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Kezban YİĞİTER

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FROM EDITOR

Dear Readers,

We are delighted to present the inaugural issue of the Turkish Journal of Prosthetics and Orthotics Science, published by the Turkish Prosthetics and Orthotics Science Association. Our mission is to disseminate current, reliable, and high-quality scientific research in the field of prosthetics and orthotics, thereby contributing to academic advancement while providing a platform for emerging researchers to make their voices heard.

This first issue features a diverse range of topics, including the investigation of varying muscle strengths in hallux valgus, different suspension systems following transtibial amputation, taping and orthotic interventions in knee osteoarthritis, orthosis use after vertebroplasty and kyphoplasty, diabetic foot ulcers, and the relationship between screen time and musculoskeletal pain. We believe that each study offers valuable insights for both the academic community and clinical practice.

Published in August, this issue also provides an opportunity to celebrate Victory Day on August 30, honoring with respect and gratitude all the heroes of Turkish War of Independence, particularly Gazi Mustafa Kemal Atatürk.

We extend our sincere appreciation to all authors, reviewers, editors, and everyone who contributed to the development of this journal. At the Turkish Journal of Prosthetics and Orthotics Science, we are committed to the power of knowledge sharing and aim to present increasingly robust content in each forthcoming issue.

We thank you for your interest and wish you an enjoyable reading experience.

Sincerely,
Prof. Dr. Kezban YİĞİTER
Editor

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CONTENTS

2025 1(1)

ORIGINAL ARTICLES

www.turkishjpos.com

Turkish Journal of Prosthetics and Orthotics Science

Volume 1, Issue 1 (2025) 1-13

Research Article

EVALUATION OF CYBERCHONDRIA, E-HEALTH LITERACY, AND PSYCHOLOGICAL STATUS IN PATIENTS WITH DIABETIC FOOT ULCERS: A PILOT STUDY

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Keywords

Anxiety disorders,
Cyberchondria,
Diabetes mellitus,
Diabetic foot,
Health literacy.

ABSTRACT

Purpose: This study was designed to assess the levels of cyberchondria, e-health literacy, and psychological status in patients with diabetic foot ulcers (DFUs).

Methods: This pilot study involved 33 participants aged 18 years and older who had a diagnosis of DFU for a minimum duration of three months, with sociodemographic and clinical information obtained through a structured questionnaire. Sociodemographic and clinical data were collected via a structured questionnaire. Participants completed the Cyberchondria Severity Scale (CSS), E-Health Literacy Scale, and Depression Anxiety Stress Scale-21 (DASS-21). Descriptive statistics will be used in the evaluation of the data.

Results: The mean age of the participants was 55.48±14.95 years, and the majority were male (81.8%). Participants' cyberchondria levels were low across all subscales and eHealth literacy scores were low (11.39±9.00). Their psychological symptom levels were moderate based on their DASS-21 total score (15.82±11.84). Most participants reported little or no internet use, with 69.7% reporting never searching online for health information. Furthermore, 93.9% did not follow any health-related social media platforms and would not recommend online health research to others.

Conclusion: Patients with DFUs exhibited low levels of cyberchondria and e-health literacy, and moderate levels of depression, anxiety, and stress. Low internet use, older age, male dominance, and low educational background may contribute to these findings. Despite the growing digitalization in healthcare, this population may face significant barriers in accessing and utilizing reliable online health information. Multidisciplinary DFU care should incorporate not only medical treatment but also psychological support and digital health literacy education.

INTRODUCTION

Diabetes mellitus (DM) represents an escalating global health concern and is projected to affect nearly 592 million people by 2035, positioning it as the largest epidemic of the 21st century (1). DFUs represent a common complication of diabetes mellitus, with an estimated lifetime prevalence of approximately 15% among individuals with diabetes. In diabetic wounds, tissue ischemia, hypoxic microenvironments, and sustained hyperglycemia impair

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the orderly progression of wound healing cascades, ultimately leading to delayed repair, chronic non-healing ulcers, and secondary clinical complications (2). The global burden of DFUs has been reported to encompass nearly 6.4% of patients with diabetes. The presence of DFUs confers a 2.5-fold greater risk of five-year mortality relative to patients without foot ulcers. Furthermore, worldwide direct healthcare costs attributable to diabetes mellitus were estimated at 700 billion USD in 2019 and are expected to reach 825 billion USD by 2030. DFUs are recognized in clinical practice as ulcerative lesions accompanied by inflammatory changes in tissues located below the malleoli among diabetic patients (2). Ranking among the most severe complications of diabetes mellitus, DFUs substantially diminish quality of life and contribute to significant economic losses (1).

In a prospective study conducted by Ndosi et al. (3), wound healing was achieved in only 46% of patients within one year of diagnosis, whereas 10% experienced a recurrence. Additionally, approximately 17% of the patients underwent lower extremity amputation. Beyond the physical problems caused by DFUs, progressive complications such as amputation, the difficulty and cost of treatment, and the uncertainty of the healing process increase patients' anxiety levels, lead to depression, and decrease their quality of life, while also elevating psychological stress levels (4). In a review conducted by Janzen et al., 24.1% of patients with DM were reported to suffer from health anxiety (5). Confronted with the progressive course of DFUs, along with financial burden, psychological distress, uncertainty, and stress, patients frequently turn to diverse information sources as a coping strategy.

The World Health Organization defines health literacy as individuals’ capacity to access, interpret, and appropriately apply health-related information. The European Health Literacy Study reported an inadequate health literacy prevalence of 12.4%, while the U.S. Adult Literacy Survey documented a rate of 14%. In Turkey, however, the Ministry of Health’s 2018 survey indicated that 30.9% of the population had inadequate health literacy, with the highest rates observed in Southeastern Anatolia (33.3%), Eastern Anatolia (54.2%), and the Mediterranean Region (35%) (6).

As the digital age advances, the internet has increasingly become a primary medium for accessing information in nearly all areas, particularly in health. With the widespread use of the internet, e-health literacy has been recognized as a subdomain of health literacy, accompanied by the emergence of the concept of cyberchondria. E-health literacy is defined as the ability of individuals to search for, access, interpret, and evaluate the quality of health information available on online and digital platforms (6). Cyberchondria, on the other hand, denotes the excessive and persistent seeking of health information via the internet despite its

adverse consequences, and is associated with heightened health anxiety, reduced health-related quality of life, diminished well-being, and impaired daily functioning (7).

This study aims to assess the levels of cyberchondria, e-health literacy, and psychological status among patients with DFU.

Research Questions

1. What are the levels of cyberchondria in individuals with diabetic foot ulcers?
2. What are the levels of e-health literacy in individuals with diabetic foot ulcers?
3. What are the levels of psychological symptoms (anxiety, depression, stress) in individuals with diabetic foot ulcers?

METHODS

Study Design

This pilot study was conducted in the Wound Care Unit of Gaziantep City Hospital between June 3, 2025, and July 20, 2025. Ethical approval was obtained from the Non-Interventional Clinical Research Ethics Committee of Hasan Kalyoncu University on June 2, 2025, with the decision number 2025/079. The entire research process was conducted in compliance with the principles of the Declaration of Helsinki. All participants received prior information about the study, and written informed consent was obtained from those who voluntarily agreed to participate.

Participants

The study sample consisted of volunteer individuals aged 18 to 75 years who had been diagnosed with chronic DFU, were admitted to the hospital where the research was conducted, were engaged in the treatment process, and provided voluntary consent to participate

The inclusion criteria comprised individuals aged 18 years or older who had been diagnosed with DFUs persisting for three months or longer, had no cognitive or communication impairments, were admitted to the hospital where the study was carried out, were engaged in the treatment process, and voluntarily consented to participate.

Individuals with communication problems that would interfere with the administration of the questionnaire due to visual, auditory, or speech impairments; those with cognitive or psychiatric disorders; and those unable to understand or respond to the questionnaire were excluded from the study.

Assessments

Sociodemographic data of the participants (age, gender, educational status, marital status, duration of diabetes, duration of foot ulcer, and internet usage habits) were recorded using a questionnaire form. Subsequently, the following psychological and cognitive assessments were conducted:

1. Cyberchondria Severity Scale: During face-to-face interviews, the scale form was either read aloud to the patients' item by item or provided for self-administration. Comprising 33 items, the scale can typically be completed within 15–20 minutes. Participants rated items assessing their internet-based health concerns and behaviors on a 5-point Likert scale, with response options ranging from "strongly disagree" to "strongly agree" (8). The validity and reliability analyses of the scale on adults were conducted by Uzun and Zencir in 2018 (9).
2. E-Health Literacy Scale: Participants completed this 10-item scale either in the clinical setting or via the questionnaire form. This assessment, requiring approximately 5–10 minutes to complete, evaluates individuals' ability to comprehend and apply health information obtained from the internet, with each item rated on a 5-point scale (1–5). (10). The Turkish adaptation of the scale and validity-reliability studies were conducted by Gencer in 2017 (11).
3. Depression Anxiety Stress Scale – 21: The short form of the scale was presented to participants, who were asked to complete it independently. The administration took approximately 10–15 minutes. The scale, comprising 21 items, evaluates depression, anxiety, and stress using a 4-point Likert-type response format (12). The psychometric properties of the Turkish version of the scale in normal and clinical samples were adapted into Turkish by Sarıçam in 2018 (13).

All assessments were conducted under the supervision of an experienced physiotherapist in the clinical setting, with explanations provided when necessary. Data collection took place in a quiet and private room to ensure that participants could respond comfortably and attentively.

Statistical Analysis

Data analysis will be performed using IBM SPSS Statistics version 25, with descriptive measures such as percentages, frequencies, medians, and minimum–maximum values applied for data evaluation.

RESULTS

Table 1 provides a summary of the participants' sociodemographic and health-related characteristics. Among the participants, 78.8% (n=26) were diagnosed with diabetes mellitus (DM), 12.1% (n=4) with venous insufficiency, and 3% (n=1 each) with Buerger's disease, Ehlers-Danlos syndrome, or hydrocephalus. A majority of the participants were male (81.8%, n=27), while 18.2% (n=6) were female. When examining dominant foot preference, 87.9% (n=29) of the participants reported right foot dominance, while 12.1% (n=4) had left foot dominance. Only 6.1% (n=2) of the participants used assistive devices, whereas 93.9% (n=31) did not require any assistive support. In terms of educational status, 60.6% were primary school graduates, 15.2% had completed middle school, 6.1% were high school graduates, 3% had completed university education, and 15.2% were illiterate. Regarding employment status, only 18.2% (n=6) of the participants were actively working. In terms of monthly income, 91% reported earnings below 20,000 Turkish Lira (TRY), while only 3% had an income of 40,000 TRY or more. Concerning place of residence, 78.8% (n=26) lived in urban areas, and 21.2% (n=7) resided in rural regions. In terms of family structure, 78.8% lived in a nuclear family, 18.2% lived alone, and 3% lived in an extended family household. According to marital status, 75.8% (n=25) of participants were married, while 24.2% (n=8) were single. Regarding DM type, 75.8% (n=25) had Type 2 DM, and 24.2% (n=8) had Type 1 DM. When examining comorbidities, the most frequently reported condition was hypertension (HT). A total of 5 participants (15.2%) reported having only HT. In addition, combinations of HT with other chronic diseases were also observed. For example, two participants (6.1%) reported having both HT and hypercholesterolemia (see Table 1).

Table 1. Distribution of the Sociodemographic and Health-Related Characteristics of the Participants

		n	%
Diagnosis	**Buerger's Disease**	1	3
	Diabetes Mellitus (DM)	26	78,8
	Ehlers-Danlos Syndrome	1	3
	Hydrocephalus	1	3
	Venous Insufficiency	4	12,1
Gender	**Female**	6	18,2
	Male	27	81,8
Dominant foot	**Right**	29	87,9
	Left	4	12,1
Use Of Assistive Device	**No**	31	93,9
	Yes	2	6,1
Educational Level	**Primary School**	20	60,6
	Middle School	5	15,2
	High Scholl	2	6,1
	Universty	1	3
	No Formal Education	5	15,2
Employment Status	**No**	27	81,8
	Yes	6	18,2
Monthly Income (TRY)	**0-10.000 TRY**	15	45,5
	10.000- 20.000 TRY	15	45,5
	20.000- 40.000 TRY	2	6,1
	40.000 TRY and above	1	3
Place of Residence	**Rural**	7	21,2
	Urban	26	78,8
Living Arrangement	**Nuclear Family**	26	78,8
	Extended Family	1	3
	Living Alone	6	18,2
Type of Diabetes	**Type 2**	25	75,8
	Type 1	8	24,2

The participants had a mean age of 55.48 ± 14.95 years, an average weight of 84.42 ± 21.51 kg, and a mean height of 172.12 ± 8.31 cm, resulting in a calculated mean body mass index (BMI) of 28.38 ± 6.26. The mean duration of diabetes was 14.0 ± 7.00 years, with a range of 1 to 30 years. The average total score for e-health literacy among participants was 11.39 ± 9.00. The total score of the DASS-21, used for psychological evaluation, was calculated as 15.82 ± 11.84. When examining the subdimensions of cyberchondria, the following mean scores were observed; Compulsion (SCOM): 8.45 ± 2.61, Distress (SDIS): 8.85 ± 4.87, Excessiveness (SECC): 9.15 ± 5.30, Reassurance (SREA): 6.24 ± 4.92, Mistrust of Medical Professionals (SMIS): 3.48 ± 1.94 (see Table 2).

Table 2. Descriptive Statistics of Participants' Demographic Characteristics, Clinical Data, and Scale Scores

	Mean	SD	Min	Max
Age (Years)	55,48	14,95	10	75
Weight (kg)	84,42	21,51	54	138
Height (cm)	172,12	8,31	150	188
BMI	28,38	6,26	18,5	41,7
Diabetes Duration (years)	14,0	7,5	1	30
E-Health Literacy Total Score	11,39	9,00	8	40
DASS-21 Total Score	15,82	11,84	0	48
SCOM (Compulsion)	8,45	2,61	8	23
SDIS (Distress)	8,85	4,87	8	36
SECC (Excessiveness)	9,15	5,64	8	40
SREA (Reassurance)	6,24	1,09	6	12
SMIS (Mistrust in Doctors)	3,48	1,94	3	11

BMI: Body Mass Index; E-Health Total: Total score from the e-health literacy scale; DASS-21: Depression Anxiety Stress Scale total score; SCOM: Cyberchondria Compulsion subscale; SDIS: Cyberchondria Distress subscale; SECC: Cyberchondria Excessiveness subscale; SREA: Cyberchondria Reassurance subscale; SMIS: Cyberchondria Mistrust in Doctors subscale

Table 3. Internet Usage Duration and Health-Related Internet Use Among Participants

Questions	Answers	n	%
How much time do you spend on the internet per day?	**None**	11	33.3
	10-15 Minutes	1	3
	1-2 Hours	12	36.6
	2-3 Hours	3	9.1
	3-4 Hours	2	6.1
	4-5 Hours	4	12.1
How often do you search the internet for information about your illness?	**Once a month or more**	3	9.1
	Several times a day	3	9.1
	Once a week	3	9.1
	Every day	1	3
	Never	23	69.7
Do you follow any social media networks related to your illness?	**Yes**	2	6.1
	No	31	93.9
Would you recommend others to search for health-related information online?	**Yes**	2	6.1
	No	31	93.9

As presented in Table 3, the participants' duration of internet use and their utilization of the internet for health-related purposes were assessed. Based on the findings, 36.6% (n=12) of the participants reported using the internet for 1–2 hours per day, while a significant portion (n=11, 33.3%) stated that they never used the internet. Longer daily internet usage was less common: 12.1% (n=4) reported using the internet for 4–5 hours per day, and 6.1% (n=2) for 3–4 hours per day. Regarding the frequency of online searches related to their illness, the majority (n=23, 69.7%) stated that they never searched for information. The response options "Once a month or more," "Once a week," and "Several times a day" were each selected by 3

participants (9.1%). Only 3.0% (n=1) of the participants reported conducting health-related online searches every day. Similarly, the behavior of following health-related social media platforms was observed to be very limited. A vast majority (93.9%, n=31) stated that they did not follow any health-related social media networks, while only 6.1% (n=2) reported that they did. When asked whether they would recommend others to search for health-related information online, 93.9% (n=31) said they would not, while only 6.1% (n=2) stated they would recommend it. Additionally, 27.3% of the participants who conducted internet searches regarding their illness most frequently looked up topics such as disease symptoms, foot ulcers and their care, blood test results, medications, and nutrition. However, 72.7% of the participants reported that they did not conduct any internet-based research on their illness (see Table 3).

DISCUSSION

With the influence of the digital age, individuals' habits of accessing health information have shifted, with increasing reliance on online sources rather than direct medical consultation. While this shift offers fast and cost-effective access to health-related information, it also raises serious concerns regarding the accuracy and reliability of such content. The availability of unverified, non-scientific, or misleading information on digital platforms may heighten individuals' health-related anxieties and adversely influence the patient–healthcare professional relationship.

The present study was designed to assess levels of cyberchondria, e-health literacy, and psychological status in patients with DFUs. The results indicated that participants with DFUs exhibited low levels of cyberchondria and e-health literacy, while their depression, anxiety, and stress levels were moderate.

There are studies in literature that have examined cyberchondria in various chronic illnesses. For example, such studies have been conducted in individuals with diabetes (14), cancer (15), cardiovascular diseases (16,17), chronic mental illnesses (18). However, we did not identify any previous studies examining the level of cyberchondria specifically in individuals with DFUs, indicating that our study may be among the first to address this issue.

Studies exploring the determinants of cyberchondria are limited (19–22). These studies have noted that cyberchondria is influenced by sociodemographic factors such as age, gender, and education level, as well as by health literacy, e-health literacy, psychological factors, internet usage duration, and the severity of disease symptoms. Mansur et al. (21) identified a low-level positive association between e-health literacy and cyberchondria among adults in

the general population. A population-based study from Poland, which included 1613 participants, revealed that individuals with greater e-health literacy tended to exhibit increased levels of cyberchondria (20).

In our study, both e-health literacy and cyberchondria levels were found to be low among individuals with DFUs. This finding suggests that a high ability to access digital information does not necessarily offer protection; instead, it may sometimes lead to increased and uncontrolled information-seeking behavior, thereby elevating cyberchondria levels.

Kobryn et al. (20) also reported that age and gender were significant demographic determinants of cyberchondria, with younger individuals being more likely to exhibit higher cyberchondria scores. The average age in our sample was 55.48 years, and the low cyberchondria levels observed are consistent with these findings. This may be attributed to older individuals relying more on traditional sources for health information, whereas younger individuals tend to engage more frequently with digital health content. Conversely, one study reported that there was no significant relationship between age and cyberchondria (24), indicating that the effect of age may vary depending on demographic or environmental factors.

Another finding of Kobryn et al. (20) study was that men were more likely than women to have lower cyberchondria scores. Similarly, a study by Göde et al. (25) found a significant difference in cyberchondria levels by gender, with women displaying higher levels than men. In our sample, 81.8% of participants were male, which may partially explain the overall low levels of cyberchondria. This could be due to men's generally more distant attitude toward digital health content and their tendency to evaluate such information with less emotional reactivity.

In a study by Yorulmaz et al. (23), a positive relationship was found between internet addiction and cyberchondria in younger individuals, with longer internet usage strengthening this association. In our study, 33.3% of participants reported not using the internet at all, while 30.3% reported using it only 1–2 hours per day. The limited time participants spent online may be a key reason why cyberchondria levels were found to be low. This supports the "avoidance due to increased anxiety" dimension of Starcevic et al. (26) hybrid model of health-related internet searches, which proposes that searching for health information online may either increase or reduce anxiety. If anxiety increases, individuals may avoid online searches, while in other cases they may continue seeking reassurance, potentially intensifying the cycle.

A previous study suggests that more educated individuals demonstrate greater attentiveness to somatic symptoms and are more likely to engage in online health information-seeking behaviors, a tendency that may be driven by elevated health anxiety (19). In our study, 75.8% of participants had low educational attainment (15.2% were illiterate and 60.6% were primary school graduates), which may have contributed to the low levels of cyberchondria. Individuals with lower education levels may struggle to understand and interpret complex health information found online, thereby reducing their likelihood of engaging in excessive searching behaviors.

In our study, most DFU patients (54.5%) were in stages 0 and 1 according to the Wagner classification, indicating relatively mild or superficial ulcerations. In a study conducted by Santoro et al. (22) with 431 participants aged 18–74 years, the severity of physical symptoms was positively correlated with cyberchondria, while health anxiety was identified as a mediating factor. Similarly, in a study involving patients with fibromyalgia, higher symptom severity was associated with increased health anxiety and cyberchondria levels (27). The relatively mild condition of the participants' foot ulcers in our study may have resulted in lower perceived threat and health anxiety, which in turn could explain the lower tendency toward excessive online information seeking.

A cross-sectional study in Turkey examining individuals with DFUs reported that 77.8% of participants had inadequate health literacy (28). A study conducted in Brazil among patients with type 1 and type 2 diabetes receiving primary care reported that 52.8% had low health literacy specifically concerning DFU care. An association was observed between low health literacy and factors such as advanced age, lower educational attainment, decreased household income, unemployment, prolonged diabetes duration, and the existence of chronic complications (29). While these studies focused on general health literacy, and our study assessed e-health literacy, the consistently low scores across studies point to a shared trend. These findings suggest that individuals with DFUs face challenges in accessing and effectively utilizing both traditional and digital health information.

In research carried out by Elnaem et al. (30) in Indonesia and Malaysia, 56.5% of patients with type 2 DM were found to have depression, and 41.6% had anxiety. Depression and anxiety risks were significantly higher in individuals with DFUs. Our sample consisted solely of individuals with DFUs, and their depression levels were found to be moderate. These results indicate that the severity of psychological symptoms may differ according to both individual and environmental factors.

A systematic review and meta-analysis published in 2020 demonstrated that approximately 47% of individuals with DFUs experience depression (31). The study by Pereira et al. (32) also highlighted emotional consequences such as fear and sadness associated with DFUs, confirming the psychological distress experienced by this patient group. These findings reinforce that the moderate psychological symptoms observed in our study should be taken seriously given their potential impact on disease progression and quality of life. It is evident that multidisciplinary approaches in DFU treatment should include not only medical but also psychological support components.

Limitations of the Study

A key limitation of our study was the restricted sample size, attributable to the limited timeframe available for data collection. Additionally, differences in some sociodemographic characteristics of the participants and the unbalanced distribution across the Wagner classification stages are also among the limitations.

CONCLUSION

This study reveals that individuals with DFUs exhibit low levels of cyberchondria and e-health literacy, together with moderate levels of depression, anxiety, and stress. The limited use of the internet, older age, lower educational attainment, and male predominance within the sample may contribute to these findings. Although digital health resources are increasingly accessible, patients with DFUs appear to face significant challenges in utilizing these tools effectively. These limitations may hinder their ability to make informed health decisions or manage their condition proactively. Therefore, multidisciplinary care approaches for DFU patients should integrate not only clinical and wound management strategies but also psychological support and targeted interventions to improve digital health literacy.

Ethics Committee Approval: Ethical approval was obtained from the Non-Interventional Clinical Research Ethics Committee of Hasan Kalyoncu University on June 2, 2025, with the decision number 2025/079.

Peer-review: Externally peer-reviewed.

Author Contributions: HA: Conception, design, data collection, analysis/interpretation, literature review, writing, critical review. HC: Conception, design, data collection, analysis/interpretation, literature review, writing, critical review. KC: Conception, design, data collection, analysis/interpretation, literature review, writing, critical review. HY:

Conception, design, materials, data collection/processing, analysis/interpretation, critical review. MAÇ: Conception, design, supervision, critical review.

Conflict of Interest: The authors report there are no competing interests to declare.

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Availability of Data and Material: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Research Article

DO TAPING AND ORTHOSIS AFFECT PAIN, GAIT, OR FUNCTIONALITY IN MILD KNEE OSTEOARTHRITIS? A RANDOMIZED CLINICAL TRIAL

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Keywords

Athletic tape,
Braces,
Gait,
Kinesiotape,
Knee osteoarthritis.

ABSTRACT

Purpose: Taping or brace were found to be effective in the treatment of knee osteoarthritis. There is a lack about comparison of taping techniques and brace immediately after application in knee osteoarthritis. The aim of this study was to compare the effects of elastic, rigid taping, and braces applied to women with mild knee osteoarthritis on pain, gait, and knee functionality.

Methods: This study included 21 female patients with bilateral grade 2 knee osteoarthritis. Pain was evaluated with visual analog scale, functionality was evaluated with Western Ontario McMaster Osteoarthritis Index, and gait parameters were evaluated using gait analysis system at baseline and immediately after the applications. The variables were measured after 45 minute the applications on each participant with 1-day intervals.

Results: The pain, functionality, and adductor moment of the participants showed statistically significant differences between the groups before and after the applications ($p<0.05$). The difference was found in the the intragroup evaluation results of the no application assessment ($p<0.05$). Spatiotemporal parameters and the maximum-minimum knee flexion angles of the left-right difference were not statistically significant ($p>0.05$).

Conclusion: Braces had the most immediate effect on pain and functionality and elastic taping had the most immediate effect on gait in mild knee osteoartritis.

INTRODUCTION

Osteoarthritis (OA) is a complex disease that occurs due to many factors like joint structure, genetic factors, local inflammation, mechanic loads, and the cellular/biochemical process, which results in joint destruction (1-3). Gait analysis, which is conducted during the evaluation of participants with knee OA, makes it easy to determine the abnormalities of gait, to select the treatment program, to detect treatment effects, and to select the correct orthosis (4, 5).

Physical therapy applications like exercises (6-8), taping (9, 10), using orthosis (11), and manual therapy (6, 7) have an important role in the treatment of participants with knee OA.

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Positive effects of these applications were reported including decreasing pain, increasing range of motion, muscle strength, and functionality in daily activities, and improving gait, which is affected secondarily after knee OA (9, 11-13). Elastic taping decreases pain and edema and increases elasticity, muscle strength, and range of motion. It also activates the power of intrinsic improvement by stimulating muscle structure with the full range of motion and it does not cause any circulation problems in the (6, 12, 14). The therapeutic effects of rigid taping are correcting the patella's position, decreasing the load on the soft tissue, and improving the connection between the patella and trochlea. It also decreases pain by increasing muscle contraction (3, 15, 16). Some research has focused on neutral, medial, and lateral calcaneal wedges and braces that apply forces on the knee to the varus/valgus (17, 18). Mange et al. (9) investigated whether elastic or rigid taping had better immediate effects on knee OA and concluded that elastic taping was better than rigid taping in increasing knee range of motion and in decreasing pain during activity. Park et al. (19) stated that elastic taping had positive immediate effects on pain, balance, and gait in older adults.

From the study's findings, there is a lack of comparisons of the acute effects of taping and knee orthoses in women with mild knee OA and comparisons on all three applications together in the literature. This study aimed to compare the effects of elastic taping, rigid taping, and braces on pain, gait, and functionality in women with mild knee OA. The hypothesis of this study was to determine the acute effects of the elastic, rigid taping, and braces on pain, gait, and functionality for women with mild knee OA.

METHODS

This four-session, experimental, randomized study compared the effects of elastic taping, rigid taping, and knee braces. The study was carried out at the Physiotherapy and Rehabilitation Department. The study was approved by the regional review board and was conducted according to the Declaration of Helsinki. The study was conducted after permission was obtained (with the number of KA-120110) from the Non-Interventional Clinical Research Ethics Board of Hacettepe University. All the study participants were informed about the aims of the study prior to commencing the study and signed the consent form provided by the Non-Interventional Clinical Research Ethics Board of Hacettepe University. This trial was registered with clinicaltrials.gov (registration no: NCT05741996).

The order of the elastic taping, rigid taping, and braces was randomized using a computer-generated random sequence created before the research (Random.org). Both knees of

each participant were taped and braced. All tapings were performed by a certified physical therapist with 5 years of experience. The participants were allowed to become accustomed to the applied elastic taping, rigid taping, and braces before the gait analysis and evaluations. All the taping techniques and braces were similar for all the participants. The participants performed four evaluation condition trials at baseline and with the elastic taping, rigid taping, and braces after 45 minutes.

Twenty-one female participants, who were aged between 40-65 years, were diagnosed with bilateral knee OA according to the criteria of the American College of Rheumatology, had radiographically phase 2 based on the criteria identified by Kellgren & Lawrence, had active knee pain, did not receive any knee treatment in the last year, and who could understand test and evaluations, were included in the study (Figure 1)(20).

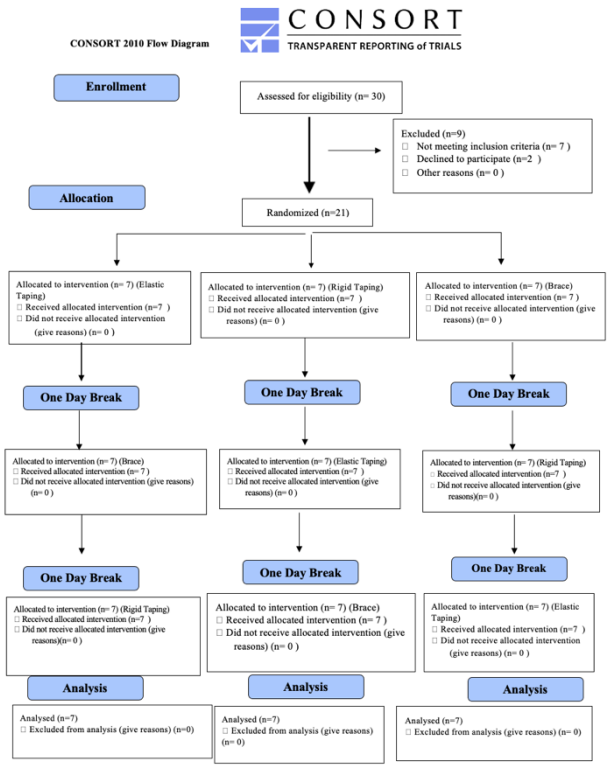

Figure 1. Flow Diagram of This Study

Participants who experienced lower extremity trauma or underwent surgery, had phase 3-4 OA severity, had any orthopedic or neurologic problem affecting walking, were allergic to taping, or did not walk independently on their own were excluded from the study.

Measurements

Each participant's knee pain was measured with a visual analog scale (VAS) that ranged from 0 (no pain) to 10 (worst pain imaginable). Four different VAS scores were recorded at first evaluation, after elastic taping, after rigid taping, and after brace application (21).

The Western Ontario and McMaster Universities Turkish Version 3.1 (WOMAC) index is a self-administered questionnaire that assesses three aspects of a patient's health status — pain, stiffness, and physical function — in those with lower limb OA. With 24 items (five about pain, two about stiffness, and 17 about difficulty with bodily functions) and a Likert scale (0–4), it was designed for people with osteoarthritis of the knee. Each subscale represents a figure and finally, a score can be obtained. Lower points represent a better health profile (22).

Gait analysis was conducted using a 3-dimensional VICON gait analysis system (Workstation Version 4.0, Oxford, UK). Each participant was assessed four times before and after the applications. The data was gathered at six high speed 50 Hz. JAI (Java Advanced Imaging) infrared digital cameras and two force plates (Bertec Force Plate, USA) in a gait analysis laboratory, which had an 8x4 gait road. Reflective indicators were placed on the patients' bodies using a standardized system called Helen Hayes Marker System. Daily walking rhythm was intended for each participant. Knee adductor–abductor moment maximum (max) and minimum (min) scores and max-min knee flexion angles were gathered for all gait cycles. Changes in spatiotemporal parameters (double support time, single support time, gait velocity, step length, step wide, and cadence) were calculated. The results were averaged from the four trials for each gait condition (23).

Intervention Protocols

The participants were evaluated for pain, gait, and functionality adaptations. For each patient, elastic taping, rigid taping, and braces were randomly applied. Between the applications, a break of at least one day was given not to affect the other participants. The participants were evaluated four times (at baseline, after elastic taping, after rigid taping, and after brace application). Measurements were taken before and 45 minutes after the application.

All tapings were applied by the same trained physiotherapist. Rigid taping was applied with hypoallergenic tape to prevent skin irritations. The hypoallergenic tape was laid over the same areas of the skin as the rigid tape. Rigid tape provided medial gliding, medial tilt, and anteroposterior tilt to the patella (Figure 2a) (3, 14).

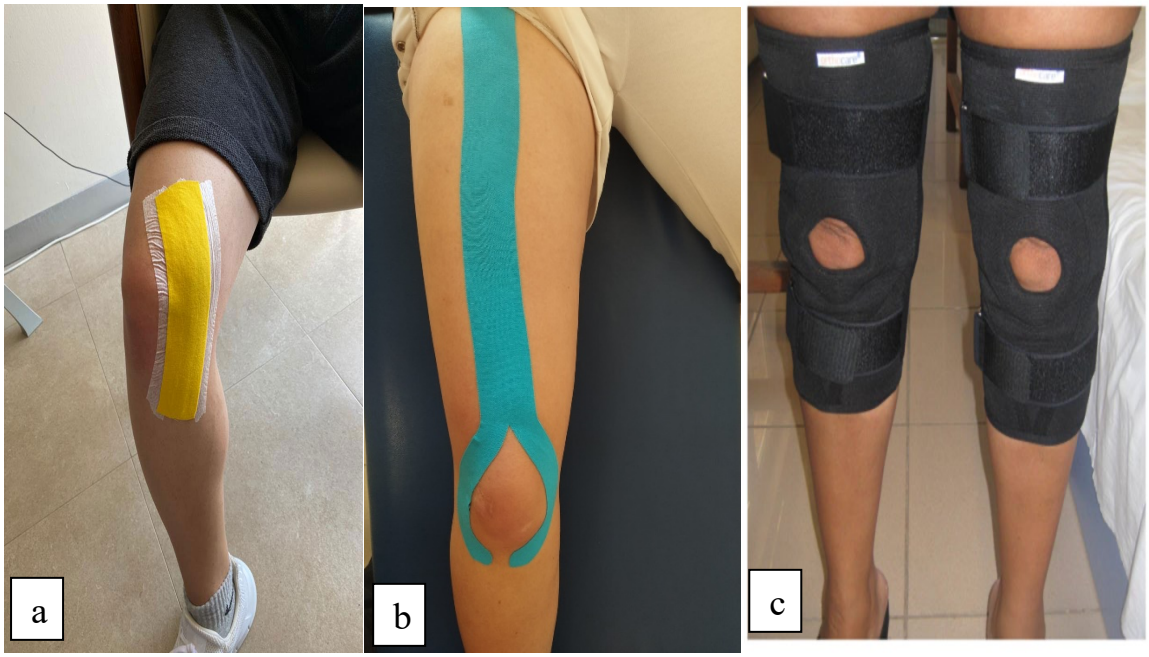

Figure 2. Rigid taping with McConnell Techique (a), Elastic Taping (b), Genucare AirX Brace (c)

The participants were taped with a Y-shaped elastic tape at the quadriceps. The patella was circled, and the tape was placed from a location 10 cm inferior to the anterior superior iliac spine, bisected at the quadriceps femoris tendon and patella junction, and finished at the inferior side of the patella. The first five centimeters of tape was not stretched and acted as the anchor. The area was expanded to 120% between the anchor and superior patella. The patella's remaining bandage was not stretched (Figure 2b) (12).

All the patients had been routinely prescribed a knee brace (Genucare Airx) by their treating physiotherapist to be used for the treatment of their OA. The brace was a fabricated system that was individually adjusted to each patient’s body measurements. This brace was a neoprene knee brace weighing less than 500 grams and did not affect the patient’s range of motion (Figure 2c) (18).

Statistical analysis

The sample size was determined using the G*power (version 3.1.9.4) program with an alpha level of 0.05, a correlation coefficient of 0.50, and a desired power (β) of 80%. The primary outcome of the randomized study was gait analysis. The estimated sample size was calculated to be at least 18 participants with at least six subjects in each group.

The statistical analyses were performed using the SPSS (version 18.0) software program. The variables were investigated using visual (histograms and probability plots) and analytical methods (Kolmogorov- Smirnov/Shapiro-Wilk's test) to determine whether they were normally distributed. Descriptive analyses were made using the median and interquartile range for the non-normally distributed and ordinal variables. To determine whether there had been a substantial change in pain, functionality, or gait analysis, Friedman tests were performed. The Bonferroni correction was used to account for multiple comparisons and to examine the significance of pairwise differences in the Wilcoxon test. An overall 5% Type-I error level was used to infer statistical significance (24).

RESULTS

Of the 30 people screened for eligibility, 21 female knee OA participants were included in this study (Figure 3). The demographic characteristics of the participants were 53.81±6.20 years for age, 158.90±7.02cm for length, 75.47±12.89 kg for weight, and 29.94±5.27 kg/m² for body mass index (Table 1).

The mean pain scores significantly changed in the groups (p=0.001). For elastic taping, there was a statistically significant difference between the first evaluation score and the score after taping (p=0.005). For rigid taping, there was a statistically significant difference before and after taping (p=0.014). For braces, there was statistically significant difference before and after the brace application (p=0.003) (Table 1).

The WOMAC index pain scores were statistically significant in the groups (p=0.022). For elastic taping (p=0.014), rigid taping (p=0.0025), and braces (p=0.009), there were statistically significant differences before and after application. The WOMAC index stiffness scores had statistically significant differences in the groups (p=0.017). For elastic taping (p=0.017), rigid taping (p=0.019), and braces (p=0.029), there were statistically significant differences before and after the applications. The WOMAC index functionality scores had statistically significant differences in the groups (p=0.042). For elastic taping (p=0.022), rigid taping (p=0.023), and braces (p=0.039), there were statistically significant differences before and after the applications (Table 2).

Significant changes were found between the right knee max adductor moment, (p=0.019), right knee min adductor moment (p=0.007) and left knee min adductor moment (p=0.003) mean scores. Significant differences in the right knee maximum adductor moment (p=0.019) and left knee minimum adductor moment were observed in the brace application (p=0.003). Rigid tape application significantly changed for the left knee max adductor moment (p=0.007) (Table 2).

Maximum and minimum knee flexion angles of the participants while walking is given in Figure 3. There was no statistically significant difference in the maximum right knee flexion range mean scores (p=0.89), the minimum right knee flexion range mean scores (p=0.29), and the maximum left knee range mean scores (p=0.78). When the minimum left knee flexion range was compared with all evaluations, a statistically significant difference was found (p=0.01) (Table 2).

The spatiotemporal parameters of gait are given in Table 3. When walking at a normal self-selected speed, no other between-group statistically significant differences were detected for the spatiotemporal parameters of gait (p>0.05).

Table 1. Demographic Features and Pain Scores of Participants (n=21)

Demographic Features	**Median (Min-Max)**
Age (year)	53 (40-65)
Length (cm)	158 (146-173)
Weight (kg)	76 (48-102)
BMI (kg/m²)	30.90 (20.0-39.10)
Pain Scores	**Median (Min-Max)**
VAS -At Baseline	6 (0-10)
VAS-Elastic Taping	5 (0-10)
VAS-Rigid Taping	5 (0-10)
VAS-Brace	4 (0-10)
Friedman Test (χ^2/ p)	16.47 / **0.001***

Max: Maximum; Min: Minimum; cm: centimeter, kg: kilogram, BMI: Body Mass Index, VAS: Visual Analog Scale, * p<0.05

Table 2. Functionality, Adductor Moment, and Knee Flexion Angle Scores of Participants

Womac	**Pain Median (Min-Max)**	**Stiffness Median (Min-Max)**	**Physical Function Median (Min-Max)**	**Total Median (Min-Max)**
First Evaluation	7(0-17)	3(0-8)	32(5-50)	40(7-76)
Elastic Taping	4(0-13)	2(0-8)	24(5-56)	30(7-72)
Rigid Taping	3(0-13)	2(0-7)	27(5-44)	34(7-60)
Brace	2(0-13)	2(0-7)	27(5-41)	35(7-60)
Friedman (χ^2/p)	9.66/ **0.02***	10.25/ **0.01***	8.19/ **0.04***	7.87/ **0.04***
	Max Adductor Moment		**Min Adductor Moment**	
N/m²	**Right Knee**	**Left Knee**	**Right Knee**	**Left Knee**
First Evaluation	0.38(0.20-0.67)	0.34(0.10-0.66)	0.003(0.001-0.008)	0.003(0.002-0.008
Elastic Taping	0.38(0.20-0.48)	0.41(0.20-0.66)	0.000(-0.06-0.06)	0.000(0.00-0.06)
Rigid Taping	0.42(0.22-0.62)	0.35(0.00-0.60)	0.002(-0.02-0.05)	0.000(-0.06-1)
Brace	0.48(0.18-0.62)	0.32(0.15-0.62)	0.01(0.00-0.04)	0.02(0.01-0.04)
Friedman (χ^2/p)	9.98/ **0.019***	4.08/ 0.25	12.12/ **0.007***	8.77/ **0.003***
	Max Flexion Angle		**Minimum Flexion Angle**	
	Right Knee	**Left Knee**	**Right Knee**	**Left Knee**
First Evaluation	43(12-58)	38(6-54)	10(1-12)	8(1-10)
Elastic Taping	39(12-60)	37(13-59)	3(1-16)	2(1-12)
Rigid Taping	45(10-57)	40(12-60)	3(1-16)	2(1-12)
Brace	39(20-64)	40(13-60)	4(0-11)	5(0-12)
Friedman (χ^2/p)	0.62/ 0.89	1.05/ 0.78	3.70/ 0.29	11.27/ **0.01***

WOMAC: Western Ontario McMaster Osteoarthrithis, N/m^2: Newton/ meter square; Max: Maximum; Min: Minimum; * p<0.05; χ^2: $Chi-square$

Table 3. Gait Parameters of Participants

Gait Parameters	First Evaluations Median (Min-Max)	Elastic Taping Median (Min-Max)	Rigid Taping Median (Min-Max)	Brace Median (Min-Max)	Friedman (χ^2/p)
Double Leg Stance (sn) (Left)	0.30(0.19-0.50)	0.30(0.26-0.48)	0.32(0.18-0.50)	0.31(0.20-0.50)	1.492/ 0.68
Double Leg Stance (sn) (Right)	0.28(0.19-0.48)	0.30(0.22-0.48)	0.30(0.18-0.50)	0.30(0.19-0.54)	3.846/0.27
Single Leg Stance (sn) (Left)	0.44(0.35-0.52)	0.44(0.32-0.50)	0.44(0.38-0.51)	0.43(0.34-0.50)	3.703/ 0.29
Single Leg Stance (sn) (Right)	0.43(0.33-0.58)	0.43(0.32-0.58)	0.42(0.36-0.52)	0.42(0.37-0.54)	0.665/0.88
Double Step Length (m)	1.05(0.85-1.030)	1.08(0.86-1.37)	1.04(0.83-1.28)	1.01(0.82-1.30)	4.00/ 0.26
Step Length (Left) (m)	0.51(0.41-0.65)	0.52(0.42-0.69)	0.51(0.41-0.65)	0.50(0.38-0.62)	2.505/ 0.47
Step Length (Right) (m)	0.54(0.44-0.65)	0.56(0.40-0.68)	0.55(0.41-0.63)	0.53(0.44-0.69)	0.81/ 0.84
Gait Speed (m/sn)	0.90(0.62-1.35)	0.90(0.64-1.52)	0.93(0.59-1.30)	0.92(0.52-1.40)	2.32/ 0.50
Gait Width (m)	0.18(0.13-0.23)	0.18(0.12-0.24)	0.18(0.12-0.24)	0.19(0.12-0.24)	2.42/ 0.48
Cadans (step/minute)	102(82-127)	104.0(84.6-131.5)	105.5(79.45-126.0)	105.5(84.20-124)	3.97/ 0.26

χ^2: $Chi-square$;; sn: second, m: meter, Max: Maximum; Min: Minimum, p>0.05

DISCUSSION

This study aimed to compare the effects of elastic taping, rigid taping, and braces on pain, gait, and functionality in women with mild knee OA. According to this study, rigid taping, elastic taping, and braces all showed improvements on pain, functionality, and gait immediately after the applications to the participants with mild knee OA. Pain and functionality improved more after the brace application. Gait improved more after the elastic taping application. This study is one of the few studies that have demonstrated that elastic taping, rigid taping, and braces are immediately effective on mild knee OA and can be a part of physical therapy applications.

Knee OA stems from loss of cartilage, and therefore, knee pain is inevitable. There are various treatment techniques available for reducing pain in individuals with knee OA (25). Elastic taping, rigid taping, and braces can be used for pain relief in literature (3, 9). Mange et al. (9) found that kinesiotape had immediate effects of pain relief, but rigid taping did not. Lu et al. (3) found that the mean VAS scores decreased in their rigid taping group compared to their no taping group. This study's results showed that all three interventions can be useful for immediate pain relief.

Functionality is the most important factor in the treatment of knee OA. A popular, dependable, and responsive indicator of the outcome for people with knee OA is the WOMAC index. Mutlu et al. (12) compared WOMAC scores in participants with knee OA using kinesiotape and placebo tape groups. Significant differences were found before and after a one-month treatment on pain, muscle strength, range of motion, and functionality. It was found that the kinesiotape group had higher scores than the placebo group. Like this study results, the first evaluations at the beginning of the study had the lowest WOMAC values. It was demonstrated in this study that both elastic and rigid taping and braces had immediate effects on functionality. Braces are the most effective method for acute effect on functionality for individuals with mild knee OA necessary for daily life activities.

A knee adduction moment may reflect the mechanical load of the medial compartment during gait in individuals with knee OA. Most studies in literature highlight the important relationship between knee OA and increasing knee adductor moments (4, 26). Fukaya et al. (27) found that severe knee OA participants had higher knee adductor moments. The result of that higher knee adductor moments causes acceleration of knee osteoarthritis process. Rezaei et al. (11) showed statistical significance about pneumatic and conventional knee brace for higher knee adductor moments. Moreover, they also noticed that a three-point knee pressure is less effective on a knee adduction moment and range of motion on participants with knee OA. In this study, it was asserted that elastic taping decreased knee adductor moments and brace increased. The increase in adductor moments may have resulted from the non-adjustable form of the brace used and from overweight participants. This result can also be considered to have contributed to the progression of gait affected by various parameters.

Most studies investigating the secondary gait changes of patients with knee OA concentrated on flexion ranges at the knee (26-29). Duffell et al. (30) and Ismailidis et al. (5) indicated that their knee OA group had less walking flexion range compared to healthy ones. As we found in this study, the participants walked with the lowest maximum and minimum

knee flexion ranges in the first evaluation. After the applications, there were no statistically significant differences, but there were clinical differences like literature.

The spatiotemporal characteristics of gait in individuals with knee OA are also affected by pain, joint stiffness, decreasing the range of motion of the joints, and worsening muscle strength (3-5, 30). Several studies concluded that gait stabilization and balance loss must be evaluated and examined in individuals with knee OA (29-31). This study results there was no difference between baseline and after all 3 applications. This result may have been related to the short duration of the application and to the fact that all participants had a mild stage of knee OA.

To the knowledge of the study's authors, this study is one of the few studies to combine elastic taping, rigid taping, and braces together to evaluate their immediate effects using gait analysis and functionality in mild knee OA. It is important to prevent progression of mild knee OA to severe knee OA.

Limitations of the Study

Finally, the limitations of this randomized study were only including participants of a single gender, OA phase-based comparisons because of all participants were women. Individuals in the severe knee OA phase and a placebo group can be included to observe changes between these groups.

CONCLUSION

This study observed the immediate effects of elastic taping, rigid taping, and braces on pain, functionality, and gait adaptations altogether. In addition, it can be concluded from this randomized study that elastic taping, rigid taping, and braces decrease pain and max-min adductor moments and increase functional ability. Moreover, this study also provides information to clinicians that patients' OA knee pain can be relieved immediately after elastic taping, rigid taping, and brace applications.

Ethics Committee Approval: Non-Interventional Clinical Research Ethics Board of Hacettepe University (with the number of KA-120110).

Informed Consent: All procedures followed were in accordance with the ethical standards of the research committee of Hacettepe University of Health Sciences and with the Helsinki Declaration of 1975, as revised in 2008. Informed consent was obtained from all patients for being included in the study.

Peer-review: Externally peer-reviewed.

Author Contributions: Conceptualization, T.Y.Ş. G.B. ; Methodology, F.E ; Software, T.Y.Ş.,SG and F.E.; Formal Analysis, T.Y.Ş., G.B. and F.E.; Investigation, T.Y.Ş., and F.E.; Resources, F.E., and T.Y.Ş.; Data Curation, F.E., and T.Y.Ş.; Writing – Original Draft, T.Y.Ş.; Writing – Review & Editing, F.E., and T.Y.Ş.; Supervision, F.E and G. B., S. G.

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

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Research Article

VACUUM SUSPENSION WITH AND WITHOUT SEALING SLEEVE IN TRANSTIBIAL PROSTHESES: COMPARISON OF MOBILITY AND SATISFACTION INDICATORS

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Keywords

Amputee,
Sealing,
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ABSTRACT

Purpose: The suspension system has a significant impact on user satisfaction and mobility, but it is not clear how suspension components affect these factors. The aim of this study was to investigate the effects of sealing sleeve in transtibial amputees who utilize either suction or elevated vacuum suspension systems in terms of balance, mobility and satisfaction.

Methods: Twenty-two participants were included in the study (age 40.18±14.75 years). Participants were divided into two groups according to the sealing type as 'with-sleeve' and 'without-sleeve'. The following tests were used: One Limb Stance Test for balance; Timed Up and Go test for functional mobility; the Mobility subcategory of the Prosthesis Evaluation Questionnaire for perceived mobility with a prosthesis; and the Satisfaction with Prosthesis Questionnaire for prosthetic satisfaction.

Results: There was no difference between the two groups in terms of functional mobility and satisfaction; without-sleeve group was found to be significantly better in terms of prosthetic limb balance and perceived mobility. There was a significant relationship between stump length and both prosthetic limb balance as well as perceived mobility.

Conclusion: The current study may provide important evidence for understanding the role of the sealing sleeve, optimizing prosthetic design, and personalizing prosthetic care for users.

INTRODUCTION

Prosthetic suspension systems are critical components that influence mobility, and user satisfaction in individuals with transtibial amputations. Among the various suspension options available, Suction Suspension (SS) and Elevated Vacuum Suspension (VS) have gained increasing attention due to their ability to remove air between the limb and socket, create a vacuum, reduce pistoning, and ensure that the socket fits securely. Previous studies have shown that vacuum systems can improve mobility and balance parameters by providing more consistent socket fit and improved proprioceptive feedback (1–3). Furthermore, prosthetic satisfaction is a multifaceted outcome that encompasses comfort, perceived stability, and confidence during ambulation—all of which may be influenced by the suspension method and the presence of prosthetic components like the sealing sleeve (4,5).

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Both SS and VS are based on the principle of creating negative pressure between the liner and the inner socket by expelling air via a distal one-way valve or vacuum pomp (6). The effectiveness of the vacuum depends on creating an airtight inner socket environment and a vacuum chamber that provides consistent suspension throughout the gait cycle. For this purpose, one of the suspension components used is the “sealing sleeve” on the proximal socket trim. While sleeves contribute to overall suspension integrity, their use may also introduce functional trade-offs, such as restrictions in knee range of motion or thermal discomfort, potentially influencing the user's mobility and satisfaction (2,7,8).

Another suspension component used for an airtight inner socket environment is silicone liners with sealing rings (or membranes) which are designed to provide vacuum suspension without a sleeve. The sealing rings of the liner isolate the distal region of the socket from the proximal section. The vacuum maintains negative pressure in the sealed distal chamber, thereby increasing socket fit and suspension in that region. The proximal region is not sealed, which provides greater freedom of movement and better heat distribution (9,10). There are no absolute criteria for choosing with- or without-sleeve options in vacuum suspension. However, for the use of without-sleeve system, it is recommended that the stump not be too short to provide a tight socket-liner interface in the distal limb region (11).

There has been no systematic comparison of the effects sealing sleeves in vacuum assisted prostheses in the literature. The aim of this study was to investigate the effects of with- and without-sleeve in transtibial amputees who utilize either suction or vacuum suspension systems in terms of balance, mobility and satisfaction. Also, the difference in stump length between with- vs without-sleeve system users and the relationship between stump length and mobility were also investigated. By comparing with- vs without-sleeve conditions in a controlled, cross-sectional design, this research seeks to provide evidence-based insights into the functional and subjective outcomes associated with sleeve use. The findings may inform clinical decisions regarding prosthetic suspension prescriptions and contribute to enhancing user-centered prosthetic care.

METHODS

This study was planned as a prospective case–control study and the level of evidence is III. This study was approved by the Gülhane Scientific Research Ethics Committee of Health Sciences University (2025-155). All participants provided written informed consent before taking part. The inclusion criteria were being between ages of 18-65 years, having unilateral transtibial amputation, using a carbon foot with solid ankle, and using SS or VS with- or

without-sleeve. Participants must also have to be using their current prosthetic system for at least six months. The same evaluation process was applied to all individuals included in the study.

Outcome Measurements

Within the scope of the study, participants' age, height, weight, date of amputation, and the type of foot, socket, suspension used in the prosthesis were recorded. Stump length (Medial Tibial Plateau - Stump Distal) and intact limb leg length (Medial Tibial Plateau - Floor) were recorded in centimeters. Stump length was recorded as a percentage relative to the intact limb ((stump length*100)/intact limb length). Then, the following assessments were done to find out about mobility parameters and satisfaction.

The *One Limb Stance Test* (OLST) was used for balance assessment. In the OLST, participants were asked to stand on one leg for as long as possible and the amount of time they could stand on one limb was recorded in seconds. The test began when they stood up, lifted one limb, and placed their hands on their iliac crest. During the test, participants were instructed to look at a mark on the wall. If they lost their balance or changed their foot or hand position, the time was stopped and recorded. The test ended for participants who could stand for more than 30 seconds. The test was first applied to the intact limb (IL), then to the prosthetic limb (PL), and repeated three times for each limb (12–14).

The *Timed Up and Go* (TUG) test was used for functional mobility assessment. The TUG measures the basic motor skills of subjects, including walking, transferring, and turning abilities. The test started with the participant in a seated position on a chair. When the test began, the subject was asked to stand up from the chair, walk 3 meters, turn 180 degrees, return to the starting point, and sit back down in the chair. The test was considered complete when the subject returned to the initial position. The total time was recorded in seconds. Lower time indicated better functional mobility level. Previous studies have assessed physical mobility and the risk of falls using this test and have confirmed the validity and reliability of the TUG test for subjects with transtibial amputation (15,16).

The *"Mobility" subcategory of the "Prosthesis Evaluation Questionnaire"* (PEQ-M) was used to evaluate the mobility level with the prosthesis. The PEQ-M assesses the perceived mobility potential of amputated individuals using a prosthesis in the last 4 weeks. It is a mobility scale consisting of 13 items that evaluates ambulation with prosthesis (8 items) and transfers (5 items). It uses a visual analog scale expressed in millimeters (0–100mm) for scoring and a high score indicates high mobility with the prosthesis (17).

The *Satisfaction with Prosthesis Questionnaire* (SATPRO) was used to assess prosthetic satisfaction. SATPRO is a 15-item, self-administered test aimed at determining satisfaction with the prosthesis used. For each item, participants mark the number that best describes their satisfaction with their current prosthesis (3: totally agree, 2: rather agree, 1: rather disagree, 0: totally disagree). Items 6, 12, and 14 are scored in reverse. Higher total scores indicate higher satisfaction. The maximum possible score is 45, indicating 100% satisfaction, whereas a score of 0 indicates 0% satisfaction. The satisfaction score was obtained as a percentage (%) by dividing the total score of the participants by the maximum score they could get from the questions they marked, multiplied by 100 (18).

Statistical Analysis

A priori power analysis was performed using G*Power Version 3.1 software for sample size estimation based on data from published studies. In the study by Çerezci-Duygu et al., the mobility scores of the independent intervention and control groups after follow-up, assessed using PEQ-M, were taken as the reference and the effect size was estimated as 1.67 (19). The minimum sample size required with this effect size was 22 participants (11 participants per group), using two-tailed hypothesis and independent sample t-test with at least 95% power and a significance level of 0.05.

The conformity of outcome measurements (including OLST, TUG, PEQ-M, SATPRO) to normal distribution was determined by analytical method (Skewness-Kurtosis) (20). Frequency distributions for categorical variables and descriptive statistics (Mean ± Standard Deviation) for quantitative continuous variables were calculated. The t-test was used to compare quantitative continuous data between two groups. Pearson's correlation coefficient was used to determine the strength of non-causal relationships among two numerical variables. Statistical comparisons were made using the *Statistical Package for the Social Sciences* (SPSS) software. Type 1 error level of 5% was accepted for statistical significance.

RESULTS

Twenty-two participants with transtibial amputation were recruited as volunteers (age 40.2±14.8 years; body mass index, 25.49±3.78 kg/m^2). Participants had an average stump length of 16.09±3.89 cm, and a stump length percentage relative to intact limb length of 35.41±8.73 %. The mobility and satisfaction scores of the participants are presented in **Table 1**.

Table 1. Mobility and satisfaction scores of the participants

	Min - Max	**Mean ± SD**
Amputation duration, year	1 – 32	12.3 ± 11.8
Stump length, cm	9 – 25	16.09 ± 3.89
Stump length, %	13.16 – 50	35.41 ± 8.73
OLST-IL, s	6.6 – 30	24.75 ± 8.47
OLST-PL, s	1.33 – 30	9.13 ± 9.41
TUG, s	7 – 12.6	9.56 ± 1.79
PEQ-M	5.39 – 9.63	7.83 ± 1.35
SATPRO, %	60 – 95	79.29 ± 8.98

Min–Max, minimum–maximum: SD, standart deviation: s, second: OLST, One Limb Stance Test: IL, Intact Limb: PL, Prosthetic Limb: TUG, Timed Up and Go Test: PEQ-M, Prosthesis Evaluation Questionnaire Mobility Subcategory: SATPRO, Satisfaction with Prosthesis Questionnaire.

In terms of the prosthetic systems used, 11 participants used a vacuum system with-sleeve (n=10 VS; n=1 SS), and 11 participants used a vacuum system without-sleeve (n=7 VS; n=4 SS). The comparison of outcome measurements between groups formed according to sealing sleeve utilization is presented in **Table 2**. The relationship between stump length and outcome measurements is presented in **Table 3**.

Table 2. Comparison of outcome measurements between groups

	With-sleeve (n=11)	**Without-sleeve (n=11)**	**Between-group difference (95%CI)**
Amputation duration, year	12.2 ± 12.4	12.5 ± 11.8	-0.3 (-11, 10.5)
Stump length, cm	13.18 ± 2.36	19 ± 2.76	**-5.82* (-8.1, -3.54)**
Stump length, %	29.49 ± 7.87	41.32 ± 4.58	**-11.83* (-17.65, 6.01)**
OLST-IL, s	22.37 ± 9.56	27.13 ± 6.84	-4.76 (-12.2, 2.68)
OLST-PL, s	4.61 ± 4.98	13.67 ± 10.79	**-9.06* (-16.71, -1.34)**
TUG, s	9.8 ± 2.16	9.31 ±1.39	0.49 (-1.13, 2.1)
PEQ-M	6.97 ± 1.2	8.7 ± 0.85	**-1.73* (-2.65, -0.8)**
SATPRO, %	79.39 ± 11.38	79.19 ±6.31	0.2 (-8.13, 8.53)

CI, confidence interval: s, second: OLST, One Limb Stance Test: IL, Intact Limb: PL, Prosthetic Limb: TUG, Timed Up and Go Test: PEQ-M, Prosthesis Evaluation Questionnaire Mobility Subcategory: SATPRO, Satisfaction with Prosthesis Questionnaire. *Statistically significant.

Tablo 3. Relationship between stump length and outcome measurements

	OLST-IL	**OLST-PL**	**TUG**	**PEQ-M**	**SATPRO**

Stump length, cm	0.326	**0.438***	0.086	**0.6****	-0.128
Stump length, %	0.375	0.168	0.047	**0.624****	-0.344

OLST, One Limb Stance Test: IL, Intact Limb: PL, Prosthetic Limb: TUG, Timed Up and Go Test: PEQ-M, Prosthesis Evaluation Questionnaire Mobility Subcategory: SATPRO, Satisfaction with Prosthesis Questionnaire. *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed).

DISCUSSION

In current study, the perceived level of mobility and static balance of the prosthetic limb were found to be better at the without-sleeve condition. Additionally, no difference was found in functional mobility or prosthetic satisfaction between with- or without-sleeve condition. Regarding the stump length, it was found that the stump length was shorter in the with-sleeve condition; and a positive, significant relationship was identified between stump length and perceived mobility and static balance on the prosthetic limb, suggesting that stump length may influence mobility and balance outcomes.

Mobility and balance are very important for individuals with amputation to perform their daily activities safely and efficiently. Although there are many determinants of mobility and balance, the present study findings indicate that the perceived mobility and static balance levels of the prosthetic limb are better in the without-sleeve condition. A previously noted disadvantage of the sealing sleeve is that it had to be worn up to the upper thigh. This limited knee range of motion and created excessive pressure on the patella (2,21). One reason why better mobility and static balance can be observed during without-sleeve condition is that the sealing sleeve restricts the knee range of motion, reducing flexibility and comfort during walking.

Stump length, its implications and biomechanics of remaining limb after amputation have been frequently discussed. It has been emphasized that there is a significant loss of strength, which may be related to stump length. This loss of strength may lead to changes in gait, decreased energy efficiency, increased walking resistance, altered joint loading, and an increased risk of osteoarthritis and chronic back pain (22,23). In addition to the predicted biomechanical effects on the remaining limb, the relationship between suspension selection, comfort, and stump length is unclear. One manufacturer's instructions state that their without-sleeve system cannot be used on stumps shorter than 11 cm; however, there is no such restriction for the with-sleeve systems. In our study, individuals using the without-sleeve system appear to have a more stump length. Based on these results, stump length appears to be a determining factor in choosing between the two systems. This is reasonable because a

vacuum forms in the distal region of the liner's ring/membrane in without-sleeve options. The shorter the distal stump region, the less the vacuum will affect it. Another reason for the improved mobility and static balance observed in individuals using without-sleeve system may be the longer stump length. The current study supports this notion by demonstrating that as stump length increases, perceived mobility and balance on the prosthetic limb improve.

The sleeve insulates the proximal end and creates a vacuum over the entire inner surface of the socket. This vacuum area is wider than that created by the without-sleeve design, but sleeve may negatively affect long-term mobility due to thermal discomfort such as sweating and heat intolerance, as well as difficulties in donning and doffing (21). Previous studies have shown that using prostheses significantly increases skin surface temperature, which can lead to discomfort (24). While using a sealing sleeve increases heat and the area of affected skin due to the increased surface area of the non-porous material (such as copolymer, rubber, or neoprene) in contact with the skin, the current study showed that it has no overall effect on prosthetic satisfaction.

Donning and doffing is also considered one of the important factors determining overall satisfaction and comfort with prostheses, and it appears to contribute to increased overall satisfaction (25,26). Previous studies have shown a direct relationship between suspension type and ease of donning and doffing (27). The present study demonstrated that sealing sleeves do not affect prosthetic satisfaction, despite the fact that they can complicate donning and doffing. As prosthetic satisfaction is a multidimensional concept incorporating factors such as perceived stability, comfort, ease of use and confidence, it is reasonable to assume that users evaluate their overall satisfaction by considering the advantages and disadvantages. In the current study, the fact that no difference was found between the satisfaction levels of users of both systems is surely due to the multiform nature of the satisfaction variable.

The functional mobility indicator did not show a statistically significant difference between the groups, which may be related to the nature of the test. TUG test used for this purpose is a combined test that focuses on short-term, basic functional mobility and transition movements. It may not be sensitive enough to detect more subtle changes in gait dynamics or long-term mobility limitations caused by the suspension system or the usage of a sealing sleeve. Previous studies, particularly in individuals using lower extremity prostheses, have shown that endurance-based assessments such as the 6-Minute Walk Test are more effective in detecting such subtle differences (28). Therefore, the inconclusive findings regarding the TUG test in our study may be related to the limited sensitivity of the test rather than the absence of functional effect and should be carefully evaluated in this context.

The current study has some limitations. First, the difference in the stump length of the two groups is a limiting factor in determining the isolated effect of sealing sleeve. Second, the vacuum option used was not standardized between the two groups (VS and SS). Third, tests with higher sensitivity could have been used for mobility assessment. Lastly, the present study examined the duration of amputation, but not the duration of use of the final prosthesis (vacuum suspension). Further studies could investigate the relationship between the duration, and outcome measures for different prosthetic components. Also, further studies with larger sample sizes, long-term follow-ups, and objective motion analyses are needed to improve clinical guidelines.

CONCLUSION

Current results suggest that sealing sleeve impacts not only suspension security, but also fundamental mobility and stability parameters. Specifically, stump length has been identified as a key determinant of these outcomes, emphasizing the necessity of considering individual anatomical characteristics when prescribing prosthetics. Additionally, balancing the mechanical benefits with the comfort-related drawbacks of cuff use highlights the importance of user-focused clinical evaluations. There is limited empirical data on the specific contribution of the sleeve component to vacuum systems' overall effects on functional outcomes. Despite the theoretical benefits, few studies specifically examine the sealing sleeve's effect on vacuum system users. Understanding the role of the sealing sleeve is important for optimizing prosthetic design and personalizing care for users.

Ethics Committee Approval: This study was approved by the Gülhane Scientific Research Ethics Committee of Health Sciences University (2025-155).

Informed Consent: All participants provided written informed consent before taking part.

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Research Article

THE EFFECT OF THE JEWETT ORTHOSIS ON PAIN AND ORTHOSIS SATISFACTION IN PATIENTS UNDERGOING VERTEBROPLASTY OR KYPHOPLASTY DUE TO MULTIPLE MYELOMA: A PILOT STUDY

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Keywords

Kyphoplasty,
Multiple myeloma,
Orthosis,
Vertebroplasty.

ABSTRACT

Purpose: Multiple myeloma (MM) is a malignancy characterized by uncontrolled plasma cell proliferation, often resulting in bone fractures, particularly vertebral compression fractures. Standard treatment includes vertebroplasty or kyphoplasty to restore load distribution and stabilization. Postoperatively, the Jewett orthosis is prescribed to maintain spinal stability. This study aimed to evaluate the effect of Jewett brace use on low back pain and patient satisfaction in MM patients who had undergone vertebroplasty or kyphoplasty.

Methods: Four male patients aged 30–45 years with MM and vertebral fractures treated with vertebroplasty or kyphoplasty were included. The Quebec Back Pain Disability Scale (QBPDS) assessed back pain, and the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) evaluated orthosis satisfaction. Vertebral curvature measurements were obtained one-month post-surgery to compare preoperative and postoperative vertebral height.

Results: According to the QBPDS, patients reported limitations in daily activities with a mean score of 49.25%. QUEST results showed that while the orthosis provided stabilization, the average satisfaction level was 3.85/5. Magnetic resonance imaging demonstrated an increase in vertebral height, from a preoperative mean of 1.92 cm to a postoperative mean of 2.25 cm.

Conclusion: Conservative treatment with postoperative Jewett orthosis contributed positively to vertebral stabilization. Patients experienced moderate back pain and improvements in daily living activities, and overall satisfaction with the orthosis was reported. Further studies with larger cohorts are recommended to clarify its impact on functional capacity and pain.

INTRODUCTION

Multiple myeloma is a malignant disorder characterized by the accumulation of monoclonal antibodies in the bone marrow, leading to their proliferation in the blood and urine. The disease may initially present with specific symptoms. Increased levels of monoclonal antibodies can cause lytic lesions in bone structures, particularly in the vertebrae. These lesions

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compromise the structural integrity of the spine, resulting in pathological fractures and severe pain that negatively impacts quality of life (1-2).

Studies have shown that thoracolumbar spine fractures account for approximately 15% of all spinal fractures. While systemic oncological treatment is essential for achieving remission and long-term disease control, surgical intervention may be necessary in certain cases involving pathological vertebral fractures. The primary goal of surgery is to restore spinal stability and neurological function, thereby improving quality of life. Spinal fractures due to high-energy trauma frequently occur in the thoracolumbar region, which serves as a transition zone between the relatively immobile thoracic and the more mobile lumbar spine. Increased biomechanical stress renders this region more susceptible to injury (3 -4-5).

Vertebral fractures may lead to height loss caused by vertebral collapse, spinal instability, and even kyphotic deformity. The resulting pain and kyphosis can progressively restrict mobility and impair respiratory function, ultimately diminishing the patient's quality of life and increasing vulnerability to further complications (6).

Spinal orthoses are external supports used as primary or adjunctive tools for immobilization in various spinal disorders. These orthoses can be classified into three categories based on their function: supportive, immobilizing, and corrective. Immobilizing orthoses are commonly used postoperatively following thoracolumbar spinal surgeries. The Jewett orthosis, designed for hyperextension, prevents flexion and lateral bending, thus supporting the thoracic and lumbar spine. It features anterior sternal and pubic pads and a posterior adjustable strap to maintain a three-point pressure system. Spinal braces operate via two primary mechanisms: one involves increasing intra-abdominal pressure to reduce the net force and stress applied to the spine; the other employs three-point fixation to maintain proper spinal alignment, thereby offloading compressive forces and ensuring spinal stability and proper load distribution (7-8).

Although there is a growing body of research on spinal orthoses, the literature lacks studies focusing on orthotic use following vertebral fractures caused by multiple myeloma and treated surgically. Therefore, this pilot study aims to assess the effectiveness of the Jewett orthosis in alleviating pain and improving user satisfaction among individuals with spinal fractures due to multiple myeloma who have undergone vertebroplasty or kyphoplasty.

METHODS

Study Design

This study was conducted in 2023 with participants who were admitted to the hematology department of Medipol Mega University Hospital due to multiple myeloma, underwent surgery for vertebral fractures caused by the disease, and subsequently used a Jewett orthosis. Ethical approval for the study was obtained from the Ethics Committee of Medipol University (approval date: 14.09.2023; reference number: E-10840098-772.02-5854). All participants signed an informed consent form indicating their voluntary participation. The study was conducted in accordance with the principles of the Declaration of Helsinki for biomedical research involving human subjects. This investigation was conducted as a pilot study to obtain preliminary data on the effects of Jewett brace use on low back pain and patient satisfaction.

Participants

Four participants diagnosed with multiple myeloma who had experienced vertebral fractures and undergone vertebroplasty or kyphoplasty followed by use of a Jewett orthosis were included. Each participant was informed about the structure, purpose, and requirements of the study, and written informed consent was obtained. Inclusion criteria required individuals to be literate, able to cooperate, ambulatory, and independent in daily activities, and to have used the Jewett orthosis for at least one month. Exclusion criteria included symptoms other than fractures caused by myeloma, neurological disorders, and serious postural or deformity-related impairments that could cause balance, gait, or functional loss.

Procedure

To assess the impact of back pain on quality of life, the Quebec Back Pain Disability Scale (QBPDS) was administered. To evaluate satisfaction with the orthosis, the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) was used. Vertebral curvature was measured one month after surgery by a specialist physician to compare vertebral height based on preoperative (Pre-op) and postoperative (Post-op) magnetic resonance imaging (MRI) scans.

Quebec Back Pain Disability Scale (QBPDS)

The QBPDS was developed in French and English as a specific tool for evaluating functional disability in patients with back pain. Functional disability is defined as difficulty in performing simple physical activities. The scale consists of 20 items categorized into six areas: resting/lying down, sitting/standing, walking, range of motion, bending and lifting/carrying, and daily activities. Each activity is rated on a 6-point scale, where higher scores indicate more severe disability (0 = no difficulty; 5 = unable to perform). The maximum total score is 100. The Turkish version has been validated and shown to be reliable (9). Vertebral measurements were performed once, after one month of orthosis use post-surgery.

Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST)

The QUEST is a standardized survey commonly used to assess satisfaction with various assistive technologies. Satisfaction is defined as the user's critical assessment of the assistive device, which may be influenced by expectations, perceptions, attitudes, and individual characteristics. The survey consists of 12 items—8 relating to device satisfaction and 4 to service satisfaction. The Turkish adaptation and validation were conducted by Yavuz Yakut and colleagues (10). Vertebral measurements were taken once, after one month of orthosis use post-surgery.

Vertebral Curvature Measurement

At the time of fracture, MRI was used to evaluate vertebral height loss at the injury site prior to surgery. Preoperative and postoperative MRI scans were used to measure the mid-body vertebral height. These measurements were taken from MR images and compared accordingly (Figure 1) (11).

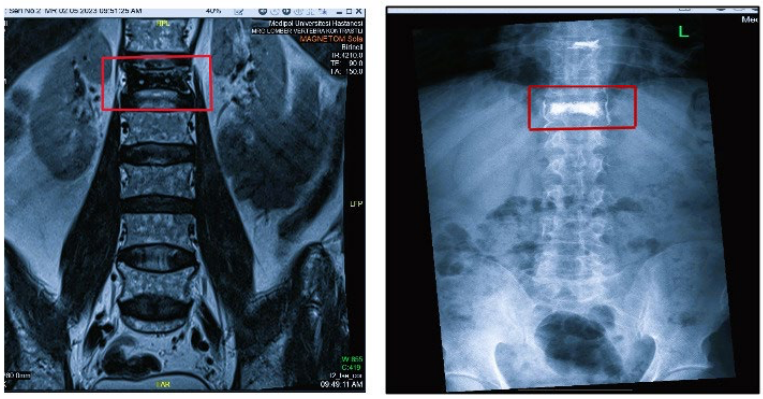

Figure 1. Pre-operative and postoperative vertebrae

Statistical Analysis

As this is a pilot study, the results of the questionnaires completed by the four participants were analyzed using mean and standard deviation.

RESULTS

Four male participants between the ages of 34 and 51 who met the inclusion criteria were enrolled in the study. Among them, three had undergone vertebroplasty only, while one had undergone both vertebroplasty and kyphoplasty. Demographic information of the participants is presented in Table 1, and the results of the Quebec Back Pain Disability Scale (QBPDS) and the Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST) are presented in Table 2.

Tablo 1. Demographic information

	Age	**Gender**	**Operation**	**Jewett Orthosis Usage Time**
CASE 1	44	Male	Vertebroplasty	1-2 Years
CASE 2	34	Male	Vertebroplasty	0-6 Months
CASE 3	40	Male	Vertebroplasty	1-2 Years
CASE 4	51	Male	Vertebroplasty and Kyphoplasty	0-6 Months

Quebec Back Pain Disability Scale (QBPDS) Results

Participants' perceived back pain following surgical intervention was assessed using the QBPDS. According to the results (Table 2), the average limitation in daily life activities due to back pain was calculated as X = 49.25%. Additionally, the median and standard deviation results are presented in Table 2.

Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST)

Participants’ satisfaction with the Jewett orthosis was evaluated using the QUEST. The average satisfaction score was X = 3.85 out of 5, indicating a generally positive perception of the orthosis in terms of comfort and support. Additionally, the median and standard deviation results are presented in Table 2 (Table 2).

Table 2. Survey Results

Surveys		X	SS	M
Quebec Back Pain Disability Scale (QBPDS)		49.25	14.72	47
Quebec User Evaluation of Satisfaction with Assistive Technology (QUEST)	**Device Satisfaction**	3.87/5	0.69	3.995
	Service Satisfaction	4.06/5	0.875	4.125
	Total QUEST	3.85/5	0.48	3.885

X: mean, SD: standard deviation, M: Median

Vertebral Height Measurement

Comparative measurements of vertebral height were obtained from preoperative and postoperative MRI scans. The mean vertebral height increased from **Pre-op X = 1.92cm** to **Post-op X = 2.25cm**, indicating an improvement in spinal alignment and stabilization following orthosis use. Additionally, the median and standard deviation results are presented in Table 3.

Table 3. Preoperative and postoperative vertebral body mid-height

	Pre-operative vertebral height	X	SS	M	Postoperative vertebral height	X	SS	M
CASE 1.	1.34 cm	1.925	0.415	2.065	1.82 cm	2.2375	0.3065	2.315
CASE 2.	1.92 cm				2.20 cm			
CASE 3.	2.23 cm				2.50 cm			
CASE 4.	2.21 cm				2.43 cm			

X: mean, SD: standard deviation, M: Median

DISCUSSION

The majority of patients diagnosed with multiple myeloma undergo surgical intervention due to vertebral fractures and require the use of assistive devices postoperatively. To date, no studies in the literature have specifically examined the use of orthoses following surgery in such cases. The findings of our pilot study indicate that patients who used the Jewett orthosis after surgery experienced a reduction in pain and an improvement in vertebral height. Although these patients simultaneously received anti-myeloma therapy, the positive outcomes cannot be

attributed solely to orthosis use. Nevertheless, it is plausible that the absence of orthotic intervention might have led to poorer postoperative results. Therefore, we believe that the use of an orthosis plays an important role in maintaining the benefits of surgical intervention.

A study by Keshavarzi et al. reported that hyperkyphotic posture, resulting from altered vertebral biomechanics, adversely affects quality of life, lung function, and physical capabilities, and increases the risk of falls, fractures, and mortality. One of the aims of our study was to investigate whether supporting spinal stability in addition to anti-myeloma treatment could reduce these risks and improve quality of life by alleviating myeloma-related pain (12).

Matussek et al. emphasized that orthotic treatments used as adjunctive therapy after vertebral fractures should be considered as part of a multidisciplinary approach. Our findings align with this view: postoperative imaging showed a return to near-normal vertebral height, accompanied by reduced pain and improved quality of life (13).

De Sire et al. found that the use of spinal orthoses was associated with improvements in pain intensity, physical function, and quality of life. Our results support this, suggesting that the Jewett orthosis, when used alongside surgery and anti-myeloma treatment, contributes to spinal stability and musculoskeletal alignment, thereby significantly reducing perceived back pain (14).

Abe et al. reported that patients with spinal fractures who were monitored during a rehabilitation program while using a Jewett orthosis completed the initial treatment phase without serious adverse events, thanks to the stabilization provided by the orthosis. According to our QUEST results, the Jewett orthosis helped restore spinal integrity within approximately one month, with patients expressing high satisfaction. Additionally, the orthosis did not excessively limit daily activities, allowing patients to complete their initial recovery phase without major complications (15).

Taher et al. demonstrated that, in spinal fractures arising from other indications, the stabilization provided by orthoses exerts a beneficial influence on spinal biomechanics, thereby reinforcing surgical outcomes. These findings align with the results of our pilot study (16).

Yokoyama et al. compared vertebral height outcomes following three different procedures for vertebral fractures and concluded that vertebroplasty offered more advantages and benefits. Our study supports the idea that the Jewett orthosis, when used in addition to vertebroplasty or kyphoplasty, is beneficial in promoting recovery and adaptation by limiting excessive movement and enhancing stability (17).

Limitations of the Study

In our study, the evaluations of participants with orthoses and postoperative assessments were conducted at one month after the procedure. Some of our participants used the Jewett orthosis for longer than one month; however, since no MRI imaging was performed after the maximum period of orthosis use, the measurements could not be evaluated. Therefore, further studies are recommended to obtain clearer and more diverse data.

As this is a pilot study, we believe that the continuation of the research with a larger sample size is essential in order to share more conclusive results with the scientific community. Furthermore, we recommend that future studies focus more extensively on orthotic interventions used in this patient population to better evaluate their clinical and functional outcomes.

CONCLUSION

In patients with vertebral fractures due to multiple myeloma, the use of a Jewett brace following vertebroplasty or kyphoplasty has been shown to provide a positive effect on impaired spinal stability in addition to anticancer therapy, thereby contributing to the reduction of low back pain. Patients are generally satisfied with the ease of use of the brace, and the Jewett brace does not significantly limit their daily life activities. The preliminary results of our study support the use of the Jewett brace as a routine treatment procedure following vertebroplasty or kyphoplasty.

Ethics Committee Approval: Ethics approval was obtained from the Istanbul Medipol University Non-Interventional Clinical Research Ethics Committee (File No: E-10840098-772.02-5854, Date: 14.09.2023).

Informed Consent: Written informed consent was obtained from all participants included in the study.

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Research Article

INVESTIGATION OF FLEXOR AND EXTENSOR HALLUCIS LONGUS MUSCLE STRENGTH IN RELATION TO HALLUX VALGUS DEFORMITY SEVERITY

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Keywords

Extensor hallucis longus, Flexor hallucis longus, Hallux valgus deformity, Muscle strength.

ABSTRACT

Purpose: This study aimed to investigate changes in the muscle strength of the flexor hallucis longus (FHL) and extensor hallucis longus (EHL) muscles, and their relationship with deformity severity in individuals with halluks valgus (HV), a condition affecting the big toe.

Methods: Thirty-three individuals aged 18 to 65 years (44.46 ± 11.132) with unilateral HV deformity were included. Demographic data was recorded. The severity of HV deformity was evaluated using Manchester Scale. Muscle strength of FHL and EHL muscles was assessed by a hand-held dynamometer, while pain, functionality and activity limitations were assessed using the Foot Function Index (FFI).

Results: A statistically significant relationship was found between deformity severity and the muscle strength of FHL and EHL ($p < 0.001$). Furthermore, the muscle strength of the FHL and EHL in the affected foot was significantly associated with the pain, disability score, activity limitation and the total scores of FFI ($p < 0.001$). Muscle strength in the HV-affected foot was significantly lower compared to the unaffected (healthy) foot for both FHL and EHL ($p< 0.001$).

Conclusion: An increase in deformity severity was associated with a significant reduction in FHL and EHL muscle strength. This reduction correlated with increased pain, functional limitation, decreased and participation in daily living activities. The observed decline in function and increase in pain may be attributed to reduced muscle strength, which leads to increased mechanical load on the joints.

INTRODUCTION

Hallux valgus (HV) is a common forefoot deformity characterized by a lateral deviation and internal rotation of the big toe (hallux) toward the second toe at the first metatarsophalangeal (MTP) joint. This deformity is accompanied by medial displacement of the first metatarsal bone (1-3).

Although its prevalence varies across age groups and populations, HV affects approximately 23% of individuals aged 18 to 65 years, and 35.7% of those aged 65 years and older (4). Hallux valgus is typically associated with progressive pain in the big toe and may result in visible strüktürel deformitesi. If left untreated, it can reduce mobility, decrease physical

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activity levels, and impair the performance of daily activities (5,6). Additionally, HV has been linked to diminished health-related quality of life (7,8).

Both intrinsic and extrinsic factors are believed to contribute to the development of HV (9). Genetic predisposition, foot morphology, and musculoskeletal imbalances are among the primary intrinsic factors (10,11). Biomechanical abnormalities such as pes planus, excessive pronation, and ligamentous laxity also play a significant role in the onset and progression of HV (12-14). Additionally, prolonged use of narrow and high-heeled shoes can increase pressure on the hallux and accelerate deformity progression (15). The higher prevalence HV among women is often attributed to both biomechanical differences and footwear choices (16). Age-related loss of connective tissue elasticity with may may further contribute the progression of the deformity (17).

Muscle imbalance is considered one of the intrinsic factors contributing to the development of HV (18). Inadequate coordination among the muscle groups in the foot and ankle impairs the big toe's ability to maintain its normal anatomical position. Particularly, weakness or dysfuntion of the abductor hallucis (AbH) muscle, which abducts the big toe, can lead to abnormal load distribution across the joints and exacerbate the deformity (19,20). Additionally, flexor hallucis longus (FHL) and extensor hallucis longus (EHL) muscles have been identified as key contributors to HV progression (21). The directional pull of these muscles may gradually alter joint alignment and exacerbate the deformity (22). Functional impairments in these muscles can further display the toe from its natural axis of motion and intesify existing muscle imbalance (23,24).

This study focuses on the FHL and EHL muscles due to their significant role in the development and progression of HV deformity. The biomechanical effects of these muscles on the hallux positioning warrants further exploration, particularly in relation to the severity of deformity. While existing literature suggests a contributory role of FHL and EHL muscles in increasing the deformity severity (25,26), empirical data directly linking muscle strength to deformity degree remain limited. Current evidence does not provide a definitive understanding of this relationship, highlighting the need for more comprehensive investigation. Therefore, the aim of this study is to assess the changes in FHL and EHL muscle strength in individuals with HV deformity, and to examine the relationship between deformity severity and muscle strength. The aim was to determine the differences between groups with and without HV deformity and to identify how these differences manifest according to the severity of HV.

METHODS

Purpose and Type of Research

This study aimed to investigate changes in the muscle strength of the FHL and EHL muscles, and their relationship with deformity severity in individuals with HV, a condition affecting the big toe. This study was designed as a descriptive-correlational investigation involving individuals with HV deformity.

Population and Sample of the Study

Participants were selected using a random sampling method, comprising 19 males and 14 females. To ensure the reliability of the study results, a preliminary power analysis was conducted using G*Power 3.1 software, which indicated that, for an effect size of $r \geq 0.5$, 33 participants were required. Subsequently, 33 participants were included in the study to achieve the desired statistical power.

Participants:

The study included individuals aged 18–65 years with unilateral HV deformity. Inclusion criteria were:

- Presence of unilateral HV deformity graded as B or C according to the Manchester Scale
- Having unilateral HV deformity,
- Age between 18 and 65 years
- No cognitive and cooperation impairments that could interfere with participation
- No orthopedic conditions or rheumatoid arthritis affecting the lower extremities
- No history of lower extremity surgery
- Voluntary consent to participate in the study.

Exclusion criteria included:

- Diagnosed diabetic neuropathy
- History of lower extremity trauma within the past 6 months
- Previous lower extremity surgery
- Current use of orthoses or assistive devices for the lower extremities
- Ongoing or prior treatment for HV.

Ethical Aspects of the Research

Ethical approval for the study was obtained from the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (23.11.2023 – Decision No: 09-042). The study was conducted between June 1, 2024, and May 8, 2025.

Data Collection and Analysis

All participants were informed about the purpose of the study, evaluation procedures, expectations, and the forms used. They were assured of the confidentially of their data, and they signed an "Informed Consent Form" indicating their voluntary participation in the study.

The evaluation methods applied to all participants included in the study are listed below:

- Sociodemographic Information
- Manchester Scale
- Muscle Strength Assessment
- Foot Function Index (FFI)

Sociodemographic Information:

Demographic data including age (years), height (cm), body weight (kg), sex, education level, and occupation were recorded. In addition history of any surgeries was documented. The side affected by HV (right or left) was noted. Body mass index (BMI) values (kg/m²) were calculated by dividing body weight (kg) by the square of height (m²).

Manchester Scale:

The Manchester Scale, developed by Garrow et al. (27) was used to assessed the severity of HV through visual observation The scale comprises four standardized photographic categories. The four levels on the scale are defined as no deformity with a normal appearance (A), mild (B), moderate (C), and severe (D) HV (27).

Grade A indicates a normal structural alignment of the first phalanx. In Grade B, there is slight medial deviation of the first metatarsal bone and a slight lateral displacement of the first phalanx. At the moderate level (Grade C), the medial translation of the first metatarsal bone increases,leading to a more prominent bony protrusion (bunion) at its distal end, and the first phalanx. In the severe level (Grade D), the deformity at the distal end of the first metatarsal bone becomes highly pronounced, and the first phalanx is completely displaced under the second phalanx (27).

In this study, only individuals classified as Grade B or C according to the Manchester Scale were included. This scale enables visual assessment of foot structure while the individual is in a standing position. Since it does not require radiographic imaging, it allows for a safe; non-invasive assessment without exposure to harmful radiation. The validity and reliability of the scale were established by Menz and Munteanu (28). The Turkish validity and reliability study was conducted by Talu et al. (29).

Muscle Strength Assessment:

The muscle strength of the FHL and EHL muscles was evaluated using a handheld dynamometer. The Commander Muscle Testing device (JTECH Medical, USA), a scientifically validated tool, was used for the measurements. The device objectively measures force in both Newtons (N) and kilograms (kg), and the maximum force value on its screen. Its interchangeable heads allow for measurements across different anatomical regions (30).

EHL Muscle Strength Assessment:

Participants were positioned supine with the hip and knee in extension, and the talocrural joint (TCJ) and the hallux in maximum plantar flexion. The physiotherapist stood on the side being assessed, stabilized the foot proximally at the interphalangeal (IP) joint, and placed the dynamometer dorsally on the foot, aligned with the IP joint. Participants were instructed to apply force against the device for 3–5 seconds. Each participant underwent three trials, with the highest value recorded. A 30-second rest period was given between repetitions to reduce muscle fatigue (31). Bilateral measurements were performed.

FHL Muscle Strength Assessment:

For FHL evaluation, participants remained supine position, with the hip and knee semi-flexed to prevent compensatory movements. The ankle was stabilized and held in maximum plantar flexion to minimize co-contraction of plantar flexor muscles. Participants were again instructed to exert force against the dynamometer for 3–5 seconds. Three trials were conducted, and the highest value was recorded. A 30-second rest interval was provided between measurements to reduce fatigue (31). The measurements were taken bilaterally.

Foot Function Index (FFI):

The Foot Function Index (FFI) is widely used self-reported tool designed to assess the effects of foot pathologies on pain, functional disability, and activity limitation (8).

The index consists of three main subscales: pain, disability, and activity limitation, comprising a total of 23 items. The pain subscale includes nine items that evaluate pain intensity during various activities. The disability subscale, also with nine items, aims to measure the level of functional difficulties encountered in daily tasks. The activity limitation subscale consists of five items assessing the degree of limitation in the individual's activities due to foot problems (32).

Participants rates each item separately for the right and left foot on a scale from 0 (no pain/difficulty) to 10 (unbearable pain or difficulty preventing the activity). Ratings are based on symptoms experienced in the past week (33).

The score for each subscale is calculated by dividing the sum of the relevant items by the number of items and then multiplying by 100. The overall total score is obtained by summing all item scores, dividing by the total number of items, and multiplying by 100. Higher scores indicate more severe issues functional limitations (32).

The FFI was originally validated by Budiman et al. (34). It has since been widely used in research on orthotic treatments and foot/ankle disorders across different age groups (35,36). The Turkish validity and reliability study was conducted by Külünkoğlu et al. (37).

In our study, scoring was performed separately for each foot. Items were scored as zero for the foot without deformity. For the foot with deformity, the scores given were summed to calculate subscale and total scores.

Statistical Analysis

Data analysis was conducted by using the Statistical Package for Social Sciences (SPSS) Version 30.0 (SPSS Inc., Chicago, IL, USA) software. Following data collection and entery into the SPSS, frequency analysis were performed for demographic variables. Descriptive statistics including minimum and maximum values, arithmetic mean, and standard deviation were used to summarize continous variables, while the categorical data were expressed as frequencies and percentages.

Shapiro-Wilk test was applied to assess the normality of data distribution. Since the sample size was less than 50, the Shapiro-Wilk test results were primarily considered in data interpretation (38).

For between-groups comparisons of continuous variables, the Mann-Whitney U test was applied to non-normally distributed data. The Independent Samples t-test was used for normally distributed data. For within-group comparisons, the Wilcoxon Signed-Rank test was employed for non-normally distributed data, and the Paired Samples t-test was used for normally

distributed data. The FHL strength of healthy and HV-affected feet, as well as the FHL and EHL muscle strength of mild and moderate HV feet, exhibited a normal distribution. The EHL muscle strength data (healthy and HV-affected feet) and the FFI pain, disability, activity limitation, and total score data (mild and moderate HV feet) did not exhibit a normal distribution. For normally distributed data, the median and IQR were reported, whereas for non-normally distributed data, the mean and standard deviation were presented.

Correlations between variables assessed using the Pearson Correlation coefficient for normally distributed data, and the Spearman Correlation coefficient for non-normally distributed data. Correlation strength was interpreted as follows: r = 0.10–0.30 indicated a weak relationship, r = 0.30–0.50 a moderate relationship, r = 0.50–0.70 a strong relationship, and r = 0.70–0.90 a very strong relationship. Statistical significance was accepted at $p \leq 0.05$.

RESULTS

The demographic characteristics of the participants in the study are presented in Table 1.

Table 1. Demographic Characteristics of the Participants

Variable (n=33)	Minimum (Min)	Maximum (Max)	Mean (X) ± Standard Deviation (SD)
Age (years)	23	64	44.36 ± 11.132
Height (cm)	148	183	167.12 ± 9.410
Body Weight (kg)	49	105	76.21 ± 15.604
Body Mass Index (kg/m²)	18.20	39.10	27.3152 ± 5.46958

cm: centimeters, kg: kilograms, m: meters, max: maximum, min: minimum, m²: square meter, n: number of participants, SD: standard deviation, X: mean

The 33 individuals with HV deformity included in the study had a mean age of 44.36 ± 11.13 years (range: 23-64 years). The participants' height ranged from 148 cm to 183 cm, with a mean of 167.1 ± 9.41 cm. Body weight ranged from 49 kg to 105 kg, with a mean of 76.21 ± 15.60 kg. The body mass index (BMI) ranged from a minimum of 18.20 kg/m² to a maximum of 39.10 kg/m², with a mean of 27.32 ± 5.47 kg/m² (Table 1). A total of 19 males (58%) and 14 females (42%) were included in the study, with all individuals having unilateral deformity. The education levels and occupational distributions of the participants are presented in Table 2.

Table 2. Education Levels and Occupational Distribution of Participants

		Number (n)	Percentage (%)
Education Level	**Primary School Graduate**	7	21,2
	Secondary School Graduate	2	6,1
	High School Graduate	14	42,4
	University Graduate	10	30,3
Occupation	**Non-commissioned Officer**	1	3,0
	Government Employee	6	18,2
	Pharmacy Technician	1	3,0
	Retired	2	6,1
	Tradesmen	11	33,3
	Freelancer	3	9,1
	Security Guard	1	3,0
	Student	1	3,0
	Unemployed	7	21,2

n: number, %: percentage

Seven participants (21%) were primary school graduates, two (6%) were secondary school graduates, fourteen (43%) were high school graduates, and ten (30%) were university graduates (Table 2).

In terms of occupation, seven participants (21%) were unemployed, six (18%) were government employees, eleven (33%) were tradesmen, three (9%) were freelancers, two (6%) were retired, one (3%) was a non-commissioned officer, one (3%) was a pharmacy technician, one (3%) was a security guard, and one (3%) was a student (Table 2). The distribution of the presence of HV and the severity of the deformity in the right and left feet of the participants is presented in Table 3.

Table 3. Distribution of Individuals According to the Presence and Severity of Hallux Valgus in the Right and Left Foot

		Number (n)	Percentage (%)
Distribution by Side of HV Involvement	**Right Foot**	20	60,6
	Left Foot	13	39,4
Distribution by Severity of HV	**Foot with Mild HV**	17	51,5
	Foot with Moderate HV	16	48,5

n: number, %: percentage

None of the participants had undergone surgery. When comparing the presence of HV between the right and left foot, 20 participants (61%) had HV in the right foot, while 13 participants (39%) had HV in the left foot (Table 3). Regarding deformity severity, 17

individuals (51.5%) had mild HV, whereas 16 individuals (48.5%) had moderate HV (Table 3).The difference between the FHL muscle strength of the healthy and HV-affected feet in the participants is presented in Table 4.

Table 4. Comparison of Flexor Hallucis Longus Muscle Strength Between Healthy and HV-Affected Feet

		Mean (X)	Standard Deviation (SD)	P-value
FHL	**Healthy Foot Muscle Strength (n=33)**	29,4424	1,24575	**<0,001***
	HV-Affected Foot Muscle Strength (n=33)	25,0606	1,55522	

*Paired Samples t Test, FHL: Flexor hallucis longus, HV: halluks valgus, n: number, SD: standard deviation, X: mean

When the FHL muscle strength of all participants was compared between the healthy and HV-affected feet, a statistically significant difference was found between the healthy and HV-affected feet ($p < 0.001$) (Table 4). The difference between the EHL muscle strength of the healthy and HV-affected feet in the participants is presented in Table 5.

Table 5. Comparison of Extensor Hallucis Longus Muscle Strength Between Healthy and HV-Affected Feet

		Median (Med)	Interquartile Range (IQR)	P-value
EHL	**Healthy Foot Muscle Strength (n=33)**	21,200	20,5-22,0	
	HV-Affected Foot Muscle Strength (n=33)	16,200	15,0-17,5	**<0,001***

*Wilcoxon Signed-Rank Test, EHL: Extensor Hallucis Longus, HV: Hallux Valgus, Med: Median, n: number, IQR: Interquartile Range

When comparing the EHL muscle strength between the healthy and HV-affected feet, a statistically significant difference was observed ($p < 0.001$) (Table 5). The difference between the severity of deformity and the strength of the FHL and EHL muscles in the participants is presented in Table 6.

Table 6. Comparison of Flexor Hallucis Longus and Extensor Hallucis Longus Muscle Strength According to Deformity Severity

		Mean (X)	Standart Deviation (SD)	P-value
FHL Muscle Strength of HV Foot	**Mild HV Foot (n=17)**	26,282	1,5287	**<0,001***
	Moderate HV Foot (n=16)	23,763	1,8745	
EHL Muscle Strength of HV Foot	**Mild HV Foot (n=17)**	17,176	1,2312	**<0,001***
	Moderate HV Foot (n=16)	14,375	1,5476	

*Independent Samples T-test, EHL: ekstensor hallucis longus, FHL: flexor hallucis longus, HV: hallux valgus, n: number of participants, SD: standart deviation; X: mean

When comparing individuals with mild and moderate severity of deformity in terms of FHL muscle strength, a statistically significant difference was found between the groups ($p < 0.001$) (Table 6). Similarly, when comparing individuals based on the severity of deformity in terms of EHL muscle strength, a statistically significant difference was also observed between the groups ($p < 0.001$). The FHL and EHL muscle strengths were found to be statistically higher in individuals with mildly affected HV feet (Table 6). The comparison of FFI scores according to deformity severity is presented in Table 7.

Table 7. Comparison of FFI Scores According to Hallux Valgus Severity

	Mild HV (n=17)			Moderate HV (n=16)			
	Median (Med)	**Minimum (Min)**	**Maksimum (Max)**	**Median (Med)**	**Minimum (Min)**	**Maksimum (Max)**	**P-value**
FFI Pain Score	15,50	6,60	22,20	29,40	18,80	40,00	**<0,001***
FFI Disability Score	20,00	10,00	23,30	33,10	12,20	47,70	**<0,001***
FFI Activity Limitation Score	6,00	0,00	12,00	17,00	10,00	30,00	**<0,001***
FFI Total Score	44,40	16,60	50,80	79,15	54,40	93,40	**<0,001***

*Mann Whitney U Test, FFI: Foot Function Index, HV: Hallux valgus, med: median, min: minimum, max: maksimum, n: number of participants,

When the participants were compared according to deformity severity, a statistically significant difference was found in the FFI pain, disability and, activity limitation scores, as well as in the total FFI score ($p < 0.001$) (Table 7). The relationship between FHL and EHL muscle strength of the HV-affected foot and FFI scores is presented in Table 8.

Table 8. The Relationship Between Flexor Hallucis Longus and Extensor Hallucis Longus Muscle Strength and FFI Scores in the HV-Affected Foot

		Spearman's Correlation Coefficient	**P-value**
FHL Strength in HV Foot	**FFI Pain Score**	-0,751	**<0,001***
	FFI Disability Score	-0,635	**<0,001***
	FFI Activity Limitation Score	-0,697	**<0,001***
	FFI Total Score	-0,784	**<0,001***
EHL Strength in HV Foot	**FFI Pain Score**	-0,786	**<0,001***
	FFI Disability Score	-0,608	**<0,001***
	FFI Activity Limitation Score	-0,722	**<0,001***
	FFI Total Score	-0,797	**<0,001***

*Spearman's Correlation Test, FFI: Foot Function Index, EHL: extensor hallucis longus, FHL: flexor hallucis longus, HV: hallux valgus

When participants were compared in terms of FHL muscle strength and FFI scores, a strong negative significant correlation was found between HV-affected foot muscle strength and FFI pain score ($r = -0.751$, $p < 0.001$), FFI disability score ($r = -0.635$, $p < 0.001$), FFI activity limitation score ($r = -0.697$, $p < 0.001$), and total FFI score ($r = -0.784$, $p < 0.001$) (Table 8).

Similarly, a strong negative significant correlation was found between HV-affected foot EHL muscle strength and FFI pain score ($r = -0.786$, $p < 0.001$), FFI disability score ($r = -0.608$, $p < 0.001$), FFI activity limitation score ($r = -0.722$, $p < 0.001$), and total FFI score ($r = -0.797$, $p < 0.001$) (Table 8).

DISCUSSION

In our study, which aimed to examine changes in FHL and EHL muscle strength according to the severity of deformity in individuals with HV, a significant decrase in both FHL and EHL muscle strength was associated with the increase in severity of the HV. When comparing the muscle strength of the HV- affected foot with the contralateral healthy foot, both FHL and EHL muscle strengths were significantly lower in the affected foot. Additionally a significant correlation was found between deformity severity and FFI scores.

Regarding the prevalence of HV, a previous study has reported rates of 23% among adults aged 18-65 and 35.7% among individuals over 65 years old (4). It is defined as a chronic deformity affecting 12% to 70% of the general population (39). Consistent with the literature, the ages of the participants in our study ranged from 23 to 64 years.

Hallux valgus affects 30-58% of women (39,40) and epidemiological studies have consistently reported a higher prevalence in females (41). In a study by Nix et al. (42), the incidence of HV was reported to be 2.3 times higher in women than in men. Similarly, Nguyen et al. (41) found a prevalence of 58% in women and 25% in men, while Dufour et al. (43) reported HV in 44% of elderly female participants. A study examining the prevalence and risk factors of HV in the Japanese population identified female gender as a significant risk factor (44).

Contrary to these findings, our study included more men than women (19 males (58%) and 14 females (42%)), which may explain unexpected gender distrfibution. A study investigating the causes of HV deformity in men concluded that the deformity is mostly hereditary, begins at an early age, and is frequently inherited from the mother (45). Although genetic transmission may be a plausible explanation forf the higher proportion male participants with HV in our study, the absence of family history data represents a limitation.

Prolonged standing has been reported to negatively affect the progression of HV deformity and potantially increasing its severity (2,46,47). In our study, most participants were employed in occupations requiring extended periods of standing, which may have contributed to the development or exacerbation of their deformity.

In a Japanese population study, Okuda et al. (48) reported that 29.7% of individuals had HV symptoms in at least one foot. Another study found that the left foot was more frequently affected (49). Contrary to this study, our results showed a higher prevalence in the right foot (60.6%) compared to the left foot (39.4%). This discrepancy may be related to the predominance of right foot dominance; however, as foot dominance was not assessed in our study, this remains a limitation.

From a pathomechanical perspective, several theories emphasize abnormal alignment of the metatarsocuneiform joint and the imbalances in the periarticular soft tissues as key factors HV development (50,51,52). The abductor hallucis (AbH) and adductor hallucis (AdH) muscles, which help maintain first metatarsal alignment, are particularly implicated. In HV, AbH weakness and the unopposed action of the AdH contribute to lateral deviation of the hallux (19). Many previous studies have focused primarily on these two muscles.

However, the FHL and EHL muscles-central to the present study- also play an important role in HV pathogenesis. These muscles have been implicated in both the development and recurrence of HV. Their tendon pull vectors deviate laterally, drawing the proximal end of the distal phalanx toward the valgus direction (22). The change in the force direction of the FHL muscle generates an additional rotational torque on the hallux, promoting pronation of the first metatarsal and progression of the deformity. FHL contraction can also increase sesamoid subluxation. While these muscles typically provide stabilization during axial loading, in HV they contribute deforming forces that perpetuate the pathology (23).

Despite their potential significance, the functional characteristics of the FHL and EHL muscles in HV remain underexplored. In a three-dimensional magnetic resonance imaging study by Sanders et al. (53), it was demonstrated that lateral displacement of the FHL muscle plays a role in the pathogenesis of HV. However, there is insufficient information in the literature regarding changes in the muscle strength of these muscles as a result of HV deformity. Existing studies generally focus on anatomical displacements and structural impairments, while research examining changes in muscle strength levels remains limited. This highlights the necessity evaluate the functional characteristics of these muscle groups in the deformity process. Our study aims to shed light on these unexplored areas in the literature.

In our study, when comparing the FHL and EHL muscle strength between the healthy foot and the HV-affected foot, a statistically significant difference was found. The muscle strength in the HV foot was significantly lower compared to the healthy foot. Literature on muscle ultrasound studies indicates that HV deformity results in a reduction in muscle cross-sectional area and changes in pull angles due to positional shifts (53,54). Furthermore, we obserde that the FHL and EHL muscle strength was lower in feet with moderate deformity compared to those with mild deformity. We think this is due to changes in the muscle length-tension relationship and load transmission, ultimately resulting in decreased muscle activation.

The Manchester Scale is a clinical method that evaluates HV deformity through images representing four different severity levels (27). It offers advantages such as requiring minimal clinical expertise, providing a standardized framework for prospective monitoring of deformity progression, and being non-invasive (27,55). Additionally, its validity and reliability have been established (28,29). Studies examining the relationship between the Manchester Scale and radiological measurements have reported a significant correlation between the Hallux Valgus Angle (HVA) and Intermetatarsal Angle (IMA) (28,56). Another study on individuals with hallux valgus assessed the relationship between the Manchester Scale and plantar pressure distribution, concluding that this scale is an effective tool for reflecting deformity severity and

pressure levels in painful areas. Moreover, that study reported that the Manchester Scale correlates with both HVA and IMA (57). For these reasons, the Manchester Scale was used to evaluate deformity severity in our study. Participants were classified as 17 with mild deformity and 16 with moderate deformity. Many studies investigating hallux valgus severity have used the Manchester Scale for severity assessment (57,58). The test reliability of the Manchester Scale and its high agreement with clinical evaluation have been demonstrated (58).

Hallux valgus is associated not only with physical impairments in the musculoskeletal system but also with pain, functional limitations, and the impact on an individual's quality of life (6,59-65).

In a study comparing healthy individuals and those with HV, it was determined that HV is associated with foot pain and levels of functional impairment (42). In a study conducted on women with hallux valgus deformity, a statistically significant relationship was found between pain levels and foot function. The results showed that as the severity of the deformity increased, pain complaints also increased, which negatively affected foot-specific functional status (5). Another study involving individuals with hallux valgus demonstrated that as the severity of the deformity increased, there was an increase in pain intensity (65).

In our study, when comparing the relationship between deformity severity and Foot Function Index (FFI) scores, a significant difference was observed, consistent with the existing literature. As the severity of the deformity increased, differences were noted in the FFI pain score, FFI disability score, FFI activity limitation score, and the total FFI score. These results align with findings from other studies in the literature. The progression of the deformity leads to an increase in pain, resulting in physical functional losses and consequently activity limitations in daily life.

When examining the relationship between FHL muscle strength and FFI scores in HV-affected feet, a significant correlation was found. As muscle strength decreased, an increase in FFI scores was observed. Similar results were found for the EHL muscle as well. Loss of strength in the lower extremity can lead to decreased joint stability, which may result in pain symptoms (66). Along with the increase in pain severity due to muscle weakness, physical functional losses are also observed (67). Considering the results of our study, the increase in FFI scores associated with muscle weakness reflects an increase in pain and functional limitations, which aligns with the existing literature.

Limitations of the Study

Although genetic transmission is an important factor in male individuals, not investigating family history constitutes a limitation of our study. Additionally, pes planus is considered one of the most significant risk factors for hallux valgus; however, no evaluation regarding pes planus was conducted in our study, which can be viewed as a limitation. Additionally, the absence of an assessment for hypermobility, another recognized risk factor, may also be regarded as a study limitation. Besides the muscle strength assessment performed on the FHL and EHL muscles, not examining muscle activation or conducting radiological evaluations can also be considered limitations. The lack of gender standardization in the sample group and the absence of related study findings can be considered a limitation of the study.

CONCLUSION

A significant decrease in the muscle strength of the FHL and EHL muscles was observed with increasing hallux valgus deformity severity, with feet exhibiting moderate deformity showing significantly lower muscle strength than those with mild deformity. Correspondingly, a significant difference was found between deformity severity and FFI scores, with higher deformity severity associated with increased pain, greater disability, and more pronounced limitations in daily activities. Furthermore, significant correlations were observed between the FHL and EHL muscle strength of the affected foot and FFI scores, indicating that reductions in muscle strength are linked to increased pain, disability, and activity limitations. These findings highlight the importance of considering changes in the FHL and EHL muscles when designing rehabilitation programs, suggesting that targeted strategies and exercise interventions aimed at strengthening these muscles may help alleviate functional limitations associated with hallux valgus. Given that this study is the first of its kind on this topic, further research is warranted to confirm and generalize these results.

Ethics Committee Approval: Ethical approval for the study was obtained from the Ankara Yıldırım Beyazıt University Health Sciences Ethics Committee (23.11.2023 – Decision No: 09-042).

Informed Consent: They were assured of the confidentially of their data, and they signed an "Informed Consent Form" indicating their voluntary participation in the study.

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Research Article

THE EFFECTS OF SCREEN USE TIME ON QUALITY OF LIFE AND PAIN IN UNIVERSITY STUDENTS IN THE PANDEMIC

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Keywords

Pain,
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Screen time.

ABSTRACT

Purpose: The study was conducted to examine the effects of screen time on quality of life and pain in university students during the pandemic.
Methods: This cross-sectional study included 83 university students (64 F, 19 M). Descriptive features and screen usage times were recorded on an online form. Quality of life was assessed using the Nottingham Health Profile, and pain using the Cornell Musculoskeletal Discomforts Questionnaire.
Results: Daily screen time was determined to be 8.06±2.92 hours. The most pain was detected in the back, neck and shoulder regions. It was observed that students with more than eight hours of screen time per day had significantly worse quality of life and pain scores ($p<0.05$).
Conclusion: It has been found that university students who spent more than eight hours a day in front of a screen during the pandemic had negative impacts on their quality of life and musculoskeletal health. Daily screen time should be reduced to avoid these negative situations.

INTRODUCTION

The new type of coronavirus causing COVID-19 disease, which first started in Wuhan, China in December 2019, has led to a dangerous epidemic, which can result in acute respiratory syndrome (1). With the rapid spread of the virus to many countries, COVID-19 was declared a global pandemic by the World Health Organization on March 11, 2020 (2). In order to prevent the spread of the epidemic, many measures and restrictions were implemented in many areas of life. One of these restrictions was the decision to continue education remotely. The first case in Turkey was detected on March 11, 2020, and it was decided to continue university education remotely on March 13, 2020 (3).

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Distance learning has increased the time students spend in front of a screen (4), and this increased screen time due to the pandemic has been reported to have a negative effect on mental health and general health (5). It has also been shown that prolonged screen time is associated with obesity, hypertension, diabetes, depression and sleep disorders (6).

In recent years, a significant increase in screen time and related sedentary behaviors of young people has been detected (7), which has had a negative impact on health and quality of life (8). Screen time is also associated with musculoskeletal problems (9). It has been reported that screen usage time has increased and physical activity levels have decreased in students during the pandemic period (10). Increasing screen time also increases musculoskeletal discomfort (11). Long-term incorrect posture causes pain by straining musculoskeletal system elements such as muscles, tendons, joints and ligaments biomechanically (12).

During the period of pandemic restrictions, the screen time of university students increased rapidly as education was continued online (13). Understanding the effects of increased screen usage time on university students' quality of life and musculoskeletal system will guide the way in which the effects of screen time are observed and the management of distance education processes. The hypothesis of the study was that spending a long time in front of a screen would negatively affect quality of life and musculoskeletal pain.

METHODS

Purpose and Type of Research

The aim of this cross-sectional study was to investigate the effects of screen time on the quality of life and musculoskeletal system in university students who received distance education during the Covid-19 pandemic.

Population and Sample of the Study

The study inclusion criteria were defined as being a university student studying online, using a device with a screen, and voluntary participation in the study. Students were excluded if they had any disease or surgery within the last 6 months that may affect the musculoskeletal system, or if they were not willing to participate.

Ethical Aspects of the Research

Ethics committee approval was obtained from Ankara Yıldırım Beyazıt University Ethics Committee on 14.06.2021 date with approval number 33. The study sample comprised university students receiving distance education at Ankara Yıldırım Beyazıt University. The

study was carried out in June 2021 with the participation of 83 university students. Before the study, the participants were informed about the content of the study and consent for voluntary participation was provided. All the study procedures were carried out in compliance with the Declaration of Helsinki's principles.

Data Collection and Analysis

Due to quarantine measures and isolation, data were collected on an online platform. A link to the evaluation form created by the researchers was sent to the participants who met the inclusion criteria and who provided consent via the online form. Within the scope of this study, demographic information of the participants and information about screen time were recorded, the Nottingham Health Profile (NHP) was used to measure quality of life, and the Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) was used to determine musculoskeletal problems.

The total screen time per day was questioned and the time was recorded in hours. In addition, the daily screen time for online courses and for other digital applications was questioned categorically (<1 hour, 1-3 hours, 3-5 hours, >5 hours). Evaluation of daily screen time is a frequently used method to evaluate screen exposure (10, 14). In order to investigate the effects of screen time on quality of life and the musculoskeletal system, the students were compared in 2 groups of those with screen time of > 8 hours and those with ≤ 8 hours.

The Turkish version of the NHP was used to assess quality of life. The NHP consists of 38 questions and 6 subsections. This questionnaire includes three items assessing energy level, eight items assessing pain, nine items evaluating emotional reactions, five items evaluating sleep, five items evaluating social isolation, and eight items evaluating physical activity. Items are answered as yes/no. The weighted score of each category ranges from 0-100, and the total score of the scale ranges from 0-600, with lower scores indicating a better quality of life (15).

Musculoskeletal discomfort was evaluated using the Turkish version of the CMDQ. The CMDQ questions pain, ache or discomfort felt in the body parts during the previous week on a body diagram map. The frequency, severity and effect of the pain felt in 20 body regions are examined. The scale score is calculated as the frequency of discomfort for each body area (Never felt=0, Felt 1-2 times during the week=1.5, Felt 3-4 times during the week=3.5, Felt once every day=5 and Several times every day = 10), the severity of the discomfort (Slightly uncomfortable = 1, Moderately uncomfortable = 2, Very uncomfortable = 3) and the state of the discomfort that interfered with work (Not at all = 1, Slightly hindered = 2, Substantially =

3). The total scale score is calculated as the total of the scores of all the body parts. In this study, the right and left shoulder, upper arm, forearm, wrist scores were recorded as right and left upper extremity scores, and the right and left upper leg, knee, and lower leg scores were recorded as right and left lower extremity scores. Accordingly, the upper extremity score was in the range of 0-360, and the lower extremity score was in the range of 0-270. Higher scores obtained from the questionnaire indicate higher levels of pain frequency, severity, and work disability (16, 17).

Statistical analysis of the data obtained in the study was performed using SPSS (Statistical Package for Social Science) version 26 software. As descriptive statistics, categorical variables were presented as frequency (n) and percentage (%), and continuous variables as mean ± standard deviation values. The Mann-Whitney U test was used to compare the quality of life and musculoskeletal discomfort of the participants whose screen usage time was over 8 hours and those with 8 hours or less. Statistical significance level was accepted as $p<0.05$.

GPower 3.1.9.7 (Heinrich-Heine-Universität Düsseldorf) program was used to calculate the power of the study. Considering the difference in quality of life between students with <8 hours of screen time and those with >8 hours, the effect size was 0.446 with 83 participants with a type 1 error margin of 0.05, and the power of the study was calculated as 0.99.

RESULTS

The descriptive characteristics, NHP scores, and screen usage information of the 83 participants are shown in Table 1. It was observed that all the students used smartphones, and most also used computers (Table 1).

Table 1. Demographic Characteristics of the Participants, Nottingham Health Profile Scores, and Screen Usage Information (N=83)

	Mean	**Standard deviation**
Age (years)	21.79	1.66
Height (cm)	167.92	7.5
Weight (kg)	61.42	13.86
Daily screen time (hours)	8.06	2.92
Daily time spent in front of a screen before the pandemic (hours)	4.00	1.86
Nottingham Health Profile Scores		
Pain	19.93	21.18
Emotional reactions	47.98	31.81
Sleep	35.15	29.10
Social isolation	37.29	34.38
Physical activity	13.58	13.21
Energy level	63.43	38.89
Total score	217.39	118.223
	N	**%**
Gender		
Women	64	77.1
Men	19	22.9
Type of device used during the day		
Computer	79	95.2
Phone	83	100
Television	44	53
Tablet	19	22.9
Time spent per day for online courses		
Less than one hour	9	10.8
1-3 hours	38	45.8
3-5 hours	21	25.3
More than 5 hours	15	18.1
Time spent per day for other digital applications		
Less than one hour	5	6
1-3 hours	31	37.3
3-5 hours	26	31.3
More than 5 hours	21	25.3

When the CMDQ scores of the participants were examined, the highest score was related to back pain, followed by neck pain and shoulder pain scores (Table 2).

Table 2. Cornell Musculoskeletal Discomfort Questionnaire Scores

Cornell Musculoskeletal Disorder Questionnaire Scores	**Mean**	**Standard Deviation**
Neck	13.34	16.11
Right shoulder	6.97	13.55
Left shoulder	6.27	12.50
Back	16.27	22.98
Right upper arm	2.05	9.37
Left upper arm	0.79	2.21
Waist	11.87	20.05
Right forearm	1.59	9.93
Left forearm	0.31	1.06
Right wrist	3.24	11.33
Left wrist	1.04	2.85
Hip	3.21	6.99
Right upper leg	1.21	3.02
Left upper leg	1.19	3.02
Right knee	3.49	10.83
Left knee	2.74	6.75
Right lower leg	0.72	2.10
Left lower leg	0.74	2.11
Right foot	1.87	7.33
Left foot	1.58	7.15
Total	80.59	91.66

Screen time of >8 hours per day was reported by 34 students and ≤8 hours by 49 students. When the NHP and CMDQ scores were compared between these two groups, a significant difference was determined in respect of NHP emotional reactions, social isolation and total scores, the CMDQ both lower extremities and right upper extremity scores, and the duration of screen use before the pandemic ($p<0.05$, Table 3).

Table 3. Comparisons of the Nottingham Health Profile and Cornell Musculoskeletal Disorder Questionnaire scores of the groups of students with >8 hours and ≤ 8 hours screen time per day.

		Screen usage time > 8 hours (N=34)		**Screen usage time ≤ 8 hours (N=49)**		**p**
		Mean	**Standard Deviation**	**Mean**	**Standard Deviation**	
Nottigham Health Profile	**Pain**	20.29	19.41	19.69	22.52	0.656
	Emotional reactions	57.30	29.27	41.51	32.17	0.025*
	Sleep	37.82	28.77	33.30	29.48	0.42
	Social isolation	49.20	37.33	29.03	29.86	0.012*
	Physical activity	14.74	11.80	12.78	14.18	0.264
	Energy level	68.42	40.06	59.96	38.09	0.223
	Total score	247.78	103.79	196.29	123.94	0.041*
Cornell Musculoskeletal Disorder Questionnaire Scores	**Lower extremity-Right**	7.52	9.61	3.97	13.55	0.002*
	Lower extremity-Left	7.36	10.29	2.82	7.84	0.012*
	Upper extremity-Right	21.58	35.32	8.52	21.83	0.011*
	Upper extremity-Left	14.44	20.18	4.26	6.80	0.057
	Total score	102.55	115.41	65.35	67.95	0.168
Daily time spent in front of a screen before the pandemic (hours)		4.97	1.89	3.32	1.52	<0.001*

*p<0.05

In both groups the device type most used was determined to be a smartphone. When the time spent in front of a screen during the day for the online course was examined, it was seen that students with screen time of >8 hours per day spent a maximum of ≥5 hours, and those with ≤8 hours per day spent a maximum of 1-3 hours. When examining the time spent in front of the screen for other digital applications, students with screen time of >8 hours per day spent a maximum of ≥5 hours, and those with ≤8 hours per day spent a maximum of 1-3 hours (Table 4).

Table 4. Device type, and the time spent on online courses and other digital applications by students with screen time of >8 hours and ≤ 8 hours per day.

	Screen usage time > 8 hours (N=34)		**Screen usage time ≤ 8 hours (N=49)**	
	N	**%**	**N**	**%**
Device type used during the day				
Computer	32	94.1	47	95.9
Phone	34	100	49	100
Television	19	55.9	25	51
Tablet	7	20.6	12	24.5
Screen time spent during the day for online courses				
Less than an hour	4	11.8	5	10.2
1-3 hours	9	26.5	29	59.2
3-5 hours	9	26.5	12	24.5
More than 5 hours	12	35.3	3	6.1
Screen time spent during the day for other digital applications				
Less than an hour	1	2.9	4	8.2
1-3 hours	8	23.5	23	46.9
3-5 hours	8	23.5	18	36.7
More than 5 hours	17	50	4	8.2

DISCUSSION

The results of this study, in which it was aimed to examine the effect of daily screen time on quality of life and musculoskeletal system discomfort in university students receiving distance education during the COVID-19 pandemic period, demonstrated that the emotional reactions, social isolation, and total quality of life results of the students with >8 hours of screen use per day were worse, and pain was more common in the both lower extremities and the right upper extremity.

Guo et al. reported that the screen time of students increased during the pandemic (10). In the current study, it was determined that screen time increased compared to the pre-pandemic period, in line with these results.

It was found that the students suffered back pain most, followed by neck and shoulder pain. The reason for this is that the static posture for a long time puts excessive strain on the joints and soft tissues in the neck, back and shoulder areas, which are mechanically closely related to each other. Long-term incorrect posture, which occurs with the increase in screen time, disrupts the spine biomechanics and may be the most common cause of pain in the back and neck (18). The interrelatedness of the neck, back and shoulder regions has been emphasized in recent studies. The increase in thoracic kyphosis and anterior tilt of the head change the orientation of the scapula on the thorax, which in turn affects shoulder functions

(19). The most common cause of shoulder pain following spinal pain may be the fact that impaired spinal mechanics affect shoulder mechanics. However, the significantly higher pain in the right shoulder may also be related to increased use of the right extremity.

Increasing screen usage time and decreasing physical activity level negatively affect quality of life (20). Increased screen time is known to cause antisocial behavior (21). The increase in screen time and decrease in physical activity level in university students has been shown to negatively affect mental health (22). In studies by Lavados-Romo et al., it was found that the quality of life of university students with high screen time was low, and psychological health and social relations were negatively affected by the increase in screen time (14). In our study, quality of life scores assessed using the Nottingham Health Profile were found to be higher in students with more than eight hours of screen time, along with emotional reactions and social isolation, and overall scores. We believe that pandemic restrictions, along with the restriction of students' social participation and reduced social interaction with others due to prolonged screen use, are the primary causes of these individuals' emotional and social impacts.

It has been shown in previous studies that prolonged duration of use of cell phones and electronic devices in university students is associated with neck and especially shoulder-related upper extremity pain (23, 24). It has also been found that internet addiction and the duration of phone use are associated with musculoskeletal pain in university students (25, 26). In the current study, the reason for more musculoskeletal pain in the students with screen time of >8 hours may be due to long-term inactivity and incorrect posture. Further studies could explore this relationship by assessing posture in individuals who spend long periods of time in front of a screen. In this context, in terms of biomechanical alignment, it would be beneficial to educate students about the correct posture to be adopted during online lessons and while they are in front of the screen at other times, and exercise training could be given to provide mobility in the neck, back and shoulder area between classes.

Guo et al. determined that the time spent in front of the screen for online lessons was more than five hours in 42.3-48.2% of students (10). In the current study, it was found that most of the students who had a total of >8 hours of daily screen use for online courses and other digital applications spent more than five hours on lessons. The fact that most of the participants exceeded the maximum two hours of screen use recommended for students can cause adverse effects on eye health, sleep and psychosocial health (27-29).

Limitations of the Study

The fact that this study was conducted during the pandemic, when university education continued completely remotely, is important in terms of showing the results of long-term screen exposure. A limitation of the study could be said to be that the study was carried out only on students studying at a university. With the digital transformation in universities, the percentage of courses given by distance education is increasing. Elective courses and common compulsory courses in particular are delivered through distance education by many universities (30). Considering this situation, the ideal daily online course duration can be determined by future studies examining the effects of screen usage time in the periods when face-to-face and online education continue together.

CONCLUSION

In conclusion, it was observed that the increase in screen time in the online education process of university students negatively affected the quality of life and musculoskeletal discomfort. During periods when distance education is required, such as during the pandemic, it may be useful for students to reduce screen time outside of online classes as much as possible, and to do exercises that especially work the back, neck and shoulder areas between classes, in order to reduce the negative effects of screen time on quality of life and musculoskeletal system problems. Apart from during the pandemic, it can be recommended that the online course duration given at universities should not be more than eight hours a day in order not to adversely affect musculoskeletal system problems and quality of life. More precise thresholds need to be determined by future research. It's important to remember that any situation involving prolonged screen time for various reasons (e.g., online work, hybrid learning, or social media use) may have similar negative effects on the musculoskeletal system. Therefore, preventing individuals from prolonged screen time, even outside of mandatory situations like pandemics, is extremely important for preventive health approaches.

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