INTRODUCTION

Rheumatoid arthritis (RA) is a systemic, inflammatory disease that causes pain, joint destruction and disability.\(^1\) Pain, loss of range of motion, decreased grip strength, and decreased muscle strength are the main factors leading to loss of function and disability in patients with RA. Hand and upper extremity functions are frequently affected in patients with RA; function deteriorates as the disease progresses and affects independence.\(^2,3\) In comparative studies, it has been reported that the functional capacity of the upper extremities of RA patients is lower than that of healthy individuals.\(^4\) RA is characterized by decreased muscle mass and increased fat mass (rheumatoid cachexia), which negatively affects body composition.\(^5\) Reduced muscle mass in people with RA has a negative effect on muscle strength, and consequently physical function and performance are also reduced.\(^6\) Muscle strength and endurance determine

Validity and reliability of the unsupported upper-limb exercise test in individuals with rheumatoid arthritis

Sebahat Yaprak Cetin\(^1\) | Bilge Basakci Calik\(^2\) | Ayse Ayan\(^3\) | Ugur Cavlak\(^4\)

1Faculty of Health Science, Department of Physiotherapy and Rehabilitation, Akdeniz University, Antalya, Turkey
2School of Physiotherapy and Rehabilitation, Pamukkale University, Denizli, Turkey
3Department of Rheumatology, Antalya Research and Education Hospital, Antalya, Turkey
4Faculty of Health Science, Department of Physiotherapy and Rehabilitation, Avrasya University, Trabzon, Turkey

Correspondence
Sebahat Yaprak Cetin, Faculty of Health Science, Department of Physiotherapy and Rehabilitation, Akdeniz University, Antalya, Turkey.
Email: fzt_s.yaprakulgen@hotmail.com

Abstract

**Background:** Rheumatoid arthritis (RA) is a chronic disease which affects the performance of the upper extremities. There is no method to evaluate the specific upper extremity endurance of individuals with this disease. The unsupported upper-limb exercise test (UULEX) is a performance test that evaluates upper extremity performance (functionality and endurance).

**Aim:** The aim of this study was to examine the reliability and validity of UULEX and the minimal detectable change (MDC) in individuals with RA.

**Methods and Materials:** The study included 71 patients (15 male, 56 female) with a mean age of 52.15 ± 10.11 years. The intraclass correlation coefficient (ICC) was used to assess the reliability of UULEX. MDC estimates were calculated using baseline data. Correlations of UULEX with the Disability of Arm, Shoulder and Hand Questionnaire (DASH), Health Assessment Questionnaire (HAQ), 30-second push-up test and 6 pegboard ring test (6PBRT) were assessed for concurrent validity.

**Results:** The level, weight and duration scores of the UULEX test were found to be excellent for intra-rater reliability (ICC = 0.922, 0.960, 0.958). Intra-rater MDC values were determined to be 0.35, 2.04, and 0.80 seconds, respectively. Moderate-excellent correlations were found between UULEX and DASH, HAQ, 30-second push-up test and 6PBRT (P < .05).

**Conclusion:** The results of this study showed that UULEX test is a valid and reliable method for the assessment of upper extremity performance in individuals with RA.

**KEYWORDS**
reliability, rheumatoid arthritis, unsupported upper-limb exercise test, upper extremity, validity
the performance of the muscle. In routine examinations of RA patients, the upper extremity muscle performance is not evaluated clinically, and more often grip and fine grip strength measurements are performed. However, these measurement methods do not give sufficient information about upper extremity muscular performance. Rehabilitation programs aim to develop upper extremity function, so there is a need for valid and reliable methods to determine upper extremity problems in RA patients and to measure the effectiveness of treatment.

Although there are many methods based on patient reporting to evaluate upper extremity functions in RA, there is no specific observation-based performance test for patients with RA. As far as we know, most performance tests used for the upper extremity are more difficult and are advanced tests for athletes or healthy individuals, and are therefore not suitable for RA patients.

The unsupported upper-limb exercise test (UULEX) is a performance test that evaluates upper extremity performance. This test was developed to evaluate the upper extremity function and endurance in individuals with chronic obstructive pulmonary disease (COPD) and healthy individuals. In the literature, this test has also been used to evaluate the upper extremity performance of the elderly. Lima recommended this test be used to assess the capacity and endurance of unsupported arm exercise in other clinical cases with arm disability and to improve exercise programs.

As UULEX can be performed in a sitting position, is a mild to difficult test and can be used for all ages, the hypothesis of this study was that this test is a performance test that can be used to assess impaired upper extremity function in individuals with RA. To date, there has been no validity and reliability study of UULEX applied to patients with RA. Therefore, the aim of this study was to investigate whether the UULEX test is valid and reliable in individuals with RA.

2 | METHODS

The study included 71 individuals with RA who met inclusion criteria, were diagnosed with RA by a rheumatologist according to the 2010 classification criteria of the American College of Rheumatology/European League Against Rheumatism for RA, and were monitored in the Rheumatology Clinic. The study was approved by Pamukkale University Medical Ethics Committee (Approval no: 60116787-020/ 58593). All participants were informed about the assessment methods before they started the study and provided signed consent forms for participation.

Inclusion criteria included:

- a diagnosis of RA
- age 18-64 years and
- no other disease which could affect functions (orthopedic, neurological, cardiovascular or metabolic diseases).

Exclusion criteria included:

- age >65 years
- presence of comorbidity affecting upper extremity and hand functions (carpal tunnel syndrome, trigger finger, impingement syndrome, thoracic outlet syndrome, lateral and medial epicondylitis, hand osteoarthritis)
- a history of surgery on the upper extremity
- pregnancy and
- cognitive impairments.

Demographic data including age, gender, weight, height and body mass index (BMI), and duration of disease were recorded. The tests were explained and demonstrated to the individuals before performance. After each test, the subjects were allowed to rest for at least 5 minutes to reduce the effect of fatigue. All evaluations were performed by a single physiotherapist (SYC) with at least 10 years of experience in this field. The tests were completed in approximately 30-40 minutes. The UULEX test was repeated 1 week later for test-retest reliability. The Disability of Arm Shoulder and Hand Questionnaire (DASH), Health Assessment Questionnaire (HAQ), 30-second push-up test and 6 peg board ring test (6PBRT) were used for the validity of the UULEX test. The assessments were performed in the outpatient clinic where patients with RA were diagnosed, so test performance was minimally affected by environmental factors.

2.1 | Statistical analyses

Data obtained in the study were analyzed statistically using SPSS for Windows 22.00 software (IBM). Descriptive statistical data were stated as mean ± standard deviation (SD) values and number (n) and percentage (%). Intraclass correlation coefficients (ICC) were used to assess the inter-rater and intra-rater reliability of the UULEX test. An ICC <0.5 indicates poor reliability, between 0.51-0.75 moderate reliability and >0.75 good reliability. The correlation of concurrent validity of UULEX test with DASH, HAQ and 30-second push-up test and 6PBRT was analyzed with Pearson correlation analysis. A correlation coefficient of 0.00-0.49 was considered unacceptable, 0.50-0.69 moderate, 0.70-0.79 high and 0.80-1.00 excellent. A value of P < .05 was considered statistically significant in all statistical analyses. As a result of power analysis, it was calculated that 80% power would be obtained with 95% confidence when at least 64 patients were included in the study.

Standard error of measurement (SEM) was applied to evaluate changes in individual scores in repeated measurements. SEM was also used to determine the variability around the mean measurement and to calculate the confidence interval. A confidence interval (CI) of 95% is the most frequently used in health-related studies. The Z score is used in SEM and CI calculations. The Z score indicates how many standard deviations data are from the average. In the 95% CI, the Z score was 1.96. The minimal detectable change (MDC) value was used in the interpretation of the results to
determine whether a change between repeated tests was a random change or a real change in performance.16 For the MDC at 95% CI, the ICC and SEM were calculated according to the formula below.17

\[
\text{SEM} = \text{SD at first assessment} \times \sqrt{(1 - \text{ICC})}
\]

\[
\text{MDC 95% CI} = \text{SEM} \times 1.96 \times \sqrt{2}
\]

### 2.2 Measures

1. **UULEX:** The UULEX uses a chart of 8 levels of horizontal parallel lines. Each level is 84 cm wide and 8 cm high. The distance between the level centers is 15 cm. For the application of this test, the subject is seated on a straight-backed chair with both feet on the floor facing the wall where the UULEX chart is mounted. The subject is holding a plastic bar, weighing 0.2 kg, and raises the bar from the level of the hip. Keeping the arms shoulder-width apart, the subject raises the bar to different levels of the UULEX chart in front of the lines. As an initial warm-up exercise, the subject is instructed to raise the bar to the first level and maintain the position for 2 minutes. Then the bar is moved to each level, increasing the levels with each movement throughout 1 minute. The beginning and end point of each level is the hip joint. To the accompanying beat of a metronome, the bar is lifted up to 30 movements per minute. When the subject reaches their maximum height, the bar weighing 0.2 kg is replaced by a 0.5 kg bar. As the exercise progresses through each minute, the weight of the bar is increased by 0.5 kg up to a maximum of 2 kg. During the test, a subject can move up to a maximum of a 2 kg bar in a maximum of 12 minutes. The subject is instructed to continue the test until limited by the emergence of symptoms9,10 (Figure 1).

2. **DASH:** The DASH questionnaire consists of 30 items; 21 related to daily living activities, five to symptoms (pain, activity-related pain, tingling, stiffness, weakness), and each of the remaining four items assesses social function, work, sleep and self-confidence. All items are answered on a 5-point Likert scale ([a]: no difficulty, [b]: mild difficulty, [c]: moderate difficulty, [d]: excessive difficulty [e]: cannot perform). According to the results of the DASH, each section is scored 0-100 (0: no disability, 100: maximum disability).3

3. Thirty-second push-up test: Subjects perform push-ups for 30 seconds on a timed start command. A stopwatch is used to record the time. The starting position is taken by the subject on the floor, with arms shoulder-width apart, elbows stretched, and knees not touching the ground. On the start command, the subject lowers the body toward the floor and then returns to the starting position. The number of push-ups completed within 30 seconds is recorded.18,19

4. **6PBRT:** This test was developed to evaluate the functional capacity of the upper extremity. A square plate with four pins 20 cm apart is used to perform the test. Before starting the test, 10 rings are placed on the pin at the bottom right and 10 rings on the lower left pin. Each of the rings weighs approximately 14.17 g. The subject is seated on a straight-backed chair with both feet on the floor against the bottom of the square plate, facing the pins at shoulder level. On the start command, the subject moves one ring at a time from the inferior to the superior pin, first using the dominant hand, then when all the rings have been moved, repeating the procedure with the non-dominant hand. This rotation continues for 6 minutes as recorded on a stopwatch. During the test, the timer was not stopped if the subject wanted to rest. At the end of 6 minutes, the total number of ring movements was recorded.10

5. **HAQ:** This questionnaire was developed to evaluate rheumatic diseases, especially for RA patients. It comprises 20 items related to eight activities: dressing, standing from sitting, eating, walking, personal hygiene, reach, grip and usual activities. Each item is scored between 0 and 3, with a high total score indicating low health status.20
RESULTS

The study included 71 patients (15 male, 56 female) with a mean age of 52.15 ± 10.11 years. The demographic and healthy related data of the patients are shown in Table 1.

The level, weight and time scores of the first and final performances of UULEX, and the scores of the DASH, HAQ, 30-second push-up test and the 6PBRT are shown in Table 2.

There was a moderate correlation between the level scores of the UULEX test and DASH, 30-second push-up test, 6PBRT and HAQ. There was an excellent correlation between the weight scores of the UULEX test and DASH, HAQ and 6PBRT, and a moderate correlation between the weight scores of the UULEX test and 30-second push-up test. There was an excellent correlation between the duration scores of the UULEX test and DASH, HAQ and 6PBRT, and a high correlation with the 30-second push-up test (Table 4).

DISCUSSION

The results of this study showed that the UULEX test was a valid and reliable method for the evaluation of upper extremity function and endurance of individuals with RA. In the literature, there are validity and reliability studies of the UULEX test for individuals with COPD and healthy adults, in which the ICC for UULEX intra-rater reliability ranges from 0.85 to 0.97. In the current study, the intra-rater reliability values (ICC: 0.92-0.96) were consistent with data in the literature.

Muscle strength and endurance are two different components of limb muscle function: limb muscle strength is related to muscle strength generating capacity, while limb muscle endurance refers to the ability of the muscle to maintain or repeat a specific task over time. The functional capacity of the upper extremity in individuals with RA is associated with the muscle strength and endurance of the upper extremity. A decrease in strength and endurance negatively affects functional capacity. Therefore, the evaluation of endurance can be considered necessary and important. However, to the best of our knowledge, there has been no report in the literature of a performance test method that specifically measures the upper extremity muscle strength and endurance of RA patients. As the upper extremity performances of these patients cannot be specifically evaluated, it is difficult to determine the effectiveness of exercise programs.

The 6PBRT has been used in previous studies in the literature to evaluate concurrent validity of the UULEX test. In the present study, DASH, HAQ, 30-second push-up test and 6PBRT were used. DASH is a quick and easy-to-use measurement tool which is frequently

### Table 1: Demographic and healthy related variables of individuals

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
<th>Min-max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y</td>
<td>52.15 ± 10.11</td>
<td>32-64</td>
</tr>
<tr>
<td>Height, cm</td>
<td>161 ± 6.88</td>
<td>1.50-1.80</td>
</tr>
<tr>
<td>Weight, kg</td>
<td>72.04 ± 12.48</td>
<td>44-113</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>33.20 ± 11.96</td>
<td>12.25-80.82</td>
</tr>
<tr>
<td>Age at diagnosis, y</td>
<td>32.77 ± 4.88</td>
<td>23-50</td>
</tr>
<tr>
<td>Disease duration, y</td>
<td>19.38 ± 10.18</td>
<td>1-38</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male</td>
<td>15</td>
<td>21.1</td>
</tr>
<tr>
<td>Female</td>
<td>56</td>
<td>78.9</td>
</tr>
<tr>
<td>Dominant hand</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Right</td>
<td>67</td>
<td>94.4</td>
</tr>
<tr>
<td>Left</td>
<td>4</td>
<td>5.6</td>
</tr>
</tbody>
</table>

### Table 2: Average values of measurement

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mean ± SD</th>
<th>Min-max</th>
</tr>
</thead>
<tbody>
<tr>
<td>UULEX</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Level</td>
<td>5.70 ± 1.12</td>
<td>2-8</td>
</tr>
<tr>
<td></td>
<td>(2nd measurement)</td>
<td>5.91 ± 1.13</td>
</tr>
<tr>
<td>Weight</td>
<td>1.24 ± 0.72</td>
<td>0.2-2</td>
</tr>
<tr>
<td></td>
<td>(2nd measurement)</td>
<td>1.33 ± 0.73</td>
</tr>
<tr>
<td>Duration</td>
<td>7.75 ± 2.48</td>
<td>1.70-11</td>
</tr>
<tr>
<td></td>
<td>(2nd measurement)</td>
<td>8.26 ± 2.36</td>
</tr>
<tr>
<td>DASH</td>
<td>32.04 ± 26.32</td>
<td>0-95.50</td>
</tr>
<tr>
<td>HAQ</td>
<td>17.98 ± 14.73</td>
<td>0-52</td>
</tr>
<tr>
<td>30-sec push-up test</td>
<td>4.14 ± 4.02</td>
<td>0-15</td>
</tr>
<tr>
<td>6PBRT</td>
<td>230.56 ± 48.39</td>
<td>113-302</td>
</tr>
</tbody>
</table>

### Table 3: Intra-rater reliability of UULEX test

<table>
<thead>
<tr>
<th></th>
<th>ICC</th>
<th>95% CI</th>
<th>SEM</th>
<th>MDC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>0.922</td>
<td>0.878-0.951</td>
<td>0.13</td>
<td>0.35</td>
</tr>
<tr>
<td>Weight</td>
<td>0.960</td>
<td>0.937-0.975</td>
<td>0.86</td>
<td>2.04</td>
</tr>
<tr>
<td>Duration</td>
<td>0.958</td>
<td>0.934-0.974</td>
<td>0.29</td>
<td>0.80</td>
</tr>
</tbody>
</table>

Abbreviations: BMI, body mass index; cm, centimeter; kg, kilogram; max, maximum; min, minimum; SD, standard deviation.
TABLE 4 Concurrent validity of the UULEX test

<table>
<thead>
<tr>
<th></th>
<th>DASH r (P*)</th>
<th>HAQ r (P*)</th>
<th>30-s push-up test r (P*)</th>
<th>6PBRT r (P*)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Level</td>
<td>−0.557 (.00)</td>
<td>−0.637 (.00)</td>
<td>0.568 (.00)</td>
<td>0.695 (.00)</td>
</tr>
<tr>
<td>Weight</td>
<td>−0.822 (.00)</td>
<td>−0.908 (.00)</td>
<td>0.609 (.00)</td>
<td>0.855 (.00)</td>
</tr>
<tr>
<td>Duration</td>
<td>−0.853 (.00)</td>
<td>−0.934 (.00)</td>
<td>0.707 (.00)</td>
<td>0.933 (.00)</td>
</tr>
</tbody>
</table>

Abbreviations: 6PBRT, 6 pegboard ring test; DASH, Disability of Arm, Shoulder and Hand Questionnaire; HAQ, Health Assessment Questionnaire; UULEX, unsupported upper-limb exercise test.

*Spearman correlation analyses, P < .05.

applied to evaluate upper extremity function in RA patients. HAQ is also frequently used to evaluate the capacity of RA patients to perform daily life activities. In the literature, both DASH and HAQ have been used to evaluate the level of disability of the upper extremity in RA patients. Aktekin et al reported that DASH is a measure of the patient’s own perception of upper-limb impairment. These scales can provide information about the patient’s disability but the data are subjective and specific to each patient. Indexes based on patient reporting such as DASH and HAQ are insufficient for the evaluation of the upper extremity muscle strength and endurance of these individuals.

The 6PBRT is similar to the UULEX test for the evaluation of unsupported upper-limb function. The 6PBRT requires smaller arm movements and the load is minimal. UULEX is a test in which the exercise is increased to a maximum, which requires larger arm movements. In studies evaluating the concurrent validity of UULEX, the relationship with the 6PBRT has been found to be high, as both UULEX and the 6PBRT measure exercise capacity. The 30-second push-up test also evaluates the strength and endurance of the arm-shoulder girdle and is a recommended test in the physical fitness test battery. The reason for the strong correlation of UULEX with these other tests may be related to the fact that they are similar in design. In addition, the use of standardized guidelines, equipment and an assessment protocol may reduce variations in the measurements.

In the examinations of the correlations of UULEX with other tests, there was seen to be a moderate relationship between the level scores of the UULEX test and DASH, 30-second push-up test, 6PBRT and HAQ. An excellent relationship was determined between the weight scores of the UULEX test and DASH, HAQ and 6PBRT, and a moderate relationship with the 30-second push-up test. There was also determined to be an excellent relationship between the duration scores of the UULEX test and DASH, HAQ and 6PBRT, and a high relationship with the 30-second push-up test. That the level scores of the UULEX test correlated with the other tests could be attributed to the level scoring being associated with arm length. The correlations between the 30-second push-up test and the weight and time scores of UULEX were lower than the correlations with other tests. This may have been due to the lower number of push-ups performed as the average age of the patients was older. The strong correlation between the UULEX test and the 6PBRT is consistent with the literature.

In previous studies, the SEM value of the UULEX test has not been calculated. In this study, the calculated SEM values were quite low except for weight scoring. This result shows that the UULEX test can accurately determine the upper extremity endurance changes in RA patients. These results obtained from RA patients can also be considered to constitute preliminary data for further research.

Minimal detectable change values for UULEX have not been calculated in previous studies. Therefore, the MDC values in this study are the first published UULEX values of RA patients. In the current study, the ICC MDC values ranged from 0.35 to 2.04. These MDC values can be considered small enough to be clinically relevant in RA patients. When this test is combined with the high test-retest reliability, the UULEX test can be seen to be both reliable and beneficial in the clinical setting. In this context, these values can be a guide for clinicians in the evaluation of interventions.

This study has some limitations. As the age range of the RA patients included in the study was 18-65 years, and mean age was 52.15 years, the results of the study cannot be considered valid for elderly patients with RA. The second limitation was that the 6PBRT and 30-second push-up test have not been determined as valid and reliable for RA patients. In studies in the literature, 6PBRT has been used for the validity of the UULEX test, and the 30-second push-up test to measure the strength and endurance of the arm and shoulder girdle muscles. Further studies are required to examine the validity and reliability of both the 6PBRT and the 30-second push-up test in RA patients. A final limitation was the absence of specific limited disease duration of the RA patients included in the study. This lack of standardized disease duration may have affected the endurance scores.

Further studies may contribute to the literature by examining whether the other performance tests which were used in this study are valid and reliable in RA patients. According to the results of this study, the UULEX test can be used as an objective assessment tool in both clinics and rehabilitation centers to evaluate the upper extremity functions and endurance of RA patients. The results can also be considered to provide guidance for clinicians in the assessment of interventions with MDC values of the UULEX test. As a valid and reliable assessment tool, we believe that it will guide the preparation of rehabilitation programs.
REFERENCES


How to cite this article: Cetin SY, Basakci Calik B, Ayan A, Cavlak U. Validity and reliability of the unsupported upper-limb exercise test in individuals with rheumatoid arthritis. Int J Rheum Dis. 2019;00:1–6. https://doi.org/10.1111/1756-185X.13720