



1 FEATURE

2 **Test–Retest Reliability and Minimal Detectable Change**  
3 **Scores for Fitness Assessment in Older Adults with Type 2**  
4 **Diabetes**

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9 **Keywords**

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11 tion; elderly.

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19 **Abstract**

20 **Purpose:** To assess the intraclass correlation coefficients (ICCs) and to deter-  
21 mine the minimal detectable change (MDC<sub>95</sub>) scores of the data for the Hand  
22 Grip Strength Test, the Chair Sit and Reach Test (CSRT), the Timed “Up and  
23 Go” (TUG) test, the Six-Minute Walk Test (6MWT) and 30 seconds Sit to  
24 Stand Test (30s-STs) test in older adults with type 2 NIDDM.

25 **Design:** Test–retest reliability.

26 **Methods:** Eighteen subject participated in two sessions (1 week apart), which  
27 included the different tests.

28 **Findings:** High ICCs ( $\geq 0.92$ ) were found for all tests. The MDC<sub>95</sub> scores were  
29 as follows: 4.0 kg for Hand Grip Strength Tests, 7.5 cm for the right leg-CSRT,  
30 9.0 cm for the left leg-CSRT, 1.0 second for the TUG test, 27 m for the  
31 6MWT, and 3.3 repetitions for the 30s-STs test.

32 **Conclusions:** All tests evaluated are reliable outcome measures for type 2 NID-  
33 DM patients.

34 **Clinical relevance:** This study has generated novel MCD<sub>95</sub> data, which will  
35 assist nursing practitioners in both prescribing the most beneficial exercise and  
36 interpreting posttreatment changes after rehabilitation in patients with T2DM.

37 **Background**

38 Type 2 diabetes mellitus (T2DM) is a metabolic disorder  
39 characterized by hyperglycemia and insufficiency of secre-  
40 tion or action of endogenous insulin (Maritim, Sanders,  
41 & Watkins, 2003). Because T2DM prevalence is increasing  
42 within worldwide (Zimmet, Alberti, & Shaw, 2001), pub-  
43 lic health authorities should encourage the implementa-  
44 tion of both clinical and preventive intervention  
45 programs to tackle the associated health and economic  
46 burden of the disease. Increasing physical fitness in this  
47 population could enhance insulin sensitivity and glycemic  
48 control (Srikanthan & Karlamangla, 2011) and may atten-  
49 uate declines in strength, endurance, and function (Bal-  
ducci et al., 2012), all of which have been reported to be

lower in this population when compared with those with-  
out the disease (Ozdirenc, Biberoglu, & Ozcan, 2003; Th  
et al., 2012). On the other hand, low levels of fitness have  
been considered to independently predict mortality  
among older adults (Sui et al., 2007) as well as those with  
T2DM (Nylen et al., 2010). Therefore, interventions  
designed to improve fitness levels are warranted for this  
population (Knowler et al., 2002; Tuomilehto et al.,  
2001).

Considering the importance of physical fitness in peo-  
ple with T2DM, nurses working with older adults with  
T2DM should be cognizant of the fitness level and abili-  
ties of individual patients and encourage appropriate  
exercise. Moreover, it is important to assess progress or  
decline in function for an optimal prescription in each

1 individual case. Therefore, specific clinical tools should be  
2 tested for reliability with individuals with T2DM. A vari-  
3 ety of physical fitness tests are currently available to assess  
4 function and to monitor improvements in a clinical set-  
5 ting.

6 In this study, the Hand Grip Strength Test, Chair Sit  
7 and Reach Test (CSRT), Timed “Up and Go” (TUG),  
8 Six-Minute Walk Test (6MWT), and 30 seconds Sit to  
9 Stand Test (30s-STs Test) were used. With the exception  
10 of the CSRT, the Hand Grip Strength Test (Gin et al.,  
11 2010), the TUG (Alvarenga, Pereira, & Anjos, 2010;  
12 Oliveira, Fachin, Tozatti, Ferreira, & Marinheiro, 2012),  
13 the 6MWT (Ozdirenc et al., 2003), and the 30s-STs Test  
14 (Lambers et al., 2008) have been previously used among  
15 patients with T2DM.

16 The Hand Grip Strength Test is often used to quantita-  
17 tively assess maximal voluntary isometric muscle strength  
18 of the arms. It has been suggested as a tool to character-  
19 ize the severity of a specific disease (Aparicio et al., 2011)  
20 and disease diagnoses (Aparicio et al., 2011). The CSRT  
21 has also been used in different older adult populations  
22 (Bautmans, Van Hees, Lemper, & Mets, 2005; Schmid,  
23 Van Puymbroeck, & Koceja, 2010) for lower limb flexibil-  
24 ity (which is also reduced in T2DM (Herriott, Colberg,  
25 Parson, Nunnold, & Vinik, 2004)) assessment purposes.  
26 The TUG test is the most widely used test for mobility/  
27 agility assessment in clinical populations (e.g., postpolio  
28 survivors or Parkinson’s disease) (Lehmann, Sunnerha-  
29 gen, & Willen, 2006; Matinolli et al., 2009). The 6MWT  
30 is a physical fitness test that is used to assess cardiorespi-  
31 ratory fitness, which is also reduced in patients with  
32 T2DM (Ozdirenc et al., 2003). The 10-repeated Sit to  
33 Stand (STS) Test (Takai et al., 2009) and the 5-repeated  
34 STS Test (Batista et al., 2012) have been used to quanti-  
35 tate lower limb muscle strength in patients with lower  
36 limb muscle strength weakness, a characteristic of patients  
37 with T2DM (Th et al., 2012). However, as both tests can  
38 suffer from floor effects (i.e., no score awarded unless the  
39 subject can complete the required number of stands), the  
40 number of full stands completed in 30 seconds (30s-STs  
41 Test) has been the preferred method to evaluate lower  
42 limb muscle strength in older adults (Rikli, 2001).

43 Unfortunately, the reliability of these tests for people  
44 with T2DM has not been yet determined. The reliability  
45 of a test should be expressed as both relative reliability  
46 and absolute reliability. Relative reliability may be mea-  
47 sured with the intraclass correlation coefficient (ICC),  
48 which is used for test–retest reliability (Weir, 2005) or  
49 the coefficient of variation, expressed as a percentage (%)

CV) (Cohen, 1988). Individual performance and measure-  
ment error are measured with absolute reliability, which  
provides information for differentiating a true change in  
performance from a change due to individual variation  
and measurement error (Weir, 2005).

Within this context, the aims of this study were to cal-  
culate the test–retest relative reliability of commonly used  
physical fitness tests in older adults with T2DM (Hand  
Grip Strength Test, the CSRT, the TUG Test, the 6MWT,  
and the 30s-STs Test) and to calculate the absolute reli-  
ability with the standard error of measurement (*SEM*)  
and minimal detectable change scores at 95% confidence  
intervals (*MDC*<sub>95</sub>).

## Research design and methods

### Participants and study design

A test–retest reliability study design was conducted. Par-  
ticipants were recruited (between January 1 and March  
30, 2012) from a local primary care facility (Seville,  
Spain). Twenty-five volunteers received detailed informa-  
tion about the aims and study procedures and were  
included in the study. Inclusion criteria were T2DM diag-  
noses (Diagnosis & classification of diabetes mellitus,  
2012) and to be able to walk independently without pain  
or a walking aid. Exclusion criteria were less than  
65 years of age, a T2DM-related complication (i.e., neu-  
ropathy, nephropathy, or vision impairment), uncon-  
trolled diabetes, history of cognitive impairment, severe  
heart and liver or kidney disease. A total of seven partici-  
pants did not meet these criteria and were not included  
in the study. Finally, 18 patients (aged 73.6 [8.1] years)  
were included.

The study was developed following the ethical guide-  
lines of the Declaration of Helsinki, last modified in 2000  
and had local research and ethics committee approval  
(University of Seville). All subjects gave written consent.

### Procedures and outcome measures

Participant characteristics were recorded, including age,  
gender, annual income, marital status, educational status,  
blood pressure, resting heart rate, number of oral glyce-  
mic medications, fasting blood glucose, hemoglobin A1C,  
and diabetes duration. Their weight, height, and waist  
and hip circumferences were measured, so that body mass  
index (BMI; kg/m<sup>2</sup>) and waist-to-hip ratio could be  
calculated. Body fat percentage (BF%) was also estimated

1 using a handheld impedance analyzer (Omron BF-306;  
2 Omron Healthcare Europe BV, Hoofddorp, The Nether-  
3 lands) according to the manufacturer's instructions  
4 (Deurenberg et al., 2001). Mid-arm and mid-calf circum-  
5 ferences were also measured.

6 Participants performed each of the tests twice, with a  
7 1-week interval between the testing sessions. Every effort  
8 was made to keep all factors associated with the testing  
9 sessions consistent: day of the week, time of day, climatic  
10 characteristics, and area in which the test was performed.  
11 Participants performed the Hand Grip Strength Test, the  
12 CSRT (Right and Left legs), the TUG Test, the 6MWT,  
13 and the 30s-STS Test. Participants were required to rest  
14 for 5 minutes between each mode of testing in an effort  
15 to allow recovery (Gusi et al., 2011).

16 Hand Grip Strength Test was used to assess upper  
17 body muscular strength (Rodriguez et al., 1998). This test  
18 was conducted with a digital dynamometer (TKK 5401  
19 Grip-D; Takei Scientific Instruments, Tokyo, Japan). The  
20 participants maintained the standard bipedal position  
21 during the entire test with the arm in complete extension.  
22 Each participant performed the test twice with each hand  
23 allowing a 1-minute rest period between measures. The  
24 best value of two trials was chosen as score of the test for  
25 each arm (dominant and nondominant arm) and an  
26 average score of both hands was computed as bimanual  
27 Hand Grip Score. The grip position of the dynamometer  
28 was adjusted to each individual's hand size.

29 The CSRT was used to assess lower body flexibility  
30 (Rikli, 2001). A ruler was used to measure the distance  
31 between the end of the 3rd digit of the hand and the toes.  
32 This value is negative if the fingertip does not reach the  
33 toes and positive if fingertip passes the toes. Both sides  
34 were measured twice and the maximal score from each  
35 leg was recorded.

36 Motor agility/mobility was assessed by the TUG test (Ri-  
37 kli, 2001). The participant had to stand up from a chair,  
38 walk 2.44 m to and around a cone, and return to the chair  
39 in the shortest possible time. The best time of two trials (1-  
40 minute rest period between each trial) was recorded.

41 To assess cardiovascular fitness, the 6MWT was used  
42 (Rikli, 2001). Participants were instructed to walk as far as  
43 they could at a fast, comfortable pace in 6 minutes. The  
44 maximum distance (meters) walked was recorded as the  
45 score of the test. Participants were discouraged from talking  
46 during the test and were notified of each passing minute.

47 The 30 seconds Sit to Stand Test was used to assess  
48 lower body strength (Rikli, 2001). Participants were  
49 instructed to perform the task starting and finishing in

the seated position. Participants were allowed a practice  
trial before the beginning of the test. The number of  
times within 30 seconds that the participant could raise  
to a full stand from a seated position with back straight  
and feet flat on the floor "as fast as possible," without  
pushing off the arms was counted.

### Sample size and study power

Before the start of the study, required sample size was  
calculated following the suggestions of Walter et al. (Wal-  
ter, Eliasziw, & Donner, 1998) to reach a power of 0.90  
on ICC, according to the following standards:  
alpha = 0.05, under the null hypothesis that the ICC was  
moderate in accordance with the criteria points used  
(0.50) (Munro, Visintainer, & Page, 1986), and the alter-  
native hypothesis had excellent ICC (0.9) (Munro et al.,  
1986). Within these criteria, the required sample size was  
at least 11 participants for each test; however, additional  
participants were recruited because of the potential for  
attrition between the two test trials. The final reported  
power achieved in each test with these specifications was  
0.96 for Hand Grip Strength, CSRT, and TUG Tests; 0.93  
for the 6MWT and 0.95 the 30s-STS test.

### Data analysis

The SPSS package version 18.0 for Windows (SPSS Inc.,  
Chicago, IL) was used for data analysis. The level of sig-  
nificance was set at  $p \leq .05$  for all statistical analyses  
performed. According to the Kolmogorov-Smirnov test,  
data were normally distributed for all measures in this  
study, and therefore parametric statistics were used. Data  
are presented as means (*SD*), unless otherwise stated.  
Paired sample *t*-tests were performed to analyze differ-  
ences between tests and retest sessions for all physical fit-  
ness assessments.

The same technician (who had more than 3 years of  
experience applying the tests used in this study in T2DM  
patients) administered all of the tests, so the intrarater  
reliability was calculated. Relative reliability was determi-  
nate using the ICC<sub>1,1</sub> (one-way random effects model  
analysis of variance) with 95% confidence intervals  
and across the two test sessions (Shrout & Fleiss, 1979).  
An ICC above 0.70 was considered to demonstrate good  
reliability (Munro et al., 1986); although for clinical  
measures, it has been suggested that the ICC should  
exceed 0.90 (Portney & Watkins, 2000). In addition, the  
%CV based on the method error to quantitate the

percentage of variation from trial to trial was calculated for a better understanding on reliability. For the CV, a change of 10%–20% in variation was considered to be adequate reliability (Cohen, 1988).

Absolute reliability was determined with the standard errors of measurement (*SEM*) and minimal detectable change scores at 95% confidence interval ( $MCD_{95}$ ) with the following equations (Weir, 2005):  $SEM = SD \sqrt{(1 - ICC)}$ . In this equation, *SD* is the mean *SD* of day 1 and day 2, and *ICC* is the reliability coefficient.  $MCD_{95} = 1.96 \sqrt{2SEM}$ . In this equation, *SEM* was calculated as previously described. The 1.96 in the  $MCD_{95}$  equation represents the z-score at the 95% confidence level. Bland–Altman plots were also performed for physical fitness tests (Bland & Altman, 1986).

## Results

Two participants were unwilling to attend the second testing session. In addition, three participants did not complete the second 6MWT due to the lack of time and one participant could not perform the second 30s-STSTest because of worsened health. No adverse events occurred during testing.

Descriptive statistics for the 18 participants are shown in Table 1. Outcomes of day 1 and day 2 testing values and the results of repeated tests are shown in Table 2. No statistically significant differences were found between testing days for all outcomes of the study except for hand grip measures, where the kg values of day 2 were greater than kg values of day 1 ( $p < 0.05$ ).

The ICCs of each test are presented in Table 3, along with the *SEM* and  $MCD_{95}$  values. The ICCs for test–retest reliability were high ( $>0.90$ ) for all of the outcome measures (Hand Grip Strength Test, the CSRT, the TUG Test, the 6MWT, and the 30s-STSTest). Also, the %CV for each test across the trials is presented in Table 3. With the exception of CSRTs, the %CVs (between 5% and 17%) shown in this study indicate that participants had low variability when both trials were considered.

Figure 1 shows Bland–Altman plots of the tests on day 1 and day 2. With the exception of the TUG Test and Right CSRT, the bias representing the average difference for measures between day 1 and day 2 was negative. This information indicates that day 2 had higher values than day 1.

The *SEM* was 1.40 kg, 1.56 kg, and 1.49 kg for the Hand Grip Strength Test (dominant arm, nondominant arm, and bimanual hand grip strength, respectively); 2.70

**Table 1** Characteristics of the type 2 diabetic older adults included in the study ( $n = 18$ )

| Socio-Demographic Characteristics          |              |
|--|--------------|
| Age (years)*                               | 73.55 (8.13) |
| Gender, women (%)                          | 44.4         |
| Income (%)                                 |              |
| <USD 1,544                                 | 72.2         |
| USD 1,544–2,315                            | 22.2         |
| >USD 2,315                                 | 5.6          |
| Educational status (%)                     |              |
| Unfinished studies                         | 22.2         |
| Primary school                             | 38.9         |
| Secondary school                           | 33.3         |
| University degree                          | 5.6          |
| Marital status (%)                         |              |
| Married                                    | 50           |
| Unmarried                                  | 11.1         |
| Separated/Divorced/Widowed                 | 38.9         |
| Clinic and health characteristics          |              |
| Oral hypoglycemic agents (number per day)* | 1.9 (1.5)    |
| Blood glucose level (mg/dL)*               | 141.4 (43)   |
| HbA <sub>1c</sub> (%)                      | 7.2 (1.2)    |
| SBP (mmHg)*                                | 15.06(2.2)   |
| DBP (mmHg)*                                | 6.50 (1)     |
| HR (bpm)*                                  | 75.7 (11.3)  |
| Years since clinical diagnosis (number)*   | 8.7 (7.3)    |
| Body composition                           |              |
| BMI (Kg/m <sup>2</sup> )*                  | 31.5 (7.3)   |
| BF%  | 38.4 (10.5)  |
| WHR*                                       | 0.91 (0.09)  |

\*Values expressed as Mean (*SD*), HbA<sub>1c</sub>: Glycated hemoglobin. SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; BMI, body mass index; BF%, body fat percentage; WHR, waist-to-hip ratio.

and 3.25 cm for the CSRT (Right and left CSRT, respectively); 0.31 seconds for the TUG Test; 9.88 m for the 6MWT, and 1.21 repetitions for the 30s-STSTest.

The  $MCD_{95}$  values were 3.85 kg, 4.32 kg, and 4.13 kg for the Hand Grip Strength Test (dominant arm, nondominant arm, and bimanual hand grip strength, respectively); 7.50 and 9.01 cm for the CSRT (Right and Left CSRT, respectively); 0.85 sec for the TUG Test; 27.37 m for the 6MWT; and 3.35 repetitions for the 30s-STSTest.

## Discussion

As a novelty, this study has provided estimates of variability for commonly used physical performance measures

**Table 2** Mean differences in physical fitness tests performed by older adults with T2DM between day 1 and day 2 of measurement

| Physical Fitness Variables                        | Day 1 Mean (SD) | Day 2 Mean (SD) | t      | p    |
|---|-----------------|-----------------|--------|------|
| Hand Grip Strength, dominant arm (kg) (n = 16)    | 25.56 (9.83)    | 27.90 (11.08)   | -2.43  | .028 |
| Hand Grip Strength, nondominant arm (kg) (n = 16) | 23.45 (10.42)   | 26.06 (11.60)   | -2.98  | .009 |
| Bimanual Grip Strength (kg) (n = 16)              | 24.50 (9.96)    | 26.98 (11.12)   | -2.98  | .009 |
| Right Chair Sit and Reach Test (cm) (n = 16)      | -10.94 (10.64)  | -13.68 (11.44)  | .932   | .366 |
| Left Chair Sit and Reach Test (cm) (n = 16)       | -11.69 (12.13)  | -12.90 (12.45)  | -.470  | .645 |
| Timed "Up and Go" Test (s) (n = 16)               | 8.77 (2.21)     | 8.75 (2.15)     | .675   | .510 |
| Six-Minute Walk Test (m) (n = 13)                 | 391.14 (97.37)  | 391.69 (100.15) | -1.757 | .101 |
| 30-Sit to Stand Test (number of times) (n = 15)   | 12.11 (3.58)    | 12.93 (4.96)    | -1.389 | .190 |

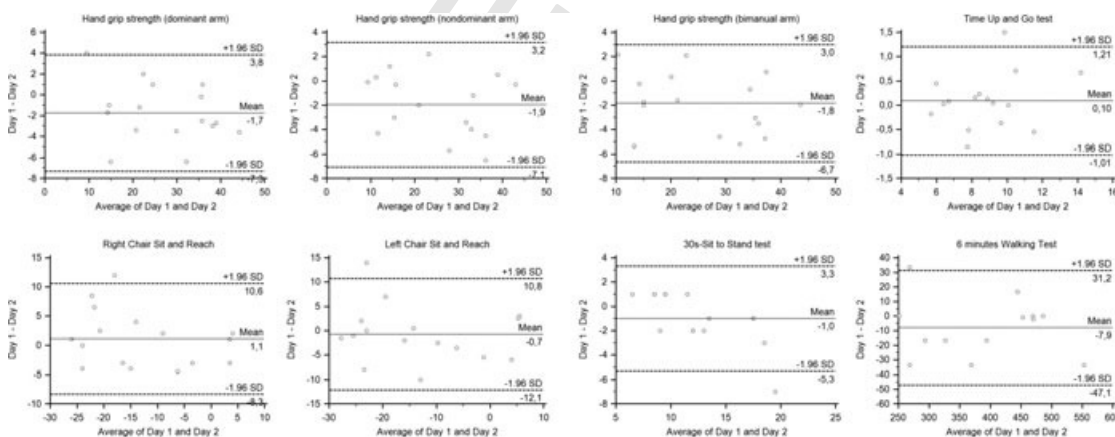
T2DM: Type 2 diabetes mellitus; Day 1: day 1 of measurement; Day 2: Day 2 of measurement; p: p value from Student's t for repeated measures.

**Table 3** Reliability analysis of the physical fitness tests performed in T2DM older adults

| Physical Fitness Tests                   | ICC | 95% CI of the ICC | SEM  | %SEM | MDC   | % MDC | %CV   |
|--|-----|-------------------|------|------|-------|-------|-------|
| Hand Grip Strength, dominant arm (kg)    | .98 | (.95 to .99)      | 1.40 | 5.2  | 3.89  | 14.5  | 10.62 |
| Hand Grip Strength, nondominant arm (kg) | .98 | (.96 to .99)      | 1.56 | 6.3  | 4.32  | 17.4  | 10.52 |
| Bimanual Grip Strength (kg)              | .98 | (.96 to 1.00)     | 1.49 | 5.8  | 4.13  | 16.1  | 9.55  |
| Right Chair Sit and Reach Test (cm)      | .94 | (.84 to .98)      | 2.70 | 22.0 | 7.50  | 60.9  | 39.22 |
| Left Chair Sit and Reach Test (cm)       | .93 | (.82 to .97)      | 3.25 | 26.4 | 9.01  | 73.3  | 47.56 |
| Time "Up and Go" Test (s)                | .98 | (.95 to .99)      | 0.31 | 3.5  | 0.85  | 9.8   | 6.46  |
| Six-Minute Walk test (m)                 | .99 | (.96 to 1.00)     | 9.88 | 2.5  | 27.37 | 7.0   | 5.12  |
| 30-Sit to Stand Test (number of times)   | .92 | (.79 to .98)      | 1.21 | 9.6  | 3.35  | 26.7  | 17.60 |

T2DM, Type 2 diabetes mellitus; ICC, intraclass correlation coefficient; CI, confidence interval; SEM, standard error of measurement; MDC, minimal detectable change; %CV, % coefficient of variation.

LOW RESOLUTION FIG



**Figure 1** Bland–Altman Plots with limits of agreement of physical fitness tests.

6

for a group of older adults with T2DM. The main findings of this study were that the test–retest relative reliability of the tests was excellent. All outcome measures were found to have high test–retest relative reliability (ICCs) having values above the threshold of 0.90 for minimal

acceptable reliability for a clinical test (Portney & Watkins, 2000).

Reported ICC values for the Hand Grip Strength Test reported in this study were similar to those reported in a clinical population (Segura-Orti & Martinez-Olmos,

2011), healthy adults (Hamilton, Balnave, & Adams, 1994), and older adults (Gusi et al., 2011). Although there is a paucity of data on the use of the CSRT, reported ICCs for this test in healthy older adults are consistent with the results of this study (Gusi et al., 2011), thus confirming that the test has good relative reliability in patients with T2DM.

Along with the 6MWT, the TUG Test is one of the most commonly used tests for functional capacity assessment on chronic diseases (Rasekaba, Lee, Naughton, Williams, & Holland, 2009). In this study, the reported ICC for the test-retest reliability of the 6MWT was 0.99. Although this test has also been used in adults with T2DM (Ozdirenc et al., 2003), no previous study, to the authors' knowledge, has determined the ICC of this test in people with T2DM. In any case, results from this study are consistent with those previously presented in studies of older adults with other special clinical situations (Lin & Bose, 2008; Ries, Echternach, Nof, & Gagnon Blodgett, 2009) as well as healthy older adults (Gusi et al., 2011). Comparable ICCs with those found in dependent older adults (Nordin, Rosendahl, & Lundin-Olsson, 2006) and healthy older adults (Gusi et al., 2011) were found for the TUG Test in this study.

The 30s-STS Test has not been used in people with T2DM; however, the ICCs of this test in older adults populations (Gusi et al., 2011) and people with musculoskeletal problems (Smeets, Hijdra, Kester, Hitters, & Knottnerus, 2006) have been reported to be similar to ICC results from this study.

Factors that may explain the high ICCs in all of the physical fitness tests are consistent timing of the tests (same day and hour of the week) and standardization of the evaluator's instructions. Despite this, using only the ICC can give a false impression about the reliability of a measurement. Bland-Altman analysis can confirm a good reliability. As results from Bland-Alman showed that systematic errors (mean difference between test-retest) for the physical fitness tests assessed in this study were nearly zero and the 95% limits of agreement were narrow, the good reliability of the measurement can be confirmed.

This study also used the method error as an adjunct to test-retest reliability because it reflected the percentage of variation from trial to trial, which is not given by the ICC. For example, a CV of 5% for the 6MWT indicates that walking 300 m in one trial might produce an expected variability of 15 m in the next trial. This knowledge could be applied for the rest of variables of this study.

However, ICC, Bland-Alman, or %CV values are not enough to interpret data from a clinical point of view.

Therefore, measurement errors should also be small and the method sufficiently sensitive to detect real changes. In this case, the *SEM* (%*SEM*) was used for these purposes. With the exception of the CSRT, the %*SEM* values in this study were low, between 3.5% and 10%, acceptable values from a clinical point of view, indicating that measurements of these tests can be made reliable for a group of older adults with T2DM. Consequently, intervention studies with improvements less than approximately 10%, in most cases, do not indicate a real change.

This study indicated that the Hand Grip Strength Test, the CSRT, the TUG Test, the 6MWT, and the 30s-STS Test are reliable measures. Health-care providers are encouraged to understand how changes in scores translate to clinical practice. To detect a real change for a single individual,  $MCD_{95}$  (independent of the unit of measurement and) was calculated (Beckerman et al., 2001). On the basis of the  $MCD_{95}$  observed in this study, if a change exceeding  $\pm 0.85$  seconds occurs in the TUG Test;  $\pm 27.37$  m in the 6MWT; or  $\pm 3.35$  repetitions in the 30s-STS Test, clinicians can be 95% confident that the difference is not due to measurement error or variability among participants. Similar conclusions could be achieved for all of the tests being evaluated (Hand Grip Strength Test and the CSRT).

### Limitations

There are several limitations to this study. The sample was one of convenience, and although it represented a wide range in physical function and T2DM clinical characteristics, all of the participants were from a primary care center situated in an urban area and may not be representative of all older adults with T2DM. Because the testing protocol of the performed measures may affect reliability, great care was taken to standardize the tests and to carefully follow the protocol. However, all tests were conducted on the same day and, as a result, some people could not attend or did not have time to complete all the tests on that day. It is therefore advisable that future studies conduct more test days to evaluate test-retest reliability to maximize participation. To minimize examiner-related variability, the same examiner performed all measurements and gave standardized instructions with all measures. Although the logistics of using a single researcher for data collection can influence sample size, this was in accordance with exigencies to achieve a high (.90) power. A 7-day interval between tests was used to avoid any influence of learning, fatigue, or pain on the

second application of the test. However, participants in the study achieved greater values in hand grip strength test during day 1 of testing, perhaps representing learning effects for this test. Another limitation was that the testing sessions were not conducted in private, so the influence of other older adults in the room may have affected performance on any particular day. The measurements are acceptably sensitive for groups of patients, but to monitor individual progress reliability, studies by age group (e.g., 65–75 years and 75 years or more) should be conducted. Therefore, a large sample size is required to confirm the results achieved in this study and to determine the reliability of these outcome measures in different age groups of older adults with T2DM.

### Conclusions

This study suggests excellent test–retest reliability for the Hand Grip Strength Test, the CSRT, the TUG Test, the 6MWT, and the 30s-STS Test in older adults with well-controlled noninsulin dependent T2DM. Despite very high ICCs for test–retest reliability, there was remarkable individual variability in the performance of some of these tests (i.e., CSRT). Presentation of SEM and MDC<sub>95</sub>, for each of the measurement tools, provides nursing practitioners with meaningful thresholds for identifying changes beyond those expected from measurement error and individual variability (i.e., “true” change) in individuals with T2DM. These findings are applicable for both clinicians and researchers. This study has generated novel MDC<sub>95</sub> values for the Hand Grip Strength Test, the CSRT Test, the TUG Test, the 6MWT, and the 30s-STS Test that will be helpful in monitoring performance changes over time and assessing the effectiveness of physical therapy and exercise interventions in older adults with T2DM.

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## Key Practice Points

- Increasing physical fitness in type 2 diabetes could enhance insulin sensitivity and glycemic control reducing declines in physical function associated with aging and accelerated by diabetes
- Nurses working with older adults need to measure outcomes to assess progress or decline in function, and therefore specific clinical tools should be tested for reliability with individuals with type 2 diabetes.
- On the basis of the MCD<sub>95</sub> observed in this study, if a change exceeding  $\pm 0.85$  seconds occurs in the TUG Test;  $\pm 27.37$  m in the 6MWT; 4 kg in hand grip; or  $\pm 3.35$  repetitions in the 30s-STS Test, clinicians can be 95% confident that the difference is not due to measurement error or variability among participants.
- The results from this study suggest that common used physical fitness tests in older adults are also reliable among those with type 2 diabetes.

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