**Title:** Balance performance in head-shake computerized dynamic posturography: aging effects and test-retest reliability.

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**Short running head:** Head Shake Sensory Organization Test

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**Key Words:** Aging; Balance; Posture; Vestibular System

**ABSTRACT**

**Background:** The ability of the Sensory Organization Test (SOT) to detect subtle balance problems has been challenged. The Head-shake SOT (HS-SOT) has been developed to improve delineation of balance performance.

**Objective:** To examine the age-related differences in balance as measured by the HS-SOT, and to establish the test-retest reliability of the HS-SOT.

**Design:** This observational measurement study used a test-retest design.

**Methods:** Ninety-two **healthy** younger adults (mean age=28.3 years) and 73 **healthy** older adults (mean age=60.3 years) underwent the SOT and HS-SOT. Seventy-seven of them (56 young adults, 21 older adults) underwent the same assessment 1-2 weeks later.

**Results:** The equilibrium scores in HS-SOT condition 2 (head movements, eyes closed while standing on a firm surface) and 5 (head movements, eyes closed while standing on a sway-referenced surface) were significantly lower than their counterparts without dynamic head movements added (SOT condition 2 and 5) ($p<0.05$). Older adults attained significantly lower scores for both HS-SOT conditions than their younger peers ($p<0.01$). Test-retest reliability [intraclass correlation coefficients (3,2)] of the HS-SOT score in condition 2 and 5 for the younger adults was 0.85 and 0.78, respectively whereas those for the older adults were 0.64 and 0.55. The corresponding minimal detectable change (MDC) values for the former were 2.7 and 16.2, whereas those for the latter were 3.6 and 22.7.

**Limitations:** Only head rotation movements on the horizontal plane were tested.

**Conclusions:** Adding head movements to SOT increased the separation of **healthy** young and older adults. **The HS-SOT has good reliability, and MDC values were computed to facilitate**

**interpretation of clinical studies in which HS-SOT is used to assess change in balance performance among young and older adults.**

## INTRODUCTION

The ability to preserve body equilibrium is a complex task that involves the integration of sensory input from the visual, proprioceptive and vestibular systems, which can be influenced by aging, trauma, and disease.[1-3] Compromised ability to use sensory inputs may contribute to balance deficits, which may translate into problems such as falls, and fear of falling with self-imposed restrictions on activity and participation.[4,5]

The Sensory Organization Test (SOT) of Computerized Dynamic Posturography, originally developed by Nashner, is a common tool for evaluating sensory interactions on balance.[1] Employing a computerized system using a servo-controlled dual forceplate and visual surround, the SOT can provide valuable information on whether the individual can effectively use inputs from visual, proprioceptive and vestibular systems to maintain balance, as well as his/her ability to suppress inaccurate sensory information.[1] The SOT has demonstrated good to moderate test-retest reliability[5-7] and has been used to assess sensory contributions to balance control in various populations, including children[8], young adults[7], older adults[9], and individuals with different types of diseases or disorders.[10-12] It has also been used as an outcome measure to evaluate the effectiveness of intervention programs to improve balance.[10,13,14]

While the SOT is common balance assessment tool, its ability to detect subtle balance deficits has been challenged.[13,15,16] For example, it is not uncommon that patients with unilateral vestibular hypofunction can perform within normal limits on the SOT, despite the presence of pathological nystagmus and gait abnormalities.[17-19] The Head Shake Sensory Organization Test (HS-SOT), which is an enhancement to the standard SOT, has been developed to improve delineation of balance performance.[18-21] In HS-SOT, dynamic head movements were incorporated when the subject was tested on the standard SOT conditions 2 (eyes closed while standing on a firm surface) and 5 (eyes closed while standing on a sway-referenced surface). **In contrast with the SOT, in which the head is to be kept still while attempting to maintain balance, the HS-SOT involves active head movements. Apart from the possible influence of the mechanics of moving the head on postural stability,[18] the dynamic head movements involved in the HS-SOT also provide stimulation to the semicircular canals, creating additional vestibular input that needs to be integrated during the balance task, thereby providing additional challenge to the sensory organizational mechanism.[18,20] Moreover, adding the motor task of moving the head also constitutes a form of dual task. It is known that vestibular function, sensory processing, and the ability to perform dual tasks can be adversely influenced by aging.[2,22,23] It is thus likely that the HS-SOT may better delineate age-related decline in balance performance than the standard SOT. It is also thought that HS-SOT may be useful in quantifying subtle balance deficits.[19]**

Preliminary research has shown that the HS-SOT can detect change in balance performance than the standard SOT.[18,24] While these findings suggest that HS-SOT may potentially be a useful outcome measure to assess changes in balance performance following rehabilitation programs[19], it would be important to first establish its test-retest reliability. For example, if repeated exposure to HS-SOT leads to an enhancement in balance, this may become a confounding factor to the use of HS-SOT to measure improvement in postural stability in treatment studies. Moreover, as sensory processing may differ depending on age[2,5,7], it is important to compare the performance in the HS-SOT between young adults and older adults. The objectives of this study were to: 1. examine the age-related differences in balance performance as measured by HS-SOT, 2. establish the test-retest reliability and the minimal detectable change (MDC) (i.e., the smallest difference that would reflect a real change) of the HS-SOT equilibrium scores.

## METHODS

### Sample size calculation and sampling

The sample size calculation was based on the data from a small-scale study by Honaker et al.[21] In their comparison of the HS-SOT equilibrium scores between the younger adult group (20-39 years old, n=10) and older adult group (60-69 years old, n=10), the effect sizes obtained varied between 0.33 and 0.77. A medium effect size of 0.5 was thus estimated for this study. With an alpha of 0.05 and power of 0.8, the minimum number of participants required to detect a significant difference in HS-SOT equilibrium scores between younger and older adults was 64 per group.

**Participants were recruited from the community by disseminating pamphlets containing the information of the study in a local university and various elderly centers, and an existing database of individuals who had participated in our previous studies (i.e., convenience sampling). For inclusion, the individual had to be aged 18 or more, able to provide informed consent, able to stand independently for a minimum of 20 minutes, have normal functional range of motion in the cervical region, hips, knees and ankles. The individual would be excluded from the study if he/she had any neurologic or musculoskeletal injury, serious cardiovascular disease (e.g., unstable angina), pain in the spine or lower extremities, nausea, dizziness, or vertigo, contraindications to exercise, or other serious diseases that precluded participation in the study.** All participants completed a Vertigo Symptom Scale Short Form (VSS-SF)[25,26] to ensure that the participants fulfilled the eligibility criteria. VSS is a 12-item questionnaire that quantifies the frequency of vertigo symptoms. Each item was rated on a 5-point scale (0-4), yielding a score range of 0-60, with higher scores indicating more severe problems. Any individual who scored $\geq$12, which indicates significant vertigo symptoms, was excluded from the study.[25,26] Ethics approval was granted by the Hong Kong Polytechnic University. All participants were given written informed consent before participating in the study. All experimental procedures were conducted in accordance with the Declaration of Helsinki.

**Instrumentation**

All measurements took place in the Balance and Motion Laboratory located at the Department of Rehabilitation Sciences, the Hong Kong Polytechnic University. **All assessments were performed by the same research personnel who was well-trained and had relevant experience in rehabilitation research.** The SMART Balance Master® system (NeuroCom International Inc., Clackamas, Oregon, USA) was used for SOT and HS-SOT testing. Participants stood on the platform in bare feet, which were placed in the designated positions, with the medial malleolus aligned with the axis of platform rotation. To prevent falls, participants wore a harness that did not restrict the amount of sway. The whole experiment was closely monitored by an experienced researcher.

Participants first underwent condition 2 and condition 5 of the SOT (i.e., SOT-2 and SOT-5) (Table 1). They were instructed to maintain an upright posture as much as possible under each individual sensory condition. Three trials were performed for each condition, with each trial lasting 20 seconds. A brief rest period of 30 seconds was given between trials. An equilibrium score was generated by the computerized system, which represents the angular difference between the individual's anteroposterior center of gravity displacements and the theoretical limits of stability.[27] The equilibrium score was expressed as a percentage and could range from 0% to 100%, with a higher score indicating better stability. If participants exceeded their limits of stability and took a step, or used the hand to hold onto an object/visual screen for support, the trial was terminated and considered a fall, and a score of 0% was registered by the system. The score obtained from the 3 trials for each sensory condition was averaged to obtain the mean score.

Each participant then completed the HS-SOT. A head tracker was used to record the amplitude and velocity of head movements. Before the actual experiment, the head tracker was placed on a stable horizontal surface for 5 seconds for calibration. The HS-SOT is a modification of the condition 2 and condition 5 of the standard SOT by adding head movements to the testing protocol (Table 1). In each of the HS-SOT testing conditions (i.e., HS-2 and HS-5), participants wore the head tracker and performed head horizontal rotation movements of about 20°-30° to each side while maintaining neutral flexion and extension of the head. The participants were instructed to follow the rhythm of the auditory signals (1 Hz) provided by the system while performing the head movement, resulting in a minimum peak head rotation velocity of 80° per second (the default minimum value set by the system). The participants were asked to stand as steady as possible while moving the head rhythmically about the horizontal axis. The system provided real-time display of amplitude and velocity of head movements on the computer screen, so that the tester could provide timely feedback to ensure that the participant performed the head movements within the set parameters. A practice period was given before actual testing until the participant managed to perform the desired head movements smoothly and consistently.

In accordance with the manufacturer's instructions, five trials were performed for both HS-2 and HS-5, with each trial lasting for 20 seconds. A 30-second rest period was given between trials. The equilibrium scores generated in these trials were averaged to yield the mean equilibrium score for each individual sensory condition. For assessing the test-retest reliability of HS-SOT, some subjects completed a second testing session after a 1-2 week period. The testing procedures of the second session strictly followed those of the first session.

**Data analysis**

To examine the effects of adding head movements to postural stability, paired t-tests were used to examine the difference in equilibrium scores between SOT-2 and HS-2, and between SOT-5 and HS-5. To examine the degree of association of age with HS-SOT equilibrium scores, Pearson's product moment correlation coefficient was used. Subjects were then divided into two groups according to age (Group 1: <50y, Group 2: ≥50y). For those subjects who completed both testing sessions, intraclass correlation coefficients [ICC(3,2)] were used to evaluate the test-retest reliability of the HS-SOT equilibrium scores. ICC values of less than 0.4 were considered to have poor reliability; 0.40 to 0.75 as having moderate to good reliability, ICC above 0.75 as having excellent reliability.[28] Based on the reliability coefficients computed above, the minimal detectable change (MDC) of each HS-SOT condition was calculated. The standard error of mean (SEM) was first computed using the following formula.[29]

$$SEM = S_x \sqrt{(1-r_{xx})},$$

where $S_x$ is the standard deviation of the equilibrium score, and $r_{xx}$ is the reliability coefficient.

The **MDC** value was estimated using the following formula.[29]

$$\mathbf{MDC} = 1.96 \times SEM \times \sqrt{2}.$$

To further assess change of HS-SOT score between sessions, two-way analysis of variance (ANOVA) with mixed design (within-group factor: time, between-group factor: age group) was used to determine whether one group has a stronger learning/practice effect than the other. If significance was found, post-hoc paired t-tests with Bonferroni's correction were used to compare the HS-SOT derived equilibrium scores in session 1 and session 2 within each group. All statistical analyses were performed using SPSS 17.0 (SPSS Inc., Chicago, Illinois, USA). A significant level of 0.05 (two tailed) was set.

## RESULTS

A total of 177 people volunteered for the study during the period between May 2008 and May 2010. The data from twelve people were excluded. Of these, eight people had VSS score ≥12, and another four subjects were unable to perform the head movements consistently. As a result, the data from 165 subjects [(68 men, 97 women; mean age (SD) = 42.4(18.4) years] were used for subsequent analysis. Subjects were divided into two groups according to age [Group 1: 92 younger adults <50y, mean age (SD) = 28.3(10.0) years, 41 men, 51 women; Group 2: 73 older adults ≥50y, mean age (SD) = 60.3(8.3) years, 27 men and 46 women).

### Effect of adding head movements on postural stability

When all subjects were considered (Table 2), it was found that the HS-2 equilibrium score was very slightly but significantly lower than SOT-2 by 0.5 (95%CI: 0.1 to 0.8, p=0.01). Similarly, HS-5 equilibrium score was also significantly lower than SOT-5, but to a much larger extent (mean=8.8), (95%CI: 6.8 to 10.9, p<0.001), indicating that adding head movements caused a degradation of postural stability (Table 2). **When the two age groups were analyzed separately, it was found that adding head movements to SOT-5 caused a significant decrease in equilibrium score among both young ($p < 0.001$) and older adults ($p<0.001$). On the other hand, the slight reduction in equilibrium score caused by adding head movements to SOT-2 only reached statistical significance in younger adults ($p = 0.002$), but not in the older adult group ($p = 0.66$).**

**Relationship to age**

The results revealed significant, negative associations of age with all SOT and HS-SOT equilibrium scores tested ($p<0.05$)(Table 2), indicating that increasing age was associated with poorer performance in different sensory conditions presented in SOT and HS-SOT. The between-group difference in HS-5 was particularly prominent (mean=9.0, 95%CI: 4.8 to 13.1, $p<0.001$).

**Reliability analyses**

Seventy-seven subjects completed both testing sessions [Group 1: mean age (SD)=24.2 (6.3) years, 28 men, 28 women; Group 2: mean age (SD)=58.0 (6.0) years, 11 men and 10 women](Table 3). Both groups achieved a peak head movement velocity at approximately 100°/s, and there was no significant difference in head movement velocity between sessions for both HS-SOT conditions ($p>0.40$). However, a significant time × group interaction in equilibrium score for HS-5 was found ($F_{1,75} = 7.22$, $p = 0.01$). Post-hoc paired t-tests revealed that the equilibrium score for HS-5 was significantly increased in the second testing session for both age groups, indicating a possible learning/practice effect, but the effect was stronger in the older adult group (Group 2) (Group 1: mean change=3.5, 95% CI: 0.9 to 6.2, p=0.01; Group 2: mean change=10.2, 95% CI: 6.0 to 14.4, p<0.001). No such time × group interaction was found for HS-2 ($F_{1,75} = 2.93$, p=0.09).

The results of reliability analyses were shown in Table 4. For the younger group, the test-retest reliability of both HS-2 and HS-5 was excellent ($ICC_{3,2} > 0.75$). The corresponding MDC values were 2.7 and 16.2 respectively. On the other hand, the test-retest reliability of HS-2 and HS-5 was moderate to good for older adults ($ICC_{3,2} > 0.5$), leading to higher MDC values (HS-2=3.6, HS-5=22.7).

## DISCUSSION

### Age-related differences

Our results show that the HS-SOT scores are significantly lower than their respective SOT scores, indicating that adding head movements to the standard SOT protocol, particularly condition 5, poses additional challenge to the subjects, leading to degradation of postural stability. **Like the SOT, the HS-SOT does not directly assess the labyrinth or vestibular nerve, and is thus not specific for vestibular disorders. In HS-SOT, the disruption of balance is likely a combination of added vestibular stimulation and the effects of the mechanics of the head movement itself while attempting to maintain an upright posture. However, Mishra et al.[18] provides some preliminary evidence that adding head movements to standard SOT increases the sensitivity of the test to discriminate patients who have unilateral, peripheral vestibular deficits as determined by the caloric test from healthy individuals. This would be less likely if the head movements alone contribute to postural instability.[18]**

Consistent with the findings in the standard SOT reported in previous studies, there is deterioration of performance in the HS-SOT with increasing age.[5-7,27] Moreover, adding head movements to SOT-5 increased the separation of **healthy** younger and older adults. As the postural tasks involved in HS-SOT, particularly HS-5, are more dependent on vestibular information, it is not surprising that older adults do not perform as well in these tasks when compared with their younger counterparts, considering the many degenerative changes in the vestibular system that occur with aging, including the loss of vestibular hair and nerve cells[30], neuronal loss in parts of the vestibular nuclear complex[31] and reduced number of myelinated vestibular nerve fibers.[32] However, there is also a possibility that the deterioration of performance in HS-SOT among older adults may be related to the reduced ability to manage dual tasks.[33,34] Among the four tested conditions, the HS-5 is the most novel and complex. The addition of dynamic head movements while attempting to maintain balance on a moveable platform imposes an additional task demand on the participants, particularly for older adults. **Further study is required to decipher the mechanisms underlying the deterioration of HS-SOT equilibrium scores with aging (e.g. vestibular, dual-tasking, mechanical effects).**

Our findings are also consistent with that of Honaker et al.[21] In their study based on a small sample of 40 subjects, negative correlations between age and HS-SOT scores were identified, although different head movement velocities were used (HS-2: 60°/s and 120°/s; HS-5: 15°/s and 60°/s).[21] They further demonstrated that adding head movements of peak velocity as low as 15°/s to SOT-5 can significantly decrease the equilibrium score.[21] We used the same peak head movement velocity for both HS-2 and HS-5 (approximately 100°/s), as it is the default value set by the system. Further study is required to evaluate the interaction between age and head movement velocity on equilibrium score.

**Reliability**

This is the first study to evaluate the test-retest reliability and MDC of the HS-SOT in different age groups. Our analyses revealed that the test-retest reliability of HS-SOT differs depending on age. The test-retest reliability of the HS-SOT is moderate to good among older adults, and excellent among younger adults. On repeated testing, there is a significant increase in equilibrium score, indicating a possible learning/practice effect. This study has established the MDC values, which represent the smallest difference in HS-SOT score that reflects a real change. **This is essential, as it provides guidelines for interpreting the change in HS-SOT scores with time or after intervention.** Based on the results of this study, for **healthy** younger adults, we recommend using the criterion of 3- and 16-point change for indicating a real improvement in HS-2 and HS-5, respectively. For **healthy** older adults, a mean change of 4 and 22 points would indicate a real change in these parameters.

Our ANOVA results revealed that older adults show a significantly greater learning/practice effect than younger adults when performing the HS-5, but not HS-2. As aforementioned, HS-5 is a more complex postural task and is more reliant upon vestibular information than HS-2. It may thus be very difficult for older adults to tackle the HS-5 on their first exposure, as vestibular functioning in aged individuals is less optimal than their younger peers. Interestingly, when exposed to the task the second time, older adults are able to improve on their performance. It may involve some kind of adaptation, in which a previous experience of a postural task influences the development of appropriate strategies for maintaining body equilibrium in subsequent trials.[7]

**Limitations and future research directions**

**Firstly, only dynamic head movements in the horizontal plane were tested, as in several previous studies.[18,19,21]** Head movements in the horizontal plane were chosen in this study because they are highly relevant to most routine activities of daily living.[18] **For example, step turning is a major component of walking activity during daily activities and is associated with undesirable events such as falls and hip fractures.[34] Horizontal eye and head turns are often used to guide the changes in walking directions.[35,36] As pointed out by Mishra et al.[18], another potential advantage of using horizontal head movement is that it primarily involves the horizontal semicircular canals. The results can thus be compared with those derived from the caloric test. There is evidence that dynamic head tilts in the pitch and roll planes may also lead to postural instability.[20,37] It is possible that headshake movements in the pitch plane may correspond more to the anterior-posterior SOT sway score than those in the horizontal plane. It would thus be important to repeat the study using head movements in the pitch plane.**

**Secondly, the four test conditions were performed in the same order across participants. In particular, the HS-SOT was always performed after the SOT. This is due to a constraint imposed by the computerized system, as the generation of the HS-SOT analysis report involves the computation of the HS-SOT:SOT score ratio for condition 2 and 5, which requires that the SOT be done first. Because of this, we could not rule out the possibility of an order effect. Nevertheless, our findings are in agreement with previous studies, which showed that the equilibrium score decreases with increasingly challenging sensory conditions as presented in the SOT or HS-SOT.[5-7,18]**

**Thirdly, only healthy young and older adults were tested in this study. The findings can only be generalizable to individuals with characteristics similar to those in our study sample, because other patient populations may demonstrate different postural responses in the HS-SOT. For example, horizontal head movements in healthy subjects may not create an asymmetry in postural responses that may be observed among subjects with unilateral vestibular deficits.[38] Future studies should address whether the HS-SOT may be more sensitive in identifying patients with unilateral vestibular deficits who are well compensated and have normal SOT scores. Using a horizontal head movement velocity of 60°/s, Mishra et al.[18] found that adding head movements to the standard SOT increased the test sensitivity in identifying patients with unilateral, peripheral vestibular deficits. However, the low specificity obtained would limit the potential usefulness of the test. It is likely that head movement velocity and direction used in their study may not be the most optimal for discriminating the balance performance of these patients from that of healthy subjects. Further study on this important topic is warranted.**

**Conclusion**

In conclusion, this study provides evidence that older age is associated with poorer performance in HS-SOT. Adding head movements to SOT-5 also increased the separation of **healthy** younger and older adults. The HS-SOT equilibrium scores have excellent test-retest reliability among **healthy** younger adults, and moderate to good test-retest reliability among **healthy** older adults. The computation of the MDC values also assists in clinical interpretation. Further study is required to determine the optimal cut-off HS-SOT score for identifying people with different balance disorders.

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**Table 1. Testing protocol: SOT and HS-SOT conditions.**

| **Condition** | **Description** | | |
|---|---|---|---|
| SOT-2 | Eyes closed | Firm surface | Stationary surround |
| SOT-5 | Eyes closed | Sway-referenced surface | Stationary surround |
| HS-2 | Eyes closed, head horizontal rotation | Firm surface | Stationary surround |
| HS-5 | Eyes closed, head horizontal rotation | Sway-referenced surface | Stationary surround |

SOT-2 = Sensory Organization Test condition 2

SOT-5 = Sensory Organization Test condition 5

HS-2 = Head-Shake Sensory Organization Test condition 2

HS-5 = Head-Shake Sensory Organization Test condition 5

**Table 2. Performance in SOT and HS-SOT (N=165)**

| Condition | All subjects (n=165) Mean±SD | Pearson's r (Correlation with age) | p-value (correlation) | Group 1: Younger adults (n=92) Mean±SD | Group 2: Older adults (n=73) Mean±SD | Mean between-group difference (95%CI) | p-value (t-test) |
|---|---|---|---|---|---|---|---|
| SOT-2 | 92.7±2.7 | -0.339 | <0.001* | 93.4±2.3 | 91.8±2.8 | 1.6 (0.8, 2.4) | <0.001* |
| SOT-5 | 60.9±14.1 | -0.188 | 0.02* | 63.0±14.4 | 58.2±13.4 | 4.8 (0.4, 9.1) | 0.03* |
| HS-2 | 92.2±2.4 | -0.222 | 0.01* | 92.6±2.3 | 91.7±2.3 | 0.9 (0.2, 1.7) | 0.01* |
| HS-5 | 52.0±14.1 | -0.394 | <0.001* | 56.0±12.7 | 47.0±14.2 | 9.0 (4.8, 13.1) | <0.001* |

*p<0.05

**Table 3. HS-SOT equilibrium scores in session 1 and 2 (N=77)**

| | Group 1: Young adults (n=56) | | | | Group 2: Older adults (n=21) | | | | p-value (time × group interaction) |
|---|---|---|---|---|---|---|---|---|---|
| | Session 1 Mean±SD | Session 2 Mean±SD | Mean change (95%CI) | p-value (within-group comparison) | Session 1 Mean±SD | Session 2 Mean±SD | Mean change (95%CI) | p-value (within-group comparison) | |
| **Equilibrium score** | | | | | | | | | |
| HS-2 | 92.9±2.5 | 92.8±2.3 | -0.1 (-0.6 to 0.4) | 0.70 | 91.6±2.3 | 90.4±2.9 | -0.9 (-1.9 to 0.1) | 0.08 | 0.09 |
| HS-5 | 58.3±12.5 | 61.9±11.6 | 3.7 (1.1 to 6.3) | 0.01* | 50.0±12.5 | 60.1±8.2 | 10.2 (6.0 to 14.4) | <0.001* | 0.01* |
| **HS-SOT peak head movement velocity** | | | | | | | | | |
| HS-2 | 104.1±13.2 | 103.6±7.4 | -0.5 (-2.7 to 1.8) | 0.68 | 106.5±8.1 | 108.0±8.0 | 1.5 (-2.9 to 6.0) | 0.48 | 0.38 |
| HS-5 | 104.5±9.0 | 104.2±8.4 | -0.3 (-2.2 to 1.7) | 0.76 | 107.1±12.3 | 106.6±7.2 | -0.5 (-6.8 to 5.7) | 0.86 | 0.92 |

*p<0.05

**Table 4. Test-retest reliability coefficients and minimal detectable change (MDC) values for HS-SOT conditions**

| | **All subjects (n=77)** | | **Group 1: Young adults (n=56)** | | **Group 2: Older adults (n=21)** | |
|---|---|---|---|---|---|---|
| Condition | ICC (3,2) | MDC | ICC (3,2) | MDC | ICC (3,2) | MDC |
| HS-2 | 0.82 | 2.9 | 0.85 | 2.7 | 0.64 | 3.6 |
| HS-5 | 0.77 | 16.9 | 0.78 | 16.2 | 0.55 | 22.7 |

ICC = intraclass correlation coefficient

MDC = minimal detectable change