*Received: 24 December 2024/ Revised: 14 January 2025/ Accepted: 20 January 2025*

ORIGINAL ARTICLE

Journal of Hacettepe University Physical Therapy and Rehabilitation

# Reference Values for The Six-Minute Pegboard and Ring Test in Young-Middle Ages Healthy Adults in Turkey

**Hacer ONCU[1], Ulas AR[1], Nurel ERTURK[2], Seyma BULBUL[1], Ayse Elif AKDAL[1], Ferhat UNAL[3], Ebru CALIK KUTUKCU[1]**

[1] Hacettepe University, Faculty of Physical Therapy and Rehabilitation, Ankara, Türkiye

[2]Tarsus University, Faculty of Health Sciences, Department of Physiotherapy and Rehabilitation, Mersin, Türkiye

[3]Middle East Technical University, Data Management Unit, Ankara, Türkiye

*Corresponding author e-mail: haceroncu1997@gmail.com

## ABSTRACT

**Objectives:** The aim of this study was to determine the reference values of the 6 Minute Pegboard and Ring Test (6PBRT) arm exercise test in young and middle-aged healthy adults in Turkey.

**Methods:** Arm length, arm and forearm circumference of participants were evaluated with a tape measure. Unsupported arm exercise capacity was evaluated with 6PBRT. Physical activity level was assessed using the Human Activity Profile (HAP) and maximum activity score (MAP) and adjusted activity score (AAP) were calculated.

**Results:** The study included 132 participants (mean age= 33.59 ± 11.65 years, 88 women and 44 men). According to MAS score, 3% (n=4) were classified as inactive, 21% (n=28) as moderately active and 75.8% (n=100) as active. When the whole model was evaluated separately by gender and in general; the effective variables on the number of rings for female were age (B=-1.063; t=-2.794;p=0.007) and AAS (B=0.591; t=3.993; p<0.001).Variables affecting the number of rings for male; dyspnea difference during 6PBRT (B=-11,537; t=-4.135; p<0.001) and MAS (B=1.740; t=3.773; p=0.001).Variables affecting the number of rings regardless of gender are age (B=-0.987; t=-3.743; p<0.001) and HAPaas (B=0.649; t=6.515; p<0.001).

**Discussion:** In this study, reference values for 6PBRT in healthy young and middle-aged adults in Turkey were determined and 6PBRT test performance is affected by age and physical activity level. Variables affecting upper extremity functional exercise capacity in men and women should be taken into account when interpreting test performance.

**Key Words:** Upper Extremity, Physical Activity, Physical Endurance, Exercise Tolerance, Exercise Test.

## INTRODUCTION

Arm activities with or without support are frequently used during activities of daily living (ADLs) such as combing hair, washing dishes, and reaching for a shelf. These simple arm lifts during ADLs lead to increased metabolic demand in healthy individuals and patients with chronic respiratory disorders (1-4). Oxygen consumption ($VO_2$) and minute ventilation ($V_E$) significantly increased compared to baseline conditions during ADLs including arm tasks (sweeping, lifting pots, changing bulbs, and erasing a blackboard)(1). Due to higher activation of respiratory/postural muscles such as trapezius, pectoralis minor, scalen, intercostal and sternocleidomastoid muscles during simple or complex ADLs, the synchronization of respiratory muscles is impaired. This causes greater arm fatigue and shortness of breath and leads to early termination of especially unsupported arm tasks (2, 5, 6). Although similar duration of arm tasks compared to healthy individuals, the intensity of arm tasks was lower and trapezius muscle effort was higher during upper extremity ADLs in patients with chronic obstructive pulmonary disease (COPD) (2). Therefore, various functional tests have been developed to evaluate endurance and exercise capacity of upper extremities. Unsupported upper limb exercise test (UULEX) (7), grocery shelf task (GST) (8), timed functional arm and shoulder test (TFAST) (9) and 6PBRT (10) are some of the functional tests developed (11). The 6PBRT is a simple, inexpensive, performance-based and useful test that can evaluate both arm functional capacity and endurance (12). The participant is asked to move as many rings as possible from two lower pegs to two upper pegs at the same time within six minutes during the 6PBRT (13). They can be used to assess individuals' unassisted arm exercise capacity and endurance and to develop exercise programs (12).

The validity and reliability of the 6PBRT have been demonstrated in healthy individuals, patients with stable COPD, COPD exacerbation, asthma, and pulmonary hypertension (14-18). Despite there are various studies that compare the 6PBRT scores of patients with healthy controls for interpretation of results of 6PBRT (3, 19), some studies determined reference values for 6PBRT in healthy individuals (12). This study reported that age correlated with 6PBRT outcomes. The number of rings carried was higher in the 30 to 39 age group than in the >80 age group (430.25 ± 77.00 vs. 265.00 ± 65.75) and the difference was significant ($p < 0.05$). Knowing the reference values for a test in healthy individuals is very important because it will enable the determination of impairment in arm functional exercise capacity in individuals with a chronic disease and the evaluation of the results of therapeutic interventions as an outcome especially in rehabilitation programs (12). However, there is no data about 6PBRT reference values for healthy adults in Turkey until today. Determination of reference values for healthy adults in Turkey will be helpful in the evaluation of upper extremity exercise capacity and better interpretation of results as decreased or preserved arm functional exercise capacity. Therefore, the aim of this study was to determine the reference values for the 6PBRT unsupported arm function exercise test in Turkish young/middle-aged adults.

## METHODS

### Study Design and Participants

This cross-sectional study was carried out at Hacettepe University Faculty of Physical Therapy and Rehabilitation between November 2021 and November 2022. The study was approved by the Hacettepe University Non-Interventional Clinical Research Ethics Committee on September 21, 2021, with approval number GO 21/966. The study's ClinicalTrials.gov registration number is NCT06010459.

The inclusion criteria were being between the ages of 18 and 65 years, willing to engage in the study, cooperative, and having a body mass index (BMI) value between 18.5 and 40 kg/m$^2$. The exclusion criteria included to have a neurological condition or another clinical diagnosis that could impair cognition, have a musculoskeletal, neurological, cardiopulmonary, neuromuscular, or metabolic condition that could impair exercise capacity, or have advanced orthopedic conditions (like kyphoscoliosis), have recently undergone shoulder or thoracic surgery.

### Measurements

***Arm Length, Arm and Forearm Circumference Measurements:*** The dominant and non-dominant sides' circumference measurements of arms and forearms and arm length were measured using a non-stretchable tape measure. The length of the arm was measured with the arm in its anatomical position, from the acromion process to the lateral border of the radial styloid process. Arm circumference was measured midway between the acromion and olecranon process. The forearm circumference was measured near the olecranon, where it has its largest diameter in relaxed position at the side of the body (20).

***Unsupported Arm Exercise Capacity:*** Unsupported functional arm exercise capacity was evaluated with the 6PBRT. The participant sat in front of a pegboard with two bars placed at shoulder level and shoulder width, and two upper bars placed 20 cm above these bars, and ten rings attached to each of these bars during the test. The healthy participants were instructed to carry these rings from the lower rings to the upper rings, then return to the lower rings. The participants were allowed to practice by moving few rings before the test. Standardized encouragement was given every minute during the 6PBRT. Heart rate (HR) and oxygen saturation (SpO2) with pulse oximeter (Nonin pulse oximeter palmsat® 2500 series, Plymouth, MN, USA), modified Borg scale (0-10) dyspnea, general fatigue and arm fatigue perceptiona were recorded before and after the test. The second 6PBRT was repeated with 30-minute interval under the same conditions. The best number of rings carried during six minutes from two tests was recorded as final 6PBRT score (10, 11, 14).

***Physical Activity Level:*** Physical activity (PA) level was assessed with the Human Activity Profile (HAP). HAP is a scale used to assess the functional and PA levels of individuals of different age groups who are healthy or have chronic diseases. This scale consists of 94 developed items. After completing the questionnaire, a maximum activity score (MAS) and an adjusted activity score (AAS) are obtained. The MAS score consists of the activities that are currently performed by individuals and require the most effort. The AAS score is obtained by subtracting the activities that the individual has stopped doing and require less effort from the MAS score. The AAS score reflects daily PA. Both scores can take values between 0-94. Participants are classified as inactive (MAS score < 53), moderately active (MAS score between 53 and 74) or active (MAS score > 74) according to the maximum activity score (MAS) (21-23).

### Statistical Analysis

Statistical analyses were performed using IBM SPSS Statistics 23.0 (SPSS, Chicago, IL, USA). Descriptive data were presented as mean and standard deviation (SD) or number and frequencies as appropriate. We computed *Pearson's* correlation coefficients for relationships between all continuous variables. Correlation coefficients were interpreted as low (0–0.25), moderate (>0.25–0.50), strong (>0.50–0.75) and very strong (>0.75) (24). To the change of categorical variables, we used to *Independent sample t test*, *Mann Whitney U test*. The changes in hemodynamic variables and dyspnea/fatigue perceptions before and after test was analyzed with *Wilcoxon signed rank test*. After we determined statistically significant variables, we done multiple regression analysis with backward elimination method according to the gender and as general. The independent variables included in the regression analysis were age, body weight, height, BMI levels, arm length, arm and forearm circumference measurements, MAS and AAS, changes in vital signs and dyspnea/fatigue perceptions during 6PBRT. The p values less than 0.05 was accepted significant (25).

We used the G*Power analysis system (G*Power Software version 3.1.9.2, Heinrich Heine University, Düsseldorf, Germany) for sample size calculation. We computed as 119 for middle effect size (0.15), Type I error (0.05), power (0.80), maximum number of tested predictors (10), and total number of predictors (23). And then, we added 10% margin error and we completed with 132 participants to this study.

## RESULTS

One hundred thirty-two healthy people who volunteered to participate were included in the study. All the groups contained 44 (33.3%) male and 88 (66.7%) female and the mean age of the individuals was 33.59±11.65 years (min-max: 19-61 years) (Table 1). The mean 6PBRT score of the all participants was 220.77±40.66 rings. Whereas the mean 6PBRT score of female participants was 224.13±40.66 rings, mean score of male participants was 214.07±40.30 rings (Table 1).

According to MAS score, 3% (n=4) of the participants were classified as inactive, 21% (n=28) as moderately active and 75.8% (n=100) as active. Among women, 4.5% (n=4) were inactive, 21.6% (n=19) were moderately active and 73.9% (n=65) were active, while 20.5% (n=9) of men were moderately active and 79.5% (n=35) were active.

The correlations between 6PBRT score and other clinical parameters were also presented in Table 1. According to MAS, 3.7% (n=4) of participants were inactive, 26.6% (n=29) of them were moderately active and 69.7% (n=76) of them were active. The 6PBRT score was moderately negative correlated with age (r=-0.402, p<0.001). Body weight (r=-0.195, p=0.025) and BMI values (r=-0.205, p=0.018) were also negatively related with 6PBRT score. Otherwise, a positive, strongly statistically significant relationship was obtained between the 6PBRT score and AAS (r=0.552, p<0.001). The 6PBRT score was also moderately related with MAS (r=0.312, p<0.001). There were any statistically significant relationships between 6PBRT score and dominant arm length, arm and forearm circumferences (p>0.05, Table 1).

**Table 1:** The physical and clinical characteristics of participants (n=132)

| | | X̄ ± SD | |
|---|---|---|---|
| | | **6PBRT score** | **t/U (p)** |
| **Gender** | Female (n=88) | 224.13 ± 40.66 | 1.344 (0.181) |
| | Male (n=44) | 214.07 ± 40.30 | |
| **Dominant hand** | Right (n=129) | 221.01 ± 41.05 | -0.664 (0.531) |
| | Left (n=3) | 210. 67 ± 17.78 | |
| | | **X̄ ± SD** | **r (p)** |
| **Age (years)** | | 33.59 ± 11.65 | -0.402 (**<0.001***) |
| **Height (cm)** | | 1.68 ±0.08 | -0.042 (0.631) |
| **Weight (kg)** | | 69.15 ± 14.19 | -0.195 (**0.025***) |
| **BMI (kg/m²)** | | 24.49 ± 4.47 | -0.205 (**0.018***) |
| **Arm length (Right)** | | 66.76 ± 9.99 | -0.105 (0.235) |
| **Arm length (Left)** | | 66.00 ± 11.14 | 0.520 (0.652) |
| **Upper arm circumference (Right)** | | 28.00 ± 4.27 | 0.033 (0.714) |
| **Upper arm circumference (Left)** | | 30.00 ± 7.94 | 0.361 (0.765) |
| **Forearm circumference (Right)** | | 24.56 ± 3.28 | 0.129 (0.147) |
| **Forearm circumference (Left)** | | 26.67 ± 6.81 | 0.391 (0.744) |
| **Modified push-ups (n)** | | 23.23 ± 14.98 | -0.038 (0.668) |
| **MAS** | | 78.94 ±11.05 | 0.312 (**<0.001***) |
| **AAS** | | 60.74 ±31.56 | 0.552 (**<0.001***) |

**Abbreviations:** 6PBRT: 6 minute pegboard and ring test; BMI: Body mass index; MAS: maximum activity score; AAS: adjusted activity score. t: Independent Sample t test; U: Mann-Whitney U test; r: Pearson's correlation coefficient. *p<0.05.

The cardiorespiratory responses during 6PBRT were shown in Table 2. There was a significant increase in HR, dyspnea, arm and general fatigue perceptions after test (p<0.001, Table 2). There was a positive low significant correlation between 6PBRT score and change in HR (r=0.204, p=0.028) and a negative moderate relation between change in dyspnea (r=-0.424, p<0.001) during 6PBRT.

The results of multiple linear regression analysis was represented in Table 3. The variables affecting the number of rings for females were age (B=-1.063, t=-2.794, p=0.007) and AAS (B=0.591, t=3.993, p<0.001). The variables affecting the number of rings for males were change in dyspnea during 6PBRT (B=-11.537, t=-4.135, p<0.001) and MAS (B=1.740, t=3.773, p=0.001). Overall, the variables affecting the number of rings regardless of gender were age (B=-0.987, t=-3.743, p<0.001) and AAS (B=0.649, t=6.515, p<0.001).

Model equations were as follows:

Equation 1 (for females):

*6PBRT score=217.946-(1.063xAge)+(0.591xAAS)*

Equation 2 (for males):

*6PBRT score=140.860-(11.537xΔDyspnea)+(1.740xMAS)*

The mean number of rings completed by healthy individuals based on age was presented in Table 4.

**Table 2:** The changes in hemodynamic variables and dyspnea/fatigue perceptions

| **Parameters** | **Pre-test** | **Post-test** | | **Difference (Δ)** | |
|---|---|---|---|---|---|
| | **X̄ ± SD** | **X̄ ± SD** | **Z (p)** | **X̄ ± SD** | **r (p)** |
| **HR (beats/min)** | 84.682 ± 11.342 | 98.345 ± 14.353 | -7.942 (**<0.001***) | 12.586 ± 10.117 | 0.204 (**0.028***) |
| **$SpO_2$ (%)** | 97.500 ± 1.516 | 97.569 ± 3.239 | -0.365 (0.715) | 0.155 ± 3.283 | 0.168 (0.072) |
| **Dyspnea (mBS)** | 0.284 ± 0.593 | 1.348 ± 1.707 | -6.488 (**<0.001***) | 1.064 ± 1.547 | -0.424(**<0.001***) |
| **Arm Fatigue (mBS)** | 0.670 ± 1.193 | 5.159 ± 2.185 | -9.002 (**<0.001***) | 4.488±2.212 | -0.068 (0.438) |
| **General Fatigue (mBS)** | 0.750 ± 1.186 | 2.508 ± 1.985 | -7.612 (**<0.001***) | 1.758 ±1.848 | -0.141 (0.108) |

**Abbreviations:** HR: Heart rate; $SpO_2$: Oxygen saturation; mBS: Modified Borg Scale.
Z: Wilcoxon signed rank test; r: Pearson's correlation coefficient. *p<0.05.

**Table 3:** The results of the regression analysis according to the gender and all model

| | **Female** | | | **Male** | | | **General** | | |
|---|---|---|---|---|---|---|---|---|---|
| **Variables** | **B [95% CI]** | **Beta** | **t (p)** | **B [95% CI]** | **Beta** | **t (p)** | **B [95% CI]** | **Beta** | **t (p)** |
| **Constant** | 217.946 [183.042;252.851] | | 12.456 (**<0.001**) | 140.860 [54.325;227.395] | | 3.290 (**0.002**) | 212.211 [187.240;237.183] | | 16.836 (**<0.001**) |
| **Δ Dyspnea** | -2.560 [-9.032;3.912] | -0.090 | -0.789 (0.433) | -11.537 [-17.175;-5.898] | -0.469 | -4.135 (**<0.001**) | -3.400 [-8.250;1.450] | -0.126 | -1.389 (0.168) |
| **Δ HR** | 0.281 [-0.756;1.318] | 0.062 | 0.540 (0.591) | 0.272 [-0.425;0.969] | 0.075 | 0.790 (0.934) | 0.430 [-0.176;1.037] | 0.104 | 1.407 (0.162) |
| **Age** | -1.063 [-1.822;-0.304] | -0.289 | -2.794 (**0.007**) | -0.330 [-1.218;0.559] | -0.097 | -0.750 (0.457) | -0.987 [-1.510;-0.465] | -0.284 | -3.743 (**<0.001**) |
| **BMI** | 0.469 [-1.619; 2.557] | 0.054 | 0.449 (0.655) | -2.149 [-4.307;0.010] | -0.190 | -2.012 (0.051) | 0.205 [-1.395;1.805] | 0.023 | 0.254 (0.800) |
| **MAS** | -0.434 [-1.674;0.806] | -0.089 | -0.698 (0.487) | 1.740 [0.808;2.672] | 0.423 | 3.773 (**0.001**) | 0.239 [-0.591;1.069] | 0.053 | 0.571 (0.569) |
| **AAS** | 0.591 [0.296;0.887] | 0.413 | 3.993 (**<0.001**) | 0.130 [-0.325;0.584] | 0.113 | 0.578 (0.567) | 0.649 [0.452;0.847] | 0.495 | 6.515 (**<0.001**) |
| | **$R^2$**=0.321; F(p) =16.303 (**<.001**) | | | **$R^2$**=0.674; F(p) = 27.546 (**<0.001**) | | | **$R^2$** =0.405; F(p) =40.172 (**<0.001**) | | |

**Abbreviations:** HR: Heart rate; BMI: Body mass index; MAS: maximum activity score; AAS: adjusted activity score.

**Table 4:** Number of rings completed by healthy individuals based on age

| **Age Group** | **X±SD** | **95% CI** |
|---|---|---|
| 20-29 years | 221.13±32.21 | 212.17-230.10 |
| 30-39 years | 223.57±31.80 | 219.81-247.32 |
| 40-49 years | 220.29±32.24 | 205.61-234.96 |
| 50-59 years | 160.91±44.89 | 130.75-191.06 |

## DISCUSSION

The present study determines reference values for the 6PBRT in healthy individuals between 18-65 years of age in Turkey. The present study also showed that age and physical activity levels are important determinants of functional arm performance reflected by 6PBRT. Whereas change in dyspnea during 6PBRT and activities with high effort currently performed by healthy individuals affect functional arm performance in males, age and daily physical activities are indicators for arm performance in females. Arm length, upper arm circumference and forearm circumference don't have any effect on 6PBRT scores. These findings will be useful for clinical application and interpretation of 6PBRT results. To our best of knowledge, this was the first study for determining reference values for the 6PBRT in healthy young-middle aged adults in Turkey.

There are limited data about the reference value of 6PBRT in the literature (26, 27). Age is closely related with 6PBRT performance as general. The functional capacity is decreased with advanced age (26, 27). Shah, Kshamata M. et al. found that young healthy participants outperformed older participants on a novel functional arm and shoulder test involving unsupported arm activities (9). Our study also confirmed that age is negatively associated with 6PBRT score in mostly physically active (69.7%) healthy individuals. These could be a result of physiological changes in muscle structure and function and decreased motor coordination with age that leads to decline in psycho-physical performance (9, 26-28). Ohara et el. (2010) reported that BMI level was not related with 6PBRT performance in healthy young adults majority of whom were physical active (29). Otherwise, BMI, body fat and fat mass values were moderately correlated with 6PBRT score in physically active (50%) young adults (age range=21.75-27.25 years) in another study (30). The weak correlation between body weight and body mass adn 6PBRT could be a result of that the 6PBRT mostly requires arm and upper body msucular performance and individuals exhibits performance when they are sitting and there may no effect of BMI on test score.

Lima et al. did not find any correlation between arm length, upper arm circumference or forearm circumference in a study (26), while Kulkarni et al. showed a significant correlation only between forearm circumference and 6PBRT score in healthy men in another study (27). We also didn't show any correlation between arm length and 6PBRT score in healthy adults. These could be a result of that the 6PBRT performance is unaffected by arm length and circumferences of arm and forearms. Since each person was seated at own arm's length in front of the pegboard for 6PBRT, there was no difficulty in reaching the lower or upper bars. Kulkarni et al. also evaluated the strength of the shoulder/elbow flexor and extensor muscles and hand grip strength and reported a correlation between the 6PBRT score and the strength of these muscles (27). Regardless of age or gender, hand length and forearm circumference measurement were shown to be related to hand grip strength in young healthy adults (31). Anakwe et al. showed that healthy individuals, especially manual workers, have higher hand grip strength and forearm circumference measurements and that forearm circumference is a determinant of maximum hand grip strength in men (32). The reason for any relation between 6PBRT performance and circumferences of upper arm and forearm could be that different antropometric characteristics of our sample compared to participants in previous studies. In addition, the association between arm/forearm size and muscle strength presents great variation. Fonseca et al. reported a significant positive correlation between 6PBRT score and hand grip endurance in healthy young individuals (30). We think that our finding is compatible with that6PBRT performance primarily depends on the muscular endurance of the upper extremities rather than muscle strength based on the available data.

The 6PBRT score was positively associated with accelerometer count and reduced upper extremity activity score in patients with COPD (33). Lime et al. reported that 6PBRT score was positively and weakly associated with PA level in healthy Brazilian adults (26). In the study by Ohara et al. no relationship was found between PA level assessed by the International Physical Activity Questionnaire and 6PBRT score (29). A study by Fonseca et al. showed that the 6PBRT test requires moderate metabolic and cardiopulmonary demands compared to arm ergometer testing in healthy subjects (30). The strong relation between 6PBRT score and daily PA, otherwise moderate association with PA requires most effort in our study could be a result of lower cardiometabolic demand during 6PBRT. There is also variations in activities that evaluated by different questionnaires and PA implemented according to gender. Peak HR and maximal HR during 6PBRT reached nearly 65% of HR during maximal arm ergometer test. Post-test dyspnea and arm fatigue perceptions were also lower in 6PBRT than those of acquired during maximal arm test. According to cardiorespiratory responses during 6PBRT in our study, 6PBRT loads cardiorespiratory system and as expected there were increases in HR, dyspnea, arm and general fatigue perceptions after test (27, 29, 30). Negative moderate relation between dyspnea increase and 6PBRT score shows us dyspnea increase could limit 6PBRT performance in healthy adults.

In the study by Kulkarni et al. reference values were reported for both sexes in all age groups. In female adults aged 20-70 years, age and hand grip strength were predictors of 6PBRT performance, while in male adults age, shoulder and elbow extensor strength were predictors of 6PBRT score (27). In our study, whereas dyspnea increase and high effort PA affected functional arm performance in males, age and daily PA were main determinants of 6PBRT in females. We think that due to relatively higher arm muscle mass and strength values of men, dyspnea increase during unsupported arm activities and activities that requires more effort could limit arm exercise capacity in man. Overall, younger age and higher daily PA was related with better performance in young/middle-aged healthy adults.

One of the limitations of the present study is that we didn't include geriatric individuals which compromises the generalizability of our findings. The another limitation of the study was that we didn't measure arm or handgrip strength/endurance. Otherwise, to the best of our knowledge, this was the first study that determines reference values for the 6PBRT in healthy young/middle-aged adults in Turkey.

In conclusion, younger age and higher level PA are related with better functional arm exercise performance in healthy adults. According to our findings, the 6PBRT could be considered as assesment for functional arm exercise capacity in chronic diseases and healthy adults for in clinical practice and for research. Knowledge of reference values for 6PBRT in healthy individuals will enable quantification of upper extremity functional capacity in patients with a chronic disease and comparison of results especially in rehabilitation programs for Turkish adult population.

## Implications on Physiotherapy Practice

1. These findings will guide physiotherapists for quantification of upper extremity functional capacity in patients with a chronic disease.
2. Age and physical activity levels are important determinants of functional arm performance reflected by 6PBRT.
3. These reference values for 6PBRT will be useful for clinical application and interpretation of 6PBRT scores.

## Acknowledgments

**Author Contributions:** Conceptualization: ECK; Methodology: ECK; Formal analysis: FU; Data curation: NE, UA, AEA, SB, FU; Investigation: NE, UA, AEA, SB; Writing - original draft preparation: ECK, HO; Writing - review and editing: all authors. Approval of final manuscript: all authors.

**Data availability:** The datasets generated during and/or analysed during the current study are not publicly available but are available from the corresponding author on reasonable request.

## Declarations

**Competing interests**: The authors declare no competing interests.

**Ethics approval**: This study was performed in line with the principals of the declaration of Helsinki. This cross-sectional study was carried out at Hacettepe University Faculty of Physical Therapy and Rehabilitation between November 2021 and November 2022. The study was approved by the Hacettepe University Non-Interventional Clinical Research Ethics Committee on September 21, 2021, with approval number GO 21/966. The study's ClinicalTrials.gov registration number is NCT06010459.

**Consent to participate**: Informed consent was obtained from all individual participants included in the study.

**Consent for publication**: Consent to publish was received from all individual participants included in the study.

**How to cite this article:** Oncu H, Ar U, Erturk N, Bulbul S, Akdal AE, Unal F, Calik-Kutukcu E. Reference Values for The Six-Minute Pegboard and Ring Test in Young-Middle Ages Healthy Adults in Turkey. Journal of Hacettepe University Physical Therapy and Rehabilitation. 2025;3(1),1-8.

## REFERENCES

1. Velloso M, Stella SG, Cendon S, Silva AC, Jardim JR. Metabolic and ventilatory parameters of four activities of daily living accomplished with arms in COPD patients. Chest. 2003;123(4):1047-53.
2. Meijer K, Annegarn J, Lima Passos V, Savelberg HH, Schols AM, Wouters EF, et al. Characteristics of daily arm activities in patients with COPD. Eur Respir J. 2014;43(6):1631-41.
3. Cakmak A, Kocaaga E, Sonbahar-Ulu H, Inal-Ince D, Vardar-Yagli N, Calik-Kutukcu E, et al. Upper Extremity Exercise Capacity and Activities of Daily Living in Individuals With Bronchiectasis Versus Healthy Controls. Phys Ther. 2023;103(4).
4. Mackey M, Ellis E, Nicholls M. Breathing patterns and heart rate during simulated occupational upper limb tasks in normal subjects. Physiother Res Int. 1998;3(2):83-99.
5. Kathiresan G, Jeyaraman SK, Jaganathan J. Effect of upper extremity exercise in people with COPD. J Thorac Dis. 2010;2(4):223-36.
6. Lima VP, Iamonti VC, Velloso M, Janaudis-Ferreira T. Physiological Responses to Arm Activity in Individuals With Chronic Obstructive Pulmonary Disease Compared With Healthy Controls: A SYSTEMATIC REVIEW. J Cardiopulm Rehabil Prev. 2016;36(6):402-12.
7. Takahashi T, Jenkins SC, Strauss GR, Watson CP, Lake FR. A new unsupported upper limb exercise test for patients with chronic obstructive pulmonary disease. J Cardiopulm Rehabil. 2003;23(6):430-7.
8. Hill CJ, Denehy L, Holland AE, McDonald CF. Measurement of functional activity in chronic obstructive pulmonary disease: the grocery shelving task. J Cardiopulm Rehabil Prev. 2008;28(6):402-9.
9. Shah KM, Baker T, Dingle A, Hansmeier T, Jimenez M, Lopez S, et al. Early Development and Reliability of the Timed Functional Arm and Shoulder Test. J Orthop Sports Phys Ther. 2017;47(6):420-31.
10. Zhan S, Cerny FJ, Gibbons WJ, Mador MJ, Wu YW. Development of an unsupported arm exercise test in patients with chronic obstructive pulmonary disease. J Cardiopulm Rehabil. 2006;26(3):180-7; discussion 8-90.
11. Janaudis-Ferreira T, Beauchamp MK, Goldstein RS, Brooks D. How should we measure arm exercise capacity in patients with COPD? A systematic review. Chest. 2012;141(1):111-20.
12. Lima VP, Almeida FD, Janaudis-Ferreira T, Carmona B, Ribeiro-Samora GA, Velloso M. Reference values for the six-

minute pegboard and ring test in healthy adults in Brazil. Jornal Brasileiro de Pneumologia. 2018;44:190-4.
13. Kulkarni MS, Alaparthi GK, Krishnan S, Ramakrishna A, Acharya V. Reference value for the six-minute peg board and ring test. A cross sectional study. Multidisciplinary Respiratory Medicine. 2020;15(1).
14. Calik-Kutukcu E, Tekerlek H, Bozdemir-Ozel C, Karaduz BN, Cakmak A, Inal-Ince D, et al. Validity and reliability of 6-minute pegboard and ring test in patients with asthma. J Asthma. 2022;59(7):1387-95.
15. Kahraman BÖ, Özsoy İ, Tanriverdi A, Akdeniz B, Özpelit E, Şentürk B, et al. Validity and reliability of the 6-minute pegboard ring test in patients with pulmonary hypertension. Türk Fizyoterapi ve Rehabilitasyon Dergisi. 2020;31(2):210-7.
16. Felisberto RM, De Barros CF, Nucci KCA, De Albuquerque ALP, Paulin E, De Brito CMM, et al. Is the 6-minute pegboard and ring test valid to evaluate upper limb function in hospitalized patients with acute exacerbation of COPD? International Journal of Chronic Obstructive Pulmonary Disease. 2018:1663-73.
17. Takeda K, Kawasaki Y, Yoshida K, Nishida Y, Harada T, Yamaguchi K, et al. The 6-minute pegboard and ring test is correlated with upper extremity activity of daily living in chronic obstructive pulmonary disease. International Journal of Chronic Obstructive Pulmonary Disease. 2013:347-51.
18. Leite HR, Queiroz IP, Santos JG, Barroso de Souza FL, Scheidt Figueiredo PH, de Cordoba Lanza F, et al. Measurement properties of the six-minute pegboard and ring test (6PBRT) in healthy adolescents. J Bodyw Mov Ther. 2021;28:56-61.
19. Ozsoy I, Ozcan Kahraman B, Ozsoy G, Ilcin N, Kahraman T, Acar S, et al. Determinants of the 6-minute pegboard and ring test as an unsupported upper-extremity exercise capacity measure in older adults with chronic obstructive pulmonary disease. Eur Geriatr Med. 2018;9(6):863-70.
20. Casadei K, Kiel J. Anthropometric Measurement. StatPearls. Treasure Island (FL)2023.
21. Daşkapan A, Kurtoğlu F, Kılıç F, Karakaş F, Özdemir F. The evaluation of physical activity levels in Turkish dialysis patients. 2018.
22. Fix AJ DD. Human activity profile professional manual. . Florida: Psychological Assessment Resources Inc; 1998.
23. Arzu Daşkapan BA, Metin Karataş, Didem Kumru Atalay. Evaluation of Physical Activity Level in Patients with Osteoarthritis. Journal of Physical Medicine and Rehabilitation Sciences. 2011;14:75-9.
24. Portney LG WM. Foundations of Clinical Research: Applications to Practice. 3rd ed: Pearson/Prentice Hall; 2009.
25. Koo TK, Li MY. A Guideline of Selecting and Reporting Intraclass Correlation Coefficients for Reliability Research. J Chiropr Med. 2016;15(2):155-63.
26. Lima VP, Almeida FD, Janaudis-Ferreira T, Carmona B, Ribeiro-Samora GA, Velloso M. Reference values for the six-minute pegboard and ring test in healthy adults in Brazil. J Bras Pneumol. 2018;44(3):190-4.
27. Kulkarni MS, Alaparthi GK, Krishnan S, Ramakrishna A, Acharya V. Reference value for the six-minute peg board and ring test. A cross sectional study. Multidiscip Respir Med. 2020;15(1):670.
28. Zullo A, Fleckenstein J, Schleip R, Hoppe K, Wearing S, Klingler W. Structural and Functional Changes in the Coupling of Fascial Tissue, Skeletal Muscle, and Nerves During Aging. Front Physiol. 2020;11:592.
29. Ohara DG MC, Reis IM, Jamami M. . Functional capacity assessment of upper limbs in healthy young adult subjects. Fisioter Mov 2017;30:159-67.
30. Fonseca AA, Scheidt Figueiredo PH, Costa HS, Costa Mota LT, Angelo de Deus F, Cardoso RF, et al. Cardiorespiratory and metabolic demand of the 6-minute pegboard and ring test in healthy young adults. J Bodyw Mov Ther. 2022;29:99-105.
31. Seethamma KM JOR, Nithin Prakash, Kshama Shetty. Correlation of Forearm Circumference and Hand Length with Grip Strength in Healthy Young Adults. Acta Scientific Orthopaedics 2019;2(10):10-5.
32. Anakwe RE, Huntley JS, McEachan JE. Grip strength and forearm circumference in a healthy population. J Hand Surg Eur Vol. 2007;32(2):203-9.
33. Takeda K, Kawasaki Y, Yoshida K, Nishida Y, Harada T, Yamaguchi K, et al. The 6-minute pegboard and ring test is correlated with upper extremity activity of daily living in chronic obstructive pulmonary disease. Int J Chron Obstruct Pulmon Dis. 2013;8:347-51.