■ *Research paper*

Polona Palma, Eva Kramar, Miroljub Jakovljević

Repeatability and Reliability of the Five-Times-Sit-to-Stand Test Performed Using a Mobile Phone Application

Abstract. The Five-Time-Sit-to-Stand Test (FTSTT) is a timed test for assessing functional lower limb muscle strength and body balance that can be administered using the Test To Go mobile application. Our purpose was to determine the repeatability and reliability of the 5TSST performed with the Test To Go mobile application. Thirty-two healthy participants (29 women and 3 men), 21 years old on average, were included in the study. Measurements of three consecutive tests with mobile phone attached at the upper chest were performed on two occasions, in the interval of 48 hours. The intra-class correlation coefficient (ICC) was computed. The average values measured in the first session ranged from 11.1 s to 9.2 s, and in the second session from 8.4 s to 8.0 s. Repeatability was weak (ICC=0.39) in the first session and moderate (ICC=0.65) in the second session. The reliability of the test was weak to moderate, depending on which measure was chosen. ICC was the highest for the average values of the last two measurements or for the last measurement (ICC=0.74 and 0.63, respectively). Repeatability and reliability of the FTSST as performed using the mobile application was weak to moderate due to measurement error of the mobile application and difficulties with positioning the mobile phone during testing. We therefore do not recommend the present version of the application for clinical use.

Key words: functional tests; balance; mobile applications; metric characteristics.

Ponovljivost in zanesljivost testa petih vstajanj s stola, izvedenega z mobilno aplikacijo

Povzetek. Test petih vstajanj s stola je časovno merjen test za ocenjevanje funkcijske mišične zmogljivosti spodnjih udov in ravnotežja, ki ga lahko izvedemo z mobilno aplikacijo Test To Go. Želeli smo oceniti ponovljivost in zanesljivost testa petih vstajanj s stola, izmerjenega z mobilno aplikacijo Test To Go. V raziskavi je sodelovalo 32 zdravih preiskovancev (29 žensk, 3 moški), v povprečju starih 21 let, ki smo jim preko prsnega koša namestili mobilni telefon z aplikacijo Test To Go. Z mobilno aplikacijo smo dvakrat, v razmiku 48 ur, izvedli tri zaporedne ponovitve testa petih vstajanj s stola. Iz povprečnih vrednosti časa petih vstajanj v prvi in drugi seji smo izračunali intraklasni korelacijski koeficient (ICC). Preiskovanci so v prvi seji za dokončanje testa potrebovali od 11,1 s do 9,2 s in v drugi seji od 8,4 s do 8,0 s. Ponovljivost treh poskusov petih vstajanj s stola je bila v prvi seji slaba (ICC=0,39), v drugi seji pa zmerna (ICC=0,65). Zanesljivost testa je bila šibka do zmerna, odvisno od tega, katere izmerjene vrednosti smo izbrali. ICC je bil najvišji za povprečno vrednost zadnjih dveh meritev ali za vrednost zadnje meritve (ICC=0,74 in 0,63). Ponovljivost in zanesljivost testa petih vstajanj s stola, izvedenega z mobilno aplikacijo, je bila slaba do zmerna zaradi napak merjenja mobilne aplikacije in težav s pritrditvijo mobilnega telefona med testiranjem. Trenutne verzije aplikacije zato ne priporočamo za klinično uporabo.

Ključne besede: funkcijski testi; ravnotežje; mobilne aplikacije; merske lastnosti.

■ **Infor Med Slov** 2021; 26(1-2): 1-7

Institucija avtorjev / Authors' institution: Faculty of Health Sciences, University of Ljubljana.

Kontaktna oseba / Contact person: Assist. Prof. Miroljub Jakovljević, PhD, University of Ljubljana, Faculty of Health Sciences, Zdravstvena pot 5, 1000 Ljubljana, Slovenia. E-pošta / E-mail: miroljub.jakovljevic@zf.uni-lj.si.

Prispelo / Received: 10. 7. 2021. Sprejeto / Accepted: 26. 11. 2021.

Introduction

Using mobile applications alters many aspects of clinical practice, such as medication and assessment.[1,2] The use of mobile devices has become common in the clinical environment, which has led to the rapid growth and development of medical software for clinical use.[1,2] For example, a search in the PubMed bibliographic database using the search term "ICT tools OR smartphone" yields 51 results for 2010 and 3967 results for 2020. There are many mobile applications available to help healthcare professionals in many important tasks such as data and time management, maintenance and access to medical documentation, communication and counselling, information and scientific literature gathering, patient monitoring and treatment, health education and learning and clinical decision-making.[1-8] The main advantages of using mobile applications are universal accessibility, quick download and ease of use.

Assessment of physical functioning is a key part of rehabilitation which can potentially benefit from mobile applications. Sit-to-stand tests are simple and informative tools for such assessment. The first standardised test for clinical assessment of the sit-to-stand movement was designed by Csuka and McCarty.[9] The sit-to-stand tests are a group of functional tests with the same purpose that can be performed in several variations. They can be performed in any health care setting, require minimal equipment (conventional chair and stopwatch) and are easy and quick to perform for most participants. The result can be the number of repetitions in a chosen time interval (30 s,[10] 60 s[11]) or the time needed for execution of a chosen number of repetitions (three,[12] five,[13-15] or ten repetitions[9,16]). The test can be carried out with different chair height (40 cm,[16] 43 cm[13,17] or 44.5 cm[9]), with or without the armrest,[18] with a different position of the feet,[19,20] and with a different position of the arms (crossed over the chest,[15,17] along the body[17,21] or on subject's thighs[18]; or unspecified[22-24]).

Five repetitions represent a good compromise when considering physiological and psychological mechanisms (warming-up, fatigue), as well as time constraints.[19] Hence, we focused on the Five-Time-Sit-to-Stand Test (FTSST) as it is the most often employed variant.[26,27] The FTSST is a functional performance test for assessing muscle strength of the lower limbs and dynamic equilibrium.[13,19,25] The participants usually begin this test sitting in an armless chair with the seat 43 cm from the ground.[28] Each participant is instructed to cross their arms over his/her chest and sit with their back against the upright back rest of the chair. The examiner then demonstrates the correct technique for performing the test, and the participant is instructed to stand up from the sitting position for five times as quickly as possible without using the hands for support. Timing begins when the examiner says "go" and stops when the participant's buttocks reach the seat following the fifth stand. The FTSST has demonstrated good clinical feasibility in the elderly[29] and good test-retest reliability (above 0.95) in healthy individuals between 14 and 85 years of age.[30]

The mobile application Test to Go version 1.0 was developed by Cheung, Ngai and To from the Motion Analysis Lab of the Hong Kong Polytechnic University.[31] It was designed for health-care providers to use two common tools for measurement of functional ability of older adults: the FTSST (using the FTSSTapp) and the Timed-Up-and-Go test (Figure 1). The instructions for using the FTSSTapp are the same as for the standard FTSST.[28]

The goal of the application was to enhance accuracy, because there is a reaction time involved when using a stopwatch and potential human error for judging the positions.[31] However, repeatability and reliability of the FTSSTapp have not been reported in the literature, and neither has been any clinical use of the FTSSTApp. To start addressing this gap, we wanted to determine repeatability and reliability of the FTSSTapp in healthy young participants. Here, repeatability refers to three or more consecutive measurements whereas reliability refers to the stability of the measured achievement over a longer, selected period of time.[32] Our hypothesis was that the mobile application would be at least as repeatable and reliable as the standard procedure.

Methods

Participants

The study involved 32 healthy students (29 women and 3 men) of the Physiotherapy department at the Faculty of Health Sciences, University of Ljubljana. The goal was to have at least 30 participants, which corresponds to precision (i.e., half the width of a 95 % confidence interval) of about 0.04 when estimating a correlation of about 0.95. There were no drop-outs before or during data collection. On average, the participants were 21 years old (SD 1 year), 168 cm high (SD 2 cm), weighted 61 kg (SD 1 kg) and had a body mass index of 22.9 kg/m^2 (SD 0.9 kg/m^2). The majority (78 %) of them were regularly physically active (on average more than 3 times per week). All the participants signed an informed consent on voluntary co-operation in the research.

Procedure

The Sony Xperia XZ2 smartphone (Sony Electronics, Japan) with the Test To Go version 1.0 application[29] was used, together with the belt in which the mobile phone was placed, and a standard chair with 43 cm high seat without armrest. All the measurements were performed by a physiotherapist (the second author).

Figure 1 Home page of the Test To Go mobile application that includes the FTSSTapp.

The belt with the mobile phone was placed around the subject's chest and the chair was secured against the wall. The subjects sat with their arms crossed over the chest, with their back against the chair and feet flat on the floor. The subjects were demonstrated how to perform the test according to the application's instructions. The application was then turned on to determine the coordinates for the sitting position (Figure 2 – left) and the upright position (Figure 2 – right). The screen had to turn red when the subject had risen correctly, and yellow when the subject correctly sat down on the chair. When the subject was sitting again, the "Start the test" button on the mobile-phone screen was touched. The application was counting down "3, 2, 1" loudly and the subject had to stand up and sit down as quickly as possible five times. When the subject rose for the fifth time, the timing was automatically stopped. According to the guidelines of developers of the FTSSTapp, the participants were allowed to practice two times before the timing of the trials. The procedure was repeated after 48 hours.

The National Medical Ethics Committee of the Republic of Slovenia approved the research (No. 0120-356/2017/3).

Statistics

Descriptive statistics were calculated for relevant demographic and anthropometric data and for FSSTapp times. To test the differences between the means of consecutive measurements, analysis of variance for repeated measurements was used with Bonferroni post-hoc tests.

Repeatability (stability across three successive measurements) and reliability (stability of the measurement over a period of 48 hours) were assessed using intraclass correlation coefficient (two-way mixed model) with 95% confidence interval ($CI_{95\%}$). For the calculation of reliability, we took into account the average of three consecutive measurements, the average of the last two consecutive measurements, the third measurement and the best (fastest) of the three measurements. ICC values of less than 0.5 indicated poor, between 0.5 and 0.75 moderate, between 0.75 and 0.9 very good and values greater than 0.9 indicated excellent repeatability or reliability.[28] To assess measurement variability, we calculated the within- and between-subject coefficient of variation (CV). Statistical analysis was performed with the MedCalc Statistical Software version 14.12.0 (MedCalc Software Bvba, Ostend, Belgium). *P*-values ≤ 0.05 were considered statistically significant.

Figure 2 The starting sitting position (left) and the ending standing position of the subject (right).

Results

The difference between means of successive attempts, both in the first session and in the second session, was not statistically significant ($p<0.05$). The between-subject variability was around 30% in all attempts except for the first one in the first session (Table 1).

Within-subject variability was higher in the first session while repeatability was higher in the second session (Table 1). When comparing the means of all six measurements across the two sessions, a statistically significant difference was observed between first attempt in the first session and the second and third attempt in the second session ($p<0.05$ for post-hoc tests after Bonferroni correction).

Regardless of the chosen combination of attempts, there was always a statistically significant difference between the mean of the first and the second session (Table 2, *t*-test). The between-subject variability was around 30% for all combinations, while the within-subject variability was the smallest when we considered all three trials in both sessions, and the largest when we considered the best result achieved (Table 2). The estimated reliability level of the FTSSTapp depended on the chosen combination of attempts and ranged from weak to moderate. The FTSSTapp was the most reliable if we selected the measurements from the second and third trials of both sessions, and the least reliable if we selected the best result of the test (Table 2).

Table 1 Descriptive statistics and repeatability estimates for the time needed to complete the Five-Times-Sit-to-Stand Test using the FTSSTapp.

Session	Statistic	Attempt 1	Attempt 2	Attempt 3	Within-subject CV range	Repeatability ICC ($CI_{95\%}$)
1st	Mean (SD) (s)	11.1 (4.6)	9.3 (2.8)	9.2 (2.8)	2% – 73%	0.39 (0.17 – 0.60)
	Between-subject CV	41%	30%	31%		
2nd	Mean (SD)	8.4 (2.5)	8.1 (2.4)	8.0 (2.7)	1% – 31%	0.65 (0.47 – 0.80)
	Between-subject CV	30%	30%	33%		

Legend: SD – standard deviation; CV – coefficient of variation; ICC – intraclass correlation; CI – confidence interval.

Table 2 Descriptive statistics and repeatability estimates for the time needed to complete the Five-Times-Sit-to-Stand Test using the FTSSTapp.

Chosen attempts	Statistic	1st session	2nd session	p (*t*-test)	Within-subject CV range	Repeatability ICC ($CI_{95\%}$)
All three	Mean (SD) (s)	9.9 (2.7)	8.2 (2.2)	0.0008	16% – 20%	0.60 (0.19 – 0.81)
	Between-subject CV	27%	27%			
2nd and 3rd	Mean (SD) (s)	9.3 (2.6)	8.1 (2.3)	0.0063	2% – 50%	0.74 (0.47 – 0.87)
	Between-subject CV	28%	29%			
3rd	Mean (SD) (s)	9.2 (2.8)	8.1 (2.6)	0.0064	0% – 40%	0.63 (0.36 – 0.80)
	Between-subject CV	31%	33%			
Best	Mean (SD)	8.3 (2.5)	7.1 (2.1)	0.0122	0% – 55%	0.38 (0.04 – 0.64)
	Between-subject CV	30%	30%			

Legend: SD – standard deviation; CV – coefficient of variation; ICC – intraclass correlation; CI – confidence interval.

Discussion

The aim of this study was to determine repeatability and intra-rater reliability of the FTSSTapp smartphone application in young, healthy and physically active individuals. The primary finding is that the FTSSTapp demonstrated poor to moderate repeatability and reliability.

The widespread adoption and use of mobile technologies is opening new and innovative ways to improve health and health care delivery. In the clinical environment, smartphones allow advanced communication with multimedia features, access to up-to-date information and research, and can be used as a device that allows remote control of patients, and as a device for performing certain tests.[32] However, smart phones in health care can also bring potential hazards and disadvantages. Bedno[33] notes that most applications are not yet scientifically supported and therefore the use of such applications can have negative consequences for the patient or even for a healthy person using the application. A smartphone can also be an annoying factor for a healthcare worker and influence his/her work and relationship with patients. The use of smartphones in a hospital environment can also be a potential source of infections.[34] An evident problem with many health-care smartphone applications is that their developers do not have sufficient knowledge in the field of health.[35] It is therefore important that professionals with appropriate knowledge are included in the application development process from the very beginning, or that the applications are critically evaluated and recommendations are made for repairs or improvements after the initial development is completed.

Reference values for the FTSST have been reported in several studies.[28,30,36,37] A meta-analysis[26] demonstrated that those individuals whose times for the five repetitions of the test exceed the reference values can be considered to have poor performance. However, the execution times achieved by the subjects in a comparable study[36] were much shorter than in our study (by about one third on average). This indicates the presence of technical problems of FSSTapp due to the installation of a smartphone and/or the detection of the final upright position. Consequently, in some cases, the time for a single raise was two or three times longer. On the other hand, in most cases, timing began when the examiner said "Go" and stopped when the subject's buttocks touched the chair on the fifth repetition, but in the case of FTSSTapp the timing stopped automatically when the subject rose for the fifth time. Therefore, the existing reference values for FTSST cannot be compared with the values obtained with the FTSSTapp.

In addition, we found out that the repeatability of the FTSSTapp is hardly acceptable. Repeatability in the first session was poor and in the second session it was moderate. If only the last two attempts were taken into consideration in the calculation of repeatability in the first session, the ICC was higher. Between-subject coefficient of variation exceeded 30% in first session; in the second session it was around 30%. Within-subject coefficient of variation in the first sessions ranged from zero to over 70%; in second session it varied from zero to around 30 %. All this indicates technical difficulties with device installation and/or time measurement when using the FTSSTapp.

According to the guidelines of the developers of the FTSSTapp, the participants were allowed two practice attempts before the timing of the third (i.e., proper test) attempt using the FTSSTapp. Yet in our study the highest ICC was not obtained when following these instructions, but when the outcome was the average of the second and the third attempt. The ICC thus obtained was comparable to the ICC estimated by two previous studies,[38,39] but lower than in several other studies.[26,29,30,40-42]

Conclusion

The FTSSTapp does not appear to offer any advantages over the traditional FTSST. It is more time consuming because it takes considerable time to set up the mobile phone. During the test, the device can move, thus degrading repeatability and reliability due to measurement errors. Therefore, we believe that the application is not suitable for clinical use in its present version. The main reason seems to be the attachment of the smartphone. A different solution rather than the ribbon around the chest may be necessary to prevent sliding of the device and ensure accurate detection of the starting and end positions during the test.

References

1. Aungst TD. Medical applications for pharmacists using mobile devices. *Ann Pharmacother*. 2013;47(7-8): 1088-1095. https://doi.org/10.1345/aph.1S035
2. Wallace S, Clark M, White J. 'It's on my iPhone': attitudes to the use of mobile computing devices in medical education, a mixed-methods study. *BMJ Open*. 2012; 2: e001099. http://dx.doi.org/10.1136/bmjopen-2012-001099
3. Divali P, Camosso-Stefinovic J, Baker R. The use of personal digital assistants in clinical decision making by health care professionals: a systematic review. *Health Informatics J*. 2013; 19(1): 16-28. https://doi.org/10.1177/1460458212446761
4. O'Neill KM, Holmer H, Greenberg SL, Meara JG. Applying surgical apps: smartphone and tablet apps prove useful in clinical practice. *Bull Am Coll Surg*. 2013; 98(11): 10-18.
5. Yoo JH. The meaning of information technology (IT) mobile devices to me, the infectious disease physician. *Infect Chemother*. 2013; 45(2): 244-251. https://doi.org/10.3947/ic.2013.45.2.244
6. Mosa ASM, Yoo I, Sheets L. A systematic review of health care apps for smartphones. *BMC Med Inform Dec Mak*. 2012; 12: 67. https://doi.org/10.1186/1472-6947-12-67
7. Ozdalga E, Ozdalga A, Ahuja N. The smartphone in medicine: a review of current and potential use among physicians and students. *J Med Internet Res*. 2012; 14(5): e128. https://doi.org/10.2196/jmir.1994
8. Kiser K. 25 ways to use your smartphone. Physicians share their favourite uses and apps. *Minn Med*. 2011; 94(4): 22-29.
9. Csuka M, McCarty DJ. Simple method for measurement of lower extremity muscle strength. *Am J Med*. 1985; 78(1): 77-81. https://doi.org/10.1016/0002-9343(85)90465-6
10. Jones CJ, Rikli RE, Beam WC. A 30-s chair-stand test as a measure of lower body strength in community-residing older adults. *Res Q Exerc Sport*. 1999; 70(2): 113-9. https://doi.org/10.1080/02701367.1999.10608028
11. Ozatevli S, Ozden A, Itil O, Akkoclu A. Comparison of the Sit-To-Stand Test with 6 min walk test in patients with chronic obstructive pulmonary disease. *Respir Med*. 2007; 101 (2): 286-293. https://doi.org/10.1016/j.rmed.2006.05.007
12. Thapa PB, Gideon P, Fought RL, Kormicki M, Ray WA. Comparison of clinical and biomechanical

measures of balance and mobility in elderly nursing home residents. *J Am Geriatr Soc.* 1994; 42(5): 493-500. https://doi.org/10.1111/j.1532-5415.1994.tb04970.x
13. Lord SR, Murray SM, Chapman K, Munro B, Tiedemann A. Sit-to-stand performance depends on sensation, speed, balance and psychological status in addition to strength in older people. *J Gerontol A Biol Sci Med Sci.* 2002; 57(8): M539-M543. https://doi.org/10.1093/gerona/57.8.M539
14. Nevitt MC, Cummings SR, Kidd S, Black D. Risk factors for recurrent nonsyncopal falls: a prospective study. *JAMA.* 1989; 261(18): 2663-2668. https://doi.org/10.1001/jama.1989.03420180087036
15. Guralnik JM, Ferrucci L, Simonsick EM, Salive ME, Wallace RB. Lower-extremity function in persons over the age of 70 years as a predictor of subsequent disability. *N Engl J Med.* 1995; 332(9): 556-561. https://doi.org/10.1056/NEJM199503023320902
16. Newcomer KL, Krug HE, Mahowald ML. Validity and reliability of the timed-stands test for patients with rheumatoid arthritis and other chronic diseases. *J Rheumatol.* 1993; 20(1): 21-27.
17. Bassey EJ, Fiatarone MA, O'Neill EF, Kelly M, Evans WJ, Lipsitz LA. Leg extensor power and functional performance in very old men and women. *Clin Sci (Lond).* 1992; 82(3): 321-327. https://doi.org/10.1042/cs082032
18. Mong Y, Teo TW, Ng SS. 5-repetition sit-to-stand Test in subjects with chronic stroke: reliability and validity. *Arch Phys Med Rehabil.* 2010; 91(3): 407-413. https://doi.org/10.1016/j.apmr.2009.10.030
19. Whitney SL, Wrisley DM, Marchetti GF, Gee MA, Redfern MS, Furman JM. Clinical measurement of sit-to-stand performance in people with balance disorders: validity of data for the five-times-sit-to-stand test. *Phys Ther.* 2005; 85(10): 1034-1045. doi: https://doi.org/10.1093/ptj/85.10.1034
20. Shepherd RB, Koh HP. Some biomechanical consequences of varying foot placement in sit-to-stand in young women. *Scand J Rehabil Med.* 1996; 28(2): 79-88.
21. Judge JO, Whipple RH, Wolfson LI. Effects of resistive and balance exercises of isokinetic strength in older persons. *J Am Geriatr Soc.* 1994; 42(9): 937-946. https://doi.org/10.1111/j.1532-5415.1994.tb06584.x
22. Byl NN. Mobility training using a bionic knee orthosis in patients in a post-stroke chronic state: a case series. *J Med Case Rep.* 2012; 6: 216. https://doi.org/10.1186/1752-1947-6-216
23. Wong CK, Bishop L, Stein J. A wearable robotic knee orthosis for gait training: a case-series of hemiparetic stroke survivors. *Prosthet Orthot Int.* 2012; 36(1): 113-120. https://doi.org/10.1177/0309364611428235
24. Weiss A, Suzuki T, Bean J, Fielding RA. High intensity strength training improves strength and functional performance after stroke. *Am J Phys Med Rehabil.* 2000; 79(4): 369-376. https://doi.org/10.1097/00002060-200007000-00009
25. Bohannon RW. Sit-to-stand test for measuring performance of lower extremity muscles. *Percept Mot Skills.* 1995; 80(1): 163-166. https://doi.org/10.2466/pms.1995.80.1.163
26. Bohannon RW. Reference values for the five-repetition sit-to-stand test: a descriptive meta-analysis of data from elders. *Percept Mot Skills.* 2006; 103(1): 215-222. https://doi.org/10.2466/pms.103.1.215-222
27. Silva PF, Quintino LF, Franco J, Faria CD. Measurement properties and feasibility of clinical tests to assess sit-to-stand/stand-to-sit tasks in subjects with neurological disease: a systematic review. *Braz J Phys Ther.* 2014; 18(2): 99-110. https://doi.org/10.1590/S1413-35552012005000155
28. Guralnik JM, Simonsick EM, Ferrucci L, Glynn RJ, Berkman LF, Blazer DG, et al. A short physical performance battery assessing lower extremity function: association with self-reported disability and prediction of mortality and nursing home admission. *J Gerontol.* 1994; 49(2): M85-M94. https://doi.org/10.1093/geronj/49.2.m85
29. Tiedemann A, Shimada H, Sherrington C, Murray S, Lord S. The comparative ability of eight functional mobility tests for predicting falls in community-dwelling older people. *Age Ageing.* 2008; 37(4): 430-435. https://doi.org/10.1093/ageing/afn100
30. Bohannon RW, Bubela DJ, Magasi SR, Gershon RC. Relative reliability of three objective tests of limb muscle strength. *Isokinet Exerc Sci.* 2011; 19(2): 77-81. https://doi.org/10.3233/IES-2011-0400
31. Cheung RTH, Ngai SPC, To W. Test To Go. 2015. https://play.google.com/store/apps/details?id=appinventor.ai_waynewaito.TestToGo. (7. 2. 2018)
32. Vidmar G, Jakovljević M. Psychometric properties of assessment instruments. *Rehabilitation (Ljubljana).* 2016; 15(Suppl 1): 7/1-7/15. https://ibmi.mf.uni-lj.si/rehabilitacija/vsebina/Rehabilitacija_2016_S1_p007_1-007_15.pdf (10. 7. 2021)
33. Bedno SA, Darrin M. Public health in the smartphone era. *Medscape* 2012. http://www.medscape.com/viewarticle/776278 (2. 5. 2013)
34. Gill PS, Kamath A, Gill TS. Distraction: an assessment of smartphone usage in health care work settings. *Risk Manag Healthc Policy.* 2012; 5: 105-114. https://doi.org/10.2147/RMHP.S34813
35. Franko OI. How helpful are mobile healthcare apps. AAOS Now. 2013; 3. https://www.aaos.org/AAOSNow/2013/Mar/managing/managing5/ (2. 5. 2013)
36. Bohannon RW, Bubela DJ, Magasi SR, Wang YC, Gershon RC. Sit-to-stand test: performance and determinants across the age-span. *Isokinet Exerc Sci.* 2010; 18(4): 235-240. https://doi.org/10.3233/IES-2010-0389
37. Butler AA, Menant JC, Tiedemann AC, Lord SR. Age and gender differences in seven tests of functional mobility. *J Neuroeng Rehabil.* 2009; 6: 31. https://doi.org/10.1186/1743-0003-6-31

38. Wolinsky, FD, Miller, DK, Andresen, EM, Malmstrom, TK, Miller, JP. Reproducibility of physical performance and physiologic assessments. *J Aging Health*. 2005; 17(2): 111-124. https://doi.org/10.1177/0898264304272784
39. Ostchega Y, Harris TB, Hirsch R, Parsons VL, Kington R, Katzoff M. Reliability and prevalence of physical performance examination assessing mobility and balance in persons in the US: data from the third national health and nutrition examination survey. *J Am Geriatr Soc*. 2000; 48(9): 1136-1141. https://doi.org/10.1111/j.1532-5415.2000.tb04792.x
40. Schaubert, K, Bohannon, RW. Reliability of the sit-to-stand test over dispersed test sessions. *Isokinet Exerc Sci*. 2005; 13(2): 119-122. https://doi.org/10.3233/IES-2005-0188
41. Tager, IB, Swanson, A, Satariano, WA. Reliability of physical performance and self-reported functional measures in an older population. *J Gerontol: A Biol Sci Med Sci*. 1998; 53(4): M295-M300. https://doi.org/10.1093/gerona/53a.4.m295
42. Bohannon RW. Five-repetition sit-to-stand test: usefulness for older patients in a home-care setting. *Percept Mot Skills*. 2011; 112(3):803-806. https://doi.org/10.2466/15.26.PMS.112.3.803-806