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THE PSYCHOMETRIC PROPERTIES OF UPPER EXTREMITY FUNCTION TEST-SIMPLIFIED VERSION IN HEALTHY YOUNG ADULTS

SAĞLIKLI GENÇ YETİŞKİNLERDE ÜST EKSTREMİTE FONKSİYON TESTİ-BASİTLEŞTİRİLMİŞ VERSİYONUNUN PSİKOMETRİK ÖZELLİKLERİ

Aylin Tanrıverdi Eyolcu[1*], Ayşenur Özcan[1], Sema Savcı[2]

[1]Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Çankırı Karatekin University, Çankırı, Türkiye

[2]Department of Physiotherapy and Rehabilitation, Faculty of Health Sciences, Acıbadem Mehmet Ali Aydınlar University, İstanbul, Türkiye

ABSTRACT

Objective: The psychometric properties of the Upper Extremity Function Test-Simplified Version (UEFT-S) in healthy young adults are unknown. The objective of this study was to investigate the validity, test-retest reliability, and minimal detectable change of UEFT-S in healthy young adults.

Method: Thirty-seven healthy individuals were recruited for our cross-sectional study. UEFT-S was utilised to assess upper extremity function. UEFT-S was administered twice, separated by one week, to evaluate test-retest reliability. To determine convergent validity, upper extremity muscle strength, handgrip strength, and upper extremity muscle activation were assessed using a handheld dynamometer, a hydraulic hand dynamometer and a surface electromyography, respectively. The test-retest reliability was determined using the intraclass correlation coefficient (ICC). Convergent validity was examined by Pearson's correlation coefficients or Spearman's rank-order correlation coefficients in accordance with the normal distribution.

Results: UEFT-S demonstrated good test-retest reliability, evidenced by an ICC of 0.86 (95% Confidence Interval:0.73-0.93). The minimal detectable change was 5.65. UEFT-S score was significantly correlated with dominant shoulder flexor (r=0.492, p=0.002), shoulder abductor (r=0.340, p=0.039), elbow flexor (r=0.579, p<0.001), elbow extensor (r=0.566, p<0.001), and handgrip strength (r=0.421, p=0.009). A significant correlation was found between the UEFT-S score and percentage of maximum voluntary isometric contraction values of the anterior deltoid (r=-0.586, p<0.001), middle deltoid (r=-0.485, p=0.002), biceps brachii (r=-0.475, p=0.003), and triceps brachii (r=-0.371, p=0.024).

Conclusion: UEFT-S is a valid and reliable tool for assessing upper extremity function in healthy young adults. UEFT-S should be repeated at least twice to account for the learning effect. Higher UEFT-S scores are associated with greater upper extremity muscle strength and lower upper extremity muscle activation.

Key Words: Outcome Assessment, Test-Retest Reliability, Upper Extremity, Validity

ÖZ

Amaç: Üst Ekstremite Fonksiyon Testi-Basitleştirilmiş Versiyonunun (UEFT-S) sağlıklı genç yetişkinlerdeki psikometrik özellikleri bilinmemektedir. Bu çalışmanın amacı, sağlıklı genç yetişkinlerde UEFT-S'nin geçerliliğini, test-tekrar test güvenilirliğini ve minimal saptanabilir değişimini araştırmaktı.

Yöntem: Kesitsel çalışmamıza otuz yedi sağlıklı birey dahil edildi. Üst ekstremite fonksiyonunu değerlendirmek için UEFT-S kullanıldı. Test-tekrar test güvenilirliğini değerlendirmek için UEFT-S, bir hafta arayla iki kez uygulandı. Yakınsak geçerliliği belirlemek için üst ekstremite kas kuvveti, el kavrama kuvveti ve üst ekstremite kas aktivasyonu sırasıyla taşınabilir dinamometre, hidrolik el dinamometresi ve yüzeyel elektromiyografi kullanılarak değerlendirildi. Test-tekrar test güvenilirliği sınıf içi korelasyon katsayısı (ICC) kullanılarak belirlendi. Yakınsak geçerlilik, normal dağılıma uygun olarak Pearson korelasyon katsayıları veya Spearman sıralı korelasyon katsayıları ile incelendi.

Bulgular: UEFT-S, 0.86 ICC değeri (%95 Güven Aralığı:0.73-0.93) ile iyi bir test-tekrar test güvenilirliği gösterdi. Minimal saptanabilir değişim 5.65'ti. UEFT-S skoru, dominant omuz fleksörü (r=0.492, p=0.002), omuz abdüktörü (r=0.340, p=0.039) dirsek fleksörü (r=0.579, p<0.001), dirsek ekstansörü (r=0.566, p<0.001) ve el kavrama kuvveti (r=0.421, p=0.009) ile anlamlı olarak ilişkiliydi. UEFT-S skoru ile anterior deltoid (r=-0.586, p<0.001), orta deltoid (r=-0.485, p=0.002), biceps brachii (r=-0.475, p=0.003) ve triceps brachii (r=-0.371, p=0.024) kaslarının maksimum istemli izometrik kasılma yüzdesi değerleri arasında anlamlı korelasyon bulundu.

Sonuç: UEFT-S sağlıklı genç yetişkinlerde üst ekstremite fonksiyonunun değerlendirilmesinde geçerli ve güvenilir bir araçtır. Öğrenme etkisini hesaba katmak için UEFT-S en az iki kez tekrarlanmalıdır. Daha yüksek UEFT-S skorları, daha fazla üst ekstremite kas kuvveti ve daha az üst ekstremite kas aktivasyonu ile ilişkilidir.

Anahtar Kelimeler: Geçerlik, Güvenilirlik, Sonuç Değerlendirmesi, Üst Ekstremite

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***Corresponding author/Sorumlu yazar:** Çankırı Karatekin University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Çankırı, Türkiye
[1*]Email: tanrverdiaylin@gmail.com, [2]Email: aysenursksk@gmail.com, [3]Email: sema.savci@yahoo.com.tr

INTRODUCTION

Upper extremity function plays a crucial role in performing activities of daily living, especially those comprising reaching, grasping, holding and carrying objects [1]. Both basic activities of daily living, such as feeding, hygiene, bathing, dressing, and instrumental activities of daily living, such as housework, food preparation and putting groceries on shelves, warrant supported and unsupported upper extremity activity [2]. Besides, deterioration of upper extremity function directly limits self-care, reduces autonomy, and affects quality of life [3]. Therefore, assessing upper extremity function, strength, endurance, and exercise capacity is essential for guiding clinical decision-making and optimising therapeutic approaches [1,4].

Objective measures of upper extremity function would be indicators of a person's ability to execute activities of daily living as well as upper limb functionality. The Upper Extremity Function Test-Simplified Version (UEFT-S) is proposed as a simple, valid, and reliable measurement to assess upper extremity functionality in patients with chronic obstructive pulmonary disease (COPD) and asthma [5]. UEFT-S originated from the Upper Extremity Function Test (UEFT), which is performed using two triaxial gyroscope sensors to measure kinetic and kinematic parameters of elbow flexion [6]. However, the applicability of UEFT is limited in different clinical settings due to the requirement of triaxial gyroscope sensors; hence, its modified form, UEFT-S, is regarded as inexpensive and an easy measurement to perform [5].

UEFT-S has the potential to be used in healthy individuals and other clinical populations, such as those with upper extremity disabilities or chronic diseases. UEFT-S can be used to evaluate upper extremity functionality, quantifying disability and assessing the impact of the therapeutic approaches and tracking the progress over time; however, the psychometric properties of UEFT-S in healthy young adults have yet to be investigated. Thus, this study aimed to investigate the validity, test-retest reliability, and minimal detectable change of UEFT-S in healthy young adults.

METHOD

Study Design and Participants

This cross-sectional study was conducted with healthy young adults from April 2024 to December 2024 at the Physiotherapy and Rehabilitation Laboratory of Çankırı Karatekin University, Türkiye. The minimum sample size of the study was calculated to be 37 healthy young adults, with 80% power, an alpha error probability of 0.05, and a 10% drop-out rate, considering an expected reliability of 0.90 intraclass correlation coefficient (ICC) and a minimum acceptable reliability of 0.75 ICC [7]. Participants were recruited from among our undergraduate students using a convenience sampling method.

The inclusion criteria were being aged between 18 and 25 years and being willing to participate in the study. The exclusion criteria were previous or present upper extremity injury, a history of upper extremity surgery, the presence of a chronic disease, or refusal to participate in the study.

Outcome Measures

Upper Extremity Function Test-Simplified Version: The Upper Extremity Function Test-simplified version (UEFT-S) was used to evaluate upper limb functionality. UEFT-S has been demonstrated to be a valid and reliable tool in patients with asthma and COPD. UEFT-S was performed as defined by Correia et al. [5]. Participants were seated on a chair with their trunk supported against the backrest. Then, participants were asked to perform repeated elbow flexion and extension movements as quickly as possible with their dominant upper limb for 20 s, moving through the full range of motion. The test commenced with the participant in a semi-extended elbow position, following the instruction: “When I say go, bend and extend your elbow as quickly as possible for 20 s. I will count the number of times your elbow will bend”. Before the actual test, participants completed a familiarisation trial using their non-dominant arm, and no verbal encouragement was provided during the assessment. The stopwatch was started upon the verbal command and was stopped at the end of 20 seconds. Total repetition completed over 20 seconds was noted [5]. Heart rate (HR), percentage of maximum heart rate (HR%), systolic blood pressure (SBP), diastolic blood pressure (DBP), oxygen saturation (SpO_2), dyspnea, and upper extremity fatigue were measured before and after the tests.

Muscle Strength: Upper extremity muscle strength, including the shoulder flexor, shoulder abductor, elbow flexor and elbow extensor, was evaluated using a handheld dynamometer (Lafayette Manual Muscle Test System™, Lafayette Instrument Company, Lafayette, Indiana, USA). Handgrip strength was measured using a hydraulic hand dynamometer (Jamar®, Nottinghamshire, UK). Handheld dynamometer has concurrent validity with Cybex, which is the gold standard, and demonstrates acceptable intra-and interrater reliability in assessing upper extremity muscle strength [8]. Likewise, Jamar shows excellent reliability in assessing handgrip strength in healthy young adults [9]. Muscle strength tests were executed by following the recommended positions [10,11]. Muscle strength assessments were performed three times on the dominant side, and the best values were noted in kg.

Muscle Activation: Upper extremity muscle activation, including the dominant anterior deltoid, middle deltoid, biceps brachii, and triceps brachii, was evaluated using a surface electromyography (sEMG) device (Noraxon USA, Inc., Scottsdale, AZ, USA). Bipolar two Ag/AgCl surface electrodes were applied with a centre-to-centre interelectrode spacing of 2 cm. The electrode had a width of 1 cm. The common-mode rejection ratio exceeded 80 dB, and the input impedance was greater than 10 MΩ. The sampling rate for the sEMG data was 1000 Hz.

Before electrode placement, the electrode sites on the body were prepared by shaving any hair from the skin, abrading the skin with fine sandpaper, and cleaning the skin with 70% isopropyl alcohol to minimise skin impedance. Then, the SENIAM’s (Surface EMG for non-invasive assessment of muscles) European Recommendations for surface electromyography were followed to carry out the electrode placements [12]. The electrodes for the anterior deltoid were placed at one finger width distal and anterior to the acromion. For the middle deltoid, the electrodes were placed at the greatest bulge of the muscle from the acromion to the lateral epicondyle of the elbow. The electrodes for the biceps brachii were placed on the line between the medial acromion and the fossa cubiti at 1/3 from the fossa cubiti. For triceps brachii, the electrodes were placed at 50 % on the line between the posterior crista of the acromion and the olecranon at 2 finger widths medial to the line. Electrodes were placed parallel to the muscle fibres.

Maximum voluntary isometric contraction (MVIC) was recorded for each muscle following the recommended position [13]. Following the practice, each muscle was tested three times, with each test lasting 5 seconds and separated by a 2-minute rest. Verbal encouragements were used to exert maximum effort during tests. MVIC values were used to normalize muscle activation levels during activities. Muscle activity was recorded as follows: anterior deltoid during shoulder flexion from 0° to 90°, middle deltoid during shoulder abduction from 0° to 90°, biceps brachii during elbow flexion, and triceps brachii during elbow extension.

The sEMG data processing was provided using Noraxon MyoResearch XP Master Edition software (Noraxon, Scottsdale, AZ, USA). The sEMG signals were band-pass filtered (20-500 Hz) and smoothed using a root-mean-square moving-window function with a time constant of 100 ms. The maximum value obtained from each MVIC test was recorded, and the mean of the three tests was used to normalise the sEMG data collected during the activities. During normalization, the EMG amplitude of the activity was divided by the MVIC value for each target muscle. Muscle activation levels, represented as a percentage of MVIC (MVIC%), were subsequently used for statistical analyses.

Data Collection

Our study was conducted over two separate days, spaced one week apart. On the first day, demographic characteristics [age, sex, body mass index (BMI)] and smoking status were recorded. The first trial of the Upper Extremity Function Test-Simplified Version was executed. Then, muscle strength and muscle activation were evaluated. After 1 week, the second trial of the Upper Extremity Function Test-Simplified Version was executed. Physiological and subjective responses were measured before and after UEFT-S during both the first and second trials. The same experienced physiotherapist performed all measurements.

Ethical Approval

This research was conducted in accordance with the principles of the Declaration of Helsinki. Ethical approval was provided by Çankırı Karatekin University Ethics Commission (date: 19.03.2024, approval number: 12). Informed written consent was obtained from all participants included in this study.

Statistical Analysis

Statistical analyses were carried out using SPSS version 26 (IBM, Armonk, NY, USA). The distribution of data was determined using the skewness and kurtosis tests. Continuous data were presented as mean±standard deviation (SD), or median (interquartile range), while categorical data were presented as numbers and percentages. The difference between the first and second trials of UEFT-S was analysed using the paired t-test. Test-retest reliability of the UEFT-S was examined by calculating ICC and corresponding 95% confidence intervals, applying a two-way mixed effects model with absolute agreement [14]. An ICC value between 0.75 and 0.90 was interpreted as representing good reliability [15]. The calculation of the standard error of measurement (SEM) followed the equation: SD of the mean difference/√2. The minimal detectable change (MDC) was then estimated as SEM×1.96×√2 [14]. A Bland-Altman plot was used to assess the agreement between the test and retest scores of the UEFT-S [16]. The paired t-test or the Wilcoxon signed-rank test was used to compare physiological and subjective responses between the pretest and post-test, as well as between the first and second trials of UEFT-S. Convergent validity was examined by Pearson's correlation coefficients or Spearman's rank-order correlation coefficients between the UEFT-S and muscle strength and muscle activation. We hypothesised that muscle strength would correlate positively with UEFT-S scores, while muscle activation would correlate negatively with UEFT-S scores. The correlation coefficient was interpreted as weak for values between 0.20 and 0.39, moderate for values between 0.40 and 0.59, and strong for values between 0.60 and 0.79 [17]. Statistical significance was considered significant if $p<0.05$.

RESULTS

A total of 37 healthy individuals were enrolled in our study. The median age of healthy individuals was 21.00. The majority of participants were female and non-smokers. Table 1 presents the characteristics of participants.

The UEFT-S score was found to be 38.84±5.54 in the first trial and 40.00±5.95 in the second trial. There was a statistically significant difference between the UEFT-S scores of the first and second trials ($p=0.019$). UEFT-S demonstrated good test-retest reliability, evidenced by an ICC of 0.86 (95%CI:0.73-0.93). The SEM was determined to be 2.04, and the MDC was calculated to be 5.65. Table 2 presents the results of the test-retest reliability analysis. The agreement analysis between the first and second UEFT-S trials showed a mean bias of 1.16 repetitions, with 95% limits of agreement ranging from -4.48 to 6.81. Figure 1 presents the Bland-Altman plot for the two trials of UEFT-S.

Table 1. Characteristics of the participants

Characteristic	Mean ±SD or Median (interquartile range) (n=37)
Age, years	21.00 (20.00-21.00)
Sex, n (%)	
Female / Male	28 (75.7)/9 (24.3)
BMI, kg/m²	22.73 ± 3.44
Smoking status, n (%)	
Non-smoker/Smoker	27 (73.0)/10 (27.0)
Muscle strength	
Dominant shoulder flexor, kg	19.76 ± 4.35
Dominant shoulder abductor, kg	19.20 ± 4.05
Dominant elbow flexor, kg	21.15 ± 6.18
Dominant elbow extensor, kg	11.56 (10.07-14.28)
Dominant handgrip, kg	30.00 (26.00-33.00)
Muscle activation	
Dominant anterior deltoid, MVIC%	19.33 (14.13-24.12)
Dominant middle deltoid, MVIC%	29.23 (22.55-41.17)
Dominant biceps brachii, MVIC%	15.97 (11.16-30.35)
Dominant triceps brachii, MVIC%	3.33 (2.17-5.28)

SD:Standard deviation, BMI:Body mass index, MVIC%:Values are presented as mean±SD, median (interquartile range) or number (percentage).

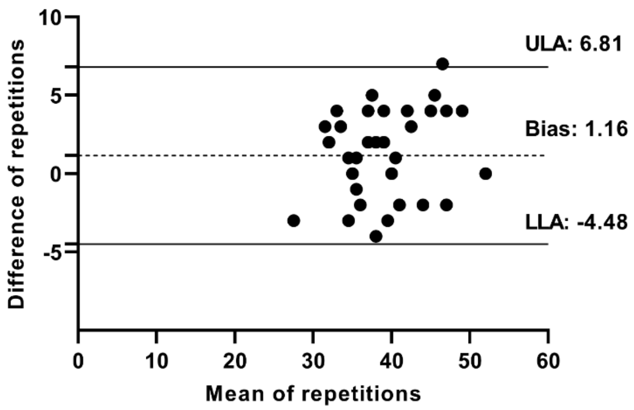

Figure 1. The Bland-Altman plot illustrates the agreement between two trials of the Upper Extremity Function Test-Simplified version performed by healthy individuals. The bias is illustrated as a dotted line, and the limits of agreement are illustrated as solid lines. ULA, upper limit of agreement; LLA, lower limit of agreement.

HR, HR%, DBP, dyspnea and upper extremity fatigue were significantly different between pre-test and post-test in both the first and second trials of UEFT-S ($p<0.05$). There was no significant difference in SBP and SpO2 between pre-test and post-test in both the first and second trials ($p>0.05$). Additionally, changes in physiological and subjective responses were not significantly different between the first trial and the second trial of UEFT-S ($p>0.05$). Table 3 presents the physiological and subjective responses to the first trial and the second trial of UEFT-S. There was a positive moderate correlation between UEFT-S score and gender ($r=0.417$, $p=0.01$), shoulder flexor ($r=0.492$, $p=0.002$), elbow flexor ($r=0.579$, $p<0.001$), elbow extensor ($r=0.566$, $p<0.001$) and handgrip strength ($r=0.421$, $p=0.009$). A positive weak correlation was found between UEFT-S score and shoulder abductor strength ($r=0.340$, $p=0.039$). There was a negative moderate correlation between UEFT-S score and MVIC% values of anterior deltoid ($r=-0.586$, $p<0.001$), middle deltoid ($r=-0.485$, $p=0.002$) and biceps brachii ($r=-0.475$, $p=0.003$). A negative weak correlation was found between UEFT-S score and MVIC% of triceps brachii ($r=-0.371$, $p=0.024$). However, no significant correlation was observed between UEFT-S score and age ($r=0.272$, $p=0.103$) or BMI ($r=-0.077$, $p=0.649$) (Table 4).

Table 2. The test results and test-retest reliability of the UEFT-S in healthy individuals (n=37)

Variable	First Trial	Second Trial	Diffrence	p^a	ICC (95% CI)	p^b	SEM	MDC
UEFT-S (repetition)	38.84±5.54	40.0 ±5.95	1.16±2.88	0.019	0.860 (0.727-0.928)	<0.001	2.06	5.65

UEFT-S:Upper Extremity Function Test- Simplified Version, SD:Standard deviation, ICC:Intraclass correlation coefficient, CI:Confidence interval, SEM:Standard error of measurement, MDC:Minimal detectable change. aDifference between first trial and second trial, bp value for ICC.

Table 3. Physiological and subjective responses to the UEFT-S in healthy individuals (n=37)

Variables	First Trial				Second Trial (re-test)				
	Pre-test	Post-test	p^a	Δ	Pre-test	Post-test	p	Δ	p^b
HR (beats/min)	81.68±14.07	85.95±15.42	0.014ƚ*	3.71±9.11	83.20±13.20	87.43±14.21	0.001ƚ*	4.23±6.91	0.806ƚ
HRmax%	40.96±7.07	43.10±7.73	0.014ƚ*	1.86±4.58	41.73±6.62	43.85±7.13	0.001ƚ*	2.12±3.47	0.804ƚ
SBP (mmHg)	122.30±13.73	123.95±14.21	0.193ƚ	1.58±7.65	123.53±13.62	125.67±16.57	0.282ƚ	2.14±11.74	0.819ƚ
DBP (mmHg)	73.14±7.15	70.81±7.42	0.004ƚ*	-2.31±4.70	74.11±7.54	70.08±8.65	0.002ƚ*	-4.03±7.07	0.075ƚ
SpO2 (%)	97.00 (96.00-98.00)	97.00 (96.00-98.00)	0.894ϕ	0.00 (-1.00-1.50)	97.00 (95.25-98.00)	97.00 (96.00-98.00)	0.652ϕ	0.00 (-1.00-2.00)	0.492ϕ
Dyspnea (0-10)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.024ϕ*	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.00 (0.00-0.00)	0.020ϕ*	0.00 (0.00-0.00)	0.414ϕ
Upper extremity fatigue (0-10)	0.00 (0.00-1.00)	1.00 (0.00-2.00)	<0.001ϕ*	1.00 (0.00-1.00)	0.00 (0.00-0.00)	1.00 (0.00-2.00)	<0.001ϕ*	1.00 (0.00-1.00)	0.613ϕ

*UEFT-S:Upper Extremity Function Test- Simplified Version, HR:Heart rate, HRmax%:Percentage of maximum heart rate, SBP:Systolic blood pressure, DBP:Diastolic blood pressure, SpO2:Oxygen saturation, Δ:Change from pre-test to post-test. [a]Difference between pre-test and post-test, [b]Difference between Δ values in first trial and second trial. ƚPaired samples t-test for normally distributed variables ϕWilcoxon signed rank test for non-normally distributed variables. *Statistically significant difference p<0.05.*

Table 4. Correlations between the UEFT-S scores and other variables in healthy individuals (n=37)

Variable		Age	Gender	BMI	Muscle Strength					Muscle Activation			
					Shoulder Flexor	Shoulder Abductor	Elbow Flexor	Elbow Extensor	Handgrip	Anterior Deltoid	Middle Deltoid	Biceps Brachii	Triceps Brachii
UEFT-S	r	0.272δ	0.417δ	-0.077#	0.492#	0.340#	0.579#	0.566δ	0.421δ	-0.586δ	-0.485δ	-0.475δ	-0.371δ
	p	0.103	0.01*	0.649	0.002*	0.039*	<0.001*	<0.001*	0.009*	<0.001*	0.002*	0.003*	0.024*

*UEFT-S:Upper Extremity Function Test- Simplified Version, #Pearson's correlation coefficient for normally distributed variables, δSpearman's correlation coefficient for non-normally distributed variables. *Statistically significant difference p<0.05.*

DISCUSSION

This study verifies the test-retest reliability and validity of UEFT-S and demonstrates physiological and subjective responses in healthy young adults. UEFT-S exhibits good test-retest reliability and moderate to strong convergent validity with the correlation of upper extremity muscle strength and muscle activation.

Reliability is considered the consistency of measurements, or of an individual's performance, on a test; or 'the absence of measurement error' [18]. Our study indicated good reliability between the two tests with an ICC value of 0.86. A previous study performed by Correia et al. found that UEFT-S showed an excellent test-retest reliability with an ICC of 0.91 in patients with moderate to severe asthma and COPD [5]. The difference in ICC values between studies may be due to the time of performing the retest.

The MDC is accepted as the smallest real difference, which distinguishes true change from measurement error. The MDC of UEFT-S was found to be 0.96 in patients with moderate to severe asthma and COPD [5], whereas it was 5.65 in healthy young adults. According to our findings, changes of 6 repetitions or above on UEFT-S should be considered a real change in detecting over time changes or in determining the effect of intervention on upper extremity function. Additionally, absolute reliability was investigated by limits of agreement using the Bland-Altman plot, which showed an agreement between the two trials of the UEFT-S score. UEFT-S indicated low bias, narrow limits of agreement and reasonable MDC in healthy young adults. However, there was a significant difference between test and retest of UEFT-S; the mean difference was lower than the MDC value of 5.65.

The demand for the UEFT-S, obtained by assessing physiological and subjective responses, provides valuable information for interpreting UEFT-S performance. UEFT-S led to significant but small changes in HR, HRmax%, DBP, dyspnea and upper extremity fatigue in both tests. These changes were similar between trials of UEFT-S executed one week apart. It is not surprising that the UEFT-S led to small changes in cardiorespiratory demand, as it consists of repeated elbow flexion and extension. Additionally, since UEFT-S requires low cardiorespiratory demand, this test may also be indicated for the clinic population suffering from dyspnea, exercise intolerance, muscle weakness, and, in some cases, limitation of daily activities.

It has been established that better upper extremity muscle strength is associated with improved performance in functional tasks, including activities of daily living, self-care, and work-related activities. The 6-minute pegboard and ring test (6PBRT), another test used to assess upper extremity performance, is associated with shoulder flexor, shoulder abductor, elbow flexor, and handgrip strengths in patients with pulmonary hypertension [19]. Additionally, another study performed on patients with chronic obstructive lung disease has reported that 6PBRT is correlated with shoulder flexion and handgrip strength [20]. In line with other upper extremity performance tests, the UEFT was also shown to be positively correlated with upper extremity muscle strength and handgrip strength in healthy young adults in our study. On the other hand, UEFT-S was found to be negatively correlated with upper extremity muscle activation assessed using sEMG, which is an objective measurement that ensures real-time data on muscle activation [21]. According to our findings, higher UEFT-S repetitions were associated with lower muscle activation levels, indicating that individuals with lower upper extremity function may need greater motor unit recruitment during activities [22]. Muscle activations of the anterior and middle deltoid are associated with activities of daily living assessed using the Functional Impairment Test-Hand, Neck, Shoulder and Arm, which is a reliable and valid test for the assessment of functional status [23]. Additionally, forearm muscle activation is linked to upper limb deficits in patients with multiple sclerosis [24]. Furthermore, anterior deltoid muscle activation demonstrates a significant relationship between upper extremity exercise capacity in adolescents and young adults with pulmonary arterial hypertension [22]. In this context, UEFT-S reflects upper extremity functional performance holistically. Consequently, UEFT-S can be used as a practical and valid tool to monitor upper extremity function during upper extremity rehabilitation.

On the other hand, in our study, no significant association was found between UEFT-S and age or BMI in healthy young adults. These findings are likely due to the narrow age range of our participants, which limits age-related variability in functional performance. Similarly, the BMI values were within the normal range with low variability, reducing the likelihood of detecting BMI-related effects. The homogeneity of the sample may therefore have attenuated potential associations. Future studies including broader age ranges and more diverse BMI categories may better clarify these relationships.

Limitations

Our study has several limitations. Firstly, our study enrolled healthy young adults aged 18-25 years, which may limit the extent to which the findings can be generalized to middle-aged or older adults. Secondly, better scores were obtained on the second trial despite the non-dominant side being familiarized with the UEFT-S test. Therefore, two UEFT-S tests should be performed to have better scores in healthy young adults. Lastly, we calculated MDC, unlike the minimal important difference (MID). Future studies should investigate anchor-based MID values to better capture the clinical relevance of the observed changes from rehabilitation approaches, as the MDC does not consistently approximate the anchor-based MID [25]. Additionally, studies are needed to establish normative values of UEFT-S, which would enable interpretation of the decline in upper extremity function in clinical practice.

CONCLUSION

Our study indicates that the UEFT-S is a reliable and valid tool for assessing upper extremity function in healthy young adults. The MDC of UEFT-S is 5.65 repetitions. The UEFT-S promotes low cardiorespiratory effort in healthy young adults. UEFT-S should be repeated at least twice due to the learning effect.

Ethical Approval: *2024/12 Çankırı Karatekin University Health Sciences Ethics Committee*

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