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GRIP STRENGTH AND GRIP ENDURANCE IN HEALTHY YOUNG ADULTS: RELATIONSHIP WITH UPPER EXTREMITY FUNCTIONAL CAPACITY AND ACTIVITIES OF DAILY LIVING

SAĞLIKLI GENÇ ERİŞKİNLERDE KAVRAMA KUVVETİ VE KAVRAMA ENDURANSI: ÜST EKSTREMİTE FONKSİYONEL KAPASİTESİ VE GÜNLÜK YAŞAM AKTİVİTELERİ İLE İLİŞKİSİ

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ABSTRACT

Objective: Several sensorimotor parameters are necessary for optimal upper extremities function. Grip strength (GS) and grip endurance (GE) may be among these main parameters. Our study investigated the association of GS and dynamic GE with upper extremity functional capacity and activities of daily living in healthy young adults.

Method: Forty-five healthy participants aged 19-23 years were included in our study. All of the participants had no trauma, surgery or diagnosis related their upper extremities. A hand dynamometer was used for GS and dynamic GE measurements. Upper extremity functional capacity with Unsupported Upper Extremity Test (UULEX) and activities of daily living (ADL) with the Glittre ADL test were evaluated. The Spearman Correlation Analysis used to investigate relationship between variables.

Results: It was found that the GS values of participants correlated to UULEX (on the dominant side; r=0.409 and on the non-dominant side; r=0.385, p<0.05) and Glittre ADL test durations (on the dominant side; r=-0.515 and on the non-dominant side; r=-0.457, p<0.05). However, there was no significant relationship between dynamic GE and protocols with UULEX and Glittre ADL durations (p>0.05).

Conclusion: According to our results, upper extremity functional capacity and ADL were related to GS but not dynamic GE. In clinical practice, evaluating GS can provide an idea for upper extremity functional capacity and ADL.

Key Words: Grip strength, Grip endurance, Upper extremity function, Functional capacity, Activities of daily living

ÖZ

Amaç: Optimal üst ekstremite fonksiyonu için birçok sensorimotor parametreler gereklidir. Kavrama kuvveti (KK) ve kavrama enduransı (KE) bu temel parametreler arasında olabilir. Çalışmamız sağlıklı genç erişkinlerde KK ve dinamik KE'nin üst ekstremite fonksiyonel kapasitesi ve günlük yaşam aktiviteleri ile ilişkisini incelemektedir.

Yöntem: Çalışmamıza 19-23 yaş aralığında 45 sağlıklı katılımcı dahil edildi. Katılımcıların hiçbiri üst ekstremiteleri ile ilişkili travma, cerrahi ya da tanıya sahip değildi. KK ve dinamik KE için el dinamometresi kullanıldı. Üst ekstremite fonksiyonları Desteksiz Üst Ekstremite Testi (DÜET) ve günlük yaşam aktiviteleri Glittre Günlük Yaşam Aktiviteleri Testi ile değerlendirildi. Değişkenler arasındaki ilişkinin incelenmesi için Spearman Korelasyon Analizi kullanıldı.

Bulgular: Katılımcıların KK değerleri, hem DÜET (dominant tarafta; r=0.409 ve non-dominant tarafta; r=0.385, p<0.05) hem de Glittre testi süreleri (dominant tarafta; r=-0.515 ve non-dominant tarafta; r=-0.457, p<0.05) ile ilişkili bulundu. Ancak dinamik KE'nin DÜET ve Glittre test süreleri ile anlamlı bir ilişkisi yoktu (p>0.05).

Sonuç: Sonuçlarımıza göre üst ekstremite fonksiyonel kapasitesi ve günlük yaşam aktiviteleri KK ile ilişkili iken dinamik KE ile ilişkili değildir. Klinik pratikte KK'yi değerlendirmek, üst ekstremite fonksiyonel kapasitesi ve günlük yaşam aktiviteleri hakkında fikir verebilir.

Anahtar Kelimeler: Kavrama kuvveti, Kavrama enduransı, Üst ekstremite fonksiyonu, Fonksiyonel kapasite, Günlük yaşam aktiviteleri

INTRODUCTION

There are certain requirements for the upper extremity to perform daily function. Wide range of motion, synchronized movement of many joints, muscle strength, power, endurance, and some sensorimotor parameters form the basis of this requirement [1,2]. The grip strength (GS) has been widely researched and showed as a predictor of functional performance and an essential parameter in the upper extremities assessment [3,4].

The GS reflects the maximum effort derived from upper extremity muscles. However, an individual is more likely to use a maintained gripping than maximum gripping in activities of daily living (ADL) [5]. It indicates the necessity of grip endurance (GE) for daily life. The dynamic part of ADL requires repeated gripping, and the static part requires the ability to maintain submaximal GS [6]. For this reason, the GE includes two separate components such as dynamic and static. This

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information shows that several sensorimotor parameters including GS and GE are necessary for optimal function of upper extremities [1]. Although these parameters is necessary for ADL, there is no comprehensive study evaluated the place of GS and GE in upper extremity function and which is the most important parameter for ADL.

Limited studies are exploring GE and related functional parameters in healthy individuals [7-9]. A study examining the concurrent validity of the GE tests found that the test is related to the six-minute walking distance, a standardized exercise capacity test [8]. Another study on healthy older women without chronic disease emphasized the relationship between GE and postural stability [9]. In a study that investigated the correlation of GE between maximum GS and the hand functional score in patients with rheumatoid arthritis and in healthy controls, the relationship of GE was not observed in healthy controls [8].

There is a hypothesis that the evaluation of dynamic GE may provide a predictor of function and functional capacity compared to the assessment of static GE [10]. However, to the best of our knowledge, no study examined the relationship of dynamic GE with upper extremity functional capacity and ADL. Our study aimed to clarify whether there is a relationship between GS and GE with upper extremity functional capacity and ADL.

METHOD

Study Design and Participants

Our study was planned as a cross-sectional study. Our sample size was calculated by GPower 3.1.9.7. program as 42 participants with a 0.50 effect size, a 5% type1 error, and 95% power. The participants aged 18-25 years were included in the study. The reason why the participants were in this age range is that the literature reports that muscle strength decreases as of the third decade of life and the anabolic process becomes more dominant in the muscle structure affecting function [11]. We included undergraduate students in İzmir Katip Çelebi University Faculty of Health Sciences as participants. The exclusion criteria were identified as a history of upper extremity trauma and surgery, diagnosis with a neurological, rheumatological, orthopeadic, or any chronic disease, and no cooperation for assessment [12].

Outcome Measures

Before the test sessions, the sociodemographic data of the participants were recorded in a form. This form included personal data such as age, height, weight, smoking status, history of surgery and/or trauma, pharmacological or medical history. For the assessment of dynamic GE, it was used 6-repetitive and 12-repetitive protocols. Upper extremity exercise capacity with Unsupported Upper Extremity Test (UULEX) and ADL with The Glittre Activities of Daily Living Test (ADL) was evaluated. For all assessment protocols, we followed a specific order, and the assessments were carried out in the order of "UULEX-Glittre ADL-GS-GE". A half-hour resting interval between the first two tests and a 15-minute resting interval between the other tests was given.

Grip Strength and Endurance Protocols: The maximal grip strength was measured by a hand dynamometer (Lafayette Professional Hand Dynamometer 5030L1, USA). The test procedure was carried out in compliance with the American Society of Hand Therapists' recommendations [13]. The measurement was received on both sides with a 1-min break and three consecutive grips were performed with a 15-sec break [14,15]. Participants placed in the standard test position were asked to squeeze the dynamometer with a maximum force three times and maintain the force for 3 sec with no verbal feedback. The average values were recorded as maximal grip strength [13].

Dynamic GE was evaluated by 6-repetitive and 12-repetitive tests. Because of the lack of a standardized method of measuring GE, we used two different dynamic GE protocols for examining the relationship between upper extremity functional capacity and ADL. Participants were placed in the same standardized test position as the grip strength assessment. They have performed 6 and 12 maximal grips controlled by a metronome (1-sec contraction/1-sec rest). It was recorded that calculated change of the first 3 grip values and the last 3 grip values [15].

Unsupported Upper Extremity Test (UULEX): The UULEX test was performed by Takahashi et al. is a performance-based test that evaluates the functional capacity of the upper extremities [16]. This parameter reflects aerobic capacity of upper extremity that is necessary to maintain function/activity. To perform the test, participants were seated in a chair in front of the test system, which consists of eight horizontal levels (120 cm height × 84 cm width) 5 cm apart and 8 cm wide. The bottom level was placed so that it was at the participant's knee alignment. Five different bars (0.2 kg, 0.5 kg, 1 kg, 1.5 kg, and 2 kg) were used during the test. During the test, the participants moved the bar held at shoulder width to the corresponding levels and returned to their hip joint accompanied by a metronome (thirty movements per minute). The starting and ending point for all movements is the hip joint of participants. The first level was maintained for 2 mins and the other levels for 1 min and the test was started with a 0.2 kg bar. When the participants reached the highest level, the bar was replaced with a 0.5 kg bar, and the test was continued at the maximum level. The bar weight was increased by 0.5 kg per minute and advanced to a weight of 2 kg. The participants continued the test until they experienced anything that would limit their ability to continue the test at the maximum level. The total score was recorded as test duration. Additionally, before and after the test, heart rate (HR), peripheral oxygen saturation (SpO_2), arm fatigue, and dyspnea evaluated using the modified Borg scale were recorded.

The Glittre Activities of Daily Living Test (Glittre ADL): The Glittre ADL test as described by Skumlien et al. involves a 10 m circuit where the participants perform a sequence of activities in the shortest time [17]. During the test, all participants carried a backpack containing 2.5 kg for women and 5.0 kg for men. The test started in a seated position. At the starting signal, they stood up from this position and then walked for 5 m, climbed up and down the two-step stairs (17 cm high and 27 cm deep for each step), and walked for another 5 m. When they reached two shelves adjusted shoulder and waist level for participants at the end of the 10 m, three objects with 1 kg each that were placed on the top shelf were moved singly to the bottom shelf, down to the ground, back to the bottom shelf, and to the top shelf again. After this activity, they turned back and walked the same track and this circuit was performed five laps as quickly as possible. The main performance parameter was the total time that the completion of the test. Before and after the test, HR, SpO_2, dyspnea, and fatigue were recorded.

Ethical Approval

We received approval from the İzmir Katip Çelebi University, Department of Physiotherapy and Rehabilitation, Education, Research and Innovation Laboratories to carry out our researcb (İzmir Katip Çelebi University Non-interventional Research Ethics Board, Date: 20.01.2022, Approval number: 0609). During the study, we followed the principles of the Declaration of Helsinki. After we explained briefly the purpose and assessments of the study to participants, the informed consent form was given, and they were asked to sign that.

Statistical Analysis

All of the analyses were performed by IBM SPSS Statistics (Version 20.0. Armonk, NY: IBM Corp.). The normal distribution was checked by the Shapiro-wilk test. The variables were presented as mean/standard deviation or median/ first and third quartile or percentage (%). Paired sample t test was used to compare pre- and post- hemodynamic responses for UULEX and Glitttre ADL test. Bivariate correlations between the GS and two dynamic GE protocols, and UULEX and the Glittre ADL test were examined using Spearman correlation coefficient. Correlations were interpreted as "strong" (r>0.70), "moderate" (r=0.50–0.69), "weak" (r=0.26–0.49), and "very weak or no correlation" (r=0.00–0.25) [18]. The p values <0.05 were considered to indicate statistical significance.

RESULTS

Forty-five individuals participated in the study. Most of the participants were female gender (71.11%) and never smoker (60.0%). The mean age of participants was 21.48 with a minimum 19 and maximum 23 years. Participants sociodemographic variables such as weight, height, and body mass index were presented in Table 1. Only four participants (8.89%) used the left hand dominantly.

Table 1. Sociodemographic variables of participants

Variables	Statistics
Gender (men/women)	13/32
Age (years)	21.48±1.12
Height (cm)	169.37±9.24
Weight (kg)	65.56±15.22
Body mass index (kg/m^2)	22.88 ±2.31
Smoking status n (%)	
Never	27 (60.00)
Ex-smoker	2 (4.44)
Active smoker	16 (35.56)

cm:centimetre; kg:kilogram; kg/m2:kilogram/square meter; n:number; %:percentage; data presented as mean ±standart deviation or median (1./3. quartiles) according to the normal distribution

In Table 2, participants' grip functional variables, Glittre ADL test, and UULEX test results were presented. The UULEX test durations of the participants range from 384.6 to 549.8 and median 454.7 sec. After the UULEX test, a mean of 12 beats in HR, a mean of 0.15 units in SpO_2, a mean of 0.2 units in dyspnea, and a mean of 1.5 units in general fatigue were observed according to the resting state (Table 2).

Table 2. Test results of participants

Variables		Statistics
Grip strength (kg)	Dominant	31.0 (27.5/44.3)
	Non-dominant	29.2 (25.0/42.0)
6-rep dynamic grip endurance % (change)	Dominant	8.4 (3.2/12.3)
	Non-dominant	9.2 (6.3/16.7)
12-rep dynamic grip endurance % (change)	Dominant	17.5 (12.4/22.8)
	Non-dominant	21.7 (13.9/28.4)
UULEX test duration (sec)		454.7 (384.6/549.8)
Unsupported Upper Extremity Test	**Pre-test**	**Post-test**
Heart rate (beats/min*)	82.43 ±14.21	94.02 ±16.30
SpO_2	98.30 ±2.71	98.15 ±1.49
Dyspnea (0-10)	0.54 ±0.94	0.74 ±0.95
General Fatigue (0-10)*	1.76 ±1.34	3.26 ±1.79
Arm Fatigue (0-10)*	0.72 ±1.01	5.05 ±1.91
Glittre Activities of Daily Living test duration (sec)		127 (113/141)
Glittre Activities of Daily Living Test	**Pre-test**	**Post-test**
Heart rate (beats/min)*	79.42 ±13.22	119.89 ±22.85
SpO_2*	98.02 ±1.48	97.27 ±1.74
Dyspnea (0-10)*	0.43 ±0.69	2.40 ±1.53
General Fatigue (0-10)*	1.43 ±1.24	2.97 ±1.26

*kg:kilogram; %:percentage; sec:second; beats/min:beats/minutes; SpO2:peripheric oxygen saturation; data presented as mean ±standart deviation or median (1./3. quartiles) according to the normal distribution. *There is a statistically significant difference between pre-and post-values according to paired sample t-test results.*

The Glittre ADL test durations, HR, SpO2, dispnea, and general fatigue were presented. The test durations of the participants range 86 to 213 sec and median 127 sec. After the Glittre ADL test, a mean of 40 beats in HR, a mean of 0.75 units in SpO2, approximate 2 units in dyspnea, a mean of 1.5 units in general fatigue, and a mean of 4 units in arm fatigue were observed according to the resting state (Table 2). While heart rate and fatigue values increased significantly in both tests after the test, pre- and post-values of SpO2 and dyspnea increased only in the Glittre test. All participants completed the Glittre ADL test however 26.67% (n=12) of the participants left the test due to arm fatigue and 6.67% (n=3) due to inability to adapt to the metronome.

The relationship between grip functional variables with upper extremity functional capacity and ADL was shown in Table 3. There was no significant correlation between dynamic GE in both protocols with UULEX and Glittre ADL test results (p>0.05). However, the GS related to UULEX (r=0.409 and 0.385, dominant and non-dominant sides respectively, Figure 1) and Glittre ADL test results (r=-0.515 and -0.457, dominant and non-dominant sides respectively, Figure 2).

Table 3. Correlation of grip functional variables with upper extremity functional capacity and activities of daily living

Correlation	Unsupported Upper Extremity Test Duration			Glittre Activities of Daily Living Test Duration		
	P	R	95% CI	P	r	95% CI
DGS	0.005	0.409	-0.662/-0.170	0.004	-0.515	0.185/0.714
NDGS	0.008	0.385	-0.621/0.119	0.011	-0.457	0.224/0.613
D6RGE	0.401	0.071	-0.329/0.595	0.692	0.086	-0.306/0.293
ND6RGE	0.526	0.109	-0.141/0.535	0.451	0.174	-0.413/0.142
D12RGE	0.509	0.120	-0.383/0.463	0.498	0.128	-0.416/0.187
ND12RGE	0.611	0.242	-0.099/0.512	0.483	0.152	-0.448/0.108

*DGS:Dominant Grip Strength; NDGS: Non-dominant Grip Strength; D6RGE:Dominant Grip Endurance-6 repetitions; ND6RGE:Non-dominant Grip Endurance-6 repetitions; D12RGE:Dominant Grip Endurance-12 repetition; ND12RGE:Non-dominant Grip Endurance-12 repetitions; *Spearman correlation analysis was performed to examine the relationship between variables.*

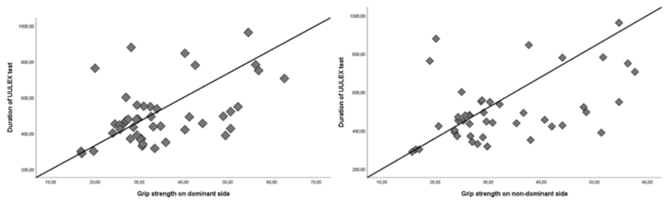

Figure 1. Correlations between UULEX and GS

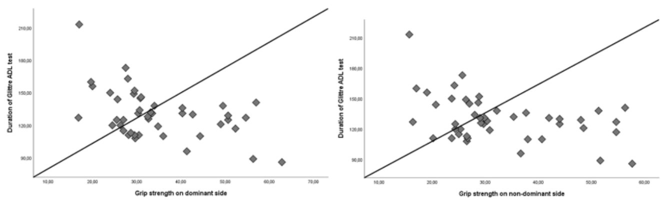

Figure 2. Correlations between Glittre ADL and GS

DISCUSSION

In this study, we examined the relationship between GS and dynamic GE (6-rep and 12-rep protocols) with upper extremity functional capacity and ADL. The main findings of this study were that both UULEX and Glittre ADL tests showed a weak to moderate correlation with GS in healthy young adults. Our study is the first study to examine the relationship between dynamic GE with upper extremity functional capacity and ADL.

The GS and GE are the important part of the assessment of upper extremity muscular function [19]. The studies revealed that GS decreases during the lifespan depending on the decrease in sensation of the hand, loss of hand dexterity, fibers of muscle impairment, and degeneration of the nervous system, and this loss may hinder activities in daily life such as bathing, dressing, and eating and contribute to the loss of independence [20,21]. Dynamic GE is an essential part of several daily activities such as writing, screwing, cleaning a floor or window, and gardening [15]. The assessment of both GE and dynamic GE may form a clearer frame for overall functional capacity in healthy individuals [22]. In our study, the GS was associated with UULEX test duration weakly but dynamic GE was not related to UULEX test. Although the studies in the literature revealed that the upper extremity functional capacity requires strength, manual dexterity, and motor coordination, there are no studies supporting that GE is associated with upper extremity exercise capacity [11]. Our study supports the evidence that strength is associated with upper extremity functional exercise capacity and reveals that GS is weakly related. This weak correlation may be due to the activation of larger muscle groups in functional exercise capacity evaluations including overhead movement patterns compared to GS measurements. However, no relationship was observed with GE, which we expected to be associated with upper extremity functional exercise capacity. The reason for this may be the dominant different energy system. Although the UULEX test requires repeated movement in a long duration (approximately 8-12 min and max 15 min) [11], the assessment of dynamic GE includes movement with 6 and 12 repeats in 12 and 24 sec. While the dominant system for UULEX is an aerobic system, an anaerobic system is the dominant energy system for both of the dynamic GE measurements.

Dependence on ADLs of individuals is related to the risk of morbidity and mortality [23]. Thus, assessment of the ADL is an important part of planning rehabilitation. The optimization of activities in daily life requires a sufficient active range of motion [24], optimal muscle parameters including mass, strength, and physical performance [25], good motor coordination including balance, dexterity, etc. parameters, good perceptual and cognitive skills [26]. The authors said that for ADL performance, a combination of self-report scales and performance-based assessment may be the best way to shed light on the impairment of the individuals [27]. However, there is a need for assessment tools that are simple, time- and cost-effective, and predictive of ADL performance for healthy individuals. Our study hypothesized that GS and GE assessments may be a predictor of ADL in healthy young. As a result of our study, it emphasized that ADL and GS were related but it is not associated with GE. Our findings are in line with previous studies that a decrease in GS is associated with problems in performing activities and that GS is important for the maintenance of ADL [28]. Although it was mentioned GE is a part of the ADL [5], it was observed no relationship between both protocols of the dynamic GE results with the duration of the Glittre ADL test in our study. The reason for this result may have originated from the dynamic GE test protocols that require maximal gripping in short intervals (1 sec contraction-1 sec rest). Gripping performed in the ADL may be longer intervals, less repetitive, and require submaximal strength. Besides, according to our knowledge, there is no evidence about the relationship dynamic GE and ADL in the literature. Therefore, these results are the first evidence of GE and ADL. Future studies may use different dynamic GE protocols and examine its relationship with ADL.

In our study, the GS of the participants had approximately similar values those previously reported in studies that investigated maximal GS values in the Turkish healthy young population [29,30]. The number of studies examining dynamic GE is limited in healthy young adults. Kopruluoglu et al. found that healthy controls had a percentage change rate of 16.16% on the dominant side and 16.37% on the non-dominant side in the 10-rep dynamic GE test [6]. Women aged 70.5 ±3.6 years had a percentage change rate of 30.27% on the dominant side and 35.68% on the non-dominant side in 12-rep dynamic GE performed with contractions for 3 secs and 5-sec rest in Konstantina's study [22]. Our participants had lower percentage change rates in both dynamic GE test protocols compared to the other test results. The reason for these results may have originated from younger participants in our study. On the other hand, no study was found in healthy young adults for the UULEX and Glittre ADL test. However, the UULEX and Glittre test durations of our participants were slightly higher than the durations of our participants and it means that our participants had better ADL performance and lower upper extremity functional capacity [11,31]. Additionally, it was observed a significant increase in hemodynamic responses after testing for both tests and both tests caused significant fatigue. It indicates that both tests provide loading in our participants. At the same time, more than 25% of the participants terminated the UULEX test due to arm fatigue. As the test involves repetitive arm flexion until exhaustion, termination of the test due to fatigue symptoms is an expected situation for the healthy population, as seen in previous studies [32].

Limitations

There are some limitations of our study. We aimed to include only healthy young adults aged 18-25 years and the women is dominant in gender distribution. This limits the generalizability of our results. Besides this study may be expanded with a larger group by deepening and more detailed method that will consider different variable such as gender, body composition etc. Additionally, we ignored the confounding variables in the analysis of the relationship between GS and GE with upper extremity functional capacity and ADL. The variables such as gender, physical activity level, and muscle mass in the upper extremity may be confounding factors related to our parameters. Further studies considering these limitations are needed to support and be clearer about these results. There is a significant knowledge gap in the literature in understanding the basic parameters required for the upper extremity to maintain normal function. Although the parameters required for normal function are known, detailed studies are needed to discuss the place of GS and GE among these parameters. Besides, these dynamic GE protocols are not appropriate to examine the relationship between upper extremity functional capacity and ADL. In future studies, this relationship may be examined with different dynamic GE protocols. We used all of the study performance-based tests. In future studies that are planned to evaluate these parameters, especially in groups with upper extremity functional problems, evaluations based on participant statements as well as performance-based evaluations can be performed.

CONCLUSION

In conclusion, we found that upper extremity functional capacity and ADL correlated to GS. Along with the findings about GE is not associated with upper extremity functional capacity and ADL, these results open space for assessment of GS in healthy young adults may be predictive of upper extremity functional capacity and ADL. In clinical practice, evaluations focus on upper extremity strength. However, our findings, which emphasize that strength is related to ADL and functional capacity in the upper extremity, highlighted importance of these parameters for the upper extremity. In particular, upper extremity functional capacity is often ignored and we included this important variable in our study. The results of GS tests can serve as a potential preliminary screening analysis for upper extremity functional capacity and ADL in healthy young adults. We also conducted the study in a healthy population. The results of this population may shed light on future studies conducted different population and disease. This is one of the areas where there is still a lack of research. For discussing and generalizing our study results, the literature needs more studies in wider age ranges and different patient groups.

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