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ORIGINAL ARTICLE

Effects of exergame on kinesiophobia, depression, and physical parameters in kinesiophobic older adults: a pilot study

Exergame 'in kinezyofobik yaşlı yetişkinlerde kinezyofobi, depresyon ve fiziksel parametreler üzerine etkisi: pilot çalışma

Gönül ERTUNÇ GÜLÇELİK[1], Ebru SEVER[2], Elmira ÖZÜTÜL[3], Hasret BOZTEPE[4]

Abstract

Purpose: It is known that virtual reality applications applied to older adults are effective on balance and mobility. Exergames is a virtual reality-based exercise. The aim of the study was to investigate the effects of exergames on kinesiophobia, balance, lower extremity muscle strength, depression and cognitive function in older adults with kinesiophobia.
Methods: The older adults over the age of 65 living in Nursing Home and Elderly Care Center were included in the study. Exergames were played for 30 minutes per week for 8 weeks and the participants who participated in the study were given rehabilitation. Before starting the application, the demographic information form, Tampa Kinesiophobia Scale, BeCure Balance Assessment System, Geriatric Depression Scale-Short Form, Mini Mental State Test and 5 Times Sit to Stand Test were applied to the participants. The assessments were performed pre- and post-treatment (8 weeks).
Results: 13 geriatric adults who completed an exergame-based rehabilitation program were included in the study. When the pre- and post-treatment evaluations were made; statistically significant differences were found in kinesiophobia, balance and depression ($p<0.05$). There was no statistically significant difference in functional muscle strength and cognitive status ($p>0.05$).
Conclusion: Exergames reduce kinesiophobia and depression and improve balance in older adults, however more studies are needed to investigate their effects on cognitive status and lower extremity muscle strength.
Keywords: Exergame, Older adults, Kinesiophobia, Balance, Depression.

Öz

Amaç: *Geriatrik bireylere uygulanan sanal gerçeklik uygulamalarının denge ve mobilite üzerinde etkili olduğu bilinmektedir. Exergame sanal gerçeklik tabanlı bir egzersizdir. Çalışmanın amacı kinezyofobisi olan geriatrik bireylerde exergame'in kinezyofobi, denge, alt ekstremite kas kuvveti, depresyon ve bilişsel işlev üzerindeki etkilerini araştırmaktır.*
Yöntem: *Çalışmaya huzurevi ve yaşlı bakım merkezinde yaşayan 65 yaş üstü geriatrik bireyler dahil edildi. 8 hafta boyunca haftada 30 dakika egzersiz oyunları oynandı ve çalışmaya katılan katılımcılara rehabilitasyon verildi. Uygulamaya başlamadan önce katılımcılara demografik bilgi formu, Tampa Kinezyofobi Ölçeği, BeCure Denge Değerlendirme Sistemi, Geriatrik Depresyon Ölçeği-Kısa Form, Mini Mental Durum Testi ve 5 Tekrar Otur Kalk Testi uygulandı. Değerlendirmeler tedavi öncesi ve sonrası (8 hafta) yapıldı.*
Bulgular: *Çalışmaya exergame tabanlı rehabilitasyon programını tamamlayan 13 geriatrik birey dahil edildi. Tedavi öncesi ve sonrası değerlendirmeler yapıldığında; kinezyofobi, denge ve depresyonda istatistiksel olarak anlamlı farklılıklar bulundu ($p<0,05$). Fonksiyonel kas gücü ve bilişsel durumda istatistiksel olarak anlamlı bir fark görülmedi ($p>0,05$).*
Sonuç: *Exergame yaşlı bireylerde kinezyofobi ve depresyonu azalttığı ve dengeyi iyileştirdiği gösterilmiştir, ancak bilişsel durum ve alt ekstremite kas gücü üzerindeki etkilerini araştırmak için daha fazla çalışmaya ihtiyaç vardır.*
Anahtar kelimeler: *Exergame, Yaşlı yetişkinler, Kinezyofobi, Denge, Depresyon.*

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INTRODUCTION

Geriatrics is a field of medicine that is related to older adults. According to the World Health Organization (WHO), old age is defined as a decrease in the ability to adapt to environmental factors. WHO classifies persons aged 65 and over as elderly and persons aged 85 and over as multi-age.[1] In older adults, physiological changes occur with advancing age and functional dependence increases gradually.[2]

Kinesiophobia means 'fear of moving', which is formed by the combination of the words 'kinesis = movement, phobus = fear'. In addition to the concept of fear of movement, re-injury anxiety is also used for the definition of kinesiophobia.[3] In the long term, consequences such as receding from movement and activity, decreased physical activity, functional limitation, decreased quality of life and depression emerge.[4] Older adults with kinesiophobia avoid physical activity because of their sensitivity. They have the idea that physical activity can harm them.[5]

Studies have indicated that virtual reality interventions implemented in geriatric individuals are effective in enhancing balance and mobility. Additionally, video game–based approaches may serve as an effective strategy for fall prevention. It leads older adults to adapting exercises and increase their functional output. The fact that the practice is fun and motivating as it allows individuals to fully focus their attention on the exercise. Studies releaved that virtual reality applications improve physical functionality in older adults with a history of falls.[6,7,8] Virtual reality games can reduce the fear of falling in the elderly and improve their balance and mobility.[9]

Exergames is a virtual reality-based exercise and may be a good alternative to increase the level of physical activity, since they have a greater component of fun. Exergames are defined as video games that promote (either via using or requiring) players' physical movements (exertion) that is generally more than sedentary and includes strength, balance, and flexibility activities. The exergames require digital devices, such as computers or game consoles and their accessories, as balance boards.[10]

There are studies on virtual reality and kinesiophobia in the literature. However, there is no study that directly applies to older adults as a population. Xbox 360 KinectTM games were used in this study for virtual reality. The study was conducted using the Xbox 360 Kinect™ and various games in older adults; however, the participants did not include geriatric individuals with kinesiophobia.[10] Although older adults are sometimes considered as a single group, previous studies have evaluated specific subgroups, such as balance in healthy older adults, cognitive function in individuals with cognitive impairment, and kinesiophobia.[11]

The aim of this study was to investigate the effects of an exergame-based rehabilitation program on kinesiophobia, balance, lower extremity muscle strength, depression, and cognitive function in older adults. To the best of our knowledge, this is the first study to evaluate the effects of exergaming specifically in older adults with kinesiophobia.

Hypotheses

H0: Exergame-based rehabilitation program will not improve kinesiophobia, balance, lower extremity muscle strength, depression, and cognitive function in older adults with kinesiophobia.

H1: Exergame-based rehabilitation will significantly reduce kinesiophobia in older adults with kinesiophobia.

H2: Exergame-based rehabilitation will improve balance performance in older adults with kinesiophobia.

H3: Exergame-based rehabilitation will reduce depressive symptoms in older adults with kinesiophobia.

H4: Exergame-based rehabilitation will increase lower extremity muscle strength in older adults with kinesiophobia.

H5: Exergame-based rehabilitation will improve cognitive function in older adults with kinesiophobia.

METHODS

Participants and study design

The study included older adults over the age of 65 living in the Kızılay Zeynep Nedim Oyvar Nursing Home and Elderly Care Center. The ethics committee of the Istanbul Gedik University Ethics Committee dated 17/01/2023 and numbered E-56365223-050.01.04-2023.137548.27-433 was recruited. A written

consent form was signed by older adults who met the conditions of this study. Inclusion and exclusion criteria of the study:

Inclusion criteria:

- Getting 38 or above on the Tampa Kinesiophobia Scale
- Mini-Mental State Test Score ≥20 (no or minimal cognitive impairment, sufficient cognitive capacity for understanding and performing the exercises)
- Being physically competent to apply the scales to be used
- Being 65 years and older
- Volunteering to participate in the study

Exclusion criteria:

- Having mental and psychiatric problems diagnosed by the physician
- Having a serious neurological and orthopedic problem diagnosed by the physician
- Having serious hearing and vision problems
- Having uncontrollable diabetes and hypertension
- Using a walking device other than a cane (crutches, walkers, etc.)
- Using drugs that increase the risk of falling (to be determined with information obtained from nurses and physiotherapists working in the nursing home)

Power analysis

In this study, a power analysis was conducted using G*Power 3.1.9.7 software to examine whether the difference between the dependent variables was statistically significant. The analysis was designed to test the difference between two means for paired samples, with the kinesiophobia measurement as the criterion. According to the analysis results, with a sample size of 13, the critical t-value was calculated as 2.17881, degrees of freedom as 12, and power (1-β error probability) as 0.9107085. The effect size was found to be 1.54. These results indicate that the sample size and effect size were sufficient and that a statistically significant difference could be detected.

Participants in the study were played exergame games for 30 minutes once a week for 8 weeks and rehabilitation was applied. Before starting the application, Demographic Information Form, Tampa Kinesiophobia Scale for kinesiophobia, BeCure Balance Assessment System for balance measurement, Geriatric Depression Scale-Short Form for depression, Mini Mental Status Test for cognitive functions and 5 Times Sit to Stand Test for lower extremity functional strength and fall risk were applied to the participants. These tests were repeated at the end of 8 sessions, and the values before and after were measured.

Applied evaluation parameters

1. Demographic Information Form

It is the form in which the frequency of sociodemographic characteristics such as name, surname, age, diseases and/or surgeries, drugs used, concomitant diseases, balance problem and history of falling is questioned.

2. Tampa Kinesiophobia Scale

It measures fear of movement and fear of re-injury. 4-point Likert scoring (1= Strongly disagree, 4= Strongly agree) is used. It consists of 17 questions. The total score is calculated after the reversal of items 4, 8, 12, and 16. It has a total score between 17 and 68. The high score indicates that kinesiophobia is also high.[12]

3. Geriatric Depression Scale - Short Form

Its validity and reliability were determined by Burke et al. in 1991. It consists of 15 questions questioning the mood in the last week. The primary goal of this 15-question self-report scale is to include questions that are easy for older adults to answer. This scale, which consists of only "yes" or "no" questions, is scored with 1 point for each response suggestive of depression, and 0 points for all other responses. The final score is considered the depression score. A score of 0-4 indicates that there is no depression, 5-8 indicates mild depression, 9-11 indicates moderate depression, and 12-15 indicates severe depression.[13]

4. Mini Mental State Test

It was first published in 1975 by Folstein et al. The test was develop because the tests used to quantitatively evaluate cognitive performance contain too many questions and take more than 30 minutes in practice. It is a cognitive test applied to the elderly, especially those with delirium and/or dementia.[14]

5. 5 Times Sit to Stand Test

It is a test used to evaluate the functional strength, balance, and risk of falling of the lower extremities. Individuals were asked to sit and stand up as fast and straight as possible 5 times in a row with their hands crossed on their breasts, and this time was measured with a stopwatch and recorded in seconds. The test was

performed with 3 repetitions and the average value of the recorded times was calculated.[15]

6. BeCure Balance Assessment System

This system is basically adapted to the balance platform of the Nintendo Wii Fit system. In the system, balance center change, balance center position, weight, and weight pressure data taken from the 4 corner points of the device are obtained by using the BalanceBoard. Includes Image/Non-Image, Eyes Open/Closed, and Intermittent Measurement parameters. To start the measurement, press the green "Start" button located in the middle under the parameterization fields. After pressing the Start button, the measurement-taking screen appears. When all measurements are completed according to the parameters we have determined, a BalanceSystem Sample PDF Report can be created.[16] The BeCure Balance Assessment System is shown in Figure 1.

The BeCure Balance Evaluation System protocol used in this study was planned to determine the amount of center of gravity change in the x and y axes and the position of the body's center of gravity while standing on the board for 15 seconds with eyes open and images.

Applied exergame games

Geriatric adults participated in an exergame-based rehabilitation program, which is exercise implemented with virtual reality technology. The intervention included game-supported therapeutic exercises designed to improve strength, balance, postural control, and functional mobility. The Nintendo Wii games used in the study are presented in Figure 2.[9,16]

The Xbox Kinect 360™ games used in the study are presented in Figure 3.[9,16]

The exergame-based rehabilitation program consisted of nine different games, each targeting specific functional outcomes such as balance, lower and upper extremity strength, postural control, and cognitive engagement. Each game was played for approximately 3 minutes per session, resulting in a total session duration of 27 minutes. While minor adjustments were made to accommodate individual participants' abilities, the sequence and duration of the games were standardized for all participants.

Figure 1. BeCure Balance Assessment System.[16]

Data analysis

The data analysis of the study was performed using the statistical program "Statistical Package for Social Sciences" (SPSS version 20.0 (SPSS Inc., Chicago, IL USA). The One-Sample Kolmogorov–Smirnov test was used to The One-Sample Kolmogorov–Smirnov test was used to investigate the suitability

Balance System Assessment System and Active Video Games Center of balance position, instantaneous change and balance distance (cm)Measuring and reporting front, back and lateral weight transfer movements, postural control and using them for exercise purposes	
Game Name	Game Description
	Stepping and weight-shifting
	Bowling simulation to improve coordination and lower limb strength
	Virtual obstacle courses for balance and mobility
	Surfing simulation to enhance balance and postural control

Figure 2. Used Nintendo Wii Games.[9,16]

Upper Extremity Xbox Kinect 360 TM Games Upper extremity strength and functional mobility	
Game Name	Game Description
	Stepping through virtual gates to improve lower limb strength and coordination
	Upper and lower limb coordination through ball-catching tasks
	Virtual cleaning activities to engage core and upper limbs
	Interactive bubble-popping to enhance upper limb mobility and reaction time
Lower Extremity Xbox Kinect 360 TM Games Lower extremity strength and functional mobility	
Game Name	Game Description
	Knee-lifting exercises to strengthen lower extremities and improve balance

Figure 3. Xbox Kinect 360 TM Games Used. [9,16]

of the variables for normal distribution. Demographic characteristics were expressed as number, percentage, medium, and standard deviation. Student's-t paired test was applied for the group's numerically normally distributed evaluation results, and Wilcoxon signed rank test was applied for the non-normally distributed evaluation results. The level of $p<0.05$ was considered statistically significant.

RESULTS

There were 46 older adults in the nursing home. Fifteen older adults who met the inclusion and exclusion criteria were included in the study. Two older adults left the study due to health problems during the rehabilitation process and the study was completed with 13 older adults The older adults included in the rehabilitation program were evaluated before

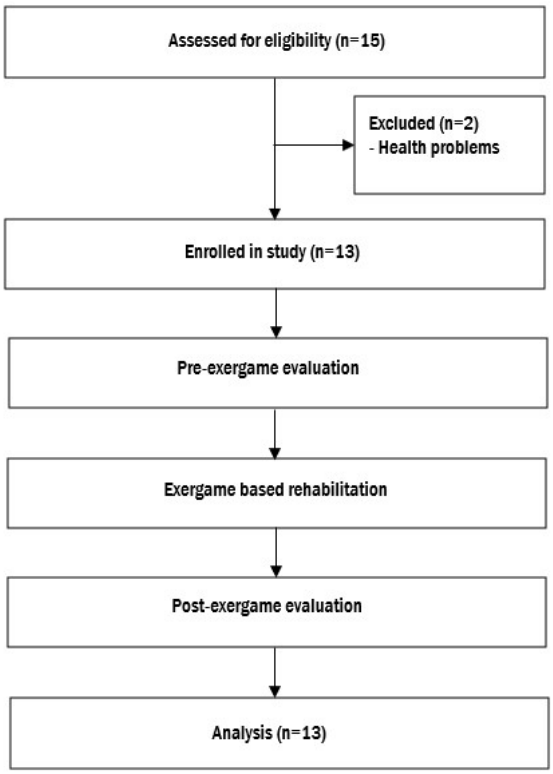

Figure 4. Flowchart of the study.

and after the exergame program. The participant selection and study process are illustrated in the flow chart (Figure 4).

Descriptive characteristics of the older adults participating in the study are shown in Table 1. Tampa Kinesiophobia Scale, Geriatric Depression Scale-Short Form, Mini Mental State Test, 5 Times Sit to Stand Test and BeCure Balance Assessment System Results are shown in Table 2. Normality of the data from these tests was assessed using One-sample Kolmogorov-Smirnov test. The results indicated that the data were not normally distributed ($p<0.05$). Consequently, non-parametric statistical tests were applied for analyses. Kinesiophobia of the participants decreased ($p=0.006$). Depression levels decreased ($p=0.007$). There was no improvement in cognitive performance ($p=0.073$). There was no progress in lower extremity muscle strength ($p=0.650$). There was an improvement in balance parameters ($p=0.023$) (Table 2).

Table 1. Descriptive characteristics of the older adults.

	Mean±SD
Age (year)	78.69±7.96
Weight (kg)	74.00±12.58
Height (m)	1.62±0.09
	n (%)
Gender	
Female	8 (61.5)
Male	5 (38.5)
Educational status	
Secondary school	5 (38.5)
High School	4 (30.8)
University	4 (30.8)
Falling History	
Yes	6 (46.2)
No	7 (53.8)

DISCUSSION

The decline in physiological reserves associated with aging can trigger the development of kinesiophobia in older adults by creating a fear of movement and reinjury.[3] Virtual reality-based exercise games can support physical and psychological functions in older individuals by providing real-life experiences.[17] In this study, exergame-based rehabilitation resulted in a significant reduction in kinesiophobia and significant improvements in depression and balance scores in older adults. These findings suggest exergame may provide both physical and psychological benefits for older adults.

Virtual reality reduces pain and kinesiophobia in individuals with chronic pain.[18] Morales Tejera et al.[19] argued that virtual reality was more effective in reducing kinesiophobia compared to exercise in patients with chronic neck pain. Although there are studies stating that virtual reality applications have a reducing effect on kinesiophobia, there are also inconsistent studies.[20] In this study, it was concluded that exergame games applied to individuals with kinesiophobia over the age of 65 in the nursing home reduced their fear of moving. The fact that the games motivated and encouraged the person to act and that they believed that they could act more confidently

Table 2. Scores of Tampa Kinesiophobia Scale, Geriatric Depression Scale-Short Form, Mini Mental State Test, 5 Times Sit to Stand Test and BeCure Balance Assessment System (N=13).

	Before	After	
	Mean±SD	Mean±SD	p
Tampa Kinesiophobia Scale	46.76±6.02	38.69±4.42	0.006*
Geriatric Depression Scale-Short Form	5.30±1.31	3.15±1.90	0.007*
Mini Mental State Test	24.84±2.79	26.15± 2.44	0.073
5 Times Sit to Stand Test	25.34±20.22	23.59±14.51	0.650
BeCure Balance Assessment System	3.46±2.25	1.74±0.77	0.023*

*p<0.05.

with positive increases in their balance, was effective in making the result meaningful.

Kim et al.[21] reported that personalized virtual reality–based cognitive training reduced depression levels in middle-aged women. Similarly, exergame interventions have been shown to improve depressive symptoms in older adults (aged 70–91) residing in long-term care facilities with neurocognitive impairment.[22] In our study, it was concluded that Nintendo Wii and Xbox Kinect 360TM games reduced depression in elderly individuals with kinesiophobia. The fact that they moved away from the negativities and problems while playing games in the virtual reality environment and carried out physical activity in a fun way has been effective in producing positive results in depression levels.

In a study conducted on older adults without cognitive problems, it was concluded that exergame games improved cognitive function and that long-term exergame games positively affected working memory.[23] In a study conducted on 55 elderly individuals, positive results were found that the Nintendo Wii application improved executive functions.[24] The effects of exergame applications on physical functions in older adults who have been in nursing homes for a long time have been proven, but many studies are needed to prove their effects on cognitive function.[25] In this study, cognitive functions were evaluated with the mini-mental state test, however, no significant change was observed in Mini Mental State Test scores. This may be attributed to several factors. First, the duration and intensity of the program may have been insufficient to produce measurable cognitive gains. Second, the Mini Mental State Test is a general cognitive screening tool and may lack the sensitivity to detect subtle improvements in specific cognitive domains over a short intervention period. Additionally, baseline cognitive function and age-related variability among participants may have limited detectable changes. Similar findings have been reported in previous studies, suggesting that longer or more targeted interventions may be necessary to achieve significant cognitive improvements in older adults.

Many studies in the literature have shown that exergame games have positive effects on balance and muscle strength. Kinect-based exercise games applied to 57 healthy elderly individuals in 2015 were found to have positive results on lower extremity muscle strength, balance and walking.[26] In the study conducted on elderly individuals over 65 years of age, the participants were divided into two groups as the exergame group and the home exercise group. After the 6-week program, more positive results were observed in the balance parameter of the participants in the exergame group compared to the home exercise group.[27] In a study conducted in 2022 in older adults, it was concluded that exergame games had positive effects on lower extremity strength and balance.[28] In this study, while positive results were found in the balance parameters according to the results of the BeCure Balance Evaluation System, no increase was found in the lower extremity muscle strength compared to the sitting and getting up test 5 times. The lack of improvement in lower extremity muscle strength, as measured by the 5 Times Sit to Stand Test, may be attributed to several factors. The duration and intensity of the intervention might not have been sufficient to elicit measurable strength gains, and the exergame content was primarily focused on balance and coordination rather than targeted

lower-limb strengthening. Additionally, the functional nature of the Sit to Stand Test may have limited sensitivity in detecting subtle strength changes. Variability in participants' baseline physical capacity and adherence to the intervention may also have contributed to the absence of significant improvement.

Limitations

The study is a cross-sectional study on the effects of exergame on kinesiophobia, balance, lower extremity muscle strength, depression and cognitive function in older adults. This study has some methodological limitations. First, the single-group design without a comparison group limits the ability to directly evaluate the effectiveness of the exergame intervention relative to other exercise programs. Second, the relatively short duration of the intervention may have restricted the observation of longer-term or more pronounced effects. Third, the small sample size may limit the generalizability of the findings. Future research with randomized controlled trials, longer intervention periods, and larger samples is warranted to confirm these results and provide more robust evidence regarding the benefits of exergame interventions in older adults with kinesiophobia. Another limitation may be the inclusion criterion for the study. The older adults in the study have kinesiophobia. With exergame, the older adults' mobility increased and their fear of movement decreased because they moved. This situation may have created a selection bias. Another limitation of the study is the potential selection bias arising from the recruitment process. Since the sample was drawn from a single institution and participation was based on voluntary involvement, the characteristics of the individuals who agreed to participate may differ from those who declined. This may limit the generalizability of the findings to the broader geriatric population.

Conclusion

Exergames used in geriatric rehabilitation are effective in reducing kinesiophobia and depressive symptoms, and they also improve balance in older adults. The adaptability and accessibility make them a promising tool for older adults potentially enabling specialized interventions to complement traditional rehabilitation programs. Long-term exergame-based rehabilitation is needed in future studies to investigate the extent of improvement in muscle strength and cognitive functions.

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ORIGINAL ARTICLE

Kronik bel ve boyun ağrılı bireylerde farklı egzersiz süpervizyon yöntemlerinin egzersiz uyumuna etkisi

Effects of different exercise supervision methods on exercise adherence in individuals with chronic back and neck pain

İrfan KÜÇÜKOĞLU[1], Kezban YİĞİTER[2], Yavuz YAKUT[2]

Öz

Amaç: Bu çalışma, kronik bel ve boyun ağrısı olan bireylerde farklı egzersiz eğitim yaklaşımlarının egzersize uyuma etkisini araştırmak amacıyla yapıldı.

Yöntem: Toplam 519 hasta, kapalı zarf yöntemiyle ev egzersizi programı, fizyoterapist eşliğinde egzersiz ve takipli ev programı olmak üzere üç gruba ayrıldı. Çalışmada ev egzersiz programı grubuna tanıya özgü egzersiz broşürleri verildi. Fizyoterapist eşliğinde egzersiz grubunda egzersizler tedavi süresince birebir uygulandı. Takipli ev programı grubuna ise egzersiz eğitimi sonrası günlük kısa mesaj (SMS) ile egzersiz hatırlatmaları yapıldı. Tüm hastalara 10 seans geleneksel fizik tedavi uygulandı. Ardından her gruba farklı egzersiz eğitimleri verildi. Klinik değerlendirme için Oswestry Özürlülük İndeksi (ODI) ve Boyun Özürlülük İndeksi (NDI)'nden faydalanıldı. Egzersiz uyumu, araştırmacılar tarafından geliştirilen 5 maddelik bir form ile memnuniyet ise 0-100 skalası ile ölçüldü. Değerlendirmeler tedavi öncesi, sonrası ve 3. ayda yapıldı.

Bulgular: Egzersizlerin doğruluğu takipli ev programı grubunda en yüksek, ev egzersiz grubunda ise en düşük bulundu ($p<0,05$). Fizyoterapist eşliğindeki grup, ev egzersizi grubuna göre anlamlı olarak daha iyi uyum gösterdi ($p<0,05$). Memnuniyet düzeyleri tüm gruplarda benzerdi ($p>0,05$).

Sonuç: Egzersiz uyumunu artırmak için egzersizlerin fizyoterapistler tarafından detaylı anlatılması ve takipli sistemlerin (SMS gibi) kullanılması önerilmektedir. Elde edilen bu sonuçlar, klinik uygulamalarda hasta eğitimi ve takibinin egzersiz uyumuna katkısını desteklemektedir.

Anahtar Kelimeler: Bel Ağrısı, Boyun Ağrısı, Egzersiz Tedavisi, Hasta Uyumu

Abstract

Purpose: *This study aimed to investigate the effects of different exercise training approaches on exercise adherence in individuals with chronic low back and neck pain.*

Methods: *A total of 519 patients were randomly assigned, using a sealed-envelope method, into three groups: home-based exercise groups, physiotherapist-led groups, and home-based follow up groups. In the home-based exercise groups, diagnosis-specific exercise brochures were provided. In the physiotherapist-led groups, exercises were demonstrated and performed one-on-one under physiotherapist supervision throughout the treatment period. In home-based follow up groups, daily text message (SMS) reminders were sent following exercise training. All participants received 10 sessions of conventional physical therapy, followed by the assigned exercise training protocol. Clinical outcomes were assessed using the Oswestry Disability Index (ODI) and the Neck Disability Index (NDI). Exercise adherence was evaluated using a five-item form developed by the researchers, and satisfaction was measured on a 0–100 scale. Assessments were conducted at baseline, post-treatment, and at the third-month follow-up.*

Results: *Exercise accuracy was highest in the home-based follow up groups and lowest in the home-based exercise groups ($p<0.05$). The physiotherapist-led groups demonstrated significantly greater adherence compared to the home-based exercise groups ($p<0.05$). Satisfaction levels were comparable across all groups ($p > 0.05$).*

Conclusion: *Detailed instruction by physiotherapists and the use of monitoring systems (e.g., SMS reminders) are recommended to improve exercise adherence. These findings support the role of structured patient education and follow-up in enhancing exercise compliance in clinical practice.*

Keywords: *Low Back Pain, Neck Pain, Exercise Therapy, Patient Compliance*

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GİRİŞ

Kronik bel ve boyun ağrısı, dünya genelinde iş gücü kaybı, yaşam kalitesinde düşüş ve sağlık hizmetleri kullanımında artışla ilişkilendirilen yaygın kas-iskelet sistemi rahatsızlıklarıdır. Bel ağrısının yaşam boyu görülme sıklığı %70–80 düzeyindedir ve sıklıkla günlük yaşam aktivitelerini kısıtlayıcı bir nitelik taşır.[1,2] 2015 yılı verilerine göre, küresel ölçekte 540 milyon insanın bel ağrısından etkilendiği bildirilmektedir. Özellikle düşük ve orta gelirli ülkelerde son yıllarda bu durumun yol açtığı engellilik belirgin şekilde artış göstermiştir.[3,4]

Benzer şekilde, boyun ağrısı da bireyin fiziksel ve psikososyal sağlığını olumsuz etkileyen önemli bir semptomdur. Dünya genelinde yaygınlığı %16,7 ile %75,1 arasında değişmekte ve kadınlarda daha sık görülmektedir.[5] Boyun ağrısı, engelliliğe neden olan sağlık sorunları arasında üst sıralarda yer almakta ve sağlık harcamaları ile iş gücü kaybına bağlı olarak ekonomik yük oluşturmaktadır. Kronikleşme sürecinde ise psikososyal faktörler, sedanter yaşam tarzı, cinsiyet ve çevresel koşullar gibi değişkenler etkili olmaktadır.[6,7]

Kronik bel ve boyun ağrısının başarılı bir şekilde yönetilebilmesi, yalnızca tanı ve tedavi protokollerinin etkinliğine değil, aynı zamanda bireylerin uygulanan tedaviye, özellikle egzersiz programlarına ne ölçüde uyum sağladığına da bağlıdır.

Dünya Sağlık Örgütü, tedaviye uyumu bireyin sağlık uzmanıyla üzerinde uzlaşılan tedavi planına ne ölçüde bağlı kaldığı şeklinde tanımlar.[8] Rehabilitasyon bağlamında bu uyum, önerilen egzersizlerin doğru biçimde ve belirlenen sıklıkta uygulanması anlamına gelir. Egzersiz uyumu, kas-iskelet sistemi rahatsızlıklarının yönetiminde uzun vadeli etkinliğin sağlanması açısından kritik öneme sahiptir.[9] Uyumsuzluk, tedavi başarısını olumsuz yönde etkileyebilmekte ve maliyetleri artırabilmektedir.[8]

Literatürde egzersiz uyumunun değerlendirilmesinde öz bildirim günlükleri, anketler ve nesnel ölçüm cihazları gibi çeşitli yöntemler kullanılmaktadır. Ancak bu yöntemlerin standardize olmaması ve subjektif değerlendirmelere açık olması, uyumun objektif biçimde izlenmesini zorlaştırmaktadır.[10,11] Uyum düzeyinin ölçümünde de ortak bir eşik bulunmamakta; bazı çalışmalar %50–75 katılımı yeterli görürken, diğerleri %100'ü ideal seviye olarak kabul etmektedir.[12]

Mevcut literatür, kronik bel ve boyun ağrısına sahip bireylerde egzersize uyumu değerlendiren çalışmaların sınırlı olduğunu, özellikle uygulanan egzersizlerin doğruluğunun ve sürekliliğinin takip edildiği araştırmaların yetersiz kaldığını göstermektedir.

Bu çalışma, kronik bel ve boyun ağrısı olan bireylerde ev egzersiz programı, fizyoterapist eşliğinde egzersiz eğitimi ve günlük kısa mesaj (SMS) destekli takipli ev programı olmak üzere üç farklı egzersiz eğitiminin egzersize uyum üzerindeki etkilerini karşılaştırmalı olarak araştırmayı amaçlamaktadır. Elde edilen bulguların, klinik uygulamalarda hasta eğitimi ve takibine ilişkin stratejilerin geliştirilmesine katkı sağlayacağı düşünülmektedir.

YÖNTEM

Çalışma dizaynı

Bu prospektif, randomize kontrollü çalışma, kronik bel ve boyun ağrısı olan bireylerde üç farklı egzersiz eğitiminin egzersize uyum üzerindeki etkisini karşılaştırmak amacıyla yürütüldü.

Randomizasyon sıralaması çalışmadan bağımsız bir araştırmacı tarafından bilgisayar destekli random sayı üretimiyle oluşturuldu. Katılımcılar kapalı zarf yöntemiyle sırasıyla üç gruba (Ev Egzersiz Programı Grubu, Fizyoterapist Eşliğinde Egzersiz Programı Grubu, Takipli Ev Programı Grubu) atandı. Değerlendirmeleri yapan araştırmacı grup bilgisinden habersiz olacak şekilde körleme sağlandı. Çalışma, Hasan Kalyoncu Üniversitesi Girişimsel Olmayan Araştırmalar Etik Kurulu tarafından 03.05.2021 tarihinde 2021/063 numarası ile onaylandı ve ClinicalTrials.gov platformunda (NCT05851495) kayıt altına alındı. Tüm katılımcılara çalışma hakkında yazılı ve sözlü bilgi verilerek, gönüllü onamları alındı.

Katılımcılar

Çalışmaya, 40-80 yaş aralığında, bel veya boyun ağrısı semptomları en az üç aydır devam eden, Mini Mental Test skoru ≥ 24 olan, Türkçe iletişim kurabilen ve başka bir fizyoterapi programına katılmayan 519 birey dahil edildi

(Şekil 1). Ciddi patolojilere sahip (ör. spinal stenoz, spondilolistezis, fibromyalji, kanser, tüberküloz, konjenital anomaliler), spinal cerrahi geçmişi olan, periferik sinir tutulumu veya spinal defisiti bulunan bireyler dışlandı.

Örneklem büyüklüğü

G*Power 3.1.9 yazılımı kullanılarak hesaplandı. Cohen d=0.37 etki büyüklüğü, %5 anlamlılık düzeyi (α=0.05) ve %80 güç (1-β=0.80) kriterlerine göre, her grup için minimum 78 katılımcı öngörüldü. Olası veri kaybını önlemek amacıyla her gruba 185 birey dahil edildi.

Değerlendirme araçları

Katılımcıların sosyodemografik verileri özel olarak hazırlanmış formlar aracılığıyla kaydedildi. Egzersiz uyumu, araştırmacılar tarafından geliştirilen 5 maddelik özgün bir değerlendirme formu ile ölçüldü. "Miktar olarak yeterli mi?" sorusuna az-çok-uygun, "Sıkıldınız mı?" ve "Zorlandınız mı?" sorularına ise evet-hayır-biraz cevaplarından birinin verilmesi istendi. Hasta memnuniyetinin değerlendirilmesi için hastalara almış oldukları tedaviyi 0-100 arası bir puan vererek değerlendirmeleri istendi. Hastalara ayrıca önerilen egzersizleri ne sıklıkla yaptığı soruldu. Egzersiz uyumunun yanı sıra hastalara verilen egzersizlerin doğru yapılıp yapılmadığının kontrolü "0: unutulmuş, 1: yapamıyor, 2: doğru pozisyon ama yanlış hareket, 3: doğru pozisyon ve hareket, solunum kontrolü yok ve 4: kesinlikle yapıyor" şeklinde değerlendirilerek yapıldı. Egzersizlerden 3 ve 4 puan alan hastaların egzersizleri hatırladığı kabul edildi.

Ayrıca, bel ağrısı olan katılımcılara Oswestry Özürlülük İndeksi (ODI) ve boyun ağrısı olanlara ise Boyun Özürlülük İndeksi (NDI) uygulanarak tedavi öncesi, tedavi sonrası ve üç ay sonrası klinik değişim izlendi.

ODI, bireyin bel ağrısına bağlı fonksiyonel yetersizliğini ölçmek için kullanılan 10 maddelik, 0–5 puan aralığında değerlendirilen ve toplam puanı yüzdeye çevrilen bir ölçektir. Türkçe geçerlilik ve güvenilirliği Yakut vd.[13] tarafından yapılmıştır. NDI ise boyun kaynaklı fonksiyonel kısıtlılığı ölçmekte olup, 10 başlıktan oluşur ve toplam puanlar 0–50 arasında değişmektedir. Türkçe uyarlaması Telci vd.[14] tarafından gerçekleştirilmiştir.

Müdahale protokolleri

Tüm katılımcılara, günde bir seans olmak üzere toplam 10 seans süresince hotpack, ultrason (US) ve transkutanöz elektriksel sinir stimülasyonu (TENS) içeren geleneksel fizik tedavi uygulandı. Tedavi sonunda:

- Ev Egzersiz Programı Grubu'na, tanıya özel egzersiz broşürleri dağıtıldı.
- Fizyoterapist Eşliğinde Egzersiz Grubu'na, egzersizler tedavi süresince birebir uygulamalı olarak gösterildi ve hastalar fizyoterapist gözetiminde uygulamalara katıldı.
- Takipli Ev Programı Grubu'na, fizyoterapist eşliğinde egzersiz eğitimi sonrasında günlük SMS aracılığıyla egzersiz hatırlatmaları gönderildi.

Üç gruptaki bireylerin egzersiz uyumu, tedavi sonrası üçüncü ay kontrollerinde değerlendirildi. Çalışmada yer alan tüm bireyler değerlendirilen parametreler ve fonksiyonel sorunlar açısından benzerdi. Başlangıç değerlendirmeleri sonrasında tüm katılımcılara, bu benzer sorun alanlarını hedefleyen bireysel tolerans düzeyine uygun sıklıkta ve fizyoterapist tarafından belirlenen yoğunlukta beş temel egzersiz önerildi. Tüm egzersizler günde üç kez, 8-10 tekrar şeklinde uygulanacak şekilde planlandı. Fizyoterapist gözetimindeki egzersizler yalnızca seans saatlerinde günde bir kez uygulandı ve katılımcılara bu egzersizleri günün diğer saatlerinde evde tekrar etmeleri önerildi.

İstatistiksel analiz

İstatistiksel analizler, SPSS v22.0 (IBM Corp., Armonk, NY) yazılımı ile gerçekleştirildi. Sürekli değişkenler ortalama ± standart sapma (X±SD) olarak, kategorik değişkenler ise yüzde (%) şeklinde raporlandı. Verilerin dağılımı Kolmogorov-Smirnov testi ile değerlendirildi. Normal dağılıma uymayan veriler için grup karşılaştırmalarında Kruskal-Wallis testi, ikili karşılaştırmalarda Mann-Whitney U testi kullanıldı. $p<0,05$ değeri istatistiksel anlamlılık sınırı olarak kabul edildi.

BULGULAR

Araştırmaya toplam her grupta 185 birey olacak şekilde toplam 555 birey dahil edildi. Ancak tedavi takipleri süresince çeşitli nedenlerle çalışmadan ayrılmak zorunda kalan bireyler olması sebebiyle ev egzersiz programı grubu (n=168), fizyoterapist eşliğinde egzersiz programı grubu (n=176) ve takipli ev programı grubu (n=175) olmak üzere toplam 519 birey ile

çalışmaya devam edildi.

Tüm katılımcıların demografik ve tanımlayıcı özellikleri Tablo 1'de sunuldu. Gruplar yaş, boy, vücut ağırlığı ve beden kütle indeksi (BKİ) açısından benzer özellikler gösterdi (p>0,05). Cinsiyet dağılımı incelendiğinde, fizyoterapist eşliğinde egzersiz programı grubunda kadın oranı (%71) diğer iki gruba kıyasla farklıydı (p<0,001). Bu sonuçlar, çalışma gruplarının demografik ve klinik değişkenler bakımından genel olarak homojen, ancak cinsiyet dağılımı açısından heterojen olduğunu gösterdi.

Bel ağrılı bireylerin tedavi öncesi, tedavi sonrası ve tedaviden sonraki üç aylık takip verileri Tablo 2'de verildi. Tedavi öncesinde gruplar arasında anlamlı fark saptanmadı. Tedavi sonrası ve üçüncü ay kontrollerinde anlamlı farklılıklar görüldü. (p<0,001). Post-hoc analizlerde, fizyoterapist eşliğinde egzersiz programı grubunun hem tedavi sonrası hem de 3. ay sonrasında ODI skorlarında ev egzersizi grubuna göre belirgin üstünlük gösterdiği, ayrıca takipli ev programı grubunun da ev egzersizi grubuna göre daha iyi sonuçlar verdiği bulundu (p<0,001). Fizyoterapist eşliğinde egzersiz grubu ile takipli ev programı grubu arasında 3. ay sonunda anlamlı fark saptanmadı (p>0,05).

Boyun ağrılı bireylerin tedavi öncesi, tedavi sonrası ve tedaviden sonraki üç aylık takip verileri ise Tablo 3'te verildi. Boyun ağrılı bireylerde NDI skorları, tüm gruplarda tedavi sonrası ve 3. ay ölçümlerinde anlamlı iyileşme gösterdi (p<0,05). Gruplar arası karşılaştırmalarda anlamlı fark saptanmadı (p>0,05).

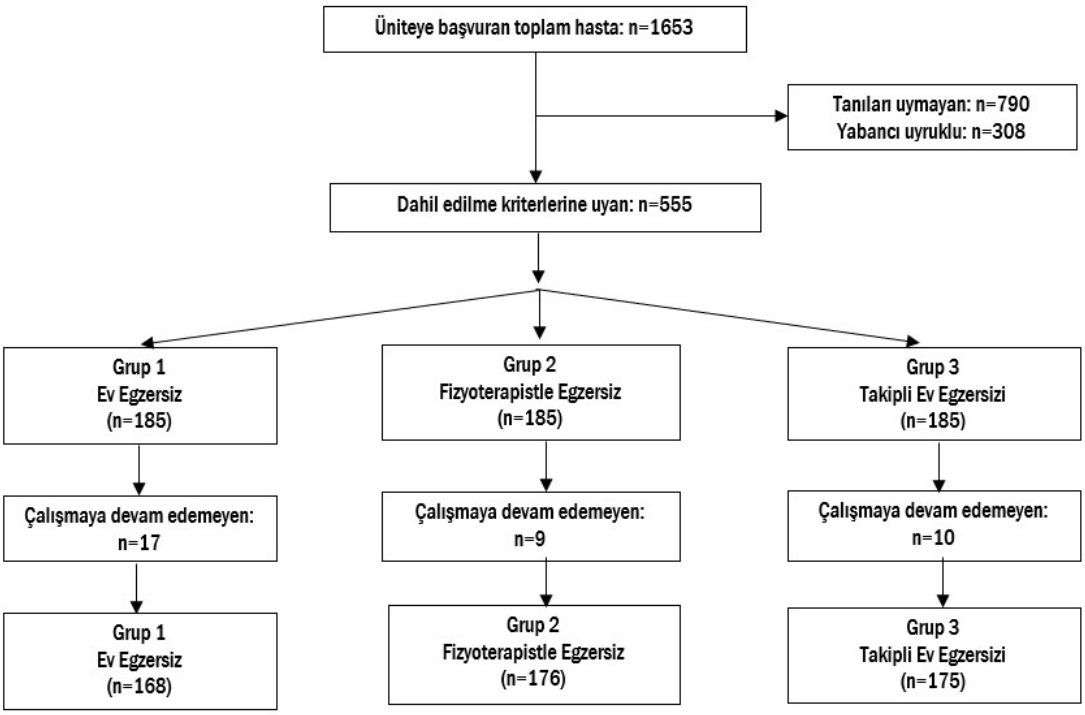
Egzersize uyum ve hasta memnuniyet düzeylerine ilişkin bulgular Tablo 4'te özetlendi. Katılımcıların genel tedavi memnuniyet düzeyleri gruplar arasında benzer bulundu (p>0,05). Yapılan egzersizlerin doğruluk toplam skorlarında anlamlı fark saptandı (p<0,001). En yüksek doğruluk skorları takipli ev programı grubunda (12,12±4,02), ardından fizyoterapist eşliğinde egzersiz programı grubunda (11,03±4,97) elde edildi. Ev egzersizi programı grubunda doğruluk skorları belirgin şekilde daha düşük bulundu (9,13±5,26). Hastaların büyük çoğunluğu egzersiz miktarını "uygun" (%89–90) olarak değerlendirdi. Zorlanma düzeyleri ve sıkılma oranları ise gruplar arasında anlamlı fark göstermedi (p>0,05).

Bel ağrılı bireylere önerilen egzersizlerin doğruluk oranlarına ilişkin veriler Tablo 5'te verildi. Bel ağrılı bireylere önerilen beş egzersiz (kedi-deve, lumbal germe, mekik, köprü, sırt ekstansör kuvvetlendirme) doğruluk oranlarına göre incelendiğinde, tüm gruplarda egzersizlerin büyük bölümünün doğru biçimde yapıldığı görüldü. Özellikle mekik ve sırt ekstansör egzersizlerinde doğru uygulama oranları yüksek olup (medyan=3), gruplar arasında anlamlı fark gözlenmedi. Ancak köprü egzersizinde fizyoterapist eşliğinde egzersiz grubunun doğruluk oranı (%41,7) ev egzersizi grubuna kıyasla daha yüksek bulundu. Takipli ev programı grubunda da benzer bir eğilim gözlendi ve SMS ile hatırlatma yapılan bireylerin egzersiz formunu daha doğru sürdürdüğü saptandı. Egzersiz uyumu analizleri kapsamında, bel ağrılı hastalardan ev egzersizi programı grubundaki 105 bireyden 19'u, fizyoterapist eşliğinde egzersiz grubundaki 113 bireyden 12'si ve takipli ev programı grubundaki 103 bireyden 5'i egzersiz yapmayı reddetti ve bu nedenle uyum analizlerine dahil edilmedi (Tablo 5).

Boyun ağrılı bireylere önerilen egzersizlerin doğruluk oranlarına ilişkin veriler Tablo 6'da yer almaktadır. Tüm egzersizlerde (boyun fleksiyon-ekstansiyon, lateral fleksiyon, rotasyon, omuz kapsül germe, omuz öne-arkaya çevirme) medyan doğruluk skorları genellikle 2–3 düzeyinde olup yüksek doğruluk oranı, fizyoterapist eşliğinde ve takipli ev programı gruplarında yapılan boyun fleksiyon-ekstansiyon egzersizlerinde görüldü (medyan=3). Boyun ağrılı hastalar arasında ise ev egzersizi programı grubundaki 63 katılımcıdan 7'si, fizyoterapist eşliğinde egzersiz grubundaki 63 katılımcıdan 9'u ve takipli ev programı grubundaki 72 katılımcıdan 2'si benzer şekilde egzersiz yapmayı reddetti. Bu bireyler de egzersize uyum analizlerinin dışında tutuldu (Tablo 6).

TARTIŞMA

Bu çalışmada, kronik bel ve boyun ağrılı hastalarda farklı egzersiz eğitim modellerinin egzersize uyuma etkisi araştırıldı. Sonuçlar, özellikle takipli ev programı ve fizyoterapist eşliğinde uygulanan egzersiz programlarının, ev egzersiz programına kıyasla daha yüksek uyum



Şekil 1. Çalışma akış diyagramı.

Tablo 1. Bireylerin demografik ve tanımlayıcı özellikleri

		Ev Egzersizi (n=105)	Fizyoterapistle Egzersiz (n=113)	Takipli Ev Egzersizi (n=103)	
		n (%)	n (%)	n (%)	p
Cinsiyet	Kadın	87 (51,8)	125 (71)	111 (63,4)	0,001
	Erkek	81 (48,2)	51 (29)	64 (36,6)	
Eğitim durumu	İlkokul	55 (32,7)	56 (31,8)	62 (35,4)	
	Ortaokul	19 (11,3)	37 (21)	30 (17,1)	
	Lise	38 (22,6)	40 (22,7)	42 (24)	
	Lisans-Önlisans	51 (30,4)	41 (23,3)	41 (23,4)	
	Lisansüstü	5 (3)	2 (1,1)	0 (0)	
Medeni hali	Evli	157 (93,5)	152 (86,4)	161 (92)	
	Bekar	11 (6,5)	24 (13,6)	14 (8)	
Sigara kullanımı	Evet	42 (25)	37 (21)	32 (18,3)	
	Hayır	126 (75)	139 (79)	143 (81,7)	
Alkol kullanımı	Evet	6 (3,6)	3 (1,7)	9 (5,1)	
	Hayır	162 (96,4)	173 (98,3)	166 (94,9)	
		X±SD	X±SD	X±SD	
Yaş (yıl)		53,99±8,97	54,31±7,74	54,08±8,47	
Boy (m)		1,69±0,08	1,67±0,08	1,67±0,10	
Vücut ağırlığı (kg)		80,54±9,83	78,40±9,41	80,39±10,61	
Beden kütle indeksi (kg/m^2)		28,20±2,76	28,17±2,74	28,62±2,27	

Tablo 2. Bel ağrılı hastaların tedavi öncesi, tedavi sonrası ve tedaviden üç ay sonrası için ölçümleri.

	Ev Egzersizi (n=105)	Fizyoterapistle Egzersiz (n=113)	Takipli Ev Egzersizi (n=103)		
Oswestry Özür İndeksi	X±SD	X±SD	X±SD	p	
Tedavi öncesi	51,57±14,44	50,91±16,68	51,16±17,28	0,910	
Tedavi sonrası	42,36±14,53	34,20±15,75	38,38±15,08	<0,001	a,c
Üç ay sonra	32,59±13,73	21,72±10,72	23,26±13,43	<0,001	a,b

a: p<0,05 (Ev Egzersizi-Fizyoterapistle Egzersiz). b: p<0,05 (Ev Egzersizi-Takipli Ev Egzersizi). c: p<0,05 (Fizyoterapistle Egzersiz-Takipli Ev Egzersizi).

Tablo 3. Boyun ağrılı hastaların tedavi öncesi, tedavi sonrası ve tedaviden üç ay sonrası için ölçümleri.

	Ev Egzersizi (n=105)	Fizyoterapistle Egzersiz (n=113)	Takipli Ev Egzersizi (n=103)	
Boyun Özürlülük İndeksi	X±SD	X±SD	X±SD	p
Tedavi öncesi	17,62±6,50	19,51±8,15	18,50±5,96	0,281
Tedavi sonrası	12,30±5,02	11,25±5,67	12,12±5,59	0,149
Üç ay sonra	7,51±4,04	7,76±4,88	8,93±5,36	0,874

Tablo 4. Tüm bireylerin egzersize uyum, hasta memnuniyeti ve yapılan egzersizlerin doğruluğunun değerlendirilmesi sonuçları (tedaviden üç ay sonra).

		Ev Egzersizi (n=105)	Fizyoterapistle Egzersiz (n=113)	Takipli Ev Egzersizi (n=103)	
		X±SD	X±SD	X±SD	p
Uygulanan tedaviden memnun kaldınız mı		82,4±7,7	83,8±7,9	83,3±7,6	0,188
Yapılan egzersizlerin doğruluğu toplam skoru		9,1±5,3	11,0±5,0	12,1±4,0	<0,001
		n (%)	n (%)	n (%)	
Miktar olarak yeterli mi	Az	1 (0,6)	2 (1,1)	1 (0,6)	
	Çok	15 (8,9)	17 (9,7)	18 (10,3)	
	Uygun	152 (90,5)	157 (89,2)	156 (89,1)	
Zorlandınız mı	Evet	55 (32,7)	36 (20,5)	47 (26,9)	
	Hayır	99 (58,9)	131 (74,4)	118 (67,4)	
	Biraz	14 (8,3)	9 (5,1)	10 (5,7)	
Sıkıldınız mı	Evet	43 (25,6)	23 (13,1)	30 (17,1)	
Evet	Hayır	109 (64,9)	132 (75)	125 (71,4)	
Hayır	Biraz	16 (9,5)	21 (11,9)	20 (11,4)	

sağladığını ortaya koydu. Tedaviye yönelik hasta memnuniyeti açısından grupların benzer olduğu gözlendi.

Literatürde benzer şekilde, yüksek egzersiz uyumunun disabilite ve ağrı düzeyinde anlamlı iyileşmelerle ilişkili olduğu bildirilmiştir. Dhondt vd.[15], egzersize uyumlu hastaların yalnızca bir kısmında klinik olarak anlamlı düzelme olduğunu ve bu durumun çeşitli bireysel ve çevresel faktörlerden etkilendiğini belirtmişlerdir. Yaş, fiziksel aktivite düzeyi, kinezyofobi, eğitim seviyesi ve sosyal destek gibi

değişkenler uyum üzerinde belirleyici olabilirken, semptomların şiddeti, beklentiler ve çevresel stresörler de dikkate alınmalıdır.

Kolt vd.[16] uyumu etkileyen faktörlerin çok boyutlu olduğunu vurgularken; Altuntaş vd.[17], artan ağrı, egzersizlerin doğruluğu konusundaki belirsizlikler ve günlük yaşam yükümlülüklerinin egzersiz uyumunu olumsuz etkilediğini belirtmiştir. 121 hasta ile başlayan çalışmada ilk kontrolde 73, ikinci kontrolde ise hasta sayısı 21'e düşmüş bu da bireysel motivasyon eksikliği ve izlem eksikliği ile ilişkilendirilmiştir.

Çalışmamızda, egzersiz uyumunun en düşük olduğu grup ev egzersizi grubudur. Bu durumun, yalnızca broşür ile bilgilendirme yapılması ve uygulamaların birebir gösterilmemesi nedeniyle hastaların egzersizleri doğru ve yeterli sıklıkta uygulama konusunda yetersiz kalmalarından kaynaklandığı düşünülmektedir. Bilgilendirmenin pasif bir yöntemle gerçekleştirilmesi, hastaların egzersizlere dair soru işaretlerini gidererememesine ve motivasyon eksikliği yaşamasına yol açmış olabileceği görüşündeyiz. Buna karşılık, fizyoterapist

Tablo 5. Bel ağrılı hastalara önerilen egzersizlerin doğruluk oranları.

	0	1	2	3	4
	n (%)	n (%)	n (%)	n (%)	n (%)
Kedi deve					
Ev Egzersiz Programı	13 (15,1)	20 (23,3)	23 (26,7)	28 (32,6)	2 (2,3)
Fizyoterapist Eşliğinde Egzersiz Programı	13 (12,6)	15 (14,6)	25 (24,3)	39 (37,9)	11 (10,7)
Takipli Ev Programı	13 (13,3)	10 (10,2)	33 (33,7)	32 (32,7)	10 (10,2)
Toplam	39 (13,6)	45 (15,7)	81 (28,2)	99 (34,5)	23 (8)
Lumbar germe					
Ev Egzersiz Programı	5 (5,8)	4 (4,7)	25 (29,1)	40 (46,5)	12 (14)
Fizyoterapist Eşliğinde Egzersiz Programı	18 (17,5)	2 (1,9)	21 (20,4)	55 (53,4)	7 (6,8)
Takipli Ev Programı	2 (2)	2 (2)	13 (13,3)	68 (69,4)	13 (13,3)
Toplam	25 (8,7)	8 (2,8)	59 (20,6)	163 (56,8)	32 (11,1)
Mekik					
Ev Egzersiz Programı	2 (2,3)	0 (0)	14 (16,3)	44 (51,2)	26 (30,2)
Fizyoterapist Eşliğinde Egzersiz Programı	2 (1,9)	0 (0)	1 (1)	74 (71,8)	26 (25,2)
Takipli Ev Programı	2 (2)	1 (1)	1 (1)	56 (57,1)	38 (38,8)
Toplam	6 (2,1)	1 (0,3)	16 (5,6)	174 (60,6)	90 (31,4)
Köprü					
Ev Egzersiz Programı	12 (14)	8 (9,3)	28 (32,6)	20 (23,3)	18 (20,9)
Fizyoterapist Eşliğinde Egzersiz Programı	4 (3,9)	5 (4,9)	31 (30,1)	20 (19,4)	43 (41,7)
Takipli Ev Programı	4 (4,1)	6 (6,1)	13 (13,3)	31 (31,6)	44 (44,9)
Toplam	20 (7)	19 (6,6)	72 (25,1)	71 (24,7)	105 (36,6)
Sırt ekstansör kuvvetlendirme					
Ev Egzersiz Programı	5 (5,8)	8 (9,3)	18 (20,9)	49 (57)	6 (7)
Fizyoterapist Eşliğinde Egzersiz Programı	12 (11,7)	5 (4,9)	15 (14,6)	59 (57,3)	12 (11,7)
Takipli Ev Programı	9 (9,2)	5 (5,1)	17 (17,3)	54 (55,1)	13 (13,3)
Toplam	26 (9,1)	18 (6,3)	50 (17,4)	162 (56,4)	31 (10,8)

0: Unutulmuş. 1: Yapamıyor. 2: Doğru pozisyon ama yanlış hareket. 3: Doğru pozisyon ve hareket, solunum kontrolü yok. 4: Kesinlikle yapıyor.

Tablo 6. Boyun ağrılı hastalara önerilen egzersizlerin doğruluk oranları.

	0	1	2	3	4
	n (%)	n (%)	n (%)	n (%)	n (%)
Boyun fleksiyon-ekstansiyon					
Ev Egzersiz Programı	0 (0)	7 (12,5)	25 (44,6)	23 (41,1)	1 (1,8)
Fizyoterapist Eşliğinde Egzersiz Programı	0 (0)	0 (0)	19 (35,2)	30 (55,6)	5 (9,3)
Takipli Ev Programı	0 (0)	0 (0)	14 (20)	48 (68,6)	8 (11,4)
Toplam	0 (0)	7 (3,9)	58 (32,2)	101 (56,1)	14 (7,8)
Boyun lateral fleksiyon					
Ev Egzersiz Programı	1 (1,8)	7 (12,5)	31 (55,4)	16 (28,6)	1 (1,8)
Fizyoterapist Eşliğinde Egzersiz Programı	1 (1,9)	3 (5,6)	25 (46,3)	23 (42,6)	2 (3,7)
Takipli Ev Programı	1 (1,4)	5 (7,1)	32 (45,7)	31 (44,3)	1 (1,4)
Toplam	3 (1,7)	15 (8,3)	88 (48,9)	70 (38,9)	4 (2,2)
Boyun rotasyon					
Ev Egzersiz Programı	2 (3,6)	15 (26,8)	28 (50)	11 (19,6)	0 (0)
Fizyoterapist Eşliğinde Egzersiz Programı	1 (1,9)	2 (3,7)	25 (46,3)	25 (46,3)	1 (1,9)
Takipli Ev Programı	4 (5,7)	7 (10)	33 (47,1)	25 (35,7)	1 (1,4)
Toplam	7 (3,9)	24 (13,3)	86 (47,8)	61 (33,9)	2 (1,1)
Omuz kapsül germe					
Ev Egzersiz Programı	11 (19,6)	23 (41,1)	22 (39,3)	0 (0)	0 (0)
Fizyoterapist Eşliğinde Egzersiz Programı	5 (9,3)	15 (27,8)	28 (51,9)	6 (11,1)	0 (0)
Takipli Ev Programı	6 (8,6)	20 (28,6)	36 (51,4)	8 (11,4)	0 (0)
Toplam	22 (12,2)	58 (32,2)	86 (47,8)	14 (7,8)	0 (0)
Omuz öne arkaya çevirme					
Ev Egzersiz Programı	16 (28,6)	24 (42,9)	16 (28,6)	0 (0)	0 (0)
Fizyoterapist Eşliğinde Egzersiz Programı	5 (9,3)	17 (31,5)	30 (55,6)	2 (3,7)	0 (0)
Takipli Ev Programı	8 (11,4)	22 (31,4)	32 (45,7)	8 (11,4)	0 (0)
Toplam	29 (16,1)	63 (35)	78 (43,3)	10 (5,6)	0 (0)

0: Unutulmuş. 1: Yapamıyor. 2: Doğru pozisyon ama yanlış hareket. 3: Doğru pozisyon ve hareket, solunum kontrolü yok. 4: Kesinlikle yapıyor.

eşliğinde uygulanan eğitim süreci sayesinde, hastaların egzersizlerin doğru formunu öğrenmeleri, yanlış uygulamaların düzeltilmesi ve sürece aktif katılım göstermeleri sağlandı. Ayrıca, takip sürecinde SMS ile hatırlatma ve destek mesajlarının gönderilmesinin, hastaların egzersizlerini günlük yaşamlarına entegre etmelerini kolaylaştırdığı, unutmalarını önlediği ve motivasyonlarını arttırdığı görüşündeyiz. Bu sistematik takip, bireylerin sorumluluk duygusunu pekiştirerek tedaviye olan bağlılıklarını arttırdı. Bu sonuç, Jones vd.[18] egzersize uyumu artıran unsurlar olarak bireyselleştirilmiş tedavi, terapist ile güven ilişkisi ve geri bildirim ihtiyacına vurgu yaptığı çalışmalarıyla benzerlik göstermektedir.

Areerak vd.[19] tarafından yapılan sistematik derlemede, öz-yeterlilik, eğitim düzeyi ve psikososyal çevrenin egzersize bağlılıkla ilişkili olduğu gösterilmiştir. L'Heureux[20] ve Hörder[21] gibi araştırmacılar ise dijital takip, hatırlatma sistemleri ve hasta destek mekanizmalarının uzun dönemli uyum üzerinde etkili olabileceğini vurgulamışlardır.

Bu doğrultuda, çalışmamızdaki SMS temelli takip sisteminin etkinliği de literatürle tutarlıdır.

Hou vd.[22], tedavi planının açık hedeflerle desteklenmesinin, hasta-motivasyonunu ve sonuçları olumlu etkileyebileceğini ifade etmiş; Palazzo[23] ve Lilje'nin[24] çalışmalarında ise teknolojik araçların egzersize uyumu artırıcı rol oynayabileceği, ancak fizyoterapist-hasta ilişkisinin bu süreçte merkezi rolünü koruması gerektiği belirtilmiştir.

Boyun ağrısı olan bireylerde, her bir grubun kendi içinde yapılan analizler, uygulanan müdahalelerin NDI skorlarında anlamlı düzeyde iyileşme sağladığını ortaya koydu. Ancak gruplar arası karşılaştırmalarda, farklı egzersiz uygulamaları arasında fonksiyonel iyileşme açısından belirgin bir üstünlük sağlanmadığı görüldü. Bu durum, uygulamaların etkinlik düzeylerinin benzer olabileceğini**,** fakat bunun egzersizlerin doğru veya yanlış uygulanmasıyla ilgili olmadığı**,** tüm gruplarda belirli bir düzeyde tedavi edici etkinin sağlanmış olabileceğinden kaynaklandığı düşünüldü. Öte yandan, egzersiz uyumu açısından değerlendirildiğinde, düzenli takiple desteklenen ev programı ve fizyoterapist eşliğinde yürütülen uygulamalar, standart bilgilendirme ile yürütülen programa kıyasla daha başarılı sonuçlar ortaya koydu. Bu sonuç, egzersizlerin yalnızca verilmesi değil, doğru, sürdürülebilir ve hasta motivasyonunu artıracak şekilde uygulanmasının önemini bir kez daha ortaya koymaktadır. Takipli yaklaşımlar, hastanın sürece aktif katılımını desteklemiş, sürekliliği artırmış ve sorumluluk duygusunu pekiştirmiştir. Bu sonuçlar, Gialanella[25] ve Reina[26] gibi araştırmacıların uzun vadeli takip ve yapılandırılmış hasta eğitimi yaklaşımlarının egzersiz uyumunu artırmadaki rolünü vurgulayan çalışmalarıyla da örtüşmektedir. Sonuç olarak, bireysel faktörlerin (yaş, eğitim, ağrı algısı, motivasyon gibi), tedaviye erişim ve destek sistemlerinin (takip, hatırlatma, birebir eğitim) egzersiz uyumunu doğrudan etkilediği söylenebilir. Dijital çözümler bu süreçte yardımcı olabilir, ancak insan etkileşimi ve yapılandırılmış rehberlik yerini alamayacağı düşünülmektedir.

Limitasyonlar

Bu çalışmada psikolojik faktörler (anksiyete, depresyon, kinezyofobi vb.) değerlendirme kapsamına alınmadı. Egzersiz uyumunun öz-bildirime dayalı olması ve uzun dönem (6 ay–1 yıl) takip yapılmaması çalışmanın kısıtlılıkları arasındadır. Ayrıca, gruplar cinsiyet dağılımı açısından dengeli değildir; bu durum egzersiz uyumu üzerinde etkili olabilecek bir değişken olarak göz önünde bulundurulmalıdır. Bu durum, uzun vadeli egzersiz uyumu ve sürdürülebilirlik açısından bir sınırlılık oluşturabilir. Ayrıca tarafımızca geliştirilen bu formun geçerlilik güvenilirliğinin de olmaması çalışmamızın kısıtlılıkları arasındadır.

Sonuç

Tüm bireylerde yapılan değerlendirme sonucunda egzersiz uyumu sırasıyla takipli ev programı grubu, fizyoterapist eşliğinde egzersiz programı grubu ve ev egzersiz programı şeklinde oldu. Bu çalışma ile hastalara verilen egzersizlerin fizyoterapistler tarafından detaylıca anlatılması gerektiği, egzersizlerin doğru yapılıp yapılmadığıyla ilgili rutin kontrollerin belli zaman aralıklarıyla yapılmasının egzersize uyumu ve tedavinin başarısını arttırabileceği sonucuna varıldı.

Gelecek çalışmalarda, hem uzun süreli ve düzenli takibin sağlanması hem de psikososyal faktörlerin (anksiyete, depresyon, motivasyon düzeyi vb.) değerlendirmeye dahil edilmesi, egzersiz uyumuna etki eden çok boyutlu etmenlerin daha kapsamlı bir şekilde analiz edilmesine olanak tanıyacaktır. Ayrıca bireyselleştirilmiş dijital müdahalelerin (mobil uygulamalar, çevrim içi danışmanlık vb.) etkinliği de ayrıntılı biçimde araştırılabilir. Öte yandan, fizyoterapi ve rehabilitasyon uygulamalarında hastaların belirli periyotlarla kontrol randevularına çağrılması ve egzersizlerin düzenli takibinin yapılması, klinik açıdan programın etkinliğini artıran önemli unsurlar arasında yer almaktadır.

Teşekkür: *Yok*

Yazarların Katkı Beyanı: İK: Konsept/fikir gelişimi, çalışma dizaynı, veri toplama/işleme, veri analizi/yorumlama, literatür araştırması, olguların sağlanması, tesislerin/ekipmanın sağlanması, yazma; **KY:** Konsept/fikir gelişimi, çalışma dizaynı, proje yönetimi, veri toplama/işleme, veri analizi/yorumlama, kritik gözden geçirme; **YY:** Konsept/fikir gelişimi, çalışma dizaynı, proje yönetimi, veri analizi/yorumlama, kritik gözden geçirme.

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ORIGINAL ARTICLE

Effect of mirror therapy on brain re-organization, functional motor skills and quality of life in spastic hemiplegic cerebral palsy

Spastik hemiplejik serebral palside ayna terapisi uygulamasının beyin reorganizasyonu, fonksiyonel motor beceriler ve yaşam kalitesi üzerindeki etkisi

Duygu KORKEM YORULMAZ[1], Mintaze KEREM GÜNEL[2], Arzu Ceylan HAS SILEMEK[3], Kader KARLI OĞUZ[4]

Abstract

Purpose: Spastic hemiplegic cerebral palsy is a complex disability with sensory-motor problems characterized by functional movement and posture disorders and negatively effects daily living activities. The aim of this study was to investigate the effects of mirror therapy for upper extremity and hand functions on brain re-organization, functional motor development, daily living activity level, and quality of life in children with spastic hemiplegic cerebral palsy.

Methods: This self-control study employed a sample of nine children aged from 4 to 18. The children were evaluated before and after eight weeks of routine physiotherapy and were included in mirror therapy sessions of 30 minutes each for three days a week by the same physiotherapist. The evaluation measured activation intensity, upper extremity activation intensity, upper extremity skill levels, goal achievement states, functional independent states, brain re-organization states, and quality of life levels.

Results: No statistically significant difference was detected regarding the evaluation parameters before and after the first eight-week follow-up period ($p>0.05$). However, a statistically significant improvement was found in upper extremity skill states, functional independence levels, brain re-organization states, and quality of life levels in the second 8-week study period in which mirror therapy was added to physiotherapy ($p<0.05$).

Conclusion: This study contributes to the limited literature on the determination of treatment effectiveness by employing functional magnetic resonance imaging *(fMRI)* in the mirror therapy on children with spastic hemiplegic cerebral palsy.

Keywords: Cerebral palsy, Motor skills, Functional status, Quality of life.

Öz

Amaç: *Spastik hemiplejik serebral palsi, duyusal-motor sorunlar, fonksiyonel hareket ve postür bozuklukları ile karakterize, günlük yaşam aktivitelerini olumsuz etkileyen kompleks bir nöro-gelişimsel bozukluktur. Bu çalışmanın amacı, üst ekstremite ve el fonksiyonlarına yönelik ayna terapisinin beyin yeniden örgütlenmesi, fonksiyonel motor gelişim, günlük yaşam aktiviteleri ve yaşam kalitesi üzerindeki etkilerini incelemektir.*

Yöntem: *Bu özdenetimli çalışma, yaşları 4 ile 18 arasında değişen dokuz çocuktan oluştu. Çocuklar, sekiz haftalık rutin fizyoterapi öncesi ve sonrası değerlendirildi, ardından aynı fizyoterapist tarafından haftada üç gün, 30'ar dakikalık ayna terapisi seanslarını içeren bir müdahale programına alındı. Değerlendirmelerde aktivasyon şiddeti, üst ekstremite aktivasyon yoğunluğu, üst ekstremite beceri düzeyleri, hedef gerçekleştirme durumu, fonksiyonel bağımsızlık düzeyi, beyin yeniden örgütlenme durumu ve yaşam kalitesi ölçüldü.*

Bulgular: *İlk sekiz haftalık takip döneminde, değerlendirme parametreleri açısından istatistiksel olarak anlamlı bir değişiklik saptanmadı ($p>0,05$). Ancak, ayna terapisinin fizyoterapi programına eklendiği ikinci sekiz haftalık dönemde üst ekstremite becerilerinde, fonksiyonel bağımsızlık düzeylerinde, beyin yeniden örgütlenme bulgularında ve yaşam kalitesinde istatistiksel olarak anlamlı iyileşme görüldü ($p<0,05$).*

Sonuç: *Bu çalışma, spastik hemiplejik serebral palsili çocuklarda ayna terapisinin etkinliğinin belirlenmesinde fonksiyonel manyetik rezonans görüntüleme (fMRI) kullanımına ilişkin sınırlı literatüre katkı sağlamaktadır.*

Anahtar Kelimeler: *Serebral palsi, Motor beceriler, Fonksiyonel durum, Yaşam kalitesi.*

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INTRODUCTION

Spastic hemiparetic cerebral palsy (SHCP) results from brain damage during fetal and infant development, leading to motor pathway degeneration, primarily affecting the premotor (PM, BA6) and primary motor (M1, BA4) areas, involved in somatosensory control and bimanual coordination.[1] SHCP presents with complex sensory-motor issues and declined upper extremity function, particularly in distal sections.[2] Functional imaging studies demonstrate increased stimulability of the ipsilateral primary motor area (BA4) when observing extremity illusions during unilateral movement.[3] Interhemispheric disinhibition occurs after bilateral movements.[4]

Bilateral movements stimulate the affected hemisphere's primary motor area during the acute recovery phase after brain injury,[5,6,7] impacting daily living activities and bimanual coordination in children with SHCP.[8] Mirror therapy (MT) is a recent approach aiming to improve the functionality of the affected extremity and brain re-organization.[5,9-11]

MT activates the mirror neuron system using mirror visual feedback to stimulate the motor cortex.[12-15] Visual, motor order, and proprioceptive capacity play crucial roles in activating mirror neurons.[5,6,16] MT enhances awareness and spatial perception in children, reducing learned non-use following motor imagery.[4,11]

Previous studies have shown that MT can improve functional outcomes in SHCP, increasing hand strength and function.[17] It effectively enhances muscle activity, motor speed, and functionality in daily living activities.[18,19] Considering the limitations in evidence-based studies and the lack of research on MT's effect on brain re-organization in children with SHCP, this study aims to investigate the combined effect of MT and routine therapy on brain re-organization, upper extremity function, daily living activities, and quality of life.

METHODS

Participants

This study included randomly selected children with SHCP from the Department of Pediatric Physiotherapy, Faculty of Physiotherapy and Rehabilitation, Hacettepe University. Ethical approval (No: 99950669/3A) was obtained from University Health Sciences Research Ethics Committee. The minimum number of subjects required for the study was eight, based on an alpha error rate of 0.05 and a beta of 0.20, together with 80% power. Assuming the loss of 25% of individuals during the training period, we specified the number of subjects as 10. The clinical trial number was NCT03612128. Parents or their carers gave informed consent for participation. Children aged 4 to 18 years, without visual function disorders other than refractive errors, and their families agreed to participate. Exclusion criteria included upper extremity fractures, recent muscle-tendon and bone surgery, exposure to spasticity-inhibiting drugs in the last six months, dental braces, epileptic seizures, or platinum in the upper extremity. Fourteen children were assessed, but only nine completed the treatment program (Figure 1).

Study design

The study was a self-control study to ensure similarity between experimental and control groups, enhancing intervention effectiveness in SHCP (Figure 2). A single group of children participated in two eight-week periods. The first period was the control group without MT while the second period included MT alongside routine physiotherapy. Routine physiotherapy comprised various exercises for the upper extremity. Initial assessments were made before the first period, and routine physiotherapy was conducted twice a week. Second assessments were performed after the first period, and then MT was added to routine sessions. MT was applied for 30 minutes three days per week during the second period, following the literature.[19,20]

Treatment protocol

A single physiotherapist conducted all implementations. During MT, each child sat upright with both feet on the floor, supported by a chair with back support, and arms on the table. A mirror divided the body into two parts, reflecting the healthy extremities while concealing the affected ones. Each child with SHPC was given exercises for fine motor activities such as opposition, picking up and throwing objects into a box, and rolling soft

objects for MT. Prior to the MT intervention, all participants received routine physiotherapy based on neurodevelopmental principles. The program included stretching, strengthening, bilateral upper extremity activities, task-oriented functional motor training, and activities of daily living practice. These sessions were conducted twice weekly by the same physiotherapist to ensure consistency.

Clinical assessment

Brain Re-organization

Its non-invasive nature has made functional magnetic resonance imaging (fMRI) the most commonly used method for mapping the neural activities of the human brain. We used fMRI to evaluate the brain re-organization in this study (Figure 3). A neuroradiologist performed fMRI assessments.

Imaging

The 3T magnetic resonance imaging scanner (Magnetom, Trio TIM system, Siemens, Germany) with a 32-channel head coil was used for imaging before and after control and study periods. Imaging protocol included a multi-section single-shot T2* echo-planar imaging sequence (TR/TE: 2000/35 msec) with 28 sections, 3.4x3.4x3.4 mm voxel size, 220x220 FOV, and 64x64 matrix size. fMRI-BOLD procedure lasted 610 seconds with five repetitions, each cycle comprising 20 seconds of right-hand movement, 20 seconds of left-hand movement, 20 seconds of bimanual movement, and 20 seconds of rest. 3D T1-weighted high-resolution images were also obtained (TR/TE: 1900/3.4 msec; FA: 90; FOV: 256 mm; matrix: 224x256; distance factor: 50%).

fMRI Analysis

fMRI data were analyzed using Brain Voyager QX 1.2 (Brain Innovation, Netherlands). Image preprocessing involved eliminating low-frequency shifts, 3D motion detection, and correction, and spatial antialiasing (6 mm FWHM). The General Linear Model (GLM) determined voxel correlations between BOLD signal and predictor. Six motion parameters from fMRI pretreatment (X, Y, Z translation and rotation) were used as covariates in GLM. Images were reconciled with an anatomical dataset, and Talairach transformation was performed by manual detection of AC-PC point for normalization. Correlation estimation used $p<0.05$ threshold (family-wise errors) with minimum cluster threshold of 10 mm and $t>3.1$. Regions of interest (ROI) were created with bilateral Brodmann areas 4 and 6, extracting mean t-stat value for each ROI.

Functional Motor Capacity

Functional motor capacity of cerebral palsy was measured by using the Gross Motor Function Classification System (GMFCS). GMFCS is a 5-level system used for classifying motor activation intensity in children with cerebral palsy. Level I and Level II indicate that ambulation can be performed in society or at home without any restriction. In contrast, children at level V do not have independent mobility (Cronbach's alpha 0.99).[21,22]

Manual Skills

The Upper Extremity Bimanual Ability Classification System (MACS) classified subjects' manual abilities into five levels. Level I indicates easy object handling, while Level V reflects limited activity performance (Cronbach's alpha 0.99). The Quality of Upper Extremity Skills Test (QUEST) evaluated upper extremity skills in children with spastic cerebral palsy aged 18 months to 18 years. QUEST comprises 7 sections, assessing various aspects of hand function (Cronbach's alpha 0.98).[23]

Goal Achievement

The Goal Achievement Scale (GAS) evaluates children's success in achieving targets. Scores range from -2 (poor) to +2 (above expected). GAS measures individualized progress and is reliable for assessing treatment effects.[24] In our study, three goals were set for each child based on importance and difficulty. Achievement was assessed using GAS (Cronbach's alpha 0.83).

Functional Independence

The Functional Independence Measure for Children (WeeFIM) is a pediatric scale with 18 items in 6 areas: self-care (6), sphincter control (2), transfers (3), locomotion (2), communication (2), and social status (3). Scores range from 1 (entirely dependent) to 7 (full independence), considering assistance, timing, and device use (Cronbach's alpha 0.95).[25]

The Evaluation of Health-Related Quality of Life

The Child Health Questionnaire–Parent Form 50 (CHQ-PF50), a 50-item parent-reported measure, was used to assess the health-related quality of life (HRQoL) of the participants. CHQ-PF50 has been prepared for

children aged 5–18 years. It has 12 subscales. Each subscale is scored between 0 and 100, and high scores express a better quality of life and well-being (Cronbach's alpha 0.96).[26]

Statistical analysis

SPSS 22.0 analyzed data. Cronbach's alpha estimated internal consistency. Descriptive stats used mean and standard deviation for quantitative data (X±SD), and number/percentage for qualitative. Kolmogorov-Smirnov tested normal distribution. Friedman test assessed time change significance. Wilcoxon test with Bonferroni correction ($p<0.017$) conducted post-hoc comparisons. Variance analysis examined changes in normally distributed body activation and upper extremity quality. Cohen's d measured effect sizes (0.2: small, 0.5: moderate, 0.8: large). The significance level was set up as 0.05. Greenhouse-Geisser corrected non-sphericity assumption.

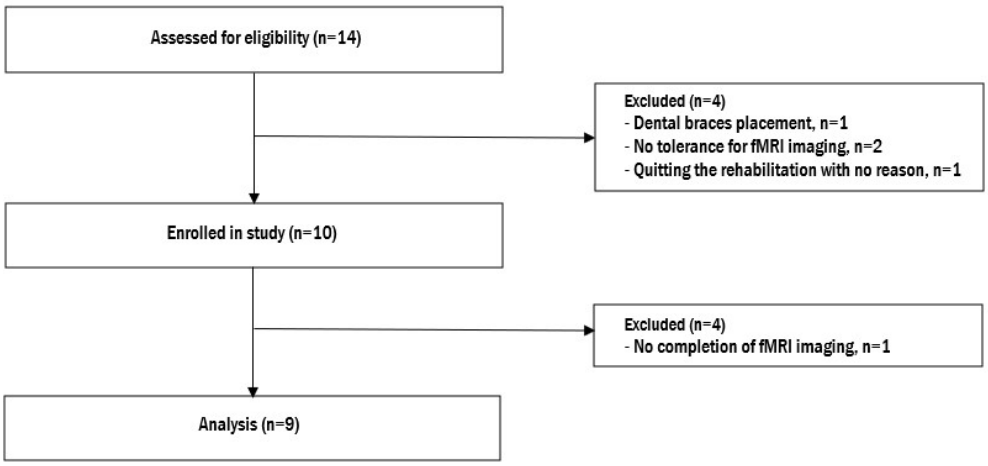

Figure 1. The flow diagram of the individuals included in the study.

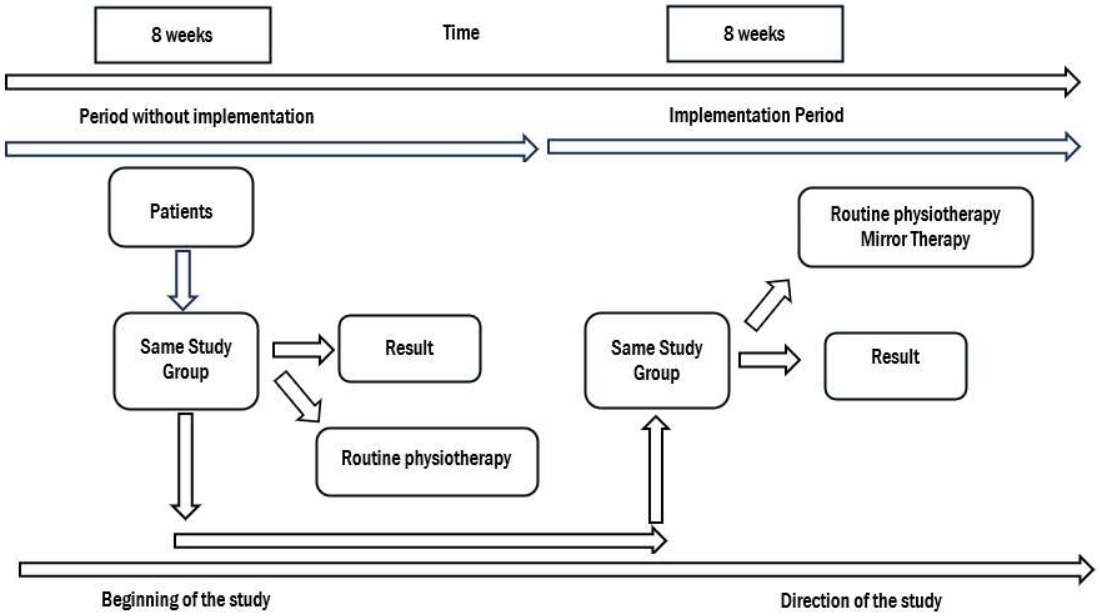

Figure 2. Study design.

Figure 3. fMRI sample showing increased hemisphere activation with movements of both hands compared to rest at 2 months follow up. Time course segmentation was extracted from highly activated nodes in the BA4.

RESULTS

Sociodemographic characteristics

Nine children with SHCP completed the study (mean age: 12.3±2.4 years, disease symptom onset: 6±2.8 months, diagnosis age: 7.9±4.0 months). Table 1 shows sociodemographic and descriptive characteristics. Bimanual hand skills and GMFCS levels showed no significant difference between control and study periods (p>0.05) (Table 1).

Primary outcomes

Brain Re-organization

At the beginning and end of the control period, brain re-organization in BA4 and BA6 areas showed no statistically significant difference (p>0.05). However, after the study period, significant differences were found in the affected hemisphere's BA6 area during affected extremity and in the affected and unaffected hemisphere BA4 and affected hemisphere BA6 areas with bilateral extremity movement after the study period (p<0.05).

When a comparative evaluation of brain re-organization at the beginning and end of the study period was performed, a statistically

Table 1. Socio-demographic and descriptive characteristics, Gross Motor Functional Classification System (GMFCS), and Manual Ability Classification System (MACS) scores of individuals (n=9).

	X±SD
Age of child (year)	12.3±2.4
Age of onset of disease symptoms (months)	6.0±2.8
Time of diagnosis by the doctor (months)	7.9±4.0
Physiotherapy period (years)	8.9±3.1
	n (%)
Gender	
Male	2 (22
Female	7 (78)
Classification	
Right Hemiplegia	4 (44)
Left Hemiplegia	5 (56)
	Median (Min-Max)
GMFCS	
1st assessment	2 (1-2)
2nd assessment	2 (1-2)
3rd assessment	2 (1-2)
MACS	
1st assessment	3 (1-3)
2nd assessment	3 (1-3)
3rd assessment	3 (1-3)

Min-Max: minimum – maximum. GMFCS: Gross Motor Function Classification System. MACS: Manual Ability Classification System.

significant difference was found in the affected hemisphere BA6 area with the movement of the affected extremity and in the unaffected hemisphere BA6 area with bilateral extremity movement ($p<0.05$) (Table 2).

Effect sizes for BA4 activation in the non-affected hemisphere with bilateral limb movement were medium (2nd and 3rd assessments: d=0.79) and large (1st and 3rd assessments: d=0.9). Effect sizes for BA6 activation in the affected hemisphere with bilateral limb movement were medium (1st and 2nd assessments: d=0.65) and large (2nd & 3rd assessments: d=0.93, 1st and 3rd assessments: d=1.63). Other variables had small effect sizes.

Upper Extremity Manual Skills

No statistically significant difference was found in the QUEST sub-sections between evaluations at the beginning and end of the control period ($p>0.05$).

However, disassociated movements, grip, weight carrying, and protective extension sub-sections showed a significant difference ($p<0.05$) (Table 2). Effect sizes for disassociated movements were medium (2nd and 3rd assessments d= 0.54, 1st and 3rd assessments d= 0.59). Other variables had small effect sizes.

Secondary outcomes

Functionality in Daily Living Activities

No difference at control period's start and end, but a significant difference in motor score and total score of self-care sub-section in the functional independence measurement at study period's start and end ($p<0.05$). All variables had small effect sizes.

The State of Achieving the Identified Goals

No significant difference in achieving identified goals between control period evaluations ($p>0.05$). However, a significant difference in goal 1 at study period's start and end ($p<0.05$) (Table 3). GAS' effect sizes were medium (2nd & 3rd assessments d=0.52, 1st & 3rd assessments d=0.52).

Health-Related Quality of Life

No significant difference in life quality levels between control period evaluations ($p>0.05$). However, HRQoL showed significant differences in Physical Function (PF), Role/Social-Physical Behavior (REB), Self-Esteem (SE), Parent Effect/Time (PT), and

Table 2. Evaluation of brain re-organization (fMRI) and quality of upper extremity skills test (QUEST).

	1. week Median (IQR)	8. week Median (IQR)	16. week Median (IQR)	p	
Functional Magnetic Resonance Imaging (fMRI)					
BA4 ACT in AF-Hem w/ associated affected limb movement	2.3 (7.5)	5.4 (12.5)	6.6 (9.8)	1.00	
BA4 ACT in NAF-Hem w/ associated affected limb movement	5.1 (5.87)	2.8 (7.9)	2.9 (6.2)	0.79	
BA6 ACT in AF-Hem w/ associated affected limb movement	0.0 (0.0)	0.0 (3.9)	5.8 (5.6)	<0.001	a,b
BA6 ACT in NAF-Hem w/ associated affected limb movement	0.0 (0.0)	0.0 (4.3)	2.7 (6.1)	0.07	
BA4 ACT in AF-Hem w/ associated non-affected limb movement	2.5 (5.5)	2.7 (6.5)	0.0 (5.3)	0.94	
BA4 ACT in NAF-Hem w/ associated non-affected limb movement	5.9 (7.4)	6.2 (8.2)	8.6 (3.6)	0.19	
BA6 ACT in AF-Hem w/ associated non-affected limb movement	0.0 (0.0)	0.0 (5.0)	0.0 (0.0)	0.17	
BA6 ACT in NAF-Hem w/ associated non-affected limb movement	0.0 (0.0)	0.0 (6.1)	5.7 (7.0)	0.11	
BA4 ACT in AF-Hem w/ associated bilateral limb movement	5.2 (6.1)	5.5 (4.4)	7.2 (2.8)	0.03*	b
BA4 ACT in NAF-Hem w/ associated bilateral limb movement	6.2 (7.2)	7.5 (2.8)	8.0 (3.1)	0.03*	b
BA6 ACT in AF-Hem w/ associated bilateral limb movement	0.0 (0.0)	2.3(5.7)	5.6 (7.6)	0.01*	b
BA6 ACT in NAF-Hem w/ associated bilateral limb movement	0.0 (0.0)	2.6 (6.0)	6.2 (9.7)	0.08	
The Quality of Upper Extremity Skills Test (QUEST)					
Dissociated movement	73.4 (21.1)	73.4 (17.9)	76.6 (10.2)	0.01*	a,b
Grasp	55.5 (25.3)	55.5 (25.3)	60.0 (29.6)	<0.001	a,b
Weight bearing	82.0 (22.0)	82.0 (22.0)	84.0 (20.0)	<0.001	a,b
Protective extension	83.3 (26.4)	83.3 (26.4)	88.9 (23.6)	0.40	
Total Score	70.6 (23.7)	70.6 (22.9)	77.1 (20.3)	<0.001	a,b

*p<0.05. IQR; Inter Quantile Range. a: p<0.05, , 8-16. Week. b: p<0.05, , 1-16. Week. ACT: Activation. AF-Hem: Affected hemisphere. NAF-Hem: Non-affected hemisphere.

Table 3. Functional independence level (WeeFIM), achievement of defined goals (GAS) and health-related quality of life (CHQ_PF50).

	1. week	8. week	16. week		
	Median (IQR)	Median (IQR)	Median (IQR)	p	
The Functional Independence Measure for Children (WeeFIM)					
Self-care	32.0 (8.5)	32.0 (8.50)	35.0 (7.5)	0.01*	a,b
Sphincter Control	14.0 (0.5)	14.0 (0.50)	14.0 (0.5)	1.00	
Transfers	21.0 (2.0)	21.0 (2.00)	21.0 (2.0)	1.00	
Locomotion	14.0 (0.5)	14.0 (0.50)	14.0 (0.5)	1.00	
Motor Subtotal Score	81.0 (10.5)	81.0 (10.5)	83.0 (10.0)	0.01*	a,b
Communication	14.0 (1.0)	14.0 (1.0)	14.0 (1.0)	1.00	
Social Cognition	19.0 (5.0)	19.0 (5.0)	19.0 (5.0)	1.00	
Cognitive Subtotal Score	33.0 (6.0)	33.0 (6.0)	33.0 (6.0)	1.00	
Total Score	110.0 (8.5)	110.0 (8.5)	113.50 (7.5)	0.01*	a,b
The Goal Achievement Scale (GAS)					
Goal 1	2.0 (1.0)	2.0 (1.0)	2.0 (0.5)	0.01*	a,b
Goal 2	2.0 (1.0)	2.0 (1.0)	2.0 (0.5)	0.50	
Goal 3	2.0 (1.5)	3.0 (1.0)	2.0 (1.0)	0.50	
The Child Health Questionnaire Parent Form (CHQ_PF50)					
Physical functioning (PF)	61.1 (36.9)	61.1 (50.8)	72.2 (36.1)	0.06	
Role/social-behavior (REB)	61.1 (64.5)	77.8 (61.1)	100.0 (65.6)	0.01*	
Role/social-physical (RP)	66.7 (48.1)	50.0 (55.6)	66.7 (33.3)	0.12	
Bodily pain (BP)	83.3 (33.9)	80.0 (30.0)	100.0 (20.0)	0.29	
Behavior (BE)	72.5 (42.1)	64.2 (27.1)	85.0 (31.7)	0.04*	a
Mental Health (MH)	80.0 (35.0)	80.0 (27.5)	80.0 (26.7)	0.29	
Self-esteem (SE)	65.0 (25.0)	70.0 (29.2)	75.0 (34.6)	<0.001	a,b
General health (GH)	35.0 (37.5)	39.2 (31.3)	43.3 (32.5)	0.19	
Parental impact/ emotional (PE)	33.3 (37.5)	26.7 (25.0)	41.7 (52.5)	0.07	
Parental impact/ time (PT)	66.7 (36.1)	55.6 (27.8)	77.8 (14.6)	<0.001	a,b
Family activities (FA)	77.8 (22.1)	75.0 (16.7)	83.3 (29.2)	0.09	
Family Harmony	60.0 (38.3)	70.8 (25.0)	85.0 (25.0)	0.15	
Physical Health Summary Score	35.2 (12.7)	33.9 (13.3)	40.2 (11.3)	<0.001	a,b
Psychosocial Health Summary Score	42.8 (14.1)	43.3 (13.1)	50.3 (15.4)	<0.001	a,b

*p<0.05. IQR; Inter Quantile Range. a: p<0.05, , 8-16. Week. b: p<0.05, , 1-16. Week.

Parent Effect/ Emotional (PE) sub-sections of CHQ-PF50 and, Physical and Psychosocial Health Summary Scores at study period's start and end ($p<0.05$) (Table 3). Effect sizes were medium and large (REB 1st and 3rd assessments d=0.59; BE 2nd and 3rd assessments d=0.77; SE 2nd and 3rd assessments d=0.70, 1st and 3rd assessments d=0.86; PT 2nd and 3rd assessments d=1.08, 1st and 3rd assessments d=0.77; Physical Health Summary Score 2nd and 3rd assessments d=0.83, 1st and 3rd assessments d=0.59; Psychosocial Health Summary Score 2nd and 3rd assessments d=0.78, 1st and 3rd assessments d=0.84).

DISCUSSION

Authors observed an activation increase in the PM(BA6) area of the affected hemisphere with the movement of the hemiplegic arm and in the M1(BA4) area of the affected hemisphere as well as in the M1(BA4) and PM(BA6) areas of the unaffected hemisphere with bilateral arm movement when the brain re-organization evaluations were compared with fMRI in our study. The observation could indicate that the motor area of the hemisphere containing the lesion can be activated when the hemiplegic side is active, and the motor areas in both hemispheres can be activated with the use of both arms.

To the best of our knowledge, no study has explored fMRI for MT effectiveness in SHCP. Altschuler et al.[10] suggested that mirror illusion enhances PM(BA6) region by compensating for decreased proprioception in adult hemiplegic patients. Fukumura et al.[27] found increased activation in PM(BA6) and M1(BA4) with MT using transcranial magnetic stimulation. In this study showed activation in PM(BA6) and M1(BA4) in both hemispheres during MT.

Garry et al.[28] found increased PM(BA6) activation due to mirror neurons' increase using transcranial magnetic stimulation and MT in healthy subjects. Inverzinni et al.[29] showed MT activates patients' mirror neuron system, improving upper extremity mobility and functional independence. In this study, bilateral hand movements on fMRI revealed activation in motor regions of both hemispheres. PM(BA6) area activation in both hemispheres suggests involvement of mirror neurons in this development.

This study also showed increased activation in the affected hemisphere during hemiplegic hand movement, in contrast to the healthy hemisphere. Perry and Bentin[30] found stronger brain waves in the contralateral hemisphere after MT. Both hemispheres exhibited activation increase by MT, with the affected hemisphere showing stronger effects, consistent with our results. Previous studies have proven activation increase in specific neuronal regions of the lesioned hemisphere. Studies on mirror illusion related to poor motor function found decreased activation in control motor regions.[13,28,30]

In this study, MT improved disassociated movements, grasp, and weight-bearing in the upper extremity, aiding protective extension and supporting upper extremity skill development. Neuronal regeneration in M1(BA4) and PM(BA6) areas likely justifies these improvements.

Bruchez et al.[31] studied 90 children with hemiparetic cerebral palsy, finding that MT improves upper extremity strength, function, and daily performance, especially grasp strength. Feltham et al.[32] measured MT's effect on muscle strength using EMG in children with SHCP, observing increased muscle activation, especially in the shoulder and elbow region. Michielsen et al.[33] studied 40 chronic adult hemiplegic patients, revealing increased upper extremity motor function development and neuronal re-organization, with a shift in hemispheric activation towards the affected hemisphere after MT. MT was found to have additional benefits beyond repetitive tasks and focused training, enhancing motor cortex excitability and somatosensory input. Summer et al.[34] reported that simultaneous movement of the hemiplegic and intact extremities during MT increased activation in the motor cortex, improving affected upper extremity motor functions. Steven and Stoykov[35] showed that MT positively affects affected extremity function by providing visual feedback, reinforcing our study's outcomes. Altschuler et al.[10] found that positive visual feedback during MT restructured decreased proprioceptive input in hemiplegic individuals. Kuys et al.[36] demonstrated MT's improvement of sensory disturbances, including mild touch sensation and proprioception, supporting our study's findings of increased weight bearing. Afferent messages transmitted to the spinal cord, along with joint mechanoreceptors' pressure sensation and proprioceptive knowledge restructuring, likely explain the development of weight-bearing in the upper extremities. In summary, various studies confirm the positive effects of MT on upper extremity skills and functions. The therapy's impact is attributed to enhanced motor cortex excitability and somatosensory input, providing valuable insights into its potential benefits for individuals with SHCP. Understanding the mechanisms underlying MT's effects may aid in refining its implementation and optimizing outcomes in clinical practice.

Various studies have explored the impact of MT on upper extremity skills, including grasp and disassociated movements.[19,37] Gygax et al.[17] investigated ten children with SHCP, observing increased grasp strength and functional arm movements with MT. Smorenburg[37] compared the effects of mirror visual feedback on impaired and less-impaired upper limbs, demonstrating that mirrors can offer appropriate visual feedback for intended and dissociated movements, grasp, and weight-bearing.

Dohle et al.[38] proved that MT increased corticospinal stimulability for motor function development in 25 hemiplegic adults, specifically affecting distal arm muscles. Proximal and distal motor functions were

differently influenced by both hemispheres, with distal movements organized unilaterally and proximal movements primarily represented bihemispherically. Based on this, we believe MT stimulated lateralized motor areas, improving grasp in the distal parts of our study. The illusion of MT also activated both hemispheres, enhancing disassociated movements by increasing proximal extremity movements.

Altschuler et al.[10] found increased functionality associated with motor and sensory development. Park et al.[39] reported positive effects of MT on upper extremity function and daily living activities in 30 hemiplegic patients, enhancing independence, particularly in self-care. Yavuzer et al.[11] observed motor improvement and functional development in 20 hemiplegic patients after four weeks of MT, with improved self-care activities. Our study demonstrated that MT positively impacted upper extremity motor function, leading to better self-care activities, and increased functional independence levels.

In this study demonstrated that goal-oriented MT positively impacted self-care activities and increased functional independence levels. Similar findings were shown by Park et al.[39] where goal-oriented MT improved upper extremity function and self-care in hemiplegic patients. Eom-Ji et al.[40] also found positive effects of goal-oriented MT on upper extremity function and independence in daily activities for 20 hemiplegic patients. Increased daily living activities and motivation can lead to greater achievement, independence, and self-confidence, promoting positive behavioral development and encouraging individuals to fulfill their social and physical roles in life.

Previous studies were pilot studies without investigating brain re-organization with fMRI. Limited literature on MT in SHCP makes this study relevant.

Limitations

Although the number of individuals required was eight in the power analysis performed to detect the adequacy rate of the children, we believe that this number is inadequate for inter-group evaluations and should be increased for more detailed analysis in future studies.

The wide age range of the participants (4–18 years) represents a methodological limitation, as developmental differences across this span may influence neuroplasticity, motor learning capacity, and functional performance. Such heterogeneity may partially affect the interpretability and generalizability of the findings regarding the effects of MT on brain re-organization, functional motor skills, and quality of life. Future studies should include more age-homogeneous cohorts to strengthen the validity of the outcomes.

Out of the individuals included in the study, four had left hemisphere involvement and five had right hemisphere involvement. The fMRI imaging results for brain re-organization were not included in the group analysis based on etiological classification. We suggest evaluating the data according to hemisphere activation for more objective insights in future studies.

Long-term treatment evaluation is a limitation in our study. Future studies with follow-up time points can determine the continuity of MT effectiveness.

Conclusion

This study indicates that MT supports upper extremity motor recovery and functional independence in children with SHCP by enhancing activation in the M1(BA4) and PM(BA6) regions of both hemispheres, suggesting a positive influence on brain re-organization. Improvements in grasp, dissociated movements, and weight-bearing align with these neurophysiological changes and highlight the therapy's potential to augment motor cortex excitability through visual–somatosensory feedback. Despite the small sample size and lack of long-term follow-up, the findings contribute valuable evidence to pediatric neurorehabilitation literature and suggest that MT can serve as an effective, low-cost clinical adjunct to conventional treatment for improving upper extremity function in this population.

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Analysis and interpretation of results, reviewed the results and approved the final version of the manuscript; **HKK:** Study conception and design, analysis and interpretation of results, reviewed the results and approved the final version of the manuscript.

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Conflicts of Interest: *None*

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ORIGINAL ARTICLE

Acute effects of different foam rolling durations on agility, dynamic balance, and speed in young male soccer players: a randomized crossover design

Genç erkek futbolcularda farklı foam rolling sürelerinin çeviklik, dinamik denge ve sürat üzerine akut etkileri: rastgele bir çapraz tasarım

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Abstract

Purpose: This study aimed to compare the acute effects of different foam rolling (FR) durations on agility, dynamic balance, and speed in young male soccer players.

Methods: Fifteen volunteer young male soccer players (mean age: 16.73±0.44 years) were included in the study, which was planned as an experimental randomized crossover design. All players performed the 3 sessions [FR (1 min), FR (2 min), and FR (3 min)] on separate occasions in a randomized order, with an interval of 7 days. Before and after the interventions, dynamic balance was assessed with the Y balance test, agility was assessed with the agility t-test, and speed was assessed with the 20-m sprint test.

Results: Compared with the pre-test results, significant improvement in dynamic balance (Time (T): $p<0.01$, $F=107.26$, $\eta p^2=0.719$), agility (T: $p<0.01$, $F=52.84$, $\eta p^2=0.557$), and speed (T: $p<0.01$, $F=31.98$, $\eta p^2=0.432$) was observed in all groups. Group × time interaction was not significant for dynamic balance (Group × Time (G x T): $p=0.87$, $F=0.14$, $\eta p^2=0.007$), agility (G × T: $p=0.72$, $F=0.32$, $\eta p^2=0.015$), and speed (G × T: $p=0.23$, $F=1.51$, $\eta p^2=0.067$).

Conclusion: FR training for 1 minute appears to effectively enhance dynamic balance, agility, and speed in young male soccer players. Strength and conditioning coaches should consider integrating this approach into their training programs for optimizing player development.

Keywords: Athletic Performance; Exercise; Football; Myofascial Release; Sport.

Öz

Amaç: *Bu çalışma, genç erkek futbolcularda farklı foam rolling (FR) sürelerinin performans ile ilişkili fiziksel uygunluk parametreleri üzerindeki akut etkilerini karşılaştırmayı amaçladı.*

Yöntem: *Deneysel bir rastgeleleştirilmiş çapraz tasarım şeklinde planlanan bu çalışmaya 15 gönüllü genç erkek futbolcu (ortalama yaş 16,73±0,44 yıl) dâhil edildi. Tüm oyuncular 3 ayrı seansı [FR (1 dk), FR (2 dk) ve FR (3 dk)] rastgele bir sırayla 7 gün arayla gerçekleştirdiler. Müdahale öncesi ve sonrasında dinamik denge Y denge testi ile, çeviklik çeviklik t testi ile, sürat ise 20 m sprint testi ile değerlendirildi.*

Bulgular: *Ön test sonuçlarıyla karşılaştırıldığında, tüm gruplarda dinamik dengede (Zaman (T): $p<0,01$, $F=107,26$, $\square p2=0,719$), çeviklikte (T: $p<0,01$, $F=52,84$, $\square p2=0,557$) ve süratte (T: $p<0,01$, $F=31,98$, $\square p2=0,432$) anlamlı iyileşme gözlendi. Dinamik denge (Grup x Zaman (GxT): $p=0,87$, $F=0,14$, $\square p2=0,007$), çeviklik (GxT: $p=0,72$, $F=0,32$, $\square p2=0,015$) ve sürat (GxT: $p=0,23$, $F=1,51$, $\square p2=0,067$) açısından grup x zaman etkileşimi anlamlı değildi.*

Sonuç: *1 dakikalik FR antrenmanının, genç erkek futbolcularda dinamik denge, çeviklik ve sürat gibi performansa bağlı fiziksel uygunluk parametrelerini etkili bir şekilde geliştirdiği görülüyor. Güç ve kondisyon antrenörleri, oyuncu gelişimini optimize etmek için bu yaklaşımı antrenman programlarına entegre etmeyi düşünmelidir.*

Anahtar Kelimeler: *Atletik Performans; Egzersiz; Futbol; Miyofasyal Gevşetme; Spor.*

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INTRODUCTION

Foam Rolling (FR) has emerged as a highly popular self-myofascial release (SMR) tool, believed to mimic the effects of myofascial release (MR).[1] It has rapidly gained popularity among both elite and recreational athletes.[2] However, despite its widespread use, there is no consensus on its physical and physiological benefits.[3] This may be attributed to the limited research investigating the underlying physiological mechanisms of FR.[4] Proposed physiological mechanisms include increased blood flow, parasympathetic nerve system activation, inflammatory responses, and the break down of trigger-points.[5] Furthermore, mechanical mechanisms encompass several sub-mechanisms, including a reduction in tissue adhesions, altered tissue stiffness, and thixotropic responses.[6] Due to these potential underlying physiological and mechanical mechanisms, FR is believed to enhance dynamic balance, agility, speed, and acute athletic performance.[7]

Dynamic balance, a parameter of performance-related physical fitness, is the ability of an individual to maintain stability of the center of mass during movement. Dynamic balance tests are valuable in detecting potential lower-limb asymmetries, which can increase the risk of injury, particularly in team sports like soccer, where unilateral movements are frequent.[8] Agility, another parameter of performance-related physical fitness, is the capacity to change directions quickly and involves perceptual and decision-making factors.[9] In field sports such as soccer, agility is a crucial performance determinant and plays a role in sports injuries.[10] Lastly, speed is another performance-related physical fitness parameter, similar to dynamic balance and agility. Furthermore, speeding is the most frequent action preceding goals, both for scoring and assisting players in soccer.[11]

Current literature investigating the acute effects of FR on health- or performance-related physical fitness parameters is still emerging.[12] However, FR protocols used throughout the literature are quite diverse with no clear consensus regarding the most efficacious duration.[13] Previous studies have reported similar conclusions that further studies are needed to determine the optimal FR duration.[14,15] It appears that the acute effects of FR periods of 1 to 3 minutes on health- or performance-related physical fitness parameters are generally tested in the current literature.[14,15] Therefore, the present study aimed to compare the acute effects of different FR durations [FR (1 min), FR (2 min), and FR (3 min)] on dynamic balance, agility, and speed in young male soccer players. Also, we hypothesized that there would be a difference between the acute effects of different FR durations on dynamic balance, agility, and speed in young male soccer players.

METHODS

Experimental approach to the problem

An experimental randomized crossover design was conducted to compare the acute effects of different FR durations on dynamic balance, agility, and speed in young male soccer players. Before the experimental sessions, each player underwent a one-day of familiarization with FR intervention. Each player performed the following 3 experimental conditions in a randomized order: FR (1 min), FR (2 min), and FR (3 min) interventions. A 7-day washout period was implemented between experimental sessions. Players were instructed to avoid strenuous training and competition 24 hours prior to each experimental session. The study was conducted during the competition period.

Participants

There were 232 licensed soccer players, including all age groups, in the soccer club where the study was conducted. Due to the intense training and match schedule of other categories soccer players in the club, it was decided to conduct the study on soccer players (n=22) in the club's U-17 category. All available players in the U-17 category were selected to participate in the study. Inclusion criteria included no history of musculoskeletal injury involving the lower extremities. Players with a history of major sports injury or time-loss injury that required surgery (n=5), and those who did not volunteer (n=2) were excluded. Fifteen healthy volunteer soccer players (mean age 16.73±0.44 years, 15 males) performed 3 trials; FR (1 min), FR (2 min), and FR (3 min) on separate occasions in a randomized order with

an interval of 7 days. The priori sample size was estimated at 12 with a power of 0.80, and an effect size (ES) of 0.60.[16] The G*Power (version 3.1.9.2, Heinrich Heine University, Düsseldorf, Germany) was used for calculations. Fifteen players were enrolled to increase statistical power.

Ethical considerations

All players were informed about the details of the study protocol, the experiment procedures, and the possible risks and benefits related to the participation. Informed assent was obtained directly from the players before their participation, and informed consent was obtained from their parents. The study protocol was approved by the Izmir Katip Celebi University Non-Interventional Clinical Studies Ethics Committee (Approval number: 327). The principles of the Declaration of Helsinki were adhered to in the treatment of human research participants.

Procedure

Before participation, all players attended an informational session about the study and were familiarized with the procedures, assessment tools, and equipment by a certified physiotherapist. A computer-generated randomized table of numbers was preferred for randomization. The assessor was blinded to group allocation. The statistical analysis was performed by a professional, blinded to the study's aim. All sessions were conducted under the same physical conditions at an indoor gym at the sports club and at the same time of day (between 5:00 PM and 7:00 PM). Furthermore, all players used the same uniforms and shoes provided by the club in all sessions throughout the study. Each player performed the 3 sessions on separate occasions in a randomized order, with an interval of 7 days. All players were guided by the same certified physiotherapist for all FR sessions. During each session, all players performed 10 minutes of light jogging followed by pre-test measures in the following order: dynamic balance (3 times), agility (2 times), and speed tests (2 times). The duration between jogging and pre-test measures was approximately 5 minutes. After the pre-test measures, all players performed FR (1 min), FR (2 min), and FR (3 min) interventions. Post-test measures were performed in the same order as the pre-test measures approximately 5 minutes after the interventions (Figure 1).

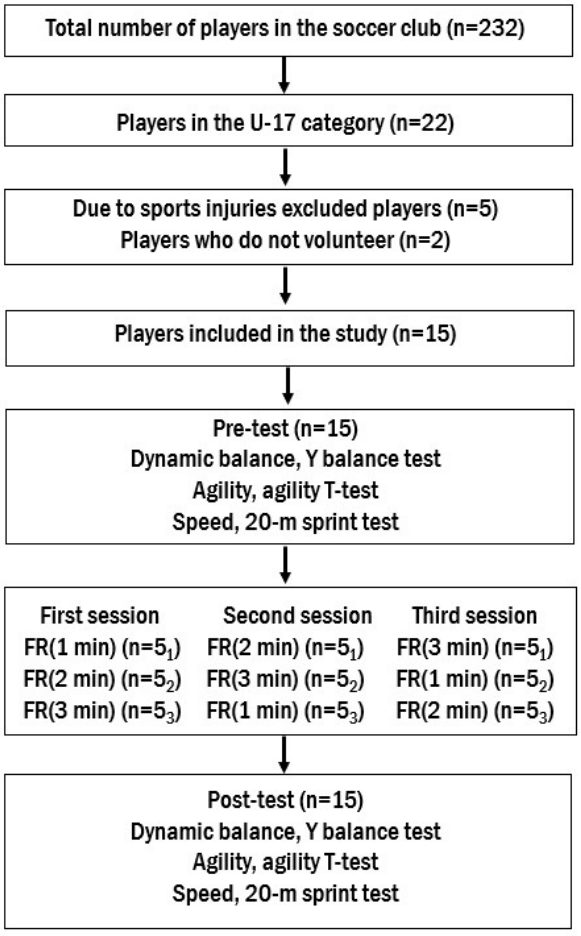

Figure 1. Flowchart of the study.

Primary outcome measure

Dynamic Balance

Dynamic balance was assessed using the Y balance test, a valid and reliable method developed as a version of the star excursion balance test.[17] During test preparation, 3 tape measures were positioned at 135° between the anterior direction and the posterolateral/posteromedial directions. Players were instructed to maintain balance on their dominant leg at the junction of the tapes while reaching as far as possible with the non-dominant leg in three directions, namely anterior, posterolateral, and posteromedial. Measurements were taken 3 times for the dominant side, and the average of the endpoints reached by the players was used for data analysis. Leg dominance was determined by

asking players, "If you were to shoot a ball at a target, which leg would you use to shoot the ball?" During reaches to different sides, the players' stable feet remained stationary, and their feet were placed completely on the junction of the tapes. Reach distances were normalized to limb length by calculating the maximized reach distance (in percentage of maximized reach distance) using the formula: (excursion distance/limb length) × 100 = percentage of maximized reach distance.[18] The composite score was calculated by summing the 3 reach directions, dividing by 3 times the limb length, and then multiplying by 100. The mean value for the Y balance composite score was used for data analysis.

Secondary outcome measures

Agility

Agility was assessed using the agility t-test, a valid and reliable method used in the assessment of agility performance.[19] For this test, an agility circuit was created using 4 cones named a, b, c, and d. Cones were also set up at a distance of 10 yards between a and b, and 5 yards between b and c, and b and d. At the "go" command, the players sprinted forward from cone a to cone b, sidestepped to cone c, sidestepped to cone d, sidestepped to cone b, then backpedal as fast as possible to cone a. The test was conducted with timing gates (SmartSpeed System, Fusion Sport, Brisbane, Australia) positioned to the right and left of a cone. The test was performed 2 times with at least 2-minute rest periods between trials. The best score of the 2 trials was used for data analysis.[20]

Speed

Speed was assessed using the 20-m sprint test, a valid and reliable method used in studies to evaluate speed.[21] During the test, at the "go" command, the players were instructed to complete the 20-meter distance as quickly as possible, and timing gates (SmartSpeed System, Fusion Sport, Brisbane, Australia) were used to determine the time to complete the test. All players performed the test 2 times with at least 2-minute rest periods between trials. The best score of the 2 trials was used for data analysis.[20]

Foam Rolling Interventions

FR was performed using a foam roller (The Grid Foam Roller, Trigger Point Technologies, Austin, TX, USA). Before the experimental sessions, all players performed a familiarization session on the correct FR technique. Players actively rolled back and forth between the origin and insertion of the target muscles, applying their body weight as much as possible for 1, 2 and 3 minutes. In all conditions, players performed foam rolling for each muscle group interspersed with 30 seconds of rest between sets. Rolling frequency was standardized using a metronome set at 60 beats per minute. Subjects were instructed to roll at a velocity of 2 metronome beats for each rolling direction. Intensity of pressure was controlled with a target rating of 7 out of 10 on a Numerical Rating Scale (0 = no discomfort and 10 = maximum discomfort) during FR interventions.[22] The target muscle groups were the bilateral anterior thigh, posterior thigh, gluteals (buttocks), and posterior calf (Figure 2).

Statistical analysis

Statistical analyses were performed using the statistical package program IBM SPSS Statistics Standard Concurrent User V 26 (IBM., Armonk, New York, USA). Descriptive data were reported as mean ± SD. The normal distribution of the data was confirmed using the Shapiro-Wilk test. Differences in all variables at the pre-test assessments between the FR (1 min), FR (2 min), and FR (3 min) interventions were determined using one-way analysis of variance (ANOVA). A two-way repeated-measures ANOVA using two factors (test time: pre-test vs. post-test) and (conditions: FR (1 min) vs. FR (2 min) vs. FR (3 min)) was used to analyze the interaction and main effects for all the variables. Classification of effect size (ES) was set where $\eta p^2 < 0.01$ was considered small, 0.02 - 0.1 was considered medium, and more than 0.1 was considered to be a large effect size.[23] If the interaction or main effect was significant, a post-hoc analysis was conducted using a paired t-test with Bonferroni correction on each group to determine differences between pre-test and post-test values. Additionally, ES was calculated ($d = M1 - M2 / \sigma pooled$) for each group. ES values in the range of 0.00-0.19 were considered trivial, and values in the ranges of 0.20-0.49, 0.50-0.79, and ≥0.80 were considered small, moderate, and large, respectively.[23] The significance level (α) was set at 0.05.

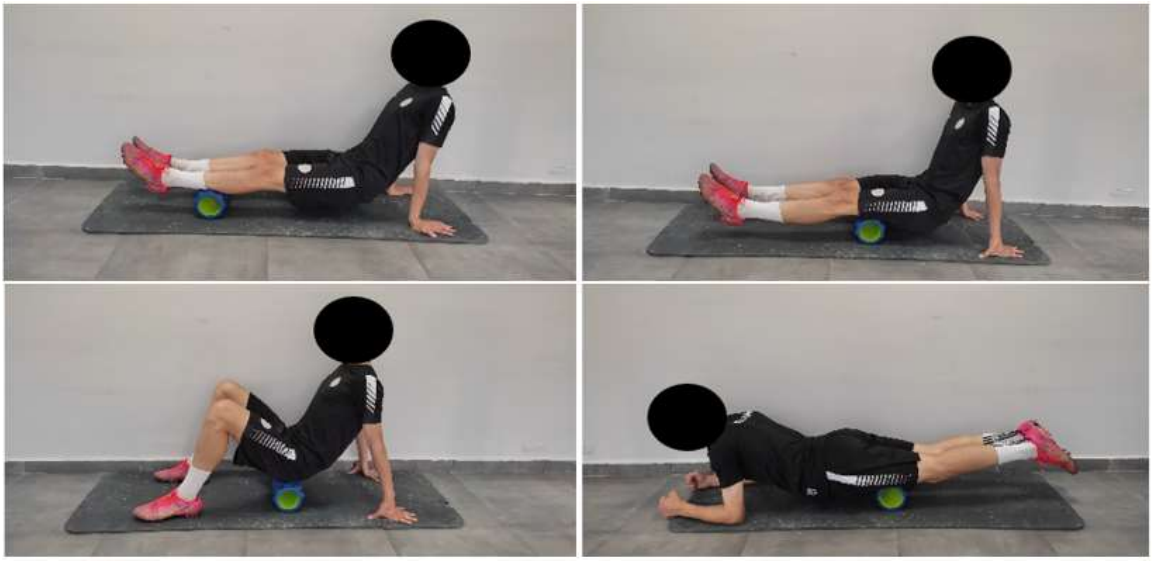

Figure 2. Foam rolling performed in the study.

RESULTS

Players' characteristics are presented in Table 1. The one-way ANOVA showed no differences in pre-test values between FR (1 min), FR (2 min), and FR (3 min) groups, presented in Table 2. There were main effects for time for dynamic balance (Time (T): $p<0.01$, $F=107.26$, $\eta p^2=0.719$), agility (T: $p<0.01$, $F=52.84$, $\eta p^2=0.557$), and speed (T: $p<0.01$, $F=31.98$, $\eta p^2=0.432$). Accordingly, dynamic balance, agility, and speed improved in all conditions [FR (1 min), FR (2 min), and FR (3 min)] (Table 2 and Figure 3).

Table 1. Players' characteristics (N=15).

	Mean±SD
Age (year)	16.73±0.44
Height (cm)	177.86±6.04
Weight (kg)	68.66±6.41
Body mass index (kg/m^2)	21.70±1.37
Soccer experience (year)	7.93±1.25

The two-way repeated-measures ANOVA indicated no significant interactions for dynamic balance (Group x Time (G×T): $p=0.87$, $F=0.14$, $\eta p^2=0.007$), agility (G×T: $p=0.72$, $F=0.32$, $\eta p^2=0.015$), and speed (G×T: $p=0.23$, $F=1.51$, $\eta p^2=0.067$). Accordingly, the improvement in dynamic balance, agility, and speed were similar in all conditions [FR (1 min), FR (2 min), and FR (3 min)] (Table 2 and Figure 3).

DISCUSSION

The present study aimed to compare the acute effects of different durations of FR on dynamic balance, agility, and speed in young male soccer players. The main findings revealed that 1, 2, and 3 minutes of FR significantly improved dynamic balance, agility, and speed. Additionally, the positive effects of different FR durations on dynamic balance, agility, and speed were similar.

Current literature investigating the effects of different FR durations on performance-related physical fitness parameters in various populations is still emerging.[24-26] One of the performance-related physical fitness parameters is dynamic balance, a key determinant of performance in sports and is associated with agility and speed.[27] Therefore, the change in dynamic balance was the primary interest of the present study. Similar results have been observed in previous studies

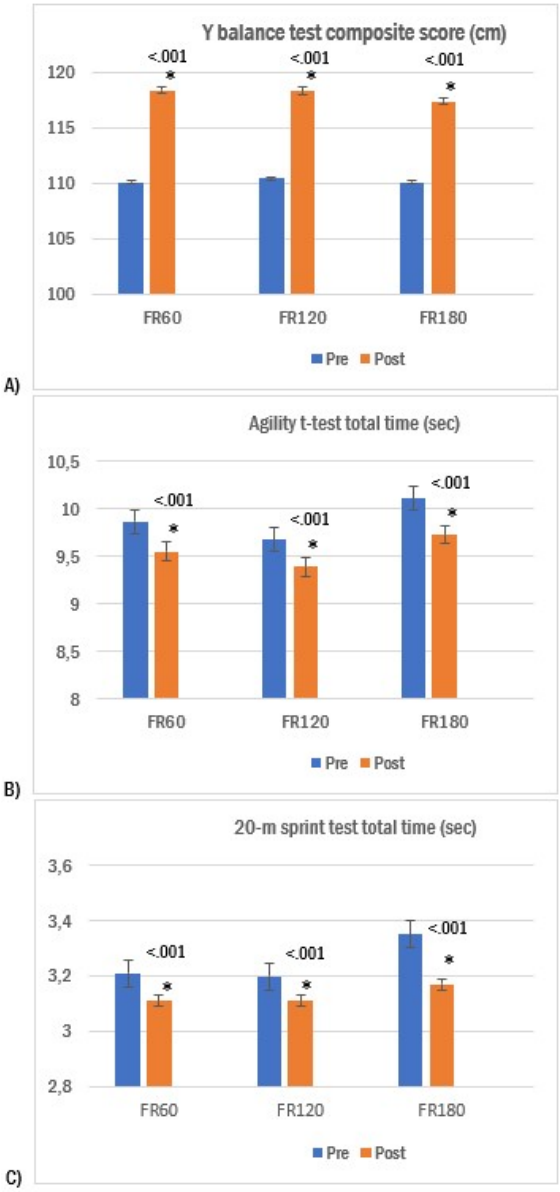

Figure 3. Comparison of (mean ± SD) Y balance test composite score (A), agility t-test total time (B), and 20-m sprint test total time (C) changes from pre-test to post-test measurements within and between the groups. "*" indicates the difference from pre-test to post-test measurements within the group.

investigating the acute effects of FR on dynamic balance. Accordingly, De Benito et al.[24] reported the positive effects of FR applied for 2 minutes on dynamic balance in healthy recreationally active participants. Lee et al.[25] found that FR applied for 90 seconds improved dynamic balance in young adults. Furthermore, Dadfar et al.[26] showed that FR applied for 3 minutes improved dynamic balance in recreationally active females. Similarly to the current literature, the results of the present study revealed the positive effects of FR on dynamic balance in young male soccer players. Moreover, according to the present study, FR applied for 1 minute is sufficient to improve dynamic balance. Considering the results of studies in the current literature, the positive effects of the FR on balance can be explained by different mechanisms, even when applied with different durations or protocols. Firstly, mechanical pressure on soft tissues during FR stimulates mechanoreceptors and increases proprioceptive input.[28] Another explanation is that FR improves the perception of stability in the knee and ankle joints.[24]

On the other hand, agility and speed were the secondary interest of the present study. Agility, like balance, is a crucial determinant of high-level performance in sports. Therefore, agility is also included in studies examining the acute effects of FR on performance determinants in sports.[29-32] Accordingly, some studies have reported that FR applied for 1 minute is effective in increasing agility on different subjects.[29-31] However, Henning et al.[32] reported that FR applied for 1 minute did not improve the agility in recreationally active subjects. Contrary to the positive effects reported in the literature, they stated that these results may be due to the different types of subjects used. Considering the results of the studies in the literature, it was seen that FR applied for at least 1 minute may be sufficient duration to increase agility. Similarly, as a result of the present study, it was concluded that the FR applied for 1 minute was sufficient to increase agility. These results can be explained by an increase in arterial blood flow and tissue perfusion.[33] In other words, these peripheral changes may have a positive effect on muscle performance. Furthermore, the improvement in dynamic balance may have positively affected agility.

Lastly, speed is also one of the parameters of performance-related physical fitness and a determinant for high-level performance in sports, like dynamic balance and agility.

Table 2. Changes in dynamic balance, agility, and speed before (Pre-test) and after (Post-test) FR (1 min), FR (2 min), and FR (3 min) interventions.

	FR (1 min) (n=15)		FR (2 min) (n=15)		FR (3 min) (n=15)	
	Pre-test Mean±SD	Post-test Mean±SD	Pre-test Mean±SD	Post-test Mean±SD	Pre-test Mean±SD	Post-test Mean±SD
Dynamic balance (cm)	110.12±11.48	118.39±12.05* *d*= 0.70	110.45±11.00	118.30±10.22* *d*= 0.73	110.09±8.49	117.39±7.78* *d*= 0.89
Agility (sec)	9.87±0.45	9.55±0.44* *d*= 0.71	9.68±0.40	9.39±0.34* *d*= 0.78	10.11±0.44	9.73±0.42* *d*= 0.88
Speed (sec)	3.21±0.24	3.11±0.20* *d*= 0.45	3.20±0.11	3.11±0.11* *d*= 0.81	3.35±0.27	3.17±0.24* *d*= 0.70
	ANOVA results p value, F value, $\square p^2$					
Dynamic balance (cm)	T: $p < 0.01$, $F = 107.26$, $\square p^2 = 0.719$, G × T: $p = 0.87$, $F = 0.14$, $\square p^2 = 0.007$					
Agility (sec)	T: $p < 0.01$, $F = 52.84$, $\square p^2 = 0.557$, G × T: $p = 0.72$, $F = 0.32$, $\square p^2 = 0.015$					
Speed (sec)	T: $p < 0.01$, $F = 31.98$, $\square p^2 = 0.432$, G × T: $p = 0.23$, $F = 1.51$, $\square p^2 = 0.067$					

* $p<0.05$, diference from the Pre-test values. FR(1 min): Foam rolling applied for 1 minute. FR(2 min): Foam rolling applied for 2 minutes. FR(3 min): Foam rolling applied for 3 minutes. ANOVA: Analysis of variance. d: Cohen's d. T: time. G: group. G x T: group x time. The two-way ANOVA results (T: time effect, G x T: group x time interaction effect; F-value) and partial $\square^2$ ($\square p^2$) are shown in right column.

However, different results are reported in previous studies examining the acute effects of FR on speed in the literature. Accordingly, Kaya et al.[34] reported that FR applied for 45 seconds improved speed in male soccer players. Conversely, Lopez-Samanes et al.[29] showed that FR applied for 1 minute did not improve speed in elite tennis players. Similarly, Pelana et al.[31] reported that FR applied for 1 minute did not improve speed in elite futsal players. Also, Klich et al.[35] found that FR applied for 90 seconds improved speed in academic athletes. The reason for the differences in the results of the studies may be the application of different protocols and the preference of different populations. As a result of the present study, it was concluded that the FR applied for 1 minute was sufficient to increase speed, like dynamic balance and agility. These results can be explained by similar mechanisms described above. Other possible mechanisms are that FR reduces myofascial and arterial stiffness, increases vascular endothelial functions, and changes the viscoelastic and thixotropic properties of fascia.[36] Additionally, the improvement in dynamic balance may have positively affected speed as well as agility. Interestingly, in the present study, it was observed that applying the FR method for a longer period did not provide additional benefits to dynamic balance, agility, and speed. This result can be explained by the fatigue due to possible insufficient strength and endurance of the upper extremity and core region muscles that occurs during long-term FR in players and the reflection of this fatigue on performance.

Limitations

The present study had some limitations. The present study did not include a control group. Therefore, the lack of comparative analysis of the results obtained with the control group is an important limitation of the study. The present study was conducted on young male soccer players. Performance-related physical fitness parameters may worsen with age due to adverse physiological changes. This may affect the results obtained from the studies. Therefore, these results cannot be generalized to all age groups of soccer players. Although the intensity of pressure is controlled by the Numerical Rating Scale, pressure exerted during FR interventions may vary due to differences in the player's body weight. This difference may have affected the effect of FR and the results obtained. Similarly, possible differences in the pain threshold of players may have prevented the standardization of the application dose of FR.

Conclusion

FR training for 1 minute appears to effectively enhance dynamic balance, agility, and speed in young male soccer players. Strength and conditioning coaches should consider integrating this approach into their training programs for optimizing player development.

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Authors' Contributions: **ES:** Concept/Idea Development, Study Design, Data Collection/Processing, Data Analysis/Interpretation, Literature Search, Provision of Facts, Provision of Facilities/Equipment, Writing; **SGU:** Concept/Idea Development, Study Design, Literature Search, Provision of Case, Provision of Facilities/Equipment, Critical Review; **DÖK:** Concept/Idea Development, Study Design, Literature Search, Provision of Case, Provision of Facilities/Equipment, Critical Review.

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ORIGINAL ARTICLE

Comparison of the effects of massage gun and foam roller applications on jump performance in female basketball players

Kadın basketbolcularda masaj tabancası ve foam roller uygulamalarının sıçrama performansına etkilerinin karşılaştırılması

Mironshokhbek URİNOV[1], Veysel ULUDAĞ[2], Fatma ÜNVER[1]

Abstract

Purpose: The purpose of this study is to compare the effects of massage gun (MG) and foam roller (FR) applications on vertical and horizontal jump performance in female basketball players.

Methods: This study included 15 female basketball players with an average age of 18. Participants completed a demographic information form in the first week, followed by measurements of vertical and horizontal jump distances after a 5-minute warm-up. In the second week, FR application was performed and final test measurements were taken. In the third week, MG application was conducted and final test measurements were repeated. Each application was followed by a 48-hour rest period to minimize residual effects. Measurements were scheduled to align with participants' regular training routines and were taken at the same time of day.

Results: Both MG and FR applications significantly increased vertical and horizontal jump distances compared to baseline measurements (FR: p=0.028 for horizontal, p=0.001 for vertical; MG: p=0.004 for horizontal, p=0.002 for vertical). The MG application appeared to be more effective in improving jump performance compared to the FR application.

Conclusion: Massage gun and foam roller applications are effective methods for enhancing jump performance in female basketball players. However, the MG application appears to provide superior results. MG application may be preferred in training and rehabilitation processes, but further studies are needed to confirm its efficacy.

Keywords: Basketball, Foam roller, Jump, Massage gun.

Öz

Amaç: *Bu çalışmanın amacı, kadın basketbolcularda masaj tabancası (MT) ve foam roller (FR) uygulamalarının dikey ve yatay sıçrama performansına etkilerini karşılaştırmaktı.*

Yöntem: *Çalışmaya yaş ortalaması 18 olan 15 kadın basketbolcu katıldı. Katılımcılara, ilk hafta demografik bilgi formu doldurtuldu ve 5 dakikalık ısınma sonrası dikey ve yatay sıçrama değerleri ölçüldü. İkinci hafta FR uygulaması yapıldı ve son test ölçümleri alındı. Üçüncü hafta ise MT uygulaması gerçekleştirildi ve son test ölçümleri tekrar edildi. Her uygulama arasında, uygulamanın etkilerinin kaybolmasını önlemek için 48 saatlik bir ara verildi. Ölçümler, katılımcıların düzenli antrenman programıyla uyumlu şekilde ve günün aynı saatinde gerçekleştirildi.*

Bulgular: *Hem MT hem de FR uygulamaları, başlangıç ölçümleri ile karşılaştırıldığında dikey ve yatay sıçrama mesafelerinde anlamlı artış sağladı (FR: yatay için p=0,028, dikey için p=0,001; MT: yatay için p=0,004, dikey için p=0,002). MT uygulamasının, FR uygulamasına kıyasla sıçrama performansını iyileştirmede daha etkili olduğu görüldü.*

Sonuç: *Masaj tabancası ve foam roller uygulamaları, kadın basketbolcularda sıçrama performansını artırmada etkili yöntemlerdir. Ancak MT uygulamasının daha üstün olduğu görülmektedir. MT uygulaması, antrenman ve rehabilitasyon süreçlerinde tercih edilebilir ancak etkinliğini doğrulamak için daha fazla çalışmaya ihtiyaç vardır.*

Anahtar kelimeler: *Basketbol, Foam roller, Sıçrama, Masaj tabancası.*

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INTRODUCTION

Vertical and horizontal jumping are critical components of success in power sports such as soccer, volleyball, and basketball. Among these, basketball heavily relies on explosive movements like jumping for scoring, rebounding, and defensive actions. The vertical jump test is a widely used, simple, and reliable method for assessing power output in athletic populations. Accurate evaluation of jump performance is essential for tailoring training and rehabilitation protocols in athletes.[1, 2]

Massage gun (MG) and foam rolling (FR) are two commonly used methods in athletic training and rehabilitation routines, aimed at enhancing power output and improving performance. Fascia, a major component of connective tissue, plays a pivotal role in muscle function. Stress, tension, or trauma-induced imbalances in fascial tissue can lead to reduced joint range of motion, muscle pain, and neuromuscular hypertonicity. When fascia loses its gel-like properties and becomes stiff, it negatively impacts movement and performance.[3,4]

Foam rollers provide a self-myofascial release technique that enhances recovery, flexibility, and performance by applying pressure to soft tissues and fascia. This method is widely used due to its simplicity and cost-effectiveness. Similarly, massage gun devices utilize percussive therapy, combining vibration and mechanical stimulation to alleviate muscle stiffness, improve blood flow, and enhance range of motion. However, despite the growing popularity of MG in sports applications, its effects on performance remain underexplored.[5,6]

Although both FR and MG are known to positively affect flexibility and recovery, there is a lack of comparative studies investigating their specific impacts on vertical and horizontal jump performance. Understanding the differences between these methods can provide athletes, coaches, and clinicians with evidence-based recommendations for optimizing performance outcomes.[7-10]

The purpose of this study is to compare the acute effects of 2-minute massage gun and foam roller applications on the hip, upper leg, and lower leg muscles in junior female basketball players. By focusing on functional anaerobic power output, this research aims to identify the more effective method for enhancing athletic performance, thereby contributing valuable insights to the existing literature.

METHODS

Participants

This study was conducted in accordance with ethical guidelines and approved by the Non-Invasive Clinical Research Ethics Committee of Pamukkale University (approval date: 17.08.2021, number: 15). Informed consent was obtained from all participants prior to the study.

The study included 15 junior female basketball players from a professional team in Turkey, with a mean age of 18 years. Inclusion criteria included being 18 years old, actively participating in competitive basketball, and having no medical conditions affecting performance. Exclusion criteria were a history of musculoskeletal injuries, lower extremity surgeries, or any condition that could interfere with participation in the study within the last 3 months.

Procedures

The study spanned three weeks, during which participants underwent vertical and horizontal jump performance tests under different conditions. Before each testing session, participants completed a 5-minute standardized warm-up routine consisting of dynamic stretching exercises.

In the first week, baseline measurements of jump performance were taken following the warm-up. In the second week, the FR intervention was applied to targeted muscle groups, followed by post-intervention performance measurements. In the third week, the MG intervention was applied, and performance measurements were repeated. To minimize residual effects and ensure recovery, a 48-hour interval was maintained between each application. All measurements were conducted at the same time of day (between 11:00 am and 2:00 pm) and aligned with participants' regular training schedules. Height and body weight measurements were among the data collection methods. Height was measured with a Seca 700 device with a precision of ± 0.1 cm, with participants standing barefoot, feet together,

and their heads, backs, and heels touching the measuring instrument. Body weight was measured with a Seca 700 scale with a precision of ±0.1 kg, while participants wore shorts and t-shirts and were barefoot.

Interventions

Foam Roller (FR): A medium-density EVA foam roller (33 cm x 14 cm) was used. The FR intervention targeted the gluteal muscles, hamstrings, quadriceps, tibialis anterior, and gastro-soleus muscle complex. Participants performed rolling motions by transferring their body weight onto the foam roller for 120 seconds per muscle group. Rolling was conducted bilaterally, with each direction lasting approximately 4 seconds. Examples of foam roller application are given in Figure 1.

Massage Gun (MG): The MG intervention was performed using a Theragun Pro massage gun with a large round head attachment. The application targeted the same muscle groups as the FR intervention and utilized a frequency of 40 Hz. Each muscle group was treated for 120 seconds bilaterally. The MG intervention was performed by a trained physiotherapist to ensure standardization.[10]

Outcome Measures

Vertical Jump Performance: Vertical jump height was assessed using the My Jump mobile application, a validated tool for measuring jump height in athletic populations. Participants performed the test with hands on hips to isolate lower body power. The test was repeated three times with a 1-minute rest between attempts, and the highest value was recorded.[11]

Horizontal Jump Performance: Horizontal jump distance was measured using a tape measure. Participants were instructed to jump forward with both feet, maintaining balance upon landing. The distance between the starting line and the heel closest to the starting line was measured. The test was repeated three times, and the best value was recorded.[11]

Visuals of the vertical and horizontal jumping application are given in Figure 2.

Statistical analysis

Data were analyzed using the SPSS 25.0 software package. Continuous variables were presented as mean ± standard deviation, and categorical variables were presented as numbers. When parametric test assumptions were met, the significance of the difference between two means was tested with the Independent Samples T-Test; when parametric test assumptions were not met, the Mann-Whitney U test was used to compare differences between independent groups. For dependent group comparisons, the Paired Samples T-Test was used when parametric test assumptions were met, and the Wilcoxon Test was used when parametric test assumptions were not met.

Figure 1. Examples of the application of foam rollers.

Figure 2. Jump performance (A: Vertical jump, B: Horizontal jump).

RESULTS

The demographic characteristics of the participants are shown in Table 1. When the horizontal jump distances of the participants before and after the FR application were compared, a significant increase was observed ($p<0.05$) (Table 2). When the vertical jump distances of the participants before and after the FR and MT applications were compared, a significant increase was observed ($p<0.05$) (Table 2).

Table 1. Demographic characteristics of participants (N=15).

	Mean± SD
Height (cm)	178.86±6.37
Weight (kg)	71.13±8.14
Body mass index (kg/m^2)	22.17±1.49
Age	18±0

DISCUSSION

In this study, the effects of MG and foam FR applications on vertical and horizontal jump performance in female basketball players were compared. The results show that both MG and FR applications significantly increased jump distances compared to baseline measurements. However, MG application was found to be more effective than FR application in improving jump performance.

Although studies examining the individual effects of MG and FR are available, direct comparisons of their effects on jump performance are scarce. This study contributes to the literature by addressing this gap and providing comparative data on these two methods.[12,13]

Coaches and athletes often use warm-up techniques before competitions or physical activities to optimize performance. While traditional warm-up methods consist of submaximal aerobic exercises or static stretches, dynamic warm-up techniques are more effective in increasing range of motion and preparing the muscles for sport-specific movements. In this study, a standardized 5-minute warm-up consisting of dynamic stretching exercises was applied before each intervention. This protocol likely contributed to the observed improvements in jump performance by optimizing muscle flexibility and activation, as supported by previous research.[14-16]

MGs represent a relatively novel technology in sports applications, with limited evidence available on their effects on athletic performance. Previous studies have demonstrated that MG can increase local blood flow, modulate pain, and improve myofascial mobility. Similarly, our findings suggest that MG enhances performance by more effectively preparing the muscles and tissues, possibly through mechanical percussion and reduced passive stiffness of tendons. The significant improvement in jump performance observed in this study aligns with these proposed mechanisms, adding valuable insights to the growing body of evidence supporting MG's efficacy.[17-19]

FR, on the other hand, is a well-established method with extensive evidence supporting its role in enhancing flexibility, recovery, and athletic performance. Studies have shown that FR application improves hamstring flexibility, increases jump height, and enhances performance when combined with dynamic warm-up exercises. While our findings confirm the effectiveness of FR in improving jump performance, they also suggest that MG may provide superior results within a shorter timeframe, making it a more efficient option in certain scenarios.[20,21]

It is important to note that the improvements observed in this study are based on acute interventions. Future studies should investigate the long-term effects of repeated MG and FR applications on various performance parameters to better understand their potential in training and rehabilitation processes.

The interaction between participants' regular training schedules and intervention effects warrants consideration. Although 48-hour intervals were maintained between interventions to minimize residual effects, the potential overlap with training-induced adaptations may have influenced the outcomes. Future studies should control for such variables to isolate the effects of MG and FR more effectively.

This study has several limitations that should be considered when interpreting the results. First, the sample size was relatively small, with only 15 participants, and no power analysis was conducted to determine the optimal sample size. The limited availability of eligible participants from a single professional basketball team constrained the sample size. Second, the menstrual cycle phases of the participants were not recorded, which could have influenced the results due to hormonal fluctuations affecting performance. Future studies should control for this factor to ensure

Table 2. Comparison of horizontal jump and vertical jump distances before and after foam rolling (FR) and massage gun (MG) applications.

	Baseline	After	
	Mean± SD	Mean± SD	p
Horizontal Jump Distances			
Foam rolling (FR)	209.38±10.09	211.23±9.96	<0.001
Massage gun (MG)	209.38±10.09	213.43±9.81	<0.001
Vertical Jump Distances			
Foam rolling (FR)	32.91±3.47	33.96±3.51	<0.001
Massage gun (MG)	32.91±3.47	35.32±4.14	<0.001

more reliable outcomes. Third, the study focused exclusively on female basketball players, limiting the generalizability of the findings to other athletic populations or male athletes. Fourth, only vertical and horizontal jump performance parameters were assessed. Other performance metrics such as agility, speed, or strength were not evaluated, which could provide a more comprehensive understanding of the interventions' effects. Lastly, the interventions were assessed for their acute effects. The long-term impacts of repeated MG and FR applications remain unclear and warrant further investigation. Future research should explore these methods over extended periods and in more diverse populations to better understand their broader applications in training and rehabilitation.

Conclusion

In conclusion, while both MG and FR applications are effective in enhancing jump performance, MG demonstrates a potential advantage by delivering more pronounced improvements within a shorter timeframe. These findings provide valuable guidance for coaches and physiotherapists in selecting appropriate methods for training and rehabilitation.

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ORIGINAL ARTICLE

Fizyoterapi ve rehabilitasyon bölümü öğrencilerinin teknostres seviyeleri ile bilgi, medya ve teknoloji becerilerinin incelenmesi

Investigation of technostress levels, information, media, and technology skills among physiotherapy and rehabilitation students

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Öz

Amaç: Bu çalışma, Hacettepe Üniversitesi, Fizyoterapi ve Rehabilitasyon Bölümü öğrencilerinde teknostres düzeyleri ile bilgi, medya ve teknoloji becerilerini incelemek amacıyla yapıldı.

Yöntem: Tanımlayıcı ve kesitsel tasarıma sahip araştırmaya Hacettepe Üniversitesi Fizyoterapi ve Rehabilitasyon Bölümü'nde öğrenim gören 231 öğrenci (yaş=20.52±2.08 yıl) katıldı. Veriler çevrim içi anket formu ile toplanmış, teknostres düzeyi Üniversite Öğrencilerinin Teknoloji Destekli Öğrenme Ortamında Teknostres Düzeyleri Ölçeği ve dijital yeterlilik Bilgi, Medya ve Teknoloji Becerileri Yeterlilik Ölçeği kullanılarak değerlendirildi.

Bulgular: Katılımcıların %80.5'i kadın, %19.5'i erkektir. Ortalama teknostres puanı 32.1±10 ve dijital yeterlilik puanı 73.8±12.6 bulundu. Teknostres ile dijital yeterlilik arasında zayıf ve negatif yönde anlamlı ilişki saptandı (r=− 0.273, p<0.001). Alt boyut analizlerinde, problem çözme, dijital içerik geliştirme, bilgi-veri okuryazarlığı, güvenlik ve iletişim-iş birliği becerileri ile teknostres arasında benzer biçimde zayıf düzeyde negatif ilişkiler gözlendi.

Sonuç: Fizyoterapi öğrencilerinin dijital yeterlilik düzeyi arttıkça teknostres düzeyi azalmaktadır. Dijital yeterliliği artırmaya yönelik eğitim müdahalelerinin, öğrencilerin teknoloji destekli öğrenme ortamlarına uyumunu kolaylaştırarak teknostresi azaltabileceği düşünülmektedir.

Anahtar kelimeler: Dijital teknoloji, Profesyonel yetkinlik, Fizyolojik stres, Fizyoterapist.

Abstract

Purpose: *This study aimed to examine the relationship between technostress levels and information, media, and technology (IMT) skills among students of the Department of Physiotherapy and Rehabilitation at Hacettepe University.*

Methods: *A descriptive and cross-sectional design was employed. The study included 231 students (mean age=20.5±2.1 years) enrolled in the Department of Physiotherapy and Rehabilitation. Data were collected online using self-administered questionnaires. Technostress levels were assessed with the Technostress Scale for Technology-Enhanced Learning Environments, and digital competence was evaluated using the Information, Media, and Technology Skills Competency Scale.*

Results: *Of the participants, 80.5% were female and 19.5% were male. The mean technostress score was 32.1±10, and the mean IMT skills score was 73.8±12.6. A weak negative correlation was found between technostress and IMT skills (r=− 0.273, p<0.001). Subscale analyses revealed similarly weak negative relationships between technostress and problem-solving, digital content creation, information and data literacy, security, and communication-collaboration skills.*

Conclusion: *Higher digital competence levels were associated with lower technostress among physiotherapy students. Implementing educational interventions that enhance digital skills may reduce technostress and facilitate students' adaptation to technology-enhanced learning environments.*

Keywords: *Digital technology, Professional competence, Physiological stress, Physiotherapist.*

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GİRİŞ

Dijital dönüşüm süreci, yükseköğretimde öğrenme ve öğretme biçimlerini köklü biçimde değiştirmiştir. Özellikle sağlık bilimleri alanında, çevrim içi öğrenme ortamları, simülasyon temelli uygulamalar ve dijital değerlendirme sistemleri, öğrencilerin eğitim deneyimini yeniden şekillendirmiştir.[1,2] Fizyoterapi eğitimi, doğası gereği teknolojiyle yakından ilişkili olup; üç boyutlu hareket analiz sistemleri, giyilebilir sensörler ve sanal rehabilitasyon platformları gibi dijital araçların yoğun biçimde kullanıldığı bir alandır.[3] Ancak dijitalleşmenin bu hızla artması, öğrenciler açısından yeni stres faktörlerini de beraberinde getirmiştir. Bu bağlamda, bilgi ve iletişim teknolojilerinin zorunlu veya yoğun kullanımı sonucu ortaya çıkan psikolojik ve bilişsel stres türü olarak tanımlanan teknostres, eğitim ortamlarında giderek daha önemli bir araştırma konusu haline gelmiştir.[4]

Teknostres, bireylerin teknolojiyle etkileşimi sırasında yaşadığı stres tepkilerini kapsayan çok boyutlu bir yapıdır.[4] Kavram; aşırı bilgi yükü (*techno-overload*), sistem karmaşıklığı (*techno-complexity*), yetersizlik ve beceri kaygısı (*techno-insecurity*), teknolojik değişimin hızı nedeniyle belirsizlik (*techno-uncertainty*) ve özel zamana müdahale (*techno-invasion*) gibi alt boyutlardan oluşmaktadır.[5,6] Üniversite öğrencilerinde bu stres kaynaklarının varlığı, öğrenme tükenmişliği, düşük öz-düzenleme, akademik üretkenlikte azalma ve bilişsel yorgunluk ile ilişkilendirilmiştir.[7] Özellikle çevrim içi veya teknoloji destekli öğrenme ortamlarında, yeterli teknik destek ve dijital beceri bulunmadığında, teknostresin öğrencilerin akademik performansını ve genel iyi oluşunu olumsuz etkileyebildiği belirtilmiştir.[8] Güncel literatür, teknostresin sadece bilişsel değil aynı zamanda duygusal sonuçlar da doğurduğunu göstermektedir. Teknostres düzeyi yüksek öğrencilerde tükenmişlik, kaygı ve düşük öz-etkililik gibi sonuçlar daha sık rapor edilmiştir.[5,6,9] Bununla birlikte, öğretim elemanı desteği, teknik kaynaklara erişim ve dijital öz-yeterlik gibi faktörlerin bu olumsuz etkileri hafifletebildiği belirtilmiştir.[8]

Teknostresin azaltılmasında önemli bir koruyucu faktör olarak dijital yeterlilik öne çıkmaktadır. Dijital yeterlilik, bireyin bilgiye erişme, dijital içeriği değerlendirme, dijital ortamlarda iletişim kurma, içerik üretme, güvenli ve etik biçimde teknoloji kullanma becerilerini kapsayan çok boyutlu bir yapıdır.[10] Sağlık profesyonelleri açısından dijital yeterlilik; e-sağlık uygulamalarını yönetme, klinik veri sistemlerini kullanma, tele-rehabilitasyon ve hasta eğitimi süreçlerinde etkin rol oynama açısından büyük önem taşımaktadır.[1,2]

Birçok araştırma, dijital yeterlilik düzeyi ile teknostres arasında ters yönlü bir ilişki bulunduğunu göstermektedir. İsviçre'de psikiyatri hastanelerinde çalışan sağlık profesyonelleri üzerinde yapılan bir çalışmada, dijital yeterliliği yüksek bireylerde teknostresin anlamlı olarak daha düşük olduğu, ayrıca teknostresin tükenmişlik ve kötü sağlık sonuçlarını yordadığı bulunmuştur.[8] Benzer şekilde, üniversite öğrencilerinde yapılan araştırmalarda dijital beceri düzeyinin artmasının, algılanan teknolojik yükü azalttığı ve öğrenme tükenmişliği riskini düşürdüğü rapor edilmiştir.[6,9] Ancak bu bulguların büyük çoğunluğu kesitsel araştırmalara dayanmaktadır ve nedensel ilişkinin yönü henüz net olarak ortaya konmamıştır.[11] Ayrıca Türkiye'de, özellikle fizyoterapi öğrencilerinde teknostres ile dijital yeterlilik arasındaki ilişkinin incelendiği bir çalışma bulunmamaktadır. Bu nedenle, dijitalleşmenin yoğun olarak yaşandığı sağlık bilimleri eğitimi bağlamında bu ilişkinin değerlendirilmesi önem arz etmektedir. Bu doğrultuda çalışmanın amacı, Hacettepe Üniversitesi Fizyoterapi ve Rehabilitasyon Bölümü öğrencilerinin teknostres düzeyleri ile bilgi, medya ve teknoloji becerileri yeterlilikleri arasındaki ilişkiyi incelemektir.

Araştırmanın hipotezi şu şekildedir: "H1: Öğrencilerin dijital yeterlilik düzeyleri arttıkça teknostres düzeyleri azalır."

YÖNTEM

Araştırmanın yeri ve zamanı

Bu araştırma, fizyoterapi ve rehabilitasyon bölümü öğrencilerin teknostres düzeyleriyle dijital yeterlikleri arasındaki ilişkiyi belirlemek amacıyla tanımlayıcı ve kesitsel nitelikte bir araştırma olarak gerçekleştirildi. Araştırma,

Hacettepe Üniversitesi Fizik Tedavi ve Rehabilitasyon Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü öğrencileri üzerinde yürütüldü. Etik kurul onayının alınmasının ardından çalışma süresi 1 Ocak – 1 Temmuz 2023 tarihleri arasındaki altı aylık dönemde tamamlandı. Katılımcılara araştırmanın amacı, kapsamı ve gizlilik ilkeleri açıklandı; dijital ortamda aydınlatılmış onam alındı.

Araştırmanın evreni ve örneklemi

Araştırmanın evrenini, Hacettepe Üniversitesi Fizyoterapi ve Rehabilitasyon Bölümü'nde öğrenim gören lisans öğrencileri oluşturuldu. İlk aşamada 200 öğrencinin araştırmaya dâhil edilmesi planlandı. Literatürde benzer bir çalışma bulunmadığından, örneklem büyüklüğü pilot uygulama verileriyle %80 güç ve %95 güven aralığı esas alınarak H1 hipotezi gözetilerek ve post-hoc olarak GPower 3.1. (Düseldorf Üniversitesi, Almanya) yazılımıyla hesaplandı. Teknostres toplam puanı ile Bilgi, Medya ve Teknoloji Yeterlilikleri Ölçeği toplam puanı arasındaki ilişkinin ($r = -0.273$) büyüklüğüne göre yapılan post-hoc güç analizi, örneklem büyüklüğü ($n = 231$) ve $\alpha = 0.05$ anlamlılık düzeyi altında çalışmanın istatistiksel gücünün %98.7 olduğunu tespit edildi. Araştırmaya; 18 yaşından büyük, aktif olarak öğrenimine devam eden, araştırmaya katılmaya gönüllü olan bireyler dahil edildi. Dahil edilme kriterlerini karşılamayan ve onam vermeyen bireyler araştırmaya dahil edilmedi.

Veri toplama süreci

Katılımcıların araştırmaya daveti için hazırlanan "Araştırmaya Davet Afişi" sosyal iletişim araçlarında (*WhatsApp*) ve duyuru panolarında paylaşılmıştır. Veriler *Google Forms* altyapısı kullanılarak toplandı.

Veri toplama araçları

Katılımcıların yaş, cinsiyet, sınıf düzeyi ve genel not ortalaması gibi akademik ve demografik veriler, araştırma için tasarlanan genel bilgi formu aracılığıyla kaydedildi. Katılımcıların teknostres düzeyi Üniversite Öğrencilerinin Teknoloji Destekli Öğrenme Ortamında Teknostres Düzeyleri Ölçeği (TDÖ) kullanılarak; dijital yeterlilikleri ise, Bilgi, Medya ve Teknoloji Becerileri Yeterlilik Ölçeği (BMTYÖ) kullanılarak değerlendirildi.

Üniversite Öğrencilerinin Teknoloji Destekli Öğrenme Ortamında Teknostres Düzeyleri Ölçeği (TDÖ)

Ölçek, Wang (2020) tarafından geliştirilmiş ve Baş vd. (2021) tarafından Türkçeye uyarlanmıştır. Toplam 13 maddeden ve iki alt boyuttan (Yetenek–Talepler Uyuşmazlığı, İhtiyaç–Tedarik Edilenler Uyuşmazlığı) oluşan ölçek, 5'li Likert tipi (1=Kesinlikle katılmıyorum, 5=Kesinlikle katılıyorum) bir derecelendirme sistemine sahiptir. Ölçekten alınan yüksek puanlar, yüksek teknostres düzeyini göstermektedir. Orijinal formun iç tutarlılık katsayısı $\alpha=0.93$, Türkçe formun ise $\alpha=0.90$ olarak bildirilmiştir.[12,13]

Bilgi, Medya ve Teknoloji Becerileri Yeterlilik Ölçeği

Hazar (2018) tarafından geliştirilen ölçek, bireylerin bilgi ve veri okuryazarlığı, dijital iletişim, içerik oluşturma, güvenlik ve problem çözme becerilerini değerlendirmektedir. Ölçek 23 maddeden oluşmakta ve 5'li Likert tipi (1=Hiçbir zaman, 5=Her zaman) ölçeklendirme kullanmaktadır. Toplam puan aralığı 23–115'tir. Ortalama puanlara göre yeterlik düzeyleri 1.00–1.80 arası zayıf, 1.81–2.60 yetersiz, 2.61–3.40 orta, 3.41–4.20 yeterli ve 4.21–5.00 çok yeterli olarak derecelendirilmiştir.[14]

İstatistiksel analiz

Tüm veriler, *IBM SPSS Statistics for Mac, Version 27.0* (IBM Corp., Armonk, ABD) yazılımı kullanılarak analiz edildi. Normallik dağılımı Kolmogorov–Smirnov testi, çarpıklık ve basıklık değerleri, varyasyon kat sayısı ve histogram grafikleri incelendi. Parametrik değişkenler ortalama ± standart sapma, non-parametrik değişkenler medyan (Q1–Q3) olarak özetlendi. Değişkenler arası ilişkiler normal dağılım sağlandığında Pearson, sağlanmadığında Spearman korelasyon testi ile analiz edildi. Bütün testlerde istatistiksel anlamlılık düzeyi $p<0.05$ olarak kabul edildi. Korelasyon katsayısı yorumlanırken; 0-0.1 ihmal edilebilir, 0.1-0.39 zayıf, 0.4-0.69 orta, 0.7-0.89 kuvvetli ve 0.9-1 çok kuvvetli ilişki olarak kabul edildi.[15]

BULGULAR

Çalışmaya toplam 231 fizyoterapi öğrencisi katıldı. Katılımcıların %80.5'i kadın (n= 186) ve %19.5'i erkekti (n=45). Sınıf düzeyine göre dağılım 1. sınıf %25.1 (n=58), 2. sınıf %25.5 (n=59), 3. sınıf %25.1 (n=58) ve 4. sınıf %24.2

(n=56) şeklinde bulundu. Katılımcıların yaş ortalaması 20.5±2.1 yıl, medyan değeri 20 (IQR=19–21) olarak saptandı. Genel akademik not ortalaması (GANO) 3.0±0.4 olarak belirlendi. İhtiyaç–tedarik edilenler uyuşmazlığı 17.8±5.8, yetenek–talepler uyuşmazlığı 14.2±4.8 ve teknostres toplam puanı 32.1±10.0 olarak tespit edildi. Dijital yeterlilik alt boyutlarının ortalamaları sırasıyla; iletişim ve iş birliği 19.7±3.6, programlama 6.4±2.9, problem çözme 9.7±4.1, dijital içerik geliştirme 12.3±2.9, bilgi ve veri okuryazarlığı 15.8±3.4 ve güvenlik 9.9±3.2 olarak bulundu. Bilgi, Medya ve Teknoloji Yeterlilik Ölçeği toplam puanı 73.8±12.6 olarak saptandı (Tablo 1).

Analiz sonucunda, ihtiyaç–tedarik edilenler uyuşmazlığı ile yetenek–talepler uyuşmazlığı arasında pozitif yönlü ve kuvvetli bir ilişki tespit edildi (r=0.721, p<0.001). Teknostres toplam puanı, ihtiyaç–tedarik edilenler uyuşmazlığı (r=0.944, p<0.001) ve yetenek–talepler uyuşmazlığı (r=0.901, p<0.001) ile pozitif yönlü ve çok kuvvetli ilişki tespit edildi.

İhtiyaç–tedarik edilenler uyuşmazlığı ile dijital yeterlilik alt boyutları arasındaki ilişkiler incelendiğinde; problem çözme ile zayıf ve negatif (r=−0.204, p=0.003), dijital içerik geliştirme ile zayıf ve negatif (r=−0.263, p<0.001), bilgi ve veri okuryazarlığı ile zayıf ve negatif (r=−0.151, p=0.026) ve iletişim ve iş birliği ile zayıf ve negatif (r=−0.142, p=0.040) ilişkiler tespit edildi.

Yetenek–talepler uyuşmazlığı ile dijital yeterlilik alt boyutları arasında zayıf düzeyde negatif yönlü ilişkiler saptandı. Dijital içerik geliştirme ile zayıf ve negatif (r=−0.243, p<0.001), dijital güvenlik ile zayıf ve negatif (r=−0.170, p=0.009) ve iletişim ve iş birliği ile zayıf ve negatif (r=−0.162, p=0.014) ilişkiler bulundu. Problem çözme (r=−0.141, p=0.035) ve bilgi ve veri okuryazarlığı (r=−0.131, p=0.044) ile ilişkiler de zayıf ve negatif olarak tespit edildi.

Teknostres toplam puanı ile dijital yeterlilik alt boyutları arasındaki ilişkiler incelendiğinde; problem çözme ile zayıf ve negatif (r=−0.173, p=0.009), dijital içerik geliştirme ile zayıf ve negatif (r=−0.264, p<0.001), bilgi ve veri okuryazarlığı ile zayıf ve negatif (r=−0.155, p=0.022), dijital güvenlik ile zayıf ve negatif (r=−0.165, p=0.017) ve iletişim ve iş birliği ile zayıf ve negatif (r=−0.154, p=0.018) ilişkiler tespit edildi.

Teknostres toplam puanı ile Bilgi, Medya ve Teknoloji Yeterlilik Ölçeği toplam puanı arasında zayıf ve negatif bir ilişki tespit edildi (r=−0.273, p<0.001). Ayrıca dijital yeterlilik alt boyutları arasında pozitif yönlü ve çoğunlukla orta düzeyde ilişkiler saptandı. Problem çözme ile dijital içerik geliştirme arasında orta düzeyde (r=0.301, p<0.001) ve dijital içerik geliştirme ile bilgi ve veri okuryazarlığı arasında orta düzeyde (r=0.484, p<0.001) pozitif ilişkiler bulundu. Dijital güvenlik ile diğer alt boyutlar arasında da benzer şekilde orta düzeyde pozitif ilişkiler tespit edildi (Tablo 2).

TARTIŞMA

Bu çalışmada, fizyoterapi öğrencilerinde teknostres düzeyleri ile dijital yeterlilik arasındaki ilişki incelendi. Çalışmanın bulguları, dijital yeterlilik düzeyi yüksek olan öğrencilerin teknoloji kaynaklı stresle daha etkin başa çıkabildiklerini göstermesi açısından literatürdeki benzer çalışmalarla uyumludur.[8,11] Sağlık bilimleri eğitiminde dijitalleşmenin hızla arttığı günümüzde, öğrencilerin teknolojik araçlara adaptasyonunu kolaylaştıran faktörlerin belirlenmesi, hem eğitim kalitesinin artırılması hem de öğrenci refahının korunması açısından kritik önem taşımaktadır.[16,17] Bu bağlamda, fizyoterapi öğrencilerinin teknostres ve dijital yeterlilik profillerinin ortaya konması, müfredat planlaması ve destek mekanizmalarının geliştirilmesi için değerli veriler sunmaktadır.

Çalışmada elde edilen teknostres toplam puanı orta düzeyde teknostres varlığına işaret etmektedir. Bu bulgu, Türkiye'de fizyoterapi ve rehabilitasyon öğrencileriyle yürütülen önceki çalışmalarda bildirilen orta düzey teknostres skorlarıyla benzerlik göstermektedir.[18] Seçer ve Özer Kaya (2024) tarafından yapılan çalışmada, fizyoterapi öğrencilerinin teknostres ölçeği medyan değeri 26.00 (IQR 18.00–29.00) olarak raporlanmış ve kadın öğrencilerde anlamlı düzeyde daha yüksek teknostres saptanmıştır.[18] Benzer şekilde, uluslararası literatürde sağlık bilimleri öğrencilerinde teknostresin aşırı teknoloji kullanımı, bilgi yükü, teknolojik karmaşıklık ve sürekli erişilebilirlik

Tablo 1. Katılımcıların demografik, akademik, teknostres ve dijital yeterliklerine ilişkin tanımlayıcı özellikleri (N=231).

	X±SD
Yaş (yıl)	20.5±2.1
Genel akademik not ortalaması (0 – 4 puan)	3.0±0.4
İhtiyaç–tedarik edilenler uyuşmazlığı alt boyut	17.8±5.8
Yetenek–talepler uyuşmazlığı alt boyut	14.2±4.8
Üniversite Öğrencilerinin Teknoloji Destekli Öğrenme Ortamında Teknostres Düzeyleri Ölçeği toplamı	32.1±10.0
İletişim ve İş birliği Becerileri	19.7±3.6
Programlama becerileri	6.4±2.9
Problem çözme becerileri	9.7±4.1
Dijital içerik geliştirme becerileri	12.3±2.9
Bilgi ve Veri Okuryazarlığı Becerileri	15.8±3.4
Güvenlik becerileri	9.9±3.2
Bilgi, Medya ve Teknoloji Becerileri Yeterlilik Ölçeği toplamı	73.8±12.6
Cinsiyet	n (%)
Erkek	45 (19)
Kadın	186 (81)
Sınıf	n (%)
1. Sınıf	58 (25)
2. Sınıf	59 (26)
3. Sınıf	58 (25)
4. Sınıf	56 (24)

Tablo 2. Katılımcıların teknostres düzeyleri ile dijital yeterlikleri arasındaki ilişkinin incelenmesi.

	1	2	3	4	5	6	7	8	9
	r	r	r	r	r	r	r	r	r
1. ITU									
2. YTU	0.72**								
3. Teknostres Toplam	0.94**	0.90**							
4. Problem Çözme	– 0.20*	– 0.14*	– 0.17**						
5. Dijital İçerik Geliştirme	– 0.26**	– 0.24**	– 0.26**	0.30**					
6. Bilgi ve Veri Okuryazarlığı	– 0.15*	– 0.13*	– 0.15*	0.12	0.48**				
7. Dijital Güvenlik	– 0.13	– 0.17*	– 0.16*	0.47**	0.38**	0.41**			
8. İletişim ve İş birliği	– 0.14*	– 0.16*	– 0.15*	0.20**	0.43**	0.40**	0.27**		
9. Programlama	– 0.10	– 0.01	– 0.05	0.39**	– 0.07	– 0.02	0.17*	– 0.04	
10. BMTYÖ Toplam	– 0.27**	– 0.26**	– 0.27**	0.71**	0.63**	0.58**	0.73**	0.60**	0.35**

*: p<0.05, **: p<0.001. r: Spearman korelasyon katsayısı. 1: İhtiyaç–Tedarik Uyumsuzluğu (ITU). 2: Yetenek–Talepler Uyumsuzluğu (YTU). 3: Teknostres Toplam Puanı, 4: Problem Çözme, 5: Dijital İçerik Geliştirme, 6: Bilgi ve Veri Okuryazarlığı, 7: Dijital Güvenlik, 8: İletişim ve İş birliği, 9: Programlama, 10: Bilgi, Medya ve Teknoloji Becerileri Yeterlilik (BMTYÖ) Toplam Puanı.

beklentileri gibi faktörlerle tetiklendiği bildirilmiştir. Urrejola-Contreras ve Herrera-Lillo tarafından gerçekleştirilen sistematik derleme, sağlık öğrencilerinde teknostresin yaygın olduğunu ve bu durumun akademik tükenmişlik, motivasyon kaybı ve öğrenme performansında düşüşle ilişkili olduğunu göstermiştir.[19] Mevcut çalışmada tespit edilen orta düzey teknostres, fizyoterapi eğitiminde artan dijital öğrenme platformları, simülasyon yazılımları ve çevrimiçi değerlendirme sistemlerinin kullanımıyla ilişkilendirilebilir. Özellikle COVID-19 pandemisi sonrası dönemde hibrit eğitim modellerinin yaygınlaşması,

öğrencilerin teknolojik araçlarla etkileşim sıklığını artırmış ve bu durum teknostres düzeylerinin yükselmesine katkıda bulunmuş olabilir.[20]

Dijital yeterlilik açısından elde edilen toplam puan öğrencilerin yüksek düzeyde dijital yetkinliğe sahip olduklarını göstermektedir. Ancak literatür, dijital yeterliliğin alt boyutlar arasında heterojen bir dağılım gösterebileceğini vurgulamaktadır. Aydınlar vd. tarafından Türkiye'de sağlık bilimleri öğrencileriyle yapılan çalışmada, öğrencilerin ağ/iletişim ve yapay zekâ alanlarında yüksek puanlar aldıkları, ancak bilgi yönetimi ve kodlama gibi alanlarda daha düşük yetkinlik gösterdikleri saptanmıştır. Ayrıca, kadın öğrencilerin bilgisayar bilgisi ve kodlama deneyiminde erkek öğrencilere kıyasla daha düşük düzeyde olduğu bildirilmiştir.[21] Roe vd., fizyoterapi öğrencilerinin dijital yetkinliklerinin Avrupa Dijital Yetkinlik Çerçevesi (DigComp) boyutlarına göre değişkenlik gösterdiğini ve bu dağılımın program planlamasında dikkate alınması gerektiğini vurgulamıştır.[22,23] Mevcut çalışmada dijital yeterlilik alt boyutları arasında pozitif ve çoğunlukla orta düzeyde ilişkiler bulunması, dijital becerilerin birbiriyle entegre bir yapı sergilediğini ve bir alandaki yetkinliğin diğer alanlardaki performansı da desteklediğini göstermektedir.

Çalışmanın temel bulgusu dijital yetkinliği yüksek öğrencilerin teknolojik zorluklarla daha etkin başa çıkabildiklerini göstermektedir. Bu bulgu, literatürdeki çeşitli çalışmalarla desteklenmektedir. Golz vd. (2021), İsviçre'de psikiyatri hastanelerinde çalışan sağlık profesyonellerinde dijital yetkinlik ile teknostres arasında anlamlı negatif ilişki ($\beta = -0.20$, $p < 0.001$) bildirmiştir.[8] Benzer şekilde, Vásquez-Pajuelo vd., yüksek öğretim kurumlarında dijital yeterliliklerin teknostres varyansının önemli bir kısmını açıkladığını ve logistik regresyon analizinde $R^2 \approx 0.622$ değeri elde edildiğini raporlamıştır.[9] Bu bulgular, dijital becerilerin teknostresin yaklaşık %62'sini açıklayabildiğini göstermektedir. Mevcut çalışmada ihtiyaç–tedarik edilenler uyuşmazlığı ve yetenek–talepler uyuşmazlığı alt boyutları ile dijital yeterlilik alt boyutları arasında zayıf düzeyde negatif ilişkiler saptanması, Person-Environment (P-E) uyum teorisi perspektifiyle açıklanabilir. Bu teoriye göre, bireylerin teknolojik yetenekleri ile çevresel talepler arasındaki uyumsuzluk teknostrese yol açmaktadır.[24] Dijital yeterliliği yüksek öğrenciler, teknolojik araçları daha etkili kullanabilmekte, sorunları daha hızlı çözebilmekte ve teknoloji destekli öğrenme ortamlarına daha kolay adapte olabilmektedir.[25] Bu durum, algılanan ihtiyaç–kaynak uyumsuzluğunu azaltarak teknostres düzeylerinin düşmesine katkıda bulunmaktadır.

Fizyoterapi eğitiminde dijital teknolojilerin kullanımı giderek artmakta; sanal gerçeklik, oyunlaştırma, hibrit öğrenme modelleri ve dijital değerlendirme araçları müfredatın ayrılmaz parçaları haline gelmektedir. Pagels vd., dijital öğrenme uygulamalarının bilgi ve beceri kazanımını desteklediğini ancak öğrenciler arasında doğrudan etkileşim eksikliği ve düşük öz-yeterlik algısının sorun oluşturduğunu bildirmiştir.[26] Bu nedenle, fizyoterapi programlarında dijital yeterlilik eğitimlerinin müfredata entegre edilmesi ve öğrencilerin teknolojik öz-yeterliklerinin desteklenmesi kritik önem taşımaktadır. Seçer ve Özer Kaya, teknostres ve yapay zeka konularının ders programlarına dahil edilmesini ve öğrencilerin etik/mesleki kaygılarının giderilmesini önermektedir.[18] Ayrıca, kurumsal düzeyde bilgisayar öz-yeterliğinin güçlendirilmesi, öğretim elemanlarına ve öğrencilere yönelik dijital eğitimler, teknik destek mekanizmaları ve dijital mola/bağlantı kesme stratejilerinin geliştirilmesinin teknostresi azaltabilecek önemli yaklaşımlar olduğu düşünülmektedir. Klinik açıdan, teknostresin tükenmişlik, iş tatmini azalması ve sağlık sorunlarıyla ilişkisi göz önüne alındığında, gelecekteki fizyoterapistlerin mesleki yaşamlarında karşılaşacakları dijital sağlık teknolojilerine hazırlanmaları için eğitim döneminde uygun destek sağlanması gerekmektedir. Elektronik hasta kayıt sistemleri, tele-rehabilitasyon platformları ve dijital değerlendirme araçları gibi teknolojilerin klinik pratikte yaygınlaşması, mezunların bu alanlarda yetkin olmasını zorunlu kılmaktadır.

Limitasyonlar

Çalışmanın bazı sınırlılıkları bulunmaktadır. İlk olarak, kesitsel tasarım nedeniyle neden-sonuç ilişkisi kurulamamaktadır; teknostres ve dijital yeterlilik arasındaki ilişkinin yönünü ve

zamansal dinamiklerini anlamak için boylamsal çalışmalara ihtiyaç vardır. İkinci olarak, örneklem %80.5 kadın ve %19.5 erkek öğrenciden oluşmakta olup cinsiyet dağılımındaki dengesizlik, cinsiyete özgü analizlerin gücünü sınırlamaktadır. Literatürde kadın öğrencilerin daha yüksek teknostres bildirdiği gösterilmiş olsa da[18,21], mevcut çalışmada bu değişkenin etkisi detaylı olarak incelenmemiştir. Üçüncü olarak, çalışma tek bir üniversiteden veri toplamış olup bulguların genellenebilirliği sınırlıdır. Farklı coğrafi bölgelerde, çeşitli kurumlarda ve değişen eğitim modellerinde (yüz yüze, hibrit, tamamen çevrimiçi) yürütülecek çok merkezli çalışmalar daha kapsamlı bir perspektif sunabilir. Dördüncü olarak, öz-bildirime dayalı ölçekler kullanılmış olup sosyal beğenilirlik eğilimi ve hatırlama yanlılığı gibi faktörler sonuçları etkilemiş olabilir. Ayrıca, teknostresi azaltmak için yapılacak müdahale çalışmalarının tasarlanması ve dijital yeterlilik eğitim programlarının etkinliğinin değerlendirilmesi önerilmektedir. Özellikle, dijital yeterlilik eğitimlerinin teknostres düzeylerini azaltmadaki rolünün randomize kontrollü çalışmalarla test edilmesi, kanıt temelli eğitim stratejilerinin geliştirilmesine katkı sağlayacaktır. Ek olarak öz-bildirim temelli ölçeklerde sık rastlanan sosyal-beğenirlik yanlılığı araştırma sonuçlarını etkilemiş olabilir. Gelecekte yapılacak araştırmalarda bu durumun giderilmesi için öz-bildirim temelli anketlere ek olarak açık uçlu sorular barındıran nitel araştırma dizaynının uygulanması tavsiye edilmektedir.

Sonuçlar

Bu çalışma fizyoterapi öğrencilerinde orta düzeyde teknostres ve yüksek düzeyde dijital yeterlilik olduğunu, iki değişken arasında ise negatif yönlü zayıf bir ilişki bulunduğunu göstermiştir. Bulgular, dijital yeterliliğin artırılmasına yönelik eğitim programlarının teknostres düzeylerini azaltabileceğini ve öğrencilerin teknoloji destekli öğrenme ortamlarına adaptasyonunu kolaylaştırabileceğini ortaya çıkarmaktadır. Bu sonuçlar, fizyoterapi eğitiminde dijital yeterlilik gelişimine yönelik sistematik yaklaşımların benimsenmesi ve kurumsal destek mekanizmalarının güçlendirilmesi gerektiğini vurgulamaktadır.

Teşekkür: *Yok*

Yazarların Katkı Beyanı: MD: Konsept/fikir gelişimi, çalışma dizaynı, proje yönetimi, veri toplama/işleme, veri analizi/yorumlama, literatür araştırması, olguların sağlanması, tesislerin/ekipmanın sağlanması, yazma, kritik gözden geçirme; **EA:** Konsept/fikir gelişimi, çalışma dizaynı, proje yönetimi, veri toplama/işleme, veri analizi/yorumlama, literatür araştırması, olguların sağlanması, tesislerin/ekipmanın sağlanması, kritik gözden geçirme; **FA:** Konsept/fikir gelişimi, çalışma dizaynı, proje yönetimi, veri toplama/işleme, veri analizi/yorumlama, literatür araştırması, olguların sağlanması, tesislerin/ekipmanın sağlanması, yazma, kritik gözden geçirme; **ÖOK:** Çalışma dizaynı, proje yönetimi, literatür araştırması, kritik gözden geçirme; **GŞU:** Çalışma dizaynı, proje yönetimi, literatür araştırması, kritik gözden geçirme; **MK:** Çalışma dizaynı, proje yönetimi, olguların sağlanması, tesislerin/ekipmanın sağlanması, kritik gözden geçirme; **SAY:** Çalışma dizaynı, proje yönetimi, olguların sağlanması, tesislerin/ekipmanın sağlanması, kritik gözden geçirme.

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ORIGINAL ARTICLE

Kahramanmaraş Depremi sonrası depremden etkilenen bireylerde deprem kaygısının depresyon, anksiyete, stres ve fiziksel aktivite düzeyleri üzerine etkilerinin incelenmesi

Investigation of the effects of earthquake anxiety on the levels of depression, anxiety, stress, and physical activity in people affected by the earthquake after the Kahramanmaras Earthquake

Tuğba GÖNEN[1], Elif DİNLER[1], Erkin Oğuz SARI[1], Yavuz YAKUT[1]

Öz

Amaç: Bu çalışmanın amacı, 6 Şubat 2023 Kahramanmaraş depremi sonrası depremden etkilenen bireylerde deprem kaygısının depresyon, anksiyete, stres ve fiziksel aktivite düzeyleri üzerine etkilerini incelemektir.
Yöntem: Depremden etkilenen 187 birey [131 (%70,05) kadın, 56 (%29,95) erkek] çalışmaya dahil edildi. Demografik bilgilerin ardından, deprem kaygısının değerlendirilmesinde "Deprem Kaygı Ölçeği", depresyon değerlendirmesinde "Beck Depresyon Ölçeği", anksiyete değerlendirmesinde "Ankiyete Duyarlılık İndeksi-3", stres değerlendirmesinde "Algılanan Stres Ölçeği" kullanıldı. Depremden etkilenen bireylerin fiziksel aktivite düzeyleri ise ''Uluslararası Fiziksel Aktivite Anketi-Kısa Formu'' ile değerlendirildi.
Bulgular: Çalışmaya 18-67 yaş aralığında (27,8±10,8 yıl) 131 kadın, 56 erkek olmak üzere toplam 187 birey katıldı. Tek değişkenli lojistik regresyon analizleri sonucunda ev tipinin (ß=0,284, p=0,048), anksiyete duyarlılığının (ß =0,368, p=0,017), oturma sürelerinin (ß=0,332, p=0,002) ve algılanan stres düzeyinin (ß=0,235, p=0,018) deprem kaygısı ile ilişkili ve anlamlı etkiye sahip olduğu bulundu.
Sonuç: Çalışmamız sonucunda anksiyete duyarlılığının, algılanan stresin, oturma sürelerinin ve yaşanılan ev tipinin deprem kaygısına etki eden esas faktörler olduğu belirlendi.
Anahtar Kelimeler: Deprem, Deprem kaygısı, Stres, Depresyon, Fiziksel aktivite.

Abstract

***Purpose**: This study aimed to examine the effects of earthquake-related anxiety on depression, anxiety, stress, and physical activity levels in individuals affected by the February 6, 2023, Kahramanmaraş Earthquake.*
***Methods:** A total of 187 earthquake-affected individuals [131 (70.05%) female and 56 (29.95%) male] participated in the study. After collecting demographic information, the Earthquake Anxiety Scale was used to assess earthquake-related anxiety, the Beck Depression Inventory to assess depression, the Anxiety Sensitivity Index-3 to measure anxiety, the Perceived Stress Scale to evaluate stress levels, and the International Physical Activity Questionnaire-Short Form to determine physical activity levels.*
***Results:** The participants included 187 individuals (131 women and 56 men) aged between 18 and 67 years (mean age: 27.8±10.8 years). Univariate logistic regression analyses revealed that house type (ß=0.284, p=0.048), anxiety sensitivity (ß=0.368, p = 0.017), sitting time (ß = 0.332, p = 0.002), and perceived stress (ß = 0.235, p = 0.018) had statistically significant effects on earthquake-related anxiety.*
***Conclusion:** This study found that anxiety sensitivity, perceived stress, duration of residence, and type of housing were the primary factors influencing earthquake-related anxiety.*
***Keywords:** Earthquakes, Earthquake anxiety, Stress, Depression, Physical activity.*

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GİRİŞ

Türkiye'de 06 Şubat 2023 tarihi saat 04:17'de Kahramanmaraş/Pazarcık merkezli 7,7 büyüklüğünde bir deprem ve ardından aynı gün saat 13:24' te Kahramanmaraş/Elbistan merkezli 7,6 şiddetinde ikinci bir deprem meydana gelmiştir. Şiddetli bu iki depremden sonra 3 ay içerisinde 33.591 artçı depremin meydana geldiği ifade edilmiştir. Söz konusu depremlerden sonra Kahramanmaraş, Gaziantep, Şanlıurfa, Diyarbakır, Adana, Adıyaman, Osmaniye, Hatay, Kilis, Malatya ve Elâzığ illerinde toplam 50,783 kişi hayatını kaybetmiş, 115.353 kişi yaralanmıştır. Yapılan hasar tespit çalışmalarında yıkık/acil yıkılacak bina sayısının 58.039 ve ağır hasarlı bina sayısının 205.534 olduğu bildirilmiştir. Bu rakamlar ile Kahramanmaraş merkezli yaşanan depremler, son yüzyılda ülkemizde meydana gelen en büyük deprem felaketini oluşturmaktadır.[1]

Depremler sebep oldukları sosyal, ekonomik, çevresel vb. zararların dışında bireysel ve toplumsal etkileri sebebiyle travmaya sebep olabilmektedir.[2] Deprem aynı zamanda yaşanan kayıplar ve kayıpların sonuçları itibariyle bireylerde korku ve kaygıya da sebep olmaktadır. Depremi doğrudan yaşayan bireylerde travma ve kaygılara dair semptomlar daha sık gözlense de, ekrandan maruz kalma dahi kaygı ve travma için risk faktörü oluşturmaktadır.[3]

Tüm Dünya'da yaşanan büyük depremlerden sonra bu travmaya maruz kalan bireylerin deprem kaygı düzeyleri, anksiyete belirtileri, depresif semptomları ve travma sonrası stres bozukluğu görülme oranlarının yüksek olduğu literatürde yer almaktadır.[4,5] Bu belirtilerin görülmesi için bireyin sadece can kaybı yaşamış olması da gerekmez, maddi kayıp yaşayan bireylerde de tüm bu semptomlarda artış gözlenmiştir.[6]

Çin'de meydana gelen Wenchuan depreminden uzun yıllar sonra depremi yaşayan bireylerin depresyon düzeyleri ve yaşam kalitelerinin analizini sundukları bir çalışma da yaşam kalitelerinin düşük olmasının sebebi depresif ve uykusuzluk belirtilerinin ön planda olduğu az enerjiye sahip olma ile ilişkilendirilmiştir. Bunun sonucunda bireylerin motivasyonlarını artırma ve sonucunda yaşam kalitelerini iyileştirme yönünde enerji azlığının giderilmesine yönelik fiziksel aktivite programlarının oluşturulması önerilmektedir.[7] Literatürde fiziksel aktivitenin depresyon, stres, anksiyete gibi bulguları azalttığı yönünde çalışmalar yer alsa da, depremden etkilenen ve deprem kaygısı yaşayan bireylerin fiziksel aktivite düzeyleri üzerine bir çalışmaya rastlanmamıştır.[8,9]

Bu çalışmanın amacı Kahramanmaraş depremi sonrası depremden etkilenen bireylerde deprem kaygısının depresyon, anksiyete, stres ve fiziksel aktivite düzeyleri üzerine etkilerini incelemektir.

YÖNTEM

Bireyler

Kesitsel çalışma olarak planlanan bu araştırma Hasan Kalyoncu Üniversitesi Sağlık Bilimleri Fakültesi Fizyoterapi ve Rehabilitasyon Bölümü'nde gerçekleştirildi. Çalışmaya başlamadan önce Hasan Kalyoncu Üniversitesi Sağlık Bilimleri Girişimsel Olmayan Araştırmalar Etik Kurulu'ndan 03.08.2023 tarihinde gerekli izin ve onay alındı (2023/72). Çalışma Helsinki Bildirgesinde tanımlanan ilkelere uygun şekilde yürütüldü. Çalışma kapsamında dahil edilme kriterlerini sağlayan bireylere çalışma hakkında detaylı bilgi verildi. Katılmayı kabul eden bireylere aydınlatılmış onam formu imzalatıldı.

Çalışmaya 6 Şubat 2023 tarihinde gerçekleşen Kahramanmaraş depremleri sırasında afet bölgesi illerinde (Kahramanmaraş, Gaziantep, Hatay, Kilis, Diyarbakır, Adana, Osmaniye, Şanlıurfa, Adıyaman, Malatya, Elazığ) bulunan, 18 yaş üstü, iletişim problemi olmayan, okuryazar ve çalışmaya katılmaya gönüllü 205 (n=136 kadın, n=69 erkek) birey dahil edildi. Psikiyatrik tanı ve fiziksel aktivite yapmaya engel olacak sağlık problemi olan bireyler çalışma dışı bırakıldı.

Çalışmanın örneklem büyüklüğünü belirlemek amacıyla G*Power 3.1.9.4 (versiyon 3.1.9.2 Universität Düsseldorf, Düsseldorf, Almanya) programı kullanıldı. Yapılan analiz sonucunda $\alpha = 0,05$ tip I hata, %80 güç oranında örneklem sayısı 168 kişi olarak belirlendi. Olası veri kaybı göz önünde bulundurularak 205 kişinin çalışmaya dahil edilmesi planlandı ($\alpha=0.05$; $1-\beta=0.80$).

Değerlendirmeler

Çalışma kapsamında deprem bölgesinde bulunan bireylere Google Form üzerinde hazırlanan veri toplama formu çevrimiçi platformlar üzerinden gönderildi (e-mail, whatsapp vb.) Bireylerin; yaş, cinsiyet, vücut kütle indeksi, medeni durumu, kronik hastalık durumu, eğitim durumu, meslek, ev tipi, kat bilgisi, evin hasar durumu, deprem esnasında bulunulan şehir, deprem kaynaklı sakatlık durumu, enkazda kalma durumu ve depremde 1. derece yakını vefat durumu sorgulanarak demografik bilgileri kaydedildi.

Bireylerin deprem kaygısının değerlendirilmesinde "Deprem Kaygı Ölçeği", depresyon değerlendirmesinde "Beck Depresyon Ölçeği", anksiyete değerlendirmesinde "Ankiyete Duyarlılık İndeksi-3", stres değerlendirmesinde "Algılanan Stres Ölçeği" ve fiziksel aktivite düzeyinin değerlendirilmesinde "Uluslararası Fiziksel Aktivite Anketi-Kısa Formu" kullanıldı.

Deprem Kaygı Ölçeği (DKÖ)

Deprem kaygısının değerlendirilmesinde Bal vd. tarafından geliştirilen (2023) deprem kaygı ölçeği kullanıldı. Ölçek 34 maddeden oluşmakta ve ölçek maddeleri içerisinde ters kodlama yapılan bir madde yer almamaktadır. Her madde kişinin şuan deprem öncesine göre durumunu sorgulamaktadır. Bireyler 5 li likert ölçümde "1-Hiç Katılmıyorum", "5-Tamamen Katılıyorum" olacak şekilde 1'den 5'e kadar verilen ifadelerden en uygun olanı seçer. Ölçekten alınacak en düşük puan 34, en yüksek puan ise 170'dir. Ölçekten alınan puan arttıkça deprem kaygısının arttığı düşünülmektedir.[10]

Beck Depresyon Ölçeği (BDÖ)

Duygusal, bilişsel, somatik ve motivasyonel bileşenleri ölçmek amacıyla Hisli tarafından 1998 yılında Türkçe geçerlik güvenirlik çalışması yapılan ölçek 21 maddeden oluşmakta ve her madde farklı bir ruh durumlarına yönelik 4'lü likert tipi ölçüm sağlamaktadır. Her madde 0 ile 3 arasında puanlanmaktadır. Elde edilen puana göre depresyon düzeyi sınıflandırılır. Ölçekten en düşük "0" en yüksek "63" puan alınabilir. Bireyin aldığı puan arttıkça depresyon eğiliminin arttığı bildirilmiştir. BDÖ puanlama sonuçlarına bakıldığında; bireyin aldığı puan 0 ile 9 arasında ise minimal, 10 ile 16 puan arasında hafif, 17 ile 29 puan arasında orta ve 30 ile 63 arasında ise şiddetli depresyon olarak tanımlanmaktadır.[11]

Anksiyete Duyarlılık İndeksi-3 (ADİ-3)

Bireylerin anksiyete duyarlılığını değerlendirmek için Anksiyete Duyarlılığı İndeksi- 3 (ADİ-3) kullanıldı. Mantar vd. tarafından 2010 yılında Türkçe geçerlilik ve güvenirliği yapılan indeks, bireyin anksiyeteye bağlı duyum ve belirtilere karşı aşırı korkusunu ölçmektedir. İndeks 18 önerme içerir ve beşli Likert tipi ölçüm sağlar. "0" çok az, "4" çok fazla anlamına gelmektedir. Birey önerme için kendisine en uygun puanı seçer. Ölçekten en düşük 0, en yüksek 72 puan alınır. Puan arttıkça anksiyete duyarlılığı artmaktadır.[12,13]

Algılanan Stres Ölçeği (ASÖ)

Bireylerin stres algısı Türkçe geçerlik ve güvenirlik çalışması 2013 yılında Eskin vd. tarafından yapılan ASÖ ile değerlendirildi. Ölçek toplam 14 maddeden oluşmaktadır. "0- Hiçbir zaman", "4- Çok Sık" anlamına gelmektedir. Ölçekte 6-7-9 ve 10 numaralı maddeler ters puanlanmaktadır. Ölçekten en düşük "0" en yüksek "40" puan alınabilmektedir. Ölçekten alınan puan arttıkça bireyin stres algısının arttığı gösterilmektedir.[14,15]

Uluslararası Fiziksel Aktivite Anketi-Kısa Form (UFAA-KF)

Bireylerin fiziksel aktivite düzeyleri UFAA-KF ile değerlendirildi. Anketin Türkçe geçerlilik ve güvenirlik çalışması 2010 yılında Sağlam vd. tarafından yapıldı. Uygulanan anket ile bireylerin bir hafta içerisinde; şiddetli-orta dereceli fiziksel aktivite ile yürüme ve günlük oturma süreleri sorgulandı. Şiddetli, orta dereceli aktivite ve yürüme süreleri aşağıdaki hesaplamalarla bazal metabolik hıza karşılık gelen MET'e (1 MET=3.5 ml/kg/dk) çevrilerek toplam fiziksel aktivite skoru (MET-dk/hafta) hesaplanır. Fiziksel aktivite düzeyi; Toplam skor 600 MET'den küçük ise, "Aktif Değil", toplam skor 600-3000 MET arasında ise "Düşük aktivite düzeyi", toplam skor 3000 MET'den daha yüksek ise 'Yeterli aktivite düzeyi' olarak belirtilir.[16]

İstatistiksel analiz

Verilerin istatistiksel analizi SPSS 25.0 (IBM SPSS Statistics 25 software (Armonk, NY: IBM Corp.)) paket programı kullanılarak yapıldı. Ölçülebilir değişkenlere ilişkin veriler ortalama±standart sapma (X±SD) ile kategorik değişkenlere ilişkin veriler sayı ve yüzde olarak verildi. Değişkenlerin normal dağılıma uygunluğu Kolmogorov-Smirnov testi ile değerlendirildi. Bağımlı değişken olan DKÖ'nin

üzerinde etkisi olduğu düşünülen bağımsız değişkenlerin (cinsiyet, ev tipi ve bulunduğu kat, medeni durum, ADI-3, UFAA, BDÖ ve ASÖ) incelenmesinde çoklu lojistik regresyon modeli kullanılarak analiz yapıldı. Bağımsız değişkenlerin etki oranı r^2 ve beta değeri ile hesaplandı. Tüm istatistiklerde anlamlılık değeri $p<0,05$ olarak kabul edildi.

BULGULAR

Çalışma için oluşturulan 205 kişilik örneklem grubundan 18 birey çalışma kapsamında hazırlanan veri toplama formunun %50'den fazlasını yanıtlamadığı için çalışmayı tamamlayamadı. Sonuç olarak çalışmaya 18-67 yaş aralığında (27,83±10,83 yıl) 131 kadın, 56 erkek olmak üzere toplam 187 birey katıldı (α = 0.05; 1 - β = 0.83). Bireylerin demografik bilgi ve klinik verileri Tablo 1' de yer almaktadır.

Tablo 1. Bireylerin demografik ve klinik verileri (N=187).

		X±SD
Yaş (yıl)		27,8±10,8
Boy (cm)		1,7±0,1
Kilo (kg)		67,3±13,4
BKİ (kg/m^2)		23,6±4,1
		n (%)
Cinsiyet	Kadın	131 (70,05)
	Erkek	56 (29,95)
Medeni durum	Evli	89 (47,6)
	Bekar	98 (52,4)
Eğitim durumu	Okur-yazar	11 (5,9)
	İlköğretim	11 (5,9)
	Lise	32 (17,2)
	Önlisans	9 (4,8)
	Lisans	121 (65,1)
	Lisansüstü	2 (1,1)
Meslek	Öğrenci	98 (52,7)
	Ev hanımı	23 (12,4)
	Öğretmen	11 (5,9)
	Diğer	55 (29,4)
Kronik hastalık	Var	16 (8,6)
	Yok	170 (91,4)

BKİ: Beden kütle indeksi.

Depremden etkilenen bireylere sorulan açık uçlu sorulara verilen yanıtlara bakıldığında; bireylerin %63,4'ü (n=118) depremi Gaziantep ilinde yaşamışken, %10,8'i (n=20) deprem esnasında Kahramanmaraş ilinde bulunmaktaydı. Bireylerin %25,8'i ise farklı deprem bölgelerinde idi. Bireylerin 139'u (%74,7) apartman dairesinde ikamet ederken, 47'si (%25,3) müstakil evde oturmaktaydı. Çalışmaya katılan bireylerin %51,6 sının evi 0 ile 3. kat arasında iken, %48,4'ü 3. kattan daha yüksek dairelerde depreme yakalandı. Deprem sonrası evlerin hasar durumu sorgulandığında 56 (%30,1) bireyin evi hasarsız iken, 100 (%53,8) kişinin evi az hasarlı, 26 (%14) kişinin orta ve ağır hasarlı olarak tespit edilirken, 4 bireyin ise evi yıkıldı. Deprem sonrası bireylerin %98,4'ü herhangi bir sakatlık durumu bildirmedi. 183 birey enkaz altında kalmadan depremden kurtulurken 4 birey 8-48 saat arası enkaz altında kalmış ve daha sonrasında sağ olarak çıkarılmıştır. Çalışmaya katılan bireylerin %6,5'inde (12 kişi) 1. derece can kaybı tespit edildi.

Bireylere uygulanan DKÖ, BDÖ, ADİ-3, ASÖ ve UFAA-KF'a ilişkin tanımlayıcı istatistikler Tablo 2' de gösterildi.

Tek değişkenli lojistik regresyon analizleri sonucunda ev tipinin (β=0,284, p=0,048), anksiyete duyarlılığının (β=0,368, p=0,017), oturma sürelerinin (β=0,332, p=0,002) ve algılanan stres düzeyinin (β=0,235, p=0,018), deprem kaygısı üzerinde ilişkili ve anlamlı etkiye sahip olduğu, medeni durum (β=-0,174, p=0,118), cinsiyet (β=-0,136, p=0,157), evin bulunduğu kat (β=-0,098, p=0,462), şiddetli fiziksel aktivite düzeyi (β=0,109, p=0,243), orta şiddette aktivite düzeyi (β=0,149, p=0,168) yürüme skoru (β=0,035, p=0,690), ve depresyon düzeyinin (β=0,067, p=0,477) deprem kaygısını etkilemediği tespit edildi (Tablo 3).

TARTIŞMA

6 Şubat 2023 Kahramanmaraş depremlerinden sonra depremden etkilenen bireylerde deprem kaygısının depresyon, anksiyete, stres ve fiziksel aktivite düzeyleri üzerine etkilerini incelemek amacıyla planladığımız bu çalışma sonucunda, deprem kaygısının anksiyete duyarlılığı, algılanan stres ve fiziksel aktivite düzeyi (oturma süresi) ile

Tablo 2. DKÖ, BDÖ, ADI-3, ASÖ, UFAA Verilerinin Tanımlayıcı İstatistikleri (N=187).

	X±SD
Deprem Kaygı Ölçeği (DKÖ)	103,1±27,4
Beck Depresyon Ölçeği (BDÖ)	18,8±10,3
Anksiyete Duyarlılık İndeksi-3 (ADI-3)	30,6±13,6
Algılanan Stres Ölçeği-10 (ASO-10)	21,5±5,7
Uluslararası Fiziksel Aktivite Anketi (UFAA)	
Şiddetli (UFAA-S)	565,1±1672,7
Orta (UFAA-O)	320,3±835,2
Yürüme (UFAA-Y)	974,2±271,1
Oturma Süresi (UFAA-OTUR)	376,5±363,1
Toplam (UFAA-TOP)	2236,1±2372,6

Tablo 3. Lojistik regresyon analizi sonuçları.

	Standardize edilmemiş katsayı		Standardize katsayı		
Bağımlı Değişken: DKÖ	B	SH	Beta	t	p
Medeni Durum	-8,962	5,661	-0,174	-1,583	0,118
Cinsiyet	-8,219	5,741	-0,136	-1,432	0,157
Ev Tipi	-15,561	7,710	-0,284	-2,018	0,048*
Bulunduğu kat	-0,942	1,274	-0,098	-0,740	0,462
ADI-3	0,681	0,277	0,368	2,459	0,017*
UFAA-S	0,001	0,001	0,109	1,178	0,243
UFAA-O	0,004	0,003	0,149	1,394	0,168
UFAA-Y	0,001	0,002	0,035	0,401	0,690
UFAA-OTUR	0,026	0,008	0,332	3,276	0,002*
BDÖ	0,188	0,263	0,067	0,715	0,477
ASO-10	1,254	0,518	0,235	2,422	0,018*

*p<0,05. B: Standart olmayan regresyon katsayısı. SH: standart hata. DKÖ: Deprem Kaygı Ölçeği. ADI-3: Anksiyete Duyarlılık İndeksi-3. UFAA-S: Uluslararası Fiziksel Aktivite Anketi-Şiddetli. UFAA-O: Uluslararası Fiziksel Aktivite Anketi-Orta. UFAA-Y: Uluslararası Fiziksel Aktivite Anketi-Yürüme. UFAA-OTUR: Uluslararası Fiziksel Aktivite Anketi-Oturma Süresi. BDÖ: Beck Depresyon Ölçeği. ASO-10: Algılanan Stres Ölçeği-10.

ilişkili olduğu görüldü. Bununla birlikte evli olan bireylerin çocuklarının var olması ve sayısı ile ev tipinin apartman dairesi olması deprem kaygısının artmasında önemli rol oynamıştır.

Son yirmi yılda meydana gelen doğal afetler göz önüne alındığında, 552 deprem meydana gelmiş ve deprem, diğer doğal afetler arasında %8 ile üçüncü en yaygın afet olarak kayıtlara geçmiştir. (3.254 sel - %44 ve 2.043 fırtına - %28).[17] Depremler, 2000-2019 yılları arasında dünya çapında meydana gelen tüm doğal afetlerin küçük bir bölümünü oluştursa da, etkilenen bölgelerde binlerce can kaybı, yaralanma ve evsiz bireyin olduğu mega felaketlere yol açabilmeleri nedeniyle en yıkıcı doğal afetler arasında yer almaktadır. 6 Şubat'ta meydana gelen 7,8 ve 7,6 büyüklüklerindeki 2023 Kahramanmaraş depreminin 50.000'den fazla can kaybına ve 119.000 yaralanmaya yol açtığı bilinmektedir.[18]

Deprem sonrası yapılan araştırmalara bakıldığında; hayatta kalanların önemli bir kısmında duygusal semptomlar içerisinde yer alan kaygı bozukluğunun görüldüğü tespit edildi.[19] Kaygı, yoğun bir endişe duygusuyla karakterize istenmeyen ve tehlikeli bir durumla karşılaşıldığında ortaya çıkan duygusal bir semptomdur. Bu semptomun kalıcı olma olasılığı "sürekli kaygı" ya dönüştüğünde yüksektir.[20] Sürekli kaygı, devam eden stresli

durumlara verilen endişeli tepkilerle ilişkilidir. Bu anlamda afetler, herhangi bir yerde ve herhangi bir zamanda meydana gelme olasılığı yüksek olaylar olması nedeniyle insanlarda sürekli kaygıyı tetikler.[21] Bizim çalışmamızda da deprem kaygısının çalışmaya katılan bireylerde yüksek olduğu görülmüştür.

Caia vd.'nin depremzedelerin özelliklerine ilişkin yapmış oldukları bir çalışmada yaşları 15-82 arasında değişen 80 gönüllü katılımcıda depremin üzerinden iki yıl geçmiş olmasına rağmen anksiyete semptomlarının görüldüğü literatürde belirtilmiştir.[22] Bununla birlikte 2008 yılında Çin'de meydana gelen "Wencuhan Depremi" sonrası 1181 erişkin üzerinde yapılan çalışma sonuçlarında bireylerin anksiyete düzeylerinin yüksek olduğu gösterilmiştir.[23] Çalışmamızda da deprem sonrası anksiyete duyarlılığı bireylerde yüksek bulunmuş ve deprem kaygısının artması ile bu sonuçların doğru orantılı olarak artış gösterdiği literatür de yer alan çalışmalar ile uyumluluk göstermiştir.

2019 yılında Bavafa vd. tarafından yapılan çalışmada 2017 yılında İran'da meydana gelen ve 620 kişinin vefatı ile sonuçlanan depremden 10 gün sonra 999 bireyin anksiyete ve stres düzeyleri değerlendirilmiştir. Çalışmanın sonuçlarına bakıldığında deprem mağdurlarının; %70 oran ile orta derecede kaygı, %60.5 oran ile yoğun stres yaşadıkları tespit edilmiştir.[24] Ülkemizde yapılan bir diğer çalışma incelendiğinde yaşanan Kahramanmaraş depremi sonrası 570 katılımcının anksiyete ve stres düzeyleri incelenmiştir. %58 oranında yüksek anksiyete düzeyine sahip örneklemde deprem kaygısı ile travmatik stres belirtileri arasında güçlü ve pozitif bir korelasyon bulunmuştur.[25] Çalışmamızda da deprem kaygısı ile algılanan stres birbiriyle ilişkili bulunmuş ve literatür ile paralellik göstermiştir.

Çalışmamızın sonuçlarına bakıldığında anksiyete ve stres düzeyi deprem kaygısı ile ilişkili iken, deprem kaygısının depresyonu etkilemediği görülmüştür. 6 Şubat Kahramanmaraş depremi sonrası öğretmenlerin kaygı düzeylerinin incelendiği bir çalışmada; yaşa göre kaygı düzeyleri incelenmiş ve 61 yaş üzerinde deprem sonrası kaygı düzeyinin daha fazla görüldüğü ve yaşlılıkta kaygının depresyon ile birlikte arttığı çalışma sonuçlarında belirtilmiştir.[3] Bizim çalışmamızda da örneklemin yaş ortalamasının 27,83 olması depresyonun etkilenmemesine sebep olmuş olabilir. Literatürde yer alan bir diğer çalışma 2020 yılında meydana gelen Elazığ depremi sonrası deprem travmasının psikolojik etkilerini belirlemek amacıyla yapılmıştır. Çalışmaya 360 kişi dahil edilmiş olup, bireylerin 284'ü deprem mağduru, 76 kişi de kontrol grubu olarak seçilmiştir. Depremden 2,5 ay sonra bireylerin depresyon BDÖ ile değerlendirilmiş ve sonuçlar iki grupta da benzerlik göstermiştir. Çalışmaya bakıldığında yaş ortalamasının 32,09 olduğu belirtilmiş ve bizim çalışmamız ile benzer sonuçlar gösterilmiştir.[26] Depresyon ile yaşam doyumunun incelendiği bir diğer çalışmada ise; Kahramanmaraş depremi sonrası depresyon belirtilerinin yaşam doyumunu negatif yönde etkilediği ortaya konmuştur. Bunun aksine deprem stresinin depresyon ile pozitif ilişkisi bulunmamıştır. Literatür incelendiğinde sonuçlarımız içerişimde yer alan deprem kaygısının depresyonu etkilemediğini destekleyen çalışmalar yer almaktadır.[27]

Çalışmamızda deprem kaygısının fiziksel aktivite üzerine etkilerinin sonuçlarına bakıldığında; UFAA-KF içerisinde yer alan parametrelerden oturma süresinin deprem kaygısı ile ilişkili olduğu, yüksek-orta şiddette fiziksel aktivite ve yürüme skorunu etkilemediği görüldü. Literatürde yer alan güncel çalışmalara bakıldığında fiziksel aktivitenin stres, kaygı, depresyon gibi semptomlar üzerinde etkili olduğu gösterilmiştir.[28] 6 Şubat Kahramanmaraş depremi sonrası Sirkadiyen ritm, uyku-uyanıklık bozuklukları ile baş etmede fiziksel aktivite ve egzersizin önemine vurgu yapan bir derleme çalışması yer almaktadır. Deprem sonrası düzenli yapılacak fiziksel aktivitenin önemine vurgu yapılmıştır.[29] Ancak deprem sonrası fiziksel aktivitenin etkileri üzerine bir çalışmanın yapılmamış olması üzerine sonuçlarımız literatür ışığında tartışılamamıştır. Deprem öncesi bireylerin fiziksel aktivite düzeyleri sorgulanmadığı için deprem sonrası yüksek-orta şiddette aktivitenin veya yürüme skorunun etkilenmemesi bundan kaynaklanmış olabilir. Bununla birlikte deprem kaygısı ile birlikte oturma sürelerinin artması 6 Şubat 2023 tarihinden itibaren gerek öğrenciler - gerek öğretmenler için uzaktan çevrimiçi eğitime geçiş yapılması, birçok kişinin depremi yaşadığı şehirden geçici veya kalıcı süre ile

ayrılmak durumunda olması, işine uzaktan devam etmesi veya ara vermesi gerekçeleriyle oturma sürelerinin artış göstermiş olabileceği görüşündeyiz. Çalışma örneklemimizin büyük çoğunluğunu öğrenciler ve öğretmenlerin oluşturması sonuçlarımızı bu yönlü etkilemiş olabilir.

Çalışmaya katılan bireylerin %74,7'si apartman dairesinde ikamet etmekteydi. Apartman dairesinde yaşayan bireylerin neredeyse yarısı (%48,4) 3. Kat ve üzerinde oturmaktaydı. Çalışmamızda bireylerin yaşamış olduğu evin apartman dairesi olması deprem kaygısı ile ilişkili bulunmuştur. Afet ve Acil Durum Yönetimi Başkanlığı verilerine istinaden deprem anı ve sonrasında 50000'den fazla binanın yıkılmış olması bireylerin çok katlı binalarda kaygı düzeylerinin de arttığını göstermektedir.

Limitasyonlar

Çalışmamızın bazı limitasyonları mevcuttur. Bu limitasyonlardan ilki bireylerin deprem öncesi fiziksel aktivite düzeylerinin bilinmiyor olmasıdır. Deprem sonrası etkilenimin olmamasının sebebi olarak sedanter yaşam tarzı düşünülebilir. Ayrıca depremden etkilenen her ilde yaşayan bireylerin sonuçlarının karşılaştırmalı olarak sunulması ilerleyen çalışmalar için çok yönlü değerlendirme fırsatı sunacaktır.

Sonuç

Çalışmamızda; depremi yaşayan bireylerin deprem kaygısını etkileyen faktörlere bakıldığında anksiyete duyarlılığının, algılanan stresin, fiziksel aktivite düzeyinin ve yaşanılan ev tipinin deprem kaygısını arttırdığı görüldü. Asrın felaketi olarak tanımlanan bu yıkıcı doğal afetten etkilenen bölgelerde depremden etkilenen bireylerin deprem kaygılarını arttıran faktörlerin azaltılabilmesine yönelik oluşturulacak fiziksel aktivite programlarının bu popülasyonda akılda tutulması önemlidir. Programların uygulanması ve etkilerinin araştırıldığı çalışmaların yapılarak sonuçların incelenmesini önermekteyiz.

Teşekkür: Yaşadığımız bu büyük felaket sonrası devam eden zorlu süreçte çalışmamıza büyük bir özveri ile katılan, çalışmamızı yürütmemize verdiği cevaplar ile tüm içtenlikleriyle destek olan bütün katılımcılarımıza sonsuz teşekkürlerimizi sunarız.

Yazarların Katkı Beyanı: TG: Konsept, çalışma dizaynı, veri toplama, yazma; **ED:** Veri toplama/işleme, yazma; **EOS:** Veri toplama/işleme; **YY:** Çalışma dizayn, veri analizi/yorumlama, kritik gözden geçirme.

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ORIGINAL ARTICLE

Comparison of the mechanical properties of hand and wrist muscles at rest and during activity in patients with rheumatoid arthritis and their healthy peers

Romatoid artritli hastalarda sağlıklı akranlarına göre el ve el bileği kaslarının mekanik özelliklerinin istirahat ve aktivite halinde karşılaştırılması

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Abstract

Purpose: The aim of this study is to evaluate the mechanical properties of the hand and wrist muscles in patients diagnosed with Rheumatoid Arthritis (RA) both at rest and during contraction.

Methods: A total of 83 individuals, including 42 Rheumatoid Arthritis (RA) patients and 41 healthy individuals, were included in the study. Hand and wrist functionality was assessed using the Duru Öz Hand Index, and the mechanical properties of the muscles were evaluated using the MyotonPro® device during both contraction and rest.

Results: The tone and stiffness values of the flexor muscle in the left and right wrists of healthy individuals (except for the right wrist at rest) during both rest and during contraction were higher compared to RA patients ($p<0.05$), while the scores for the extensor muscle were similar ($p>0.05$).In RA patients, the tone and stiffness values of the muscle in the right and left thenar region, measured at rest, were higher compared to healthy individuals ($p<0.05$), whereas the mechanical properties of the muscle in the hypothenar region were similar ($p>0.05$). The Duru Öz Hand Index scores of RA patients were lower than those of healthy individuals ($p<0.05$).

Conclusion: The mechanical properties (stiffness and tone) of the flexor and thenar muscles in RA primarily affect the wrist and hand regions. Rehabilitation programs for the hands and wrists in these patients should prioritize specific exercises targeting the flexor and thenar muscle groups (e.g., relaxation, stretching, functional exercises) and include approaches aimed at improving overall hand functionality.

Keywords: Elasticity, Hand and wrist, Rheumatoid arthritis, Stiffness.

Öz

Amaç: *Bu çalışmanın amacı, Romatoid Artrit tanısı almış hastalarda el ve el bileği bölgesindeki kasların mekaniksel özelliklerinin istirahat ve aktivite halinde değerlendirmekti.*

Yöntem: *Çalışmaya 42 Romatoid Artrit (RA) hastası, 41 sağlıklı birey olmak üzere toplam 83 birey dahil edildi. El ve el bileği fonksiyonelliği DuruÖz El İndeksi, kasların mekaniksel özellikleri MyotonPro® cihazı ile aktivite ve dinlenme halinde değerlendirildi.*

Bulgular: *Sağlıklı bireylerin sol ve sağ el bileği ölçülen fleksör kasın (sağ istirahat hariç) istirahat ve aktivite halindeki tonus ve sertlik değerleri RA'lı hastalara göre daha yüksek iken ($p<0,05$), ekstansör kasın skorları benzerdi ($p>0,05$). RA'lı hastaların sağ ve sol tenar bölge istirahat halinde ölçülen kasın tonus ve sertlik değerleri sağlıklılara göre yüksek iken ($p<0,05$), hipotenar bölgedeki kasın tüm mekanik özellikleri benzerdi ($p>0,05$). RA'lı hastaların duru öz el indeksi skorları sağlıklara göre daha düşüktü ($p<0,05$).*

Sonuç: *RA'de fleksör ve tenar bölge kasların mekanik özellikleri (sertlik ve tonus), bölgesel olarak ta önce el bileği ve el olmak üzere etkilendiği görülmektedir. Bu hastaların el-el bileği rehabilitasyonunda öncelikli olarak fleksör ve tenar kas gruplarına yönelik spesifik egzersizler (gevşeme, germe, fonksiyonel egzersizler, vb.) içermeli ve genel el fonksiyonlarını geliştirmeye yönelik yaklaşımlar belirlenmelidir.*

Anahtar Kelimeler: *Elastisite, El ve el bileği, Romatoid artrit, Sertlik.*

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INTRODUCTION

Rheumatoid Arthritis (RA) is an autoimmune, chronic inflammatory, progressive, and systemic disease that affects 0.5% to 1% of the adult population, particularly those with genetic predisposition.[1,2] The disease progresses through periods of activity and remission.[3] With increased disease duration and activity, the joints and the surrounding muscles and ligaments become affected.[4] The joints most commonly involved in RA are the hand and wrist joints.[5] RA impacts six anatomical regions of the hand: the skin, muscles, nerves, joints, tendons, and blood vessels.[6] Involvement of the hand and wrist leads to a reduction in functional grip strength and a two-thirds decrease in lateral and tip pinch strength performed with the thumb.[7] The effects of RA on body functions manifest as restrictions in daily living activities. These restrictions are attributed to pain, decreased range of motion, muscle weakness, and reduced aerobic capacity. Notably, muscle strength decline can be observed even in the early stages of RA.[8]

Hand functions include components such as mobility, muscle strength, coordination, and sensory integration. Since the hand is involved in numerous daily activities, hand functionality is critical for individual independence.[9] Effective hand use depends on factors such as anatomical integrity, joint mobility, adequate muscle strength, proper sensory input, motor coordination, and the absence of pain. In individuals with RA, pathological changes such as joint swelling, pain, deformities, and reduced joint mobility lead to decreased grip strength and impaired hand function. These impairments are further exacerbated by factors like fear of pain, reflex inhibition, disuse atrophy, and joint instability.[10-11] Additionally, the coordinated activity of the thenar and hypothenar muscles is essential for maintaining muscular balance required for proper hand and wrist function. [12] A review of the literature reveals that in two separate studies, RA patients demonstrated lower wrist flexor and extensor muscle strength scores compared to healthy individuals, with joint position sense and proprioception negatively affected.[9,10] However, no specific study was found investigating the impact of RA on the viscoelastic properties of hand and wrist muscles. Existing studies suggest that muscle tone may either increase or decrease.[11-14] Prolonged inflammation and joint damage in RA are associated with muscle weakness and deterioration, while factors such as morning stiffness and inactivity may also affect muscle tone and function.[11,12] Inflammation in RA may influence the viscoelastic properties of joints and periarticular muscles. Clinical features such as morning stiffness and prolonged immobility have been associated with changes in muscle function, including increased perceived stiffness.[13,14]

The literature indicates a lack of sufficient studies examining the wrist and hand muscles in RA patients. Given the frequent hand involvement in RA and its impact on hand functions, we hypothesize that the hand and wrist muscles of RA patients, particularly the thenar and hypothenar muscles, may exhibit differences in mechanical properties during rest and activity compared to their healthy peers due to changes in muscle activation. Evaluating muscle mechanical properties both at rest and during contraction provides valuable insight into the passive and active behavior of muscle tissues. While resting measurements reflect baseline viscoelasticity and muscle tone, contraction-based assessments reveal how muscle properties change under load, which is more functionally relevant to daily activities. Considering that individuals with RA often experience both rest-related stiffness and activity-related limitations, analyzing both states is essential for a comprehensive understanding of muscle dysfunction.

This study aimed to compare the mechanical properties of specific hand and wrist muscles (particularly focusing on thenar and hypothenar muscles) between patients with RA and their age-matched healthy peers and evaluate these properties under two conditions: at rest and during controlled muscle activity.

METHODS

This study was conducted as a collaboration between the Department of Physiotherapy and Rehabilitation and the Department of Rheumatology at Sanko University. The study was designed as a cross-sectional research project. All participants who met the inclusion

criteria were informed face-to-face about the study, and voluntary consent forms were signed to confirm their participation. The study adhered to the ethical principles outlined in the Declaration of Helsinki and received ethical approval from the Non-Interventional Clinical Research Ethics Committee of SANKO University during its meeting dated November 20, 2024, with protocol number 2024/11.

Participants

The study included 42 patients diagnosed with RA based on the 2010 ACR/EULAR criteria, who were being monitored at the Rheumatology Clinic of Sanko University, as well as 41 healthy volunteers with similar average ages. The inclusion criteria were being diagnosed with rheumatoid arthritis according to the 2010 ACR diagnostic criteria, willingness to participate in the study, being aged between 18 and 70 years, being able to speak Turkish and comprehend written text, having stable medication usage for at least three months or longer, no history of orthopedic surgery within the last three years, not undergoing physiotherapy, being right-handed as the dominant hand. As an additional inclusion criterion, participants were required to have clinically low-to-moderate disease activity and to be under stable medical treatment for at least the past three months. This criterion aimed to reduce variability in muscle mechanical properties due to acute disease exacerbations. Individuals with clinical signs of median or ulnar nerve entrapment neuropathies (e.g., carpal tunnel syndrome or cubital tunnel syndrome), trapeziometacarpal joint osteoarthritis, or local tendon inflammation affecting the thenar or hypothenar muscles were excluded from the study based on clinical examination. Neurological assessment and palpation were performed to rule out such conditions.

Study design

Demographic information such as age, gender, marital status, occupation, and disease duration of the participants was recorded. Measurements for individuals who met the inclusion criteria and agreed to participate in the study were conducted face-to-face by the same physiotherapist. Hand and wrist functionality of the participants was assessed using the Duru Öz Hand Index, while the mechanical properties of the hand and wrist muscles were evaluated using the MyotonPro® device. The mechanical properties of the muscles were measured both at rest and during contraction. For contraction measurements, participants were asked to perform a submaximal isometric contraction of the target muscle (flexor or extensor for wrist; thenar or hypothenar for hand) while the MyotonPro® probe was applied perpendicularly to the muscle belly. For the hand, measurements of the thenar and hypothenar muscles were performed using a pinch meter. Only individuals with a dominant right extremity were included in the study. Dominant extremity preference was determined using the Edinburgh Handedness Inventory.[15]

Demographic information form

This form is designed to assess participants' demographic information, contact details, and general background. It includes questions about the participants' disease duration, medications used, age, contact information, gender, height, body weight, marital status, education level, and occupation.

MyotonPro®

The MyotonPro® is a portable digital device that objectively and non-invasively measures the tone or tension state, biomechanical, and viscoelastic properties of muscles and other soft biological tissues. The device's probe (3 mm in diameter, made of polycarbonate) is placed perpendicularly on the skin projection of the target muscle. A constant pre-pressure (0.18 N) is applied to the skin surface to compress the subcutaneous superficial tissues. Beneath these compressed tissues, the device delivers rapid, mechanical impulses (0.4 N) with a brief duration (15 ms) to the target muscle using a stable mechanical force. These mechanical impulses from the probe create local and elastic deformation in the measured muscle. After this deformation, the muscle returns to its original state, responding with natural damped oscillations. These oscillations are recorded as an acceleration graph by frictionless and highly sensitive accelerometers located at the opposite end of the probe. The device simultaneously calculates the muscle's tone (characterized by natural oscillation frequency; Hz), stiffness (N/m), and elasticity (characterized by logarithmic decrement of natural oscillations), along with the tissue's tension state, biomechanical, and viscoelastic property parameters. During the measurement, the

probe of the device is placed perpendicularly on the muscle surface, targeting the motor point of the relevant muscle. The assessment position and points for each muscle are determined according to the criteria published on the official website of MyotonPro®.[16]

The Extensor Carpi Radialis (ECR) muscle and the Flexor Carpi Ulnaris muscle were used as reference points for wrist measurements.[17] For measurements in the thenar and hypothenar regions, the Abductor Pollicis Brevis muscle was used as the reference for the thenar muscle, and the Abductor Digiti Minimi muscle was used as the reference for the hypothenar muscle.[18] For myotone assessments; participants were asked to rest for a while (3-5 minutes) while sitting on a chair. The participant was asked to sit upright on the edge of the table and extend their arms comfortably on the table. For Flexor Carpi Ulnaris (FCU); 1/3 of the distance between the proximal medial epicondyle and the ulna styloid, the point where the muscle is most bulging, for ECR, 1/3 of the distance between the lateral epicondyle and the radius styloid process was taken as reference.[19,20] The hypothenar region is a thick soft tissue mass on the ulnar side of the palm. The pisiform is located on the palmar aspect of the fifth metacarpal bones and the proximal part of the proximal phalanx of the fifth finger. The reference point for the hypothenar region was determined as the midpoint of one-third the distance between the ulnar styloid process and the head of the fifth proximal phalanx, measured with a tape measure, as previously described.[21] For the thenar region, the reference point was identified as the most prominent part of the abductor pollicis brevis muscle, which lies between the radial styloid process and the base of the thumb. This location was selected based on anatomical palpation and surface anatomy guidelines.[22] In the evaluation of both the thenar and hypothenar regions, the appropriate L-shaped probe of the MyotonPro device was used in accordance with manufacturer instructions. Since the use of this probe was not specified in the cited anatomical studies, reference to the device manual was applied for methodological standardization. The selection of the FCU and ECR muscles for wrist measurements was based on their anatomical accessibility and relevance in wrist flexion and extension. These muscles are more superficial and easier to isolate for mechanical property assessment using the MyotonPro®. In contrast, Flexor Carpi Radialis (FCR) and Extensor Carpi Ulnaris (ECU) were not included due to their deeper location or overlapping muscle structures, which may hinder accurate measurement with surface-based devices.

Hydraulic Hand Dynamometer

This dynamometer (Hand-grip, Jamar dynamometer) is capable of measuring force values ranging from 0 kg-f (kilogram-force) to 90 kg-f. The device has two parallel handles and can be adjusted to five different grip span settings (ranging from 3.5 cm to 8.5 cm in 1.3 cm increments) to accommodate individuals with varying hand sizes.[23] During the hand grip strength assessment, the participant was seated in a chair with back support, feet flat on the ground, hips and knees at 90-degree flexion, the forearm in a neutral position, and the wrist in 0–30 degrees of extension and 0-5 degrees of ulnar deviation. The dynamometer was set to the "0" position before each trial. Participants were instructed to apply maximum grip strength for approximately 3-5 seconds, and the test was repeated three times with 30 seconds of rest between trials. The highest value among the three trials was recorded for analysis. During each trial, standardized verbal encouragement was provided to ensure maximal effort.[24]

Pinch Meter

The pinch meter is a type of dynamometer used to assess peripheral muscle strength and measure hand grip strength. Measurements were performed in the standard position recommended by the American Society of Hand Therapists (ASHT): the participant was seated with the shoulder in adduction and neutral rotation, elbow in 90-degree flexion, forearm in mid-rotation and supported, and wrist in a neutral position. A one-minute rest period was provided between each measurement, and the average of three measurements was recorded.[25] Each pinch trial lasted approximately 3-5 seconds, during which participants were instructed to apply maximum force. Standardized verbal encouragement was provided during each attempt to promote maximal effort.

Lateral pinch (key pinch) force was assessed using the pinch meter. Participants were instructed to perform a lateral pinch

between the thumb pad and the radial side of the index finger, as per the American Society of Hand Therapists protocol.

Duru Öz Hand Index

The Duru Öz Hand Index is an 18-item questionnaire designed to assess activity limitations related to hand function. It was first developed in 1996 by Duruöz et al. to evaluate rheumatoid hand functions. The 18 questions are divided into five categories: kitchen tasks, dressing, personal hygiene, workplace activities, and other activities. Possible responses, along with their corresponding scores, are as follows: No difficulty (= 0), very little difficulty (= 1), some difficulty (= 2), quite difficult (= 3), almost impossible (= 4), ımpossible (= 5). The total score is the sum of the scores from all 18 questions (ranging from 0 to 90), with higher scores indicating greater impairment in hand function.[26]

Statistical analysis

Descriptive statistics included means and standard deviations for continuous variables and frequencies and percentages for categorical variables. The normality of data distribution was assessed using the Kolmogorov-Smirnov test. For independent group comparisons: The *t-test* was used for continuous variables when parametric test assumptions were met. The *Mann-Whitney U test* was used when parametric test assumptions were not met. A significance level of $p<0.05$ was considered statistically significant. Data analysis was conducted using the IBM SPSS Statistics 23 software package. The study sample size was calculated using the G-power program, based on primary assessments considering stiffness as the key variable. Assuming a power of 80% ($\beta=0.20$), $\alpha=0.05$, the minimum sample size was determined to be 21 participants per group, with a total of 42 participants.[27] Considering potential dropouts (20%), it was decided to include a total of 51 individuals in the study.

RESULTS

The study included a total of 83 participants: 42 patients diagnosed with RA and 41 healthy individuals with no chronic illnesses. The mean ages of the participants were 49.86 ± 11.27 years in the RA group and 48.56 ± 9.86 years in the control group, with no statistically significant difference between the groups ($p>0.05$). In terms of gender distribution, the RA group consisted of 85.7% women and 14.3% men, while the control group comprised 80.5% women and 19.5% men. The physical and sociodemographic characteristics of the participants are presented in Table 1. The disease duration of the patients with rheumatoid arthritis included in the study was 87.80 (3-360) months

The tone and stiffness parameters of the right wrist during contraction. as well as the tone and stiffness parameters of the left wrist during rest and activity, were statistically higher in the healthy group compared to the RA group ($p<0.05$). The elasticity values of the left wrist during contraction were statistically lower ($p<0.05$). No statistically significant differences were found in the other evaluated parameters ($p>0.05$) (Table 2).

No statistically significant differences were observed in the tone, stiffness, and elasticity parameters of the wrist extensor muscle groups during contraction and rest ($p>0.05$) (Table 2). When examining the myotonometric properties of the thenar muscle groups during contraction and rest, the tone and stiffness parameters of the right and left extremities in the RA group were statistically higher than those in the healthy group at rest ($p<0.05$) (Table 2).

No statistically significant differences were observed in the tone, stiffness, and elasticity parameters of the hypothenar muscle groups during contraction and rest ($p>0.05$). However, when comparing the Duru Öz Hand Index scores between the groups, the RA group had statistically higher scores than the control group ($p<0.05$).

DISCUSSION

This study aimed to compare hand and wrist muscle mechanical properties between RA patients and healthy controls, revealing significantly lower muscle tone and stiffness in the RA group, particularly in flexor muscles during contraction and the left wrist at rest, compared to their healthy peers.

Although the patient and control groups were homogeneous in terms of age and gender, our findings revealed that the flexor muscle tone

Table 1.Physical and sociodemographic characteristics of the participants.

	Rheumatoid Arthritis(n=42)	Healthy Group (n=41)	
	X±SD	X±SD	p
Age	49.9±11.3	48.6±9.9	
Duru Öz Hand Index (Score)	23.1±22.0	0.9±2.2	<0.001
Disease Duration (Months)	87.8 (3–360)	-	
	n (%)	n (%)	
Gender (Female/Male)	36/6 (86/14)	33/8 (80.5/19.5)	

Table 2. Myotonometric properties of wrist flexor muscle groups, wrist extensor muscle groups, thenar muscle groups and hypothenar muscle groups during contraction and rest.

		Rheumatoid Arthritis (n=42)	HealthyGroup (n=41)	
		X±SD	X±SD	p
Wrist Flexors				
Right				
Tone (Hz)	Rest	20.4±6.0	21.6±5.3	0.340
Tone (Hz)	During Contraction	25.2±12.9	30.1±10.6	0.010*
Stiffness (N/m)	Rest	432±202	480±161	0.060
Stiffness (N/m)	During Contraction	533±324	779±261	0.001*
Elasticity (log)	Rest	1.24±0.3	1.12±0.2	0.045*
Elasticity (log)	During Contraction	1.2±0.5	1.11±0.5	0.383
Left				
Tone (Hz)	Rest	19.31±5.2	22.2±5.1	0.012*
Tone (Hz)	During Contraction	23.4±10.0	31.8±10.9	0.001*
Stiffness (N/m)	Rest	39±161	468±152	0.020*
Stiffness (N/m)	During Contraction	538±271	777±230	0.001*
Elasticity (log)	Rest	1.23±0.2	1.13±0.2	0.047*
Elasticity (log)	During Contraction	1.2±0.4	1±0.3	0.012*
Wrist Extensors				
Right				
Tone (Hz)	Rest	25.7±10.8	23.2±7.4	0.639
Tone (Hz)	During Contraction	25.5±8.9	24±6.7	0.831
Stiffness (N/m)	Rest	554±259	566.±206	0.466
Stiffness (N/m)	During Contraction	618±233	628±205	0.834
Elasticity (log)	Rest	1.27±0.3	1.32±0.3	0.413
Elasticity (log)	During Contraction	1.26±0.4	1.18±0.3	0.318
Left				
Tone (Hz)	Rest	24.4±10.3	21.8±6.4	0.689
Tone (Hz)	During Contraction	25.8±9.8	24.1±8.1	0.441
Stiffness (N/m)	Rest	541±294	530.±181	0.503
Stiffness (N/m)	During Contraction	623±264	664±296	0.511
Elasticity (log)	Rest	1.3±0.3	1.3±0.3	0.946
Elasticity (log)	During Contraction	1.2±0.4	1.3±0.5	0.355

* p<0.05 log: Logarithmic.

Table 2 *(Contd.).* Myotonometric properties of wrist flexor muscle groups, wrist extensor muscle groups, thenar muscle groups and hypothenar muscle groups during contraction and rest.

		Rheumatoid Arthritis (n=42)	HealthyGroup (n=41)	
		X±SD	X±SD	p
Thenar Region				
Right				
Tone (Hz)	Rest	25.5±4.4	23.2±3.6	0.007*
Tone (Hz)	During Contraction	31±4.7	32.8±5.7	0.122
Stiffness (N/m)	Rest	519±124	436±98	0.002*
Stiffness (N/m)	During Contraction	747±150	798±124	0.094
Elasticity (log)	Rest	1.4±0.2	1.3±0.2	0.009*
Elasticity (log)	During Contraction	1.2±0.3	1.2±0.2	0.331
Left				
Tone (Hz)	Rest	25.±5.	23.9±4.5	0.033*
Tone (Hz)	During Contraction	30.7±5.6	30.6±5.3	0.892
Stiffness (N/m)	Rest	519±129	453±108	0.014*
Stiffness (N/m)	During Contraction	727±168	737±137	0.767
Elasticity (log)	Rest	1.4±0.3	1.3±0.2	0.103
Elasticity (log)	During Contraction	1.3±0.3	1.3±0.1	0.701
Hypothenar Region				
Right				
Tone (Hz)	Rest	23.5±4.1	22.9±2.4	0.795
Tone (Hz)	During Contraction	26.1±5.1	24.9±3.7	0.239
Stiffness (N/m)	Rest	468±108	452±77	0.695
Stiffness (N/m)	During Contraction	530±158	493±95	0.303
Elasticity (log)	Rest	1.5±0.2	1.5±0.2	0.698
Elasticity (log)	During Contraction	1.4±0.3	1.5±0.2	0.662
Left				
Tone (Hz)	Rest	22.6±3.3	22.5±2.2	0.851
Tone (Hz)	During Contraction	30.4±33	32.1±51.5	0.188
Stiffness (N/m)	Rest	442±87	439±60	0.871
Stiffness (N/m)	During Contraction	525±122	476±103	0.068
Elasticity (log)	Rest	1.5±0.2	1.5±0.2	0.902
Elasticity (log)	During Contraction	1.5±0.3	1.5±0,1	0.335

* p<0.05 log: Logarithmic.

and stiffness values during contraction were significantly lower in individuals with RA compared to healthy controls. This may reflect disease-related alterations in neuromuscular control or structural muscle changes; however, these interpretations remain speculative and require further investigation with direct assessments such as EMG or imaging techniques. Additionally, the absence of consistent effects across all muscles or both sides of the body suggests that local factors - such as hand dominance, joint protection behaviors, or subclinical inflammation - may contribute to the variability in muscle response.

The lack of significant differences in the extensor group, and the observed asymmetry in left versus right wrist measurements, may reflect disease-related variability in joint protection strategies, hand dominance, or subclinical inflammation. Clinically, these

results emphasize the importance of early detection and rehabilitation of dynamic muscle dysfunction in RA patients, particularly in the wrist flexors, to prevent functional decline and enhance hand use in daily life.

The higher tone and stiffness scores in the Rheumatoid Arthritis group suggest that the flexor muscles are more affected by the disease's pathophysiological process compared to the healthy group. Smith et al. stated that inflammation in the joints, synovial hypertrophy, and decreased range of motion observed in RA patients are associated with changes in muscle tone.[28] Stamm et al. suggested that the flexor muscles of the hand play a greater role than the extensor group during daily living activities, which may result in more pronounced viscoelastic changes in the flexor muscle group.[29]

Tone can be classified into two forms: neural and non-neural.[30] Inflammation observed in RA can lead to adverse outcomes such as motor neuron loss, synaptic degeneration, and muscle atrophy as a result of microglial activation.[31] In the peripheral nervous system, a reduction in axon caliber may be accompanied by a decrease in conduction velocity.[32] This neurodegenerative process may explain why muscle tone in the RA group is lower compared to the healthy group. The decrease in tone and stiffness parameters of the flexor muscles during contraction may result from the negative impact on neuromuscular control mechanisms.

One of the key findings of this study is the difference between passive (at rest) and active (during contraction) muscle properties in individuals with RA. Passive measurements reflect the intrinsic viscoelastic structure of the muscle, which may be altered by chronic inflammation, fibrosis, or disuse. In contrast, contraction-based assessments depend on active neuromuscular control and voluntary muscle recruitment. In RA, pain, joint damage, and inflammation can impair central and peripheral neuromuscular pathways, leading to reduced activation capacity during contraction even when passive properties appear relatively preserved.

This discrepancy is clinically relevant as it suggests that muscle dysfunction in RA may not always be visible at rest but becomes evident during functional use. Therefore, evaluation and rehabilitation strategies should include assessments under both conditions to accurately detect dynamic impairments and guide targeted interventions. Pain avoidance behavior and reduced muscle usage in RA patients could also contribute to this decline when compared to healthy individuals. Köprülüoğlu et al. highlighted the relationship between decreased flexor muscle tone and joint dysfunction in their study involving RA patients, emphasizing that this should be a key consideration during the rehabilitation process.[33]

Although increased tone and stiffness in flexor and thenar muscles were initially interpreted as targets for relaxation strategies, it is also possible that these changes represent a compensatory neuromuscular mechanism to stabilize joints affected by ligamentous laxity in RA. Since joint stability was not specifically assessed in this study, caution should be exercised when recommending generalized relaxation exercises. Instead, individualized rehabilitation programs that include functional exercises such as grip strengthening, object manipulation, and wrist stabilization should be considered, based on clinical evaluation of joint integrity. In particular, targeted stabilization exercises for the wrist flexor muscles - especially eccentric training - may be beneficial to counteract the observed reductions in tone and stiffness. Similarly, neuromuscular retraining focused on dynamic activation of the thenar muscle group may help improve grip efficiency. For patients with increased tone in thenar muscles, stretching or soft tissue release techniques could be considered to reduce compensatory overactivity.

The lack of significant differences in extensor muscle groups during rest and activity has also been observed in some studies in the literature. Chung et al. discussed the functional differences between muscle groups in RA patients, noting that extensor muscles play a lesser role in stabilization and tension control of the wrist compared to the flexor group. They highlighted that the absence of changes in tone and stiffness in the extensor muscles is an expected finding.[34] Our study findings were consistent with the limited studies available in the literature. We believe that the changes in the viscoelastic properties (tone, stiffness, and elasticity) of the wrist flexor and extensor muscle groups are not solely related to the

nature of the disease but are also influenced by usage patterns and compensation mechanisms. From a clinical standpoint, decreased stiffness and tone in the wrist flexor muscles during contraction may indicate a need for strength-based interventions under load, whereas preserved passive properties suggest that passive stretching may be of limited value. In contrast, the lack of change in the extensor group may reflect underutilization rather than pathology, and thus controlled activation strategies - such as resisted extension movements - could be beneficial.

Further investigation into the lack of changes in the extensor muscle group through more detailed biomechanical analyses and larger patient cohorts would be valuable. The RA group had statistically higher tone and stiffness scores in the thenar muscle groups of both extremities during contraction and rest compared to the healthy group, whereas no differences were observed in tone, stiffness, or elasticity in the hypothenar region. The Duru Öz Hand Index scores were also higher in the RA group than in the control group. Smith et al. noted that the presence of inflammation, fibrotic changes, and compensatory mechanisms are associated with increased tone and stiffness in the RA group.[35]

Compared to the hypothenar region, the thenar muscles play a more significant role in grip strength and fine motor skills, making it expected for RA to have a more pronounced impact on these muscles. We also believe this may be associated with clinical findings and symptoms such as muscle spasms and increased muscle activity. Brorsson et al. reported that changes in neuromuscular control mechanisms can lead to clinical problems such as hypertonia and rigidity.[36] Izod et al. stated that the hypothenar muscles are used less frequently in daily living activities compared to the thenar region, and this reduced usage leads to less impact from disease-related degeneration.

As a result, no changes were observed in the tone, stiffness, and elasticity parameters of the hypothenar region.[37] The higher Duru Öz Hand Index scores in the RA group indicate limitations in hand functions. Joint deformities and muscle dysfunction not only negatively impact hand functions but also suggest adverse effects on the mechanical properties of the muscles. Therefore, rehabilitation planning should consider both passive and active muscle properties. For example, reduced contraction stiffness in the thenar group highlights the need for resistance-based precision grip training. On the other hand, the absence of hypothenar changes may not require direct intervention, but should be monitored in case of compensatory overuse. By "functional exercises," we refer to clinically oriented movements such as grip strengthening, fine motor coordination tasks, object transfer, and activities mimicking daily hand use. These exercises are intended to improve practical hand function in RA patients and should be selected based on the patient's individual joint integrity and muscle performance.

Limitations

This study has some limitations. Although our study was conducted in a single center and our sample size calculation was appropriate for our study, clinicians should be careful when interpreting our results obtained in a small sample to the general RA population. Our second limitation is that submaximal contraction was asked from the participants in the measurements during activity. However, how homogeneous this contraction level is realized may vary between participants and may affect the reliability of the measurement. Our third limitation is that the pain felt by RA patients during contraction may limit muscle activation. However, in this study, pain levels during the measurement were not recorded. Occupational information, pinc and grip strength measurements were not questioned.

Conclusion

In RA, the mechanical properties (stiffness and tone) of the flexor and thenar muscles appear to be primarily affected, with the impact observed regionally, starting with the wrist and hand. While hand and wrist functionality decreases, strength may remain unaffected. Rehabilitation programs for the hands and wrists of these patients should prioritize specific exercises targeting the flexor and thenar muscle groups (e.g., relaxation, stretching, and functional exercises) and incorporate approaches aimed at improving overall hand functionality.

Clinically, these findings suggest that decreased hand function in RA may be linked to altered mechanical properties (increased stiffness/tone) in specific muscles like flexors

and thenar groups, even if overall strength is maintained. Therefore, rehabilitation strategies should extend beyond general strengthening to include targeted interventions such as stretching, relaxation techniques, and functional exercises specifically for these affected muscle groups to effectively improve hand functionality.

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ORIGINAL ARTICLE

Digital transformation of knowledge: role of YouTube electrotherapy videos in physiotherapy and rehabilitation

Bilginin dijital dönüşümü: fizyoterapi ve rehabilitasyonda YouTube elektroterapi videolarının rolü

Elif DİNLER[1], Nail Abidin YARAŞIR[1], Deniz KOCAMAZ[1]

Abstract

Purpose: YouTube is one of the most important websites among university students and researchers. Because of this reason, it is important to determine the quality and reliability of videos in this platform to be used as educational content. The purpose of this study is to evaluate the quality and reliability of YouTube videos in electrotherapy education.

Methods: The keywords namely; electrotherapy in physiotherapy, electrotherapy in physiotherapy lecture, electrotherapy in physical therapy and rehabilitation were searched on YouTube. The reliability and quality of the videos were evaluated respectively by using DISCERN and Global Quality Scale (GQS) scores.

Results: A total of 150 videos were reviewed in the current study. Finaly, 28 videos met the inclusion criteria were included in the study. The level of agreement between the two investigators was good regarding classifying the videos as reliable (Kappa coefficient: 0.904). Inter-observer agreement was 0.86 and 0.92 for DISCERN and GQS scores, respectively. The types of organizations that upload videos with Electrotherapy videos were most commonly uploaded by Physiotherapists. Doctors uploaded the lowest number of videos. It was found that physiotherapist uploaded the highest quality videos. DISCERN instrument, where the average total score was 3 (range 0 to 5).

Conclusion: YouTube can be a valuable platform for making application-based electrotherapy techniques more comprehensible, leveraging contemporary technological tools.

Keywords: Electrotherapy, Education, Internet, Video, YouTube

Öz

Amaç: *YouTube, üniversite öğrencileri ve araştırmacılar arasında en önemli web sitelerinden biridir. Bu nedenle, bu platformdaki videoların eğitim içeriği olarak kullanılmak üzere kalitesinin ve güvenilirliğinin belirlenmesi önemlidir. Bu çalışmanın amacı, elektroterapi eğitiminde YouTube videolarının kalitesini ve güvenilirliğini değerlendirmekti.*

Yöntem: *YouTube'da fizyoterapide elektroterapi, fizyoterapi dersinde elektroterapi, fizik tedavi ve rehabilitasyonda elektroterapi anahtar kelimeleri aranmıştır. Videoların güvenilirliği ve kalitesi sırasıyla DISCERN ve Genel Kalite Ölçeği (GKÖ) puanları kullanılarak değerlendirilmiştir.*

Bulgular: *Mevcut çalışmada toplam 150 video incelenmiştir. Sonuç olarak, dahil edilme kriterlerini karşılayan 28 video çalışmaya dahil edildi. İki araştırmacı arasında videoların güvenilirlik açısından sınıflandırılması konusunda iyi bir uyum sağlandı (Kappa katsayısı: 0,904). Gözlemciler arası uyum, DISCERN ve GKÖ puanları için sırasıyla 0,86 ve 0,92 idi. Elektroterapi videoları yükleyen kuruluşların türleri arasında en yaygın olanı fizik tedavi uzmanlarıydı. Doktorlar en az sayıda videoyu yüklemiştir. Fizyoterapistlerin en yüksek kaliteli videoları yüklediği tespit edilmiştir. DISCERN aracında ortalama toplam puan 3 (0 ila 5 aralığı) bulunmuştur.*

Sonuç: *YouTube, çağdaş teknolojik araçlardan yararlanarak uygulama tabanlı elektroterapi tekniklerini daha anlaşılır hale getirmek için değerli bir platform olabilir.*

Anahtar kelimeler: *Elektroterapi, Eğitim, İnternet, Video, YouTube*

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INTRODUCTION

In the 21st century, the internet has become a vital and increasingly convenient source of information for patients and their families.[1] YouTube is considered one of the largest internet platforms with more than one billion users and is the second most visited website after the Google search engine.[2] YouTube is a popular video sharing platform that has been providing online video viewing. It is reported that approximately eight out of ten internet users obtain their health-related information from online information sources. First of all interns and medical school students frequently use the internet for educational purposes.[3] YouTube has become an important tool for the students in their access to information, learning and academic development processes. The easily accessible, audiovisual and interactive content offered by YouTube supports students in understanding complex concepts, reinforcing course materials and developing multifaceted perspectives on topics across different disciplines. In addition to this many patients and families utilize. YouTube to learn more about their disease and available treatment options.[1] This situation supports individuals' active participation in their own treatment processes, increases health literacy and strengthens awareness in therapeutic processes. Furthermore, physiotherapists sharing educational materials via YouTube contributes to the widespread dissemination of clinical knowledge and ensures that current approaches to electrotherapy reach wider audiences.

Developing digital technologies and social networking sites offer people opportunities to learn and collaborate without time and space restrictions.[4,5] Social networking tools are now a part of medical education and allow people to obtain information, stay up to date, present their knowledge to others, communicate with others effectively and instantly develop a sense of community,[6,7] and control video content characteristics, including speed and time.[8,9]

In medical education, students reported high levels of satisfaction with the brevity and conciseness of educational videos, ease of access and use, and the ability to watch videos in a variety of settings to support clinical experiences and reinforce their learning.[10] YouTube also has easy-to-use feedback tools. Viewers can comment on videos to review and discuss the content, share additional resources, or ask and answer questions through forums, and they also support the content by using the like feature.[11] Because this platform is free and easily accessible, students and academicians have increasingly begun to combine YouTube videos with other medical education resources to meet their learning needs.[12] In addition, the fact that it has many advantages such as being easily accessible, being able to share videos on social media, and allowing options for commenting, liking, and disliking has increased the interest of publishers in YouTube.[11] Unfortunately, it has been stated that the popularity of YouTube videos does not depend on the quality and educational value of the video, but on the viewing rate, number of comments and likes.

On the other hand, there are concerns about the quality and reliability of the content of videos uploaded to YouTube. Since videos can be uploaded by anyone without verification and many videos are produced for commercial purposes, the information contained in the video content and the accuracy of this information can be questioned.[13,14] Considering all these conditions there is a constant need to evaluate the quality of YouTube's health-related videos. A research investigation of You Tube videos on a variety of topics found that YouTube can provide high-quality health-related information, but can also provide conflicting and misleading health-related information.[15] There are a large number of videos on Electrotherapy education on the YouTube Video platform, and it is important to determine the quality and reliability of these videos in order to be used as educational content.

As a result of our literature review, we could not find any study on You Tube using as a electrotherapy education platform. In the current literature, a study was conducted to evaluate the reliability and quality of YouTube videos as an information source for Transcutaneous Electrical Nerve Stimulation (TENS),[16] but no study examining the reliability and quality of YouTube videos in electrotherapy education could be found. The aim of this study is to evaluate the quality and reliability of YouTube videos in electrotherapy education.

The hypothesis of our study; YouTube platform can be used in electrotherapy education consists of high quality and reliable videos.

METHODS

This research was designed as a descriptive study and was conducted at Hasan Kalyoncu University. YouTube was searched with the keywords " electrotherapy in physiotherapy", " electrotherapy in physiotherapy lecture", and "electrotherapy in physical therapy and rehabilitation" for this research on 16-17 June 2023. The search was conducted in English, and each keyword was written separately and all related videos were identified. Since the information analyzed in this study was publicly accessible on YouTube, ethical approval was not obtained.

The video uploaders were divided into 4 categories: (1) physicians, (2) physiotherapist, (3) medical companies, (4) independent users.

Selection of keywords

There are no standardized guidelines for keyword selection in studies analyzing YouTube content; therefore, researchers typically determine keywords based on their own criteria. To enhance the generalizability of the findings and reduce potential selection bias, a systematic review of multiple databases was conducted to identify the most frequently used terms related to electrotherapy. The keyword selection process was carried out independently by three physiotherapists with expertise in the field, Two of them held doctoral degrees in physiotherapy and rehabilitation. Each researcher performed the search on a separate computer to ensure objectivity. The final set of keywords was determined through a consensus-based approach, incorporating expert input to strengthen methodological rigor and reproducibility.[17]

Data collection and eligibility criteria

The inclusion criteria were defined as YouTube videos that (1) matched the predefined keywords ("electrotherapy in physiotherapy", "electrotherapy in physiotherapy lecture", and "electrotherapy in physical therapy and rehabilitation"); (2) were presented in English; (3) contained educational or clinical information related to electrotherapy-including its principles, therapeutic techniques, applications, or safety considerations-within physiotherapy and rehabilitation practice; (4) demonstrated adequate audiovisual quality; (5) included narration or visual explanation provided by a physiotherapist, educator, or healthcare professional to ensure the reliability of the content; and (6) had a duration between 30 seconds and 30 minutes, as viewer engagement tends to decline significantly in longer videos.

Videos were excluded if they were duplicated, unrelated to the study topic, or inaccessible during the data collection process. The applied search strategy and eligibility criteria were consistent with those used in previous. YouTube-based content analyses. In total, 28 videos meeting the inclusion criteria were analyzed in this study.

Video selection

The previous browsing history and cookies were cleared before the search. A total of 150 top videos were aimed to be examined and saved in a separate playlist. Fifty top videos were targeted for each keyword, which has been reported to be a feasible method of video selection in the literature. Previous research has shown that individuals tend to watch the first videos listed on any media server.[18,19] The number of views on the YouTube videos was used to search for them. As a result, the videos with the greatest views were shown first. Links to the videos were recorded by the researchers. The study was completed within two days. During the viewing of the videos, the researchers scored them independently in different environments.

Evaluation of the videos

The reliability and quality of the videos were evaluated by two independent physiotherapists (ED, NY) Discrepancies between the scores of the two researchers were determined. In case of any disagreements, a consensus discussion was held to resolve them. To ensure inter- and intra-rater reliability of the customized scoring system, the same reviewers re-evaluated 28 videos 2 weeks after the initial assessment, which were selected using a simple random sampling method. Additionally, these videos were evaluated by the third researcher (DK) without knowing the scores of the other two researchers. Finally, the final decision was reached. Inter-rater reliability was calculated for DISCERN and Global Quality Scale (GQS) scores as described as below.[20,21]

Review

The characteristics of videos (number of views, duration, days, years of upload, number of likes and dislikes, comments) were recorded. The number of likes, dislikes, and comments related to the interaction level of the videos was determined. The engagement rate was calculated with the following formula: number of views/day. The like ratio was calculated with the following formula: likes × 100/(likes + dislikes).

Video quality

The quality of the videos was evaluated by GQS. The scale was created by Bernard et al. The scoring system of this scale is based on the usefulness, flow, and quality of the video for the target individual who will potentially watch the video.[22] This scale was designed to evaluate the content quality of online resources. It is a Likert-type scale. It evaluates between a minimum of 1 and a maximum of 5 points. A score of 4 or 5 indicates that the video has high quality, a score of 3 indicates that it has medium quality, and a score of 1 or 2 indicates that it has low quality.[20]

Reliability of videos

The reliability of the videos was evaluated with modified DISCERN. The scale is created to examine the quality of written health information. Each question of this instrument, which consists of 5 items, is answered "yes" or "no". Each yes answer receives 1 point, and the maximum score is 5. Higher scores indicate greater reliability.[21]

In addition, the video contents were categorized and analyzed according to specific electrotherapy-related themes, such as types of currents. This classification allowed for a more systematic and comprehensive evaluation of the educational and clinical aspects presented in the videos.

Statistical analysis

The normality of data was analyzed with the Shapiro-Wilk test. The data were expressed as median (min-max) for continuous variables and number (n) and median for categorical variables. Cohen's Kappa coefficient of agreement was used to measure the degree of agreement of the reviewed video between two investigators. The Statistical Package for Social Science version 22.0 (IBM Corp. Armonk, NY, USA) was used for analysis. A P-value of <.05 was considered significant.

RESULTS

In a YouTube search on 16-17 June 2023, a total of 150 videos were reviewed in the current study. 39 non-English language videos, 11 poor quality (voice or resolution) videos, 4 repetative videos, 34 duplicated videos, 5 irrelevant content videos and 11 videos with inappropriate time were excluded. The level of agreement between the two investigators was good regarding classifying the videos as reliable and no reliable (Kappa coefficient: 0.904). The remaining 28 videos were assessed in this study. Inter-observer agreement was 0.86 and 0.92 for DISCERN and GQS scores, respectively. The flow chart of the video selection process is shown in Figure 1.

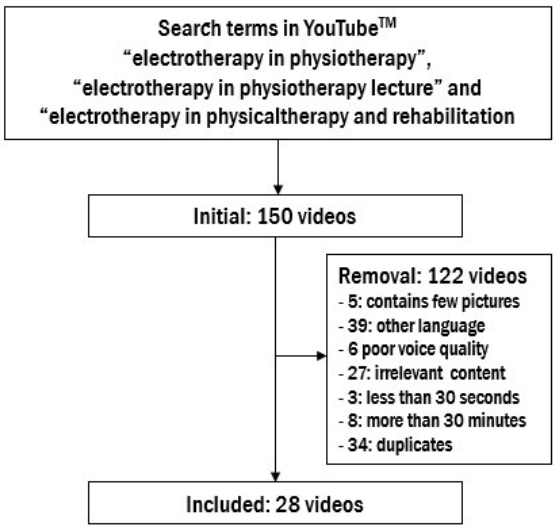

Figure 1. The flow chart of the video selection process

Video characteristics

In our study conducted on the YouTube platform, it was determined that videos containing the keywords we selected for electrotherapy and meeting the inclusion criteria were uploaded between 2020 and 2023.Videos had a median of 6314 views (range 178 to 80,177), with all analyzed videos together being viewed 647,180 times. There were no dislikes in any videos. Electrotherapy education videos available on YouTube received 775

comments. The video duration, knowledge of upload, amounts of views, likes, dislikes, comments, and like ratio are given in Table 1.

Table 1. Video characteristics.

	Median	Min-Max
Video duration (minutes)	6.58	2.01-12.47
Months since upload	48	12-264
Views	6314	178-80177
Likes	3.5	0-19.000
Dislikes	0	0
Comments	0	775
Like rate	100	0-100
Global Quality Scale (GQS)	3	2-4
DISCERN Total	3	2-5

There are six categories of video uploaders in this study. The types of organizations that upload videos with Electrotherapy videos were most commonly uploaded by physiotherapist. Doctors uploaded the lowest number of videos. Independent user has no videos. It was found that physiotherapist uploaded the highest quality videos. The video quality details by GQS and knowledge of video uploaders are given in Table 2.

Video quality evaluation with DISCERN scores and Global Quality Score (GQS)

Videos were assessed for user-focused video quality using the DISCERN instrument, where the average total score was 3 (range 0 to 5). Question-based clustering of the questionnaires examining video quality is demonstrated in Table 3. Two videos received a score of 0 on the DISCERN assessment, while three videos included all questions from the survey and achieved a score of 5. According to DISCERN, the most basic problem in videos is that they are no additional sources of information listed. The distribution of responses according to the DISCERN scoring and the quality of the videos according to the GQS are presented together in Table 3. The responses clustering demonstrated that many videos achieved high scores according to GQS.

Content of electrotherapy methods

The distribution of treatment methods in articles published on YouTube in the field of electrotherapy is presented in Table 4. The largest segment in the chart represents electrical stimulation, which was the most studied and discussed method in the field of electrotherapy (50%). Other video content topics were distributed as follows: TENS (25%), combined electrotherapy applications (20%), iontophoresis (10%), biofeedback (5%), Shortwave Diathermy (SWD) (5%), shock therapy (5%), and paraffin therapy (5%).

DISCUSSION

In the digitalized world, driven by the expectations of Generation Z, technology has become an essential tool in the field of education. With advancements in global technology, education has extended beyond traditional classroom settings and has increasingly embraced digital platforms [23]. A key reason for this transition is that Generation Z tends to favor interactive and non-traditional approaches to learning.[24]

In recent years, YouTube has transcended its initial role as an entertainment platform and has emerged as an educational resource across various domains, including academic subjects, hobbies, and cultural topics.[25]

Electrotherapy education comprises both theoretical knowledge and practical skills. The theoretical concepts taught in class are expected to be integrated with hands-on practice and applied in clinical settings. While students typically receive device-related information from course instructors during practical sessions, opportunities to practice and reinforce this knowledge outside the classroom are often limited. This limitation arises due to factors such as the cost, size, and safety requirements of the devices, which are typically available only in specialized laboratories. Consequently, there is a growing need for visual materials that enable students to revisit and reinforce their practical applications.[26]

Practical demonstrations performed by experts using devices commonly encountered in clinical settings play a crucial role in reinforcing course content and supporting repeated practice. Short, focused, and comprehensible videos that align with the learning outcomes of the course can be used by students for

Table 2. Video quality assessment according to the Global Quality Scale by source group.

	Poor Quality (n=9)	Moderate Quality (n=12)	High Quality (n=7)	Total (n=28)
Sources	n	n	n	n
Doctor	-	1	-	1
Physiotherapist	4	6	5	15
Hospital/Clinic	3	4	2	9
Patient	-	-	-	0
Medical Company	2	1	-	3
Independent user	-	-	-	0

Table 3: Question-based clustering of the questionnaires according to video quality

	Q 1	Q 2	Q 3	Q 4	Q 5	DISCERN Total	GQS (Quality)
1.	Yes	No	Yes	No	Yes	3	3 (Moderate Q)
2.	Yes	Yes	Yes	Yes	Yes	5	5 (High Q)
3.	Yes	No	Yes	No	No	2	4 (High Q)
4.	Yes	No	Yes	No	Yes	4	5 (High Q)
5.	Yes	No	Yes	No	No	2	4 (High Q)
6.	No	No	No	No	No	0	2 (Low Q)
7.	Yes	No	Yes	No	No	2	3 (Moderate Q)
8.	No	No	No	No	No	0	2 (Low Q)
9.	Yes	No	No	No	No	1	3 (Moderate Q)
10.	Yes	No	Yes	No	Yes	3	3 (Moderate Q)
11.	Yes	No	Yes	No	Yes	3	3 (Moderate Q)
12.	Yes	No	Yes	No	Yes	3	3 (Moderate Q)
13.	Yes	No	Yes	No	Yes	3	3 (Moderate Q)
14.	Yes	No	Yes	No	No	2	3 (Moderate Q)
15.	Yes	No	Yes	No	No	2	2 (Low Q)
16.	Yes	No	Yes	No	No	2	2 (Low Q)
17.	Yes	No	Yes	No	Yes	3	2 (Low Q)
18.	Yes	No	No	No	Yes	2	4 (High Q)
19.	No	Yes	Yes	No	Yes	3	2 (Low Q)
20.	Yes	No	Yes	No	Yes	3	3 (Moderate Q)
21.	Yes	Yes	Yes	No	Yes	4	3 (Moderate Q)
22.	Yes	No	Yes	Yes	No	3	2 (Low Q)
23.	Yes	Yes	Yes	Yes	Yes	5	4 (High Q)
24.	Yes	Yes	Yes	No	Yes	4	4 (High Q)
25.	Yes	Yes	Yes	No	Yes	4	3 (Moderate Q)
26.	Yes	Yes	Yes	Yes	Yes	5	2 (Low Q)
27.	Yes	Yes	Yes	No	No	3	3 (Moderate Q)
28.	Yes	Yes	Yes	Yes	No	4	2 (Low Q)

Table 4. Distribution of electrotherapy methods.

Electrotherapy method	n (%)
Electric stimulation	11 (40)
TENS	6 (20)
Combine method	5 (16)
Shockwave therapy (ESWT)	2 (8)
Shortwave diathermy	1 (4)
Biofeedback	1 (4)
Iontophoresis	1 (4)
Paraffin	1 (4))

independent study and can also be recommended by instructors as supplementary materials. Such instructional content enables learners to progress at their own pace and helps detach the learning process from time and place restrictions. In this way, practice-based topics can be reviewed as often as needed in an online environment, contributing to more permanent and meaningful learning.[27]

In this context, the present study aimed to evaluate the quality and reliability of YouTube videos as educational resources for electrotherapy.

The YouTube videos included in the study were created by physiotherapists, which aligns with the fact that electrotherapy is a primary domain of physiotherapy students and professionals.[28] Other healthcare professionals and assistants, apart from physiotherapists and physical therapy technicians, do not generally utilize this method. Therefore, it is both reliable and appropriate for such videos to be created and uploaded by these professional groups.

A prior study examined the perspectives of physical therapy graduates on electrotherapy education. According to the findings, graduates emphasized the importance of covering topics such as ultrasound, hot pack, cold pack, shortwave diathermy, paraffin therapy, TENS, interferential current, electrical stimulation, and iontophoresis within electrotherapy courses (28). In the current analysis, the most commonly covered topics in the YouTube videos included electrical stimulation, TENS, combined electrotherapy applications, iontophoresis, biofeedback, shortwave diathermy, shock therapy, and paraffin therapy. This overlap suggests that the electrotherapy-related video content on YouTube largely meets the expectations of physical therapy graduates.

The findings of the present study are consistent with our initial hypothesis, which assumed that the YouTube videos used in electrotherapy education would demonstrate an acceptable level of quality and reliability. Although only a limited number of videos met the inclusion criteria, those selected videos were of sufficient educational value and aligned well with the needs of electrotherapy training. From an educational perspective, these results highlight the importance of carefully curated and evidence-based video content as a supportive tool for students, particularly in skill-oriented courses with limited laboratory time. When integrated into the learning process, structured online videos have the potential to reinforce knowledge, enhance self-paced learning, and contribute to competency-based electrotherapy education.

To ensure optimal quality, videos were evaluated based on predefined criteria, resulting in only 19% of the videos being included in the study. While the videos that met the criteria demonstrated high quality and reliability, the limited number highlights the need to enhance existing content in terms of material quality, narration, and visual presentation. Therefore, it is recommended that future video content be enriched to better support educational objectives.

Limitations

Certain limitations of this study should be acknowledged. The subjective scales utilized in the study may have been influenced by the personal perceptions and opinions of the evaluators. However, as no standardized quantitative method exists for this purpose, similar criteria have been commonly employed in previous studies. Another notable limitation pertains to the timing of the video assessments. YouTube is a dynamic platform where millions of new videos are uploaded daily, and the characteristics of these videos can change over time. Consequently, the findings of this study are confined to a specific time frame. Future research should consider this dynamic nature and analyze the same videos at different time points to assess potential changes over time.

Conclusion

YouTube appears to be a valuable platform

for making application-based electrotherapy techniques more comprehensible, leveraging contemporary technological tools. However, there remains a need to increase the number of high-quality videos available on the platform. Additionally, newly uploaded videos should be further enriched to maximize their educational impact.

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ORIGINAL ARTICLE

Reliability of tele-evaluation of Timed Up and Go, Single Leg Stand, and 30 s Sit to Stand Tests in patients with low back pain

Bel ağrısı olan hastalarda Zamanlı Kalk Yürü, Tek Ayak Üzerinde Durma ve 30 Saniye Otur Kalk Testlerinin tele-değerlendirmesinin güvenirliği

Muhammed Zahid UZ[1], Hayriye YILMAZ[2], Bilge KARA[3]

Abstract

Purpose: This study aimed to examine the reliability of the Timed Up and Go (TUG), Single Leg Standing (SLS), and 30-Second Sit-to-Stand (30STS) tests, both between different raters (inter-rater) and within the same rater (intra-rater), when administered through face-to-face and tele-evaluation methods in individuals with low back pain (LBP).
Methods: Fifty individuals diagnosed with LBP and meeting the inclusion criteria participated in the study. Detailed demographic characteristics, including age, sex, and body mass index (BMI), were recorded. Functional tests were conducted both in a traditional face-to-face setting and under synchronous (real-time) and asynchronous (recorded) tele-evaluation conditions.
Results: Inter-rater reliability between face-to-face and tele-evaluation methods was found to be very high (TUG: ICC=0.999; SLS: ICC=0.998; 30STS: ICC=0.996). Similarly, inter-rater reliability between two tele-evaluation sessions was also excellent (TUG: 0.997; SLS: 0.999; 30STS: 0.999). Intra-rater reliability, representing repeated measurements by the same rater, was also high in synchronous tele-evaluations, with ICC values of 0.997, 0.925, and 0.924 for TUG, SLS, and 30STS, respectively.
Conclusions: The TUG, SLS, and 30STS tests demonstrated high reliability in tele-evaluation applications among individuals with LBP. These findings indicate that the tests are valid, feasible, and clinically useful tools for standardized, safe, and remote evaluation of functional capacity in a home environment.
Keywords: Low back pain, Telemedicine, Telerehabilitation, Reliability.

Öz

Amaç: *Bu çalışmanın amacı, bel ağrısı olan bireylerde Zamanlı Kalk-Yürü (Timed Up and Go; TUG), Tek Ayak Üzerinde Durma (Single Leg Standing; SLS) ve 30 Saniye Otur-Kalk (30-Second Sit-to-Stand; 30STS) testlerinin, hem aynı değerlendirici hem de farklı değerlendiriciler arasında, yüz yüze ve tele-değerlendirme yöntemleriyle güvenirliğini incelemekti.*
Yöntem: *Çalışmaya, bel ağrısı tanısı almış ve dahil edilme kriterlerini karşılayan 50 birey katıldı. Katılımcıların yaş, cinsiyet ve beden kitle indeksi (BKİ) gibi ayrıntılı demografik verileri kaydedildi. Fonksiyonel testler hem geleneksel yüz yüze ortamda hem de senkron (eş zamanlı) ve asenkron (farklı zamanlı) tele-değerlendirme koşullarında uygulandı.*
Bulgular: *Yüz yüze ve tele-değerlendirme yöntemleri arasında farklı değerlendiriciler arası (inter-değerlendirici) güvenirlik çok yüksek bulundu (TUG: ICC=0,999; SLS: ICC=0,998; 30STS: ICC=0,996). İki tele-değerlendirme oturumu arasındaki farklı değerlendiriciler arası (inter-değerlendirici) güvenirlik de oldukça yüksekti (TUG: 0,997; SLS: 0,999; 30STS: 0,999). Aynı değerlendirici tarafından yapılan tekrar ölçümler arasındaki (intra-değerlendirici) güvenirlik, senkron tele-değerlendirmede TUG, SLS ve 30STS için sırasıyla 0,997, 0,925 ve 0,924 olarak bulundu.*
Sonuç: *TUG, SLS ve 30STS testleri, bel ağrısı olan bireylerde tele-değerlendirme uygulamaları açısından yüksek düzeyde güvenirlik sergilemiştir. Bu bulgular, söz konusu testlerin fonksiyonel kapasitenin ev ortamında uzaktan, güvenli ve standardize bir biçimde değerlendirilmesi için geçerli, uygulanabilir ve klinik olarak yararlı araçlar olduğunu göstermektedir.*
Anahtar kelimeler: *Bel ağrısı, Tele-tıp, Tele-rehabilitasyon, Güvenirlik.*

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INTRODUCTION

Low back pain (LBP) is defined as discomfort or pain occurring between the lower rib margins and the gluteal folds, with or without radiating symptoms to the lower extremities. It represents one of the most prevalent musculoskeletal disorders globally and is a major cause of disability, work loss, and reduced quality of life.[1] According to the Global Burden of Disease Study, more than 80% of adults experience at least one episode of LBP during their lifetime, and recurrence rates are high. The persistent nature and economic consequences of LBP make it an important public health problem.[1-3]

Conventional management of LBP primarily involves physical therapy and rehabilitation. However, access to such services is often limited-particularly in rural or underserved areas-due to workforce shortages, mobility limitations, and economic barriers.[2] These challenges have stimulated the development of telerehabilitation, an emerging approach that enables healthcare providers to deliver physiotherapy and monitoring remotely through video conferencing and digital tools.[2-4] Telerehabilitation offers advantages such as increased accessibility, reduced travel costs, and continuity of care during situations like the COVID-19 pandemic.[5,6]

In physical rehabilitation, objective and reliable functional tests are essential for evaluating a patient's mobility, balance, and overall functional status.[4] Among the most widely used are the Timed Up and Go (TUG), Single Leg Stand (SLS), and 30-Second Sit-to-Stand (30STS) tests. The TUG assesses functional mobility and dynamic balance by measuring the time needed to stand up, walk 3 m, turn, and sit down again.[7,8] The SLS evaluates static balance and postural control,[9] while the 30STS measures lower-limb muscle strength and endurance.[10-12] These tests are practical, inexpensive, and easily applicable in both clinical and tele-based contexts.[13,14]

Although numerous studies have verified the reliability of these tests in traditional face-to-face evaluations, their reliability under tele-evaluation conditions remains limited.[13,15,16] Recently, Ozsoy and Uz demonstrated excellent tele-reliability of the TUG and five-repetition sit-to-stand tests in individuals with chronic non-specific low back pain.[17] Similarly, Bowman et al. confirmed the feasibility and safety of remote administration of the 30STS test,[18] and Karim et al. verified the practicality of tele-TUG in older adults.[19] These studies suggest that tele-evaluation can be a valid tool for functional performance measurement;[20,21] however, evidence among individuals with LBP is still scarce.

Therefore, this study aimed to investigate the intra-rater and inter-rater reliability of the TUG, SLS, and 30STS tests when administered via tele-evaluation in individuals with LBP. By comparing face-to-face and tele-based outcomes, this research sought to determine whether these tests could be safely and reliably integrated into telerehabilitation programs.[6,22,23]

METHODS

Study design and ethical considerations

This methodological reliability study was conducted at the Department of Physical Therapy and Rehabilitation, University of Health Sciences İzmir Bozyaka Training and Research Hospital. The research protocol was approved by the institutional ethics committee (Approval No: 2022/142; October 19, 2022) and complied with the ethical principles of the Declaration of Helsinki.[24] All participants signed informed consent forms prior to participation.

Participants

A total of 50 participants (33 female, 17 male) with LBP were recruited using simple random sampling. Randomization was generated by computer to minimize evaluator bias[38]. Participants were aged between 18 and 65 years (mean±SD = 52.4±7.1 years) and had experienced pain for at least three months.

Inclusion criteria

- Age between 18-65 years
- Body mass index (BMI) < 30 kg/m²
- Literate and able to follow instructions
- Basic smartphone skills sufficient for video calls
- Voluntary participation

Exclusion criteria

- History of spinal surgery or major orthopedic intervention

- Structural spinal pathologies (scoliosis, kyphosis, spondylolisthesis)
- Neurological, metabolic, vascular or psychiatric disorders affecting balance or mobility
- Uncontrolled cardiopulmonary conditions
- Inability to complete the test protocol or withdrawal from the study

Demographic and clinical data collected included age, sex, height, weight, BMI and dominant side.

Evaluation tools

Oswestry Disability Index (ODI)

"The Oswestry Disability Index (ODI) is used to determine the degree of functional limitation caused by LBP, providing a standardized measure of how the condition affects daily activities. The ODI assesses functional disability related to LBP across ten items (0-5 scale per item). Scores are converted to percentages (0-100%), with higher values indicating greater disability.[4,13]

Timed Up and Go (TUG)

This functional assessment evaluates the time required for an individual to rise from a standard chair, walk 3 meters at a usual walking speed, turn around, return to the starting point, and sit down again. Participants' performance was recorded in seconds using a stopwatch, and this measurement served as the primary outcome variable.[7] In line with established guidelines for conducting evaluations in the home environment, the appropriate chair dimensions for the TUG test were predetermined. These required measurements were communicated to all participants, and chairs that met the optimal specifications were identified based on the participants' feedback.

Single Leg Stand (SLS)

Participants stood on their preferred leg while crossing arms over the chest; time was recorded until the raised foot touched the floor or arms moved for balance.[9] Participants who achieved a score of less than 10 seconds on their first attempt were allowed to repeat the test. When necessary, they were given a rest period between trials to allow sufficient recovery. This test assessed static postural control.

30-Second Sit-to-Stand (30STS)

The 30STS test measured lower-limb strength and endurance.[10-12] Participants stood up and sat down as many times as possible within 30 seconds from a 43 cm-high chair placed against a wall for safety. Participants completed the test three times, and the highest number of repetitions among the trials was documented as the final score. When necessary, they were permitted to rest for more than 5 minutes between trials to allow adequate recovery.

Procedures

Each participant was evaluated under both face-to-face and tele-evaluation conditions to compare reliability between methods.[8-10] Tele-evaluations were conducted via *WhatsApp* video calls in two forms: *Synchronous* (real-time supervised session by Evaluator 1), Asynchronous (video recordings analysed later by Evaluator 2).

Evaluator 1 initially performed all evaluation face-to-face in the clinical environment.

The same evaluation procedures were subsequently repeated remotely and synchronously by Evaluator 1.

The video recordings generated during these remote evaluations were reviewed asynchronously by Evaluator 2.

During the retest phase, Evaluator 1 again conducted the evaluation via synchronous tele-evaluation.

The recordings from the retest session were also evaluated asynchronously by Evaluator 2.

Face-to-face evaluations were performed in the clinic by Evaluator 1. The evaluation procedure is visually outlined in Figure 1.

The smartphone camera was placed horizontally at hip height, 3 m from the participant, ensuring the entire movement remained visible during testing.[18,19] Each participant performed three trials per test; the mean of the trials was used for analysis. Rest periods of ≥ 5 minutes were provided between tests to prevent fatigue. A second evaluation session was performed 24-48 hours later to assess test-retest reliability.[25]

Statistical analysis

Data analysis was performed using IBM SPSS Statistics v25. Normality was checked using the Kolmogorov-Smirnov test and histograms.[26]

COnsensus-based Standards for the Selection of Health Measurement Instruments (COSMIN) guidelines provide a qualitative

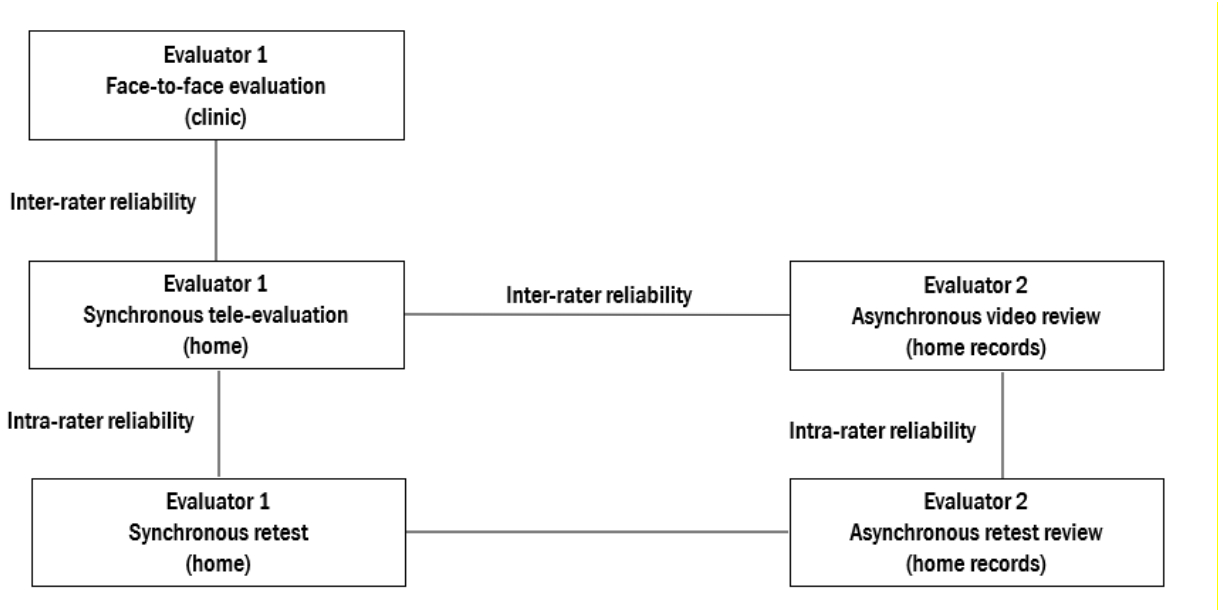

Figure 1. Evaluation procedure of the study.

rating framework in which a sample size of approximately 50 participants is categorized as 'adequate' for reliability studies.[24] Accordingly, in the present study, the selection of 50 participants was not based on a formal sample size calculation but was guided by COSMIN's indication of an acceptable minimum sample size for reliability research. This approach aligns with recommended methodological standards for conducting validity and reliability analyses.[24]

Reliability was evaluated using the Intraclass Correlation Coefficient (ICC) and Bland-Altman plots:[27]

- Intra-rater reliability: two-way mixed-effects model
- Inter-rater reliability: two-way random-effects model

Interpretation of ICC values was as follows: <0.50=poor, 0.50-0.75=moderate, 0.75-0.90=good, >0.90=excellent. The Standard Error of Measurement (SEM) and Smallest Detectable Change (SDC95%) were computed using established formulas.[26]

$SEM = SD * \sqrt{1-R}$

$SEM95\% = SEM * 1.96$

$SDC95\% = SEM95\% * \sqrt{2}$

Systematic differences between sessions were examined using repeated-measures ANOVA.[38] A p-value<0.05 was considered statistically significant.

RESULTS

Sixty patients with a diagnosis of LBP who met the inclusion criteria were initially enrolled in the study. However, ten participants were excluded due to relocation or failure to complete the tele-evaluation process (Figure 2.) Consequently, the evaluation was completed for fifty patients. The mean age of the participants was 52.4±7.1 years, and 66% (n=33) were female. Detailed demographic characteristics of the participants are provided in Table 1.

Each participant successfully performed the Timed Up and Go (TUG), Single Leg Stand (SLS), and 30-Second Sit-to-Stand (30STS) tests, both through face-to-face clinical evaluation and tele-evaluations conducted in the home environment. The descriptive results of these functional evaluations are summarized in Table 2.

Inter-Rater Reliability

The study demonstrated high inter-rater reliability between the face-to-face and tele-evaluation methods for all three functional tests. The statistical models revealed exceptionally high levels of agreement between

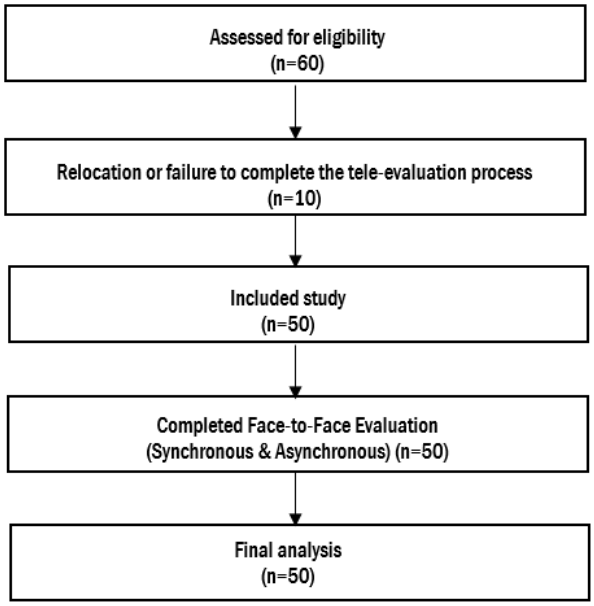

Figure 2. Flow chart of the study.

in-person and tele- evaluation results: TUG (ICC=0.999), SLS (ICC=0.998), and 30STS (ICC=0.996).

Evaluator experience was standardized to ensure consistency: the first tele-evaluator had 16 years of clinical physiotherapy experience, and the second had 14 years. Between these two tele-evaluators, the inter-rater reliability was also excellent: TUG (ICC=0.963), SLS (ICC=0.995), and 30STS (ICC=0.983).

Analysis of Bland-Altman plots (*Figures 3-5*) showed no systematic bias or trend, indicating the absence of proportional error or drift between in-person and tele- evaluation outcomes. A comprehensive summary of inter-rater reliability values, including ICC, 95% confidence intervals (CI), standard error of measurement (SEM), SEM 95%, and smallest detectable change (SDC 95%), is presented in Table 3.

Intra-Rater Reliability

The results from two-way mixed-effects models demonstrated excellent intra-rater reliability for synchronized tele-evaluations: TUG (ICC=0.997), SLS (ICC=0.925), and 30STS (ICC=0.924).

Similarly, the intra-rater reliability of asynchronous (video-based) tele-evaluation was excellent for the TUG (ICC=0.995) and good for both the SLS (ICC=0.807) and 30STS (ICC=0.839) tests. Visual inspection of Bland-Altman plots again showed no systematic differences, confirming measurement stability across sessions.

Repeated-measures ANOVA further indicated no significant differences between the two synchronized tele-evaluation sessions for the TUG (F=2.590, p=0.116), SLS (F=1.640, p=0.202), and 30STS (F=1.487, p=0.223) tests (Figures 3-5).

A detailed summary of the intra-rater reliability metrics for all three functional evaluations is provided in Table 3.

Overall, both synchronous and asynchronous tele-evaluation methods yielded reliability levels comparable to face-to-face evaluations for the TUG, SLS, and 30STS tests. The high intra- and inter-rater agreement supports the methodological robustness of tele-evaluation procedures in individuals with LBP. These results also highlight the consistency of test performance irrespective of evaluator experience and testing environment, aligning with the literature on remote functional evaluation reliability.

Table.1 Descriptive characteristics of patients.

	Mean±SD
Age (years)	52.4±7.1
Height (m)	1.66±0.08
Weight (kg)	81.6±13.2
Body mass index (kg/m²)	29.59±4.92
Oswestry Disability Index	54.6±9.1
	n (%)
Gender	
Male	17 (34)
Female	33 (66)
Educational status	
Illiterate	1 (2)
Primary-secondary education	37 (74)
High school	9 (18)
University	3 (6)
Social security	
Yes	48 (96)
No	2 (4)
Marital Status	
Married	48 (96)
Single	2 (4)
Dominant Side	
Right	44 (88)
Left	6 (12)

Table.2 Range of data of all evaluations of the tests.

	Face-to-face evaluation in clinic	Tele- evaluation in home (synchronized)	Retest tele-evaluation in home (synchronized)	Evaluation in home from video records (asynchronized)	Retest evaluation in home from video records (asynchronized)
	Evaluator 1	Evaluator 1	Evaluator 1	Evaluator 2	Evaluator 2
	Mean±SD	Mean±SD	Mean±SD	Mean±SD	Mean±SD
TUG (sec)	9.31±2.42	9.30±2.46	9.33±2,42	9.71±2.48	9.78±2.31
SLS (sec)	26.92±24.27	26.90±24.25	26.93±24.27	25.44±24.28	24.40±22.72
30STS (n)	9.78±2.36	9.74±2.30	9.78±2.36	9.70±1.98	9.58±2.13

n: number of repetitions. TUG: Timed Up and Go Test. SLS: Single Leg Stance Test. 30STS; 30-s Sit-to-Stand Test.

Table.3 Reliability results of the tests.

	ICC (%95CI)	SEM	SEM95%	SDC95%
Inter-reliability between face to face and tele- evaluation				
TUG (sec)	0.999 (0.998-0.999)	0.03	0.06	0.08
SLS (sec)	0.998 (0.997-0.999)	0.18	0.35	0.49
30STS (n)	0.996 (0.994-0.998)	0.03	0.06	0.08
Inter-reliability between two tele-evaluators				
TUG (sec)	0.999 (0.998-0.999)	0.002	0.004	0.006
SLS (sec)	0.999 (0.998-0.999)	0.003	0.006	0.008
30STS (n)	0.990 (0.974-0.996)	0.06	0.012	0.18
Intra rater-reliability of the tele-evaluation (synchronized)				
TUG (sec)	0.997 (0.996-0.998)	2.06	4.03	5.71
SLS (sec)	0.925 (0.863-0.958)	0.11	0.22	0.31
30STS (n)	0.924 (0.871-0.956)	0.11	0.22	0.31
Intra rater-reliability of the tele-evaluation from video records (asynchronized)				
TUG (sec)	0.995 (0.992-0.997)	2.07	4.05	5.73
SLS (sec)	0.807 (0.721-0.908)	0.19	0.37	0.52
30STS (n)	0.839 (0.733-0.905)	0.17	0.33	0.47

ICC: intraclass correlation coefficient. CI: confidence interval. SEM: Standard Error of Measurement (with a 95% confidence interval). SDC: Smallest Detectable Change (with a 95% confidence interval). TUG: Timed Up and Go Test. SLS: Single Leg Stance Test. 30STS:30-s Sit-to-Stand Test. n: number of repetitions.

DISCUSSION

This study evaluated the intra- and inter-rater reliability of three widely used functional tests—TUG, SLS, and 30STS—when performed via tele-evaluation in individuals with LBP. The results revealed good-to-excellent reliability for all tests, confirming that tele-evaluation is a feasible and accurate method for assessing physical performance in this population.[17-19,20,21]

The present findings align with previous research showing that remote administration of functional tests yields consistent and reproducible results. Ozsoy and Uz found excellent reliability for the tele-assessed TUG and sit-to-stand tests in chronic LBP patients.[17] Similarly, Bowman et al. demonstrated that the 30STS test can be safely administered through telehealth platforms,[18] and Karim et al. reported comparable findings for the TUG test in older adults.[19] Together, these studies support the validity of remote performance testing in musculoskeletal and geriatric populations,[22] further reinforcing the consistency observed in the present study.

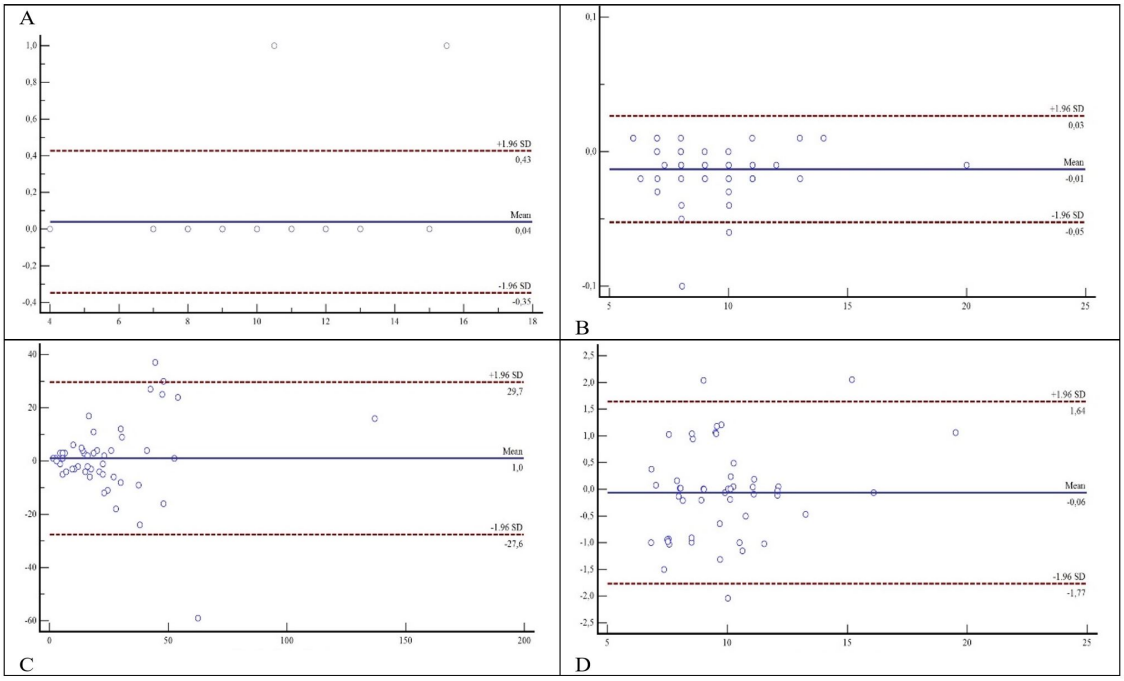

Figure 3. Bland-Altman plots for the Timed and Go Test. The means on the x axis are the average of two trials for the Timed and Go Test, and the differences between Timed and Go Test scores are in the y axis. (A) Inter-reliability between face-to-face and tele-evaluation. (B) Inter-reliability between two tele-raters. (C) Intra-rater reliability of the tele-evaluation (synchronized). (D) Intra-rater reliability of the tele-evaluation from videorecords (asynchronized). The 95% limits of agreement are depicted (dashed line). SD, standard deviation.

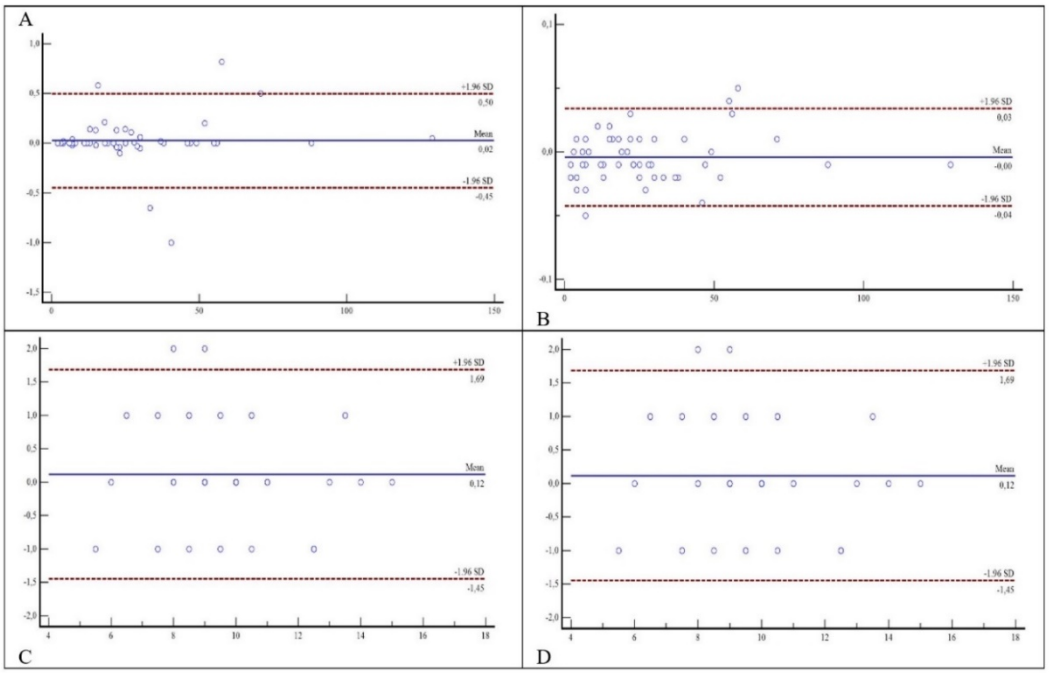

Figure 4. Bland-Altman plots for the Single Leg Stance Test. The means on the x axis are the average of two trials for the Single Leg Stance Test, and the differences between Single Leg Stance Test scores are in the y axis. (A) Inter-reliability between face-to-face and tele-evaluation. (B) Inter-reliability between two tele-raters. (C) Intra-rater reliability of the tele-evaluation (synchronized). (D) Intra-rater reliability of the tele-evaluation from videorecords (asynchronized). The 95% limits of agreement are depicted (dashed line). SD, standard deviation.

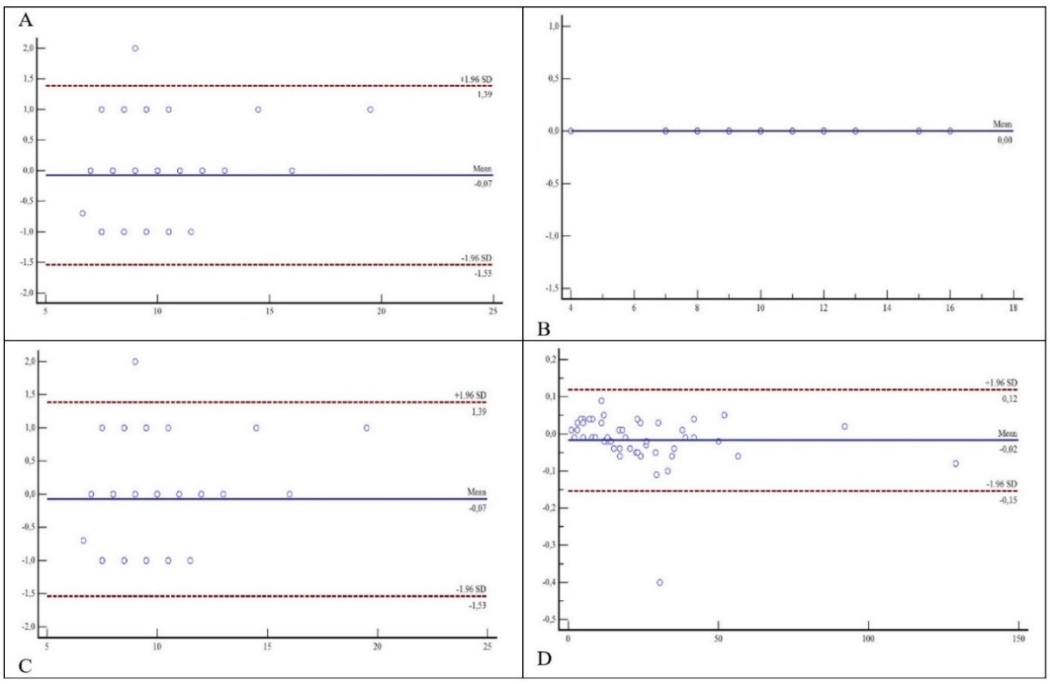

Figure 5. Bland-Altman plots for the 30-s Sit-to-Stand Test. The means on the x axis are the average of two trials for the 30-s Sit-to-Stand Test, and the differences between 30-s Sit-to-Stand Test scores are in the y axis. (A) Inter-reliability between face-to-face and tele-evaluation. (B) Inter-reliability between two tele-raters. (C) Intra-rater reliability of the tele-evaluation (synchronized). (D) Intra-rater reliability of the tele-evaluation from videorecords (asynchronized). The 95% limits of agreement are depicted (dashed line). SD, standard deviation.

The relatively lower ICC values observed for the SLS test appear to be associated with limitations in camera angles during tele-evaluation and the difficulty of capturing subtle postural adjustments that occur during balance tasks.[9] A similar pattern was noted for the 30STS test, particularly in asynchronous evaluations, where challenges in accurately identifying the start and end points of the movement from video recordings, as well as issues such as reduced resolution and frame drops caused by rapid repetitions, may diminish intra-rater consistency. These findings are in line with previous reports indicating that both static and dynamic balance evaluations are sensitive to visual perspective, camera distance, and environmental factors in tele-evaluation settings.[23,29] Despite these constraints, the acceptable reliability demonstrated by both SLS and 30STS tests in synchronous and asynchronous tele-evaluation formats suggests that, when appropriate camera positioning, adequate lighting, and standardized recording procedures are ensured, these tests remain feasible tools for remote functional evaluation.

Tele-evaluation offers several clinical advantages, such as reduced transportation barriers, improved accessibility for individuals in rural areas, and enhanced patient engagement in home environments.[2,5,6] Furthermore, the reliability demonstrated here suggests that remote evaluation may complement traditional in-person physiotherapy, particularly in follow-up and maintenance phases where continuity of care and convenience are critical.[20,22]

The excellent reliability of TUG and 30STS may stem from their clearly defined start-end actions and high visual detectability of gross motor movements, which minimize interpretation errors.[7,11,12] Conversely, the SLS test requires precise visual feedback to detect subtle sway patterns, explaining its slightly reduced ICC values in asynchronous conditions.[9] These differences highlight the importance of selecting appropriate camera perspectives and ensuring sufficient video

quality when administering balance-focused tests remotely.

The absolute reliability of measurements and tests depends primarily on the precision of repeated test results. SEM and SDC95% are more clinically useful than ICC values because they are expressed in the same units as the instruments. In clinical practice, SDC95% can aid in categorizing research participants as either 'changed' or 'unchanged'. For instance, in the context of synchronous tele-SLS, SEM95% was determined to be 0.22 seconds. This indicates that if a patient's SLS score is 10 seconds, the actual score, 95% of the time, will fall within the range of 9.78 to 10.22 seconds. Under the same test conditions, SDC95% was calculated to be 0.31 seconds. Consequently, for a patient with an SLS score of 10 seconds, any score between 9.69 and 10.31 seconds would be considered within the margin of error.[26]

In repeated testing, it is anticipated that 95% of the time, the performance will accurately reflect an 'unchanged' status. However, it is essential to emphasize that these values represent measurement error rather than minimum clinically important difference values. According to the findings from repeated-measures ANOVA analysis, the results of the TUG, SLS, and 30STS tests did not exhibit statistically significant systematic errors, indicating the absence of consistent discrepancies between test trials.[30]

This study also contributes methodologically by providing explicit details on evaluator training, randomization, and camera setup—factors that have been underreported in previous tele-evaluation research.[20,22,26] Additionally, the participants' BMI, which was close to 30 kg/m², might have influenced test performance, as overweight individuals often demonstrate reduced balance and endurance capacity.[1,31]

Consistent with prior systematic reviews, our results reaffirm the feasibility and safety of telerehabilitation in musculoskeletal conditions, while underscoring the importance of standardizing video protocols and environmental parameters.[5,22,28] These findings align with growing evidence that tele-evaluation can deliver outcomes comparable to in-person evaluations,[6,23,32,33] provided that technical and procedural standards are carefully maintained.

Finally, this study adds to the expanding body of literature supporting digital physiotherapy, which has become increasingly relevant in the post-COVID-19 era.[34,35] Ensuring patient privacy, adequate technology access, and user-friendly telehealth interfaces will be essential for the widespread and sustainable implementation of such approaches.[36]

Limitations

This study has several limitations. First, although the sample size (n=50) aligns with COSMIN's recommendations for reliability studies, a larger and more heterogeneous population would enhance the generalizability of the findings. Second, the participants were recruited from a single rehabilitation center, limiting external validity. Third, the mean BMI was close to 30 kg/m², and overweight status might have influenced postural control and endurance. Fourth, tele-evaluation accuracy depends on technical factors such as camera placement, lighting, and internet quality, which may vary across home environments. Fifth, all tests were performed under the supervision of a single research team, which may restrict inter-center comparability. Future studies should include multiple centers and assess test-retest reliability across different time points and devices to enhance generalizability and external validity.

Conclusions

The current study demonstrated that the Timed Up and Go (TUG), Single Leg Stand (SLS), and 30-Second Sit-to-Stand (30STS) tests exhibit good-to-excellent intra- and inter-rater reliability when administered via tele-evaluation in individuals with low back pain. These findings confirm that remote administration of functional performance tests is both feasible and reliable, suggesting that such evaluations may be safely incorporated into telerehabilitation programs.

Tele-evaluation offers significant potential for improving accessibility and continuity of rehabilitation services, especially in rural regions and post-pandemic healthcare settings. Further large-scale studies are warranted to standardize tele-evaluation protocols and determine the long-term clinical utility of digital rehabilitation systems.

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Conflicts of Interest: *None*

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