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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, EMBASE, Open Ukrainian Citation Index, Scilit, IdealOnline, Asian Science Citation Index, Gale Cengage and Electronic Journals Library – EZB.

Start Year: 2023

Average Duration of the First Review Round: 2 months

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

Language of Publication: English

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

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

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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 in accordance 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.

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Scope

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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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 in accordance 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 AI-assisted 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/ictcp/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 Formatting 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,
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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.

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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:

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(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 autorefractor. *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.

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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,

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 Evalu-

- Name, affiliation, ORCID ID number, e-mails and highest academic degree of the author(s),
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 - Acknowledgment of the individuals who contributed to the preparation of the manuscript but who do not fulfill the authorship criteria,
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3. Abstract and the main text,
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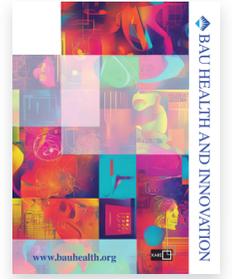


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Cognitive Differences Between Multilinguals and Monolinguals in Terms of Motor Skills

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Abstract

Objectives: Multilingualism has been proposed to enhance executive control and domain-specific cognitive and motor processes. This study examined whether multilingual adults show advantages over monolinguals in visuospatial working memory, sensorimotor speed, and short-term motor learning during an exergame program.

Methods: In a between-groups, repeated-measures design, forty healthy adults aged 18–50 years (20 multilingual, 20 monolingual) completed neuropsychological tests (Fitts's law task, Corsi Block Span, Stroop, Wisconsin Card Sorting Test (WCST), cued task switching). They played Kinect-based exergames on Days 1, 3, 5, and 7. Language proficiency (LexTALE), prior gaming frequency, and health measures (Pittsburgh Sleep Quality Index, Beck depression inventory, Beck Anxiety Inventory, mini-mental state examination) were recorded. Group comparisons used independent t-tests or Mann-Whitney U tests as appropriate, and repeated-measures analysis of variance assessed learning trajectories across sessions.

Results: Multilinguals showed significantly faster response times in the Fitts's law task ($p < 0.001$) and higher spans on the Corsi Block test ($p = 0.003$). No reliable group differences were observed for Stroop, WCST, or task-switching performance (all $p > 0.05$). Exergame performance improved across sessions in both groups, with a significant group \times day interaction indicating steeper learning trajectories among multilinguals ($p < 0.01$).

Conclusion: Multilingualism was associated with enhanced visuospatial working memory and sensorimotor speed and greater short-term gains in motor learning during exergame practice. These findings support the view that multilingual experience may strengthen visuomotor integration networks through experience-dependent plasticity. Replication in larger, longitudinal samples is warranted to clarify mechanisms and inform neurorehabilitation applications.

Keywords: Exergames, Kinect, monolingual, motor learning, multilingual, Xbox.

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Language is one of the most complex human abilities, shaping communication, cognitive processes, and brain organization. Advances in neuroimaging and analytical methods have revealed that learning and using language are associated with structural and functional plasticity in the brain.^[1,2]

Bilingualism and multilingualism, in particular, have been a significant focus of cognitive neuroscience research. Conforming in multiple languages requires continuous

monitoring, selection, and switching between linguistic codes, which can enhance cognitive flexibility and attentional control. Numerous studies have shown that bilinguals often recruit overlapping but dynamically adapted neural circuits, with language experience modulating universal linguistic pathways through individual practice.^[3–7]

Despite this, the so-called “bilingual advantage” remains debated. Some meta-analyses and large-scale studies have reported benefits in executive control, working

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memory, and attentional shifting, while others have failed to find reliable effects.^[8–14] This inconsistency suggests that the cognitive effects of multilingualism may be domain-specific rather than global, emerging more strongly in certain tasks or under specific environmental and methodological conditions.

One underexplored area is the relationship between multilingualism and sensorimotor processing. Language switching requires rapid and flexible coordination, potentially engaging posterior perceptual–motor systems alongside frontal executive networks.^[3–5,7,15] This raises the possibility that multilingual adults may show enhanced visuospatial working memory, faster motor responses, and improved motor learning compared to monolinguals.

At the same time, emerging evidence highlights the role of digital exergames – interactive video games requiring physical movement – in promoting cognitive and motor functions. Exergaming has been linked to improved attention, visuospatial abilities, and motor coordination across clinical and non-clinical groups.^[16–20] However, no study has directly investigated whether multilingual experience influences short-term motor learning during exergame training.

The present study addresses this gap by examining whether multilingual adults outperform monolinguals in (a) neuropsychological measures of visuospatial working memory, sensorimotor speed, and executive control, and (b) learning trajectories across 1 week of Kinect-based exergame practice. We hypothesized that multilinguals would demonstrate faster responses on the Fitts' law task and greater visuospatial span on the Corsi block test. We further expected steeper improvements in exergame performance across sessions, while analyses of Stroop, Wisconsin Card Sorting, and cued task switching were treated as exploratory.

Materials and Methods

Participants

These between-groups, repeated-measures study was conducted at Bahçeşehir University, Graduate School of Health Sciences, Department of Neuroscience. The study complied with the Declaration of Helsinki and was approved by the Bahçeşehir University Ethics Committee on 15/01/2020.

Forty healthy adults (20 multilingual; 20 monolingual; age range 18–50 years; balanced for sex) were recruited according to predefined inclusion and exclusion criteria (Table 1). Multilingual participants were Turkish speakers who also spoke English and/or French. Exclusion criteria included prior diagnosis of neurological or psychiatric disorders, regular use of psychoactive medication, and gaming experience of more than four sessions per week in the past 6 months. All participants provided written informed consent in their native language (Turkish for monolinguals, English for multilinguals).

Health and Screening Measures

To ensure general health comparability, participants completed the Beck Depression Inventory (BDI), Beck Anxiety Inventory (BAI), Pittsburgh Sleep Quality Index (PSQI), and Mini-Mental State Examination (MMSE). Only individuals with scores within the accepted thresholds (Table 1) were included.

Neuropsychological Testing

On Day 1, participants completed the LexTALE language proficiency test (French version: Brysbaert, 2013).^[21] A minimum cut-off score of 50% was required for inclusion in the multilingual group.

Participants then underwent standardized neuropsychological tests assessing attention, visuospatial working memory, executive function, and sensorimotor speed. These included:

Table 1. Inclusion and exclusion criteria

	Inclusion criteria	Exclusion criteria
BDI score	1–16± medication	>16±medication
BAI score	0–25± medication	>25±medication
Age	18–50 years	<18 or >50 years
MMSE score	30	<30
Gender	Male/female	-
Language	Turkish	University Majors in English, French, Turkish
Level of education	Undergraduate and above	
Gaming experience	<4 times per week	≥4 times per week

BDI: Beck depression inventory, BAI: Beck anxiety inventory, MMSE: Mini-mental state examination

- Fitts's law task (reaction time),
- Corsi block-tapping test (visuospatial span),
- Stroop task,
- Wisconsin card sorting test (WCST),
- Cued task-switching test.

All tasks were administered via PsyToolki.^[22,23]

Exergame Intervention

Participants played Kinect Adventures (Microsoft Xbox 360 Kinect system) in four sessions (Day 1, 3, 5, and 7). Each session lasted 30 min and included three exergames: Reflex Ridge, Rally Ball (Peek-a-Boo), and 20,000 Leaks (Go with the Flow). The system automatically recorded performance scores and tabulated them for analysis.

Primary and Secondary Outcomes

The primary outcomes were selected to capture core visuomotor and visuospatial abilities most likely to differentiate multilinguals from monolinguals based on prior evidence of bilingual advantage in sensorimotor and working memory domains.

1. Sensorimotor response speed was quantified using the mean movement time in the Fitts' law task, which indexes visuomotor coordination and speed-accuracy trade-off efficiency.
2. Visuospatial working memory was assessed via the Corsi Block-Tapping test, using the highest correctly recalled sequence length (Corsi span) as the dependent variable.
3. Exergame learning trajectories were operationalized as total Kinect performance scores across four sessions (Days 1, 3, 5, and 7), reflecting short-term motor learning and adaptation.

These measures were defined as primary outcomes because they directly represent sensorimotor integration and visuospatial processing, functions previously linked to bilingual language control and experience-dependent plasticity.

Secondary exploratory outcomes included measures primarily reflecting executive control: Stroop interference scores (inhibitory control), WCST categories completed and perseverative errors (set-shifting), and cued task-switching cost, representing cognitive flexibility. These outcomes were examined to determine whether multilingual advantages extend beyond the visuomotor domain to broader executive processes.

Statistical Analysis

Baseline demographic and health variables (e.g., age, sex, BDI, BAI, PSQI, MMSE) were compared between groups using independent-samples t-tests or chi-square

(χ^2) tests, as appropriate. Between-group differences in neuropsychological task performance and exergame scores were initially evaluated using independent-samples t-tests. Normality assumptions were assessed using the Shapiro–Wilk test, and homogeneity of variances was examined with Levene's test. When statistical assumptions were violated, the non-parametric Mann–Whitney U test was applied.

To examine performance changes across exergame sessions, a repeated-measures analysis of variance (ANOVA) was conducted with Group (multilingual vs. monolingual) as the between-subjects factor and Time (Day 1, Day 3, Day 5, Day 7) as the within-subjects factor. Effect sizes (Cohen's *d* and partial η^2) and 95% confidence intervals were reported where applicable. All statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Statistical significance was set at $p < 0.05$.

Results

Demographics

The demographic characteristics of participants are shown in Table 2. Of the 40 participants, 23 (57.5%) were female, and 17 (42.5%) were male. The multilingual group included 13 females and seven males, while the monolingual group comprised 10 females and 10 males. The mean age across the total sample was 27.3 ± 3.1 years, with no statistically significant difference between the groups ($p > 0.05$). Thus, the two groups were comparable regarding basic demographic variables, minimizing potential confounding effects of age and gender.

General Health Results

Table 2 also presents the results of general health screening measures. The mean PSQI score was 7.0 ± 3.6 , indicating poor sleep quality overall. Multilingual participants demonstrated slightly lower PSQI values than monolinguals, suggesting a trend toward better subjective sleep quality, though differences were not statistically significant ($p > 0.05$). Mean BDI and BAI scores were 7.6 and 8.4, respectively, within the non-clinical range. While multilinguals had somewhat lower depression scores than monolinguals, anxiety scores were comparable across groups.

Language Test Results

LexTALE scores are summarized in Table 3. Among multilinguals, 80% reported bilingual proficiency and 20% trilingual proficiency. The average English LexTALE score was 68.7, and the average French score was 74.4, comfortably above the 50% inclusion threshold.

Table 2. Health assessment group differences between monolingual and multilingual

Grouping (Monolingual=A, Multilingual=B)	Mean
Gender distribution	
A (male)	10±0
(Female)	10±0
B (male)	7±0
(Female)	13±0
Age	
A	27.25±3.076
B	27.35±3.216
Pittsburgh sleep quality index	
A	8.80±3.592
B	5.35±2.796
Beck's depression score	
A	8.75±3.291
B	6.35±4.626
Beck's anxiety score	
A	8.60±3.747
B	8.10±7.405

Neuropsychological Test Results

- Fitts's law task: Multilinguals exhibited significantly faster response times than monolinguals (Table 4). Group differences were confirmed by independent t-tests ($p < 0.001$, Table 5).
- Corsi block-tapping test: Multilinguals achieved higher mean span scores ($M = 5.45$) compared to monolinguals ($p < 0.05$).
- Stroop test: No significant group differences ($p > 0.05$, Table 5).
- WCST: Multilinguals made fewer errors, but group differences were insignificant ($p > 0.05$, Table 5).
- Cued task-switching: No significant group differences ($p > 0.05$, Table 5).
- Reflex ridge: Significant group differences ($p < 0.05$; Mann-Whitney $p < 0.001$ on some days).
- Rally ball: Multilinguals scored higher each session; Day 3 required Mann-Whitney ($p < 0.05$).
- 20,000 leaks: Multilinguals significantly outperformed monolinguals across all sessions ($p < 0.05$).

Table 4. Neuropsychological tests mean frequency distribution

Neuropsychological tests mean frequency distribution (mean±standard deviation)		
	Monolinguals	Multilinguals
Fitt's mean response time	883.55±164.6	676.34±106.0
Corsi block test mean	4.60±0.754	5.45±0.945
Stroop test speed in correct incongruent	871.500±209.48	894.500±143.49
Speed in correct incongruent	981.25±241.40	1008.60±129.55
Stroop effect	109.75±126.49	114.35±114.64
Wisconsin card sorting test preservation	8.5000±2.259	7.9500±3.817
Non-preservation	4.1000±2.751	3.5500±2.187
Task switching cued avg. RT in all correct	720.05±211.41	618.45±105.77
Avg. RT in task repeat	682.60±192.28	586.30±86.378
Avg. RT in task switch	723.30±281.09	651.00±130.89
Task switch cost	68.400±81.602	64.700±93.392
Avg. RT in task congruent	724.65±227.84	609.60±93.091
Avg. RT in task incongruent	722.90±201.92	631.75±114.92
Task interference	16.1500±112.45	22.150±56.727

Table 3. Language score mean distribution between English and French speakers

Lextale exam score distribution		
Total No. of participants (n=20)	LexTale English score (n=20)	LexTale French score (n=4)
Mean	68.7065	74.4875
Median	73.1250	74.6750
Standard deviation	13.08421	4.21137

- Stroop test: No significant group differences ($p > 0.05$, Table 5).
- WCST: Multilinguals made fewer errors, but group differences were insignificant ($p > 0.05$, Table 5).
- Cued task-switching: No significant group differences ($p > 0.05$, Table 5).

Exergame Scores

Table 6 summarize performance across four exergaming sessions. Both groups improved over time. Multilinguals consistently achieved higher scores, indicating steeper learning trajectories.

- Reflex ridge: Significant group differences ($p < 0.05$; Mann-Whitney $p < 0.001$ on some days).
- Rally ball: Multilinguals scored higher each session; Day 3 required Mann-Whitney ($p < 0.05$).
- 20,000 leaks: Multilinguals significantly outperformed monolinguals across all sessions ($p < 0.05$).

Table 5. Neuropsychological tests sample t-test distribution

Neuropsychological tests sample t-test distribution						
Fitt's mean response time	Levene's test for equality of variances		t-test for equality of means			
		F	Significant	t	df	Significant (2 tailed)
Corsi block test mean	EVA	0.948	0.336	4.731	38	0
	EVNA			4.731	32.446	0
	EVA	0.346	0.56	-3.145	38	0.003
	EVNA			-3.145	36.221	0.003
Stroop test						
Speed in correct congruent	EVA	5.256	0.028	-0.405	38	0.688
	EVNA			-0.405	33.613	0.688
Speed in correct incongruent	EVA	9.456	0.004	-0.446	38	0.658
	EVNA			-0.446	29.106	0.659
Stroop effect	EVA	0.124	0.727	-0.12	38	0.905
	EVNA			-0.12	37.638	0.905
Wisconsin card sorting test						
Preservation	EVA	0.885	0.353	0.554	38	0.583
	EVNA			0.554	30.855	0.583
Non-preservation	EVA	1.124	0.296	0.7	38	0.488
	EVNA			0.7	36.167	0.489
Task switching cued						
Task switch cost	EVA	0.567	0.456	0.133	38	0.895
	EVNA			0.133	37.328	0.895
Task interference	EVA	5.52	0.024	-0.213	38	0.832
	EVNA			-0.213	28.082	0.833

EVA: Equal variances assumed; EVNA: Equal variances not assumed.

Discussion

This study investigated whether multilingualism is associated with advantages in cognitive performance and short-term motor learning. The main findings were that multilingual participants outperformed monolinguals on the Fitts's law task and the Corsi Block-Tapping test, indicating enhanced visuomotor speed and visuospatial working memory. By contrast, no significant group differences were observed for Stroop, WCST, or cued task-switching measures. In the exergame intervention, multilinguals consistently achieved higher scores and steeper improvements across sessions than monolinguals. These results contribute to the ongoing debate regarding the "bilingual advantage." While some studies have reported cognitive benefits of bilingualism, others have found inconsistent or null effects. Recent meta-analyses emphasize that such advantages are not global but rather domain – and context-specific.^[8–14,24–26] Our findings align with this perspective: multilingualism was not associated with

broad enhancements in executive control but was linked to advantages in visuospatial and motor learning domains.

The superior performance of multilinguals in the Fitts's law and Corsi tasks may reflect experience-dependent plasticity in perceptual-motor networks. Frequent switching between languages engages executive and posterior perceptual-motor systems, potentially reinforcing visuospatial working memory and rapid motor responses.^[3–7,15,27] This interpretation is supported by previous work showing the benefits of visuospatial memory in bilinguals.^[28] The exergame findings extend this interpretation, as multilinguals demonstrated steeper learning trajectories in tasks requiring dynamic visuomotor coordination, consistent with evidence that gaming interventions can support motor learning.^[16–20,29]

An important implication of these results is that multilingual experience may act as a form of "cognitive-motor training." Language switching requires rapid inhibition and activation of competing representations, which recruit prefrontal

Table 6. Xbox Kinect games sample t-test distribution

	Day 1		Day 3		Day 5		Day 7		Total scores	
	EVA*	EVNA**	EVA	EVNA	EVA	EVNA	EVA	EVNA	EVA	EVNA
Reflex ridge										
Levene's test for equality of variance										
F	2.068		2.154		10.732		6.041		6.53	
Sig.	0.159		0.15		0.002		0.019		0.15	
t-test for equality of means										
t	-7.063	-7.063	-8.098	-8.098	-8.655	-8.66	-8.458	-8.458	-8.398	-8.398
df.	38	35.972	38	34.94	38	29.3	38	32.532	38	31.835
Sig. (2 tailed)	0	0	0	0	0	0	0	0	0	0
Mann-Whitney U Results ^a										
Mann-Whitney U	22.5		15		11		11		11	
Wilcoxon W	232.5		225		221		221		221	
Z	-4.802		-5.004		-5.113		-5.112		-5.113	
Asymp. Sig. (2-tailed)	0		0		0		0		0	
Exact Sig. [2 (1-tailed Sig.)]	000b		000b		000b		000b		000b	
Rally Ball										
Levene's test for equality of variance										
F	2.16		4.647		1.962		0.756		1.731	
Sig.	0.15		0.038		0.169		0.39		0.196	
t-test for equality of means										
t	-4.83	-4.83	-5.169	-5.169	-6.156	-6.16	-6.073	-6.073	-6.069	-6.069
df.	38	36.013	38	30.94	38	33.3	38	33.5	38	34.987
Sig. (2 tailed)	0	0	0	0	0	0	0	0	0	0
Mann-Whitney U Results ^a										
Mann-Whitney U	62		45		.5		29		34	
Wilcoxon W	272		255		240.5		239		244	
Z	-3.733		-4.194		-4.585		-4.626		-4.491	
Asymp. Sig. (2-tailed)	0		0		0		0		0	
Exact Sig. [2 (1-tailed Sig.)]	000b		000b		000b		000b		000b	
20,000 Leaks										
Levene's test for equality of variance										
F	7.981		0.029		1.046		0.001		2.342	
Sig.	0.007		0.866		0.313		0.971		0.134	
t-test for equality of means										
t	-8.103	-8.103	-6.981	-6.981	-7.336	-7.34	-7.382	-7.382	-8.179	-8.179
df.	38	30.705	38	37.96	38	37.6	38	37.983	38	35.618
Sig. (2 tailed)	0	0	0	0	0	0	0	0	0	0

^a: Grouping variable: Multilingual, ^b: Not corrected for ties. *: EVA: Equal variances assumed, **: EVNA: Equal variances not assumed.

regions and premotor and subcortical structures such as the basal ganglia.^[6,15] Over time, this repeated engagement may strengthen critical pathways for sensorimotor coordination. Furthermore, neuroimaging evidence suggests that bilingual experience recruits the cerebellum

and motor cortices during linguistic and non-linguistic tasks, providing a mechanistic link between multilingual practice and enhanced motor learning. The overlap between language and sensorimotor circuits supports the idea that managing multiple languages could generalize

beyond executive control to motor skill acquisition. In line with this interpretation, studies highlight the cerebellum's dual role in speech-language processing and fine motor control,^[30] and electrophysiological evidence indicates that sensorimotor circuits underpin aspects of language perception and production.^[31] From this perspective, multilingualism may confer cognitive reserve and enhance motor adaptability through shared neural substrates.

Our results showed no reliable group differences for Stroop, WCST, and task-switching. This is consistent with studies reporting limited or absent multilingual advantages in inhibition and cognitive flexibility.^[13,14] Some authors argue that such tasks rely more heavily on domain-general executive control, where effects of multilingualism may be less pronounced or moderated by other factors such as age of acquisition, daily language use, and sociocultural context.^[32]

The integration of exergames in this study adds a novel dimension. Prior work has shown that exergaming can enhance visuospatial skills, attention, and motor learning.^[16–20] Our data extend these findings by showing that multilingual participants may benefit more strongly from repeated exergame training. The convergence of advantages observed in neuropsychological and exergame tasks suggests that multilingualism may confer specific benefits when tasks place high demands on visuomotor integration.

At the same time, our findings must be interpreted cautiously. The sample size was modest, limiting power to detect more minor effects and precluding multivariate analyses to control for confounders such as sleep quality and mood. The duration of the intervention was short (1 week), and participants varied in their age of acquisition and proficiency levels in the second and third languages. Sociocultural and educational factors may also contribute to cognitive and motor differences. These limitations underscore the need for larger, longitudinal studies with careful stratification of language background variables.

Despite these caveats, the current study highlights potential implications for neurorehabilitation. Exergame-based training combined with the cognitive reserve associated with multilingualism could represent a promising avenue for enhancing rehabilitation outcomes in conditions involving motor deficits, such as Parkinson's disease or cerebral palsy. Future research should explore whether language experience moderates the efficacy of such interventions and whether incorporating multilingual training elements into rehabilitation protocols could further enhance outcomes.

Conclusion

The present study suggests that multilingual adults show measurable advantages in visuomotor speed, visuospatial working memory, and short-term motor learning compared to monolinguals. These effects were consistently observed in the Fitts' law and Corsi tasks and in exergame performance across repeated sessions. By contrast, no reliable group differences were found for Stroop, WCST, or task-switching, supporting recent evidence that multilingual advantages are domain-specific rather than global.^[8–14,24–26]

Taken together, these findings highlight that multilingualism may contribute to cognitive reserve and enhanced motor adaptability. The observed link between language experience and sensorimotor efficiency suggests that multilingualism can act as a form of ongoing "cognitive-motor training." This perspective emphasizes the overlap between language networks and motor circuits, including prefrontal, cerebellar, and sensorimotor pathways.^[15,30,31]

Although preliminary, our results may carry implications for clinical and translational neuroscience. Exergame-based interventions combined with the cognitive enrichment of multilingualism could support rehabilitation strategies for disorders involving motor and cognitive decline, such as Parkinson's disease, stroke, or mild cognitive impairment. Future work should examine whether multilingual experience moderates the efficacy of such programs and whether integrating language-based enrichment into rehabilitation protocols can further optimize outcomes.

Disclosures

Ethics Committee Approval: The study was approved by the Bahçeşehir University Ethics Committee (no: 20021704-604.01.01, date: 15/01/2020).

Informed Consent: Informed consent was obtained from all participants.

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The Association Between Chronotypes, Eating Behavior, and Obesity Risk Among Undergraduate Students: A Cross-Sectional Study

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Abstract

Objectives: Individuals differ in their sleep and activity timings, aligning with their circadian rhythms and this situation is described within the chronotype concept. It is stated that people who prefer evening sleep and have longer sleep duration have a higher prevalence of overweight/obesity than those who prefer morning sleep and have adequate sleep duration. The process of starting university is a critical period for many students as they start to make their own food choices. The aim of our study is to evaluate the impact of chronotypes on obesity and unhealthy eating and accordingly assess university students' tendencies toward these behaviors.

Methods: In this cross-sectional study, individuals' body composition was determined by utilizing the bioelectric impedance method. The Morningness – Eveningness Questionnaire, the Night Eating Questionnaire and the 30-Item Mindful Eating Questionnaire were used to evaluate participants' chronotype categories, night eating status and mindful eating status, respectively.

Results: A total of 103 undergraduate students whose mean age is 21.4±3.1 and who comprise 80.6% (n=83) women participated in our study. No significant differences between chronotype categories and anthropometric measurements were found (p>0.05). Eating discipline scores of students from health-related departments were shown to be higher than those of students from other departments (p=0.000).

Conclusion: Even though the main hypothesis was not confirmed, this study focuses on promoting healthy eating behaviors among undergraduate students by increasing nutrition knowledge and enhancing mindful eating, with the ultimate goal of preventing obesity which is a significant public health concern today.

Keywords: Circadian rhythm, eating behavior, mindful eating, obesity, public health, unhealthy eating.

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The term “circadian” is used to describe the functions that happen in a 24-hour cycle and derives from the combination of the words “circa”, meaning approximately, and “diem”, meaning a day or 24 hours. Individuals differ in their sleep and activity timings, aligning with their circadian rhythms and this situation is described within the

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chronotype concept. Three different chronotype categories were identified: morning, evening, and intermediate types.

^[1] Research shows that early chronotype individuals sleep early at night and wake up early in the morning, so they have a better performance in the morning. Whereas evening types sleep late in the evenings and have a hard time waking up in the morning, so have a better performance in the afternoon. It is known that chronotypes not only protect one's physical and mental health but also affect one's eating behaviors. Additionally, early types show healthier eating behaviors and have more control over overeating than evening types. Therefore, they are prone to being healthy.^[2]

According to the World Obesity Atlas, published by the World Obesity Federation in 2024, it is projected that the number of adults living with obesity, which was 0.81 billion in 2020, will increase to 1.53 billion by 2035.^[3] Chronotypes, which reflect individuals' sleep timing and preferences in other behaviors, are not generally known to be associated with obesity. Even though a direct connection between weight gain and chronotype has not been described yet, evening chronotype is associated with negative health outcomes. It is stated that people who prefer evening sleep and have longer sleep duration have a higher prevalence of overweight/obesity than those who prefer morning sleep and have adequate sleep duration.^[4] Another finding in the literature regarding chronotypes is that while morning types regularly have breakfast, evening types habitually skip it.^[5] Moreover, evening types are associated with night eating syndrome (NES) and higher body mass index (BMI).^[6] However, studies investigating the relationships between chronotype, healthy eating and obesity are limited.^[7]

The process of starting university is a critical period for many students as they start to make their own food choices. During this period of life, students develop health-related habits that will impact their life when they become adults^[8] and regardless of their existing eating habits and family habits, these behaviors can change due to friends and other factors and the tendency towards unhealthy food choices and negative eating behavior might increase.^[2] Notably, young adults show decreased vegetable, fruit and whole grain consumption and higher intake of high-calorie and low-nutrient-dense food such as sugar-sweetened beverages and processed meats. Therefore, it is important to investigate the factors that impact young adults' and university students' nutrition habits to build their lifelong health, as they face more nutrition challenges than other age populations.^[9]

Sleep problems are a crucial source of concern among university students around the globe and high stress

levels, academic performance pressure, irregular academic and social plans, late usage of electronic devices, caffeine consumption and alcohol intake can be counted as the reasons.^[10,11] Research indicates that young adults are more prone to an evening chronotype; they have a natural tendency for sleeping late and waking up late. Furthermore, it has been reported that this natural preference is associated with poor sleep quality.^[11] There is a notable lack of research, particularly among undergraduate students in Türkiye, that integrates chronotype, night eating syndrome, mindful eating, and objective body composition measurements within a single study. Therefore, this study aims to fill this gap by simultaneously evaluating chronotype, night eating behavior, mindful eating, and detailed body composition parameters in a sample of university students, thereby providing a more comprehensive perspective on the behavioral and physiological pathways associated with obesity risk.

Materials and Methods

Study Design

In this cross-sectional study, an online survey was created by using Google Forms and the data collection process was conducted between October 2024 and February 2025. University students residing in Istanbul, Türkiye, comprised the study population, and participants were contacted via LinkedIn and Instagram through the announcement posters. Additionally, an announcement text that includes the project topic was prepared and sent via WhatsApp to groups that consist of undergraduate students from Istanbul, Türkiye. Participants who expressed interest in the study and met the inclusion criteria were contacted, and appointments for anthropometric measurements were scheduled at mutually convenient dates and times with the researcher. The ethical commission application was prepared according to the Helsinki Declaration ethical standards and approved by Bahçeşehir University's ethical commission (E-85646034-604.02.02-70060). A total of 147 individuals were contacted to participate in the study; however, 13 were excluded due to meeting exclusion criteria, 2 were excluded because they completed the questionnaire but did not have anthropometric measurements, 2 were excluded because they had measurements but did not complete the questionnaire, 6 were excluded due to being foreign nationals and, despite having both measurements and questionnaires, could not provide statistically meaningful data, and 21 were not included because a mutually convenient date and time could not be arranged. In the end, out of 147 people, a total of 103 individuals participated in the study. After the

completion of data collection and analysis, a post hoc power analysis was conducted using the GPower software (GPower 3.1.9.2, Düsseldorf, Germany) to evaluate the adequacy of the sample size. The analysis was based on the correlation coefficient between the chronotype total score and the night eating total score ($r=-0.284$). The significance level was set at $\alpha=0.05$, and based on the final sample size ($n=103$), the achieved statistical power ($1-\beta$) was calculated as 90.1%. Informed consent form was taken from all the participants. Individuals who had been diagnosed with an eating disorder in the past, individuals who have sleep disorders, individuals who are working in shifts and individuals who did not sign the informed consent forms were excluded from the study. Participants' sociodemographic information and dietary habits were assessed using a questionnaire prepared by the researcher based on a literature review.

Anthropometric Measures

Height was measured using a stadiometer (Seca 769) with participants standing barefoot, feet together, and head positioned in the Frankfort plane. Individuals' body composition was determined by utilizing the bioelectric impedance method (Tanita RD-545-sv). With this bioelectric impedance analysis-based measurements, participants' body weight, BMI, body fat mass and percentage, fat-free mass and percentage were assessed. The analysis was conducted under standard conditions, considering factors such as at least four hours of fasting prior to analysis, avoiding measurements during participants' menstruation, the absence of metal accessories, and normal room temperature.^[12] Moreover, participants' waist and hip circumferences were measured using a non-stretchable tape measure, and then their waist-to-hip ratios were calculated.

Chronotype Categories

Individuals' chronotype categories were determined by using the morningness – eveningness questionnaire. The Morningness – Eveningness Questionnaire (MEQ) was developed by Horne and Östberg^[13] and its Turkish adaptation was carried out by Pündük et al.^[14] The questionnaire consists of 19 questions. This questionnaire is used for evaluating morning and evening types in the human circadian rhythm. The instrument investigates patients' physical and psychological performances which take place over 24 hours and their preferred time periods for conducting these performances. The MEQ was administered to patients in person. Scoring differs between 16–86, with 16–41 indicating a definite evening type, 42–58 indicating an intermediate type and 59–86 indicating a definite morning type.

Night Eating Status

Participants' night eating status was determined via The Night Eating Questionnaire which is a screening survey that was developed by Allison et al.^[15] and it consists of 14 questions. The survey comprises questions regarding morning appetite and day's first food intake, evening and night meals, food intake percentages after dinner, cravings, the control over night eating behavior, difficulty falling asleep, frequency of waking up to eat at night, awareness while night eating and emotional state. The first nine questions of the survey must be filled out by all participants. The following questions include a warning instructing participant who do not wake up at night or do not snack at night not to continue the survey. Questions 10–12 are filled out by participants who wake up at night and questions 13 and 14 are filled out by participants who snack at night. All items except for question number 7 are scored between 0–4 via a Likert-type scale. The seventh item assesses changes in mood throughout the day, and individuals who do not experience any mood variation receive a score of zero. Questions numbered 1, 4, and 14 are reverse-scored. Item 13 asks how aware individuals are of their nocturnal snacking in order to differentiate night eating syndrome from sleep-related eating disorder. However, it is not included in the total score. The total score ranges from 0 to 52, and participants with higher scores are presumed to have developed night eating behavior. In this questionnaire, individuals who score 25 or higher are considered to have developed NES. The questionnaire's Cronbach Alpha value is 0.69 and the survey demonstrates internal consistency. In this study, the Cronbach Alpha is 0.682. Additionally, the Turkish reliability and validity study was conducted by Atasoy et al.^[16] in 2013.

Mindful Eating Status

Participants' mindful eating status was assessed using the 30-Item Mindful Eating Questionnaire (MEQ-30), which measures levels of mindful eating. The questionnaire was first introduced to the literature by Framson et al.^[17] and its Turkish validity and reliability were established by Köse et al.^[18] The MEQ-30 consists of 30 items designed to evaluate mindful eating in daily life. Each item is scored on a 5-point scale, with "never" scored as 1, "rarely" as 2, "sometimes" as 3, "often" as 4, and "always" as 5. While 20 items are scored reversely, questions numbered 1, 7, 9, 11, 13, 15, 18, 24, 25 and 27 are scored normally. The seven subscales of the questionnaire are: disinhibition, emotional eating, eating control, focus, eating discipline, awareness and interference. Getting a high score from each subscale

demonstrates that the individual has the feature that the subscale evaluates. Furthermore, a total mindful eating score is calculated from the questionnaire. When scoring the questionnaire, the mean of the subscales and the total score is calculated. MEQ-30 has been shown to be a valid and reliable tool for evaluating mindful eating in the Turkish population.

Statistical Analysis

The obtained data were analyzed by using SPSS software (version 30.0 Inc., Chicago). In all analyses, a p-value of <0.05 was considered statistically significant. Descriptive statistics were expressed as numbers, percentages, means, and standard deviations. The Kolmogorov-Smirnov test was used to assess the normality of the data distribution. Chronotype and mindful eating scores were evaluated according to BMI categories by utilizing one-way ANOVA test and post hoc Tukey-HSD test. The relationships between questionnaire scores and anthropometric measurements were examined using Pearson correlation analysis. In addition, scale scores were compared across independent groups according to gender, academic program, and the presence of a diagnosed disease using the t-test.

Results

General Characteristics Of Participants

A total of 103 undergraduate students whose mean age is 21.4 ± 3.1 and comprise 80.6% (n=83) women participated in our study. Participants' mean BMI is 22.1 ± 3.3 kg/m² and while 70.9% of them are categorized as normal, 17.4% of them are classified as overweight and obese. General characteristics of participants are shown in Table 1.

Evaluation of Anthropometric Measurements According to Chronotype Categories

Table 2 demonstrates the evaluation of anthropometric measurements according to chronotype categories. No significant differences between chronotype categories and anthropometric measurements were found ($p > 0.05$).

Correlation Between Survey Data and Anthropometric Measurements

In Table 3, the relationship between participants' questionnaire results and anthropometric measurements is examined. A weak negative correlation was found between chronotype total score and night eating score ($R = -0.284$; $p = 0.004$). Between the night eating score and mindful eating score, a moderate negative significant correlation was found ($R = -0.429$; $p < 0.001$).

Table 1. General characteristics of participants (n=103)

Age (years)	21.4±3.1
Sex, n (%)	
Female	83 (80.6)
Male	20 (19.4)
Body weight (kg)	61.2±11.0
Body mass index (kg/m ²)	22.1±3.3
Body mass index categories, n (%)	
Underweight	12 (11.7)
Normal	73 (70.9)
Overweight or obese	18 (17.4)
Body fat mass (kg)	17.3±6.4
Body fat percentage (%)	28.1±7.6
Fat free mass (kg)	33.1±11.1
Fat free mass percentage (%)	54.4±15.5
Waist circumference (cm)	74.1±9.1
Hip circumference (cm)	99.0±7.2
Waist to hip ratio	0.75±0.1
Presence of diagnosed disease, n (%)	
Yes	17 (16.5)
No	86 (83.5)
Field of study, n (%)	
Health	66 (64.1)
Other	37 (35.9)
Grade, n (%)	
Preparatory year or 1 st year	12 (11.7)
2 nd year	48 (46.6)
3 rd year	29 (28.2)
4 th and above	14 (13.6)
Chronotypes categories, n (%)	
Morning type	19 (18.4)
Intermediate type	54 (52.4)
Evening type	30 (29.2)
Night eating syndrome categories, n (%)	
Night eating syndrome	7 (6.8)
Normal	96 (93.2)

When evaluated according to waist circumference, significant negative correlations were found between the total mindful eating score ($R = -0.199$; $p = 0.044$) and the disinhibition ($R = -0.229$; $p = 0.020$) and eating control ($R = -0.376$; $p = 0.000$) subscale scores.

Scale Outcomes in Relation to Participants' Gender, Field of Study, and Diagnosed Medical Conditions

The scores obtained from the questionnaires by the participants were examined in Table 4 according to various variables. The chronotype total score was found to be significantly higher in female participants than in male

Table 2. Distribution of anthropometric measurements by chronotype categories of the participants

	Evening type (n=30)	Intermediate type (n=54)	Morning type (n=19)	F	p
Body weight (kg)	59.5±12.9	62.5±10.9	60.3±7.5	0.764	0.469
Body mass index (kg/m ²)	21.2±3.6	22.5±3.2	22.3±2.7	1.688	0.191
Body fat mass (kg)	15.6±6.0	18.0±6.9	17.9±5.2	1.439	0.242
Body fat percentage (%)	26.4±8.0	28.5±7.9	29.2±5.6	1.065	0.349
Fat free mass (kg)	33.2±12.3	34.9±11.2	27.8±6.2	2.981	0.055
Fat free mass percentage (%)	55.8±15.5	56.1±15.5	47.2±14.0	2.578	0.081
Waist circumference (cm)	72.4±10.4	75.2±9.1	73.4±6.5	0.948	0.391
Hip circumference (cm)	97.4±7.9	99.8±7.2	99.1±5.9	1.105	0.335
Waist to hip ratio	0.74±0.06	0.75±0.05	0.74±0.04	0.458	0.634

participants ($p=0.047$). Moreover, while emotional eating is found to be significantly lower in female individuals ($p=0.009$); eating control was found to be significantly higher ($p=0.015$). Eating discipline scores of students from health-related departments were shown to be higher than those of students from other departments ($p=0.000$). In addition, the same score was observed to be higher among individuals with a diagnosed medical condition than among those without one ($p=0.011$).

Discussion

This study contributes to the literature by examining chronotype, night eating behavior, and mindful eating together with objective body composition measures in a young university population, providing a more comprehensive view of factors related to obesity risk. The main purpose of our study was to find a significant correlation between students' chronotype categories and obesity tendencies. Nonetheless, there was no significant correlation found between participants' anthropometric measurements and chronotype categories. This finding might be caused by the low study population. However, there is a study available in the literature with a similar sample size but a higher average age, which found significant correlations between chronotype categories and BMI, body weight, waist circumference, hip circumference, waist/hip ratio and body fat percentage.^[19]

Circadian misalignment and insufficient sleep cause the brain's specific parts that are stimulated by food to activate. Therefore, endocannabinoid system changes and as a result, it can be understood that BMI and metabolic dysfunctions are in a strong relationship with sleep disorders. NES has been associated with a misaligned circadian rhythm, which is linked to delayed overall food intake, increased energy intake, and higher fat consumption.^[20] In light of this information, we

hypothesized that the night eating score would be higher in individuals who are evening types. Consequently, in agreement with prior research,^[21–23] we found a significant correlation between the night eating score and chronotype total score. Thus, this finding may indicate that NES is more prevalent among evening chronotype individuals compared to other chronotypes.

Eating behavior and circadian rhythms have emerged as important factors in obesity etiology.^[24] Additionally, NES is among the eating behaviors that are more commonly observed in people with obesity.^[25] Awareness techniques have been shown to be beneficial in eating disorder treatment or prevention and weight management.^[26] As shown in Table 3, the inverse relationship between NES scores and mindful eating scores may highlight the importance of incorporating mindful eating-based approaches in NES treatment. In agreement with our findings, Kılıçaslan et al.^[27] have also found a significant negative relationship between the night eating total score and the mindful eating total score in psychiatric patients. This finding supports our findings in terms of observing a similar relationship across different groups.

Waist circumference can serve as a complementary measure to BMI for evaluating disease risk, as it is a marker of visceral adiposity.^[28] Mindful eating is traditionally defined as approaching the act of eating with awareness, being fully present in the moment, and refraining from making judgments about one's own eating habits.^[29] Additionally, it has been demonstrated that mindful eating supports weight loss and weight management and is beneficial for individuals with obesity and individuals with eating behavior disorders.^[30] Lazarevich et al.^[31] found in a study conducted among university students in Mexico with a mean age of 21.95 ± 2.16 years that participants with higher BMI, waist circumference, and body fat percentage showed lower mindful eating compared to those with

Table 3. Relationships between survey results and anthropometric measurements

	Chronotype total score	Night eating total score	Disinhibition	Emotional eating	Eating control	Focus on eating	Eating discipline	Awareness	Interference	Mindful eating total score
Chronotype total score	R= -0.284, p=0.004	R= 0.106, p=0.285	R= 0.066, p=0.506	R= 0.002, p=0.984	R= 0.046, p=0.641	R= 0.153, p=0.123	R= -0.035, p=0.725	R= 0.244, p=0.013	R= 0.134, p=0.177	
Night eating total score	R= -0.284, p=0.004	R= -0.283, p=0.004	R= -0.238, p=0.016	R= -0.182, p=0.066	R= -0.317, p=0.001	R= -0.347, p<0.001	R= -0.111, p=0.266	R= -0.221, p=0.025	R= -0.429, p<0.001	
Body fat percentage	R= -0.121, p=0.225	R= 0.087, p=0.381	R= -0.272, p=0.005	R= 0.002, p=0.985	R= 0.192, p=0.053	R= 0.110, p=0.267	R= 0.008, p=0.939	R= 0.161, p=0.104	R= 0.007, p=0.943	
Fat free mass percentage	R= -0.159, p=0.109	R= 0.115, p=0.246	R= 0.340, p=0.000	R= -0.092, p=0.354	R= -0.093, p=0.348	R= -0.340, p=0.000	R= 0.083, p=0.405	R= -0.019, p=0.850	R= 0.040, p=0.686	
Waist circumference	R= -0.084, p=0.398	R= -0.229, p=0.020	R= -0.191, p=0.054	R= -0.376, p=0.000	R= 0.006, p=0.954	R= 0.192, p=0.052	R= -0.005, p=0.956	R= -0.027, p=0.787	R= -0.199, p=0.044	
Waist to hip ratio	R= 0.038, p=0.704	R= -0.236, p=0.017	R= -0.106, p=0.287	R= -0.345, p=0.000	R= -0.035, p=0.727	R= 0.091, p=0.361	R= 0.008, p=0.936	R= -0.114, p=0.253	R= -0.204, p=0.039	

Table 4. Scale results according to participants' gender, field of study, and presence of diagnosed disease

	Sex		Field of study			Presence of diagnosed disease	
	Female	Male	Health	Other	Yes	No	p
Chronotype							
Total score	48.6±9.9	44.5±8.6	48.6±10.2	46.3±8.92	50.8±9.4	47.2±9.8	0.085
Night eating							
Total score	16.1±5.1	15.6±4.3	16.3±5.6	15.5±3.6	17.7±7.2	15.7±4.3	0.070
Mindful eating							
Disinhibition	3.4±0.76	3.1±0.72	3.4±0.78	3.3±0.71	3.2±0.98	3.3±0.71	0.330
Emotional eating	3.2±0.99	3.8±0.96	3.2±1.1	3.5±0.92	3.0±1.1	3.4±0.98	0.087
Eating control	3.7±0.88	3.3±0.90	3.7±0.91	3.5±0.88	3.6±1.0	3.7±0.88	0.380
Focus on eating	3.3±0.50	3.1±0.46	3.3±0.55	3.2±0.36	3.3±0.63	3.3±0.47	0.399
Eating discipline	3.0±0.87	2.9±0.94	3.2±0.81	2.57±0.85	3.4±0.73	2.9±0.88	0.011
Awareness	3.1±0.35	3.1±0.4	3.1±0.34	3.1±0.39	3.1±0.33	3.1±0.37	0.428
Interference	3.5±0.79	3.4±0.73	3.6±0.78	3.47±0.79	3.7±0.77	3.50±0.78	0.136
Total score	3.3±0.44	3.2±0.37	3.3±0.45	3.2±0.35	3.3±0.56	3.3±0.39	0.487

normal parameters. Similarly, our findings also support the presence of an inverse relationship between mindful eating and waist circumference.

Men appeared to be more evening-focused than women according to the results of a meta-analysis where 164 studies were investigated that include a total of 186,289 people, in which 75,622 of them were men and 110,667 of them were women.^[32] In our study, we also found that male participants acquired lower scores in the MEQ and therefore they are in the evening type category. On the other hand, there are several studies available that did not find a significant correlation between sex and chronotype total score.^[33,34] In a study conducted with a total of 476 public employees and with a higher mean age, whereas our study included a younger population, the reduced Morningness-Eveningness Questionnaire (rMEQ) was administered, and no significant difference was found between males and females in terms of rMEQ scores.^[34] Likewise, in a study conducted on nursing students aged between 18 – 25, no significant relationship was found between sex and chronotype categories.^[33] The differences in the aforementioned demographic characteristics and sample sizes may be a factor to consider when comparing the findings regarding the relationship between sex and chronotype categories.

The population of our study comprised undergraduate students without having an exclusion criteria regarding their field of study. As can be interpreted from Table 1, more than half of the students in our study group were from health-related departments. According to the analysis outcomes, students who are studying in health-related departments are found to have higher eating discipline scores. Yanagihara & Narumi-Hyakutake conducted a study with 801 people and evaluated the general characteristics of participants according to their nutrition knowledge scores. The study comprised 52.9% students from health-related departments and found that they have higher eating knowledge than students from non-health-related departments.^[9] The term nutritional knowledge is described as “an awareness of nutrients and their relevance to health and well-being, as well as the ability to obtain reliable information regarding foods and their appropriate inclusion in a balanced diet.”^[35] The possibility that students from health-related departments have higher nutrition knowledge may explain why a higher eating discipline score was observed in our study among these students.

This study has several limitations. Because students’ food choices can be affected by their living conditions (such as

residing in a dormitory or with family), not inquiring about participants’ living conditions represents a limitation of this study. The exclusion criteria did not contain criteria concerning students’ field of study. Students from the nutrition and dietetics department may have more extensive nutritional knowledge than students from other departments and therefore, their mindful eating levels might be expected to be higher. Since students from health-related departments comprise the majority of our sample, their exclusion might have led to different findings. Another limitation of our study is that the sample consisted predominantly of individuals with normal body weight. Therefore, the null findings should be interpreted with caution, and it should be noted that the results may not be generalizable to populations with a broader range of BMI. Additionally, physical activity levels of the participants and other lifestyle factors (such as alcohol consumption and smoking) were not questioned. Therefore, an interpretation could not be made between these factors and obesity risk among students.

Conclusion

In this study, no significant difference was found between students’ chronotypes and anthropometric measurements. This finding may be attributed to more than half of the study sample falling within the normal BMI category and the relatively small sample size. Therefore, maintaining a large sample size and including participants according to their BMI categories may enable the attainment of more meaningful results. The total mindful eating score was found to be significantly correlated with various variables. Such findings support the view that interventions aimed at increasing mindful eating may serve as a potential tool in the treatment of obesity. Providing education on healthy nutrition may improve the low levels of mindful eating among students who do not study in health-related programs, and consequently, this could reduce their risk of developing diseases. In the future, conducting longitudinal and intervention-based research with different age populations and cultural contexts may demonstrate the correlation between chronotype categories and obesity, and potentially related sub-parameters better. Even though the main hypothesis was not confirmed, this study focuses on promoting healthy eating behaviors among undergraduate students by increasing nutrition knowledge and enhancing mindful eating, with the ultimate goal of preventing obesity which is a significant public health concern today.

Disclosures

Ethics Committee Approval: The study was approved by the Bahçeşehir University Ethics Committee (no: E-85646034-604.02.02-70060, date: 30/11/2023).

Informed Consent: Informed consent was obtained from all participants.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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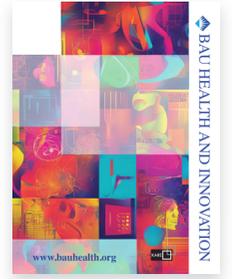
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The Effect of Instrument-Assisted Application on Posture, Quality of Life, and Work Role Functionality in Office Workers

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Abstract

Objectives: To evaluate the effects of instrument-assisted spinal manipulation delivered with the Activator Method on posture, health-related quality of life, and work role functioning in office workers with musculoskeletal complaints related to prolonged sitting.

Methods: Fifty office workers (20–45 years) were randomly allocated to an Activator group (weekly Activator Method spinal manipulations for 6 weeks) or a control group (no intervention). Posture was assessed using the PostureScreen Mobile app. Quality of life and work role functioning were assessed with the SF-12 and Work Role Functioning Questionnaire (WRFQ), respectively, at baseline, week 3, and week 6. Data were analyzed in SPSS v22.0; statistical significance was set at $p < 0.05$.

Results: At week 6, between-group differences favored the Activator group for the SF-12 physical component score, the WRFQ total score and physical demands subscale, and several postural parameters (nominal $p < 0.05$; FDR-adjusted q-values reported for postural outcomes). Within the Activator group, improvements were observed in both SF-12 component scores, all WRFQ subdomains, and most postural parameters. The control group showed small but statistically significant changes in a limited number of work-role and postural outcomes ($p < 0.05$).

Conclusion: Activator-assisted spinal manipulation was associated with improvements in posture, quality of life, and work role functioning in office workers. These findings suggest that instrument-assisted spinal manipulation may contribute to improvements in occupational health settings; however, confirmatory sham-controlled trials are needed.

Keywords: Activator method, office workers, posture, spinal manipulation, work role functioning.

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Modern working life often requires prolonged sitting. Among office workers, extended sedentary and non-ergonomic positions are associated with musculoskeletal complaints and reduced quality of life.^[1] Office workers may spend a large proportion of the workday seated, often in uninterrupted bouts.^[2] Sustained suboptimal posture can increase mechanical stress on musculoskeletal structures and contribute to symptoms such as neck, shoulder, and back discomfort.^[3,4]

Posture is linked to both physical and psychological states.^[5] Poor posture has been associated with reduced workplace performance and adverse psychosocial outcomes.^[6] Therefore, posture-targeted interventions may be relevant for physiotherapy and occupational health.

Spinal manipulation therapy is a commonly used manual therapy approach for musculoskeletal disorders. The Activator Method® Chiropractic Technique (AMCT) is characterized by low-force, high-speed, instrument-

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assisted thrusts and is often considered a safe alternative because dosing is more standardized and less dependent on clinician-applied force.^[7] The Activator Method aims to correct segmental dysfunction, optimize spinal alignment, and enhance proprioceptive stimulation.^[8]

Previous studies suggest that Activator manipulation may positively affect pain, muscle activation, postural stability, and functional capacity across different clinical conditions.^[9,10] However, research in sedentary worker populations that simultaneously evaluates multidimensional outcomes such as quality of life, work role performance, and postural parameters remains limited.

Accordingly, this study investigated the effects of instrument-assisted spinal manipulation on posture, health-related quality of life, and work role functioning in office workers. The aim was to provide evidence that may inform the integration of manual therapy with physiotherapeutic and ergonomic strategies in occupational settings.

Materials and Methods

Ethical Approval

Ethical approval for the study was obtained from a local Institutional Scientific Research and Publication Ethics Committee on October 26, 2022 (Decision No: 2022/6). All procedures were conducted in accordance with the Declaration of Helsinki and relevant ethical standards.

Participants

A total of 50 office workers aged 20–45 years voluntarily participated. Participants were recruited using purposive

sampling based on predefined inclusion and exclusion criteria. Key inclusion criteria were office employment for ≥ 6 months, sedentary desk work ≥ 4 hours/day, no regular exercise in the previous 3 months, no contraindications to spinal manipulation, a forward flexion test angle $< 7^\circ$, and written informed consent. Exclusion criteria were recent surgery (past 6 months), prior cervical/thoracic/lumbar spinal surgery, and current or suspected pregnancy. Participants were randomized (Microsoft Excel sequence) with allocation concealment using sequentially numbered, sealed opaque envelopes; outcome assessments were performed by an independent researcher blinded to allocation.

A total of 50 individuals were enrolled in the study, and all participants completed the intervention and assessments as planned. Thus, the study was completed with 50 participants, as illustrated in Figure 1.

Instruments

Demographic information form

A demographic information form was used to collect participants' basic characteristics, including age, gender, height, weight, and body mass index (BMI), as well as general health status. The form was also used to screen for exclusion criteria, and was completed by the physiotherapist during the initial evaluation.

The work role functioning questionnaire (WRFQ)

The Work Role Functioning Questionnaire (WRFQ 2.0) is a self-administered tool assessing how health problems

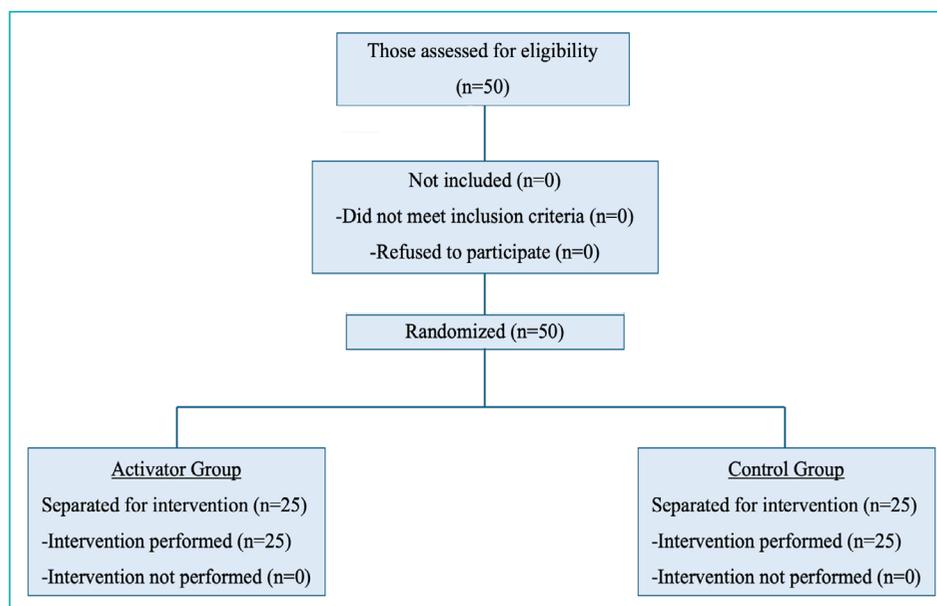


Figure 1. Study protocol.

affect the ability to meet work demands. It includes 27 items across five domains (work scheduling, output, physical, mental and social, and flexibility). Items are rated on a 5-point response scale, with “not applicable” responses excluded from scoring. Subscale and total scores are transformed to a 0–100 scale, with higher scores indicating better work functioning. The WRFQ has demonstrated high internal consistency (Cronbach’s $\alpha > 0.80$) and good construct validity in occupational populations.^[11]

Short form-12 (SF-12)

The Short Form-12 Health Survey (SF-12) was used to evaluate perceived physical and mental health status. The instrument provides two summary scores: the Physical Component Summary (PCS) and the Mental Component Summary (MCS), both scaled from 0 to 100, with higher scores indicating better perceived health status.^[12] Scoring procedures were applied according to the SF-12 scoring guide.^[13]

PostureScreen mobile app

Postural assessment was conducted using the PostureScreen Mobile App (PSM), a validated photogrammetric tool that analyzes head-to-toe posture through standardized anterior, posterior, and lateral photographs. Participants were photographed in standing position from four views (anterior, posterior, right lateral, and left lateral) using a tripod-mounted iPhone camera to ensure consistency in image capture. PSM was used to capture anterior and posterior (coronal plane), as well as left and right lateral (sagittal plane) views. The application digitally calculates postural variables by marking specific anatomical landmarks, with the analysis depending on the number and type of selected variables.^[14]

Activator instrument

The Activator Instrument is a handheld, spring-loaded device designed to deliver a controlled and rapid mechanical thrust to specific vertebral segments. It is used in the Activator Method Chiropractic Technique (AMCT), a low-force spinal manipulative therapy that aims to restore joint mobility, improve alignment, and reduce neuromusculoskeletal pain.^[15]

In this study, spinal manipulation was performed using the Activator Method Basic Scan Protocol, which includes systematic assessment and treatment of spinal segments based on leg length checks, motion palpation, and neurological responses. The method is considered safe and suitable for patients who may not tolerate manual high-velocity, low-amplitude (HVLA) thrusts.

Procedure

After providing informed consent, eligible participants completed a demographic information form and baseline assessments. Participants were allocated to the Activator or control group using a computer-generated random sequence, with concealment ensured by sequentially numbered, sealed opaque envelopes. The Activator group received one session per week of Activator Instrument spinal manipulation for 6 weeks, while the control group received no treatment. Assessments were performed at baseline (Week 0), Week 3, and Week 6 by a researcher blinded to group allocation, using the PostureScreen Mobile app (four views), SF-12, and WRFQ.

AMCT intervention protocol

Each treatment session followed the standardized Activator Method Basic Scan Protocol. Participants were positioned prone on a treatment table. The practitioner first performed a prone leg-length analysis and isolation tests (e.g., prone knee flexion) to identify a functional short leg and laterality. A structured scan was then conducted from the pelvis/sacroiliac region through the spine using segmental palpation and motion assessment, with confirmation using Activator isolation procedures. Target segments were selected only when the scan yielded a positive indicator (e.g., a change in leg-length inequality during isolation or reproduction of segmental tenderness), and could include pelvic/sacroiliac, lumbar, thoracic, and/or cervical segments depending on the individual findings. For each indicated segment, an instrument-assisted impulse was delivered with the Activator device tip placed on the designated bony contact point; the thrust was applied perpendicular to the contact surface with minimal preload in accordance with the manufacturer’s instructions. Typically, one impulse was applied per indicated segment and repeated only if the indicator persisted. Following each adjustment (and at the end of the session), the relevant indicators were re-checked to confirm response and to determine whether additional segments required treatment. No additional manual high-velocity thrust manipulation was performed.

Session frequency (once weekly for 6 weeks) and the sequence of treated regions/segments were standardized by the Basic Scan decision rules, and adherence was monitored by using a session checklist to document the indicated segments and completed steps at each visit.

Sample Size Justification

An a priori sample size calculation was not performed because there were insufficient prior data using a comparable Activator-assisted protocol and the same

primary outcomes to support a reliable effect-size assumption. Therefore, the sample size = 50; n = 25 per group) was determined primarily by feasibility and recruitment capacity within the study period. With n = 25 per group and a two-tailed $\alpha = 0.05$, the study has approximately 80% power to detect standardized between-group differences of about $d \approx 0.79$ (large effect) in primary outcomes.

Post Hoc Power Analysis

In addition, a post hoc power analysis was conducted for exploratory purposes to evaluate the adequacy of the achieved sample size. Power calculations were based on observed effect sizes derived from the study data. Cohen's d values were calculated using the observed between-group t statistics and group sizes (n = 25 per group) according to the standard formula for independent samples ($d = t \times \sqrt{(1/n_1 + 1/n_2)}$). Statistical power was estimated assuming a two-tailed significance level of $\alpha = 0.05$ using G*Power software (version 3.1.9.7; Heinrich Heine University, Düsseldorf, Germany). This analysis was conducted solely to contextualize sample adequacy and was not used to justify statistical significance or to interpret non-significant findings. Accordingly, the study was primarily powered to detect large effects, and smaller between-group effects cannot be ruled out. Using the between-group change-score comparisons for the primary outcomes (n = 25 per group; two-tailed $\alpha = 0.05$), the observed effect sizes (Cohen's d) and corresponding achieved power values were: Physical Change ($d = 0.973$; power = 0.921), Mental Change ($d = 1.153$; power = 0.979), and Work Role Functionality Total Change ($d = 1.613$; power = 1.000). These values are reported to contextualize sample adequacy and were not used to justify statistical significance or interpret non-significant findings.

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 22.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics (frequencies, percentages, means, and standard deviations) were used to summarize the data. Between-group differences in categorical variables were assessed using the chi-square test. Continuous variables were compared between groups using the independent-samples t -test. Within-group changes over time were examined with repeated-measures analysis of variance (ANOVA), followed by Bonferroni-adjusted post hoc comparisons where appropriate.

To address multiplicity, outcomes were interpreted according to a prespecified hierarchy. Physical, mental, and work role functioning outcomes were considered primary,

whereas individual postural parameters were treated as secondary/exploratory. For postural outcomes, multiplicity across the family of between-group change-score tests was controlled using the Benjamini–Hochberg false discovery rate (FDR), with adjusted q -values reported alongside nominal p -values. For between-group comparisons, standardized effect sizes (Hedges g) with 95% confidence intervals were reported to support interpretation beyond statistical significance.

Results

Sex distribution was identical in both groups (52% male, 48% female). There were no significant between-group differences in BMI categories ($\chi^2 = 3.148$, $p = 0.533$), age (31.35 ± 5.29 vs. 34.92 ± 7.55 years, $p = 0.062$), height (174.15 ± 12.10 vs. 169.83 ± 7.68 cm, $p = 0.136$), body weight (77.73 ± 13.37 vs. 75.71 ± 13.33 kg, $p = 0.595$), or BMI (25.60 ± 3.27 vs. 26.18 ± 3.81 kg/m², $p = 0.562$). Overall, these findings indicate that the Activator and control groups were comparable at baseline in terms of demographic and anthropometric characteristics.

For primary outcomes, a significant between-group difference in SF-12 physical component scores was observed at T2, favoring the Activator group ($t(48) = 2.929$, $p = 0.007$), whereas no between-group differences were found at T0 or T1. No significant between-group differences were detected in SF-12 mental component scores at the individual assessment time points (T0, T1, and T2); however, the Activator group demonstrated a significant within-group improvement at T2 compared with T0 and T1, while the control group showed no temporal changes. For total work role functioning, a significant between-group difference was identified at T2 in favor of the Activator group ($t(48) = 2.052$, $p = 0.046$). Within-group changes over time are presented descriptively in Table 1.

Postural outcomes were treated as secondary/exploratory variables. To reduce repetitive reporting across multiple planes and time points, postural results are summarized by overall patterns in the text, while detailed values are provided in Tables 2-5. Overall, the Activator group demonstrated more consistent directional improvements across translations and angulations over time compared with the control group. Accordingly, primary inference was based on between-group change scores together with standardized effect sizes (Hedges g) and FDR-adjusted q -values, while within-group changes are reported descriptively. Between-group change-score analyses favored the Activator group for the functional outcomes (physical, mental, and total work-role functioning), with

Table 1. Comparison of physical, mental, and work role functioning measures of activator and control groups over time

	AG (n=25) mean±SD	CG (n=25) mean±SD	t ^a	p
Quality of life				
Physical				
T0	49.143±6.678	47.834±8.068	0.627	0.534
T1	51.014±5.065	47.655±8.435	1.722	0.100
T2	53.393±5.125	47.700±8.358	2.929	0.007
F ^b	18.691	0.029		
p	0.000	0.905		
Bonferroni	1<2.3; 2<3			
Etakare	0.428			
Mental				
T0	44.631±11.470	45.955±11.448	-0.408	0.685
T1	46.760±9.698	45.622±11.558	0.378	0.707
T2	50.536±7.054	44.851±12.213	2.035	0.054
Bonferroni	1<3; 2<3			
Etakare	0.344			
F ^b	13.100	0.897		
p	0.000	0.400		
Work role functioning				
T0	111.000±12.484	117.917±13.253	-1.900	0.063
T1	116.385±9.996	117.042±13.030	-0.201	0.842
T2	121.923±9.419	115.167±13.631	2.052	0.046
F ^b	20.677	9.264		
p	0.000	0.002		
Bonferroni	1<2.3; 2<3	1>2.3; 2>3		
Etakare	0.453	0.287		

AG: Activator group, CG: Control group, SD: Standard deviation, p<0.05.

large standardized effects (Hedges $g \approx 0.96-1.59$; Table 6). For postural parameters, between-group effects were not uniform across variables; therefore, we emphasize effect-size magnitude/direction and report FDR-adjusted q-values. After FDR correction, 21 of 28 postural change-score comparisons remained significant, whereas a subset (e.g., anterior shoulder translation, posterior hip–pelvis angulation, and selected left-sided knee measures) did not and are interpreted cautiously (Table 6).

Discussion

This study suggests that six weeks of Activator-assisted spinal manipulation was associated with improvements in physical quality of life, work role functioning, and several measures of postural alignment in office workers. Prolonged sitting and static working postures are common in office-based occupations and are frequently associated with self-reported musculoskeletal symptoms. These occupational exposures provide a plausible context in

which interventions targeting spinal function and posture may influence symptoms and work-related outcomes. Consistent with this perspective, observational evidence reports a high prevalence of musculoskeletal complaints among office workers.^[16]

To assess quality of life, the Short Form-12 (SF-12) questionnaire was utilized to evaluate both physical and mental health components.^[13] Several randomized controlled trials have previously demonstrated improvements in SF-12 scores following spinal manipulation or in comparison to conventional treatments for musculoskeletal conditions.^[17,18] In alignment with these findings, our study revealed a statistically significant increase in the SF-12 physical component scores in the Activator-assisted spinal manipulation group at the T2 time point compared to both T0 and T1.

Recent international clinical practice guidelines for low back pain commonly recommend remaining active, therapeutic exercise, and—in selected patients—spinal

Table 2. Changes in anterior and posterior translation measurements over time in activator and control groups

	AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p		AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p
Anterior translations head					Posterior translations head				
T0	0.667±0.530	0.716±0.630	-0.303	0.763	T0	0.690±0.542	0.755±0.639	-0.391	0.697
T1	0.612±0.508	0.686±0.601	-0.471	0.640	T1	0.635±0.512	0.729±0.619	-0.588	0.559
T2	0.570±0.489	0.680±0.585	-0.723	0.473	T2	0.569±0.488	0.724±0.613	-0.993	0.326
F ^b	37.917	3.656			F ^b	27.903	4.426		
p	0.000	0.059			p	0.000	0.043		
Bonferroni	1>2.3; 2>3				Bonferroni	1>2.3; 2>3	1>2		
Etakare	0.603				Etakare	0.527	0.161		
Anterior translations shoulder					Posterior translations shoulder				
T0	0.404±0.543	0.379±0.494	0.170	0.865	T0	0.720±0.543	0.545±0.605	1.080	0.285
T1	0.375±0.521	0.360±0.475	0.109	0.914	T1	0.636±0.512	0.545±0.607	0.571	0.571
T2	0.344±0.482	0.354±0.474	-0.070	0.944	T2	0.593±0.489	0.542±0.604	0.327	0.745
F ^b	13.090	2.131			F ^b	20.744	0.100		
p	0.001	0.156			p	0.000	0.798		
Bonferroni	1>2.3; 2>3				Bonferroni	1>2.3; 2>3			
Etakare	0.344				Etakare	0.453			
Anterior translations hip pelvis					Posterior translations hip pelvis				
T0	1.123±0.901	1.120±1.049	0.011	0.991	T0	0.899±0.887	0.748±0.641	0.683	0.498
T1	1.055±0.863	1.090±1.045	-0.132	0.895	T1	0.827±0.847	0.728±0.629	0.466	0.643
T2	0.988±0.832	1.068±1.041	-0.302	0.764	T2	0.760±0.786	0.715±0.636	0.221	0.826
F ^b	28.568	3.491			F ^b	22.276	4.523		
p	0.000	0.067			p	0.000	0.032		
Bonferroni	1>2.3; 2>3				Bonferroni	1>2.3; 2>3	1>2.3		
Etakare	0.533				Etakare	0.471	0.164		

AG: Activator group, CG: Control group, SD: Standard deviation, p<0.05.

manipulation as part of a multimodal approach. Therefore, the observed within-group improvements in SF-12 scores in the activator-assisted spinal manipulation group are directionally consistent with guideline-supported care pathways, although causal inference is limited by the absence of consistent between-group differences.^[19]

The WRFQ v2.0 has demonstrated consistent factor structure across heterogeneous working samples, supporting its use to quantify health-related work functioning. In line with recommendations in the validation literature, reporting both total and subscale scores may provide more granular insight into which work demands change over time.^[20]

Postural assessment was performed using PostureScreen Mobile, a digital photogrammetric posture assessment tool supported in the literature for posture evaluation using mobile applications. Previous studies suggest that mobile-application-based posture assessments can demonstrate acceptable validity and reliability under standardized

conditions; however, measurement error and marker placement variability may still influence small between-group differences. Thus, non-significant between-group findings should be interpreted cautiously, especially for subtle postural changes.^[21]

In our study, no statistically significant differences were observed between groups in anterior and posterior postural measurements (translations in cm and angulations in degrees). From a clinical perspective, the observed reductions in translations and angulations may reflect modest improvements in multidimensional alignment (e.g., less forward head/shoulder displacement and reduced lateral asymmetry), which could plausibly decrease cumulative mechanical loading, sustained muscle activation, and fatigue during prolonged desk work. In office workers, even small improvements in head-shoulder-pelvic alignment may translate into more comfortable sitting tolerance, fewer movement-compensation strategies, and improved ability to meet

Table 3. Changes in anterior and posterior angulation measurements over time in activator and control groups

	AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p		AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p
Anterior angulations head					Posterior angulations head				
T0	2.435±2.539	1.783±1.993	1.003	0.321	T0	1.477±1.453	1.579±1.672	-0.231	0.818
T1	2.354±2.494	1.767±1.978	0.917	0.364	T1	1.388±1.402	1.567±1.655	-0.412	0.682
T2	2.308±2.467	1.767±1.948	0.856	0.396	T2	1.332±1.351	1.571±1.652	-0.562	0.580
F ^b	25.302	0.346			F ^b	25.052	0.193		
p	0.000	0.631			p	0.000	0.693		
Bonferroni	1>2.3; 2>3				Bonferroni	1>2.3; 2>3			
Etakare	0.503				Etakare	0.501			
Anterior angulations shoulder					Posterior angulations shoulder				
T0	0.777±0.973	1.304±1.344	-1.598	0.117	T0	0.662±1.021	0.925±1.061	-0.894	0.376
T1	0.727±0.926	1.292±1.327	-1.756	0.091	T1	0.623±0.973	0.942±1.064	-1.106	0.274
T2	0.703±0.896	1.288±1.322	-1.844	0.077	T2	0.601±0.953	0.929±1.062	-1.152	0.255
F ^b	13.196	0.555			F ^b	9.002	1.000		
p	0.000	0.533			p	0.003	0.356		
Bonferroni	1>2.3; 2>3				Bonferroni	1>2.3; 2>3			
Etakare	0.345				Etakare	0.265			
Anterior angulations hip pelvis					Posterior angulations hip pelvis				
T0	1.046±1.187	0.729±0.932	1.044	0.301	T0	1.177±1.148	0.550±0.898	2.138	0.038
T1	1.000±1.145	0.696±0.894	1.041	0.303	T1	1.102±1.091	0.508±0.832	2.149	0.037
T2	0.957±1.126	0.721±0.926	0.807	0.424	T2	1.047±1.055	0.483±0.793	2.120	0.039
F ^b	10.574	3.602			F ^b	14.345	4.490		
p	0.001	0.040			p	0.000	0.042		
Bonferroni	1>2.3; 2>3	1>2; 2<3			Bonferroni	1>2.3; 2>3	1>3; 2>3		
Etakare	0.297	0.135			Etakare	0.365	0.163		

AG: Activator group, CG: Control group, SD: Standard deviation, p<0.05.

physical work demands across the workday. Although we did not directly measure pain intensity or objective work performance, the concurrent improvements in work role functioning suggest that postural changes—together with potential symptom modulation—may relate to perceived capacity to perform occupational tasks. However, the minimal clinically important difference for these posture metrics is not well established and measurement error may influence small changes; therefore, the clinical relevance of posture findings should be interpreted as preliminary and hypothesis-generating, ideally confirmed using objective biomechanical or symptom-based outcomes in future trials.

From a mechanistic standpoint, spinal manipulation has been proposed to influence sensorimotor control through neurophysiological pathways, including altered afferent input from paraspinal tissues and subsequent changes in central processing and reflex muscle activity. Such effects could plausibly contribute to improvements

in movement patterns and posture-related measures, even if these changes are modest and not consistently detectable in between-group comparisons.^[22]

In addition, improvements in work role functioning suggest that this intervention may enhance perceived capacity to meet work demands in occupational settings. More broadly, workplace-focused interventions aimed at musculoskeletal health—including strategies that reduce occupational sitting time—have shown potential to improve health and related outcomes, although evidence quality and effect sizes vary across intervention types. In this context, changes in work role functioning observed over time may reflect not only symptom modulation but also improved capacity to meet physical and psychosocial work demands.^[23,24]

Despite the strengths of this randomized study, several limitations should be acknowledged. First, the control group did not receive a sham or active intervention, which limits the ability to fully account for placebo effects,

Table 4. Changes in right and left lateral translation measurements over time in activator and control groups

	AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p		AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p
Lateral translations right head					Lateral translations left head				
T0	3.784±2.437	4.194±2.184	-0.625	0.535	T0	3.211±2.485	4.040±1.588	-1.392	0.164
T1	3.682±2.421	4.172±2.153	-0.754	0.455	T1	3.087±2.441	3.983±1.527	-1.540	0.124
T2	3.585±2.392	4.123±2.122	-0.838	0.406	T2	3.003±2.421	3.926±1.522	-1.598	0.111
F ^b	48.660	4.879			F ^b	38.393	6.708		
p	0.000	0.031			p	0.000	0.012		
Bonferroni	1>2.3; 2>3	1>3; 2>3			Bonferroni	1>2.3; 2>3	1>2.3; 2>3		
Etakare	0.661	0.175			Etakare	0.606	0.226		
Lateral translations right shoulder					Lateral translations left shoulder				
T0	4.326±2.947	5.915±2.729	-1.973	0.054	T0	3.401±2.200	4.464±2.504	-1.597	0.117
T1	4.190±2.934	5.857±2.724	-2.076	0.043	T1	3.245±2.125	4.413±2.516	-1.778	0.082
T2	4.049±2.892	5.831±2.747	-2.230	0.030	T2	3.120±2.065	4.375±2.535	-1.925	0.060
F ^b	39.686	4.643			F ^b	35.637	6.180		
p	0.000	0.037			p	0.000	0.014		
Bonferroni	1>2.3; 2>3	1>2.3			Bonferroni	1>2.3; 2>3	1>2.3; 2>3		
Etakare	0.614	0.168			Etakare	0.588	0.212		
Lateral translations right hip pelvis					Lateral translations left hip pelvis				
T0	2.684±2.838	3.255±2.023	-0.813	0.420	T0	3.536±2.702	3.843±2.111	-0.445	0.659
T1	2.564±2.724	3.210±1.992	-0.951	0.347	T1	3.280±2.368	3.793±2.070	-0.812	0.421
T2	2.476±2.700	3.180±1.985	-1.044	0.302	T2	3.160±2.350	3.763±2.041	-0.965	0.339
F ^b	17.586	4.895			F ^b	7.910	3.843		
p	0.000	0.034			p	0.008	0.055		
Bonferroni	1>2.3; 2>3	1>3; 2>3			Bonferroni	1>2.3; 2>3			
Etakare	0.413	0.175			Etakare	0.240			
Lateral translations right knee					Lateral translations left knee				
T0	2.898±1.647	2.385±1.588	1.119	0.269	T0	2.556±1.941	3.208±1.833	-1.218	0.229
T1	2.775±1.625	2.356±1.568	0.926	0.359	T1	2.456±1.903	3.153±1.835	-1.317	0.194
T2	2.680±1.580	2.328±1.577	0.788	0.435	T2	2.355±1.807	3.133±1.836	-1.510	0.138
F ^b	31.701	5.037			F ^b	9.783	6.418		
p	0.000	0.030			p	0.004	0.013		
Bonferroni	1>2.3; 2>3	1>2.3; 2>3			Bonferroni	1>2.3	1>2.3		
Etakare	0.559	0.180			Etakare	0.281	0.218		

AG: Activator group, CG: Control group, SD: Standard deviation, p<0.05.

expectation bias, and nonspecific treatment effects. Therefore, improvements in the intervention group may partly reflect natural time-related changes and nonspecific effects (e.g., attention/Hawthorne effects) rather than a treatment-specific effect; accordingly, the results should be interpreted cautiously. Although randomization was applied and outcome assessments were performed by a blinded evaluator, the lack of participant and practitioner blinding may have influenced subjective outcomes, particularly quality of life and self-reported work role functioning measures. Second, the inclusion of a relatively

large number of postural outcome variables increases the risk of type I error, even though FDR-based adjustments (Benjamini–Hochberg) were applied for the family of postural comparisons. However, residual false-positive risk cannot be fully eliminated when many correlated outcomes are tested; therefore, postural findings should be considered exploratory and interpreted cautiously, particularly when between-group differences are limited or inconsistent. Third, the reliance on within-group comparisons to describe improvements, while informative, does not provide the same level of causal inference as

Table 5. Changes in right and left lateral angulation measurements over time in activator and control groups

	AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p		AG (n=25) mean±SD	CG(n=25) mean±SD	t ^a	p
Lateral angulations right head					Lateral angulations left head				
T0	10.900±6.108	12.513±6.036	-0.938	0.353	T0	9.523±6.115	12.704±4.727	-2.046	0.046
T1	10.699±6.045	12.467±5.958	-1.040	0.304	T1	9.335±6.035	12.671±4.712	-2.166	0.035
T2	10.492±5.894	12.417±5.871	-1.156	0.254	T2	9.222±6.037	12.621±4.679	-2.211	0.032
F ^b	21.907	1.366			F ^b	25.185	3.190		
p	0.000	0.261			p	0.000	0.068		
Bonferroni	1>2.3; 2>3				Bonferroni	1>2.3; 2>3			
Etakare	0.467				Etakare	0.502			
Lateral angulations right shoulder					Lateral angulations left shoulder				
T0	4.088±2.483	6.192±2.487	-2.990	0.004	T0	3.254±2.246	4.350±2.382	-1.675	0.100
T1	3.923±2.453	6.104±2.515	-3.103	0.003	T1	3.114±2.170	4.313±2.407	-1.852	0.070
T2	3.821±2.451	6.121±2.545	-3.255	0.002	T2	2.917±2.142	4.279±2.403	-2.119	0.039
F ^b	56.985	4.615			F ^b	18.256	2.931		
p	0.000	0.033			p	0.000	0.092		
Bonferroni	1>2.3; 2>3	1>2			Bonferroni	1>2.3; 2>3			
Etakare	0.695	0.167			Etakare	0.422			
Lateral angulations right hip pelvis					Lateral angulations left hip pelvis				
T0	5.196±4.937	6.767±3.817	-1.251	0.217	T0	6.704±4.364	7.817±4.191	-0.918	0.363
T1	4.882±4.611	6.675±3.801	-1.493	0.142	T1	6.377±4.089	7.763±4.111	-1.194	0.238
T2	4.805±4.628	6.663±3.779	-1.546	0.129	T2	6.323±4.142	7.742±4.101	-1.216	0.230
F ^b	6.829	4.711			F ^b	23.336	2.721		
p	0.014	0.028			p	0.000	0.102		
Bonferroni	1>2.3; 2>3	1>2.3			Bonferroni	1>2.3; 2>3			
Etakare	0.215	0.170			Etakare	0.483			
Lateral angulations right knee					Lateral angulations left knee				
T0	4.831±2.938	3.713±2.340	1.481	0.145	T0	4.062±2.942	4.983±2.766	-1.139	0.260
T1	4.650±2.868	3.638±2.333	1.363	0.179	T1	3.919±2.790	4.888±2.774	-1.230	0.225
T2	4.505±2.877	3.638±2.316	1.168	0.248	T2	3.846±2.801	4.888±2.761	-1.323	0.192
F ^b	33.131	2.836			F ^b	11.224	4.488		
p	0.000	0.094			p	0.001	0.037		
Bonferroni	1>2.3; 2>3				Bonferroni	1>2.3; 2>3	1>2		
Etakare	0.570				Etakare	0.310	0.163		

AG: Activator group, CG: Control group, SD: Standard deviation, p<0.05.

consistent between-group effects. Finally, the relatively short intervention duration and absence of long-term follow-up restrict conclusions regarding the sustainability of the observed improvements. Follow-up was limited to the immediate post-intervention assessment at Week 6, with no subsequent follow-up; therefore, the durability of effects beyond the intervention period remains unknown. Future studies should incorporate sham-controlled or active comparator designs, reduce the number of postural outcome measures to those of greatest clinical relevance, and include longer follow-up periods to better clarify the

specific and lasting effects of instrument-assisted spinal manipulation. Because the sample size was feasibility-based and no a priori power analysis was performed, the study may be underpowered for small-to-moderate effects; therefore, non-significant findings should be interpreted cautiously. In addition, the modest sample size and the specific study population (office workers aged 20–45 years) may limit the generalizability of the findings to other occupational settings, age groups, or individuals with different baseline symptom profiles. Although participants spanned a broad age range (20–45

Table 6. Comparison of change scores of physical, mental, work role functioning, and postural parameters in activator and control groups

Groups	AG (n=25) mean±SD	CG (n=25) mean±SD	t	p	Hedges g [95% CI]	q (BH-FDR, postural)
Physical Change	4.250±4.153	-0.134±4.833	3.448	0.001	0.96 [0.38, 1.54]	
Mental Change	5.905±7.025	-1.104±4.958	4.045	0.000	1.13 [0.54, 1.73]	
Work Role Functionality Total Change	10.923±11.377	-2.750±3.768	5.607	0.000	1.59 [0.96, 2.22]	
Anterior Translations Head Change	-0.097±0.074	-0.037±0.095	-2.513	0.015	-0.69 [-1.26, -0.13]	0.023
Anterior Translations Shoulder Change	-0.060±0.081	-0.025±0.084	-1.483	0.145	-0.42 [-0.97, 0.13]	0.150
Anterior Translations Hip Pelvis Change	-0.135±0.117	-0.052±0.130	-2.380	0.021	-0.67 [-1.23, -0.11]	0.031
Anterior Angulations Head Change	-0.127±0.122	-0.017±0.146	-2.902	0.006	-0.80 [-1.36, -0.23]	0.011
Anterior Angulations Shoulder Change	-0.074±0.097	-0.017±0.101	-2.063	0.045	-0.57 [-1.12, -0.01]	0.057
Anterior Angulations Hip Pelvis Change	-0.089±0.122	-0.008±0.072	-2.812	0.006	-0.80 [-1.36, -0.23]	0.011
Posterior Translations Head Change	-0.121±0.106	-0.032±0.077	-3.391	0.001	-0.91 [-1.48, -0.33]	0.002
Posterior Translations Shoulder Change	-0.127±0.128	-0.003±0.051	-4.451	0.000	-1.23 [-1.81, -0.63]	0.001
Posterior Translations Hip Pelvis Change	-0.139±0.135	-0.033±0.070	-3.417	0.001	-0.94 [-1.51, -0.36]	0.002
Posterior Angulations Head Change	-0.145±0.133	-0.008±0.125	-3.748	0.000	-1.05 [-1.63, -0.46]	0.001
Posterior Angulations Shoulder Change	-0.061±0.098	0.004±0.075	-2.613	0.012	-0.72 [-1.29, -0.15]	0.020
Posterior Angulations Hip Pelvis Change	-0.130±0.169	-0.067±0.149	-1.406	0.166	-0.39 [-0.94, 0.16]	0.166
Lateral Translations Right Head Change	-0.199±0.123	-0.072±0.156	-3.206	0.002	-0.91 [-1.48, -0.33]	0.004
Lateral Translations Right Shoulder Change	-0.277±0.183	-0.083±0.186	-3.712	0.001	-1.04 [-1.62, -0.45]	0.002
Lateral Translations Right Hip Pelvis Change	-0.209±0.236	-0.075±0.161	-2.320	0.025	-0.63 [-1.19, -0.07]	0.034
Lateral Translations Right Knee Change	-0.218±0.172	-0.057±0.121	-3.795	0.000	-1.11 [-1.70, -0.52]	0.001
Lateral Angulations Right Head Change	-0.408±0.394	-0.096±0.368	-2.887	0.006	-0.78 [-1.34, -0.21]	0.011
Lateral Angulations Right Shoulder Change	-0.268±0.146	-0.071±0.190	-4.131	0.000	-1.15 [-1.74, -0.56]	0.001
Lateral Angulations Right Hip Pelvis Change	-0.391±0.690	-0.104±0.233	-1.935	0.059	-0.55 [-1.11, 0.01]	0.072
Lateral Angulations Right Knee Change	-0.326±0.237	-0.075±0.233	-3.771	0.000	-1.10 [-1.69, -0.51]	0.001
Lateral Translations Left Head Change	-0.208±0.155	-0.114±0.205	-1.846	0.071	-0.51 [-1.06, 0.05]	0.080
Lateral Translations Left Shoulder Change	-0.281±0.226	-0.089±0.165	-3.411	0.001	-0.97 [-1.54, -0.39]	0.002
Lateral Translations Left Hip Pelvis Change	-0.376±0.606	-0.080±0.193	-2.287	0.027	-0.66 [-1.22, -0.10]	0.036
Lateral Translations Left Knee Change	-0.201±0.299	-0.075±0.142	-1.886	0.065	-0.53 [-1.09, 0.03]	0.076
Lateral Angulations Left Head Change	-0.301±0.260	-0.083±0.204	-3.274	0.002	-0.92 [-1.49, -0.34]	0.005
Lateral Angulations Left Shoulder Change	-0.337±0.376	-0.071±0.192	-3.109	0.003	-0.88 [-1.45, -0.30]	0.006
Lateral Angulations Left Hip Pelvis Change	-0.381±0.346	-0.075±0.207	-3.749	0.000	-1.06 [-1.64, -0.47]	0.002
Lateral Angulations Left Knee Change	-0.215±0.295	-0.096±0.240	-1.563	0.125	-0.44 [-0.99, 0.12]	0.135

AG: Activator group, CG: Control group, SD: Standard deviation, CI: Confidence interval, p<0.05.

years), we did not perform prespecified age-adjusted or age-stratified analyses; thus, residual age-related heterogeneity may have influenced change scores, and future studies with larger samples should evaluate age as a potential covariate or effect modifier.

Conclusion

This study indicates that spinal manipulation delivered with the Activator Method was associated with improvements in posture, physical quality of life, and work role functioning in office workers who sit for prolonged periods. The results suggest that Activator

Method-assisted care may be considered a potentially useful, non-invasive adjunct for addressing postural and musculoskeletal problems associated with sedentary work; however, these findings should be interpreted cautiously given the study limitations.

Disclosures

Ethics Committee Approval: The study was approved by the Gümüşhane University Scientific Research and Publication Ethics Committee (no: 2022/6, date: 26/10/2022).

Informed Consent: Informed consent was obtained from all participants.

Conflict of Interest Statement: The authors have no conflicts of interest to declare.

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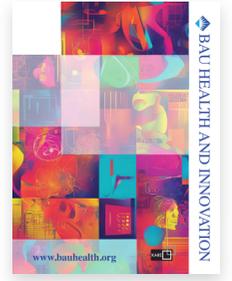
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Impact of Prebiotic and Probiotic Knowledge and Consumption on Oral Health in Adults Attending Dental Clinics

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Abstract

Objectives: Studies on specific probiotics and oral health are insufficient, and studies on prebiotics are very few in the literature. Therefore, this study investigated whether there is a relationship between prebiotic and probiotic food consumption and oral health.

Methods: The study was conducted with 151 adult individuals. Data on sociodemographic characteristics, prebiotic and probiotic knowledge and consumption frequency were obtained through an online questionnaire. Dental health levels of the individuals were determined by calculating the DMFT (Decayed, Missing, Filled Tooth) index after a dental examination. The data obtained were statistically analyzed using SPSS package program version 29.0.2.0.

Results: Most of the participants mentioned that they were familiar with the concept of probiotics, while they had heard of the concept of prebiotics before but did not know it completely. When the frequency of probiotic food consumption and oral health of the participants were analyzed, it was observed that individuals with a higher frequency of yogurt, buttermilk, pickles and olives consumption had better oral and dental health markers and this difference was statistically significant ($p < 0.05$). When the same situation was analyzed for prebiotic foods, it was observed that individuals with higher consumption frequency of whole grains, oats, onions and garlic, tomatoes, bananas, honey, cruciferous vegetables (cauliflower, broccoli, etc.), legumes, asparagus, soybeans, oil seeds (nuts) and red fruits (blackberries, rose hips, etc.) had better oral and dental health markers and this difference was statistically significant ($p < 0.05$).

Conclusion: Especially the level of knowledge about the prebiotic concept was found to be insufficient. Consumption of probiotic and prebiotic foods was significantly associated with improved oral health indicators in this population.

Keywords: Oral health, nutrition, prebiotic, probiotic.

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Oral health consists of the mouth, teeth and orofacial structures that enable individuals to perform basic functions such as eating, breathing and speaking, and encompasses psychosocial conditions such as self-confidence, well-being and the ability to socialize and work without pain, discomfort and embarrassment. Oral health varies throughout life, from early life to old age, and is an inseparable part of overall health. It supports

individuals to participate in society and realize their potential.^[1] Diet and nutrition have important impacts on oral health. It can influence the development and progression of oral diseases and conditions such as dental caries, periodontal disease, erosion and others. The relationship between diet and nutrition and oral health is bidirectional, as impaired integrity of the oral cavity can also affect an individual's ability to eat.^[2]

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Probiotics are defined as live microorganisms that, when administered in sufficient quantities, provide health benefits to the host. A prebiotic is defined as a selectively fermented compound that induces specific changes in the composition and/or activity of the gastrointestinal microbiota and provides host health benefits.^[3] Usually, probiotics have been associated with gut health and mostly focused on the prevention or treatment of gastrointestinal infections and diseases; however, in the last decade, some authors have suggested that probiotic bacteria originally intended for gut health may also be beneficial for oral health.^[4] Although there are no controlled studies investigating the effect of prebiotics in oral health, it is thought that prebiotics may also be effective in oral health due to the known health effects of prebiotics.^[5]

Studies have shown that individuals who have adopted healthy living strategies to their lives and have a higher level of education are more familiar with the concepts of probiotics, prebiotics and microbiota and have a higher level of knowledge about these issues. Therefore, it is thought that it is important for health professionals to use these terms more and for them to become commonly used expressions in society in order to improve public health.^[6,7]

Objective of the Study

According to all this information, when the literature was examined, the knowledge levels of probiotic and prebiotic concepts were supported by studies on a regional basis. The number of studies on oral and dental health with probiotic consumption is small and mostly conducted on children. There is no controlled study on the effect of prebiotics on oral health and the information available is limited. Therefore, this study is a cross-sectional study designed to measure the level of probiotic and prebiotic knowledge in a specific region, to contribute to the interpretation of the level of knowledge on the subject in more global environments, and to establish a relationship between probiotic and prebiotic consumption frequencies and oral and dental health of adults.

Materials and Methods

Study Procedures

This study was conducted in Sakarya Private Ofis Dent Oral and Dental Health Clinic between August and December 2023. The research population consists of individuals who are residents of Sakarya and attend Private Ofis Dent Oral and Dental Health Clinic, who meet the inclusion criteria and volunteer. Ethics committee approval was obtained from Istanbul Bahçeşehir University, Scientific Research

and Publication Ethics Committee on 18.10.2023, meeting numbered 2023/08. Individuals who were adults over the age of 18, who did not have a chronic disease that would affect oral and dental health (uncontrolled diabetes and uncontrolled hypertension), who were not in the gestation or lactation period, and who did not use all prostheses were included in the study. The sample size of the study was calculated using the power analysis program G*Power 3.1.9.7.^[8] Sample size calculations showed that at least 124 individuals should be included with a 95% confidence level ($\alpha=0.05$) and 80% power in line with a similar study and are presented in the appendix.^[9] Considering possible losses during the study, the sample size was targeted as 150. The sample of the study consisted of 151 volunteer participants in total and the required number was achieved. This study was conducted in accordance with the Helsinki Declaration.

Collection of Data

Questionnaire form

The questionnaire consists of 25 questions and 3 sections and is presented in the appendix. The questionnaire form was created via Google Surveys, and the participants were asked to fill it in online. In the first part of the questionnaire form, demographic characteristics of the individuals (gender, age, educational status, etc.), in the second part, their level of knowledge about microbiota, probiotic and prebiotic concepts, and in the third part, the frequency of consumption of probiotic and prebiotic foods was asked. Some questions were designed and specified so that more than one answer could be given. The questionnaire form consisted of open-ended and multiple-choice questions. It takes an average of 10 minutes to complete a questionnaire form.

Calculation of the DMFT index

The DMFT (Number of Decayed, Filled and Missing Permanent Teeth) index will be used to assess the oral health of individuals in the study. This index measures the number of caries in a population and therefore provides data on oral health. The DMFT index is an index for assessing oral health recommended by the World Health Organization (WHO). The letters in the index are the initials of some abbreviations. DT represents the number of decayed teeth, MT the number of missing teeth and FT the number of filled teeth. The index is expressed as the sum of the number of decayed, missing and filled teeth. This sum can be divided by the number of people participating in the study and used as a parameter in epidemiologic studies.^[10,11] The DMFT index

was calculated by Yasin Burak SÜTLÜ, a dentist working in Sakarya Private Ofis Dent Oral and Dental Health Clinic. Ofis Dent Oral and Dental Health Clinic is a private health institution in Sakarya province where dental treatments are provided. No invasive intervention was performed to calculate this index; the index was calculated by dental examination alone. In this context, approval was obtained from this clinic for the dental examinations of the people included in the study by accepting the informed consent form and is presented in the appendix.

Analysis of Data

SPSS (Statistical Package for Social Sciences) version 29.0.2.0 (Armonk, NY: IBM Corp.) was used for statistical analysis of the data collected for the study. The level of significance in the study was accepted at $\alpha=0.05$. Descriptive statistical calculations (arithmetic mean, frequency, minimum, and maximum) were used to evaluate the study data. When comparing quantitative data, continuous data were first subjected to a normality test. As a result of the normality test, it was seen that the continuous data were not normally distributed. Therefore, nonparametric tests were used when comparing the data. While the Mann-Whitney U test was used when comparing two groups, the Kruskal-Wallis test was used when comparing three or more groups.

Results

A total of 151 adults, 52 males (34.4%) and 99 females (65.6%), voluntarily participated in the study. Adults between the ages of 18–50 years, with an average age of 29 ± 7.96 years, who applied to oral and dental health care participated in the study, and most of the participants were between the ages of 26–35 years. It was observed that most of the participants were undergraduate graduates (41.1%). This was followed by associates' and high school graduates, respectively. 54.3% of the participants were single (82 individuals), 42.4% were married (64 individuals) and 3.3% (5 individuals) were divorced.

39.7% (60 individuals) of the participants mentioned that they did not know the concept of microbiota, 34.4% (52 individuals) mentioned that they had heard it before but did not know exactly what it was and 25.8% (39 individuals) mentioned that they knew it. 60.9% (92 individuals) of the participants mentioned that they knew the concept of probiotics, 28.5% (43 individuals) had heard of it but did not know exactly what it was and 10.6% (16 individuals) did not know the concept of probiotics. When the participants were asked whether some probiotic foods are probiotic, 87.4% (132 individuals) mentioned that kefir is probiotic,

86.1% (130 individuals) mentioned that yogurt is probiotic, and 68.2% (103 individuals) mentioned that probiotic yogurt is probiotic. According to the answers of the participants, the least probiotic foods were determined as pickled olives, turnip juice and boza, respectively.

35.8% (54 individuals) of the participants mentioned that they knew the concept of prebiotics, 39.7% (60 individuals) mentioned that they had heard of it but did not know exactly what it was and 37% (37 individuals) did not know the concept of prebiotics. When the participants were asked whether some prebiotic foods are prebiotic foods, 55.3% (83 individuals) mentioned that oats, breakfast cereals are prebiotic, 54.7% (82 individuals) mentioned that whole grain, mixed grain breads are prebiotic, 34.7% (52 individuals) mentioned that onions, garlic are prebiotic foods and 34.7% (52 individuals) mentioned that red fruits are prebiotic foods. The least prebiotic foods were tomatoes, grape seeds and honey, in order.

The frequency of food consumption among individuals was examined in seven categories in the Table 1 and 2, but the two categories with the highest level of significance among these food consumption frequencies were compared.

The mean DT value of the individuals who consumed yogurt every day was 2.23, while the mean DT value of the individuals who consumed yogurt once a week was 5.34, and this difference was statistically significant ($p < 0.05$). The mean DMFT index of the participants who consumed yogurt once a week was 7.51, while the mean DMFT index of the individuals who consumed yogurt every day was 4.06 and this difference was statistically significant ($p < 0.05$). The mean DMFT index of the participants who consumed ayran 1–3 times a month was 8.03, while the mean DMFT index of the participants who consumed ayran 4–5 times a week was 3.79 and a statistically significant difference was found ($p < 0.05$). The mean DMFT index of the non-working individuals who consumed pickles less than once a month was 7.83, while the mean DMFT index of those who consumed pickles 4–5 times a week was 2.90 and this difference was found to be statistically significant ($p < 0.05$). Among the individuals who participated in the study, the mean DT values of those who consumed pickled olives once a week were 5.42, while those who consumed them every day were 2.53 and this difference was statistically significant ($p < 0.05$). The mean MT value of those who consumed brined olives less than once a month was calculated as 1.78, while that of those who consumed them every day was calculated as 0.25 and the difference was statistically significant ($p < 0.05$). The mean DMFT index of those who never consumed pickled

Table 1. Comparison of frequency of consumption of probiotic foods and DMFT indices of participants

Frequency of probiotic consumption	DT (Decayed tooth)			MT (Missing tooth)			FT (Filling tooth)			DMFT		
	Mean	p	Min-Max	Mean	p	Min-Max	Mean	p	Min-Max	Mean	p	Min-Max
Yogurt												
Once a week	5.34	0.002	0.00–13.00	0.23	0.124	0.00–2.00	1.94	0.570	0.00–5.00	7.51	0.013	2.00–16.00
Every day	2.23		0.00–10.00	0.35		0.00–5.00	1.48		0.00–6.00	4.06		0.00–17.00
Kefir												
Never	4.56	0.052	0.00–12.00	0.47	0.120	0.00–5.00	2.14	0.929	0.00–10.00	7.17	0.192	0.00–20.00
Every day	0.00		0.00–0.00	0.00		0.00–0.00	2.00		2.00–2.00	2.00		2.00–2.00
Ayran												
1–3 times a month	5.06	0.075	0.00–11.00	0.94	0.150	0.00–5.00	2.03	0.153	0.00–10.00	8.03	0.045	2.00–20.00
4–5 times a week	2.36		0.00–7.00	0.14		0.00–1.00	1.29		0.00–4.00	3.79		2.00–8.00
Boza												
Never	4.19	0.275	0.00–13.00	0.51	0.066	0.00–5.00	2.15	0.655	0.00–14.00	6.86	0.505	0.00–20.00
2–3 times a week	8.00		8.00–8.00	1.00		1.00–1.00	1.00		1.00–1.00	10.00		10.00–10.00
Tarhana												
Never	5.25	0.430	0.00–12.00	0.94	0.470	0.00–5.00	2.56	0.175	0.00–6.00	8.75	0.220	0.00–17.00
Every day	3.00		1.00–5.00	0.00		0.00–0.00	2.00		0.00–4.00	5.00		1.00–9.00
Pickle												
Less than 1 per month	4.83	0.084	0.00–12.00	0.57	0.638	0.00–5.00	2.43	0.182	0.00–10.00	7.83	0.049	0.00–20.00
4–5 times a week	1.70		0.00–7.00	0.10		0.00–1.00	1.10		0.00–3.00	2.90		0.00–8.00
Turnip juice												
Never	3.86	0.635	0.00–12.00	0.57	0.363	0.00–5.00	2.30	0.841	0.00–14.00	6.72	0.495	0.00–20.00
2–3 times a week	7.00		2.00–10.00	0.00		0.00–0.00	2.00		1.00–3.00	9.00		3.00–12.00
Pickled olives												
Never	4.86			0.48			2.90	0.382	0.00–10.00	8.24*	0.038	1.00–20.00
Less than 1 per month	5.33			1.78*	0.029	0.00–5.00	1.67			8.78		
Once a week	5.42*	0.032	0.00–13.00	0.25			1.62			7.29		
Every day	2.53*		0.00–10.00	0.25*		0.00–3.00	1.75		0.00–6.00	4.53*		0.00–16.00
Probiotic yogurt												
Never	4.34	0.314	0.00–13.00	0.55	0.624	0.00–5.00	2.07	0.720	0.00–14.00	6.96	0.095	0.00–20.00
Once a week	3.19		0.00–9.00	0.13		0.00–1.00	2.31		0.00–4.00	5.63		0.00–15.00
Probiotic milk												
Never	4.13	0.123	0.00–12.00	0.52	0.476	0.00–5.00	2.28	0.720	0.00–15.00	6.93	0.095	0.00–20.00
Once a week	2.64		0.00–8.00	0.09		0.00–1.00	2.18		0.00–4.00	4.91		0.00–13.00
Probiotic kefir												
Never	4.07	0.348	0.00–12.00	0.44	0.170	0.00–5.00	2.23	0.843	0.00–15.00	6.74	0.224	0.00–20.00
4–5 times a week	4.00		0.00–7.00	1.67		0.00–5.00	2.00		0.00–3.00	7.67		0.00–13.00

*: The mean values in each marked column indicate which two parameters were compared. Kruskal Wallis Test. DMFT: Number of Decayed, Filled and Missing Permanent Teeth, Mean: Average of the numbers, Min-max: Minimum and maximum values.

olives was 8.24, while the mean DMFT index of those who consumed them every day was 4.53 and this difference was statistically significant ($p < 0.05$).

The mean DMFT values of the participants who never consumed whole grain, mixed grain bread were 9.30, while the mean DMFT values of those who consumed it every day were 4.48, and this difference was statistically significant

($p < 0.05$). The mean DMFT values of the individuals who never consumed oat cereals were 8.04, while the mean DMFT values of those who consumed oat cereals every day were 2.50, and this difference was statistically significant ($p < 0.05$). The mean DMFT values of the participants who consumed onion and garlic less than once a month were 11.13, while the mean DMFT values of those who

Table 2. Comparison of prebiotic food consumption frequency and DMFT indices of participants

Frequency of prebiotic consumption	DT (Decayed tooth)			MT (Missing tooth)			FT (Filling tooth)			DMFT		
	Mean	p	Min-Max	Mean	p	Min-Max	Mean	p	Min-Max	Mean	p	Min-Max
Whole grain												
Never	5.79	0.001	0.00–13.00	0.88	0.007	0.00–5.00	2.64	0.569	0.00–10.00	9.30	0.003	2.00–20.00
Every day	2.36		0.00–9.00	0.20		0.00–3.00	1.92		0.00–15.00	4.48		0.00–15.00
Oats												
Never	5.06	0.037	0.00–13.00	0.74	0.096	0.00–5.00	2.24	0.662	0.00–14.00	8.04	0.004	0.00–20.00
Every day	1.00		0.00–3.00	0.00		0.00–0.00	1.50		0.00–6.00	2.50		2.00–3.00
Onion, garlic												
Less than 1 per month	6.94	0.001	2.00–11.00	1.00	0.004	0.00–5.00	3.19	0.075	0.00–10.00	11.13	0.001	2.00–20.00
Every day	2.00		0.00–7.00	0.16		0.00–3.00	1.77		0.00–15.00	3.94		0.00–15.00
Tomato												
1–3 times a month	6.05	0.001	1.00–13.00	0.76	0.073	0.00–5.00	2.62	0.268	0.00–10.00	9.43	0.001	3.00–20.00
Every day	2.43		0.00–7.00	0.27		0.00–3.00	1.78		0.00–15.00	4.49		0.00–15.00
Jerusalem artichoke												
Never	4.11	0.383	0.00–13.00	0.51	0.328	0.00–5.00	2.03	0.132	0.00–10.00	6.64	0.258	0.00–20.00
2–3 times a week	2.13		0.00–5.00	1.25		0.00–5.00	1.75		0.00–4.00	5.13		0.00–13.00
Banana												
Never	6.80			1.80*	0.020	0.00–5.00	2.80	0.203	0.00–6.00	11.40		
Less than 1 per month	7.00*	0.001	2.00–13.00	0.80			2.96			10.76*	0.001	0.00–17.00
2–3 times a week	2.69			0.14*		0.00–2.00	1.86		0.00–4.00	4.69		
4–5 times a week	0.89*		0.00–3.00	0.00			2.67			3.56		
Every day	1.89			0.56			0.89			3.33*		0.00–13.00
Honey												
Less than 1 per month	5.61	0.021	1.00–13.00	0.42		0.00–3.00	2.74		0.00–14.00	8.77	0.026	2.00–18.00
4–5 times a week	2.43		0.00–9.00	0.07		0.00–1.00	1.93		0.00–15.00	4.43		0.00–15.00
Cruciferous vegetables												
Less than 1 per month	5.79*	0.001	0.00–13.00	0.69	0.157	0.00–5.00	2.36	0.039		8.85*	0.004	2.00–18.00
1–3 times a month	3.74			0.54			3.03*		0.00–15.00	7.31		
Once a week	3.07			0.29			1.29*		0.00–4.00	4.64		
2–3 times a week	2.11*		0.00–7.00	0.32		0.00–5.00	1.89			4.32*		0.00–13.00
Legumes												
Less than 1 per month	6.81*	<0.001	1.00–13.00	0.70	0.168	0.00–5.00	2.37	0.195	0.00–14.00	9.89*	0.002	2.00–20.00
2–3 times a week	2.45*		0.00–9.00	0.26		0.00–3.00	1.65		0.00–4.00	4.35		
Every day	1.20			0.00			0.40			1.60*		0.00–3.00
Asparagus												
Less than 1 per month	5.81*	0.043	0.00–13.00	0.48	0.319	0.00–5.00	3.19	0.334	0.00–15.00	9.48*	0.022	1.00–20.00
1–3 times a month	2.42			0.08			1.58			4.08*		0.00–10.00
2–3 times a week	0.67*		0.00–2.00	1.00		0.00–3.00	2.67		1.00–4.00	4.33		
Soybeans												
Less than 1 per month	5.42	0.126	0.00–13.00	1.05	0.370	0.00–5.00	2.42	0.567	0.00–15.00	8.89	0.043	3.00–18.00
Once a week	1.50		1.00–2.00	0.00		0.00–0.00	.50		0.00–1.00	2.00		2.00–2.00
Nuts												
Never	7.40	0.003	1.00–13.00	1.20	0.020	0.00–5.00	2.90	0.567	0.00–6.00	11.50	0.001	2.00–18.00
Every day	1.67		0.00–6.00	0.00		0.00–0.00	1.53		0.00–4.00	3.20		1.00–8.00
Red berries												
Less than 1 per month	5.60	0.004	0.00–13.00	1.00	0.019	0.00–5.00	2.68	0.524	0.00–14.00	9.28	0.001	0.00–20.00
2–3 times a week	2.44		0.00–8.00	0.12		0.00–1.00	1.64		0.00–4.00	4.20		0.00–10.00

*: The mean values in each marked column indicate which two parameters were compared. DMFT: Number of Decayed, Filled and Missing Permanent Teeth, Kruskal Wallis Test. Mean: Average of the numbers, Min-Max: Minimum and maximum values.

consumed onion and garlic every day were 3.94, and this difference was statistically significant ($p < 0.05$). The mean DMFT values of the individuals who consumed tomatoes 1–3 times a month were 9.43, while the mean DMFT values of those who consumed tomatoes every day were 4.49 and this difference was statistically significant ($p < 0.05$). The mean DMFT values of the individuals who consumed less than 1 banana per month were 10.76, while the mean DMFT values of those who consumed less than 1 banana per month were 3.33, and this difference was found to be statistically significant ($p < 0.05$). Among the participants, the mean DMFT values of those who consumed honey less than once a month were 8.77, while the mean DMFT values of those who consumed it 4–5 times a week were 4.43, and this difference was found to be statistically significant ($p < 0.05$). Among the participants, the mean DMFT values of those who consumed cruciferous vegetables less than once a month was 8.85, while the mean DMFT values of those who consumed them 2–3 times a week was 4.32, and this difference was found to be statistically significant ($p < 0.05$). The mean DMFT values of the participants who consumed dried legumes less than once a month were 9.89, while the mean DMFT values of those who consumed them every day were 1.60 and this difference was found to be statistically significant ($p < 0.05$). The mean DMFT values of the participants who consumed asparagus less than once a month was 9.48, while the mean DMFT values of those who consumed asparagus 1–3 times a month was 4.08 and this difference was found to be statistically significant ($p < 0.05$). Among the individuals who participated in the study, the mean DMFT index of those who consumed soybeans less than once a month was 8.89, while the mean DMFT index of those who consumed soybeans once a week was 2.00 and this difference was statistically significant ($p < 0.05$). The mean DMFT values of the participants who never consumed oilseeds were 11.50, while the mean DMFT values of those who consumed them every day were 3.20 and this difference was statistically significant ($p < 0.05$). The mean DMFT values of the participants who consumed less than 1 red fruit per month were 9.28, while the mean DMFT values of those who consumed 2–3 times a week was 4.20 and this difference was found to be statistically significant ($p < 0.05$).

Discussion

99 female and 52 male adults participated in our study. The number of dental caries and the number of filled teeth were significantly higher in men than in women. The DMFT index, which provides information about general oral and dental health, was higher in men than in women, thus women had a higher oral and dental health score and

this result is significant. According to the Türkiye-wide oral and dental health profile research report initiated by the Ministry of Health of the Republic of Türkiye in 2018 and published in 2021, among adults aged 35–44 years, the DMFT scores of women were found to be higher than the DMFT scores of men, that is, the oral and dental health parameters of adult women were found to be worse than men.^[12] As a result, it is supported by the literature that gender is a factor on oral and dental health.

In our study, the frequency of probiotic food consumption and DMFT and sub-indices were examined and compared. Individuals who consumed yogurt more frequently had a lower number of dental caries and DMFT index. Those who consumed buttermilk and pickles more frequently had a lower DMFT index. Those who consumed pickled olives more frequently had a lower number of dental caries, number of missing teeth and DMFT index. All of these differences were significant. Apart from that, no significant difference was observed between the frequency of consumption of kefir, boza, tarhana, turnip juice, probiotic yogurt, probiotic milk and probiotic kefir among probiotic foods and DMFT and subgroup indices. In a study by Kantorowicz et al.^[13] food consumption frequencies of 20 women and 20 men aged 19–21 years were taken and DMFT indices were analyzed. Women and men were divided into two different groups and evaluated. While no significant difference was found between the frequency of milk and dairy consumption and DMFT indices in women, the DMFT index of individuals who consumed less than 3 milk and dairy products per week in men was found to be lower than those who consumed almost every day. A study of 6885 children aged 2–17 years showed that high yogurt and low cheese intake was associated with a reduced risk of dental caries in American children and adolescents.^[14] In another study, 405 female participants aged 13–18 years were included in the study. The results showed that high yogurt consumption may reduce plaque formation in adolescents. However, milk and cheese consumption had no significant effect on dental caries.^[15] Another study showed that *L. plantarum* K41 isolated from traditional Sichuan pickles had an inhibitory effect on the biofilm formation of *S. mutans*. Thus, it offers a potential alternative for the control of oral biofilm/dental plaque and dental caries.^[16] Studies on probiotic products such as tarhana, boza, turnip juice were not found in the literature, but in conclusion, the importance of probiotics for oral health is supported by the studies in the literature in parallel with the results of our study.

In our study, the frequency of consumption of foods known as prebiotics was compared with oral and dental health parameters, and those who consumed more whole

grains, oats, onions and garlic, tomatoes, bananas, honey, cruciferous vegetables (cauliflower, broccoli, etc.), legumes, asparagus, soybeans, oil seeds (nuts) and red fruits (blackberries, rose hips, etc.) had better oral and dental health findings. In a study conducted in China, in parallel with our research, increasing the frequency of whole grain consumption may reduce the risk of dental caries in adolescents.^[17] Another study conducted on 204 adults aged 18–64 years showed that the increase in DMFT index decreased as cereal consumption increased, thus showing that it is a protective factor in increasing the DMFT index.^[18] In a meta-analysis, it was stated that studies showed that the level of *S. mutans*, known as the caries agent, in saliva decreased with the consumption of garlic extract, but it was said that more studies should be done to support this situation.^[19] A study conducted on children in Egypt showed a positive correlation between legume consumption and DMFT score. Thus, it is stated that the DMFT index increases as legume consumption increases.^[20] In another study conducted in 380 school-age children, eating habits and the DMFT index were compared. As a result, an inverse correlation was found between vegetable consumption and DMFT score. Thus, they showed that the DMFT index decreased as vegetable consumption increased.^[21]

Strengths

In the literature, findings related to general oral and dental health parameters and dental caries are most commonly discussed in studies conducted on children. Our study is a cross-sectional study on adults. Studies comparing the frequency of consumption of probiotic foods and the DMFT index are limited in the literature. There are no studies comparing the frequency of consumption of prebiotic foods with the DMFT index and discussing prebiotic mechanisms.

Limitations

Our study is a cross-sectional study. It is not an experimental study. Therefore, conducting this study as an intervention study may provide healthier results. While comparing probiotic and prebiotic consumption frequencies with the DMFT index in our study, it should be kept in mind that many factors affect oral and dental health. At the same time, expanding the sample may give healthier results.

Conclusion

In our study, in which we examined the frequency of probiotic and prebiotic food consumption and oral and dental health status of adult individuals, it was observed that those with higher consumption frequency of most probiotic and prebiotic foods had better oral and dental

health status. In particular, it was revealed that individuals with a higher consumption frequency of probiotic foods such as yogurt, ayran, pickles and olives; prebiotic foods such as whole grains, oats, onions and garlic, tomatoes, bananas, honey, cruciferous vegetables (cauliflower, broccoli, etc.), legumes, asparagus, soybeans, nuts and red berries (blackberries, rose hips, etc.) had better DMFT scores indicating oral and dental health. Although the main factors affecting the oral and dental health of individuals are factors such as genetic structure, oral care, and nutrition, it is recommended according to the results of this study to add the expression of a diet rich in probiotic and prebiotic foods as well as recommendations such as healthy eating, reducing simple sugar consumption, and a diet rich in anticariogenic foods to the recommendations given for oral health. However, more studies (especially intervention studies) are recommended in order to be more precise on the subject. In addition, the increase in consumption of probiotic and prebiotic foods may encourage the use of probiotic and prebiotic ingredients in oral and dental health products, but more research is needed in this area.

Disclosures

Ethics Committee Approval: The study was approved by the Istanbul Bahçeşehir University, Scientific Research and Publication Ethics Committee (no: E-85646034-604.02.02-67073, date: 18/10/2023).

Informed Consent: Informed consent was obtained from all participants.

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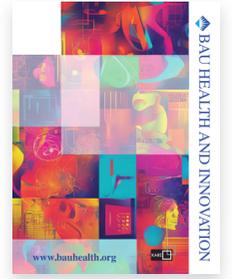
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A Review of Eating Disorders: Complications and Cognitive Aspects

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Abstract

Anorexia nervosa, bulimia nervosa, binge eating disorder, pica, avoidant restrictive food intake disorder, and rumination disorder are eating disorders defined according to the Diagnostic and Statistical Manual of Mental Disorders 5 (DSM V). Eating disorders have the second-highest case fatality rate among all mental illnesses. They are associated with numerous physical and psychological complications. These complications affect multiple systems, including the cardiovascular, dermatological, gastrointestinal, endocrine, and neurological systems, leading to serious health consequences. Nutritional deficiencies, gastrointestinal issues, and psychiatric disorders are particularly prevalent, and some complications may be irreversible. In addition, previous studies have shown that individuals with eating disorders have cognitive deficits compared to healthy individuals. Particularly in attention, memory, and cognitive flexibility. Leptin, an adipokine involved in energy regulation, neurogenesis, and learning, is also known to be reduced in individuals with eating disorders. Leptin deficiency is believed to be one of the underlying factors contributing to cognitive dysfunction in these individuals. Moreover, inadequate and unbalanced nutrition is a key factor driving cognitive impairments in individuals with eating disorders. Therefore, it is crucial to assess cognitive functions and examine nutritional habits in individuals with eating disorders. This review aims to provide an overview of eating disorders, discuss their complications, and synthesize research exploring the relationship between eating disorders and cognition.

Keywords: Cognition, complications, eating disorders.

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Eating disorders (ED) are serious psychiatric conditions defined by unusual eating habits that have a negative impact on an individual's physical and mental health. They are also characterized by individuals' attempts to control eating behavior. People with ED frequently experience excessive concern about what, when, and how they eat. These concerns tend to differ based on sex; men may focus on muscularity, whereas women are often more concerned with weight loss.^[1] Additionally, individuals of both sexes engage in various compensatory behaviors to regulate their dietary intake, such as fasting, skipping meals, self-induced vomiting, and excessive exercise.^[2]

ED has the second-highest case fatality rate among all mental disorders. Approximately 10,000 deaths each year are a direct result of an ED. The financial burden of ED in the United States (U.S.) is estimated at \$64.7 billion per year.^[3] It is further estimated that 9% of the U.S. population will experience an ED in their lifetime. In terms of sex, women are five times more likely to be diagnosed with an ED than men and 1.5 times more likely to receive treatment for an ED.^[4] Adolescents are also significantly affected by ED; a systematic review found that 22% of children and adolescents engage in unhealthy eating behaviors that may indicate or contribute to the development of an ED.^[5]

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Both the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) and the International Classification of Diseases (ICD-11) classify ED into six major categories. These include the diagnostic categories of anorexia nervosa (AN), bulimia nervosa (BN), and binge eating disorder (BED). In recent editions, avoidant restrictive food intake disorder (ARFID), pica, and rumination disorder, previously considered mostly childhood disorders, have also been included.^[6,7]

ED is associated with numerous physical and psychological complications, affecting the cardiovascular, gastrointestinal, endocrine, and neurological systems. Furthermore, some studies have highlighted the differential effects of various ED on cognitive functioning.^[8,9] The aim of this review is to examine the diagnosis and epidemiology of eating disorders, their complications, and their relationship with cognition.

Diagnosis and Epidemiology

Anorexia Nervosa

AN is an ED characterized by severe restriction of energy intake relative to the body's needs, leading to significantly reduced body weight. In addition to being unable to understand the seriousness of their significantly low body weight, patients have an intense fear of gaining weight and a distorted body image.^[10] Clinicians specializing in the field report an increasing number of AN cases in their daily practice. Hoek (2006) noted a rise in AN incidence until the early 2000s, with the majority of cases occurring in women aged 15–24.^[11] Lifetime occurrence rates of AN can be up to 4% in women and 0.3% in men.^[12] A study conducted among 2,907 high school students in Türkiye reported a point prevalence of AN at 0.034%.^[13]

A significant proportion of patients with AN have a poor prognosis and high mortality rates.^[14] A 2021 study found that the standardized mortality rate among AN patients with severe malnutrition-related complications could reach 15.9% after five years of follow-up.^[15]

AN is categorized into two subtypes: the restrictive type and the binge/purging type. A diagnosis of the binge/purging subtype requires the presence of recurrent episodes of binge eating or purging behaviors within the past three months. Conversely, the restrictive subtype is characterized by the absence of such episodes during the same time frame. In the restrictive type, weight loss is primarily achieved through methods such as strict dieting, prolonged fasting, and/or excessive physical activity.^[6]

Bulimia Nervosa

BN, most commonly observed in adolescent women, is a condition characterized by a tendency to overeat and

inappropriate compensatory behaviors to prevent weight gain. Compensatory behaviors are described as self-induced vomiting, misuse of laxatives, use of diuretics, excessive physical activity, and self-starvation.^[16] According to diagnostic criteria, binge-eating episodes and compensatory behaviors must occur at least once a week for a minimum of three months to warrant a BN diagnosis.^[17] Traditional diagnostic approaches primarily rely on patient self-reports of symptoms.

Prevalence estimates suggest that BN affects approximately 1%–1.5% of adults 3% of women and more than 1% of men suffer from BN in their lifetime.^[6] A study conducted among 414 female university students in Türkiye reported a BN prevalence of 0.5%.^[18] The highest incidence is observed among women aged 20–29 years, and BN is strongly associated with mood and anxiety disorders.^[12] In particular, the level of suicidal tendencies of patients diagnosed with BN was found to be clinically concerning. Adolescents with BN report higher rates of suicidality than adults with BN and exhibit greater suicidality risk compared to youth diagnosed with other eating disorders.^[19] One study reported a crude mortality rate for BN of 1.7 per 1000 person-years and a systematic mortality rate of 1.9.^[20]

Binge Eating Disorder

BED is a psychiatric condition characterized by the consumption of abnormally large quantities of food within a short period, accompanied by various psychological and physiological issues, significant impairment in daily functioning, and serious health consequences. Unlike bulimia nervosa (BN), BED is diagnosed based on the presence of recurrent binge-eating episodes occurring at least once per week for a minimum of three months.^[21] Although BED is commonly observed in individuals with normal weight, overweight, or obesity, it is essential to distinguish BED from obesity.^[6]

Prevalence estimates for BED vary significantly, ranging from 0.2% to 3.6% in women and 0.03% to 1.2% in men.^[22] Studies in Türkiye have reported a BED prevalence of approximately 1%, with a higher incidence among women and an average onset age of 23 years.^[13] A representative study conducted in the U.S. found that up to 23% of individuals diagnosed with BED had attempted suicide.^[23] The estimated standardized mortality rate of BED ranges from 1.5 to 1.8.^[24]

Pica

Pica is defined by the DSM-5 as consuming non-nutritive, non-food substances for at least a month. For diagnosis, the eating behavior must not be a part of a socially or

culturally accepted practice, it must be inappropriate for the individual's developmental level, and it must persist for at least one month.^[6] The true prevalence of pica is difficult to assess because most people do not report it and data collection methodology varies between populations, as does its definition.^[25] A study conducted in Germany with 2,403 adults estimated the prevalence of pica to be 5.33%.^[26] Similarly, a study conducted in Türkiye found that 9% of individuals diagnosed with iron deficiency anemia had a history of pica.^[27]

Pica is frequently observed in individuals with neurodevelopmental conditions such as autism spectrum disorder. The condition involves the consumption of a wide range of non-nutritive substances, which are classified based on the specific item ingested. Common forms of pica include geophagy (soil consumption), pagophagia (ice consumption), rhizophagy (raw rice consumption), and amylophagia (starch consumption). Additionally, various other unusual forms of pica have been documented, including the ingestion of mothballs, eggshells, paper, and cardboard.^[28] Pagophagia is common in the U.S., affecting 25% of patients with iron deficiency, whereas geophagia is more prevalent in other parts of the world. Geophagy, in particular, is considered an accepted cultural practice in certain regions, especially in Africa.^[29]

Avoidant Restrictive Food Intake Disorder

Avoidant/restrictive food intake disorder (ARFID) was first introduced into psychiatric terminology in 2013, replacing the concept of feeding disorder in infancy.^[6] Over time, it became evident that ARFID, characterized by avoidant and restrictive eating patterns, could manifest at any stage of life. The DSM-5 identifies three specific presentations of ARFID, which may occur independently or in combination. Individuals in the sensory-sensitive category tend to avoid particular foods (commonly meat, vegetables, or fruits) due to an aversion to certain tastes, textures, or smells. Others may limit their food intake because of a lack of interest in eating or diminished appetite. Additionally, some individuals with ARFID avoid certain foods or cease eating entirely after experiencing a distressing event related to eating, such as choking, vomiting, or gastrointestinal discomfort.^[30]

According to the literature, ARFID prevalence rates vary between 5% and 22.5%. There are currently no specific and up-to-date data on ARFID prevalence in Türkiye. However, preliminary studies in pediatrics, adolescent medicine, and ED clinics indicate that ARFID patient groups tend to be younger compared with patients with AN or BN.^[31] While ARFID can occur at any age, it is most commonly

identified in children and adolescents. Studies conducted in ED clinics report that the average age of individuals diagnosed with ARFID ranges from 11.1 to 14.6 years.^[32]

Rumination Disorder

Rumination disorder is a functional gastrointestinal disorder defined as the effortless vomiting of recently digested food from the stomach into the oral cavity without any underlying organic disease.^[33] The main clinical features are early postprandial regurgitation, effortlessly vomited material similar to swallowed food, and vomited material being spat out or re-swallowed. Rumination disorder is frequently misdiagnosed or overlooked, leading to prolonged symptoms and delayed treatment for affected individuals.^[34]

Rumination disorder can occur in both children and adults. However, there is insufficient data on the incidence and prevalence of rumination disorder in adults. A recent global epidemiological study from the Rome Foundation found that the overall worldwide prevalence of rumination syndrome was 2.8%, with a slightly higher prevalence in women (3.1%) than in men (2.5%).^[35]

The pathophysiology of rumination disorder is not yet fully understood, but imperceptible activation of the abdominal wall is thought to be an important pathogenic feature in the pathophysiological process of the postprandial period. It is also known that rumination disorder is associated with relaxation of the upper and lower esophageal sphincters during increased gastric pressure.^[36]

Complications

Weight loss and malnutrition contribute to various medical complications in AN. In patients with AN, nearly every body system is negatively affected by this progressive malnutrition state. From a cardiovascular perspective, patients are at risk of bradycardia and hypotension, arrhythmia, refeeding syndrome, and sudden death. Dermatologically, complications such as itching, dry skin and lanugo hair may occur due to starvation. Constipation, refeeding pancreatitis, acute gastric dilatation, and dysphagia are gastrointestinal symptoms seen in AN. In terms of endocrine and metabolic aspects, amenorrhea, infertility, osteoporosis, thyroid abnormalities, hypoglycemia, hypercortisolemia, and neurogenic diabetes insipidus are observed. Starvation-related pancytopenia, cerebral atrophy, lagophthalmos and respiratory failure are other complications that can also be observed.^[37,38]

Patients with BN are prone to medical complications affecting multiple organ systems, with a notable impact on renal and electrolyte balance. Discontinuation of disordered eating

behaviors may reverse some, though not all, associated medical complications.^[39] When the systems in BN patients are examined, sore throat, irregular menstrual bleeding, constipation, headache, fatigue, drowsiness, abdominal pain and bloating are observed. Frequent physical examination symptoms associated with BN include low blood pressure, dry skin, swelling of the parotid glands, calluses on the back of the hand, and dental erosion, which may also be associated with hair loss, edema, and epistaxis.^[40]

Although obesity is linked to excessive calorie intake, individuals with obesity and BED are still at risk for nutritional deficiencies. Analyses of the nutritional composition during binge eating episodes reveal that calorie-dense foods are typically high in carbohydrates, sugar, and fat but low in protein. People with BED frequently report symptoms such as acid reflux, difficulty swallowing, bloating, abdominal pain, gastrointestinal urgency, diarrhea, and constipation. Furthermore, around 79% of individuals with BED are diagnosed with a psychiatric condition.^[41] Common co-occurring disorders include specific phobias, social anxiety, post-traumatic stress disorder, and alcohol dependence or abuse.^[42]

Pica, in contrast, is linked to adverse effects such as electrolyte imbalances (notably potassium disturbances), throat irritation, and gastrointestinal complications ranging from abdominal pain to obstructions and colonic ischemia. Bidirectional effects related to pica—conditions that both cause and result from it—include iron deficiency, parasitic infections, and heavy metal exposure (notably lead, mercury, and arsenic).^[25] Additionally, complications such as liver and kidney damage are frequently observed in individuals with pica.^[43]

As ARFID is a relatively newly recognized disorder, the number of medical studies examining its specific complications remains limited. ARFID impairs social functioning, prevents the individual from eating with others, and also causes wasting and micronutrient deficiencies.^[44] Patients may be thought to be at greater risk for malnutrition than AN patients owing to their diets being low in protein and vegetables and high in processed foods. Additionally, malnutrition itself may be associated with gastrointestinal symptoms such as nausea or early satiety after meals and constipation. Diagnostically, children with ARFID often have a history of abdominal pain and infection before diagnosis.^[45]

Rumination disorder can lead to both mental and physical problems that affect quality of life.^[46] Frequent regurgitation can cause notable weight loss, particularly in adolescents, and result in complications such as electrolyte disturbances

and dental damage. Studies have shown that patients with rumination syndrome are often accompanied by anxiety, depression, and somatization.^[33]

Eating Disorders and Cognition

Cognitive differences have been reported between individuals diagnosed with ED and healthy individuals. Research has primarily focused on functions such as attention, memory, and cognitive flexibility in individuals with ED.^[8,47,48]

AN has been shown to negatively affect cognitive functions, particularly in the domains of attention, processing speed, visual and verbal memory, and visuospatial abilities. In a study on individuals with AN, participants reported difficulties in retrieving details of autobiographical memories, despite an enhanced ability to recall salient, often negative events. It is thought that the underlying reasons for this situation may be decreases in hippocampal volume, high levels of attention bias related to food may reduce cognitive resources, fatigue and brain fog resulting from low body weight.^[8] The results of a study show that performance in visual memory is lower in the long-term clinical ED group. Regarding the visual-perceptual difficulties found in the ED group, it is well known that these changes play a role in the body image distortions specific to these disorders.^[49]

Pica is highly prevalent among patients with severe cognitive impairment. One study compared the cognitive and behavioral functions of individuals with pica and hyperorality who did not eat non-food items. More semantic memory impairment and fewer frontal oscillatory symptoms were found in the pica group. There was no meaningful difference between the two groups in terms of changes in eating behavior. Individuals in the pica group had a lesion in the posterior part of the middle temporal gyrus. These findings suggest that semantic memory impairments associated with temporal lobe damage may be linked to the development of pica.^[50]

Working memory is the ability to hold information in mind and process it for short periods of time during complex cognitive tasks.^[51] A meta-analysis examining executive function domains in individuals with binge eating disorder (BED) revealed poorer performance on working memory tasks compared to obese control participants.^[52] Also, systematic reviews in BED have shown cognitive impairments in BED patients as assessed by neuropsychological tasks. Individuals with BED have been found to have poorer performance in decision-making, inhibitory control, and cognitive flexibility compared to healthy participants.^[53]

Cognitive flexibility, the ability to adapt behavior in response to changing environmental demands, is a key neuropsychological function that is often impaired in individuals with ED. Research has consistently reported deficits in cognitive flexibility among individuals with ED, particularly those diagnosed with AN and BN. These individuals often exhibit rigid behavioral patterns, including maladaptive eating habits, which contribute to the persistence of the disorder.^[48] Empirical evidence suggests that individuals with AN, as well as their unaffected sisters, demonstrate lower performance on tasks assessing set-shifting and central coherence.^[54] Similarly, another study found that both AN and BN patients exhibited deficits across multiple domains of cognitive flexibility tasks. Notably, individuals in recovery from AN performed better than those who were acutely ill.^[55] These findings suggest that impaired cognitive flexibility may hinder the ability to modify maladaptive eating behaviors that are no longer reinforcing.^[56]

Leptin, an adipokine primarily involved in energy regulation, may also play a role in the cognitive deficits observed in ED. The quantity of fat stored in adipose tissue is indicated by this long-term satiety signal, which is released by fat cells. It exerts anorexigenic effects by regulating several hypothalamic neuropeptides.^[57] The observed role of leptin in neurogenesis and learning brings into focus whether leptin deficiency mediates the cognitive deficits observed in AN. Furthermore, impairments in learning and memory in leptin-deficient mice were restored through leptin treatment.^[58] For all these reasons, it is thought that one of the underlying reasons for the cognitive function changes seen in individuals with ED may be leptin deficiency.

The primary underlying cause of cognitive impairments in ED may be inadequate and unbalanced nutrition. Malnutrition is known to affect the functioning of the brain, leading to changes in cognitive abilities. Nutrient deficiencies in AN can impair brain metabolism, reduce the availability of amino acids required for neurotransmitter synthesis, and alter cell membrane structure, ultimately affecting neuronal function. In addition, hypoglycemia caused by starvation may affect blood glucose levels and alter acetylcholine release, resulting in negative effects on learning and memory.^[59] In addition to inadequate nutrition, an unbalanced diet in individuals with eating disorders may also negatively affect cognitive functions. Individual nutrient deficiencies can significantly affect brain development and subsequent cognitive health. Several micronutrients, such as B vitamins and iron, play an important role in cognitive health.^[60]

Conclusion

ED varies in prevalence rates, diagnostic criteria, and associated medical complications. Despite being life-threatening mental illnesses with severe health consequences, they remain under-reported and under-researched, making it challenging to determine their true prevalence. Healthcare professionals must recognize the symptoms of EDs and ensure timely diagnosis, as delayed intervention can lead to severe, potentially fatal complications. Early diagnosis is crucial in preventing or mitigating these complications and improving disease prognosis. Furthermore, it is important to acknowledge that individuals with EDs often experience cognitive impairments, primarily in attention, memory, and cognitive flexibility. These deficits are largely attributed to inadequate and unbalanced nutrition resulting from EDs. Therefore, individuals diagnosed with EDs should undergo cognitive performance assessments, and their dietary habits should be carefully evaluated by specialists to enhance cognitive function and prevent further deterioration.

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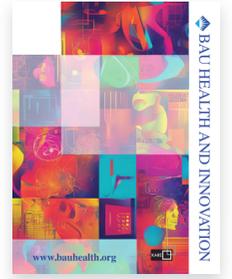
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Effects of Mandibular Advancement with Clear Aligners on Class II Patients and Their Comparison with Traditional Functional Appliances: A Scoping Review

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Abstract

Clear aligners are increasingly used for various orthodontic treatments, including mandibular advancement in patients with skeletal Class II. Mandibular advancement with clear aligners (MA) aims to achieve skeletal effects by promoting mandibular growth. This scoping review aims to evaluate the dental and skeletal effects of mandibular advancement with clear aligners and to compare it with traditional functional appliances. A literature search was conducted in PubMed, Scopus, Web of Science, and Google Scholar for studies published between 2017 and February 2025. The search identified 53 articles, of which 10 studies meeting the eligibility criteria were included. The quality of the studies was examined using the Joanna Briggs Institute (JBI) Critical Appraisal Checklist. Most studies reported a reduction in A point–Nasion–B point (ANB) angle and Wits appraisal after MA treatment. Comparisons with Twin Block (TB) showed similar skeletal outcomes, although MA caused less lower incisor protrusion. Studies comparing MA and Herbst appliance found greater lower molar mesialization with the Herbst appliance, while Sella–Nasion–A point (SNA), Sella–Nasion–B point (SNB), and ANB values were similar. It is important to note that the effects of the Herbst appliance reported in the included studies were evaluated in patients at the pubertal growth peak, although the appliance can also be used in the post-peak period. The included studies show that mandibular advancement with clear aligners can induce forward mandibular growth and achieve skeletal improvement. Reported advantages in these studies include simultaneous dental alignment during advancement, improved aesthetics, and potentially higher patient compliance compared to conventional appliances. Additionally, clear aligners may allow better control of lower incisor inclination during mandibular advancement. However, the findings should be interpreted with caution due to the limited number of high-quality studies and heterogeneity in study designs.

Keywords: Clear aligners, functional appliances, Herbst appliance, mandibular advancement, skeletal class II, twin block.

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Class II malocclusion is a common orthodontic issue caused by anteroposterior discrepancies in the positioning of the upper and lower jaws.^[1] This can occur when the maxilla is anteriorly positioned, the mandible is posteriorly positioned, or a combination of both conditions.^[2] In many cases, the primary goal of treatment is to stimulate mandibular growth and inhibit maxillary growth.^[3] Class II malocclusion is often associated with

mandibular retrusion. To correct this, functional appliances are used to advance the mandible. These devices displace the mandibular condyle beyond the fossa, which reduces condylar pressure and alters muscle tension, promoting additional mandibular growth. In the early 1900s, Robin introduced the Monoblock appliance as a precursor to functional appliances. However, Andresen later refined the Activator, the first widely accepted functional

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appliance. Since then, numerous removable and fixed functional appliances have been developed. Functional appliances produce dental and skeletal effects that correct Class II malocclusion associated with mandibular retrognathia. These effects include increased mandibular length, decelerated maxillary forward growth, anterior movement of the lower arch, and distal inclination of the upper incisors.^[4]

Various fixed and removable functional appliances are used to treat class II malocclusion. Removable functional devices include Activator, Bionator, and Twin Block, while fixed functional devices include Herbst, Forsus, and Jasper Jumper. It is crucial to time the treatment correctly when using functional appliances. The optimal time to initiate treatment is at the onset of the pubertal growth spurt.^[2] The treatment protocol is different in adult patients, where the stimulation of mandibular growth may be unattainable. Orthodontic camouflage or orthognathic surgery are treatment options for these patients.^[1]

The history of clear aligners dates back to 1945, when Kesling developed the 'positioner.' However, the widespread use of clear aligners began with the launch of Invisalign in 1999 by Align Technology, founded in 1997. Clear aligners were initially used only in patients with Class I malocclusion and mild crowding but are currently used in many situations, from preparation for orthognathic surgery to interdisciplinary treatments.^[5]

Increasing clinical demand for aesthetic treatment options, such as clear aligners, has driven interest in their potential for functional mandibular advancement. In 2017, Align Technology™ produced the Invisalign Mandibular Advancement appliance for Class II patients with ongoing growth and development. This appliance, similar to the Twin Block, allows for further positioning of the mandible with the wings on both lateral sides attached to the Invisalign aligners (Fig. 1).

The aligners can reposition the mandible while aligning the teeth. This functional treatment occurs in three stages. The first stage is the pre-mandibular advancement phase,

which eliminates molar rotation, overjet, and overbite problems that hinder the mandible's forward positioning. The second stage is the mandibular advancement stage. Unlike other functional appliances, the mandible is gradually advanced during this stage, using eight aligners for every 2 mm of advancement. The final stage is the transition phase, which aims to preserve the corrected Class II relationship.^[6]

Despite the increasing interest in clear aligner-based mandibular advancement, the available literature remains limited and highly heterogeneous in terms of appliance design, advancement protocols, and outcome measures. Notably, previous reviews have often grouped studies involving fundamentally different biomechanical systems—such as Precision Wings, occlusal bite blocks, or aligners combined with Class II elastics—under a single category of “mandibular advancement with clear aligners.” However, these systems differ markedly in their mechanisms of action: for example, occlusal bite blocks primarily induce vertical opening, while Class II elastics apply distalizing and extrusive forces, complicating direct comparisons with the Precision Wings design. To minimize heterogeneity, only studies using the Precision Wings design for mandibular advancement were included.

Moreover, although there is a growing number of studies exploring clear aligner-based mandibular advancement, much of the current literature consists of case reports or uncontrolled observational studies, limiting the ability to draw evidence-based conclusions. To address this gap, our scoping review specifically included studies with control or comparison groups to enable a more structured and clinically meaningful synthesis of outcomes. For these comparative studies, an untreated control group was not mandated, as the primary focus was on evaluating relative efficacy between active treatments.

The available literature is both limited and heterogeneous. While systematic reviews aim to synthesize high-quality, homogeneous studies to answer specific clinical questions, scoping reviews are valuable, especially when

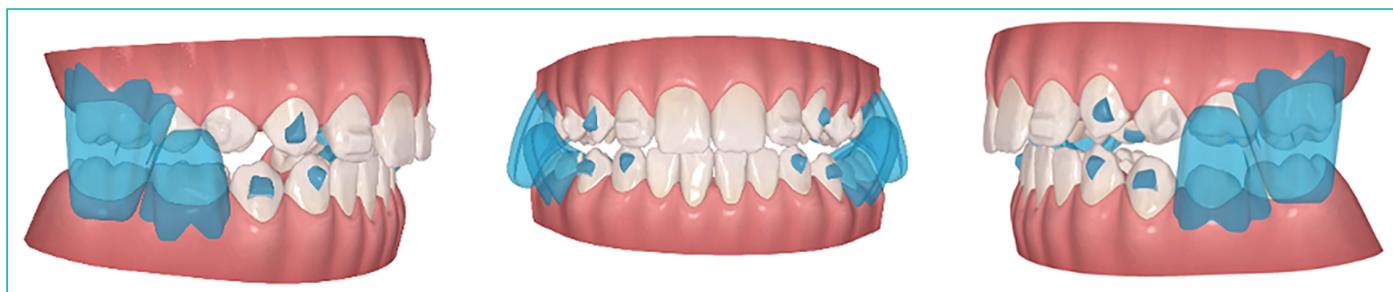


Figure 1. Wings on both lateral sides, visible in blue, attached to the Invisalign aligners are called precision wings.

there is limited, heterogeneous literature. Given the limited number of well-executed primary studies and the variability in study designs, a scoping review was selected as the most appropriate methodology. This approach allows for comprehensively mapping the existing evidence, identifying research gaps, and guiding future studies.

To assess the effects of mandibular advancement with clear aligners on Class II patients and their comparison with traditional methods, our scoping literature review addresses the following two research questions:

1. What are the dental and skeletal effects of mandibular advancement with clear aligners?
2. Does mandibular advancement with clear aligners have the same effects as traditional functional appliances?

Materials and Methods

The present scoping review was designed and developed following the Preferred Reporting Item for Systematic Reviews and Meta-analysis extension for scoping review guidelines (PRISMA-ScR).^[7]

Eligibility Criteria

All clinical studies published from 2017 to February 2025 that evaluated mandibular advancement with clear aligners were screened for eligibility based on titles and abstracts. Observational studies and clinical trials with control groups were included, while case reports, reviews, and animal studies were excluded. In clinical studies comparing MA with other functional appliances, the requirement for a control group was not mandated to allow for the broader inclusion of relevant comparative studies. Due to the authors' linguistic proficiency, the search was limited to English-language studies.

Search Strategy

The literature search used PubMed, Scopus, Web of Science, and Google Scholar to identify relevant studies. The search was restricted to articles published from 2017 to 2025, as 2017 marked the year mandibular advancement with clear aligners was first introduced. Articles containing the following keywords or MeSH (Medical Subject Heading) terms were included: 'Clear aligners OR Invisalign OR Aligner AND Mandibular Advancement OR Functional Orthodontic Appliances OR Functional Appliances AND Class II Malocclusion OR Retrognathism OR Mandibular Deficiency'

Data Charting and Result Synthesis

Two reviewers independently screened titles, abstracts, and full texts for eligibility. Disagreements were resolved through discussion or by consulting a third reviewer. From

each selected article, the following items were summarized and recorded: year of publication, clinical interventions and related outcomes, first author, methodology, study aim, study design, and patient selection.

To assess the methodological quality of the included studies, we used the JBI Critical Appraisal Checklists, selecting the appropriate version based on study design. Two reviewers independently performed the assessments. Disagreements were resolved through discussion or consultation with a third reviewer. The results of the quality appraisal were used to contextualize the findings during synthesis, not to exclude any studies.

We divided the 10 selected articles into three separate groups. Our focus was specifically on comparing the outcomes of mandibular advancement with clear aligners treatment against the control group and consolidating the effects of mandibular advancement. The remaining two groups consisted of articles comparing removable functional appliances, the Twin Block and MA, while the other compared fixed functional appliances, Herbst and MA.

Results

Study Selection

In total, 204 references were initially identified across various online databases. After removing duplicates, 139 unique titles remained. After carefully reviewing the titles and abstracts, 53 potentially relevant full-text articles were examined. Finally, 10 studies that met the inclusion criteria were included in this scoping review (Fig. 2).

Study Characteristics

A total of ten studies from six countries were included: the United States of America (n=2), Italy (n=1), China (n=3), Saudi Arabia (n=1), Korea (n=1), and Canada (n=2). Table 1 presents the studies' publication year and author, number of patients and their age, aims, design, outcomes, and main findings related to each intervention.^[8-17]

Critical Review

The Joanna Briggs Institute (JBI) Critical Appraisal Checklists were used to assess the methodological quality of the included studies. All studies except Zybutz et al.^[11] were designed as cohort studies and were therefore assessed using the JBI Critical Appraisal Checklist for Cohort Studies, while Zybutz et al.^[11] was assessed using the JBI Critical Appraisal Checklist for Analytical Cross-Sectional Studies. Two reviewers independently performed the quality assessment, with disagreements resolved through discussion or consultation with a third reviewer.

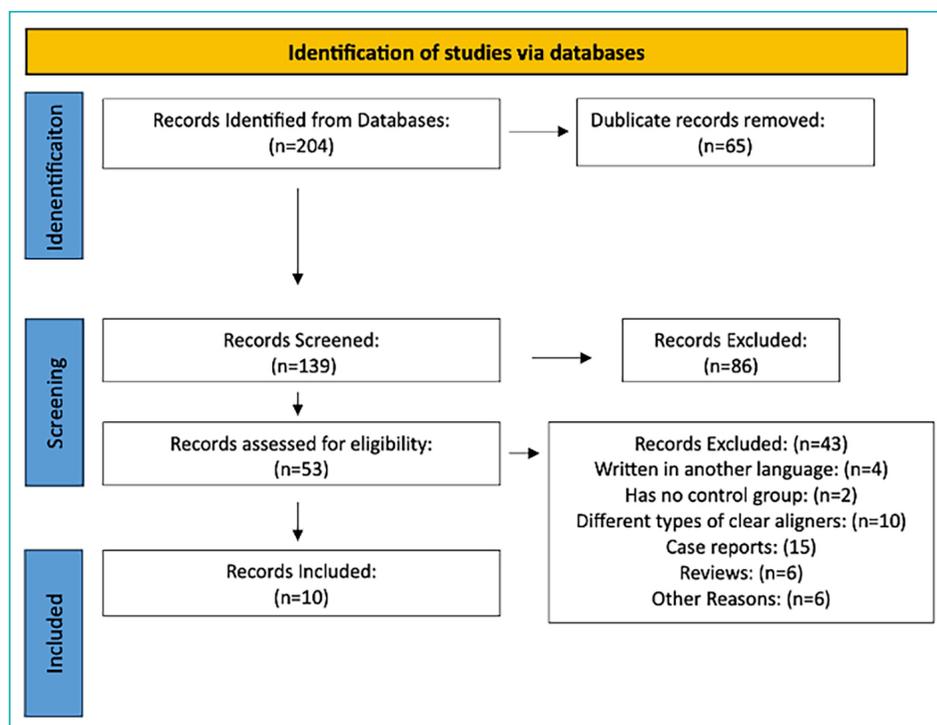


Figure 2. Flow chart for literature search.

According to the JBI checklists, the studies demonstrated moderate to good methodological quality, based on the number of “yes” responses. However, it should be noted that most were retrospective in nature, and clinical factors such as patient compliance, reasons for incomplete correction, or full achievement of the planned mandibular advancement could not be consistently evaluated across studies. Table 2 summarizes the critical appraisal of the included articles. For clarity and space, the JBI checklist items are presented in abbreviated form in Table 2. The full wording of each item can be found in the original JBI Critical Appraisal Checklists.^[18,19]

Discussion

In clinical practice, the selection of a functional appliance depends largely on patient compliance, growth stage, and vertical growth pattern. Removable functional appliances require a high level of cooperation, whereas fixed functional appliances can be used independently of compliance and are therefore suitable for non-cooperative patients. In terms of treatment timing, skeletal effects are most pronounced when therapy is initiated around the pubertal growth peak; however, fixed appliances may also be indicated in the post-peak period. Patients with a normodivergent or hypodivergent growth pattern may represent the most favorable candidates for functional appliance therapy. Nevertheless, since functional appliances tend to increase

lower incisor inclination, they may be contraindicated in patients who already present with excessive proclination. When considering the clinical application of these appliances, these factors should always be taken into account during patient selection.^[4,20]

Skeletal Effects of Mandibular Advancement with Clear Aligners

Studies showed that mandibular advancement with clear aligners may be associated with skeletal changes. A reduction in the ANB angle was consistently observed across studies, reflecting improved sagittal relationship. An et al.^[15] found a significant difference in the female group and stated that it was about better cooperation in the female group. These findings suggest that patient cooperation may be crucial to the effectiveness of treatment.^[8,9,12,13,17] While increases in SNB values, indicative of mandibular advancement, were reported by Blackham et al.,^[8] Wu et al.^[13] and Subaie et al.,^[17] other studies showed limited changes.^[9,12] Interestingly, no significant changes in SNA values were observed across any study, indicating that the treatment predominantly affects mandibular positioning rather than the maxilla.^[8,9,12,13,15,17]

Regarding Wits values, Blackham et al.,^[8] Ravera et al.,^[9] and Subaie et al.^[17] reported significant reductions compared to control groups, indicating sagittal skeletal improvements. However, other studies observed

Table 1. Study characteristics

	Author and year	Number of patients	Age	Appliance	Comparison	Aim	Outcome
1	Blackham et al, 2017 ^[8]	38 patients	13.15±1.37 to 11.82±1.74	Invisalign Mandibular Advancement	Twin Block Historical Control Group	Compare short-term effects of MA to TB and historical controls on Class II malocclusions in skeletal, dental, and soft tissue aspects.	MA is effective correcting Class II malocclusion. MA may result less protrusion compared to TB.
2	Ravera et al., 2021 ^[9]	72 patients	9.2±1.4 to 12.10±1.4	Invisalign Mandibular Advancement	Control Group (Untreated)	Dentoskeletal effects of the MA in pre-pubertal and pubertal stages.	In pre-pubertal stage, MA mainly has dentoalveolar effects, while during puberty, it transitions to dento-skeletal effects.
3	Caruso et al., 2021 ^[10]	20 patients	10±1.03 to 10±1.05	Invisalign Mandibular Advancement	Twin Block	Dentoskeletal effects of the MA compared to TB	Both appliances are effective correcting skeletal Class II. MA has better control of upper teeth position.
4	Zybutz et al., 2021 ^[11]	68 patients (37 female, 31 male)	10.6±1.92 to 13.6±1.54	Invisalign Mandibular Advancement	Twin Block	Comparison of patient experiences with MA versus TB	Both MA and TB experiences were generally similar. TB patients found their appliance more intimidating and harder to insert.
5	Lombardo et al., 2022 ^[12]	71 patients (40 female, 31 male)	10.9±1.1 to 12.0±1.3	Invisalign Mandibular Advancement	Twin Block Control Group (Untreated)	Dentoskeletal effects of the MA compared to TB	Both treatment groups had improvements in overjet and overbite compared to control group (untreated).
6	Wu et al., 2023 ^[13]	63 patients (26 female, 36 male)	10.71±1.44 to 12.11±1.16	Invisalign Mandibular Advancement	Vanbeek Activator, Herbst, Twin Block, Control Group (Untreated) Herbst	Dentoskeletal effects of the MA compared to traditional functional appliances	All four appliances effectively advance the mandible, improve facial profiles, and correct skeletal Class II. MA allows aligning while leading the mandible and has good control of incisor inclination.
7	Hosseini et al., 2023 ^[14]	40 patients (22 female, 18 male)	12.7±1.8 to 13.1±1.5	Invisalign Mandibular Advancement	Vanbeek Activator, Herbst, Twin Block, Control Group (Untreated) Herbst	Dentoskeletal effects of the MA compared to Herbst followed by comprehensive orthodontic treatment	Both appliances are effective correcting Class II malocclusion. MA has better control of mandibular incisor inclination.
8	An et al., 2023 ^[15]	40 patients (20 female, 20 male)	6 to 18 Treatment group mean age 9.3	Invisalign Mandibular Advancement	Control Group (Untreated)	Dentoskeletal effects of the MA	MA usage during the growth phase significantly reduces anteroposterior discrepancies in skeletal, dental, and soft tissue structures in Class II Division 1 malocclusion.
9	Yue et al., 2023 ^[16]	32 patients (17 female, 15 male)	8 to 11.5 Mean Age 10.2±0.84 years	Invisalign Mandibular Advancement	Twin Block	Upper airway and hyoid bone position improvements treated with Invisalign mandibular advancement and Twin-Block appliances	Both MA and TB improved narrowness of the upper airway and hyoid bone position.
10	Subaie et al., ^[17]	70 patients (34 female, 36 male)	11.98±2.18 to 11.75±1.59	Invisalign Mandibular Advancement	Control Group (Untreated)	Dentoskeletal and soft tissue effects of the MA	MA in growing patients with Class II malocclusion achieved significant skeletal correction. Soft tissue was significantly improved.

MA; Mandibular Advancement with Clear Aligners, TB; Twin Block

Table 2. Critical appraisal for included studies⁽¹⁸⁾

Author and year	Group similarity	Exposure assignment	Exposure validity	Confounders identified	Confounding strategies	Outcome-free at baseline	Outcome validity	Follow-up duration	Follow-up completeness	Incomplete follow-up strategies	Statistical appropriateness	Objective criteria
Blackham et al, 2017 ⁽⁸⁾	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Not applicable	Yes	-
Ravera et al., 2021 ⁽⁹⁾	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	No	Yes	-
Caruso et al., 2021 ⁽¹⁰⁾	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Not applicable	Yes	-
Zybutz et al., 2021 ⁽¹¹⁾	Yes	Yes	Yes	Yes	No	-	Yes	-	-	-	Yes	No
Lombardo et al., 2022 ⁽¹²⁾	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Not applicable	Yes	-
Wu et al., 2023 ⁽¹³⁾	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Not applicable	Yes	-
Hosseini et al., 2023 ⁽¹⁴⁾	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Not applicable	Yes	-
An et al., 2023 ⁽¹⁵⁾	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Not applicable	Yes	-
Yue et al., 2023 ⁽¹⁶⁾	Yes	Yes	Yes	No	No	Yes	Yes	Yes	Yes	Not applicable	Yes	Yes
Subaie et al., ⁽¹⁷⁾	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Not applicable	Yes	Yes

reductions in Wits values that did not reach statistical significance, possibly due to variations in patient characteristics, particularly growth stages.^[12,15]

Various parameters were used to evaluate vertical skeletal development post-MA treatment, but none of these studies demonstrated a significant increase compared to the control group.^[8,9,12,13,15,17] We can attribute this finding to clear aligners' biomechanical advantage due to their thickness, which provides better vertical control. However, Lombardo et al.^[12] observed an increase in the lower facial height ratio, as did Ravera et al.^[9] and Wu et al.^[13] with the bispinal plane-gonion measurement, although these were not statistically significant when compared with the control group. Additionally, all studies except for Blackham et al.^[8] indicated an increase in lower jaw length compared to the control group, highlighting the ability of MA to promote mandibular development.^[9,12,13]

Dental Effects of Mandibular Advancement with Clear Aligners

Mandibular advancement with clear aligners resulted in significant dental changes, particularly in overjet reduction. However, other parameters, such as incisor inclination and molar relationships, showed variability. Overjet reduction was consistently reported across all studies, demonstrating the efficacy of clear aligners in addressing Class II malocclusions.^[8,9,12,13,17]

Upper incisor inclination changes were generally insignificant across most studies, except for Ravera et al.,^[9] who reported significant decreases in the CVM2 group, whereas no significant changes were noted in the CVM3 group. Ravera et al.^[9] also observed more pronounced dental effects in the CVM2 group, which might explain these findings. Upper incisor retrusion was observed in some studies, though the findings were not consistent. For example, Blackham et al.^[8] and An et al.^[15] reported no significant differences in U1-NA values, but Blackham et al.^[8] noted significant retrusion in U1-APo values.^[8,15] Wu et al.^[13] also observed substantial reductions in U1-PP values after MA treatment. It is important to note that measurement parameters differed across studies, and upper incisor retrusion could also result from ClinCheck planning strategies customized for each case.

Lower incisor changes demonstrated variability across studies. Blackham et al.^[8] reported a significant increase in L1-APo values, indicating incisor protrusion. Conversely, An et al.^[15] noted a significant decrease in L1-NB values in female patients, attributing the

findings to better cooperation and treatment adherence. However, this variable was only examined in two studies, and it's crucial to remember that measurement parameters differed between them. Therefore, making a definitive statement regarding lower incisor protrusion may not be appropriate, as the results remain controversial.

Across all studies, IMPA values showed no significant differences between treatment and control groups.^[8,9,12,13,15,17] Unlike the lower incisor protrusion commonly observed as a side effect in traditional functional appliances, this finding emphasizes the advantage of clear aligners in preserving lower incisor axis inclination.

Improvements in molar relationships were primarily attributed to skeletal corrections resulting from mandibular advancement. Blackham et al.^[8] and Subaie et al.^[17] reported mesialization of lower molars, although Blackham et al.^[8] found these changes to be statistically insignificant. Subaie et al.,^[17] however, observed significantly greater mesialization of lower molars compared to the control group, highlighting the dental compensatory effects of MA treatment.

Overbite changes varied significantly between studies. Lombardo et al.^[12] reported a significant reduction in overbite, aligning with the skeletal and dental improvements achieved through treatment. In contrast, Blackham et al.^[8] and Subaie et al.^[17] both observed reductions in overbite; however, these changes were not statistically significant. Blackham et al. specifically highlighted that the decrease in overbite was primarily attributed to the inhibition of lower incisor eruption, possibly due to the complete coronal coverage provided by the clear aligner. The combined effect of managing lower incisor eruption and controlling the inclination of incisors (IMPA) is critical for effective overbite correction. This ability of the aligner to prevent lower incisor eruption is a notable advantage. Achieving this balance—stabilizing IMPA while controlling incisor eruption—is inherently challenging but offers a distinct benefit in maintaining overbite without unwanted vertical changes.

Soft Tissue Effects of Mandibular Advancement with Clear Aligners

The impact of treatment on soft tissues showed variation across studies. Blackham et al. reported a significant decrease in facial convexity but found no significant changes in the nasolabial angle compared to the control group. In contrast, An et al.^[15] and Subaie et al.^[17] also observed improvements in facial convexity; however, these changes were not statistically significant. Additionally, An et al.^[15] reported a significant decrease in the nasolabial

angle, specifically in the female group.^[8,17] Variations in age, growth stages, patient compliance, and the wear time of functional appliances may contribute to these differences in soft tissue outcomes.

Twin Block versus Mandibular Advancement with Clear Aligners

Current research shows conflicting results regarding the comparative effects of MA and TB appliances. Most studies found no significant differences in the SNA angle when comparing TB and MA appliances.^[8,12,13] However, Caruso et al.^[10] observed a statistically significant reduction in the SNA angle with TB treatment. This effect was attributed to the retroclination of the upper incisors, which led to bone remodeling around the incisor roots and displacement of point A.

When examining the SNB angle, no study reported statistically significant differences between the two appliances. This indicates that both devices achieve comparable mandibular advancements, consistent across multiple investigations.^[8,10,12,13]

Most studies, excluding Caruso et al.,^[10] did not report significant differences in the ANB angle between TB and MA treatments. In contrast, Caruso et al. observed a significant reduction in the ANB angle in the TB group. This finding was linked to changes in the SNA angle caused by upper incisor retroclination and its skeletal remodeling effects.^[8,10,12,13] When Wits appraisal values were examined, no significant differences were found between TB and MA groups across studies. This consistency in Wits values further supports the notion that the skeletal effects of both appliances are comparable.^[8,12]

Dentoalveolar changes also varied between the two appliances. TB demonstrated a greater retroclination of upper incisors, as reported by Caruso et al.,^[10] however, this difference was not observed in other studies.^[8,12,13] Although no significant differences were found in the lower incisor inclination (L1-MP angle),^[8,10,12,13] lower incisor protrusion was notably less with MA in two studies.^[8,13]

During the promotion of Invisalign Mandibular Advancement, one of the main focuses was its potential for improved aesthetics and increased patient compliance. In a valuable study conducted by Zybutz et al.,^[11] comparing MA and TB, it was found that, although there was no significant overall difference between the two groups, the MA group preferred the appliance due to its aesthetic appeal and ease of application. Additionally, the TB group experienced more instances of breakage and fitting issues. Beyond these findings, patients reported that the

TB appliance was perceived as more intimidating at first impression, while MA was considered more discreet and acceptable. Parents also more easily noticed the TB, further emphasizing the aesthetic advantage of MA. Moreover, patients using TB reported greater embarrassment in social settings, which strongly supports the notion that MA provides a superior aesthetic and psychological benefit compared to TB. In addition, patients in the MA group more frequently reported sore lips and dental pain, which may be explained by the fact that during MA therapy, all teeth are fully covered by the aligners while simultaneous dental movements are incorporated into the treatment plan. On the other hand, although TB patients faced higher rates of appliance breakage, MA patients expressed greater dissatisfaction when clinical visits were required for appliance adjustments. This suggests that the population choosing MA may place a higher value on comfort and aesthetics.^[11]

When discussing functional therapies, it is important to consider the impact on the upper airway, as studied by Yue et al.,^[16] who examined developments in the upper airway and the position of the hyoid bone following TB and MA using CBCT. It was found that both MA and TB appliances effectively decreased respiratory resistance and increased the upper airway's structural narrowness. In contrast to TB, MA was more successful in enlarging the hypopharynx's narrowest segment. Additionally, both appliances promoted anterior downward movement of the hyoid bone. Yue et al.^[16] also suggested that MA might be more effective in increasing the upper airway volume because it can intrude lower incisors without extruding the posterior teeth and causing less clockwise rotation. However, it is important to note that CBCT-based airway measurements can be influenced by factors like head position, breathing during the scan, and tongue posture, which may affect the accuracy of the results.^[19]

Herbst versus Mandibular Advancement with Clear Aligners

Only two studies have compared a fixed functional appliance, Herbst, with a removable functional appliance, MA. Both studies found no differences in SNA, SNB, and ANB values after using Herbst and MA. These findings suggest that both appliances successfully treat Class II malocclusions, producing similar skeletal results, despite their differences in design and application.

Hosseini et al.^[14] found no significant difference between the Herbst and MA groups when analyzing the distal movements of upper molars. However, Wu et al.^[13] determined that the distal movement of upper molars

with Herbst was greater than that achieved with MA. Regarding the mesial movement of lower molars, both studies found that Herbst resulted in greater movement than MA. The improvement in molar relationship: Hosseini et al. observed that both Herbst and MA resulted in more skeletal component-related improvement in the molar relationship, while Wu et al. discovered that Herbst produced more dental improvement, while MA produced more skeletal improvement.

Both studies found that mandibular incisors were significantly more proclined with Herbst than MA when examining L1-MP values. This finding highlights the critical role of mandibular incisor angulation, especially in cases where incisor inclination is already a limiting factor. Excessive proclination may lead to dental compensation, potentially impacting the skeletal and dental balance achieved during treatment.

Hosseini et al.^[14] reported that overjet reduction was significantly more with Herbst, whereas Wu et al.^[13] found no significant difference. While Hosseini et al. suggested that overjet reduction with both appliances was more skeletal, Wu et al. noted that with Herbst, it was predominantly skeletal. In contrast, with MA, it was primarily dental. Hosseini et al. attributed the greater overjet reduction with the Herbst appliance to overcorrection and the longer treatment duration associated with the Herbst protocol. On the other hand, the discrepancies in findings may be due to leveling and alignment in the upper incisors during the MA phase, as suggested by Wu et al.

The combined evidence suggests the following clinical implications and considerations for patient selection:

The findings of this review suggest that mandibular advancement with clear aligners may be a suitable treatment modality for growing patients with mild to moderate Class II malocclusion, particularly those who are highly cooperative and motivated.

Notably, several included studies reported that lower incisor inclination remained relatively stable, indicating that this technique may be advantageous in cases where proclination of the lower incisors is contraindicated.

Moreover, although definitive conclusions cannot be drawn due to the observational nature of the included studies, the majority did not report substantial changes in vertical skeletal parameters. This may suggest that aligner-based mandibular advancement is more appropriate for patients with horizontal or mildly normo-divergent growth patterns, rather than those with vertical, high-angle growth. The lack of occlusal opening or the potentially intrusive influence of the aligner material could explain the minimal

vertical effects observed. While these hypotheses remain speculative, they highlight areas for further investigation.

Due to the heterogeneity in study designs, short follow-up durations, and the absence of randomized controlled trials, further high-quality prospective research is necessary to validate these trends and better define the ideal patient profile and long-term outcomes of aligner-based mandibular advancement protocols.

In contrast to the previous review by Yu et al.,^[21] our study differs significantly in terms of accessibility and scope. Their study also includes trials that use Class II elastics in addition to aligners, broadening their focus beyond the use of clear aligners alone with mandibular advancement. Furthermore, the full text of their review is published in Chinese, which limits its accessibility to a global audience.

Limitations and Future Directions

This review is limited by the small number of available articles on Invisalign Mandibular Advancement. Moreover, long-term follow-up and monitoring for relapse are essential for evaluating treatment stability, yet most studies lacked sufficient follow-up duration. The heterogeneity in methodology, patient characteristics, and outcome measures made it difficult to perform data synthesis. Variations in skeletal maturation stages, compliance levels, and diagnostic tools further complicated the comparability of results.

Additionally, most studies did not report whether mandibular advancement was initiated immediately or preceded by a leveling and alignment phase (pre-mandibular advancement phase), making it difficult to evaluate the influence of treatment sequencing on skeletal and dental outcomes. Relapse risk—especially in growing Class II patients—remains insufficiently explored due to the lack of long-term data.

Aligner-based mandibular advancement commonly follows a staged protocol; however, the clinical implications of gradual versus single-step advancement have not been clearly defined, particularly in comparisons with traditional functional appliances. Future studies should aim to standardize advancement protocols across different appliance systems, treatment phases, and durations to facilitate meaningful clinical comparisons and determine whether certain methods provide superior outcomes or long-term stability.

A critical gap also lies in the lack of measurement standardization. The included studies utilized a wide range of cephalometric parameters with limited consistency. Establishing a core set of diagnostic and outcome variables

would greatly improve inter-study comparability and enhance the validity of future meta-analyses.

Furthermore, due to the retrospective design of many studies, key clinical details were frequently not mentioned—such as levels of patient cooperation, reasons for incomplete correction, and whether the planned mandibular advancement was fully achieved. These missing data points limit the interpretation of treatment effectiveness. To overcome these limitations, there is an urgent need for well-designed randomized controlled trials to provide higher-level evidence and address the existing gaps in treatment efficacy and long-term outcomes. Lastly, this review included only English-language publications, which may have led to the exclusion of relevant findings from non-English sources, introducing potential language bias.

Conclusion

Mandibular advancement can be achieved through the use of clear aligners. These aligners induce forward growth of the mandible while also enabling alignment. Additionally, they offer enhanced comfort and aesthetics compared to other functional appliances. However, there is currently limited literature on this subject, with only a few studies addressing the efficacy of mandibular advancement using clear aligners. Upon examination of the studies conducted thus far, the following results have been obtained regarding the use of MA;

1. Clear aligners with mandibular advancement features may promote forward mandibular growth and assist in the correction of skeletal Class II malocclusion in growing patients. Current evidence suggests favorable skeletal and dental outcomes though further high-quality studies are needed to confirm these results.
2. MA and the Twin Block may produce similar skeletal effects, though only a few studies have directly compared them.
3. MA and Herbst appliances can correct Class II molar relationships and reduce overjet. Some studies suggest that MA may better preserve lower incisor inclination compared to Herbst, which may be beneficial in selected cases. On the other hand, fixed appliances might be more appropriate in patients with poor compliance.

In summary, further research with larger sample sizes, standardized methodologies, and extended follow-up periods is necessary to fully understand the long-term effects and clinical potential of mandibular advancement using clear aligners.

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