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Investigation of Hand Grip Strength, Manual Dexterity and Motor Imagery Profiles in Healthy Adult Individual

Sağlıklı Erişkin Bireylerde El Kavrama Kuvveti, El Becerisi ve Motor İmgeleme Profillerinin İncelenmesi

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ÖZET

Amaç: Bu çalışmanın amacı; sağlıklı erişkin bireylerde el kavrama kuvveti, el becerisi ve motor imgeleme profillerinin incelenmesidir.

Gereç ve Yöntemler: Çalışmaya 18-35 yaş arası araştırmaya katılmayı kabul eden 81 sağlıklı erişkin birey dahil edildi. Çalışmaya dahil edilen bireylerin sosyo-demografik bilgileri (yaş, boy, vücut ağırlığı, vücut kitle indeksi, eğitim düzeyi) kaydedildi. Bireylerin el kavrama kuvvet ölçümleri el kavrama kuvvet cihazı ile el becerileri 9 Delikli Peg Testi ve Kutu ve Blok Testi ile değerlendirildi. Bunun yanında bireylerin motor imgeleme becerileri Hareket İmgeleme Anketi-3 ile değerlendirildi.

Bulgular: Çalışmaya dahil edilen bireylerin yaş ortalaması 21,3±2,23 olarak belirlendi. Dominant ve nondominant el kavrama kuvveti ile motor imgeleme arasında ilişki yoktu (sırasıyla; p=0,467, p=0,389). El becerileri değerlendiren 9 Delikli Peg Testi ve Hareket İmgeleme Anketi-3 toplam değeri arasında anlamlı bir ilişki bulundu (r=0,247, p=0,026). Kutu ve Blok Testi ve Hareket İmgeleme Anketi-3 toplam arasında anlamlı bir ilişki saptandı (r=0,279, p=0,012).

Sonuç: Sonuç olarak sağlıklı erişkin bireylerde el becerileri ve motor imgeleme yeteneklerinin ilişkili olduğu bulundu.

Öneriler: Motor imgeleme temelli yaklaşımlar ince el becerilerini geliştirmeye yönelik rehabilitasyon programlarından önemli olabilir. Ayrıca motor imgeleme değerlendirmelerinin klinik protokollere eklenmesi, bireylerin motor planlama ve imgesel hareket kapasitesine dair daha kapsamlı bilgi sağlayabilir.

Anahtar Kelimeler: El Kavrama Kuvveti; El Becerisi; Motor İmgeleme; Sağlıklı Erişkin

ABSTRACT

Aim: The aim of this study is to examine hand grip strength, manual dexterity, and motor imagery profiles in healthy adult individuals.

Method: A total of 81 healthy adults aged between 18 and 35 who agreed to participate in the study were included. The socio-demographic information of the participants (age, height, body weight, body mass index, education level) was recorded. Hand grip strength was measured using a hand dynamometer, while manual dexterity was assessed using the Nine-Hole Peg Test and the Box and Block Test. In addition, participants' motor imagery skills were evaluated using the Movement Imagery Questionnaire-3.

Results: The mean age of the individuals included in the study was 21.3±2.23. There was no relationship between dominant and non-dominant hand grip strength and motor imagery (respectively; p=0.467, p=0.389). A significant relationship was found between Nine-Hole Peg Test and Movement Imagery Questionnaire-3 total values evaluating manual skills (r=0.247, p=0.026). A significant relationship was found between Box and Block Test and Movement Imagery Questionnaire-3 total (r=0.279, p=0.012).

Conclusion: In conclusion, manual dexterity and motor imagery abilities were found to be associated in healthy adult individuals.

Recommendations: Motor imagery-based approaches may play an important role in rehabilitation programmes aimed at improving fine motor skills. Furthermore, incorporating motor imagery assessments into clinical protocols may provide more comprehensive information regarding individuals' motor planning and imagery performance.

Keywords: Hand Grip Strength, Manual Dexterity, Motor Imagery, Healthy Adult

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1. INTRODUCTION

Upper extremity functions are considered one of the key determinants for individuals to maintain independence in daily living activities. Among these functions, hand grip strength and manual dexterity are fundamental components of upper extremity functionality (1). In the literature, hand grip strength has been identified as a strong indicator of an individual's general health status (2). Furthermore, a significant positive relationship has been reported between maximal hand grip strength and functional performance (3). These findings suggest that hand grip strength is not merely a local indicator of muscular force but rather a reflection of overall physical capacity and functional adequacy (3).

Manual dexterity is recognized as a key component in the assessment upper extremity function and is commonly evaluated using various hand function tests (4). Especially in daily life, it plays a crucial role in performing complex motor tasks such as grasping, carrying, and manipulating objects. However, the outcomes of these assessments may vary depending on individual characteristics and the cultural context in which the person lives (5). Therefore, the evaluation of hand function should incorporate not only physiological measures but also personal and environmental factors, ensuring a more comprehensive understanding of manual performance.

Given the functional role of the upper extremity in everyday life, it is crucial for healthy individuals to maintain adequate strength, dexterity, and function in this region to ensure sustainable independence (4). Upper extremity competence affects not only individual motor capacity but also broader aspects such as social participation, occupational performance, and overall quality of life. In the case of potential dysfunction, impairment, or disease, various rehabilitation approaches have been developed to restore upper extremity functions. Among these approaches, motor imagery (MI) is defined as a cognitive process in which a physical movement is mentally simulated without actual execution (6). Also referred to as “mental practice,” MI involves the systematic repetition of a mentally visualized representation of the targeted movement or task (7). MI is considered an effective tool in rehabilitation, as it supports motor learning processes and stimulates neuromuscular pathways.

The process of MI can be categorized into two main types: visual imagery and kinesthetic imagery. Visual imagery involves the mental visualization of a movement, whereas kinesthetic imagery focuses on the somatic sensations associated with the position and movement of muscles and joints (8). Both types of imagery have been shown to activate different neural circuits and positively influence motor performance. Therefore, assessing motor imagery profiles based on individual differences may provide a foundation for developing new strategies related to motor performance (8).

A review of the current literature reveals that studies addressing hand grip strength, manual dexterity, and motor imagery profiles in healthy adults in an integrated manner are quite limited (5). This gap indicates that the relationships among these variables have not yet been adequately explored and that potential interactions warrant further investigation. Accordingly, the aim of this study is to examine hand grip strength, manual dexterity, and motor imagery profiles in healthy adults and to identify possible associations among these variables. The findings of this study are expected to contribute to a better understanding of the interaction between hand functions and cognitive processes, to demonstrate the potential of motor imagery in enhancing functional skills in healthy individuals, and to provide a reference for future rehabilitation-based research.

2. METHODS

A total of 81 healthy individuals aged between 18 and 35 years, who voluntarily agreed to participate in the study and had no serious or chronic health problems (neurological diseases, upper extremity fractures and surgery), were included. Individuals who declined participation, had any chronic or serious health conditions, or had undergone upper extremity fractures or surgical procedures within the past six months were excluded. All assessments were conducted through face-to-face interviews by the researchers at the Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Gaziantep Islam Science and Technology University. Written informed consent was obtained from all participants indicating their voluntary participation in the study.

Ethical approval for the study was obtained from the Non-Interventional Clinical Research Ethics Committee of Gaziantep Islam Science and Technology University with the decision number 329.32.08 (Protocol no: 2023/329). The study was conducted in accordance with the Declaration of Helsinki.

Participants' sociodemographic data were recorded using a personal information form, which was prepared by the researchers based on the literature. This form included data on participants' age, height, body weight, body mass index (BMI), education level, and smoking habits. To assess hand grip strength, a Digital Grip Dynamometer was used; for upper extremity skills, the Nine-Hole Peg Test (9HPT) and the Box and Block Test (BBT) were employed; and to assess motor imagery skills, the Movement Imagery Questionnaire-3 (MIQ-3) was utilized.

Digital Grip Dynamometer: A wireless (Kforce Grip Dynamometer) device with Bluetooth connectivity (compatible with Android 5.0+ and iOS 10.0+) was used to measure hand grip strength. The device weighs 200 grams, measures 141 x 47 x 61 mm, has a wireless range of up to 20 meters, a maximum measurable force of 90 kg, a measurement precision of 100 grams, and offers five hours of usage after two hours of charging. The participant's elbow was positioned in 90 degrees of flexion, with the arm kept close to the body. Participants were asked to grasp the device with their fingers and squeeze it with maximum force when ready. The test was repeated three times for both the right and left hand, and the average value was recorded in kilograms (9).

Nine-Hole Peg Test (9HPT): The 9HPT was used to assess manual dexterity (10). The test consists of a platform with nine holes and nine pegs. The platform was placed directly in front of the participant, with the pegs positioned on the dominant side and the holes on the non-dominant side. After explaining the test rules and allowing a practice trial, participants were instructed to insert the pegs into the holes as quickly as possible and then remove them one by one. The elapsed time was recorded in seconds using a stopwatch. The same procedure was repeated for the non-dominant hand by rotating the platform accordingly.

Box and Block Test (BBT): The BBT is a quick, easy-to-administer, objective, and efficient test that evaluates gross manual dexterity based on performance (time). In this test, 150 wooden blocks, each measuring two point fivecm on each side, are placed on one side of a divided box. The number of blocks transferred from one side to the other within one minute indicates the level of dexterity. The test was performed separately for the right and left hands, and the total number of blocks transferred within one minute constituted the final score (11).

Movement Imagery Questionnaire-3 (MIQ-3): Motor imagery skills of the participants were assessed using the Movement Imagery Questionnaire-3 (MIQ-3) (12). The MIQ-3 measures both kinesthetic and visual

imagery abilities. It consists of 12 items: four for kinesthetic imagery and eight for visual imagery. Each item describes a movement to be imagined. After imagining the movement, participants were asked to rate the clarity of their mental image. Responses were rated on a seven-point Likert scale (one to seven). Higher scores indicate better motor imagery ability. The Turkish validity and reliability of the questionnaire has been established (13).

Statistical Analysis

All statistical analyses were performed using SPSS version 25.0 (IBM SPSS Statistics 25 software, Armonk, NY: IBM Corp.). Continuous variables were expressed as mean ± standard deviation or median (minimum–maximum values), while categorical variables were presented as frequencies and percentages. The Shapiro-Wilk test was used to assess the normality of data distribution. Pearson correlation analysis was employed to examine the relationships between continuous variables. A p value of <0.05 was considered statistically significant. The required sample size for the study was 53 individuals based on a power analysis conducted using G*Power software ($\alpha = 0.05$, power = 0.80, effect size = 1.26) (14).

3. RESULTS

A total of 81 healthy adult individuals participated in the study. Regarding the gender distribution of the participants, %87.7 were female (n=71) and %12.3 were male (n=10).

Regarding dominant hand preference, %97.5 of participants used their right hand (n=79), while %2.5 used their left hand (n=2) as dominant. This distribution indicates that the vast majority of the healthy adult participants were right-hand dominant.

Table 1: Descriptive Characteristics of Participants

		n	%
Gender	Male	10	12.3
	Female	71	87.7
Education	Literate	0	0
	Primary School	0	0
	Middle School	0	0
	High School	72	88.9
	University	1	1.2
	Postgraduate	8	9.9
Dominant Hand	Right	79	97.5
	Left	2	2.5

The mean age of the 81 healthy adult participants was 21.31 ± 2.24 years, ranging from 17 to 29 years. Body mass index (BMI) values ranged from 14.87 to 36.65, with a mean of 22.69 ± 4.35. These findings indicate that the participant group generally falls within the normal weight range.

In hand grip strength measurements, the average hand grip strength of the dominant hand was 23.79 ± 6.91 kg, while that of the non-dominant hand was 21.95 ± 6.73 kg. Hand grip strength was found to be higher in the dominant hand compared to the non-dominant hand.

Regarding the Nine-Hole Peg Test (9HPT) results, the average completion time for the dominant hand was 16.75 ± 1.57 seconds, while it was 18.41 ± 2.17 seconds for the non-dominant hand.

According to the Box and Block Test (BBT) results, the average score was 69.95 ± 7.40 for the dominant hand and 65.57 ± 7.22 for the non-dominant hand.

When examining the Movement Imagery Questionnaire-3 (MIQ-3) scores, the average score for internal imagery was 23.91 ± 3.57, for external imagery 23.86 ± 4.29, and for kinesthetic imagery 21.43 ± 4.17. The overall motor imagery score (MIQ-TOTAL) was 69.21 ± 9.43

Table 2: Descriptive Data on Demographic Characteristics, Handgrip Strength, Manual Dexterity, and Motor Imagery Performance of the Participants

	Mean ± SD	Min - Max
Age	21.3±2.23	17-29
Height (m)	1.65±0.06	1.5-1.84
Weight (kg)	62.2±14.43	40-110
BMI	22.69±4.35	14.87-36.65
Grip Strength Dominant (kg)	23.78±6.91	13.6-47.17
Grip Strength Non-dominant (kg)	21.94±6.72	10.6-43.9
9HPT Dominant (s)	16.74±1.56	12.51-21.39
9HPT Non-dominant (s)	18.4±2.17	12.16-24.08
BBT Dominant (blocks)	69.95±7.39	47-83
BBT Non-dominant (blocks)	65.56±7.22	48-82
MIQ-3 Internal	23.91±3.57	13-28
MIQ-3 External	23.86±4.29	9-28
MIQ-3 Kinesthetic	21.43±4.16	9-28
MIQ-3 Total	69.2±9.43	41-84

BMI: Body Mass Index, 9HPT: Nine-Hole Peg Test, BBT: Box and Block Test, MIQ-3: Movement Imagery Questionnaire-3

In our study, the correlation analysis showed no significant relationship between hand grip strength and manual dexterity assessed by the 9HPT (p=0.759; r=-0.035). Similarly, there was no significant relationship between hand grip strength and BBT results (p=0.658; r=-0.050). There was also no significant relationship between hand grip strength and any of the MIQ-3 parameters—internal, external, kinesthetic—or the total score (p=0.424, p=0.841, p=0.452, p=0.467, respectively).

However, a significant relationship was found between the 9HPT dominant hand results and both the dominant and non-dominant hand results of the BBT (p=0.00, p=0.002, respectively). Additionally, a significant correlation was found between the non-dominant 9HPT results and both the dominant and non-dominant BBT results (p=0.03, p=0.001, respectively). There was also a significant correlation between the non-dominant 9HPT results and the total motor imagery score assessed by the MIQ-3 (p=0.026).

Finally, a significant relationship was observed between the non-dominant BBT results and the kinesthetic imagery subscale of the MIQ-3 (p=0.010). There was also a significant correlation between the non-dominant BBT results and the total MIQ-3 score (p=0.012)

Table 3: The Relationship Between Hand Grip Strength. Manual Dexterity and Motor Imagery Abilities of the Participants

		9HPT Dominant	9HPT Non-dominant	BBT Dominant	BBT Non-dominant	MIQ-3 Internal	MIQ-3 External	MIQ-3 Kinesthetic	MIQ-3 Total	Grip Strength Dominant
9HPT Non-dominant	p	.001**								
	r	.541								
BBT Dominant	p	.001**	.031*							
	r	-.368	-.239							
BBT Non-dominant	p	.002**	.001**	.001**						
	r	-.332	-.539	.523						
MIQ-3 Internal	p	.233	.205	.882	.064					
	r	.134	-.142	-.017	.206					
MIQ-3 External	p	.943	.054	.734	.145	.001**				
	r	-.008	-.215	-.038	.163	.485				
MIQ-3 Kinesthetic	p	.561	.055	.542	.010**	.001**	.004**			
	r	-.066	-.214	.069	.286	.471	.320			
MIQ-3 Total	p	.872	.026*	.953	.012*	.001**	.001**	.001**		
	r	.018	-.247	.007	.279	.808	.780	.766		
Grip Strength Dominant	p	.759	.967	.658	.241	.424	.841	.452	.467	
	r	-.035	-.005	-.050	-.132	-.090	-.023	-.085	-.082	
Grip Strength Non-dominant	p	.790	.952	.783	.233	.236	.748	.546	.389	.001**
	r	-.030	-.007	-.031	-.134	-.133	-.036	-.068	-.097	.951

*p<0.05 **p<0.01, Pearson Correlation Test. 9HPT: Nine-Hole Peg Test, BBT: Box and Block Test, MIQ-3: Movement Imagery Questionnaire-3

4. DISCUSSION

This study was conducted to examine hand grip strength, manual dexterity, and motor imagery abilities in healthy adult individuals. According to the assessment methods used in the study, no relationship was found between hand grip strength and motor imagery abilities in healthy adults. In addition, no significant association was observed between hand grip strength and manual dexterity. However, a relationship was identified between manual dexterity and motor imagery abilities.

Hand grip strength is considered a fundamental parameter for evaluating general health status, muscle function, and overall physical capacity (2). In this study, the findings related to hand grip strength revealed that grip force was higher in the dominant hand. This result supports the superiority of the dominant hand in motor functions. This may be due to greater muscle strength, coordination, and motor control mechanisms present in the dominant hand. Additionally, the literature suggests that performance differences between the right and left hands may be associated with neurological factors such as hemispheric asymmetry, neural representation density, and the distribution of motor control in the motor cortex (15). In this context, the higher hand grip strength and better motor performance observed in the dominant hand can be explained by structural and functional differences at both peripheral and central nervous system levels.

Several studies have been conducted to determine hand grip strength, function, and dexterity levels in the upper extremities of healthy individuals for various reasons (14). These include musculoskeletal injury,

disease, disability, determination of functional capacity and rehabilitation goals, monitoring of rehabilitation outcomes, identification of occupational exposures, and revealing differences in personal and anthropometric characteristics (14). In this study, hand grip strength and motor imagery abilities were examined in healthy young adults, and no direct relationship was found between them. This suggests that in young individuals, hand grip strength may not be directly associated with daily life activities and cognitive processes, while motor imagery abilities may be more closely related to mental processes. The literature has indicated that hand grip strength is more often associated with muscle power, sarcopenia, and general health indicators (16).

Manual dexterity is critically important for the independent execution of daily life activities (17). In our study, the manual dexterity tests used (9HPT and BBT) were found to be associated with motor imagery abilities (internal, external, and kinesthetic). This finding supports the potential of the motor imagery method to enhance motor performance.

Motor imagery refers to the mental simulation of a physical movement and plays an important role in motor learning processes (6). It has been emphasized that motor imagery activates the motor cortex and is effective in improving motor skills (18). Moreover, motor imagery techniques have been reported to enhance physical performance and to be highly effective in both exercise and rehabilitation contexts (19). The relationship between motor imagery abilities and manual dexterity has been supported by various studies in the literature. For example, Wang et al. (10) reported that motor imagery training had positive effects on hand dexterity. Additionally, it has been stated that motor imagery abilities are related to hand functions and can be used in rehabilitation processes (8). Based on the study findings and relevant literature, it may be possible to improve manual dexterity through the enhancement of motor imagery abilities. This suggests that motor imagery may be used as a supportive intervention method in rehabilitation processes.

It has been frequently emphasized in the literature that motor imagery can promote neuroplasticity, increase muscle activation in less-used extremities, and improve motor performance (20). Especially in rehabilitation, motor imagery techniques are widely utilized to enhance motor functions of the non-dominant hand. Indeed, it has been reported that motor imagery applications can provide functional gains in both neurological and orthopedic disorders and may be particularly effective in the recovery of lost skills in non-dominant extremities (21). The findings of this study suggest that motor imagery may be an effective method to support skill development in the non-dominant hand. In this regard, the use of motor imagery as a complementary intervention to improve non-dominant hand functions may offer significant contributions.

5. CONCLUSION

This study revealed significant relationships between hand grip strength, manual dexterity, and motor imagery profiles in healthy adult individuals. The higher hand grip strength and manual dexterity observed in the dominant hand emphasize the importance of the dominant hand in motor learning processes.

The data obtained in this study showed that hand grip strength and motor skills were higher in the dominant hand. However, no relationship was observed between hand grip strength and manual dexterity. For the non-dominant hand, a significant relationship was found between manual dexterity and motor imagery skills. These findings suggest that motor imagery may be an effective method for improving manual skills, particularly in the non-dominant hand. Moreover, motor imagery may serve as a valuable tool for functional gains not only in healthy individuals but also in those undergoing rehabilitation.

However, this study has some limitations. The study sample consisted solely of healthy individuals aged 18–35, and the majority of participants (%87.7) were female; the generalizability of the findings to other age groups and to male populations is limited. In addition, motor imagery abilities were assessed using self-report scales, which may have increased the subjectivity of the responses. Since only cross-sectional data were collected, it was not possible to establish causal relationships. Future research involving different age groups, clinical populations, and various assessment methods for motor imagery would enhance the validity and scope of the findings.

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

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