program, significant improvements were observed in IAP, trunk flexion, and side plank measurements.
Ackerman et al.,[29] 2020	To examine the effects of DNS exercises and TheraBand exercises on shoulder joint range of motion, shoulder strength, and ball-throwing velocity.	18 baseball players	Elite baseball players	TheraBand and DNS exercises 3 times a week for 12 weeks	Positive effects were observed in the ball throwing speed, shoulder internal and external joint range of motion, and shoulder internal and external muscle strength of the DNS group participants.
Son et al.,[43] 2017	To evaluate the effects of DNS application on motor functions, diaphragm movements, and abdominal muscle activation (external oblique, internal oblique, and transversus abdominis) in individuals with cerebral palsy.	15 individuals with diplegic spastic cerebral palsy	Individuals with cerebral palsy	They investigatedthe effects of a 4-week, 3-day-a-week DNS intervention on gait control, gait, and balance.	It was observed that the active muscle chain, including the diaphragm, transversus abdominals, and internal obliques, was effective in providing deep core activation; standing, jumping, and walking were improved in individuals with spastic diplegic CP.
Juehring et al.,[42] 2011	Investigating the effects of DNS in migraine	Case study	Migraine patient with hyperextension of the cervical spine	12 weeks of DNS treatment	It was observed that the head disability score decreased from 48% to 34%.
Shin et al.,[18] 2019	To investigate the effects of isometric chin stretching exercises and DNS exercise method on neck flexor muscle tension and posture during sitting.	43 participants	Patients with a forward head posture and neck pain for at least 6 months	Participants were first given three repetitions of isometric chin stretching exercises for 30 s, then three repetitions of DNS exercises for 30 s.	It has been observed that DNS exercises reduce muscle tension in the neck flexors and improve posture while sitting.
Ross,[19] 2017	To investigate the effect of a 12-week DNS program on pain in a patient with chronic low back pain.	Case study	Male participant with low back pain for at least 3 months	4 days a week, 30 min DNS workout program, for 12 weeks	It was observed that DNS exercises provided stabilization by increasing intra-abdominal pressure, thus protecting the spine by decreasing the load on the lumbar region.
Cha et al.,[20] 2018	To investigate the effects of the DNS method on core instability with bilateral straight leg tests in young people with core instability.	20 Adult Participants	Adult, healthy participants with core instability	After the first tests, all participants were given DNS exercises, and their final tests were examined.	It was observed that the tests performed at the end of the study yielded more successful results than those at the beginning.

DNS: Dynamic neuromuscular stabilization.

method aims to reactivate the individual's postural control mechanisms and increase movement efficiency through motor learning. When problems such as decreased joint range of motion, muscle strength, and coordination after stroke are systematically addressed with DNS, it is possible to improve postural stability in individuals and prevent secondary complications. Supporting neuromuscular control of the trunk muscles, in particular, not only increases balance and mobility but also contributes positively to the individual's quality of life.

In conclusion, DNS offers a complementary approach in the management of functional losses after stroke in neurological rehabilitation. Regaining trunk stabilization and postural control increases the level of independence of individuals in daily life and reduces secondary problems. The individual applicability of DNS allows it to be used in a wide range of both acute and chronic rehabilitation processes. To increase the effectiveness of DNS in post-stroke neurological rehabilitation, a multidisciplinary approach and planning appropriate to the needs of the individual are of critical importance (Table 1).

Discussion

In line with the information obtained as a result of the literature review we conducted within the scope of our study, it has been observed that the DNS exercise method has positive effects on core stabilization, neurological disorders, postural disorders, pediatric rehabilitation, and athlete performance.

In a study conducted by Shin et al.[18] it was proven that DNS exercises reduce muscle tension in the neck flexors and improve posture while sitting in individuals with forward head posture. It was understood that DNS restores postural stabilization, reduces the load on the spine, and corrects muscle imbalances. Similarly, Ross (2017) examined the effects of 12 weeks of DNS exercises in a case with chronic low back pain and stated that DNS provides stabilization in the lumbar region by increasing intra-abdominal pressure, thus helping to protect the spine.[19]

The effectiveness of DNS in improving core stability has also been demonstrated in the study by Cha et al.[20] DNS applications in young individuals with core instability provided significant improvements in bilateral straight leg tests.x These findings show that DNS has a direct effect on muscle strength, postural control, and stabilization.

Evaluating the effect of DNS on maximum rowing strength, Davidek et al.[28] proved that adding DNS-based core stabilization exercises to regular ski exercises 5 days a week for 6 weeks will support shoulder girdle and trunk stabilization. DNS is an exercise method that can increase strength in sports activities.

Juehring et al.[42] reported in a case study they conducted to investigate the effects of DNS in migraine that subjective improvement was recorded after deep neck flexors and core stability activation were applied to a patient with hyperextension in the cervical spine for 12 weeks, and the Head Disability Score decreased from 48% to 34%. Using DNS to activate the cervical muscles in people with migraine and adding core stability to this decreases the pain level of migraine patients, improves their recovery, and provides functional recovery.

Son et al.[43] investigated the effects of DNS intervention applied 3 days a week for 4 weeks on gait control, gait, and balance in their study with 15 individuals with diaplegic spastic cerebral palsy. As a result of this study, in which ultrasound and EMG were also used in the evaluation, they found that the active muscle chain, including the diaphragm, transversus abdominals, and internal obliques, was effective in providing deep core activation; and that standing, jumping, and walking improved in individuals with spastic diplegic CP.[43] This study proved that the DNS method contributes to functional recovery in individuals with CP.

Study Limitation

This study is a review examining the role of DNS exercises in rehabilitation programs. The lack of many studies in the literature on DNS exercises is seen as a limitation of our study.

Conclusion

This research shows that DNS exercises have positive effects on rehabilitation processes. As a result of the literature review conducted within the scope of this study, studies in different areas, in addition to the publications made with the DNS method, will contribute to the literature. It is thought that this review will contribute to future studies.

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References

1. Frank C, Kobesova A, Kolar P. Dynamic neuromuscular stabilization & sports rehabilitation. Int J Sports Phys Ther 2013;8(1):62–73.
2. Yılmaz EA. Dinamik Nöromüsküler Stabilizasyon (DNS). Research in Sport Education and Sciences 2022;24(2):60–4.
3. Liebenson C, editor. Rehabilitation of the spine: a practitioner's manual. 2nd ed. Philadelphia (PA): Lippincott Williams & Wilkins; 2007.
4. McGill SM. Core training: evidence translating to better performance and injury prevention. Strength and Conditioning Journal 2010;32(3):33–46.
5. Akuthota V, Nadler SF. Core strengthening. Arch Phys Med Rehabil 2004;85(3 Suppl 1):S86–92.
6. Richardson C, Jull G, Hodges P, Hides J. Therapeutic exercise for spinal segmental stabilization in low back pain: scientific basis and clinical approach. London: Harcourt Brace and Company Ltd; 1999.
7. Akuthota V, Ferreiro A, Moore T, Fredericson M. Core stability exercise principles. Curr Sports Med Rep 2008;7(1):39–44.

8. Aggarwal A, Kumar S, Kumar D. Effect of core stabilization training on the lower back endurance in recreationally active individuals. Journal of Musculoskeletal Research 2010;13(04):167–76.
9. Örgün E, Kurt C, Özsu İ. The effect of static and dynamic core exercises on dynamic balance, spinal stability, and hip mobility in female office workers. Turk J Phys Med Rehabil 2019;66(3):271–80.
10. Salar S, Daneshmandi H, Ardakani MK, Sharif HN. The relationship of core strength with static and dynamic balance in children with autism. Ann Appl Sport Sci 2014;2(4):33–42.
11. Golsefidi NR, Younesi A, Golsefidi AS. Effects of 8-week core stabilization exercises on the balance of students with high-functioning autism. International Journal of Sport Studies 2013;3:1369–74.
12. Hewett TE, Zazulak BT, Myer GD, Ford KR. A review of electromyographic activation levels, timing differences, and increased anterior cruciate ligament injury incidence in female athletes. Br J Sports Med 2005;39(6):347–50.
13. Devlin L. Recurrent posterior thigh symptoms detrimental to performance in rugby union: predisposing factors. Sports Med 2000;29(4):273–87.
14. Scott S. ABLE Bodies balance training. Champaign (IL): Human Kinetics; 2008.
15. Bokarius AV. Long-term efficacy of dynamic neuromuscular stabilization in treatment of chronic musculoskeletal pain. Poster presented at: 12th World Congress on Pain; 2008 Aug 17–22; Glasgow, Scotland. Poster No. PF225.
16. Sharma K, Yadav A. Dynamic neuromuscular stabilization-a narrative. International Journal of Health Sciences and Research 2020;10(9):221–31.
17. Mascal CL, Landel R, Powers C. Management of patellofemoral pain targeting hip, pelvis, and trunk muscle function: 2 case reports. J Orthop Sports Phys Ther 2003;33(11):647–60.
18. Shin J-w, Yoon H-s, Park J-h, Kim H-y, You JSH. Comparative immediate effects of isometric chin-tuck and dynamic neuromuscular stabilization on neck flexor muscle thickness and upright sitting height posture. Phys Ther Korea 2019;26(4):1–9.
19. Ross H. A comparison of dynamic neuromuscular stabilization and abdominal bracing on pain in adults with chronic low back pain: a case report [PhD dissertation]. Azusa Pacific University; 2017.
20. Cha YJ, Lee JJ, Kim DH, You JSH. The validity and reliability of a dynamic neuromuscular stabilization-heel sliding test for core stability. Technol Health Care 2017;25(5):981–8.
21. Yılmaz EA, Meral BT, Göbel D. Spor Bilimleri Fakültesinde okuyan öğrencilere uygulanan 4 haftalık DNS egzersizlerinin yüzme süreleri ve core stabilizasyonuna Etkisi. JSAR 2024;6:370–5.
22. Saki F, Shafiee H, Tahayori B, Ramezani F. The effects of core stabilization exercises on the neuromuscular function of athletes with ACL reconstruction. Scientific reports 2023;13(1):2202.
23. Larwa J, Stoy C, Chafetz RS, Boniello M, Franklin C. Stiff landings, core stability, and dynamic knee valgus: a systematic review on documented anterior cruciate ligament ruptures in male and female athletes. Int J Environ Res Public Health 2021;18(7):3826.
24. Yörükoğlu AÇ, Şavkın R, Büker N, Alsayani KYA. Is there a relation between rotator cuff injury and core stability? J Back Musculoskelet Rehabil 2019;32(3):445–52.
25. Kuniki M, Iwamoto Y, Kito N. Effects of core stability on shoulder and spine kinematics during upper limb elevation: A sex-specific analysis. Musculoskelet Sci Pract 2022;62:102621.
26. Cope T, Wechter S, Stucky M, Thomas C, Wilhelm M. The impact of lumbopelvic control on overhead performance and shoulder injury in overhead athletes: a systematic review. Int J Sports Phys Ther 2019;14(4):500–13.
27. Jebavy R, Baláš J, Vomackova H, Szarzec J, Stastny P. The effect of traditional and stabilization-oriented exercises on deep stabilization system function in elite futsal players. Sports (Basel) 2020;8(12):153.
28. Davidek P, Andel R, Kobesova A. Influence of dynamic neuromuscular stabilization approach on maximum kayak paddling force. J Hum Kinet 2018;61:15–27.
29. Ackerman K, Meinhold C. The effects of DNS on youth baseball athletes [dissertation]. Azusa Pacific University; 2020.
30. Erol E, Elbasan B, Erol BÖ, Yazıcı G, Apaydın U, Koçyiğit MF, Gücüyener K. Pediatrik fizyoterapi rehabilitasyon ünitesine başvuran hastalarin demografik özellikleri. Gazi Sağlık Bil 2016;1:49–59. [Article in Turkish]
31. Damiano DL, Abel MF. Relation of gait analysis to gross motor function in cerebral palsy. Dev Med Child Neurol 1996;38(5):389–96.
32. Hodges PW, Gandevia SC. Changes in intra-abdominal pressure during postural and respiratory activation of the human diaphragm. J Appl Physiol (1985) 2000;89(3):967–76.
33. Hodges PW, Cresswell AG, Daggfeldt K, Thorstensson A. *In vivo* measurement of the effect of intra-abdominal pressure on the human spine. J Biomech 2001;34(3):347–53.
34. Demir GT, Ethemoğlu O, Ağırcan D, Demir HA. Awareness of ischemic stroke among physicians in primary care and emergency departments. Medical Science And Discovery 2023;10(4).
35. Topçuoğlu MA, Tülek Z, Boyraz S, Özdemir AO, Özakgül A, Güler A, et al. Inme hemşireliği: standartlar ve pratik uygulamalar kılavuzu: Türk Beyin Damar Hastalıkları Derneği ve Nöroloji Hemşireliği Derneği ortak strateji projesi. Turk J Cerebrovasc Dis 2020;26(1):1–90.

36. Bártlová S, Šedová L, Havierniková L, Hudáčková A, Dolák F, Sadílek P. Quality of life of post-stroke patients. Zdr Varst 2022;61(2):101–8.
37. Meek C, Pollock A, Potter J, Langhorne P. A systematic review of exercise trials post stroke. Clin Rehabil 2003;17(1):6–13.
38. Yu SH, Park SD. The effects of core stability strength exercise on muscle activity and trunk impairment scale in stroke patients. J Exerc Rehabil 2013;9(3):362–7.
39. Genthon N, Rougier P, Gissot AS, Froger J, Pélissier J, Pérennou D. Contribution of each lower limb to upright standing in stroke patients. Stroke 2008;39(6):1793–9.
40. Karaduman AA, Yıldırım SA, Yılmaz ÖT. İnme sonrası fizyoterapi ve rehabilitasyon. 1st ed. Ankara: Pelikan Yayıncılık; 2013. p. 272.
41. Özengin N. Pelvik organ prolapsusu olan kadınlarda stabilizasyon egzersizleri ile elektromiyografik biofeedback eğitiminin karşılaştırılması [master's thesis]. Bolu: Abant İzzet Baysal Üniversitesi; 2012.
42. Juehring DD, Barber MR. A case study utilizing Vojta/Dynamic Neuromuscular Stabilization therapy to control symptoms of a chronic migraine sufferer. J Bodyw Mov Ther 2011;15(4):538–41.
43. Son MS, Jung DH, You JSH, Yi CH, Jeon HS, Cha YJ. Effects of dynamic neuromuscular stabilization on diaphragm movement, postural control, balance and gait performance in cerebral palsy. NeuroRehabilitation 2017;41(4):739–46.

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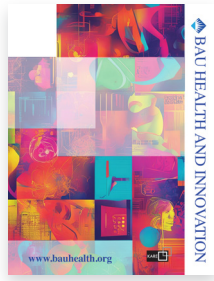

Case Report

Does Every Wound Heal with Dressing? Repair of a Chronic Ankle Wound with Free Tissue Flap and Nursing Care: Case Report

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Abstract

Chronic wounds may not always heal with traditional dressings and may require reconstructive surgical intervention. Free tissue flaps are an effective method for repairing complex defects; however, the success rate is associated with nursing monitoring and quality of care during the early post-operative period. A 78-year-old male patient presented with a chronic wound on the posterior aspect of his left ankle that had been present for 2 years. The lesion was excised through wide excision, and the resulting defect was repaired with an anterolateral thigh free flap. Systematic nursing care was provided during the post-operative period, focusing on flap monitoring and risk-oriented nursing diagnoses. Complication-free flap survival was achieved through systematic nursing monitoring. Nursing interventions for infection, pain, anxiety, pressure injury, and respiratory function contributed to successful recovery and complete wound healing in this patient. This case demonstrates that dressing alone is insufficient for chronic wounds and highlights the importance of nursing care in free flap surgery.

Keywords: Chronic wound, flap monitoring, free tissue flap, nursing care, postoperative care.

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Chronic lower-extremity wounds are especially common in the elderly, reducing their quality of life and placing a significant burden on the healthcare system. In the global health challenge, approximately 2.5% of the population is affected by these wounds, with the incidence increasing with age.[1] Lower extremity wounds can be resistant to conventional dressings owing to their anatomical structure and poor blood circulation, which may prolong the healing process. In such cases, free tissue flaps provide effective functional and esthetic reconstruction and offer a therapeutic solution, particularly for chronic, infected, or large tissue losses.[2] Furthermore, it has been reported that the success of free flap surgeries performed in elderly patients is independent of age and that this procedure can be performed safely when appropriate patient selection and perioperative care are provided.[3,4]

The most critical period in flap surgery is the first 48–72 h, during which most complications arise. According to the literature, clinical examination (color, temperature, capillary refill, turgor) and the use of handheld Doppler are considered the "gold standard" for monitoring flaps.[5,6]

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However, nursing care is essential for managing additional issues such as infection, pain, anxiety, and pressure injuries.[7] An experienced team and multidisciplinary approach are required for effective flap monitoring. Training nurses in flap assessment and conducting regular checks can help with the early detection of complications. In addition, patient education and psychological support can influence various aspects of recovery.[8]

In this article, the nursing care process conducted after the successful repair of a chronic ankle wound – unresponsive to long-term traditional dressing methods but successfully treated with the flap technique – is comprehensively discussed. In this context, the frequency of monitoring, care planning, patient education, and evaluation of uncomplicated healing is examined in detail.

Case Report

Patient Information

An 78-year-old male, a retired banker. History: Burn injury on the posterior left ankle during childhood. For the past 2 years, the patient had a chronic open wound in the same area, which was managed with conservative dressings. Punch biopsy performed the previous month revealed hyperkeratosis. The lesion was 7×5 cm in size with irregular borders, nodules, and hyperkeratosis. Plantar flexion contracture was observed at the ankle, along with limited dorsiflexion (Fig. 1). The lesion was excised under general anesthesia (Fig. 2). The posterior tibial vessels were then prepared. An anterolateral thigh flap (single perforator) was elevated from the right thigh. Vein anastomosed end-to-end, artery end-to-side, nerve end-to-end. Flap ischemia time was 50 min, and operation duration was 4.5 h. No intraoperative complications were noted. Pathological results revealed well-differentiated squamous cell carcinoma (Grade I). The surgical margins were negative. Penrose drains were placed intraoperatively in the patient. The foot was elevated in a position that did not exert pressure on the flap. Systematic nursing observations were performed for the first 72 h (Figs. 3, 4).

Nursing Care

The systematic structure of the nursing care process for the case is presented below. In line with the North American Nursing Diagnosis Association diagnoses, goals (Nursing Outcomes Classification) and interventions (Nursing Interventions Classification) regarding the maintenance of tissue perfusion, prevention of infection, management of pain and anxiety, and prevention of pressure injuries and respiratory complications are

Figure 1. In the preoperative period, an irregularly demarcated, hyperkeratotic, chronic wound was observed on the Achilles tendon on the posterior aspect of the left ankle.

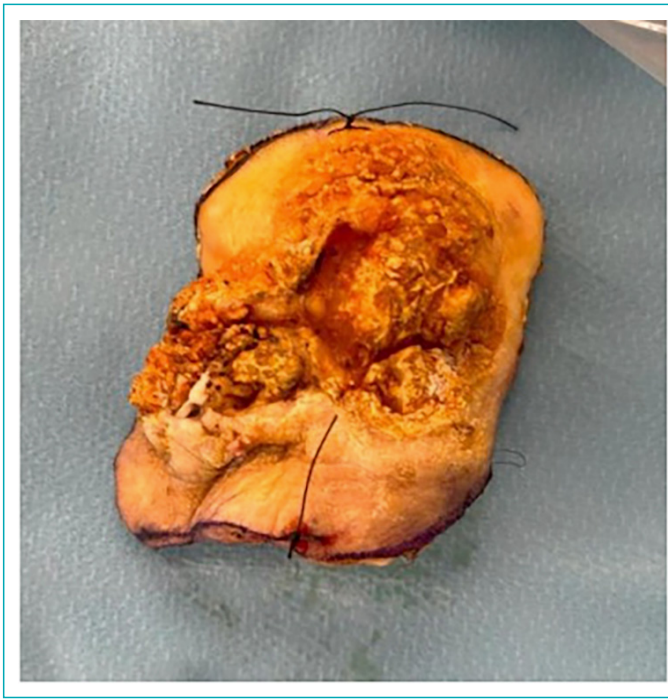

Figure 2. Specimen image after tumor excision.

Figure 3. Postoperative early appearance after adaptation of the free flap to the recipient area.

detailed. This structure demonstrates that nursing care is not only limited to symptom management but also encompasses preventive measures against complications and aspects that enhance the patient's quality of life (Table 1). As a result of systematic flap monitoring, infection control, pain and anxiety management, and

Figure 4. The flap appeared fully healed at the posterior of the left ankle in the late postoperative period.

nursing interventions for pressure injury and respiratory complications, flap viability was preserved, and wound healing was completed without problems (Fig. 4).

Flap temperature was monitored hourly for the first 72 h using a non-contact infrared thermometer. Measurements were taken from the center of the flap and compared with the surrounding skin and the contralateral limb to ensure a temperature difference of <2°C. Table 2 presents nursing monitoring during the critical first 72 h after free flap surgery, along with sample records. Parameters such as flap color, temperature, capillary refill, and Doppler signal were recorded at regular intervals and correlated with the vital signs. Table 2 demonstrates the impact of early warning sign detection and continuous nursing observation on the success of the surgery.

Table 1. NANDA–NIC–NOC nursing diagnoses and interventions

Nursing diagnosis (NANDA)	Target (NOC)	Nursing interventions (NIC)
Risk for ineffective peripheral tissue perfusion	Preservation of flap viability	Hourly flap color, temperature, capillary refill, and Doppler monitoring; positioning (elevation); maintaining room temperature; pain palliation
Risk for infection	No infection develops	Aseptic dressing; daily wound assessment; monitoring of fever and laboratory tests
Acute pain	Visual analog scale ≤3	Analgesic application; comfortable positioning; relaxation techniques
Anxiety	Reduction of anxiety	Patient and family education; encouraging family support; teaching relaxation exercises
Risk for pressure injury	Protection of skin integrity	Use of an air mattress; barrier cream; frequent inspection of pressure areas
Risk for impaired respiratory function	Ensuring effective ventilation	Deep breathing exercises with Triflo; postural drainage; preparation for mobilization

NANDA: North american nursing diagnosis association, NOC: Nursing outcomes classification, NIC: Nursing interventions classification.

Table 2. Flap monitoring chart for the first 72 h

Hour	BP (mmHg)	Flep color	Flep temperature	Capillary refill	Doppler signal quality	Intervention/note
1st h	BP: 114/78	Pink	Normal	3 s	Strong triphasic signal	Elevation, pain control
2nd h	BP: 120/80	Pink	Normal	3 s	Strong triphasic signal	Dressing check
3rd h	BP: 118/76	Pink	Normal	3 s	Strong triphasic signal	Drain tracking
4th h	BP: 116/74	Pink	Normal	3 s	Strong triphasic signal	Skin integrity assessment
5th h	BP: 118/78	Pink	Normal	3 s	Strong triphasic signal	Use of air mattress
6th h	BP: 122/80	Pink	Normal	3 s	Strong triphasic signal	Breathing exercise
7th h	BP: 120/76	Pink	Normal	3 s	Strong triphasic signal	Anxiety training
8th h	BP: 118/74	Pink	Normal	3 s	Strong triphasic signal	Findings are stable
9th h	BP: 120/78	Pink	Normal	3 s	Strong triphasic signal	The findings returned to normal
12th h	BP: 122/80	Pink	Normal	3 s	Strong triphasic signal	Stable, no complications
24th h	BP: 118/76	Pink	Normal	3 s	Strong triphasic signal	Stable, no complications
48th h	BP: 120/78	Pink	Normal	3 s	Strong triphasic signal	Mobilization preparation
72th h	BP: 122/80	Pink	Normal	3 s	Strong triphasic signal	Preparation for discharge

BP: Blood pressure

Table 3. Home care training content

Title	Training content
Flap care	Daily monitoring for color, temperature, swelling, and pain; adherence to dressing frequency
Position	The flap area should be kept above heart level
Hygiene	The surgical site should be cleaned under aseptic conditions
Nutrition	A diet rich in protein should be recommended
Activity	Do not lift heavy objects or engage in strenuous exercises without the surgeon's permission
Emergency symptoms	In case of discoloration, cooling, severe pain, bleeding, or fever, seek medical attention immediately.

Table 3 summarizes the home care education that covers the responsibilities of the patient and their families after discharge. The importance of daily observation, correct positioning, adequate nutrition, and hygiene in flap care was emphasized. In addition, the necessity of immediate medical attention in the case of complications, such as discoloration or severe pain, is clearly stated. This educational content plays a critical role in enhancing patient safety and minimizing the risk of complications after discharge.

During the mobilization process, the patient was monitored in an immobilized state for the first 72 h, and from the 3rd-day onward, was safely mobilized with the help of a walker without bearing weight on the left foot. This approach contributed to both preserving flap circulation and preventing possible complications.

Ethical Considerations

This study was conducted in accordance with the Declaration of Helsinki. As this is a case report, formal ethics committee approval was not required; however, written and verbal informed consent were obtained from the patient for the publication of this case and any accompanying images. The case was reported in line with the CARE guideline recommendations.

Discussion

This case demonstrates that chronic ankle wounds that do not heal despite long-term follow-up with conservative dressings may require surgical reconstruction. The literature reports that when chronic lower extremity wounds cannot be treated with wound care methods due to limited soft tissue coverage and vascular challenges, free tissue flaps offer a reliable treatment option.[2] In our patient, healing could not be achieved despite 2 years of dressing treatment, and after a punch biopsy that did not yield a diagnosis, wide excision and surgical reconstruction became inevitable.

Focusing particularly on the first 48–72 h after flap surgery is a key factor that maximizes success in flap monitoring. A prospective study by Salgado et al.[9] on head-and-

neck reconstructions showed that hourly flap monitoring during the first 48 h significantly increased flap salvage rates. A comprehensive study by Rogon et al.[10] revealed that after the first 48 h, the frequency of monitoring can be reduced; however, systematic follow-up up to 72 h allows for the detection of late complications. In addition, increasing nurses' knowledge and awareness of flap care is important. Goldman et al.[11] demonstrated that the success rate of venous congestion detection increased from 40.3% to 88.9% after nurse training, showing that structured training programs significantly improve the quality of care. In this case, systematic monitoring of follow-up frequency and parameters (color, temperature, capillary refill, and Doppler) resulted in success before any complications developed, demonstrating that effective care is possible despite the challenges posed by age-related skin characteristics. Although Knoedler et al.[5] noted that flap assessment can be difficult in elderly patients owing to skin morphology, they emphasized that clinical examination and Doppler monitoring provide a reliable foundation. This case supports the notion that nursing care is not only essential for enhancing patient comfort but also serves as a clinical strategy that directly affects flap survival.

Consistent with the literature, when systematic nursing monitoring is reinforced with knowledge-based training, it becomes one of the most important factors in sustaining surgical success.

Conclusion

This case demonstrates that free tissue flaps are an effective and reliable reconstruction option for chronic ankle wounds that do not heal despite conservative dressing treatment. The continuation of surgical success depends on systematic and protocol-based care interventions performed by nurses in the early post-operative period. Regular flap monitoring, infection prevention, pain and anxiety management, and nursing practices aimed at preventing pressure injuries and respiratory complications have played a critical role in maintaining flap viability. Therefore, considering nursing care as an integral part of the multidisciplinary team for patients undergoing free flap surgery is essential for preventing complications and ensuring patient safety.

Disclosures

Ethics Committee Approval: This is a single case report, and therefore ethics committee approval was not required in accordance with institutional policies.

Informed Consent: Written informed consents were obtained from patient and his family.

Conflict of Interest Statement: None declared.

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References

1. Sen CK. Human Wound and Its Burden: Updated 2022 Compendium of Estimates. Adv Wound Care (New Rochelle) 2023;12(12):657–70.
2. Almeida BSSD, Brandão ES, Fonseca ERD, Domenis LAM. Postoperative care in reconstruction with flaps of a traumatic lower limb wound: scope review. Rev Enferm UERJ 2023;31(1):e74516.
3. Sorg H, Sorg CGG, Tilkorn DJ, Thönnes S, Karimo R, Hauser J. Free flaps for skin and soft tissue reconstruction in the elderly patient: indication or contraindication. Med Sci (Basel) 2023;11(1):12.
4. Spindler N, Pieroh P, Spiegl U, Arakelyan S, Fakler JKM, Heyde CE, et al. Free flap reconstruction of the extremities in patients who are ≥65 years old: a single-center retrospective 1-to-1 matched analysis. Clin Interv Aging 2021;16:497–503.
5. Knoedler S, Hoch CC, Huelsboemer L, Knoedler L, Stögner VA, Pomahac B, et al. Postoperative free flap monitoring in reconstructive surgery-man or machine? Front Surg 2023;10:1130566.
6. Yalçın L. Flep takibi ve komplikasyon yönetimi. TOTBİD Derg 2024;24(1):97–9. [Article in Turkish]
7. Guo FX, Wu CY. Study on the prevention and nursing intervention of infection after flap transfer for hand trauma. Medicine (Baltimore) 2023;102(34):e34756.
8. Pelletier A, Tseng C, Agarwal S, Park J, Song D. Cost analysis of near-infrared spectroscopy tissue oximetry for monitoring autologous free tissue breast reconstruction. J Reconstr Microsurg 2011;27(8):487–94.
9. Salgado CJ, Chim H, Schoenoff S, Mardini S. Postoperative care and monitoring of the reconstructed head and neck patient.

Semin Plast Surg 2010;24(3):281–7.
10. Rogoń I, Rogoń A, Kaczmarek M, Bujnowski A, Wtorek J, Lachowski F, et al. flap monitoring techniques: a review. J Clin Med 2024;13(18):5467.
11. Kleban SR, Ogley SC, MacDavid JC, Goldman JJ, Francis A, Colombini CJ, et al. Nursing monitoring of microsurgical free flaps: identifying and addressing knowledge gaps. J Reconstr Microsurg 2020;36(9):673–9.