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# EXPERIMENTAL AND APPLIED MEDICAL SCIENCE

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**GAZİANTEP İSLAM BİLİM VE TEKNOLOJİ ÜNİVERSİTESİ TIP FAKÜLTESİ**

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Contact information:

Gaziantep Islam Science and Technology University, Faculty of Medicine
Beştepe neighbouhood, Street number 192090 6/1 27010 Şahinbey/Gaziantep
Tel: +90 342 909 7500
E-mail: eams@gibtu.edu.tr

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# Aim

***Experimental and Applied Medical Science*** aims at being a current and easily accessible academic publication in which striking research results that will improve the quality of life and are unique from every field of medical sciences.

# Amaç

***Experimental and Applied Medical Science***, yaşam kalitesini arttıracak çarpıcı araştırma sonuçlarının sunulduğu, tıp bilimlerinin her alanında benzersiz, güncel ve kolay erişilebilir bir akademik yayın olmayı hedeflemektedir.

# Scope

***Experimental and Applied Medical Science*** is an open-access, internationally double-blind peer reviewed academic medical journal which is published in English four times a year, under the auspices of Medical Faculty of Gaziantep Islam Science and Technology University. The journal receives manuscripts for consideration to be publishing in the form of research articles, reviews, letter to editor, brief notification, summary notification etc. which could have been presented from within the country or abroad and including experimental animal studies related to the pathogenesis of diseases, pharmacological, clinical, epidemiological and deontological studies, also studies in the fields of improving public health, health services or health insurance.

During evaluation or publication no charge is demanded from authors. The journal is published quarterly. The literary language of the journal is English. Abstract part of the manuscript only should also be submitted in Turkish.

# Kapsam

***Experimental and Applied Medical Science***, Gaziantep İslam Bilim ve Teknoloji Üniversitesi Tıp Fakültesi himayesinde yılda dört kez İngilizce olarak yayınlanan açık erişimli, uluslararası çift kör hakemli bir akademik tıp dergisidir. Dergi, yurt içinden veya yurt dışından, hastalık patogenezleri ile ilişkili deneysel hayvan çalışmaları, klinik, farmakolojik, epidemiyolojik, deontolojik çalışmalar ile beraber halk sağlığının geliştirilmesi amacı taşıyan ve sağlık hizmetleri veya sağlık sigortaları konularında araştırma makaleleri, derlemeler, vaka sunumları, kısa bildirimleri, özet bildirimleri vs. yayınlamak için değerlendirmeye kabul etmektedir. Değerlendirme veya yayın sırasında yazarlardan herhangi bir ücret talep edilmez.

Dergi yılda 4 sayı olarak yayımlanır. Derginin yazı dili İngilizcedir. Makalenin sadece özet kısmı Türkçe olarak da gönderilmelidir.

# Ethical Principles and Publication Policy

Manuscripts are only considered for publication provided that they are original, not under consideration simultaneously by another journal, or have not been previously published. Direct quotations, tables, or illustrations that have extracted from any copyrighted material must be accompanied by written authority for their use from the copyright owners. All manuscripts are subject to review by the editors and referees. Deserving to be publishing is based on significance, and originality of the material. If any manuscript is considered to deserve publishing, it may be subject to editorial revisions to aid clarity and understanding without changing the data presented.

***Experimental and Applied Medical Science*** strictly adheres to the principles set forth by "Helsinki Declaration" whose web address is below.

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Editorial Board declares that all reported or submitted studies conducted with "human beings" should be in accordance with those principles.

Manuscripts presenting data obtained from a study design conducted with human participants must contain affirmation statements in the *Material and Methods* section indicating approval of the study by the institutional ethical review committee and "informed consent" was obtained from each participant. Also all manuscripts reporting experiments in which laboratory animals have been used should include an affirmation statement in the *Material and*

# Etik İlkeler ve Yayın Politikası

Makaleler, orijinal/özgün olmaları, eş zamanlı olarak başka bir dergi tarafından incelenmemeleri veya daha önce yayınlanmamış olmaları koşuluyla yayına kabul edilir. Telif hakkıyla korunan herhangi bir materyalden alınan doğrudan alıntılar, tablolar veya resimler, kullanımları için telif hakkı sahiplerinden alınan yazılı izinle birlikte sunulmalıdır. Tüm yazılar editörler ve hakemler tarafından incelemeye tabidir. Yayınlanmaya hak kazanılması, materyalin önemine ve özgünlüğüne bağlıdır. Herhangi bir makalenin yayınlanmayı hak ettiği düşünülürse, sunulan veriler değiştirilmeden netlik ve anlayışa yardımcı olmak için editör revizyonlarına tabi tutulabilir.

***Experimental and Applied Medical Science***, internet adresi aşağıda yer alan "Helsinki Deklarasyonu" ile belirlenen ilkelere sıkı sıkıya bağlıdır.

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Editör Kurulu, "insan" ile yapılan tüm raporlanan veya sunulan çalışmaların bu ilkelere uygun olması gerektiğini beyan eder. İnsan katılımcılarla yürütülen bir çalışma tasarımından elde edilen verileri sunan makaleler, *Gereç ve Yöntemler* bölümünde çalışmanın kurumsal etik inceleme komitesi tarafından onaylandığını ve her katılımcıdan "bilgilendirilmiş onam" alındığını belirten onay ifadeleri kullanmalıdır. Ayrıca laboratuvar hayvanlarının kullanıldığı deneyleri bildiren tüm yazılar, *Gereç ve Yöntemler* bölümünde, internet adresi aşağıda

*Methods* section validating that all animals have received human care in compliance with the "Guide for the Care and Use of Laboratory Animals" whose web address is below and reveal approval by the institutional ethical review board. https://www.gibtu.edu.tr/Medya/Birim/Dosya/20210818130308_dca61056.pdf

If there is a commercial relation that contributes to the study process or there is an institution that provides financial support for the study; the authors must declare that they have no commercial relationship with the commercial product, drug, company used, or what kind of relationship (consultant or any other agreement) they have, if any.

Processing and publication are free of charge with the journal. No fees are requested from the authors at any point throughout the evaluation and publication process. All manuscripts must be submitted via the online submission system, which is available at https://dergipark.org.tr/tr/pub/eams. The journal guidelines, technical information, and the required forms are available on the journal's web page.

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belirtilmiş olan "Laboratuvar Hayvanlarının Bakımı ve Kullanımı Kılavuzu"na uygun olarak tüm hayvanların insanî bir bakım aldığını doğrulayan bir beyan ile kurumsal etik inceleme kurulunun onayını içermelidir. https://www.gibtu.edu.tr/Medya/Birim/Dosya/20210818130308_dca61056.pdf

Çalışma sürecine katkı sağlayan ticari bir ilişki veya çalışmaya maddi destek sağlayan bir kurum varsa; yazarlar ticari ürün, ilaç, aracılık eden şirket ile ticari bir ilişkilerinin olmadığını veya varsa ne tür bir ilişkisi (danışmanlık veya başka bir anlaşma) olduğunu beyan etmelidir.

Değerlendirme ve yayınlama süreçleri ücretsizdir. Değerlendirme ve yayın sürecinin hiçbir aşamasında yazarlardan ücret talep edilmez. Tüm yazılar https://dergipark.org.tr/tr/pub/eams adresinde bulunan çevrimiçi başvuru sistemi üzerinden gönderilmelidir. Dergi ile ilgili kullanım kılavuzları, teknik bilgiler ve gerekli formlar derginin internet sayfasında yer almaktadır.

Derginin tüm masrafları Gaziantep İslam Bilim ve Teknoloji Üniversitesi Tıp Fakültesi tarafından karşılanmaktadır. Reklam vermeyi düşüne kişi veya kurumlar yayın ofisi ile iletişime geçmelidir. Reklam görselleri sadece Baş Editör'ün onayı ile yayınlanabilir. Tüm araştırmacılar, makaleye doğrudan akademik veya bilimsel olarak katkıda bulunmuş olmalıdır. Yazarlar, makalenin planlanması, uygulanması, yazılması veya gözden geçirilmesi aşamalarından birine veya birkaçına katkıda bulunmuş olmalıdır. Tüm yazarlar nihai versiyonu onaylamalıdır. Bilimsel kriterlere uygun bir makale hazırlamak yazarların sorumluluğundadır.

the final version. It is the authors' responsibility to prepare a manuscript that meets scientific criterias.

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All manuscripts involving a research study must be evaluated in terms of biostatistics and it must be presented altogether with appropriate study design, analysis and results. ***p*** values must be given clearly in the manuscripts. Other than research articles, reviews, case reports, letters to the editor, etc. should also be original and up to date, and the references and, if any, their biostatistical parts should be clear, understandable and satisfactory.

The publication language of the journal is English. In addition, the abstract part of the article must be uploaded in both Turkish and English. Manuscripts should be evaluated by a linguist before being sent to the journal.

All manuscripts and editorial correspondence must be submitted online to the editorial office, https://dergipark.org.tr/tr/pub/eams.

According to the Law on Intellectual and Artistic Works, which was first published in the Official Gazette with the law number 5846 on 13/12/1951, whose web address is below, and on which subsequently various changes have been made or novel parts have been added in time, all kinds of publication rights of the articles accepted

Dergide yayınlanan yazılarda ifade edilenler veya görüşler, Gaziantep İslam Bilim ve Teknoloji Üniversitesi Tıp Fakültesi, editörler, yayın kurulu ve/veya yayıncının görüşlerini değil, yazar(lar)ın görüşlerini yansıtır; editörler, yayın kurulu ve yayıncı bu tür materyaller için herhangi bir sorumluluk veya yükümlülük kabul etmez.

Araştırma çalışması içeren tüm yazılar biyoistatistiksel açıdan değerlendirilmeli ve uygun çalışma düzeni, verilerin analizi ve sonuçları ile birlikte sunulmalıdır. ***p*** değerleri yazılarda açık olarak verilmelidir. Araştırma makaleleri dışında derlemeler, olgu sunumları, editöre mektuplar vb. de orijinal/özgün ve güncel olmalı, kaynaklar ve varsa biyoistatistiksel kısımlar açık, anlaşılır ve tatmin edici olmalıdır.

Derginin yayın dili İngilizce'dir. Ayrıca makalenin özet kısmı hem Türkçe hem de İngilizce olarak yüklenmelidir. Yazılar dergiye gönderilmeden önce bir dilbilimci/konunun uzmanı tarafından değerlendirilmelidir.

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İnternet adresi aşağıda belirtilmiş olan, ilk olarak 13/12/1951 tarih ve 5846 sayılı Kanun ile Resmi Gazete'de yayımlanan, sonraları üzerinde değişiklikler yapılmış veya yeni kısımlar eklenmiş olan Fikir ve Sanat Eserleri Kanunu'na göre; yayına kabul edilen makalelerin her türlü yayın hakkı dergiyi yayınlayan kuruma aittir. Ancak makalelerdeki düşünce ve öneriler tamamen yazarların sorumluluğundadır. https://www.gibtu.edu.tr/Medya/Birim/Dosya/20210818145630_406d24df.pdf

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# Author Guidelines

Submission of a paper will be taken to imply that it has not previously been published and that it is not being considered for publication elsewhere. Decision as to publication of papers submitted to the Experimental and Applied Medical Science will be based on the opinion of the Editorial Board as to the significance and originality of the work.

Manuscripts should be prepared electronically using an appropriate “office word” compatible text-processing package, formatted for A4 size, double-spaced throughout, and using a “Times New Roman” 12 point font. Articles must be written in English. Abstracts must be written in both Turkish and English. Text should flush left, and not be justified. Words should not be hyphenated. Pages should be numbered sequentially.

There should be a separate title page with:

a) The title

b) The authors' names

c) The laboratory of origin, with complete address of each author

d) A running title

e) Corresponding author and e-mail

f) Conflict of interest

g) Acknowledgements

The main body of full-length paper should be divided into:

1. Abstract

2. Introduction

3. Material and Methods

4. Results

5. Discussion

# Yazım Kuralları

Bir çalışmanın dergimize gönderilmesi için bu çalışmanın daha önce yayınlanmamış veya başka bir akademik dergide şu anda yayınlanmak üzere değerlendirilmiyor olması koşulu ile mümkündür. Experimental and Applied Medical Science’a gönderilen her türlü çalışmanın yayınlanmasına ilişkin karar, Yayın Kurulu'nun çalışmanın önemi ve özgünlüğü konusundaki görüşüne dayanacaktır.

Çalışmalar, ya “office word” programı ile ya da bu program ile uyumlu uygun bir metin işleme programı kullanılarak, A4 boyutunda hazırlanmalı, baştan sona çift aralıklı ve “Times New Roman” tarzında 12 punto yazı tipi kullanılarak elektronik ortamda yazılmalıdır. Makaleler İngilizce yazılmalıdır. Özetler hem Türkçe hem de İngilizce olarak yazılmalıdır. Metin iki yana yaslandırılmamalı, sadece sola yaslanmamalıdır. Kelimeler kısa çizgi ile hecelenmemelidir. Sayfalar sırayla numaralandırılmalıdır.

Aşağıdakileri içeren ayrı bir başlık sayfası olmalıdır:

a) Başlık

b) Yazarların isimleri

c) Her yazarın tam adresi ile birlikte çalıştıkları laboratuarlar

d) Kısa başlık

e) İletişimdeki yazar ve iletişim bilgileri

f) Çıkar çatışması beyanı

g) Teşekkür, bilgilendirme

Tam uzunluktaki kağıdın ana gövdesi şu bölümlere ayrılmalıdır:

1. Özet

2. Giriş

6. Conclusion
7. Conflict of interest
8. Acknowledgement
9. References

In general, there are no specific word lengths for any manuscript. The general principle is that a manuscript can be as long as necessary to communicate clearly and most effectively the scientific message, but should be as short as possible to achieve a complete presentation of the information without undue repetition or redundancy.

In the *Materials and Methods* section, the source of all compounds, equipment or software should be identified by the full name of the supplier, city, state/country. The chemical names of any drug should precede the trade name.

Papers describing animal experiments must define species, strain, sex, age, supplier and number of animals used. An ethical statement concerning the use of animals, or the details of ethical approvals, consent and recruitment of human subjects should be clearly stated. *Results* and *Discussion* can be broken down into subsections for improving the comprehensibility. The Results should not repeat methodological details and should avoid the discussion of the data.

The results of statistical tests should be incorporated in the body of the text, typically in the *Results* section, rather than in figure legends. Adequate description of statistical analysis should be provided. Statistical measures of variation in the text, illustrations and tables, should be identified. All dimensions and measurements must be

3. Gereç ve Yöntemler
4. Sonuçlar
5. Tartışma
6. Bağlam
7. Çıkar çatışması
8. Teşekkür, bilgilendirme
9. Kaynaklar

Genel olarak, herhangi çalışma için şart koşulan belirli bir kelime sayısı/metin uzunluğu yoktur. Genel ilke; bir makalenin bilimsel mesajı açık ve etkili bir şekilde iletmek için gerektiği kadar uzun olabileceği, ancak gereksiz tekrar veya fazlalık olmadan bilgilerin eksiksiz bir sunumunu elde etmek için mümkün olduğunca kısa olması gerektiğidir.

*Gereçler ve Yöntemler* bölümünde, tüm bileşiklerin, malzemelerin veya yazılımların kaynağı, tedarikçinin tam adı, şehir, eyalet/ülke ile tanımlanmalıdır. Herhangi bir ilacın kimyasal isimleri ticari isminden önce gelmelidir.

Hayvan deneylerini açıklayan makaleler, tür, soy, cinsiyet, yaş, tedarikçi ve kullanılan hayvan sayısını açıkça tanımlamalıdır. Hayvanların kullanımına ilişkin bir etik beyan veya insan deneklerin etik kurul onayları, bilgilendirilmiş onamları ve çalışmaya dâhil edilmelerine ilişkin ayrıntılar açıkça belirtilmelidir. *Sonuçlar ve Tartışma* bölümleri, anlaşılırlığı artırmak için alt bölümlere ayrılabilir. Sonuçlar, metodolojik ayrıntıları tekrarlamamalı ve verilerin tartışılmasından kaçınmalıdır.

İstatistiksel testlerin sonuçları, şekillerin altındaki açıklama kısımlarından ziyade metnin gövdesine, tipik olarak Sonuçlar bölümüne dâhil edilmelidir. İstatistiksel analizin yeterli bir şekilde açıklaması sağlanmalıdır. Metinde, resimlerde ve

specified in the metric system.

All subscripts, superscripts, Greek letters and unusual characters must be clearly identified.

In the text, abbreviations should be used consistently. Abbreviations should be defined on first use.

References should be designed in “Vancouver” style. While writing references, “Times New Roman” 10 point font should be used. Multiple authors should be separated by a comma. If there are more than three authors, after the 3rd author, "et al." should be inserted without a comma for both article and book references. If reference is made from a chapter in a book and there are many authors belonging only to this chapter, the title and chapter of the book are indicated, the first three of the chapter authors are written, and "et al." statement is added for subsequent authors.

Example:

1. Perell KL, Nelson A, Goldman RL, et al. Fall risk assessment measures: an analytic review. The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(12):M761-6.

2. Ha H, Han C, Kim B. Can Obesity Cause Depression? A Pseudo-panel Analysis. Journal of preventive medicine and public health = Yebang Uihakhoe chi. 2017;50(4):262-7.

3. Çekmen MB, Turgut M, Türköz Y, et al. Nitrik Oksit (NO) ve Nitrik Oksit Sentaz (NOS)'ın Fizyolojik ve Patolojik Özellikleri. Türkiye Klinikleri Journal of Pediatrics. 2001;10(4):226-35.

4. Parlakpınar H, Örüm MH, Acet A. Kafeik asit fenetil ester (KAFE) ve miyokardiyal

tablolarda istatistiksel varyasyon ölçütleri tanımlanmalıdır.

Tüm boyutlar ve ölçüler metrik sistemde belirtilmelidir.

Tüm alt simgeler, üst simgeler, Yunan harfleri ve olağandışı karakterler açıkça tanımlanmalıdır.

Metinde kısaltmalar tutarlı bir şekilde kullanılmalıdır. Kısaltmalar ilk kullanımda tanımlanmalıdır.

Kaynaklar “Vancouver” tarzında yazılmalıdır. Kaynaklar yazılırken, “Times New Roman” 10 punto kullanılmalıdır. Birden çok yazar virgülle ayrılmalıdır. Hem makale hem de kitap referanslarında, eğer üçten çok yazar varsa, 3. Yazardan sonra virgül ve “et al.” ifadesi kullanılmalıdır. Kitapta bir bölümden referans yapılıyorsa ve sadece bu bölüme ait çok sayıda yazar varsa, kitabın başlığı ve bölümü belirtilip, bölüm yazarlarının ilk üçü yazılıp ve ardından sonraki yazarlar için “et al.” ifadesi eklenmelidir.

Örnek:

1. Perell KL, Nelson A, Goldman RL, et al. Fall risk assessment measures: an analytic review. The journals of gerontology Series A, Biological sciences and medical sciences. 2001;56(12):M761-6.

2. Ha H, Han C, Kim B. Can Obesity Cause Depression? A Pseudo-panel Analysis. Journal of preventive medicine and public health = Yebang Uihakhoe chi. 2017;50(4):262-7.

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iskemi reperfüzyon (Mİ/R) hasarı. İnönü Üniversitesi Sağlık Bilimleri Dergisi 2012; 1: 10-5.
5. Yıldırım AB. The effects of maternal hypothyroidism on the immunoreactivity of cytochrome p450 aromatase in the postnatal rat testes. 2015; Doctoral thesis.
6. https://hsgm.saglik.gov.tr/depo/birimler/kanserdb/istatistik/Trkiye_Kanser_statistikleri_2016.pdf (Last access date: 21.09.2020).
7. Kuran O, İstanbul, Filiz Kitabevi. Sistematik Anatomi. 1983 p. 76-9.
8. Abbas AK, Andrew H Lichtman, Shiv Pillai. Cellular and Molecular Immunology. 6th ed. Philadelphia: Saunders Elsevier; 2007 p. 121-56.
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Tables of numerical data should each be typed with double spacing on separate pages numbered in sequence in numerals, provided with a heading, and referred to in the text, as Table 1, Table 2, etc. Each table should have a brief but descriptive heading. Explanatory matter should be included in footnotes to the table.
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4. Parlakpınar H, Örüm MH, Acet A. Kafeik asit fenetil ester (KAFE) ve miyokardiyal iskemi reperfüzyon (Mİ/R) hasarı. İnönü Üniversitesi Sağlık Bilimleri Dergisi 2012; 1: 10-5.
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6. https://hsgm.saglik.gov.tr/depo/birimler/kanserdb/istatistik/Trkiye_Kanser_statistikleri_2016.pdf (Last access date: 21.09.2020).
7. Kuran O, İstanbul, Filiz Kitabevi. Sistematik Anatomi. 1983 p. 76-9.
8. Abbas AK, Andrew H Lichtman, Shiv Pillai. Cellular and Molecular Immunology. 6th ed. Philadelphia: Saunders Elsevier; 2007 p. 121-56.
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Bilimsel araştırmalarınızı desteklemek ve geliştirmek için elektronik ek materyaller kabul edilmektedir. Ek dosyalar, yazara, destekleyici uygulamaları, filmleri, animasyon dizilerini, yüksek çözünürlüklü

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görüntüleri, arka plan veri kümelerini, ses kayıtlarını ve daha fazlasını yayınlamak için ek olanaklar sunmaktadır.

Başvuru sırasında çıkar çatışmasının ve mali destek konularının açıklanması elzemdir. Yazarlar, makalelerinin yayımlanma tarihinden önce ortaya çıkabilecek ek çıkar çatışmalarını veya bulunan mali destekleri dergiye bildirmekle yükümlüdür. Tüm yazarlar, makalelerinin konusuyla doğrudan ilgili olsun ya da olmasın, tüm olası çıkar çatışmalarını ve mali desteği bireysel olarak açıklamalıdır.

Özlem Akay, Assoc. Prof. Dr.
Gaziantep Islam Science and Technology University, Medical Faculty, Department of Biostatistics
*ozlem.akay@gibtu.edu.tr*
Zekiye İpek Katırcı Kırmacı, Assoc. Prof.
Gaziantep Islam Science and Technology University, Faculty of Health Sciences
*ipek.kirmaci@gibtu.edu.tr*
Rabia Taşdemir, Asst. Prof.
Gaziantep Islam Science and Technology University, Medical Faculty, Department of Medical Anatomy
*rabia.tasdemir@gibtu.edu.tr*
Safiah Olabi, Dr.
Helmholtz Zentrum München
*safiah@olabi.com*
Tülay Öncü Öner
Manisa Celal Bayar University Faculty of Engineering, Department of Bioengineering
*tulay.oncu@cbu.edu.tr*
Roghaiyeh Safari Dr.
Imperial College London
*Roghaiyeh.safari@rsrsscientific.com*
Ayşegül Burçin Yıldırım, Assoc. Prof. Dr.
Gaziantep Islam, Science and Technology University, Medical Faculty, Department of Medical Histology and Embryology
*abyildirim@gibtu.edu.tr*
Gönül Elpeze, Asst. Prof.
Gaziantep Islam Science and Technology University, Faculty of Health Sciences
*gonul.elpeze@gibtu.edu.tr*
Kaifee Arman, Dr.
Montreal Clinical Research Institute
*mohammadkaifee.arman@ircm.qc.ca*
Ferhat Aslan, Asst. Prof. Dr.
Gaziantep Islam Science and Technology University, Medical Faculty, Department of Gynecology and Diseases
*ferhat.aslan@gibtu.edu.tr*
Sinem Yılmaz, Dr.
Alanya Alaaddin Keykubat University
*yilmaz.sinem.ege@gmail.com*
Marie Cutiongco
Nanyang Technological University
*marie.cutiongco@ntu.edu.sg*

**Layout Editors**

Nazlı Hilal Eke, Research Assistant.
Gaziantep Islam Science and Technology University, Medical Faculty, Medical Physiology Department
*nazlihilal.eke@gibtu.edu.tr*
Şerife Küçükhüyük, Research Assistant.
Gaziantep Islam, Science and Technology University, Medical Faculty, Department of Medical Histology and Embryology
*serife.kucukhuyuk@gibtu.edu.tr*
Ebru Sena Poyraz, Research Assistant.
Gaziantep Islam Science and Technology University, Medical Faculty, Department of Medical Anatomy
*ebrusena.calisir@gibtu.edu.tr*

## Contents/İçindekiler

Experimental and Applied Medical Science, 6, 2: 146-148, 2025. DOI: 10.46871/eams.1678748
**Letter to Editor**

# Decoding Biological Networks: A Network Pharmacology Approach Powered by Artificial Intelligence

Seyda Kaya[1*]

[1]*Gaziantep Islam Science and Technology University, Department of Medical Services and Techniques, Medical Laboratory Techniques Program, Gaziantep, Turkiye.*

**Dear Editor,**

In recent years, many techniques have been developed to elucidate the complex structure of biological systems that are difficult to analyze and to understand many diseases at the molecular level. These advancements have revealed that drug development approaches that only focus on a single target are often inadequate in the treatment of complex diseases in which multiple genetic and environmental factors have a major impact (1). This has increased the importance of multidisciplinary approaches and led the scientific world to seek more holistic models. Systems biology-based approaches are gaining more and more importance, and the concept of network pharmacology, which evaluates the intrinsic dynamics of biological systems through networks, including multi-component, multi-target and multi-level analyzes, is coming to the fore (2). Network pharmacology has become a strategic tool in today's drug discovery processes, especially because it provides the opportunity to evaluate gene, protein and drug interactions at multiple levels (3). However, for this approach to be used efficiently, large and complex datasets need to be processed. At this point, the possibilities offered by artificial intelligence come into play.

Artificial intelligence, especially machine learning and deep learning techniques, make the analysis of biological data much more meaningful and faster. Modeling processes that could take months with traditional methods can now be done in minutes. However, artificial intelligence has become not only an accelerator, but also a tool that can establish new relationships, make predictions and generate hypotheses (4, 5).

***Corresponding author:** Seyda Kaya**,** E-mail: sydkaya58@gmail.com, ORCID ID: 0000-0001-8489-8687

Network pharmacology aims to analyze the interactions of genes, proteins, metabolites, etc. through networks. However, these networks are often very large and complex, so classical statistical approaches may be insufficient.

The role of artificial intelligence at this point is critical. Especially in studies conducted in countries with a strong traditional medicine background such as China and India, the effects of herbal compounds on the network have been systematically mapped with the help of artificial intelligence (6). Likewise, evaluating the ethnobotanical knowledge widespread in Anatolia with these methods can make significant contributions to both the preservation of cultural legacy and the discovery of potential therapeutic candidates.

While the potential of AI-supported network pharmacology is high, there are some challenges that slow the progress of this field. First of all, the decision processes of AI algorithms are often "black box" in nature, meaning that they have limited explain ability, making biological interpretation difficult (7). Moreover, the quality, standardization and reliability of the data are factors that directly affect model performance. In particular, noise and missing data problems, which are frequently encountered in-omics data sets, can reduce the reliability of AI models (8).

Another important aspect is the need for interdisciplinary collaboration. Developing a common language between biologists, computer scientists, pharmacologists and clinicians is critical for the successful implementation of these models. In this regard, issues such as platforms that encourage open data sharing, the development of modular and explainable artificial intelligence models, and ensuring data privacy within the framework of ethical rules are expected to be on the agenda more in the coming years (9, 10).

Network pharmacology approaches supported by artificial intelligence pioneer the understanding of disease mechanisms at the system level and the development of effective treatment strategies. Especially in the modeling of multi-target and multi-component therapies, this approach offers more holistic and effective solutions compared to classical methods (11). This interdisciplinary field has great potential in terms of scientifically analyzing complex therapeutic elements such as herbal products, developing individualized medicine practices and accelerating drug discovery processes (6).

Through this letter, I hope that more researchers will embrace, support and strengthen international collaborations in this powerful approach that combines artificial intelligence and network pharmacology.

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**Clinical Research**

# Effects of L-Carnitine on iNOS Expression and Apoptosis in CCL4-induced Testicular Damage in Rats

Derya Karabulut[1*], Ayca Kara[2], Ali Tugrul Akin[3], Tugce Merve Ozturk[1], Murat Unsal[1], Emin Kaymak[4]

[1]*Erciyes University, Faculty of Medicine, Department of Histology-Embryology, Kayseri, Turkiye.*

[2]*Erciyes University, Genome and Stem Cell Center (GENKOK), Kayseri, Turkiye.*

[3]*Istinye University, Faculty of Medicine, Department of Medical Biology, Istanbul, Turkiye.*

[4]*Bozok University, Faculty of Medicine, Department of Histology-Embryology, Yozgat, Turkiye.*

## Abstract

***Purpose:*** *This study aimed to investigate the effects of L-carnitine on inducible nitric oxide synthase (iNOS) and apoptosis in testicular damage caused by carbon tetrachloride (CCL4).*
***Methods****: Forty male Sprague Dawley rats were used. Experimental groups; Group I: Control group; Group II: L-carnitine; 200 mg/kg L-carnitine (ip) twice a week for 6 weeks, Group III: CCL4; 0.2 ml CCL4 (ip) twice a week for 6 weeks, Group IV: L-carnitine + CCL4 group, 200 mg/kg ip L-carnitine was administered 24 hours before CCL4 administration twice a week for 6 weeks, Group V: CCL4+L-carnitine; 200 mg/kg L-carnitine was administered half an hour after CCL4 administration twice a week for 6 weeks. Histopathology, Johnsen's testicular biopsy score (JTBS), seminiferous tubule diameter measurement, iNOS immunoreactivity and apoptosis, which is programmed cell death, were evaluated in testicular tissue sections.*
***Results:*** *Compared to Group I, histological deterioration, decreased JTBS and MSTD, increased iNOS expression and apoptotic cells were observed in Group III tissue sections. All of these parameters showed corrective effects in L-carnitine applied groups.*
***Conclusion:*** *L-carnitine has both protective and healing effects on tissue against CCL4 toxicity by helping regulate iNOS expression.*

***Key words****: Carbontetrachloride, L-carnitine, iNOS, Testis*

*** Corresponding author:** Derya Karabulut, E-mail: deryakkus@hotmail.com, ORCID ID: 0000-0003-2067-6174

## Introduction

Causes such as alcohol-cigarette use, drug consumption, aging, varicocele, urogenital infections, and exposure to toxic chemicals are risk factors for male infertility (1, 2).

In such cases, the severity of the dysfunction result from tissue or organs is affected by variety of factors depends on the duration that structure is affected by those factors. Carbon tetrachloride (CCl4) is a colorless, volatile, toxic substance that is rapidly miscible in air, water and soil (1). It is used as a solvent in industrial industry, but also in agriculture as a disinfectant for cereals and as a pesticide (3). Direct or accidental ingestion of CCl4 may cause serious damage in the testicular tissue using high accumulation ability (4). CCl4 is frequently used in experimental animal models at different doses especially to induce experimental liver fibrosis (5, 6). Moreover, it has been reported that CCl4 has detrimental effects on other organs such as the liver (7), heart (8) and testis (9). CCl4 causes the emergence of harmful metabolites such as trichloromethyl in the cell and directly affects the mitochondrial membrane by blocking the oxidative phosphorylation of free radicals containing an unpaired electron (10, 11). Nitric oxide (NO) is a free radical that can be covalently bound to other molecules because it has an unpaired electron in its final orbit (12). NO is synthesized from L-arginine by the activity of nitric oxide synthase enzymes (NOS) (13). There are three forms of NOS: neuronal NOS (nNOS, NOS-I), inducible (iNOS, NOS-II) and endothelial NOS (eNOS, NOS-III) (14, 15). The iNOS gene is a Ca 2+ and calmodulin-independent molecule encoded by 1153 amino acid proteins, consisting of 26 exons, 25 introns and 130 kDa in weight (13). It is expressed in testis, epididymis, endothelial cells, smooth muscle cells, hepatocytes, chondrocytes, keratinocytes (16), mast cells and monocytes, macrophages, microglia, Kupffer cells and also expressed in phagocytic cells such as eosinophils and neutrophils (17). Revealing whether iNOS, which is also expressed in the testis, changes against CCL4 toxicity is necessary to understand the presence of NO enzymes caused by oxidative stress in the tissue.

L-carnitine is a white, water-soluble substance with good thermostability, which can be found anywhere in nature, synthesized from plant and animal cells. L-carnitine fulfills its catalytic function by the formation of fatty acids in mitochondria, and its metabolic function as a buffer for excess acyl residues (16). L-carnitine protects the cell membrane and DNA against damage caused by free oxygen radicals, and prevents protein oxidation and

lactate oxidative damage (17). Therefore, it is important to reveal the presence of iNOS expression due to oxidative stress caused by CCL4 toxicity of L-carnitine, which is known for its protective effects on the cell. Because increased oxidative stress in the cell can cause disruption of physiological processes and even trigger cell death. In this regard, changes in apoptosis, which is programmed cell death due to iNOS expression, can also be observed in CCL4-induced testicular damage.

In this study, we aimed to evaluate the damage caused by CCL4 on the testis and the protective and ameliorative effects of L-carnitine against this damage by histopathological evaluation, immunohistochemical stainings and the determination of apoptosis.

## Methods

### Animals

The study used 40 male Sprague Dawley rats. The rats were obtained from Erciyes University Experimental and Clinical Research Center (DEKAM), Kayseri, Turkey. The rats were adult, 2-3 months/ 8-12 weeks old, weighing 200-300 g. This study was performed according to the recommendations of the Guide for the Care and Use of Laboratory Animals of the National Institutes of Health (date: 04.04.2024, number: 24/072). The cages were well-ventilated and plastic. The rats were allowed to have ad libitum access to food and water. They were also housed in a room with a 12-hour light:dark cycle. At the end of the experiment, they were anesthetized under ketamine + xylazine anesthesia and their organs were removed.

### Experimental design

Group I: Control group (n:8) Olive oil was given intraperitoneally (ip) twice a week. Group II: L-carnitine group (n:8), 200 mg/kg L-carnitine (ip) was administered twice a week for six weeks (18). Group III: CCL4 group (n:8) was applied by dissolving twice a week in 0.2 ml of CCL4 (ip) olive oil for 6 weeks (19). Group IV: L-carnitine+CCL4 group (n:8) were given 200 mg/kg L-carnitine (ip) 24 hours before each CCL4 administration during the experiment. 24 hours after L-carnitine administration, 0.2 ml/100 g CCL4 was applied. Group V: CCL4 + L-carnitine group (n:8), 200 mg/kg L-carnitine (ip) was administered half an hour after CCL4 twice a week (20). Since CCL4 was dissolved in olive oil, it was deemed appropriate to give olive oil to the control group. At the end of the experiment, the testicular tissues of the rats were removed under ketamine (75 mg/kg) + xylazine (10 mg/kg) anesthesia.

**Histological Examination**

At the end of the experiment, the testicular tissues were placed in a 10% formaldehyde solution. Then, after waiting for a week in the fixation solution, they were dehydrated using alcohol. Transparent with xylol and embedded in paraffin. Hematoxylin-Eosin (H-E) staining and iNOS immunoreactivity were applied to 5 μm thick sections to evaluate the histological structure. Testicular tissue sections were subjected to Johnsen's testicular biopsy score (JTBS) by two independent histologists. According to JTBS, testis sections were systematically evaluated. This is done by giving a score of 1 to 10 for each section. Score descriptions are as follows; 1: There are no cells in the tubular section. 2: There are only Sertoli cells. 3: Germ cells are only spermatogonium. 4: There are few spermatids. 5: There is a large number of spermatocytes. 6: There are few spermatids. 7: There is a large number of spermatids without signs of discernment. 8: Late spermatids are present without mature spermatozoa. 9: There are few spermatozoa. 10: Complete spermatogenesis with a large number of spermatozoa (21). In addition, using the Analyses LS Research program at testicular tissue sections, the mean seminiferous tubule diameter measurement (MSTD) was performed at x20 magnification with 100 tubules from each group.

**Hematoxylin-Eosin (H-E) Staining Protocol**

Paraffin sections were incubated at 58 ºC. The sections were incubated in xylene and washed with alcohol. Sections washed in running water at room temperature for 10 minutes in hematoxylin solution was kept. Sections were washed again in running water. The Eosin solution were kept for 5 minutes. The washed sections were first dehydrated and then incubated in xylene (20).

**Immunohistochemistry**

Immunohistochemistry was performed with the avidin-biotin-peroxidase method to determine iNOS (ab3523, Abcam, Cambridge, UK) immunoreactivity in testicular tissue. 5 μm thick sections were taken from the paraffin sections. Then, these sections were kept in the oven to remove excess paraffin. Before staining, the sections were placed in an xylene solution and deparaffinized. The sections were rehydrated with alcohol and rinsed in deionized water. Then, antigen retrieval was carried out by microwave treatment in 0.01 M sodium citrate buffer (pH 6.0) at 95°C for 5 min. The tissue slides were washed with phosphate-buffered saline (PBS). Endogenous peroxidase activity was

inhibited by 3% $H_2O_2$ in methanol for 10 min. The staining kit (Lab Vision, Ultra Vision Detection System Large Volume, Anti-Polyvalent Thermo Scientific HRP) was used for the next stages according to the manufacturer's instructions. The sections were visualized using 3,3P-diaminobenzidine tetrahydrochloride and counterstained with hematoxylin (20). Under the light microscope (Olympus BX51, Center Valley, PA, USA) and images were obtained. A total of 80 different fields (8 slides x 10 fields) in each group were evaluated using the ImageJ program.

**Apoptosis (TUNEL)**

Samples were stained by the directives of the manufacturer (In Situ Cell Detection Apoptosis Fluorescein Kit, Roche) to evaluate apoptosis. First, deparaffinization was performed with xylene from 5 mm sections. Then, dehydration was performed using alcohol. PBS was used for subsequent washing procedures. Testis slides antigen retrieval was applied for removed formaldehyde. After being washed with PBS three times, the tissues were incubated with a TUNEL (Terminal deoxynucleotidyl transferase dUTP nick end labeling) reaction mixture in a damp and dark place at 37°C for 60 minutes. After washing with PBS three times for five minutes, the tissues were contrast colored with 4,6-diamidine-2'-fenilindol. They were all examined with the Olympus BX-51 fluorescent microscope. TUNEL-positive cells in seminiferous tubules of all groups were analyzed by counting (22).

**Statistical analysis**

For statistical analysis, GraphPad Software, Prism 10 version was used. D'Agostino & Pearson normality test was used to determine the normality analysis of the data. One-way ANOVA and post hoc Tukey testis were used to compare multiple variables. $p<0.05$ was considered significant. Data were evaluated as ± standard deviation.

**Results**

**Histological results**

Testicular tissue sections of groups I and II had normal histological appearance. Spermatogonium, Sertoli cells, primary and secondary spermatocytes, spermatids and spermatozoa had a regular appearance. Seminiferous tubules and inter-tubular connective tissue had a normal appearance. There was deterioration and vacuole formation in the seminiferous tubule germinal epithelium of group III. Also, in some tubules atrophy and necrotized germinal epithelium were observed. JTBS and seminiferous tubule diameter measurements were the lowest in this group. Tissue sections of Groups IV and V had a more regular appearance compared

with Group III. The tissue sections of Group V were more regular with seminiferous tubule germinal epithelium. The statistical analyses of the JTBS and MSTD scores of the experimental groups are shown in Table 1. The findings of the groups in the H-E stained sections are shown in Figure 1.

**Table 1.** Analysis of JTBS and MSTD scores of all groups.

| | Group I | Group II | Group III | Group IV | Group V | *p* |
|---|---|---|---|---|---|---|
| **JTBS (1 to 10)** | 8,94±0,87[a] | 9,11±0,87[a] | 7,15±1,05[b] | 8,83±0,82[a] | 8,83±0,58[a] | 0,0001 |
| **MSTD (µm)** | 228,7±43,15[a] | 223,9±32,77[a] | 221,5±31,02[b] | 231,2±29,18[a] | 229,2±35,45[a] | 0,0001 |

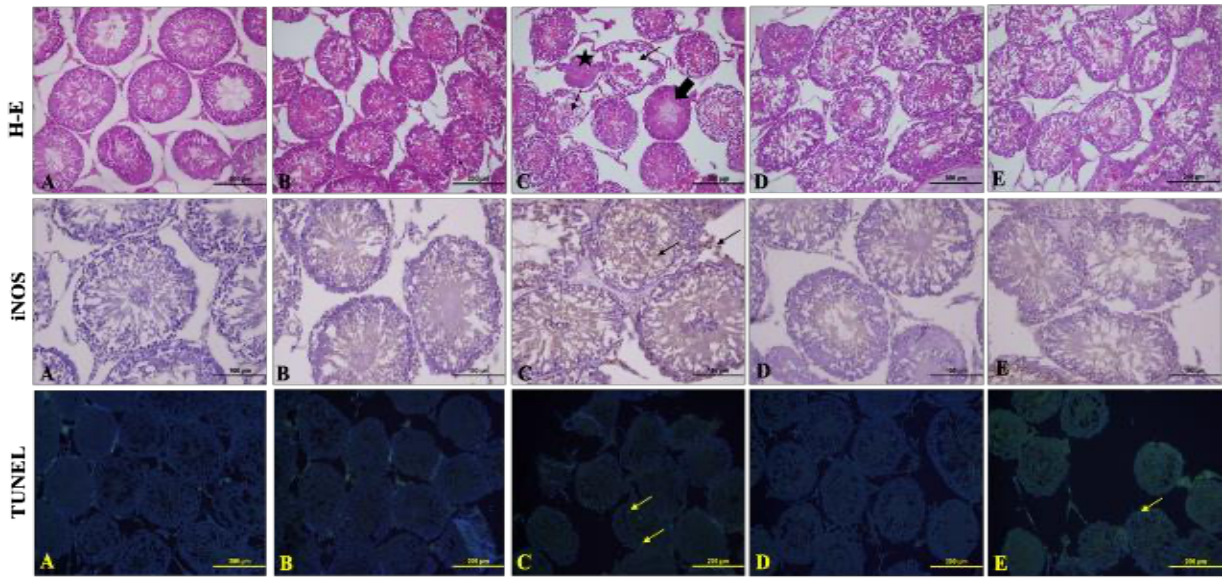


**Figure 1.** H-E, iNOS and TUNEL staining testicular sections of all experimental groups. Typical histological architecture of testis tissue in H-E stained sections Group I (A) and Group II (B). Atrophic seminiferous tubule (star), spilled germinal epithelium (arrow), and necrotic tubule (bold arrow) in Group III (C) were shown. Groups IV (D) and Group V (E) appear similar to normal testicular histology. Increased iNOS immunoreactivity (black arrows) is shown in Group III (C) compared to other groups. TUNEL-positive cells (yellow arrows) showing apoptosis are shown in Group III (C) and Group V (E). Abbreviations: Group I; Control group, Group II; L-carnitine group, Group III; CCL4 group, Group IV; L-carnitine + CCL4 group, Group V; CCL4 + L-carnitine group, iNOS; inducible nitric oxide synthase, TUNEL;Terminal deoxynucleotidyl transferase dUTP nick end labeling.

### Immunohistochemistry results

iNOS immunoreactivity was observed in both the seminiferous tubule germinal epithelium and tubular connective tissue in the testicular tissue section. No statistically significant difference was observed in Group I and Group II. A statistically significant increase was found in Group III compared to Groups I and II. iNOS immunoreactivity was decreased in Group IV compared to Group III, but this decrease was still not statistically significant. Group IV and Group V iNOS immunoreactivities were statistically similar. No statistically significant difference was found between Group V and Group II. iNOS immunoreactivity results are shown in Table 2. Testicular sections stained with iNOS are shown in Figure 1.

**Table 2.** Analysis of iNOS immunoreactivity and TUNEL-positive cell count of all groups.

| | Group I | Group II | Group III | Group IV | Group V | *p* |
|---|---|---|---|---|---|---|
| **iNOS immunoreactivity** | 131,19±77,78[a] | 132,46±94,00[ad] | 140,97±82,87[b] | 137,23±90,37[bc] | 136,52±72,70[cd] | 0,0001 |
| **TUNEL Positive cell count** | 0,08±0,34[a] | 0,12±0,38[a] | 1,82±1,42[b] | 0,20±0,53[a] | 0,16±0,46[a] | 0,0001 |

Data are expressed as mean±standard deviation. There was no significant difference between groups containing the same letter (a and b). $p<0.05$ was considered significant. Abbreviations: Group I; Control group, Group II; L-carnitine group, Group III; CCL4 group, Group IV; L-carnitine + CCL4 group, Group V; CCL4 + L-carnitine group, iNOS; inducible nitric oxide synthase, TUNEL;Terminal deoxynucleotidyl transferase dUTP nick end labeling.

### Apoptotic results

TUNEL-positive cells were observed in both seminiferous tubules and inter-tubular connective tissue. According to the cell count results, the TUNEL-positive cell number was increased in Group III when compared with other groups. There was a decrease in the number of TUNEL-positive cells in both L-carnitine groups and the values were close to Groups I and II. Statistical analyses of TUNEL-positive cell counts of the experimental groups are shown in Table 2. TUNEL-positive cells are shown in Figure 1 as FITC+DAPI (merge).

### Discussion

CCl4 has been reported to inhibit spermatogenesis depending on the dose and duration of administration, altering

reproductive function by damaging testicular androgens and gonadotropic secretion (9). The underlying cause of testicular damage is the cytochrome p450 system, which causes the formation of trichloromethyl radicals. CCl4 metabolites react with polyunsaturated fatty acids to form covalent binds with cell membrane elements, resulting in testicular damage (23). In our study, tissue sections belonging to the CCl4 group were also damaged especially seminiferous tubules and spermatogenic series cell group. The JTBS and seminiferous tubule diameter measurements that we used for tissue evaluation were significantly decreased in Group III compared to Group I. Depending on the dose and duration of CCl4 administration, it is inevitable that the testis will not be damaged. In order to reduce the negative effects of various diseases and toxic agents on the reproductive system, various plant extracts, drugs, vitamins, etc. agents were used (2, 22, 24, 25). L-carnitine was found to be effective in both JTBS and MSTD in both the protective and therapeutic groups. L-carnitine plays an important role in lipid metabolism by facilitating long-chain fatty acids and is also known to protect the cell, mitochondrial membrane and DNA integrity against free oxygen radicals (26). We found significant improvements in tissue against CCl4 damage in L-carnitine-treated groups (Group IV and V). In our study, in addition to impaired testicular histomorphology in Group III, iNOS immunoreactivity also increased in both seminiferous tubules and inter-tubular connective tissue. iNOS is induced in a wide range of tissue and cell types to which cytokines and bacterial products are exposed. It is a factor in vasodilatation and inflammation. iNOS is stimulated by proinflammatory cytokines such as lipopolysaccharide and tumor necrosis factor-α and β, interleukin-1α. The role of iNOS in the immune system is very complex, it has both protective and toxic effects (27, 28). Our results show that CCl4 is applied regularly for 6 weeks causing testicular tissue damage and increased iNOS level mediates damage. Oxidative stress and free radicals in tissue cause molecules such as NO to increase (4). NO is continuously synthesized from L-arginine through NOS enzymes, resulting in increased NO accumulation due to increased levels of iNOS. The reduced iNOS immunoreactivity in L-carnitine-treated groups may be due to its function as an agent against oxidative stress in the tissue. L-carnitine protects DNA and membranes against free radicals with its antioxidative effect. Thus, it prevents the formation of reactive oxygen species and protects germ cells (29). Increased production of free radicals and decreased antioxidant defense system cause

accumulation of radicals in the cell and strengthen the formation of testicular apoptosis (26). In our study, an increase in the number of apoptotic cells in the testicular tissues of Group III was observed. The number of apoptotic cells decreased in L-carnitine-treated, Group IV and Group V. L-carnitine has been shown to have an anti-apoptotic effect in diseases such as ischemia-reperfusion, diabetes, and toxic conditions such as atrazine-exposure (26, 30, 31).

## Conclusions

In our study, we showed that CCL4 causes testicular damage according to JTBS, MSTD, iNOS immunoreactivity and apoptosis findings. As a result, it is demonstrated that L-carnitine (200 mg/kg ip) may have a strong protective and therapeutic effect against CCL4-induced testicular damage via iNOS.

## Conflict of interest

No potential conflict of interest was reported by the author(s)

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**Research Article**

# Alterations in Heat Shock Protein 70 (Hsp70) Expression in Sperm of Individuals with Oligozoospermia and Severe Oligozoospermia

Ayla Izmitli[1], Esra Onal[1], Menekse Ulger[1*], Derya Karabulut[1], Ercan Aygen[2], Birkan Yakan[1]

[1]*Erciyes University, Faculty of Medicine, Department of Histology and Embryology, Kayseri, Turkiye.*
[2]*Erciyes University, Faculty of Medicine, Department of Gynecology and Obstetrics, Kayseri, Turkiye.*

**Abstract**

***Aim:****Infertility, defined as the inability to achieve pregnancy after one year of regular, unprotected sexual intercourse, is categorized as either female or male infertility. Male infertility is often associated with impairments in sperm quality and function. Heat shock proteins (HSPs), particularly HSP70, play a critical role as molecular chaperones, protecting cells from stress-induced damage by stabilizing proteins and ensuring proper folding. However, the relationship between HSP70 expression and male infertility has not been fully elucidated. This study aimed to investigate HSP70 expression in sperm samples from individuals with normal, oligozoospermic, and severe oligozoospermic profiles using immunocytochemical techniques.*

***Material and Methods:*** *Sperm samples were obtained from the In Vitro Fertilization Unit of *** University and divided into three groups: Control (>20 million/ml sperm), Oligozoospermic (<15 million/ml), and Severe Oligozoospermic (<5 million/ml). Samples were stained for HSP70, and hormone levels (testosterone, FSH, and LH) were evaluated.*

***Results:*** *HSP70 expression was significantly elevated in the Oligozoospermic group compared to the Control group but decreased in the Severe Oligozoospermic group, reaching levels comparable to the Control group. Hormonal analyses revealed altered levels of testosterone, FSH, and LH in both oligozoospermic groups.*

***Conclusion:*** *These findings suggest increased HSP70 expression in oligozoospermic individuals reflects intracellular disruptions, potentially linked to hormonal dysregulation and organ dysfunction. Such alterations may affect sperm parameters, including morphology, motility, and count. While this study demonstrates a relationship between HSP70 expression and sperm abnormalities under stress conditions, further research is needed to confirm these mechanisms and explore their broader implications.*

***Key Words:*** *HSP70, Male infertility, Oligozoospermia*

* **Corresponding author:** Menekse Ulger, e-mail: menekseulger@gmail.com, ORCID ID: 0000-0003-0108-7948

## Introduction

According to the World Health Organization (WHO), infertility is defined as the inability to achieve pregnancy after 12 months or more of regular, unprotected sexual intercourse. This condition may involve male or female factors, or in some cases, both partners. Male infertility can result from testicular and hypothalamic-pituitary disorders (such as cryptorchidism, orchitis, genital tract infections, varicocele, obstruction of the male genital tract, and hypogonadism), genetic conditions (including Kallmann or Klinefelter syndromes, globozoospermia, and Y chromosome microdeletions), cancer, systemic diseases, medical treatments, or exposure to endocrine disruptors (1). Additionally, lifestyle-related factors such as smoking, alcohol and drug use, high-energy diets, obesity, and psychological stress negatively impact male reproductive potential (2). However, in 10-15% of cases, the etiology remains unclear and is categorized as idiopathic infertility (3). Semen analysis is the primary step in assessing male fertility potential and is widely used in the initial evaluation of couples presenting with infertility (4). This analysis evaluates parameters such as semen volume, color, viscosity, pH, sperm concentration, motility, and morphology (5). Oligozoospermia is defined as a sperm concentration of less than 15 million/ml and is classified as mild, moderate, or severe based on sperm count (5). Heat shock proteins (HSPs), defined as intracellular molecular chaperones, are a family of proteins responsible for protein folding and translocation during cell growth and development (6). HSPs assist in protein refolding and stabilization under stress conditions (7). They are classified based on their structure, molecular weight, and functions (8). While some HSPs are continuously synthesized in cells, the synthesis of others increases under stress conditions. HSP70 belongs to the group of proteins whose synthesis is upregulated during stress (9). HSP70 proteins, located in the cytosol, mitochondria, or endoplasmic reticulum, perform various functions depending on their localization (10). HSP70 plays a significant role in testicular function, with its importance increasing with age, and it is continuously involved in spermatogenesis, a critical process (11).

Understanding the mechanisms underlying infertility is essential for developing and optimizing treatment options. Therefore, the present study aimed to investigate the relationship between HSP70, a molecule known to increase in expression under stress conditions, and oligozoospermia and severe oligozoospermia.

**Method**

Ethical approval for this study was obtained from the *** Clinical Research Ethics Committee (approval number: 2022/191, dated 23.02.2022). Male patients attending the IVF Unit Clinic at *** University Faculty of Medicine for infertility evaluation were categorized based on spermiogram results: individuals with a sperm count above 20 million/ml were included in the Control group, those with a sperm count below 15 million/ml were classified as the Oligozoospermia group, and those with a sperm count below 5 million/ml were placed in the Severe Oligozoospermia group (5). Sperm samples used in this study were obtained from 100 patients aged 20–50 years undergoing In Vitro Fertilization (IVF) treatment at the *** University Faculty of Medicine IVF Unit. Samples remaining after routine IVF procedures were used. Among these individuals, 30 patients within the sperm count range determined in the study were selected and grouped, with 10 patients in each group.

Blood test results routinely monitored in the Urology Clinic were recorded. These included measurements of testosterone, follicle-stimulating hormone (FSH), and luteinizing hormone (LH) levels.

Patients were instructed to adhere to a three-day period of sexual abstinence before providing samples. After the abstinence period, semen samples were collected through masturbation at the clinic, ensuring no use of water, soap, creams, saliva, or similar substances. Samples were collected in wide-mouth, sterile plastic containers. Each container was labeled with the patient's name, surname, and date, and patients were verbally informed about the procedures to follow during sample collection.

Semen samples collected through ejaculation were incubated at 37°C for 1 hour to allow liquefaction. Following liquefaction, the samples were evaluated by an experienced embryologist in accordance with WHO criteria for parameters such as volume, pH, count, motility, and morphology. Sperm count and motility were assessed using a Makler counting chamber. For morphology evaluation, a drop of semen (approximately 10 µl) was placed on a slide, smeared, and air-dried.

Prepared samples were smeared on poly-L-lysine-coated slides by applying 500 µl of the sample to each slide. After air-drying at room temperature, samples were stored at room temperature until staining. Before staining, the prepared samples were fixed in 70% ethanol at -20°C and washed twice with distilled water. Antigen retrieval was performed with citrate buffer at high temperature, followed by cooling.

Phosphate buffer solution was used as the washing solution. Subsequent steps were carried out using the Ultravision detection kit (Ultra Vision Detection System Large Volume TP-125-HLX, Thermo Scientific HRP, CA) following the manufacturer's protocol. HSP70 (sc-33575, Santa Cruz Biotechnology, CA) was stained to visualize the target protein in sperm. Samples were passed through a graded series of alcohol and xylene, then mounted with Entellan (12).

Ten randomly selected fields from each slide were photographed under a microscope (Olympus BX51; Olympus, Tokyo, Japan). The HSP70 staining intensity in the sperms included in the images was measured one by one using ImageJ Software (version 1.45s). Thus, HSP70 expression was measured in a total of 350 sperm in each group.

Statistical analyses for the data in this study were performed using GraphPad Prism 7 software. The normality of data distribution was assessed using the D'Agostino & Pearson normality test. Data with a normal distribution were analyzed using the one-way ANOVA test, followed by Tukey's post-hoc test for multiple comparisons between groups. For non-parametric data, median (minimum-maximum) values were reported, and the Kruskal-Wallis test was used for analysis. Dunn's multiple comparison test was applied to determine statistical differences between groups. A p-value of $<0.05$ was considered statistically significant.

## Results

Semen samples from participants were collected following sexual abstinence and evaluated macroscopically and microscopically. The macroscopic analysis of the Control group samples revealed a more viscous consistency and more intense color and odor compared to the other groups. In contrast, semen samples from the Oligozoospermia and Severe Oligozoospermia groups exhibited a lighter color, milder odor, and lower viscosity compared to the Control group.

In terms of sperm count, a statistically significant reduction was observed in the Oligozoospermia and Severe Oligozoospermia groups compared to the Control group ($p<0.05$). While the sperm count in the severe Oligozoospermia group was lower than in the Oligozoospermia group, this reduction was not statistically significant ($p>0.05$) (Table 1).

The analysis of testosterone, FSH, and LH levels revealed no statistically significant differences between the groups ($p>0.05$). Testosterone levels were higher in the Oligozoospermia group compared to the Control group. In the Severe

Oligozoospermia group, testosterone levels were slightly lower than in the Control group but remained similar overall.

**Table 1.** Results of semen analysis in the experimental groups

| | Control | Oligozoospermia | Severe Oligozoospermia | *p* |
|---|---|---|---|---|
| **Spermiogram** | 121±48.3[a] | 9±2.4[b] | 2.11±1.1[b] | 0.0001 |

*Values are expressed as *10⁶/ml. Data with a normal distribution are expressed as mean ± standard deviation. No statistically significant difference was observed between groups denoted by the same letter(a,b). A p-value of <0.05 was considered statistically significant.*

FSH levels were higher in both the Oligozoospermia and Severe Oligozoospermia groups compared to the Control group, although these differences were not statistically significant. When LH levels were evaluated, both the Oligozoospermia and Severe Oligozoospermia groups showed higher levels compared to the Control group, but these differences also lacked statistical significance.Testosterone, FSH, and LH levels for all experimental groups are summarized in Table 2.

**Table 2.** Testosterone, FSH, and LH measurement results for the experimental groups.

| | Control | Oligozoospermia | Severe Oligozoospermia | *p* |
|---|---|---|---|---|
| **Testosterone** | 403.8±126.2[a] | 513.1±223.4[a] | 407±139[a] | 0.2856 |
| **FSH** | 4.17±2.7[a] | 6.98±3.5[a] | 9.49±9.2[a] | 0.1758 |
| **LH** | 4.92(0.3-54)[a] | 5.98(3.62-10.1)[a] | 6.52(8.24-22.8)[a] | 0.8286 |

*Data with a normal distribution are expressed as mean ± standard deviation, while non-normally distributed data are expressed as median (minimum-maximum). No statistically significant difference was observed between groups denoted by the same letter(a). A p-value of <0.05 was considered statistically significant.*

HSP70 expression measurements were performed on preparations from all experimental groups, and statistical analysis was conducted on the obtained measurements. HSP70 expression was observed to be localized in the head region of the sperm samples, and measurements were made only from this area.

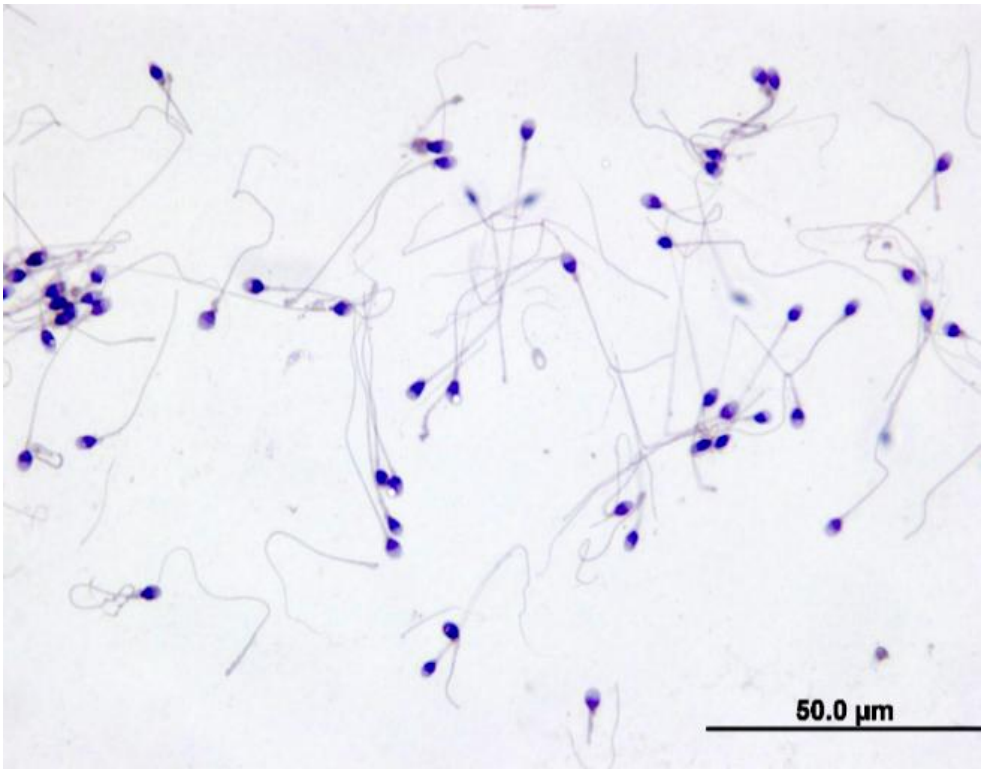


**Figure 1.** Sperm cells from the Control group displayed after staining. 100X objective. Scale bar: 50.0 µm.

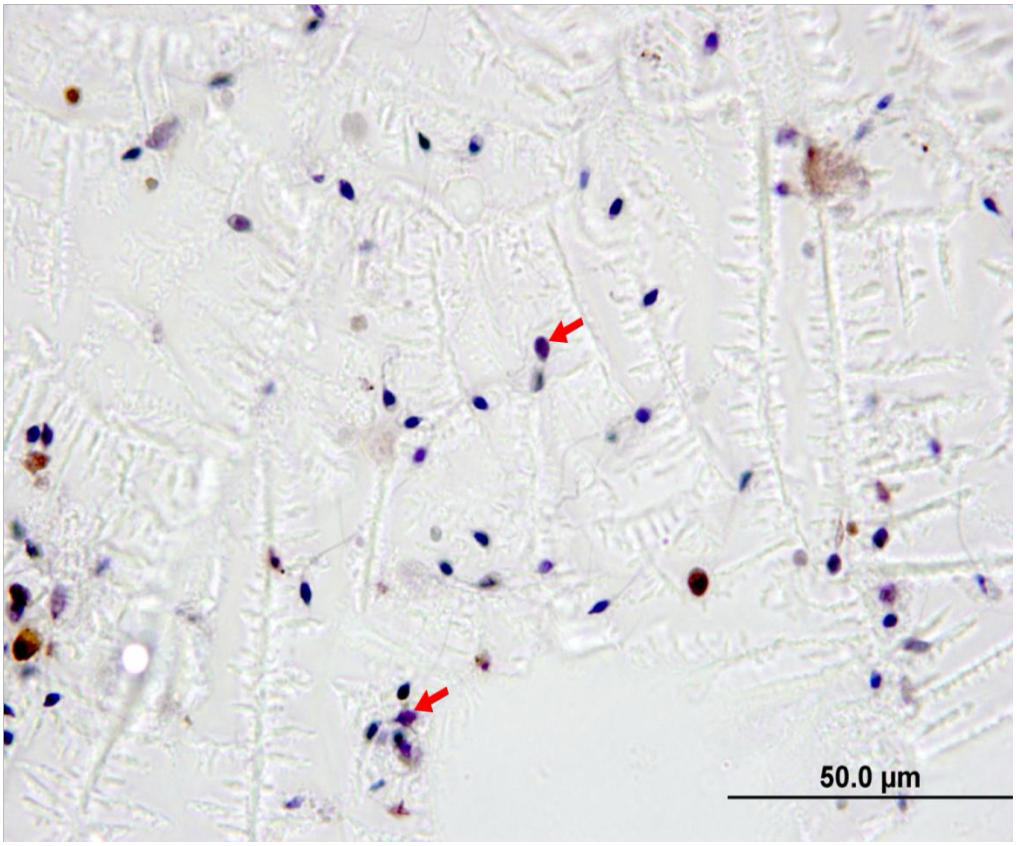


**Figure 2.** Sperm cells from the Oligozoospermia group displayed after staining, showing HSP70 expression (red arrow). 100X objective. Scale bar: 50.0 µm.

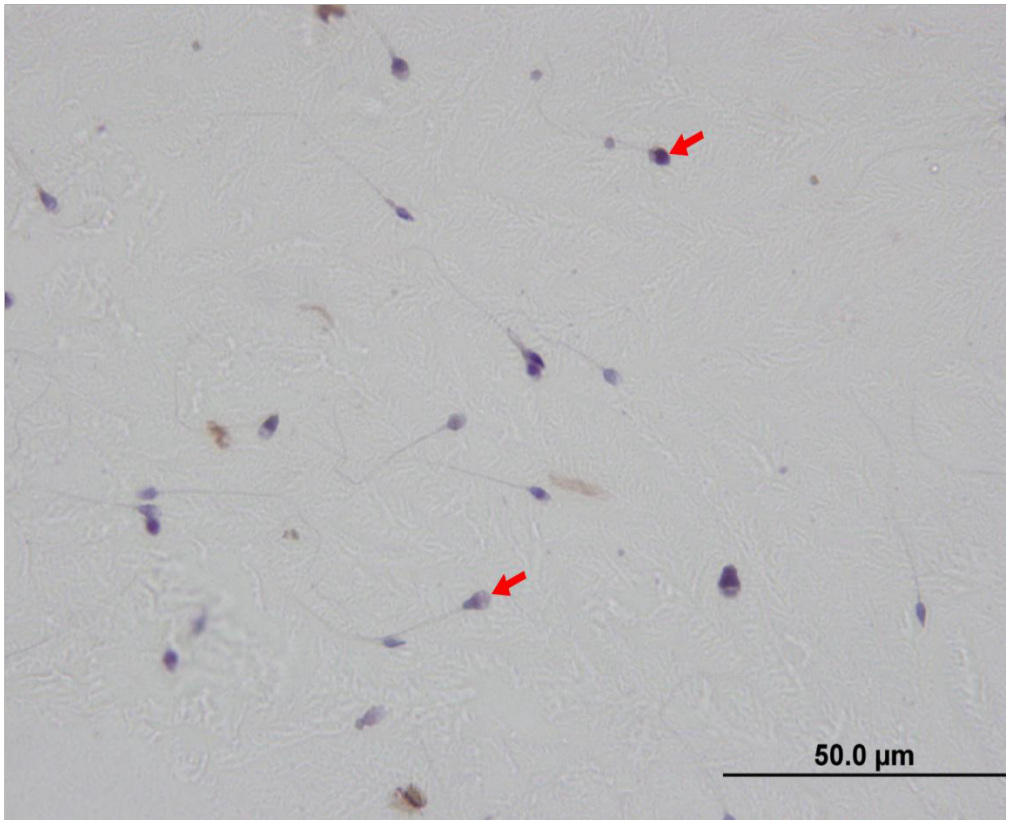


**Figure 3.** Sperm cells from the Severe Oligozoospermia group displayed after staining, showing HSP70 expression (red arrow). 100X objective. Scale bar: 50.0 µm.

The analysis revealed that HSP70 expression was higher in the Oligozoospermia group (Figure 2) compared to the Control group (Figure 1), and this difference was statistically significant ($p<0.05$). In contrast, HSP70 expression in the Severe Oligozoospermia group was lower compared to the Oligozoospermia group, and this difference was also statistically significant ($p<0.05$) (Figure 3). The HSP70 expression in the Severe Oligozoospermia group was similar to that in the Control group, with no statistically significant difference observed ($p>0.05$). The statistical data for HSP70 expression in all experimental groups are presented in Table 3.

**Table 3.** HSP70 expression measurement results for the experimental groups.

| | **Control** | **Oligozoospermia** | **Severe Oligozoospermia** | ***p*** |
|---|---|---|---|---|
| **HSP70** | 116.8(92.0-166.3)[a] | 127.2(101-217.7)[b] | 116.9(94.3-220.1)[a] | 0.0001 |

*Non-normally distributed data are expressed as median (minimum-maximum). No statistically significant difference was found between groups denoted by the same letter(a). A p-value of <0.05 was considered statistically significant.*

**Discussion**

Clinical infertility refers to a couple's inability to achieve pregnancy despite attempting to conceive for 12 months. It is estimated that around 10–20% of couples worldwide experience infertility (12). Moreover, the concept of reproductive success is defined at the couple level, meaning that infertility etiology may be attributed to one or both members of the couple (13). Many studies estimate that male factors contribute to 30–50% of infertility cases (13, 14). Male infertility can arise from various factors, including genetics, testicular dysfunction, endocrinopathies, lifestyle factors (such as smoking and obesity), congenital anatomical factors, gonadotoxic exposures, and aging (15). Furthermore, studies have shown that an imbalance between high levels of reactive oxygen species (ROS) and insufficient antioxidant defense in semen can impair sperm function. ROS are naturally produced during cellular metabolism, and while low levels play a role in sperm capacitation, excessive ROS can damage sperm DNA, lipids, and proteins, leading to decreased motility, viability, and fertility potential (16, 17).

Male fertility is typically defined by semen quality. Clinical guidelines indicate that semen analysis should be performed during the initial evaluation of a couple experiencing infertility (4). Semen analysis is divided into two categories: macroscopic and microscopic. Macroscopic analysis evaluates characteristics such as volume, viscosity, color, odor, liquefaction time, and pH, while microscopic analysis involves parameters such as sperm count, concentration, morphology, motility, and the examination of leukocytes (5, 18).

The endocrinological evaluation of serum FSH and testosterone is not routinely recommended as a laboratory test for all infertile men, but it is necessary when oligozoospermia or azoospermy is present (19). In men, androgen production is primarily carried out by Leydig cells in the testes, and the production of testosterone, a steroid hormone, is crucial for spermatogenesis, male reproduction, and sexual function (20, 21). Testosterone concentrations in the testes are significantly higher than in serum, with one study reporting levels 80 times higher in the testes (22, 23). The lack of a significant difference in serum testosterone levels across groups in this study may be attributed to this. Testosterone is necessary for sperm production, sexual activity, and the development of secondary sexual characteristics. Its production is mediated by the hypothalamic-pituitary-gonadal axis, regulated by gonadotropin-releasing hormone (GnRH), LH, and FSH. This axis

ensures that testosterone produced in the testes provides negative feedback to the hypothalamus and pituitary, thereby reducing LH and FSH secretion (24). Considering that the normal range for total testosterone levels in our clinic is 300-1200 ng/dl, the testosterone levels in our experimental groups were within the normal limits. FSH and LH levels were found to be higher in both the Oligozoospermi and Severe Oligozoospermi groups compared to the Control group. Recent studies have shown that high FSH levels in idiopathic oligozoospermia and severe oligozoospermia may be associated with Leydig cell dysfunction and Sertoli cell dysfunction. Additionally, despite stable testosterone levels, the tendency for LH to increase suggests that Leydig cell function may not be entirely impaired, and instead, a compensatory mechanism may be at play to maintain androgen production (25, 26). Disruption or alteration of the hormonal balance is crucial for the regulation of organ functions, as complex physiological processes are required for organs to perform their duties. One such process, oxidative stress, is vital for maintaining structure and integrity, especially when accompanied by an impaired hormonal balance.

One of the intracellular mechanisms, molecular chaperones known as heat shock proteins (HSPs), has become an important research topic in various areas, particularly in infertility, cancer, and autoimmune diseases (27). Studies on the overproduction of HSP70 in several cell types support the idea that HSP70 increases in cells heading toward tumor development (28). Heat and stress resulting from varicocele activate HSPs, and increased expression of HSP90 in sperm from oligozoospermic men has been observed regardless of varicocele presence (29). In a study by Dangi et al., investigating the HSP gene profile in goats across different seasons, they found that HSP60 mRNA expression was not statistically significant across age groups in the winter but increased with age in the summer (30). Therefore, it was concluded that HSP60 expression may increase with age (31). A testis-specific member of the HSP70 family, HSPA2, has been reported to have decreased expression in infertile men, whereas supplementation with N-acetylcysteine increased its expression (32). Additionally, HSP70 presence has been shown in sperm with capacitation and acrosome reactions in wild boars and mature bulls (33). In a study attempting to elucidate the relationship between HSP70 and male infertility, it was reported that HSP70 expression may have increased in the sperm of infertile men as a protective mechanism against apoptosis (34).

In the present study, HSP70 expression in

sperm samples from individuals diagnosed with Oligozoospermia and Severe Oligozoospermia was higher in the Oligozoospermi group compared to the Control group, while in the Severe Oligozoospermi group, it was lower and similar to that of the Control group. This result is consistent with the testosterone levels observed in our study, suggesting a relationship between HSP70 expression and testosterone levels. Some studies have shown that azoospermia may develop in patients with severe oligozoospermia, while it does not occur in those with mild oligozoospermia. It is also known that initial FSH levels in severe oligozoospermic individuals differ from those of oligozoospermic patients (35). Moreover, the deletion of Nlrp14, a key regulator of primordial germ cell-like cell (PGCLC) differentiation, has been shown to cause reproductive failure, severe oligozoospermia, sperm abnormalities, and decreased HSP70 expression in both male and female mice (36). In oligozoospermic patients with varicocele, the HSP70 gene was found to be decreased compared to patients with varicocele but normal sperm count (37). Considering these results along with the findings of the present study, it is suggested that individuals with decreased HSP70 gene expression may not be able to perform the protective function of HSP70 proteins in response to environmental stress, which may lead to a reduction in sperm count. The results of this study further emphasize that HSP70 expression increases in the sperm of oligozoospermic men, but it does not increase in severe oligozoospermic patients. When the necessary conditions for maintaining the functionality of various intracellular mechanisms are not met, cellular damage from disturbed intracellular structures may lead to irreversible processes. The decrease in HSP70 expression in sperm from severe oligozoospermic men may indicate the presence of dysfunctional intracellular mechanisms. While sperm samples from patients diagnosed with severe oligozoospermia are analyzed visually, detailed mechanistic techniques for assessing functionality have not been employed.

The findings of this study, demonstrating decreased HSP70 expression in sperm samples, suggest that intracellular molecular chaperone mechanisms may be disrupted. To clarify this issue further, it is concluded that both mRNA expression and the HSP70 protein levels should be evaluated in conjunction with sperm count.

**Conclusion**

The production of healthy sperm relies on the collaboration of many complex physiological processes that create a harmonious microenvironment. Organ

functionality continues under the influence of hormones; however, disrupted intracellular mechanisms during production pave the way for diagnostic criteria such as sperm morphology, motility, and count, which are obtained in the laboratory. The results of this study revealed that there were no significant differences in the levels of FSH, LH, and testosterone hormones among different patients diagnosed with oligozoospermia. Additionally, the differing HSP70 expression in sperm samples from oligozoospermic and severe oligozoospermic patients indicates the presence of intracellular dysfunctional mechanisms. As a molecular chaperone, HSP70 plays a role in correcting disrupted functionality by increasing its expression within the cell. Although this study sought to identify the potential dysfunction of molecular chaperone mechanisms in the Severe Oligozoospermia group through immunohistochemical analysis of HSP70, further detailed analyses are needed to support these findings.

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During the preparation of this work the authors used ChatGPT 3.5 in order to improve language and readability, with caution. After using this tool, the authors reviewed and edited the content as needed and takes full responsibility for the content of the publication.

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**Clinical Research**

# Comparison of Urine Microscopy Results Obtained from Semi-Automatic Camera System versus Automatic Urine Analyzer

Bagnu Dundar[1*], Hatice Nur Halipci Topsakal[2], Fatma Bozkurt[3]

[1]*Istanbul Atlas University Faculty of Medicine, Department of Medical Biochemistry, Istanbul, Turkiye.*
[2]*Istanbul Atlas University, Vocational School, Medical Laboratory Techniques Program Istanbul, Turkiye.*
[1]*Istanbul Atlas University Faculty of Medicine, Department of Medical Biochemistry, Istanbul, Turkiye.*

## Abstract

*Nowadays, it is quite common in medical laboratories to use devices with a fixed slide system under the microscope objective for microscopic examination of urine, which eliminates the hassle of preparing slides between slides for microscopic examination of urine and standardizes the sediment volume.*
***Objective:*** *In our study, we compared the microscopic analysis results obtained with the Sysmex UF-100 device, one of the fully automated systems, and the DiaSys R/S 2003 device with a fixed slide (OSA) system. We aimed to identify the parameters that can be used interchangeably and give results that support each other, to reveal inconsistent results, if any, and to determine the method that we can obtain more quantitatively consistent results.*
***Method:*** *The data obtained from the analysis results for both systems were analyzed into the SPSS 22.0 program. Descriptive values were expressed as number (n), mean (Mean), minimum (min), maximum (max), median standard deviation (SD). Continuous variables were compared with the Wicoxan Signed Ranks test because they did not fit the normal distribution. $p< 0.001$ was considered statistically significant.*
***Findings:*** *When UF-100 was compared with OSA, the analysis results for erythrocyte, leucocyte, epithelial cell parameters were not compatible with each other. We obtained, the results of manual microscopy with OSA together with the UF-100 device are highly consistent.*
***Conclusion:*** *It has been concluded that it would be more appropriate to perform microscopic examination between the slides for the evaluation of structures such as casts.*

***Key words****: DiaSys R/S 2003, Manual microscopy, UF-100, Urine analysis,*

*** Corresponding author:** Bagnu Dundar, E-mail: bagnu.dundar@atlas.edu.tr, ORCID ID: 0000-0003-1052-5911

## Introduction

Urine is considered a liquid tissue biopsy specimen of the urinary system. It is an economical material that provides detailed information about renal function. For this reason, nowadays routine urine analysis is one of the most requested tests in laboratories (1). The variability of routine urine analysis results depending on the person performing the procedure has led to the need for standardization in this field. In recent years, strips, strip readers, semi-automatic and fully automatic devices that evaluate microscopic shaped elements in urine have been developed to ensure standardization in this field. In addition, devices with a fixed slide system under the microscope objective have been developed for microscopic examination of urine, which eliminates the difficulty of preparing slide-to-lamel preparations and standardizes the sediment volume (2).

In this study, we aimed to examine the consistency and correlation of the results of microscopic analyses performed on the Sysmex UF-100, one of the standard and accepted automated systems, and the DiaSys R/S 2003 system with a fixed slide, Optical Slide Assembly (OSA) system.

## Material and Methods

This study was prospectively planned to perform microscopic analysis of urine samples collected in the morning from outpatients and outpatients in Haydarpaşa Numune Hospital Biochemistry and Clinical Biochemistry laboratories within two hours by two different methods, regardless of age and gender.

Although manual analysis in urine microscopy seems to be disadvantageous in terms of human experience and user differences, in this study, the data obtained from OSA, which seems to be more standardised than manual microscopy, was taken as the basis for comparison.

### Collection of Specimens

341 urine samples were collected from the patients. The number of erythrocytes, leukocytes, epithelial cells counted in the high power field (HPF) and the presence or absence of casts, crystals and yeast cells were evaluated and compared in the Sysmex UF-100 device ( Fig. 1) and DiaSys R/S 2003 (OSA) (Fig 2.) device in the urine samples.

**Figure 1.** Sysmex UF-100 device.

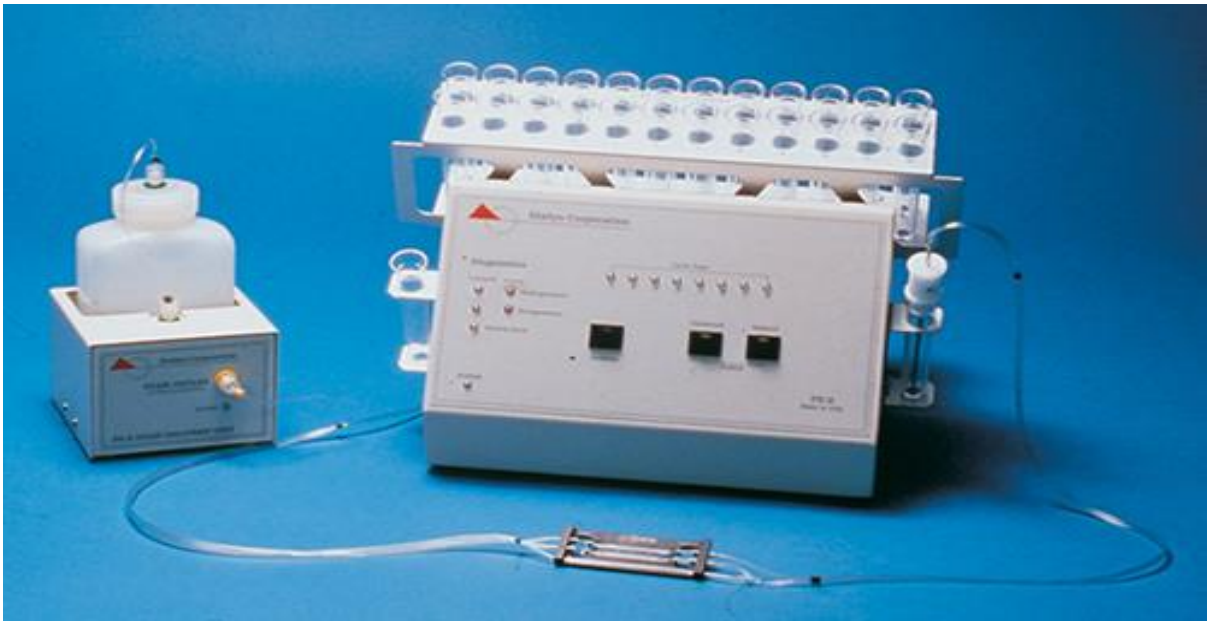

**Figure 2**. DiaSys R/S 2003, Optical Slide Assembly (OSA).

In this study, urine sample volume was determined as 10 ml and appropriate plastic conical tip tubes were used. The urine-filled tubes were then analyzed in the Sysmex UF-100 device without centrifugation. The missing volume was completed and the urine-filled tubes were centrifuged at 400 g for 5 minutes. After centrifugation, the supernatant portion of the urine sample was carefully removed from the sediment

portion and examined microscopically in the chamber connected to the DiaSys R/S 2003 device with 0.5 ml sediment volume. Data were analyzed into the SPSS 22.0 program for statistical analyses. Continuous variables were compared with the Wicoxan Signed Ranks test because they did not fit the normal distribution. $p<0.001$ was considered statistically significant.

The Sysmex UF-100 instrument (Sysmex TOA Medical Electronics, Europe; GmbH, Hamburg, Germany) is a fully automated urine analysis system. The UF-100 uses a combination of flow cytometry technology and impedance detection to identify and count structures present in urine (3). The structures in the urine pass through the Flow Cell with the 'hyrodynamic focusing' method. During this passage, they are exposed to the laser beam and stained. The change in the scattered beam is measured by staining and impedance (voltage change) and is displayed as a numerical value on the results screen. For each fragment, the change in scattered beam, staining and impedance are converted into electrical signals and the analysis is completed. Fragment distributions are displayed as 'scattergrams' and 'histograms' (4). The UF-100 can evaluate erythrocytes (RBC), leukocytes (WBC), epithelial cells (EC), casts, bacteria, small round cells (SRC), yeast-like cells (YLC), crystals (X'tal) and sperms. The results of RBC, WBC, EC, CAST and bacteria are given by the device in count/microliter and count/HPF (5, 6).

**UF-100 and DiaSys R/S 2003 Devices Analysis**

The UF-100 instrument has the ability to evaluate analysis results as positive or negative. Positive samples receive a 'review', prompting the user to compare the result with a microscope (7). When samples were observed under UF-100, it is determined as positive if the presence of casts, crystals and yeast cells. After the first observation under UF-100, the samples were examined under OSA as double check and the results were determined after both analysis. If both analysis show positive results we interpreted the test as positive for each parameters. All the statistical analysis were obtained according to that evaluation.

The UF-100 instrument can be connected to test strip readers, allowing chemical and microscopic analysis of urine to be obtained in a single study and in a single report format (4). The DiaSys R/S 2003 is a two-part instrument that does not require a special place in the laboratory. The first part is a fixed slide made of high quality optical glass. The device is known as Optical Slide Assembly, commonly abbreviated OSA. There is a capillary space between the OSA that allows the flow of fluid.

The OSA is a 81.92 mm x 27.94 mm slide with tubings on the short sides that allow fluid to enter. One tubing starts from the short side of the slide and ends with the aspirator tip, while the other tubing extends between the slide and the device. The end that ends with the aspirator tip allows the sediment to be aspirated. The instrument is automatically washed and cleaned between these two aspiration systems. This prevents sample-to-sample contamination (8)

An equal volume of 210 microliters of urine sediment sample is aspirated each time. The total sample volume in the slide is 5 microliters and is divided into 100 small squares in the middle section, the volume of this section is 1 microliter. The volume of a single small square is 0. 01 microliter. The depth of field is 0. 127mm. Counting is done in the area of 100 small squares (9).

The second part of the device consists of a fixed unit. On this unit there is a holder system that allows the tubes to be placed. Behind the unit are reservoirs containing the fluids used for cleaning. Microscopic studies performed with this device have been found to comply with NCCLS and CLIA criteria and have been approved by the FDA (10,11).

**Statistical Analysis**

I All statistical analysis were run using SPSS 2022. All data were represented as mean ± standard deviation (SD). Statistical differences between OSA and UF-100 were determined via McNemar statistical test, Chi-Square Analysis for crystals, yeasts and casts.

Statistical comparison between OSA and UF-100 for RBC, WBC, EC was performed with Wicoxan Signed Ranks statistical test. As a result of statistical evaluation, a significant difference of $p<0.001$ was found between the UF-100 device and OSA (Table 1).

**Results**

When analyzing for casts, crystals and yeast cells on the UF 100 device, it was recorded as positive or negative, and a comparison was carried on. The results were recorded as positive if an observation was recorded for casts, crystals and yeast cells, and negative if no observation was recorded on the OSA device .

When samples were observed under UF-100, it is determined as positive if the presence of casts, crystals and yeast cells. After the first observation under UF-100, the samples were examined under OSA as double check and the results were determined after both analysis. If both analysis show positive results we interpreted the test as positive for each parameters.

**Results for Casts:** 311 urine samples were

negative in UF-100, 30 urine samples were positive in OSA and 39 urine samples were positive in UF-100 under microscopic examination. The P value was 0. 151, indicating that there was no significant difference between the two devices. In addition, the sensitivity of the UF-100 device for cast was 63%, specificity 94%, positive predictive value 49% and negative predictive value 96%. The sensitivity of OSA for cilia is 61.7%, the specificity was 100%, positive predictive value was 100% and negative predictive value was 90.3%.

**Results for crystal:** 282 urine samples were negative for crystals in OSA, 235 urine samples were negative for crystals in UF-100, 59 urine samples were positive in OSA and 106 were positive in UF-100. $p<0.001$, indicating a significant difference between the two devices. The sensitivity of the UF-100 device for crystal was 75%, specificity 83%, positive predictive value 94% and negative predictive value 99%. The crystal sensitivity of OSA was 49.1%, specificity 55.6%, positive predictive value 56.8% and negative predictive value 94.9%.

**Results for yeast cells:** Yeast cells were found negative in 334 urine samples in OSA, negative in 324 urine samples in UF-100 device, positive in 7 urine samples in OSA and positive in 17 samples in UF-100 device. $p<0.05$ was obtained and a significant difference between the two devices was determined. The sensitivity of the UF-100 device for yeast cells was 71%, specificity 96%, positive predictive value 42% and negative predictive value 99%. The sensitivity of OSA for yeast cells was 61.2%, specificity 96.4%. The positive predictive value was 36.8% and the negative predictive value was 99.4%.

## Discussion

Today, routine urine analysis is the most commonly performed analysis in laboratories. Urine analysis has gained an indispensable place among routine laboratory tests because urine sample can be obtained easily, no invasive intervention is required, and it provides important information about renal and extrarenal diseases (6, 12). Microscopic analysis of urine is the most time-consuming and labor-intensive part of urine analysis and involves a wide variety of observers (13). Microscopic analysis of urine is still not standardized. In recent years, test strips and strip readers have been developed for rapid and reliable chemical analysis of urine, and some standardization has been achieved in this way. Similarly, microscopic analysis also needs to be standardized. Automatic and semi-automatic systems developed for this purpose have been examined by many researchers through comparison studies (9, 10,14).

In our study, more erythrocytes, leukocytes and epithelial cells were seen in the urine samples studied with the UF-100 device than in manual microscopic urine analysis (MSA), in accordance with other studies. Toru Hyoda et al. stated that the UF-100 device can count both lysed and unlysed erythrocytes present in fresh urine that has not been centrifuged, it can determine from which part of the urinary system the erythrocytes originate, and microscopic elements (such as bacteria and crystals) that are equal in size and smaller than erythrocytes can be considered as erythrocytes. Fogazzi et al. In their study of 1943 urine samples, they found that the number of erythrocytes determined by the UF-100 device was higher than expected compared to manual microscopic examination because the erythrocytes were lysed during the centrifugation process required for manual microscopic examination and therefore could not be detected and that this discrepancy was especially among samples containing high amounts of yeast, crystals and bacteria (15).

In our study, we found that there was no significant difference between both devices for casts. The results were consistent with each other. However, when the studies compatible and incompatible with our study results are evaluated; Fogazzi et al. (2007) reported that the reason for the weak correlation between the UF-100 device and manual microscopy in terms of casts was that mucus was evaluated as false positive casts by the device in urine samples containing high amounts of mucus in the UF-100 device, while Jonathan Ben-Ezra et al. reported in their study that the UF-100 device discovered casts less than cellular elements (16); Brilha et al. explained in their study on 1001 urine samples that the UF-100 device evaluated some shaped elements in urine as casts, which may cause false positive results (17). According to our results; the sensitivity of the UF-100 device for casts was 63%, specificity was 94% and there is no significant deifference between the devices for casts.

In our study, we found a significant difference between the UF-100 device and OSA in detecting crystals in urine. Consistent with our study results, Bai et al. reported that the UF-100 device was able to detect half of the crystal-positive manual microscopy specimens in their study of 438 urine specimens (14), while Jonathan Ben-Ezra et al. reported that the UF-100 device did not discover crystals very well but increased sensitivity by warning the user (17). Likewise, in our study, a significant difference was found in the detection of yeast cells when the UF-100 device was

compared with OSA (14). found a concordance between UF-100 and manual microscopy in terms of yeast cells in their study, while Brilha et al., in their study with 1001 urine samples, stated that the UF-100 device is not a good determinant, explaining the reason as the positive interference of yeast cells for erythrocytes, and that using the strip method is more helpful in this case.

In the study, a significant difference was found between the two devices for the presence of yeast cells ($p$>0,05). The sensitivity of the UF-100 device for yeast cells was 71%, specificity 96%.

In our study, manual microscopic examination was performed with OSA on a DiaSys R/S 2003 device. We considered that one of the reasons for the lower cell counts in the results of the study performed with OSA was the lack of adequate homogenization during the resuspension of the urine sediment, and the other reason was that the shaped elements with different molecular weights in the urine sediment may prevent homogeneous distribution between the chambers.

## Conclusion

In the light of these considerations, it is seen that there is not yet a reference method for analyzing urine. It is obvious that there is a need for the use of all automatic, semi-automatic and manual methods and that the routine use of automatic systems will increase in the future with the increase in microscopic discrimination power. In the future, the evaluation of data by artificial intelligence and the use of machine learning will add a new dimension to urine analysis methods.

## Conflict of Interest

There are no conflicts of interest in connection with this paper, and the material described is not under publication or consideration for publication elsewhere.

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**Research Article**

# The Effect of Traumatic Stress on Sleep and Attention in University Students who Experienced the 2023 Kahramanmaras Earthquake

Mine Argali Deniz[1*], Muhammed Furkan Arpaci[2] , Hidir Pekmez[2] , Rukiye Ciftci[3] , Sibel Atesoglu Karabas[4] , Ozlem Akay[5] , Davut Ozbag[6]

[1]*Suleyman Demirel University, Research and Application Hospital, Physical Therapy and Rehabilitation Unit, Isparta, Turkiye.*
[2]*Malatya Turgut Ozal University, Faculty of Medicine, Department of Anatomy, Malatya Turkiye.*
[3]*Gaziantep Islam and Technology University, Faculty of Medicine, Department of Anatomy, Gaziantep, Turkiye.*
[4]*Kahramanmaras Sutcu Imam University Faculty of Medicine, Faculty of Medicine, Department of Anatomy, Kahramanmaras, Turkiye.*
[5]*Gaziantep Islam Science and Technology University Faculty of Medicine, Department of Biostatistics, Gaziantep, Turkiye.*
[6]*Adıyaman University, Faculty of Medicine, Department of Anatomy, Adıyaman, Turkiye.*

**Abstract**

***Aim:*** *The research was conducted to determine the post-traumatic stress of earthquake-affected medical students and to reveal the effects of this stress on sleep and attention.*
***Methods:*** *458 earthquake-affected medical students were reached through Google Forms. Socio-demographic form, Traumatic Stress Symptom Scale, Richard-Cambell Sleep Scale and Adult Attention Deficit Hyperactivity Self-Report Scale were administered to all participants.*
***Results:*** *More than 80% of the students affected by the earthquake experienced moderate-severe and severe trauma. It was observed that there was a relationship between the students' traumatic stress situations, their sleep quality and the possibility of suffering from attention deficit hyperactivity disorder (*$p$*=0.000).*
***Conclusion:*** *We believe that creating psychological and social awareness caused by the earthquake will be effective in minimizing possible negativities. In addition, since lack of sleep and attention caused by stress after the earthquake may negatively affect students studying anatomy, precautions must be taken regarding course duration and methods.*

***Key Words:*** *Attention, Earthquake, Sleep disorder, Student, Traumatic stress.*

* **Corresponding author:** Mine Argali Deniz, e-mail: minedeniz@sdu.edu.tr , ORCID ID: 0000-0001-8055-9530

## Introduction

Türkiye experienced two major earthquakes centered in Kahramanmaraş on February 6, 2023. After these severe earthquakes, more than 50,000 people lost their lives, more than 100,000 people were injured, and many people in the region became homeless and unemployed, especially in Kahramanmaraş, Gaziantep, Malatya, Hatay, Adıyaman, Şanlıurfa, Diyarbakır, Adana, Osmaniye and Kilis provinces (1, 2). It is obvious that the large area affected by this earthquake, called the disaster of the century, and the large number of people exposed to the earthquake caused social trauma. Students were also seriously affected by the social trauma (3).

Post-traumatic stress symptoms, usually after trauma are considered the most common negative psychological reactions in social trauma. This situation is usually triggered by the traumatic event with fear and helplessness following direct or indirect exposure (hearing stories or seeing pictures) it presents with symptoms. The traumatic event is relived through flashbacks and uncontrollable dreams. After trauma, shock, fear, anger, sleep problems, intense panic, anxiety, hopelessness, concentration problems, social withdrawal reactions such as withdrawal and feelings of unhappiness may be observed (4) .

In addition to the stress experienced, one of the most important problems is sleep problems due to the fear of being exposed to trauma again and anxiety about the future (5, 6). In order to restore order after the earthquake, allocating dormitories to earthquake victims and providing online education, as the priority is to meet basic needs such as shelter, may affect both students' post-traumatic stress and their attention in education, too (7, 8).

The aim of our study was to determine the post-traumatic stress of volunteer medical students in Kahramanmaraş, Gaziantep, Malatya and Adıyaman provinces, which were among the provinces most affected by the earthquake, and to determine how this stress affects sleep and attention.

## Method

A total of 458 students, 159 (34.7%) males and 299 (65.3%) females, were included in this prospective, cross-sectional and analytical study. In the study, all evaluations were delivered to earthquake-affected students studying at XXXXX University Faculty of Medicine via Google Forms, and surveys were administered to volunteer students. Criteria for inclusion in the study; All volunteer medical faculty students, between the ages of 18-65, who experienced the 2023 Kahramanmaraş-centered earthquake, who spoke Turkish

and did not have a mental or physical disorder that prevented them from understanding the questions, were included.

Permission for the study was received from the rectorates of XXXXX University. The study was started after receiving approval from X University Non-Interventional Clinical Research Ethics Committee (B.177/2023).

All students within the scope of the study were evaluated with a socio-demographic form, as well as Traumatic Stress Symptom Scale, Richard-Cambell Sleep Scale, and Adult Attention Deficit Hyperactivity Self-Report Scale surveys. In the socio-demographic form, age, gender, the distance of the place where the earthquake occurred to the earthquake epicenter, whether they felt the earthquake tremors or not, where they were during the earthquake, whether they were trapped under the rubble or not, whether their family and close circle experienced the earthquake, whether anyone lost their lives, house damage in the earthquake, property loss, post-earthquake status. The place of shelter, satisfaction with the aid provided after the earthquake, whether there was financial distress after the earthquake, whether they received psychological support, the level of fear experienced during the earthquake, fear of a possible earthquake, and the feeling of helplessness related to the control situation in life were questioned.

*Post-Traumatic Stress Disorder Symptoms Scale:* It is a self-report scale developed by Foa et al. (9) to diagnose Post-traumatic Stress Disorder (PTSD) based on 4 criteria. The lightest value taken from the scale is between 1 and 10, the middle value is between 11 and 20, and the medium and severe value is between 21 and 35. Values of 36 and above indicate severe PTSD.

*Richard-Cambell Sleep Scale:* The scale was developed by Richards in 1987, and its Turkish validity and reliability study was conducted by Karaman Özlü and Özer [9] in 2015. The scale questions the depth of night sleep, the time before falling asleep, the frequency of waking up, the time spent awake after waking up, the quality of sleep and the noise in the environment. Each item in the scale is evaluated by scoring between 0-100. A score of 0-25 indicates very poor sleep, and 76-100 indicates a very good sleep. In summary, a high score indicates a good sleep quality (10).

*Adult Attention Deficit Hyperactivity Self-Report Scale:* It is a scale developed by the World Health Organization (WHO). The scale consists of two subsections: section A - attention deficit and section B - hyperactivity\impulsivity. The scale is scored on a five-point Likert scale: 0 for never, 1 for rarely, 2 for sometimes, 3 for often, 4 for very often. A Turkish validity

and reliability study was conducted by Doğan et al. Scale grading: Those with 24 points and above are considered to have "highly likely Attention Deficit Hyperactivity Disorder (ADHD)", those with 17-23 points as "possible ADHD", and those with 0-16 points as not having ADHD (11).

*Statistical Analysis:* Sample of the study According to the analysis of previous studies using the Gpower 3.1 program. The sleep variable is based on the blind coefficient of 0.70, the effect size is 0.12, the delivery power is 90%, the lowest number of samples is n, with the prediction of type one error level of α: 0.05. Calculated as :368. Descriptive statistics of the variables used in the study are given as frequency and percentage values for qualitative variables, and mean, standard deviation, median, minimum and maximum values for quantitative variables. The suitability of quantitative variables to normal distribution was examined with the Kolmogorov-Smirnov test. One-way analysis of variance (ANOVA) test was used for comparisons of normally distributed variables in more than two groups, and LSD test was used as Post Hoc test. Mann-Whitney U test was used for pairwise group comparisons of variables that did not show normal distribution. Chi-square analysis was performed to examine the relationship between categorical variables. Cronbach's Alpha values were calculated for the traumatic stress symptom scale and the adult hyperactivity self-report scale and were found to be 0.938 and 0.903, respectively. It can be said that the scales are highly reliable. It was observed that the items in both scales were not additive ($p$<0.05) and that there was a difference between the measurements for both scales ($p$ < 0.000). Analyzes were carried out with the help of IBM SPSS Statistics 25.0 program and the significance level was taken as $p$<0.05.

**Results**

Descriptive statistics of the ages of the male and female students included in the study are median (min-max) values of 20 (16-47), 20 (18-52), respectively, and there is a statistically significant difference in the age of the students according to their gender ($p$=0.041). The number of people and percentages of the questions asked to students about the earthquake are given in Table 1.

**Table 1.** Questions asked to students about earthquakes.

| | | n | % |
|---|---|---|---|
| **How far was the place where you experienced the earthquake from the epicenter?** | 1 = Within 50 km of epicenter | 186 | 40,6 |
| | 2 = 50-100 km away | 140 | 30,6 |
| | 3 = more than 100km away | 132 | 28,8 |
| **Have you felt the earthquake tremors?** | 1 = Yes | 450 | 98,3 |
| | 2= No | 8 | 1,7 |
| **Where were you during the earthquake?** | 1 = In a building | 449 | 98,0 |
| | 2 = In the open / on the street | 1 | 0,2 |
| | 3 = In a vehicle | 3 | 0,7 |
| | 4 = Other | 5 | 1,1 |
| **Have you been trapped under debris?** | 0 = No | 452 | 98,7 |
| | 1 = Yes | 6 | 1,3 |
| **Did your family or close friends experience the earthquake?** | 0 = No | 22 | 4,8 |
| | 1 = Yes | 436 | 95,2 |
| **Has anyone in your family or close friend lost their lives?** | 0 = No | 272 | 59,4 |
| | 1 = Yes | 186 | 40,6 |
| **House damage in earthquake?** | 1 = No damage | 107 | 23,4 |
| | 2 = Light | 203 | 44,3 |
| | 3 = Medium | 50 | 10,9 |
| | 4 = Damaged Ruined | 98 | 21,4 |
| **Property loss in an earthquake?** | 0 = No | 234 | 51,1 |
| | 1 = Yes | 224 | 48,9 |
| **Where did you stay after the earthquake?** | 1 = In my own home | 201 | 43,9 |
| | 2 = In a new house | 35 | 7,6 |
| | 3 = Tent-Container | 49 | 10,7 |
| | 5 = Relative-friend side | 122 | 26,6 |
| | 6 = Other | 51 | 11,1 |
| **Are you satisfied with the help and support you received after the earthquake?** | 0 = No | 259 | 56,6 |
| | 1 = Yes | 199 | 43,4 |
| **Did you experience financial difficulties after the earthquake?** | 0 = No | 233 | 50,9 |
| | 1 = Yes | 225 | 49,1 |
| **Did you receive psychological support after the earthquake?** | 0 = No | 418 | 91,3 |
| | 1 = Yes | 40 | 8,7 |
| **How would you rate the fear you experienced during the earthquake, according to the scale?** | 0 = I have almost no fear | 17 | 3,7 |
| | 1 = A little | 38 | 8,3 |
| | 2 = Quite | 73 | 15,9 |
| | 3 = Severe | 96 | 21,0 |
| | 4 = Very Severe | 234 | 51,1 |
| **How much fear/anxiety do you experience thinking about an earthquake that may happen in the near future?** | 0 = I have almost no fear/anxiety | 21 | 4,6 |
| | 1 = A little | 82 | 17,9 |
| | 2 = Quite | 110 | 24,0 |
| | 3 = Severe | 116 | 25,3 |
| | 4 = Very Severe | 129 | 28,2 |
| **How much control do you think you have over your life?** | 0 = I have no control, I feel very helpless | 189 | 41,3 |
| | 1 = I have some control, I feel quite helpless | 184 | 40,2 |
| | 2 = I have a lot of control, feel a little helpless | 66 | 14,4 |
| | 3 = I have complete control, I don't feel helpless at all | 19 | 4,1 |

n: Number of people, %: Percentage

Questions with many and excessive answers in the evaluation of the number and percentage rates according to the traumatic stress symptom scale: "1. I cannot get some memories/images about the earthquake out of my mind", "2. Sometimes my experiences suddenly flash before my eyes like a film strip and it is as if I am experiencing everything again.", "12. I get startled when there is a sudden sound or movement.","13. I feel uncomfortable when anything reminds me of my experiences with the earthquake." 180 (49.3%), 175 (38.2%), 199 (43%) respectively. .4) and 190 (41.5%). The number and percentage values of the questions "18. I feel guilty" and "22. I feel sad and dejected", to which a high rate of answers are 'never', are 232 (50.7%) and 317 (69.2%) (Table 2).

**Table 2.** Traumatic Stress Symptom Scale.

| Survey Questions | | None n (%) | A little bit n (%) | Quite n (%) | Much and Extreme n (%) |
|---|---|---|---|---|---|
| **1.** | I can't get some memories/images about the earthquake out of my mind. | 31 (6,8) | 94 (20,5) | 153 (33,4) | 180 (39,3) |
| **2.** | Sometimes my experiences suddenly flash before my eyes like a movie strip and I feel like I'm reliving everything. | 39 (8,5) | 114 (24,9) | 130 (28,4) | 175 (38,2) |
| **3.** | I often have scary dreams. | 129 (28,2) | 162 (35,4) | 88 (19,2) | 79 (17,2) |
| **4.** | I cannot do some things easily for fear of another earthquake (for example: entering safe houses, taking a bath, sleeping alone or in the dark). | 116 (25,3) | 135 (29,05) | 111 (24,2) | 96 (21,0) |
| **5.** | My interest in life has diminished. | 72 (15,7) | 124 (27,1) | 128 (27,9) | 134 (29,3) |
| **6.** | I feel that I am estranged from people and alienated from them. | 91 (19,9) | 143 (31,2) | 113 (24,7) | 111 (24,2) |
| **7.** | It feels like my emotions are dead. | 100 (21,8) | 123 (26,9) | 119 (26,0) | 116 (25,3) |
| **8.** | I'm having trouble sleeping. | 100 (21,8) | 132 (28,8) | 116 (25,3) | 110 (24,0) |
| **9.** | I get angry or angry more easily. | 92 (20,1) | 107 (23,4) | 121 (26,4) | 138 (30,1) |
| **10.** | I experience forgetfulness or have difficulty concentrating on what I am doing. | 63 (13,8) | 92 (20,1) | 129 (28,2) | 174 (38,0) |
| **11.** | I remain alert, worried that an earthquake will occur at any moment. | 78 (17,0) | 158 (34,5) | 125 (27,3) | 197 (21,2) |
| **12.** | I get startled when there is a sudden sound or movement. | 32 (7,0) | 106 (23,1) | 121 (26,4) | 199 (43,4) |
| **13.** | I feel uncomfortable when anything reminds me of my experiences with the earthquake. | 44 (9,6) | 101 (22,1) | 123 (26,9) | 190 (41,5) |
| **14.** | I'm trying to get the thoughts and feelings about the events I experienced during the earthquake out of my mind. | 73 (15,9) | 109 (23,8) | 146 (31,9) | 130 (28,4) |
| **15.** | I have difficulty remembering some parts of the events I experienced during the earthquake. | 130 (28,4) | 143 (31,2) | 103 (22,5) | 82 (17,9) |
| **16.** | Since the earthquake made me realize that I could die at any moment, making long-term plans seems pointless to me. | 66 (14,4) | 95 (20,7) | 105 (22,9) | 192 (41,9) |
| **17.** | When anything reminds me of my experiences with the earthquake, I experience physical symptoms such as palpitations, sweating, dizziness, and tension in my body. | 153 (33,4) | 138 (30,1) | 93 (20,3) | 74 (16,2) |
| **18.** | I feel guilty. | 232 (50,7) | 112 (24,5) | 62 (13,5) | 52 (11,4) |
| **19.** | I feel sad. | 43 (9,4) | 136 (29,7) | 138 (30,1) | 141 (30,8) |
| **20.** | I can't enjoy life like I used to. | 58 (12,7) | 111 (24,2) | 128 (27,9) | 161 (35,2) |
| **21.** | I am hopeless about the future. | 87 (19,0) | 121 (26,4) | 103 (22,5) | 147 (32,1) |
| **22.** | From time to time, thoughts of killing myself cross my mind. | 317 (69,2) | 66 (14,4) | 37 (8,1) | 38 (8,3) |
| **23.** | My strength to do my daily tasks has decreased. | 102 (22,3) | 145 (31,7) | 119 (26,0) | 92 (20,1) |

Data according to the Richard-Campell sleep scale are given in Table 3, and the highest value is seen in the 'noise level' (65.80±35.16) (Table 3).

**Table 3.** Richard-Campell scale results.

| Sleep scale items | Mean±Standard Deviation<br>Median (Min-Max) |
|---|---|
| Depth of sleep | 52,81±25,46<br>50 (0-100) |
| Falling asleep | 44,93±29,35<br>50,00 (0-100) |
| Frequency of waking up | 54,60±33,80<br>50,00 (0-100) |
| Awake time | 51,83±31,71<br>50,00 (0-100) |
| Sleep quality | 53,10±29,66<br>55,00 (0-100) |
| Noise level | 65,80±35,16<br>80,00 (0-100) |
| Scale total score average | 323,10±133,36<br>320,00 (0-600) |

Adult Attention Deficit Hyperactivity Self-Report Scale (ADHD) assessment numbers and percentages are given in Table 4.

**Table 4.** Adult Attention Deficit Hyperactivity Self-Report Scale (ADHD) results.

| SECTION A | Never n (%) | Rarely n (%) | Sometimes n (%) | Frequent n (%) | Very often n (%) |
|---|---|---|---|---|---|
| 1.Do you have problems collecting the final details of a job/project you are working on and completing the project? | 57 (12,4) | 94 (20,5) | 150 (32,8) | 87 (19,0) | 70 (15,3) |
| 2. How often do you have difficulty keeping things in order when you have to do a job that requires organization? | 53 (11,6) | 139 (30,3) | 146 (31,9) | 74 (16,2) | 46 (10,0) |
| 3.How often do you have trouble remembering your obligations and appointments? | 82 (17,9) | 146 (31,9) | 126 (27,5) | 60 (13,1) | 44 (9,6) |
| 4. If you have to do a job that requires a lot of thinking and concentration, how often do you avoid or delay getting started? | 32 (7,0) | 81 (17,7) | 109 (23,8) | 103 (22,5) | 133 (29,0) |
| 5. When you have to sit for a long time, how often do you become restless, feel the need to move, or move your hands and feet? | 27 (5,9) | 68 (14,8) | 114 (24,9) | 123 (26,9) | 126 (27,5) |
| 6. How often do you feel overactive and compelled to do things as if you were stuck on a motor? | 62 (13,5) | 133 (29,0) | 150 (32,8) | 61 (13,3) | 52 (11,4) |
| **SECTION B** | | | | | |
| 7.When you have to work on a boring or difficult project, how often do you make careless mistakes? | 23 (5,0) | 123 (26,9) | 157 (34,3) | 99 (21,6) | 56 (12,2) |

**Table 4.** Adult Attention Deficit Hyperactivity Self-Report Scale (ADHD) results (continued).

| | | | | | |
|---|---|---|---|---|---|
| 8. How often do you have difficulty sustaining attention when doing a monotonous or repetitive task? | 20 (4,4) | 77 (16,8) | 148 (32,3) | 118 (25,8) | 95 (20,7) |
| 9. How often do you have difficulty concentrating and listening to what people say to you, even if they are speaking directly to you? | 46 (10,0) | 119 (26,0) | 135 (29,5) | 95 (20,7) | 63 (13,8) |
| 10. How often do you have trouble finding things at home or at work or remembering where you put them? | 45 (9,8) | 142 (31,0) | 118 (25,8) | 87 (19,0) | 66 (14,4) |
| 11. How often are you distracted by the activity and noise around you? | 18 (3,9) | 79 (17,2) | 133 (29,0) | 123 (26,9) | 105 (22,9) |
| 12. How often do you leave your seat during a meeting or similar situation when you are expected to remain seated there? | 84 (18,3) | 143 (31,2) | 131 (28,6) | 65 (14,2) | 35 (7,6) |
| 13. How often do you feel restless or fidgety? | 34 (7,4) | 105 (22,9) | 174 (38,0) | 93 (20,3) | 52 (11,4) |
| 14. How often do you have difficulty unwinding and relaxing when you have free time of your own? | 52 (11,4) | 130 (28,4) | 130 (28,4) | 84 (18,3) | 62(13,5) |
| 15. When you are in social situations, how often do you catch yourself talking too much? | 56 (12,2) | 145 (31,7) | 135 (29,7) | 84 (18,3) | 37 (8,1) |
| 16. In a conversation or meeting, how often do you find yourself finishing a sentence before the other person has finished it? | 77 (16,8) | 147 (32,1) | 129 (28,2) | 68 (14,8) | 37 (8,1) |
| 17. When it comes to queuing, how often do you have difficulty waiting for your turn? | 85 (18,6) | 131 (28,6) | 124 (27,1) | 71 (15,5) | 47 (10,3) |
| 18. Do you interrupt and block other people when they are busy doing something else? | 197 (43,0) | 135 (29,5) | 77 (16,8) | 31 (6,8) | 18 (3,9) |

When students' sleep quality was compared according to traumatic stress situations, a statistically significant difference was found. Sleep perceptions of students with severe traumatic stress differ from those with mild, moderate, and moderate and severe traumatic stress (Table 5).

**Table 5.** Comparison of students' sleep quality according to traumatic stress situations.

| | **Traumatic Stress Situation** | | | | |
|---|---|---|---|---|---|
| | **Light (N=24)** | **Medium (N=57)** | **Medium and Severe (N=141)** | **Severe (N=236)** | |
| | **Mean±Standard Deviation** | **Mean±Standard Deviation** | **Mean±Standard Deviation** | **Mean±Standard Deviation** | **P value** |
| **Sleep quality** | 392,91±136,26 | 381,22±136,59 | 353,47±131,23 | 283,81±121,01 | 0.000[1] |

[1]: One-way Variance Analysis

It has been observed that there is a relationship between students' traumatic

stress situations and their likelihood of having ADHD. Students with severe traumatic stress situations are likely to have ADHD (Table 6).

**Table 6.** Relationship between students' traumatic stress situations and their likelihood of having ADHD.

| | Likelihood of having ADHD | | | |
|---|---|---|---|---|
| **Traumatic stress situation** | **Not ADHD** | **Possible ADHD** | **Highly likely ADHD** | **P value** |
| **Light** | 9 (37,5) | 6 (25,0) | 9 (37,5) | 0.000[2] |
| **Middle** | 7 (12,3) | 14(24,6) | 36 (63,2) | |
| **Medium ad severe** | 8 (5,7) | 25 (17,7) | 108 (76,6) | |
| **Severe** | 6 (2,5) | 8 (3,4) | 222 (94,1) | |

[2]: Pearson Chi-Square

## Discussion

Our study started approximately 4 months after the Kahramanmaraş earthquake and showed that the post-traumatic stress of the 458 earthquake victims participating was mild (N=24), moderate (N=57), medium-severe (141), and severe (N=236). As a result, over 80% of people experience severe trauma. Wang et al. showed that the prevalence of PTSD was 62.8% one month after the China-Wenchuan earthquake, 43% two months after the earthquake, and 37.8% three months after the earthquake (12). Boztas et al. reported the PTSD rate as 35% 9 months after the Türkiye-Van earthquake (13). In the study conducted by Eksi and Braun, PTSD was recorded as 18.9% 18-20 months after the 1999 Turkey-Marmara earthquake (14). Bedirli reported that the PTSD rate was 12.4% 14 years after the Marmara earthquake (15). Experts report that the Kahramanmaras earthquake was the most severe and destructive earthquake that occurred on land in the world after the 1939 Erzincan earthquake. According to the literature, we think that the reason why the PTSD rate was over 80% in our study may be due to the large number of individuals living in a building that experienced an earthquake and very close to the earthquake epicenter. In addition, experts emphasize that the Kahramanmaras earthquake was the most severe and destructive earthquake that occurred on land in the world after the 1939 Erzincan earthquake (16), which supports the fact that the trauma experienced after this earthquake can be severe.

Studies have shown that sleep disorders may occur after large-scale natural disasters such as earthquakes (17, 18). Sleep relieves the emotional burden of memories, processes and stores emotional experiences. When sleep is affected, the mechanism is disrupted and the emotional parts of

memories undergo hyperconsolidation (19). It has been reported that after large-scale disasters, sleep problems increase by two or three times, subsequently increasing earthquake-related stress, without any uncertainty. In our study, a greater decrease in sleep quality was detected in earthquake victims who experienced severe post-earthquake traumatic stress (0.0001). Not only was the intensity of the earthquake much higher than the earthquakes experienced in recent years, but also the constant aftershocks that occurred even after months had also triggered people's sleep problems.

Although the relationship between Post-Traumatic Stress Disorder (PTSD) and attention deficit hyperactivity disorder (ADHD) has been a topic of interest lately, not enough studies on the subject have been found in literature searches. Therefore, the evidence that can support the hypothesis that ADHD may be a risk factor for the emergence of PTSD is weak (8). In their study of 317 undergraduate students after the 2011 Van earthquake, Ozdemir et al concluded that ADHD comorbidity is not a dominant predisposing factor in the post-traumatic stress response, but if the person has PTSD, it will cause symptoms to worsen (8). In our study, it was observed that there was a relationship between students' traumatic stress situations and their probability of having ADHD (0.0002). It was concluded that individuals with poor traumatic stress situations are likely to have ADHD. We think that this result may be due to the fact that the aftershocks after the Kahramanmaras earthquake are still continuing and that people have not been able to enter their homes for months and there have been problems in meeting their basic needs.

**Conclusion**

In the earthquake that affected 11 provinces centered in Kahramanmaras, the study population included students in the provinces of Kahramanmaras, Adıyaman, Malatya and Gaziantep; the situation in other provinces could not be evaluated, and the distribution was not similar among the provinces are among limitations of this study. Another limitation of the study is that collecting the study data 6 months after the earthquake may affect the findings differently. We also think that there is a need for studies investigating the effects of long-term traumatic stress of the earthquake on sleep and attention in earthquake-affected students.

It is very important for individuals' mental health and public health to obtain preliminary information about the potential psychological effects of the earthquake and educate individuals on the subject. We believe that being prepared for the

psychological problems caused by the earthquake and creating psychological and social awareness about natural disasters will be effective in overcoming these negativities.

## Conflict of Interest

There is no conflict of interest regarding the research.

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**Clinical Research**

# Investigation of Postural Habit, Postural Awareness and Physical Activity Levels of Physiotherapy Students

Sezen Tezcan[1*], Farnaz Nemati Shishehgaran[2], Beyza Kobalas Deniz[3]

[1]*Bolu Abant Izzet Baysal University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Bolu, Turkiye.*
[2]*Ankara Yıldırım Beyazıt University, Institute of Health Sciences, Department of Physiotherapy and Rehabilitation, Ankara, Turkiye.*
[3]*Bolu Abant Izzet Baysal University, Institute of Graduate Education, Department of Physiotherapy and Rehabilitation, Bolu, Turkiye.*

## Abstract

***Purpose:*** *The purpose of this research is to investigate the postural habits, postural awareness and physical activity levels of physiotherapist candidates.*
***Methods:*** *394 undergraduate students attending in the department of physiotherapy and rehabilitation included in study. Survey forms were sent to the volunteer students online via a social media platform. Sociodemographic information of the individuals was recorded in the data form created by the researchers. The Postural Habit and Awareness Scale (PHAS) was used to assess postural habits and awareness, and the International Physical Activity Questionnaire Short Form (IPAQ-SF) was used to assess physical activity levels.*
***Results:*** *There were significant weak positive correlations between postural awareness and postural habits (r=0.124) and between postural habits and physical activity levels (r=0.145). There was a statistically significant difference between postural habits (p=0.006) and postural awareness (p=0.019) scores between grade levels. There was no difference between physical activity scores according to grade levels (p<0.05). In comparisons between genders, it was found that postural habit and physical activity scores of male students were statistically significantly higher than female students (p=0,000).*
***Conclusion:*** *As postural awareness and physical activity levels of physiotherapist candidates attending undergraduate education increased, their postural habits also increased in a good direction, and the postural habits and physical activity levels of male students were better than female students. It is important for physiotherapist candidates to use correct posture and be physically active both for their own healthy lives and to be role models for individuals.*

***Key words:*** *Postural habits, Postural awareness, Physiotherapy and rehabilitation, Student*

*** Corresponding author:** Sezen Tezcan, E-mail: fztsezen@windowslive.com, ORCID ID: 0000-0003-4046-9201

## Introduction

Posture is the alignment of body parts in different positions and the muscular balance that protects the supporting structures of the body against injury or deformity. Posture is controlled by the central nervous system (CNS), which involves muscle activation leading to postural adjustments. Postural regulations are the result of complex mechanisms controlled by multiple sensory inputs such as visual, vestibular and somatosensory inputs integrated into the CNS (1). Today, compared to the past, impairments in postural regularity have increased with the change in the activities and lifestyles of young people. Posture, which can also be defined as the position of the human body in space and the relationship between body parts, can be classified as good and bad. Good posture is a position with minimal stress on each joint. Otherwise, increased stress on the joints leads to misalignment between body parts and poor posture (2).

There are many factors affecting posture, such as physiological, emotional, physical or environmental factors. Daily habits are often performed in such a way that they fail to maintain optimal body position and lead to postural changes. Because postural habits are also an important factor affecting posture. Bad postural habits can cause changes in muscle tone and alignment of body segments, leading to body asymmetry. Therefore, it is important to have a good knowledge of ergonomics to prevent a musculoskeletal disorder caused by poor posture. Awareness of posture serves as a support in postural habits (3).

Postural awareness, which has recently gained popularity in health sciences, was defined by Cramer et al. as 'subjective conscious awareness of body posture based mainly on proprioceptive feedback from the body environment to the central nervous system' (4). Postural awareness is necessary to maintain healthy postural habits in daily life. Moreover, postural habit is influenced by the level of postural awareness. Therefore, assessments including these postural habits and awareness are needed for health sciences professionals to guide individuals on lifestyle changes and treatment options (3).

Physical activity has a wide range, including activities of daily living that require the movement of many muscles (such as housework, carrying loads) and many sporting activities. Physical activity involves the movement of many muscles. Physical activity is one of the important parameters for a healthy life and many studies on chronic diseases indicate that physical activity has a positive effect on general health level (5).

Physical inactivity is one of the most important public health problems of the 21st century worldwide (6). Factors such as the incorporation of technology into our daily lives, increased use of technological devices such as television and computers, and the use of motorized vehicles in transportation reduce physical activity and lead people to a more sedentary life. In addition, it is also stated that individuals today do not show sufficient interest in exercise, which is necessary to lead a healthy life. According to World Health Organization (WHO) data, 1 out of 4 adults in the world is not active enough, while more than 80% of the adolescent population has insufficient physical activity level (7). The university environment is an important opportunity to encourage students to engage in more physical activity. However, insufficient data on university students' exercise habits or perceptions of exercise habits constitute an obstacle to planning to increase physical activity (5). However, in the World Confederation of Physical Therapy (WCPT) report, physiotherapy professional organizations worldwide state that it is imperative to implement effective strategies for lifelong exercise and physical activity. It also states that physiotherapists who are trained in movement and exercise and are experts in risk factors, pathology and their effects on all systems are ideal health professionals to promote and guide physical activity and exercise (6).

Physiotherapy is one of the health professions that aims to make people's lives better and easier by promoting health and providing interventions that target diseases. Physiotherapy education in itself is a challenging and evolving process (8). Physiotherapists promote quality health in society. This profession requires physical fitness and a healthy neuromuscular system in physiotherapists. Caring for patients is not always carried out according to ergonomic laws. However, research shows that young people have poor perception of body position and movement. Even in groups such as physiotherapy students, who have an increased awareness of the importance of posture for health, the effort to maintain correct posture during daily activities is not always successful (9). While providing physiotherapy services, physiotherapists may exhibit abnormal postures that may adversely affect their own health (3). Considering this situation, it is important for physiotherapist candidates who receive training on posture in patients during their undergraduate education process to be aware of their proper posture and to make it a habit from their undergraduate education and to lead a physically active life in order to maintain a healthier professional life.

The purpose of this study was to investigate the postural habits, postural awareness and physical activity levels of physiotherapy students.

## Methods

Approval for this study was obtained from Bolu Abant İzzet Baysal University Non-Interventional Clinical Research Ethics Committee (No: 2024/112). A total of 394 students from different grade levels continuing their undergraduate education in the Department of Physiotherapy and Rehabilitation were included in the study. Consent was obtained from each student that they volunteered to participate in the study. The announcement text about the study and questionnaire forms were made online. Survey forms were sent to the students who gave consent to participate in the study via social media platform. The inclusion criteria were being a student of physiotherapy and rehabilitation department and volunteering to participate in the study. Exclusion criteria were the presence of orthopedic and neurologic disease, having undergone any surgery affecting posture, being pregnant and refusing to participate in the study.

First sociodemographic information was recorded by researchers. Then postural habits and awareness were assessed with the Postural Habits and Awareness Scale (PHAS) and physical activity levels were evaluated with the International Physical Activity Questionnaire Short Form (IPAQ-SF).

### Postural Habits and Awareness Scale (PHAS)

The PHAS is a valid and reliable scale developed to determine healthy adults' self-perceptions of their postural habits and awareness. It contains 19 items measured on a 5-point Likert scale. Each item is scored from 1=strongly disagree to 5=strongly agree. The maximum score for postural habits is 35 and the maximum score for postural awareness is 60. The maximum total score a participant can obtain on the scale is 95. A high score indicates good posture and awareness. Postural habits items include statements related to the posture that the individual prefers to use in activities such as sitting, standing, lying down, carrying things, shopping, which are frequently used in daily life activities, while postural awareness items include statements related to subjective conscious awareness of body posture. The scale was developed by Bayar et al. (2023) and is a valid and reliable scale (Cronbach $\alpha$=0.73) (3).

### International Physical Activity Questionnaire Short Form (IPAQ-SF)

IPAQ is a valid and reliable questionnaire used to assess the physical activity level of individuals. It is available in two versions as

long form (IPAQ-LF) and short form (IPAQ-SF). In our study, IPAQ-SF was used to assess the physical activity levels of the participants. IPAQ-SF records activity at four intensity levels (igorous intensity activity such as aerobics, moderate intensity activity such as leisure cycling, walking and sitting). The duration and day values obtained from the scale were determined for each item and multiplied by the MET value and added to the total physical activity time. MET values, sitting (1.5 MET), walking (3.3 MET), moderate physical activity (4.0 MET), vigorous physical activity (8.0 MET) was calculated. With the physical activity value obtained after the calculation, the person was classified according to physical activity level as inactive, minimally active and very active. The scale was adapted into Turkish by Sağlam et al. (2010) and a validity and reliability study was conducted (10).

**Statistical Analysis**

Sample size was calculated with the G*Power 3.1 power analysis program (11). According to the power analysis performed on our pilot data, the minimum sample size required for an effect size of 0.33 at 95% power and 5% error level was 105. The data were coded and evaluated in computer environment. Mean and standard deviation, percentage and frequency measurements were used in the evaluation of the data. Kolmogorov-Smirnov Test was used to evaluate whether the data conformed to normal distribution. According to the results of the normality test performed in the evaluation of the obtained data, t test was used to compare numerical data in two independent groups, one-way ANOVA test was used to compare data between more than two independent groups, and Pearson correlation test was used to determine the relationship between independent variables. Bonferroni correction was applied through post hoc analysis to determine the differences as a result of ANOVA test. Statistical significance level was accepted as $p<0.05$.

**Results**

The study included 394 students from four different grade levels with a mean age of 21.43±2.54 years. Participants, n=95 (24.1%), n=101 (25.6%), n=103 (26.1%) and n=95 (24.1%) were in the first, second, third and fourth grades, respectively (Table 1).

Participants, 42.6% were inactive and 55.3% were minimally active (Table 2). Most of the participants had taken a course on posture before (67.3%), had no habit of exercising or doing sports (73.4%), worked at a desk (92.4%) and did not take regular medication (85.3%).

**Table 1.** Sociodemographic characteristics of participants.

| | | Mean ± SD (n=394) |
|---|---|---|
| **Age(year)** | | 21.43 ± 2.54 |
| **Height(cm)** | | 166,88 ± 8,53 |
| **Weight(kg)** | | 64,23 ± 13,69 |
| **BMI (kg/cm$^2$)** | | 22,95 ± 3,87 |
| | | **n (%)** |
| **Gender** | **Female** | 313 (79,4) |
| | **Male** | 81 (20,6) |
| **Marital Status** | **Married** | 5 (1,3) |
| | **Single** | 385 (98,0) |
| | **Other** | 3 (0,8) |
| **Grade** | **1$^{st}$ grade** | 95 (24,1) |
| | **2$^{nd}$ grade** | 101 (25,6) |
| | **3$^{rd}$ grade** | 103 (26,1) |
| | **4$^{th}$ grade** | 95 (24,1) |

BMI: Body Mass Index

**Table 2.** Participants' postural habit, postural awareness and physical activity scores.

| | | Mean ± SD (n=394) |
|---|---|---|
| **Postural Habit** | | 19,02 ± 4,29 |
| **Postural Awareness** | | 39,57 ± 5,03 |
| **Physical Activity** | | 1239,00 ± 1580,51 |
| | | **n (%)** |
| **Physical activity status** | **Inactive** | 168 (42,6) |
| | **Minimally active** | 218 (55,3) |
| | **Very active** | 8 (2,0) |

According to Table 3, statistically significant difference was found between the postural habit ($p$=0.006) and postural awareness ($p$=0.019) scores between the grade levels of the participants. The difference was found to be between the values of 2$^{nd}$ grade students and 3$^{rd}$ grade students for postural habit and between the values of 1$^{st}$ and 3$^{rd}$ grade students for postural awareness. There was no difference between physical activity scores according to grade levels ($p$<0.05). There was a statistically significant difference between the postural habit and physical activity scores between genders in favor of male participants ($p$=0.000) (Table 4).

**Table 3.** Comparison of postural habit, postural awareness and physical activity levels of participants according to grade level.

| | | Mean ± SD | *p* | Differences | |
|---|---|---|---|---|---|
| **Postural Habit** | **1st grade** | 19,29 ± 3,95 | **0,006*** | 1-2 | 1,000 |
| | | | | 1-3 | 0,386 |
| | **2nd grade** | 20,11 ± 4,29 | | 1-4 | 1,000 |
| | **3rd grade** | 18,17 ± 4,27 | | 2-3 | **0,007*** |
| | **4th grade** | 18,52 ± 4,42 | | 2-4 | 0,054 |
| | | | | 3-4 | 1,000 |
| **Postural Awareness** | **1st grade** | 38,34 ± 5,49 | **0,019*** | 1-2 | 0,370 |
| | | | | 1-3 | **0,011*** |
| | **2nd grade** | 39,68 ± 5,46 | | 1-4 | 0,537 |
| | **3rd grade** | 40,58 ± 4,38 | | 2-3 | 1,000 |
| | **4th grade** | 39,57 ± 4,51 | | 2-4 | 1,000 |
| | | | | 3-4 | 0,947 |
| **Physical Activity** | **1st grade** | 1281,60 ± 1856,93 | 0,525 | 1-2 | 1,000 |
| | | | | 1-3 | 1,000 |
| | **2nd grade** | 1014,74 ± 1148,58 | | 1-4 | 1,000 |
| | **3rd grade** | 1326,58 ± 1855,10 | | 2-3 | 0,954 |
| | **4th grade** | 1305,78 ± 1322,18 | | 2-4 | 1,000 |
| | | | | 3-4 | 1,000 |

*$p$<0.05, One Way Anova, B

**Table 4.** Comparison of postural habit, postural awareness and physical activity levels of participants according to gender.

| | | Mean ± SD | *p* |
|---|---|---|---|
| **Postural Habit** | **Female** | 18,49± 4,14 | **0,000*** |
| | **Male** | 21,09 ± 4,27 | |
| **Postural Awareness** | **Female** | 39,61 ± 4,93 | 0,706 |
| | **Male** | 39,38 ± 5,40 | |
| **Physical Activity** | **Female** | 991,14 ± 1064,06 | **0,000*** |
| | **Male** | 2156,79 ± 2591,24 | |

*$p$<0.05, T Test

There were significant weak positive correlations between postural awareness and postural habits (r=0.124), and between postural habits and physical activity levels (r=0.145). In addition, there was a negative correlation between students' grade level and postural habits (r=-0,112) and a weak positive correlation between grade level and postural awareness (r=0,102) (Table 5).

**Table 5.** Relationship between participants' postural habit, postural awareness and physical activity levels

| | Postural Habit | Postural Awareness | Physical Activity | Grade |
|---|---|---|---|---|
| **Postural Habit** | 1 | **0,124*** | **0,145*** | **-0,112*** |
| **Postural Awareness** | **0,124*** | 1 | 0,052 | **0,102*** |
| **Physical Activity** | **0,145*** | 0,052 | 1 | 0,028 |
| **Grade** | **-0,112*** | **0,102*** | 0,028 | 1 |

*$p<0.05$, Pearson Correlation Analysis

## Discussion

This study was conducted to examine the postural habits, postural awareness and physical activity levels of physiotherapist candidates. In study results, it was found that postural awareness increased with increasing grade level but postural habits decreased, there was a statistically significant difference between postural habits and postural awareness scores between grade levels, postural habits and physical activity scores of male students were statistically significantly higher than female students and most of the students were minimally active. It was determined that the postural habits of physiotherapist candidates with high postural awareness level were also good, and the postural habits of those with high physical activity level were also good.

The profession of a physiotherapist requires a well-functioning neuromuscular system and high physical fitness. Working with patients cannot always be done in accordance with the rules of work ergonomics. Failure to organize the patient's bed and working in an inappropriate position for a long time are the causes of many disorders that physiotherapists have to deal with during their daily work (12). Saba et al. (2012) stated that most of the physiotherapy students included in their study had knowledge about correct posture while sitting to study and using computers (13). Kousar et al. (2022) found that approximately 80% of physiotherapy students had knowledge about good posture. The study revealed that physiotherapy students have knowledge about good posture and have a positive attitude towards good posture, but they do not apply it well in their daily routines (2). Physiotherapy and rehabilitation undergraduate education in Turkey lasts 8 semesters. During this process, theoretical and practical courses related to posture are given to physiotherapist candidates, especially after the 1$^{st}$ grade level. However, considering that not only the patient but also the therapist should pay attention to posture and body ergonomics considering that this profession will be practiced for many years,

it is often stated in the in-class processes and practical trainings are given on this subject. In our study, it was found that as the grade level of physiotherapist candidates increased, their postural awareness increased but their postural habits decreased. However, it was observed that physiotherapist candidates with high postural awareness had good knowledge about posture but did not apply it in their habits. It was thought that the high level of knowledge may be related to the undergraduate education they received about posture.

The physiotherapist's lack of knowledge and experience in the ergonomics of his/her work and the load associated with this work can cause a number of negative changes in a young organism. The most common group of diseases are occupational musculoskeletal disorders (12, 14, 15). Musculoskeletal pain is highly prevalent among health sciences undergraduates and is significantly associated with sedentary postures and lack of participation in structured physical activity (15, 16). Holder et al (1999) reported that the most common negative situations encountered during a physiotherapist's work were inappropriate posture, lifting, patient handling and manual therapy during long working hours. In the study, they found that the group reporting the highest number of negative situations was young people aged 21-30 years (new physiotherapists and students) (18). In addition, differences between genders were examined in studies and it was reported that women differed from men in terms of postural habits and defined their sitting positions as leaning forward, with their trunks bent and crossed legs (9). It was reported that female students had lower physical activity levels and had more musculoskeletal pain (16, 19). In our study, postural habits and physical activity levels of male participants were found to be better than those of female participants in accordance with the literature.

WHO defines physical activity as any bodily movement produced by skeletal muscles that requires energy expenditure. Physical activity refers to all movements performed during leisure time, while commuting, or as part of a person's work or home activities (20). The benefits of a physically active lifestyle on cardiorespiratory and muscle fitness, improvement of bone and cardiometabolic health, and weight status are well documented by WHO (7). In their cross-sectional study, Kgokong and Parker (2020) reported that physiotherapy undergraduate students did not perform sufficient physical activity and were not effective role models in individuals (21). Boguszewski et al. (2021) reported that more than half of

physiotherapy students did not participate in any physical activity outside the course curriculum activities (19). Khan and Sheth (2019) found that physiotherapy students engaged in low to moderate physical activity (22). In our study, most of the physiotherapy students were minimally active and the number of very active students was quite low. It is thought that it is important to increase the physical activity participation of physiotherapist candidates and physiotherapists in terms of being a role model for individuals, both for their own healthy lives and as a professional group that encourages physical activity.

## Conclusion

It is important for physiotherapist candidates to have good postural habits and to be physically active both for their own healthy lives and as a professional group that encourages physical activity, to be a role model for individuals by performing recommended practices. As a result of the study, it was concluded that physiotherapist candidates with better postural awareness level gave more importance to their posture and paid attention to their posture in daily life. This study was conducted as a cross-sectional study and the limitation of our study is that the data were not collected from different provinces.

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**Review**

# Artificial Intelligence in Geriatric Patient Follow-up: Impact on Physician Workload and Clinical Applications

Alperen Kizikli [1*], Zeynel Abidin Ozturk[1]

[1]*Gaziantep University, Faculty of Medicine, Department of Internal Medicine, Division of Geriatrics, Gaziantep, Turkiye.*

**Abstract**

***Purpose:*** *The rapid advancements in artificial intelligence (AI) have significantly influenced healthcare, especially in geriatric patient monitoring, a complex process due to multimorbidity, polypharmacy, and frailty. This study aims to evaluate the role of AI applications in geriatric monitoring and examine their potential impact on reducing physicians' workload.*

***Methods:*** *A comprehensive literature review was conducted, covering current AI-supported patient monitoring systems, clinical decision support tools, and workflow automation. Areas such as diagnosis, treatment planning, and real-time health monitoring via wearable technologies were examined in detail.*

***Results:*** *AI-supported systems have been shown to facilitate early diagnosis, optimize treatment planning, and improve clinical decision-making. These systems enhance patient outcomes while reducing administrative burdens on physicians. Remote monitoring and predictive analytics enable timely interventions, potentially reducing hospital admissions and emergency visits. Furthermore, AI-based automation can take over routine tasks, increasing clinical workflow efficiency.*

***Conclusion:*** *The integration of AI into geriatric patient monitoring offers the potential to improve healthcare efficiency, enhance patient safety, and reduce physicians' workload. However, ethical concerns, data privacy, and AI system reliability must be carefully addressed. Future research should focus on developing user-friendly AI systems and evaluating their long-term clinical effectiveness.*

***Key words:*** *Artificial Intelligence, Clinical Decision Support, Digital Health, Geriatrics, Healthcare Automation, Physician Workload*

*** Corresponding author:** Alperen Kizikli, E-mail: alperenkizikli@saglik.gov.tr, ORCID ID: 0000-0002-6840-4197

## Introduction

The aging process brings about many physical, psychological and social changes in individuals. A multidisciplinary approach is required to manage this process effectively. Factors such as multiple diseases, polypharmacy and frailty, which are common in elderly individuals, require a special understanding of care. The aim of this process is to analyze the medical needs of patients comprehensively and to ensure that appropriate health services are provided in a timely and effective manner. Geriatric patient follow-up plays a critical role in the process of assessing and managing the health status of elderly individuals.

In recent years, the increasing prevalence of artificial intelligence (AI) applications in the field of healthcare has led to significant changes in geriatric patient follow-up. The rapid increase in the elderly population and the corresponding increase in the need for healthcare services bring the opportunities offered by AI in this field to the forefront (1). Geriatric patient follow-up physicians undertake important responsibilities such as continuously monitoring the general health status of elderly individuals, detecting age-specific health problems at an early stage and managing these processes effectively. In this context, geriatric follow-up processes should be carried out meticulously in order to improve the quality of life of elderly individuals and minimize health problems (2).

The main aim of this study is to examine the role of AI applications in geriatric patient follow-up and to evaluate their potential to alleviate the workload of physicians. In this direction, existing data were analyzed using literature review and compilation method, and a comprehensive evaluation was made on the integration of AI into health service delivery.

## Process Management in Geriatric Patient Follow-up

Health problems that arise with aging make geriatric patient follow-up a very complex process. Many factors such as the increase in chronic diseases, drug interactions due to polypharmacy, risk of falls, nutritional deficiencies and loss of cognitive function indicate the need for a special approach in geriatric patient care. Effective management of these factors is of great importance in terms of improving the health status of elderly individuals and increasing their quality of life (3).

In the geriatric patient follow-up process, personalized health services should be provided for the needs of individuals. This approach can make the process more efficient and effective for both patients and

healthcare professionals. Today, traditional methods used in geriatric patient follow-up increase the workload of physicians and make it difficult to respond quickly enough to the individual health needs of patients. Therefore, technological solutions and artificial intelligence-supported systems can contribute to more effective management of the process.

## Artificial Intelligence Applications in Medicine and Health Management

### What is Artificial Intelligence?

Artificial intelligence (AI) refers to computer systems that mimic human intelligence and can perform specific tasks. In healthcare delivery, AI is widely used to optimize the diagnosis and treatment processes of patients, improve medical imaging analysis, accelerate drug research and increase the overall efficiency of healthcare services. Especially thanks to big data analysis and machine learning techniques, many processes in the field of healthcare are being made faster and more efficient (4). AI techniques such as machine learning and deep learning can analyze large-scale health data to help diagnose certain diseases early. In addition, by evaluating the individual health histories of patients, they can enable the creation of personalized treatment plans. This makes clinical decision-making faster and more accurate and reduces the workload of physicians (5).

### Artificial Intelligence Applications in Healthcare

AI is used effectively in many areas such as diagnosis, treatment planning, patient follow-up and hospital management in the provision of medical and healthcare services. Especially in the field of medical imaging, cancer screenings, radiological evaluations and pathological analyzes can be performed faster and more accurately thanks to artificial intelligence-supported systems. These systems allow images to be analyzed automatically and abnormalities to be detected at an early stage, helping physicians to make more informed decisions (6).

In addition, AI-based patient monitoring systems analyze the data obtained from patients and provide recommendations to healthcare professionals. Thanks to these systems, the health status of individuals can be continuously monitored and early interventions can be made when necessary. In this way, patients' access to healthcare services is facilitated and the workload on healthcare professionals is eased.

### Artificial Intelligence Applications in Geriatric Patient Follow-up

In geriatric patient follow-up, artificial intelligence stands out as an important tool

that facilitates the monitoring and management of the health status of elderly individuals. Modern technology makes it possible to collect and analyze the health data of the elderly, who may be more difficult to admit to hospital than younger people, and provide real-time information to healthcare professionals. Thus, physicians can monitor the health status of their elderly patients more closely and intervene early (7).

Smart sensors and wearable health technologies can monitor the daily activities of individuals and provide instant data to healthcare professionals. These systems offer a great advantage in assessing the general health status of elderly individuals, allowing healthcare professionals to recognize changes in patients early. By increasing the accuracy and efficiency of these, artificial intelligence-supported patient monitoring systems improve the quality of healthcare services and contribute to improving the quality of life of elderly individuals (8).

**Patient Follow-up and Monitoring**

Patient tracking and monitoring is one of the areas where AI technologies have shown the most development. These systems offer the opportunity to continuously monitor and analyze individuals by collecting their medical data. Patients' daily life activities, laboratory results and general health status are regularly monitored, providing instant data flow to physicians. In this way, healthcare professionals can respond quickly to patient situations and perform appropriate interventions when necessary (9).

By analyzing patient data, these AI systems identify potential health risks and alert healthcare professionals early, helping them to take preventive measures. Thus, the progression of diseases can be prevented and individuals can lead a healthier life.

**Diagnosis and Treatment Support Systems**

AI applications in geriatric patient follow-up include data analysis systems that make diagnosis and treatment processes more effective. AI-supported decision-making systems can guide healthcare professionals by evaluating patients' medical imaging data. This facilitates early diagnosis of diseases and the creation of personalized treatment plans (10).

For example, artificial intelligence-based models have been developed to predict geriatric syndromes such as sarcopenia, malnutrition and fall risk. By analyzing the clinical data of patients, these systems provide important insights to healthcare professionals and help minimize health risks that may occur in elderly individuals. AI not only facilitates individual patient

follow-up, but also increases the overall efficiency of healthcare services, enabling the implementation of more effective treatment methods (11).

**Workload of Physicians and the Problems**

The workload of physicians in healthcare services is becoming a bigger problem due to many factors such as the increasing number of patients, the intensity of diagnosis and treatment processes, and the necessity to access continuously updated medical information. In addition, additional responsibilities such as patient assessments, management of medical records and administrative tasks increase the pressure on physicians by making time management difficult (12). Geriatric patient follow-up is a process that requires more time and attention compared to other medical fields, especially due to the multiple diseases and complex treatment processes of elderly individuals. Factors such as regular follow-up of this patient group, chronic disease management, control of drug interactions and prevention of possible complications significantly increase the workload of physicians (13).

**Workload in Geriatric Patient Follow-up**

Geriatric patient care is a process that usually requires long-term follow-up and a multidisciplinary approach. The fact that most elderly patients have multiple health problems makes treatment plans more complex and increases the workload of healthcare professionals. In addition, age-related changes such as cognitive decline and communication difficulties may further complicate patient-physician interaction and hinder the effective delivery of health services (14).

Artificial intelligence-based decision support systems have the potential to ease the workload of physicians in geriatric patient follow-up. Studies have shown that these systems can reduce the time allocated per patient for patient evaluation (15). While this enables physicians to manage their time more efficiently, it also has the potential to improve the quality of healthcare services provided per patient. In addition to the potential of AI applications to reduce healthcare costs, it should also be taken into consideration that it may lead to an increase in human life expectancy with the improvement of healthcare service quality.

**Physician Challenges in Elderly Patients**

One of the biggest challenges faced by physicians involved in the follow-up of geriatric patients is time management problems due to their busy work schedule. Monitoring complex treatment plans, regularly updating patient health records and maintaining healthy communication

between patients and their families create a significant pressure on physicians (16).

However, cognitive decline and linguistic communication difficulties, which are common in elderly individuals, may make diagnosis and treatment processes more complex. Such situations make it difficult for physicians to communicate effectively with patients and may negatively affect the quality of health services (17). Lack of involvement of family members in patients' health processes or problems in family dynamics may make it more difficult for older individuals to access health services.

AI-enabled healthcare systems stand out as an important aid in overcoming such challenges. For example, in processes such as automatic scheduling of patient appointments, digital tracking of medication use and regular analysis of health data, AI technologies can reduce the burden on physicians and make healthcare services more efficient (18).

**Potential to Reduce Workload of Physicians with Artificial Intelligence**

AI is an increasingly widespread technology in the healthcare sector and is considered as an important tool to reduce the workload of physicians. AI applications such as automatic data analysis, patient follow-up, acceleration of diagnostic processes and clinical decision support systems help to ease the burden on physicians. Especially in processes that require time-consuming and detailed evaluation, such as geriatric patient follow-up, the effective use of artificial intelligence-supported systems can increase the efficiency of healthcare services (19).

AI-based systems are known to reduce the routine workload of physicians, allowing them to use the time allocated per patient more efficiently. For example, by continuously monitoring and analyzing patients' health data, physicians can focus only on critical cases and thus conduct a more effective intervention process (20).

**Artificial Intelligence Supported Clinical Decision Processes**

AI can help healthcare professionals make faster and more accurate decisions in diagnosis and treatment processes. Clinical decision support systems can identify potential health risks in advance by evaluating patients' medical histories with big data analysis. Thus, physicians can analyze patients' health conditions more quickly and create appropriate treatment plans (21).

Studies have shown that AI-supported systems can provide up to 20% improvement in drug dosage adjustments and treatment planning (22). While such applications increase patient safety, they

also reduce the likelihood of healthcare professionals making mistakes.

**Increased Workflow and Productivity with Artificial Intelligence**

The integration of AI-supported applications into healthcare service delivery makes significant contributions to accelerating workflow and increasing overall efficiency. The use of artificial intelligence, especially in areas such as patient follow-up, data analysis and medical imaging, enables processes to be completed in a shorter time (23).

In addition, AI systems can also reduce the administrative burden on healthcare staff. For example, automated scheduling of patient appointments, storing and analyzing patient data digitally, and digital reminders to patients and physicians for early screening for health problems that patients may potentially face as they age can reduce the risks for healthcare workers, allowing them to care for more patients in their working time. This would both ensure that patients receive better healthcare and improve the overall efficiency of the healthcare system (24).

**Ethical and Safety Issues**

With the widespread use of AI in healthcare, ethical and security issues are becoming increasingly important. Although AI systems can optimize diagnosis and treatment processes by analyzing patient data, it is of great importance that these technologies are used in accordance with ethical principles. Issues such as patient privacy, data security and algorithmic fairness are among the critical points to be considered in the integration of AI into healthcare (25).

During the integration of AI-supported systems into healthcare services, physicians and healthcare organizations should act in accordance with ethical standards. In this context, patient information should be protected, data security should be ensured at the highest level, and conditions should be adopted in which AI systems will show a fair and impartial approach in decision-making processes (26).

**Ethical Principles in Artificial Intelligence Applications**

In order for AI applications to be used effectively and reliably in the field of health, some basic ethical principles should be observed. These principles include transparency, accountability, data privacy, fairness and ethical audit processes (27).

**Transparency:** Clear and understandable information on how AI systems work should be provided.

**Accountability:** Physicians and healthcare organizations should develop specific

procedures to determine responsibility for decisions made by AI.

**Data Confidentiality:** The security of patients' data must be ensured and data storage measures that include encryption methods specific to the protection of personal information must be taken.

**Fairness and Impartiality:** It should be ensured that AI algorithms are not biased against any patient group. Different decisions for the same situations at different times should be avoided.

## Data Security, Privacy and Protection Methods

One of the biggest controversies of AI applications is the security and privacy of patient data. AI systems used in healthcare process and analyze large amounts of sensitive data. Ensuring data security in this process is a critical requirement to prevent the misuse of patients' personal information (28).

In order to protect patient data, healthcare organizations need to take stringent security measures. These measures include the use of data encryption methods, tightening access controls and establishing continuously updated protection systems against cyber security threats. In addition, the anonymized processing of patient data by AI algorithms is considered as an effective method to ensure data privacy (29). Considering all these factors, AI systems need to be developed within the framework of ethical rules and subjected to strict control mechanisms in terms of data security. In this way, AI technologies can be used reliably and effectively in the field of health.

## Conclusion and Recommendations

The rapid development of AI in medicine and healthcare delivery has the potential to alleviate the challenges faced by physicians, especially in geriatric patient care. Advantages such as analyzing patient data, improving early diagnosis and treatment processes, and making healthcare services more efficient reveal the importance of AI-supported systems in healthcare (30).

The findings show that AI provides significant time savings for physicians in patient follow-up and clinical decision-making processes. In addition, AI-based diagnosis and treatment systems support clinical decision-making processes with high accuracy rates, contributing to an increase in the quality of patient care. This reduces the workload on healthcare professionals and enables patients to access healthcare services faster and more effectively (31).

However, some important issues should be considered for the effective use of AI in the field of health. It is of great importance for

physicians to receive the necessary training and adapt to these technologies in order to use AI-supported systems effectively. In addition, ethical and data security issues should be prioritized in the process of integration of AI systems into healthcare services (32).

Ensuring the accuracy of AI-generated content is crucial in maintaining patient safety. This can be achieved by training AI models on high-quality, evidence-based medical data and incorporating clinician oversight or automated cross-checks against clinical guidelines (33). Readability also plays a key role-medical information should be presented in plain language, free of unnecessary jargon, and formatted using readability tools to match the cognitive needs of older users (34). Furthermore, using multimodal formats such as voice narration, icons, and interactive elements can enhance understanding, particularly for individuals with sensory impairments or limited digital literacy (35). Taken together, these strategies highlight the importance of designing AI systems that are not only technically robust but also sensitive to the communication needs of an aging population.

**Future Work Areas**

The following recommendations should be taken into consideration to increase the effectiveness of the use of AI in geriatric patient follow-up and to alleviate the workload of physicians:

The integration of AI systems into the health sector should be accelerated and ethical principles should be taken into account in this process.

**1-** The adoption of technology should be encouraged by organizing training programs for physicians on the use of artificial intelligence.

**2-** Stricter legal regulations should be put in place for the security of patient data and the audit mechanisms of these systems should be strengthened.

**3-** Future research should be supported by larger clinical trials to measure the effectiveness of AI in geriatric patient care.

The success of AI-supported systems depends on physicians' effective use of this technology and continuous updating of the systems (36). Health professionals who are accustomed to traditional medical approaches may have some reservations about adopting AI technologies. Therefore, it is important for health managers and policy makers to provide in-service trainings for physicians to adopt AI systems more easily (37).

In conclusion, the effective use of AI technologies in the healthcare sector has the

potential to increase the quality of patient care while alleviating the workload of physicians. However, the rigorous implementation of ethical and safety standards and the adaptation of healthcare professionals to the technology are critical factors for successful integration.

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Gaziantep İslam Bilim ve Teknoloji Üniversitesi
Beştepe Mah. 192180 Nolu Cadde 6/1 27010 Şahinbey/Gaziantep

info@gibtu.edu.tr | +90 342 909 75 00 - 20 | www.gibtu.edu.tr

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