Published in final edited form as:

Gait Posture. 2014 September ; 40(4): 647–651. doi:10.1016/j.gaitpost.2014.07.018.

Clinimetric properties of the Tinetti Mobility Test, Four Square Step Test, Activities-specific Balance Confidence Scale, and spatiotemporal gait measures in individuals with Huntington's disease

Anne D. Kloos^{a,*}, Nora E. Fritz^a, Sandra K. Kostyk^{b,c}, Gregory S. Young^d, and Deb A. Kegelmeyer^a

^a The Ohio State University, College of Medicine, Division of Physical Therapy, Columbus, OH, United States

^b The Ohio State University, College of Medicine, Department of Neurology, Columbus, OH, United States

^c The Ohio State University, College of Medicine, Department of Neuroscience, Columbus, OH, United States

^d The Ohio State University, Center for Biostatistics, Columbus, OH, United States

Abstract

Background and purpose—Individuals with Huntington's disease (HD) experience balance and gait problems that lead to falls. Clinicians currently have very little information about the reliability and validity of outcome measures to determine the efficacy of interventions that aim to reduce balance and gait impairments in HD. This study examined the reliability and concurrent validity of spatiotemporal gait measures, the Tinetti Mobility Test (TMT), Four Square Step Test (FSST), and Activities-specific Balance Confidence (ABC) Scale in individuals with HD.

Methods—Participants with HD [$n = 20$; mean age $\pm$ SD = 50.9 ± 13.7 ; 7 male] were tested on spatiotemporal gait measures the TMT, FSST, and ABC Scale before and after a six week period to determine test–retest reliability and minimal detectable change (MDC) values. Linear relationships between gait and clinical measures were estimated using Pearson's correlation coefficients.

Results—Spatiotemporal gait measures, the TMT total and the FSST showed good to excellent test–retest reliability ($ICC > 0.75$). MDC values were 0.30 m/s and 0.17 m/s for velocity in forward and backward walking respectively, four points for the TMT, and 3 s for the FSST. The TMT and FSST were highly correlated with most spatiotemporal measures. The ABC Scale demonstrated lower reliability and less concurrent validity than other measures.

© 2014 Elsevier B.V. All rights reserved.

* Corresponding author at: 516 Atwell Hall, 453 West Tenth Avenue, Columbus, OH 43210, United States. Tel.: +1 614 688 5942; fax: +1 614 292 0210. kloos.4@osu.edu (A.D. Kloos).

Conflict of interest statement

The authors declare no conflict of interest.

Conclusions—The high test–retest reliability over a six week period and concurrent validity between the TMT, FSST, and spatiotemporal gait measures suggest that the TMT and FSST may be useful outcome measures for future intervention studies in ambulatory individuals with HD.

Keywords

Balance; Gait; Test–retest reliability; Validity; Huntington's disease

1. Introduction

Motor symptoms in Huntington's disease (HD) (i.e., chorea, bradykinesia, balance and gait abnormalities) impair walking and performance of activities of daily living placing affected individuals at high risk for falls [1,2]. Balance and gait deficits in HD include greater postural sway in stance, delayed motor responses to balance disturbances [3], slowed gait speed, decreased stride length, wider base of support, and increased stance and double support time [4–6]. Increased variability in gait parameters is associated with increased fall risk in the elderly [7] and may be a sensitive measure of fall risk in HD [8]. Many of our patients have difficulties with stepping or walking backward which may contribute to falls [9]. Clinicians seeking to determine the efficacy of interventions targeting balance and gait problems presently have difficulty selecting outcome measures because the clinical properties of many standard clinical outcome measures are unknown for the HD population.

An important measure for assessing functional gains during or after therapeutic interventions is the minimal detectable change (MDC). MDC is defined as the minimal amount of change that is not due to variation in measurement [10]. Knowing the MDC of a measure allows clinicians to interpret whether a change score represents a real change from an intervention (change score at or above the MDC value) or a value due to chance. Quinn et al. [11] recently published MDC values for several physical performance tests in individuals with premanifest and manifest HD using a between testing session gap of one week. However, the long-term stability of these measures is unknown and therefore these values may not apply for six week durations or more that are typical of physical therapy interventions. Gait measures had high reliability when testing was conducted 30–45 min apart, but the stability of these measures over weeks is unknown [12]. Test–retest reliability and MDC values on gait and clinical balance and mobility outcome measures with longer between session intervals would help clinicians to distinguish real functional change from measurement error over time periods similar in duration to physical therapy interventions in this population.

There are presently few validated clinical assessments of balance and mobility to measure motor impairments in people with HD. Rao et al. reported that the Functional Reach Test, Timed Up and Go Test, and Berg Balance Scale were correlated with gait measures and two indicators of functional limitations [13]. Kloos et al. [14] demonstrated that the Tinetti Mobility Test (TMT) has good validity for fall prediction and correlated moderately with the Unified Huntington's Disease Rating Scale (UHDRS) total motor score. Other commonly used clinical balance and mobility measures that have not been validated in the HD population include the Four Square Step Test (FSST) and the Activities-specific Balance Confidence Scale (ABC Scale). The TMT, FSST and ABC Scale may be sensitive tests of

balance and mobility in ambulatory individuals with HD, but to date no studies have examined the stability (i.e., test–retest reliability) and MDC values of these measures over durations greater than one week and their relationships to gait parameters. Therefore, the present study examined: (1) the test–retest reliability and MDC of spatiotemporal gait measures in forward and backward walking, and the TMT, FSST, and ABC Scale over a six week period; and (2) the concurrent validity of TMT, FSST, and ABC measures in reference to quantitative gait measures and with each other in individuals with HD. The rate of progression of motor symptoms as measured by the UHDRS total motor score is typically slow (mean units of change per 6 months = 3.2 ± 8.4) [15] and many of our patients with HD lead sedentary lifestyles. Therefore, we hypothesized that (1) gait and clinical balance and mobility measures would be stable over the six-week period, and (2) the TMT, FSST, and ABC measures would be correlated with spatiotemporal gait measures based on the previous findings reported by Rao et al. [13].

2. Methods

The Human Subjects Institutional Review Board approved the study and participants signed written informed consent forms prior to entering the study.

2.1. Participants

A convenience sample of 24 individuals with a confirmed diagnosis of HD was recruited from among patients at regular clinic visits or via telephone. Participants were 18 years old, could walk 10 m without a device or assistance, and lived within a 45 mile radius from the medical center. Participants were in early to middle stages of HD (TFC Stages 1–3) and were cognitively able to provide informed consent and follow multi-step directions. Exclusion criteria included presence of a neurological diagnosis other than HD, or other orthopedic or neurologic conditions that would interfere with gait or balance testing. All participants were rated on the UHDRS motor assessment, the Total Functional Capacity (TFC) scale, and the UHDRS cognitive assessment by an experienced neurologist.

2.2. Testing protocol

Evaluations were performed before and after a six-week baseline period as part of a larger study to investigate the effects of a video game-based intervention [16]. The six-week time period was selected to match the duration of the intervention that followed after the baseline period. During this baseline period, participants were instructed not to change their normal daily activities or start any new exercise programs. All testing was performed by the same researcher, who was experienced in administering all outcome measures. After obtaining demographic information, participants completed the outcome measure testing in a random order.

Participants were assessed on the following measures:

1. Spatiotemporal gait parameters were assessed during forward and backward walking at a comfortable speed using a 16 foot computerized GAITRite (Cir Systems, Inc, Haverton, PA) walkway system. Participants began walking 2 m before and stopped 2 m beyond the walkway edges to allow for acceleration and

deceleration phases. Each participant performed four trials in both conditions. The first trial was a practice trial; data from the remaining three trials was averaged. Gait measures analyzed included gait velocity, step and stride length, heel-to-heel base of support (BOS), and percentage of the gait cycle spent in the swing phase (swing percent) and in double support (double support percent). Coefficients of variation (CVs) for step time, stride length, swing time, and double support time were analyzed to assess gait variability. Previous research has shown that spatiotemporal gait measures discriminated between individuals with HD and Parkinson's disease [8] and are sensitive to change over time in individuals with HD [4].

2. The TMT consists of balance and gait subscales that assess static and dynamic balance and gait deviations, respectively. Each TMT item was scored using a scale of 0–1 or 0–2, with lower scores out of 28 possible indicating increased fall risk. TMT scores are reliable and predict falls in individuals with HD [11,14].
3. The FSST test is a timed test of dynamic standing balance that requires a person to step rapidly in a multi-directional pattern over a cane [17]. Participants performed one practice trial and two timed trials, with the better score chosen for analysis. Trials were repeated if the participant did not complete the sequence successfully, lost balance, or made contact with a cane. The FSST is a reliable and valid measure for predicting falls in the elderly [17].
4. The ABC Scale measures confidence and fear of falling and has proven reliability and validity in the elderly [18,19] and with some neurological populations [20,21]. Individuals rate their balance confidence from 0 to 100% in each of 16 tasks; higher scores indicate greater confidence and lower fall risk [18,19,22].

2.3. Statistical analyses

Descriptive statistics were calculated to describe participant characteristics. Test–retest reliability was described using several measures. In order to evaluate the presence of a learning or period effect, the mean difference and 95% confidence interval between the baseline and six week measures were calculated. The standard error of measurement (SEM) or “typical error” [23] and 95% confidence interval was calculated, and the intraclass correlation coefficient (ICC) with 95% confidence intervals was computed using the methods of Hankinson et al. [24]. Minimal detectable change at a 95% level (MDC_{95}) was calculated as $1.96 \times (SD_{baseline}) \times \sqrt{(2 \times (1 - ICC))}$ as described by Haley et al. [10]. The MDC_{95} estimates the magnitude of change that must be observed before the change can be considered in excess of the measurement error and variability at the 95% confidence level.

The relationships between initial (session 1) clinical balance and mobility measures (TMT, FSST, ABC Scale) and gait parameters were determined using Pearson correlation coefficients. The criteria used to evaluate the correlations were: fair (values of 0.25–0.50), moderate to good (values of 0.50–0.75) and good to excellent (values of 0.75 and above) [25]. A *p*-value of less than 0.05 was considered significant. All analyses were performed in SAS 9.2 (SAS Institute, Cary, NC).

3. Results

Of the 24 participants who entered the study, three participants developed other medical problems and dropped out after the first testing session, and one participant did not return for testing or treatments for unknown reasons. Data was analyzed for all 20 of the remaining participants (Table 1). One participant was unable to perform backward walking and another could not perform the FSST. One participant adopted an odd marching pattern when on the GAITRite that did not resemble his normal walking pattern and was unchanged with cueing; therefore his data were dropped from all GAITRite analyses.

Test–retest reliability was good to excellent for forward walking spatiotemporal measures (ICCs from 0.79 to 0.91), backward walking spatiotemporal measures (ICCs from 0.78 to 0.98), and clinical balance and mobility measures (ICC's from 0.67 to 0.86; Table 2) over six weeks. The most stable gait measures over time were velocity (ICC = 0.91 forward, 0.98 backward) and stride length (ICC = 0.90 forward, 0.96 backward). MDC scores are included in Table 2.

Correlations between clinical balance and mobility measures and gait parameters are shown in Table 3. The TMT total and FSST correlated significantly with all gait measures except swing percent in forward walking, and CV swing time and BOS in backward walking. The ABC Scale correlated significantly with BOS and CV step time, stride length, and swing time in forward walking. The TMT, FSST and ABC were all significantly correlated with each other.

4. Discussion

This study showed that spatiotemporal measures of forward and backward walking, the TMT and the FSST have moderate to strong clinimetric properties in the HD population. Our study is the first to establish MDC values for spatiotemporal gait measures, the TMT, the FSST, and the ABC Scale over a six week period, a common time span used for physical therapy interventions. The TMT and FSST were moderately to highly correlated with gait measures, suggesting that they are valid measures of balance [during standing or walking (TMT) or multi-directional stepping (FSST)] and mobility [during walking (TMT) or stepping in a pattern (FSST) to move from one place to another] in this population. The ABC Scale demonstrated lower reliability and less concurrent validity with other gait and balance measures. Our study provides information regarding reliable and valid measures for potential use in clinical trials in HD.

Spatiotemporal gait measures appear to be reliable measures for assessing walking ability in individuals with HD over six weeks (Table 2). Test–retest reliability for all walking measures was good to excellent (ICCs = 0.78). In a degenerative disease such as HD the finding that test–retest values for gait measures remained relatively stable over six weeks has important implications for clinical outcome analysis following interventions intended to improve gait. The MDC₉₅ of 0.30 m/s for forward walking velocity was greater than reported values for chronic stroke (0.10 m/s) [26] and PD (0.18 m/s), but was similar to values reported by Quinn et al. for HD (0.34 m/s) [11,27]. Differences in participant

characteristics (e.g., higher cognitive functioning) may account for less error and variability of measures in these populations compared to HD. Given the similarity in our findings and those of Quinn et al., future studies to determine the stability of gait measures over longer time periods (>six months) might benefit clinicians who follow patients with HD over extended durations. The differences in MDC₉₅ gait velocity values highlight the importance of calculating MDC values for different populations.

The TMT and FSST were reliable measures (ICC values = 0.83) for assessing balance and mobility in individuals with HD over six weeks. Our MDC findings suggest that any change in the TMT total score greater than four points or in the FSST greater than 3 s likely represents a real change not attributable to measurement error or week-to-week fluctuations in an individual's performance. These findings concur with previous reports of high inter- and intra-rater reliability of the TMT [28] and test-retest reliability of the FSST in PD [29]. The test-retest reliability and MDC values found in this study are similar to those reported previously by Quinn et al. (ICC = 0.91, MDC = 4) for the TMT, but are different from those reported for the FSST (ICC = 0.78, MDC = 15.27) [11]. The differences in FSST values may be related to higher cognitive function on average in our participants (UHDRS cognitive score = 188.3 ± 46.25) compared to their participants [11] (153.62 , $n = 59$). The FSST demands a high level of cognitive-motor planning and might be more challenging for individuals with greater cognitive impairments. We found that more advanced participants required greater numbers of trials to successfully perform the FSST and one participant was unable to learn the sequence. Our findings support previous observations by Quinn et al. [11] that the FSST may be a more useful tool for assessing balance and motor planning in people with premanifest and early-stage HD who are less cognitively and/or physically impaired.

The ABC Scale was not as reliable as the TMT and FSST. The MDC₉₅ of 27 for the ABC Scale was much greater than reported values in PD (MDC = 11–13 points) [27,30]. Possible explanations for the high variability in scores within participants are perseveration in repeating a particular response when filling out the ratings and difficulty imagining how confident they would be in doing activities that they were not currently doing. Perseveration is a common problem in HD [31] and there were indications that some more advanced participants perseverated on an answer once it had been chosen. Some participants who stated that they did not currently do activities such as standing on a chair to reach for something and walking on icy sidewalks had difficulty following the directions to answer the question according to their imagined confidence to do the activity if they had to. One individual who reported that he had fallen on ice rated his confidence walking on ice as 100% (fully confident) because “I am never going to walk on ice and therefore I know I won't ever fall on ice.” Given the impact that cognition could have on the use of the ABC questionnaire, further studies are recommended to accurately assess the utility of this measure in the HD population.

The FSST and TMT correlated moderately to strongly with most gait measures in both forward and backward walking and with each other (Table 3). In general, the FSST was strongly associated with backward walking measures and moderately associated with forward walking measures. The FSST involves stepping in different directions over a cane

which may explain why this test correlates more strongly with the challenging and less routine ability to walk backward than with walking forward. The TMT was strongly associated with measures of gait pattern variability (i.e., CVs) in forward walking and moderately associated with speed-related measures (i.e., velocity, stride length), and dynamic balance (i.e., double support percent and BOS) in forward and/or backward walking. Better performance on the TMT was moderately associated with better performance on the FSST. High correlations between TMT, FSST, and gait measures likely reflect the strong association of balance measures to gait performance. Based on this study, the FSST and TMT appear to be valid clinical assessments in individuals with HD that may be useful outcome measures for detecting changes in balance and/or mobility in individuals undergoing rehabilitation.

Individuals with higher balance confidence on the ABC Scale had more narrow bases of support, less gait variability in forward walking, and better performance on the FSST and TMT. Most ABC Scale items ask about activities that are more difficult to perform and demand greater balance control (walking up and down stairs or a ramp) than needed for walking over a flat surface. Not surprisingly, ABC Scale scores were more highly correlated with measures that reflect or demand a high degree of balance control (i.e., BOS, CVs of gait measures, and FSST scores). However, the low reliability and high variability of answers with the ABC Scale make any interpretation of these findings difficult.

When interpreting the present results, one must consider that MDC values are specific to the population and the time between testing. Therefore, our MDC results are limited to the HD population and to the magnitude of change that must be produced by an intervention over a six-week period to be considered real. The small sample size and diversity of disease stages included would be expected to increase variability within each outcome measure score leading to inflated MDC values. However, the participants' mean age, TFC, and UHDRS total motor scores in our study were similar to those in the larger study by Quinn et al. [11] and our MDC values for forward gait velocity, total TMT, and FSST were the same or lower than those reported by their group.

5. Conclusions

This study provides evidence that spatiotemporal gait measures, the TMT, and the FSST exhibit good to excellent test-retest reliability over a six-week period in individuals with HD. MDC scores are reported for these measures, allowing clinicians to better determine whether measurement changes following therapeutic interventions of a similar duration are likely to be real. High concurrent validity between the TMT, FSST, and gait measures suggests that the TMT and FSST may be useful outcome measures for assessing balance and mobility in future intervention studies. The FSST may not be appropriate for those with more advanced cognitive and/or physical impairments. The ABC Scale may not be a reliable and valid tool for assessing balance confidence in this population.

Acknowledgments

This study was funded by a 2008–2009 HSG/HSC Clinical Research Award from the Huntington Study Group/Huntington Society of Canada and the Robert A Vaughan Family Fund. The study was also supported by Award

Number 8UL1TR000090-05, 8KL2TR000112-05, and 8TL1TR000091-05 from the National Center For Advancing Translational Sciences. The content is solely the responsibility of the authors and does not necessarily represent the official views of the National Center For Advancing Translational Sciences or the National Institutes of Health. The study sponsors had no involvement in the study design, in the collection, analysis and interpretation of data; in the writing of the manuscript; and in the decision to submit the manuscript for publication.

References

1. Imbriglio S. Huntington's disease at mid-stage. *Clin Manage*. 1992; 12(3):63–9.
2. Kirkwood SC, Su JL, Conneally P, Foroud T. Progression of symptoms in the early and middle stages of Huntington disease. *Arch Neurol*. 2001; 58(2):273–8. [PubMed: 11176966]
3. Tian J, Herdman SJ, Zee DS, Folstein SE. Postural stability in patients with Huntington's disease. *Neurology*. 1992; 42(6):1232–8. [PubMed: 1534875]
4. Rao AK, Muratori L, Louis ED, Moskowitz CB, Marder KS. Spectrum of gait impairments in presymptomatic and symptomatic Huntington's disease. *Mov Disord*. 2008; 23(8):1100–7. [PubMed: 18412252]
5. Kloos AD, Kegelmeyer DA, White SE, Kostyk SK. The impact of different types of assistive devices on gait measures and safety in Huntington's disease. *PLoS ONE*. 2012; 7(2):e30903. [PubMed: 22363511]
6. Hausdorff JM, Mitchell SL, Firtion R, Peng CK, Cudkowicz ME, Wei JY, et al. Altered fractal dynamics of gait: reduced stride-interval correlations with aging and Huntington's disease. *J Appl Physiol*. 1997; 82(1):262–9. [PubMed: 9029225]
7. Hausdorff JM, Rios DA, Edelberg HK. Gait variability and fall risk in community-living older adults: a 1-year prospective study. *Arch Phys Med Rehabil*. 2001; 82(8):1050–6. [PubMed: 11494184]
8. Hausdorff JM, Cudkowicz ME, Firtion R, Wei JY, Goldberger AL. Gait variability and basal ganglia disorders: stride-to-stride variations of gait cycle timing in Parkinson's disease and Huntington's disease. *Mov Disord*. 1998; 13(3):428–37. [PubMed: 9613733]
9. Hackney ME, Earhart GM. Backward walking in Parkinson's disease. *Mov Disord*. 2009; 24(2):218–23. [PubMed: 18951535]
10. Haley SM, Fragala-Pinkham MA. Interpreting change scores of tests and measures used in physical therapy. *Phys Ther*. 2006; 86:735–43. [PubMed: 16649896]
11. Quinn L, Khalil H, Dawes H, Fritz NE, Kegelmeyer D, Kloos AD, et al. Reliability and minimal detectable change of physical performance measures in individuals with pre-manifest and manifest Huntington disease. *Phys Ther*. 2013; 93(7):942–56. [PubMed: 23520147]
12. Rao AK, Quinn L, Marder KS. Reliability of spatiotemporal gait outcome measures in Huntington's disease. *Mov Disord*. 2005; 20(8):1033–7. [PubMed: 15838854]
13. Rao AK, Muratori L, Louis ED, Moskowitz CB, Marder KS. Clinical measurement of mobility and balance impairments in Huntington's disease: validity and responsiveness. *Gait Posture*. 2009; 29(3):433–6. [PubMed: 19111470]
14. Kloos A, Kegelmeyer DA, Young G, Kostyk S. Fall risk assessment using the Tinetti Mobility Test in individuals with Huntington's disease. *Mov Disord*. 2010; 25(16):2838–44. [PubMed: 20960478]
15. Huntington's Study Group. Unified Huntington's Disease Rating Scale: reliability and consistency. *Mov Disord*. 1996; 11(2):136–42. [PubMed: 8684382]
16. Kloos AD, Fritz N, Kostyk SK, Young G, Kegelmeyer DA. Video game play (Dance Dance Revolution) as a potential exercise therapy in Huntington's disease: a controlled clinical trial. *Clin Rehabil*. 2013; 27(11):972–82. [PubMed: 23787940]
17. Dite W, Temple VA. A clinical test of stepping and change of direction to identify multiple falling older adults. *Arch Phys Med Rehabil*. 2002; 83(11):1566–71. [PubMed: 12422327]
18. Powell L, Myers AM. The Activities-specific Balance Confidence (ABC) Scale. *J Gerontol A Biol Sci Med Sci*. 1995; 50A(1):M28–34. [PubMed: 7814786]
19. Brouwer B, Musselman K, Culham E. Physical function and health status among seniors with and without a fear of falling. *Gerontology*. 2004; 50(3):135–41. [PubMed: 15114034]

20. Jacobs JV, Horak FB, Tran VK, Nutt JG. Multiple balance tests improve the assessment of postural stability in subjects with Parkinson's disease. *J Neurol Neurosurg Psychiatry*. 2006; 77(3):322–6. [PubMed: 16484639]
21. Legters K, Verbus NB, Kitchen S, Tomecsko J, Urban N. Fear of falling, balance confidence and health-related quality of life in individuals with postpolio syndrome. *Physiother Theory Pract*. 2006; 22(3):127–35. [PubMed: 16848351]
22. Salbach NM, Mayo NE, Robichaud-Ekstrand S, Hanley JA, Richards CL, Wood-Dauphinee S. Balance self-efficacy and its relevance to physical function and perceived health status after stroke. *Arch Phys Med Rehabil*. 2006; 87(3):364–70. [PubMed: 16500170]
23. Hopkins WG. Measures of reliability in sports. *Sports Med*. 2000; 30(1):1–15. [PubMed: 10907753]
24. Hankinson SE, Manson JE, Spiegelman D, Willett WC, Longcope C, Speizer FE. Reproducibility of plasma hormone levels in postmenopausal women over a two to three year period. *Cancer Epidemiol Biomark Prev*. 1995; 4:649–54.
25. Portney, L.; Watkins, M. *Foundations of clinical research: applications to practice*. Appleton and Lange; New York: 1993.
26. Flansbjer UB, Holmback AM, Downham D, Patten C, Lexell J. Reliability of gait performance tests in men and women with hemiparesis after stroke. *J Rehabil Med*. 2005; 37(2):75–82. [PubMed: 15788341]
27. Steffen T, Seney M. Test–retest reliability and minimal detectable change on balance and ambulation tests, the 36-item short-form health survey, and the unified Parkinson disease rating scale in people with parkinsonism. *Phys Ther*. 2008; 88(6):733–46. [PubMed: 18356292]
28. Kegelmeyer DA, Kloos AD, Thomas KM, Kostyk SK. Reliability and validity of the Tinetti Mobility Test for individuals with Parkinson disease. *Phys Ther*. 2007; 87(10):1369–78. [PubMed: 17684089]
29. Duncan RP, Earhart GM. Four square step test performance in people with Parkinson disease. *J Neurol Phys Ther*. 2013; 37(1):2–8. [PubMed: 23364168]
30. Dal Bello-Haas V, Klassen L, Sheppard MS, Metcalfe A. Psychometric properties of activity, self-efficacy, and quality-of-life measures in individuals with Parkinson disease. *Physiother Can*. 2011; 63(1):47–57. [PubMed: 22210979]
31. Rosenblatt A. Neuropsychiatry of Huntington's disease. *Dialogues Clin Neurosci*. 2007; 9(2):191–7. [PubMed: 17726917]

Table 1

Participant characteristics.

Participant characteristics	Mean $\pm$ SD	Range
Age (years)	50.9 $\pm$ 13.7	23-75
Sex (male/female)	7/13	
Time with HD (years)	5 $\pm$ 3.97	0-14
TFC score	8.2 $\pm$ 2.7	3-13
UHDRS TMS	39.0 $\pm$ 16.1	6-65
UHDRS cognitive score	188.3 $\pm$ 46.25	88-265

HD, Huntington's disease; TFC, Total Functional Capacity (range 0-13, higher score is better); UHDRS TMS, Unified Huntington's Disease Rating Scale total motor score (range 0-124, lower score is better); UHDRS cognitive score (0 - no maximum, higher score is better; n = 15 due to unintentional failure to test five participants).

Table 2

Test-retest reliability and minimal detectable change of gait and clinical balance and mobility measures over six weeks.

Measures	Mean score	Mean session 2 – session 1 difference (95% CI)	SEM (95% CI)	MDC	ICC (95% CI)
Forward walking (n= 19)					
Velocity (m/s)	1.25	−0.02 (−0.10, 0.06)	0.12 (0.090, 0.18)	0.30	0.91 (0.84,1.00)
Stride length (cm)	121.65	−3.33 (−9.42, 2.75)	8.92 (6.74,13.20)	23.17	0.90 (0.82,1.00)
Base of support (cm)	11.11	1.46 (0.17, 2.75)	1.89 (1.43, 2.80)	5.43	0.81 (0.681,1.00)
Swing percent	36.74	−0.037 (−1.02, 0.94)	1.44 (1.09, 2.13)	3.91	0.79 (0.65,1.00)
Double support percent	26.78	−0.05 (−1.47, 1.36)	2.07 (1.57, 3.07)	5.14	0.87 (0.77,1.00)
Step time (s)	0.56	0.01 (−0.01,0.04)	0.04 (0.03, 0.06)	0.10	0.87 (0.77,1.00)
Swing time (s)	0.41	0.01 (−0.01,0.03)	0.03 (0.02, 0.04)	0.08	0.84 (0.72,1.00)
Double support time (s)	0.30	0.02 (−0.01, 0.04)	0.04 (0.03, 0.06)	0.10	0.85 (0.74,1.00)
Backward walking (n = 18)					
Velocity (m/s)	0.67	0.001 (−0.041, 0.043)	0.06 (0.05, 0.09)	0.17	0.98 (0.96,1.00)
Stride length (cm)	69.88	−0.42 (−4.52, 3.68)	5.83 (4.37, 8.74)	15.89	0.96 (0.93,1.00)
Base of support (cm)	21.99	−0.74 (−2.21, 0.74)	2.10 (1.57, 3.14)	6.27	0.78 (0.63,1.00)
Swing percent	34.88	0.10 (−1.34, 1.54)	2.05 (1.54, 3.08)	5.34	0.89 (0.79,1.00)
Double support	31.53	0.33 (−1.64, 2.30)	2.80 (2.10, 4.19)	7.42	0.95 (0.90,1.00)
Step time (s)	0.71	−0.02 (−0.07, 0.03)	0.07 (0.06, 0.11)	0.23	0.94 (0.89,1.00)
Swing time (s)	0.49	−0.01 (−0.03, 0.01)	0.03 (0.02, 0.05)	0.09	0.98 (0.97,1.00)
Double support time	0.54	−0.06 (−0.22, 0.09)	0.22 (0.17, 0.33)	0.74	0.82 (0.69,1.00)
Clinical balance and mobility measures (n = 20)					
FSST (n =19)	11.22	0.67 (−1.44, 0.11)	1.14 (0.86, 1.68)	3.25	0.86 (0.76,1.00)
ABC Scale	77.66	−1.34 (−7.45, 4.76)	9.22 (7.01,13.47)	27.33	0.74 (0.58,1.00)
TMT total	22.60	−0.60 (−1.72, 0.52)	1.69 (1.29, 2.47)	4.44	0.83 (0.70,1.00)

ABC, Activities-specific Balance Confidence Scale; CI, confidence interval; CV, coefficient of variation; FSST, Four Square Step Test; ICC, intraclass correlation coefficient; MDC, minimal detectable change; SEM, standard error of the mean; TMT, Tinetti Mobility Test.

Table 3

Pearson correlations between gait measures in forward and backward walking and clinical balance and mobility tests.

Gait parameters	Tinetti Mobility Test (total score)	Four Square Step Test	Activities-specific Balance Confidence Scale
Forward walking			
Velocity	0.68 **	-0.69 **	0.42
Stride length	0.74 ***	-0.62 ***	0.41
Swing percent	0.34	-0.37	-0.18
Double support percent	-0.54 *	0.63 **	-0.15
Base of support	-0.58 **	0.39	-0.58 **
CV step time	-0.83 ***	0.63 **	-0.72 ***
CV stride length	-0.88 ***	0.75 ***	-0.53 *
CV swing time	-0.82 ***	0.72 ***	-0.74 ***
Backward walking			
Velocity	0.68 **	-0.78 ***	0.34
Stride length	0.74 ***	-0.74 ***	0.39
Swing percent	0.52 *	-0.59 *	0.28
Double support percent	-0.64 **	0.68 **	-0.29
Base of support	-0.40	0.14	-0.24
CV step time	-0.67 **	0.63 **	-0.33
CV stride length	-0.73 ***	0.66 **	-0.44
CV swing time	-0.41	0.42	-0.01
Clinical balance and mobility measures			
TMT (total score)		-0.67 **	0.50 *
Four Square Step Test			-0.57 *

CV, coefficient of variation; TMT, Tinetti Mobility Test.

* Significance level < 0.05.

** Significance level < 0.01.

*** Significance level < 0.001.