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ORIGINAL RESEARCH

The Multisurface Obstacle Test for Older Adults (MSOT): development and reliability of a novel test for older adults

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Abstract Locomotion is an essential component of independence and well-being at old age. Performance deficits in the gait of older adults most often become evident on multisurface and varying terrains. Research results substantiate that falls occur in everyday movement situations that are characterized by instability. A test track, the Multisurface Obstacle Test for Older Adults (MSOT), was developed to diagnose individual performance. The 10-m track consists of different obstacles and varying surfaces, which represent everyday movement situations in a compact way. Twenty-nine untrained, healthy older adults (11 men, 18 women) were tested on three different days at 1-week intervals in a test–retest design by the same conductor. Mean age of the participants was 68.8±5.3 years with a mean body mass index of 24.4±2.5 kg/m^2. The measured outcome variable was the required time (seconds) on the MSOT. The feasibility for the tested sample of untrained older adults was very good. The MSOT was undertaken safely by the participants, and no falls occurred. The range of the mean for time was between 8.12±1.53 s and 9.00±1.62 s. Regarding intertrial reliability, mean differences (MD) of −3.39 to −5.52 % and coefficients of variation (CV) of 2.72 to 4.19 % between the first and second trials and MD of −0.69 to −0.85 % and CV of 2.57 to 4.54 % over the three test sessions were observed. The correlation coefficients between the sessions were .92–.98. There were significant differences ($p<.05$) between the first and second trials of each session and between the first and second sessions. The smallest detectable differences (SDD) revealed that a small improvement is enough to detect changes in performance in the MSOT. Selecting tasks from real-life situations of older adults contributes to substantiate practical usability of the MSOT. The measured time on the MSOT showed high relative and absolute reliability in the target group of older adults between 60 and 80 years.

Keywords Assessment · Gait · Daily movements · Methods and quality criteria · Older persons

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Introduction

Locomotion is essential to maintain independence in the life of older adults. Safe locomotion is based on a secure gait. Thus, gait is one of the most frequent movements in everyday life. Age-dependent influences affect decrease of physical performance: with increasing age, a loss of cells in the brain is observed as a reduction of muscle mass and motor units. The inevitable aging processes of our sensory system are connected to a decrease in visual performance and tactile sensitivity. This is accompanied by impairments in proprioceptive and vestibular performances [31]. Furthermore, the different degeneration processes of the nervous system in the course of aging include decreasing myelinization of axons and morphological and biochemical changes in the brain. This, in turn, leads to a reduced performance in attention, sensory integration, and difficulties in the selection of relevant information for a target-aimed movement execution [17]. The decelerated transmission speed of afferent and efferent signals in conjunction with impaired muscle functioning leads to slower muscular reactions and actions; therefore, coping with unexpected new situations becomes more difficult [31]. The assessment of gait parameters is helpful to observe changes in this essential movement of daily life—the assessment of further performance loss requires the need of an application of additional functional tests (for example, a reactive component) [10, 27, 31].

Two studies have shown an increase in gait parameter in older adults compared to younger adults, whereby a variety of different surface conditions have been utilized [21, 24]. An additional two studies have shown that both reduced gait velocity and limited mobility are risk factors for gait instability, mobility disorders, and falls [6, 13]. Considering more technical elements, seven studies have demonstrated how the inclusion of different surface conditions can facilitate the evaluation and implementation of different wearable systems measuring subjects' gait parameters [11, 19, 25, 34] for monitoring mobility-related activities [2, 7] or diabetes [8].

Analyzing the locations where falls occur, a study that included a sample of 333 people (age M=74.9 years) demonstrated the majority of indoor falls occurred during stair climbing (10.8 %), unlike outdoor falls that primarily occurred while walking to the garden (10.5 %) or on the road, pavement, park, forest, or at the playground with their grandchildren (44.1 %) [4]. Results from previous studies have substantiated that falls are mostly likely to occur in everyday movement situations (e.g., slippery or uneven surfaces, stumbling on carpets, stairs, or climbing a ladder). These facts have frequently been identified as main risk factors for falls [4, 32].

The causes of falls illustrate that a valid assessment should include different demands and tasks. In previous studies, gait assessments for fall prevention comprise of the measurement of gait speed (general), Timed Up and Go (TUG), the Tinetti gait assessment tool, or the GAITRite® system [27]. For several years, different approaches such as the development of obstacle courses for older adults have been utilized because it is suggested that the frequency of falls is associated with an effective ability to master obstacles [5, 9, 22, 28, 29, 30]. There is a necessity for older adults to adapt their movements that would, in turn, facilitate them to accomplish the obstacles and not to reach their limits of stability and balance. Thus, they will have a lower risk of falling when obstacles and changing surfaces occur [18]. The respective authors concluded that the integration of different environmental conditions in tests is essential [20, 33] to combat these obstacles.

The following test was developed to follow these demands. With their approach, the authors considered, initially, the assessment of gait and, secondly, movements and surfaces where falls are most likely to occur. Other studies identified this in different stations but not in one single track. Therefore, it was chosen to combine these to devise a new measurement. The Multisurface Obstacle Test for Older Adults (MSOT) is innovative in so far that the short track consists of different obstacles and movement skills taken from everyday life of older adults. The cost effectiveness of implementing the test with minimal and additional technical effort for practitioners, who work with older adults, was easily utilized that is important for integration. The proposed study is presented in the first part of phase I [11] (diagnostic study). The range of results obtained with the MSOT was analyzed in healthy older adults.

Methods

Participants

Participants were recruited by advertisements placed on web pages, in local newspapers, journals, posters, and flyers throughout the city of Cologne and surrounding areas. Initially, each participant completed a health questionnaire and submitted a medical clearance certificate.

Exclusion criteria included: severe heart diseases; respiratory, renal, or hepatic problems; severe osteoporosis; unstable diabetes; neurological diseases or arterial hypertension; diagnosed gait disorders; artificial joints and need of walking aids for gait; and one or more falls during the last 6 months. Prospective participants who reported to have fallen were not included at this stage of the study in order to draw a homogenous sample. Prior to analysis, all performance data was anonymous. Participants were tested on three different days at 1-week intervals (on the same day of the week) in a test–retest design by the same researcher. Participants were required to maintain their usual behavior (nutrition, hydration, and physical activity) over the duration of the study. To avoid circadian variations in the performance, all participants performed their measurements at the same time of the day. The duration of the study was 10 weeks. This study was approved by the Ethic Committee of the German Sport University Cologne, and all participants signed a written informed consent form before study participation.

The sample consisted of 29 untrained, healthy participants (11 men and 18 women, M = age: 68.8±5.3 years, mean body mass index: 24.4±2.5 kg/m^2). One of the participants had mild osteoporosis, seven with stable diabetes, two with a slight scoliosis, and one was a smoker. Four participants performed strength training once a week and completed the self-reported physical performance (using a five-point scale from very poor to very good) survey. All of the participants were rated between medium and very good. Participants wore their usual footwear, which was identical on each test day.

Instruments

Layout of the MSOT

The MSOT integrated different ground surfaces that simulated different locations and tasks were reported with high incidences of falls in previous studies [4, 20, 32]. To fulfill these presuppositions, they were minimized into a track of 10 m. This track provides a functionally oriented assessment of real-life conditions and tasks to the environmental conditions regularly experienced by older adults. The primary object was to reproduce a situation similar to that experienced in the real world by older adults. The MSOT was developed by sport scientists, working in the field of movement science, sport gerontology, and fall prevention. Initially, specific fall movements and obstacles were researched and discussed, which resulted in a selection of suitable obstacles to be implemented. The developed track was tested by individual participants, discussed with colleagues, and modified on the basis of their feedback. At the end of the pilot phase, the final version of the MSOT was determined and documented.

The total length of the test track was 10 m (cf. Fig. 1; Appendix Fig. 3). The first and last meters provide space for acceleration and deceleration; therefore, the distance timed includes only the intermediate distance of 8 m (testing zone). The testing zone consists of different surface conditions and obstacles to overcome while walking (cf. Fig. 1; Appendix Fig. 3). After 0.5-m flat surface, the first obstacle (length: 2 m) simulates road kerbs. It is constructed of a wooden box (step on 10 cm height, step off 8 cm height; length: 0.6 m) and a 2-cm high area (0.8 m length). Together with a second box (step on 13 cm height, step off 15 cm height; length: 0.6 m), the first obstacle should simulate different kerb heights and edges located on pavements or in the home.

Additionally, this is followed by an area with fixed round pebble stones on a length of 0.6 m, as a simulation of a path in a municipal park or in the garden. The next surface condition is similar to an uneven forest or garden path in the form of two Terrasensa® plates (Ludwig Artzt GmbH, Dornburg, Germany) with a length of 1 m. Stepping off the plates, there is a 1.20 m long carpet with artificial turf integrated onto the pathway, followed by wooden plates (0.6 m), similar to that found on a terrace. The track ends with a stairs element. At first, there are three stairs upwards, then a small flat area on top, and three stairs downwards. The flat surface comprises of 0.4 m prior to 8 m at the end. The stairs element has a total length of 1.70 m; each step is 17 cm high and 29 cm deep (according to German standards-DIN for stairs). The final element reproduces basic stair climbing or, in combination with the previous elements, a walk from the garden into the house. The MSOT was developed in relation to the general recommendations for gait analysis [28]. A flat track of 12 m length and 2 m width is needed to put the MSOT into practice. The integrated objects can be handled by two persons and need a storage area of 2 m^2.

Measurements

The walking time in the 8-m testing zone was taken using a digital stop watch on 1/100 s. To exclude subjective influences of the researcher on the test and handling the digital stop watch, we used the three first trials on flat ground to compare the results with the data of a gait analysis system RehaWatch (Hasomed GmbH, Magdeburg, Germany). Results showed high correlations from r=.90 to .97 (p<.001). A stop watch was used in terms of future usability under practice conditions with older adults in the field. Because of the high correlations between the two measures, using the digital stop watch seems to be justifiable.

The time commenced when the first foot of the participant(s) made contact with the ground in the testing zone and stopped at the first contact out of the 8 m zone. The 8-m testing zone was highlighted with dark green tape to make measuring easier for the researcher but not to cause distraction to the participant. The participants were unaware that their time was being recorded during the testing zone. This approach was considered to prevent unwanted influence on acceleration and deceleration. The number of steps required for the 8-m distance was counted with a handheld counter for calculating cadence (steps per minute). See Appendix, for the instructions.

Testing procedures

The MSOT was conducted in an indoor environment. Participants walked on the flat surface (laboratory/floor surface) for 10 m. The initial trials were performed as a physical warm-up and to become familiar with their habitual gait velocity. Afterwards, participants received instructions to walk the entire distance of the MSOT (10 m) with their habitual gait velocity as safely as possible.

The researcher provided the participants with the instruction, "Please gear up for the start of the measurement," which was given in front of the yellow-marked line in a parallel stance. At the end of the track, participants had to stop with their toes behind the second yellow line (after 10 m), again with a parallel stance. The researcher walked alongside but slightly behind the participant to ensure their safety. The stop watch and the counter were attached by a cord at the wrist of the researcher.

On each test session, the same testing procedure was applied with three trials on flat ground followed by three trials on the MSOT (cf. Fig. 2). To evaluate the requirement

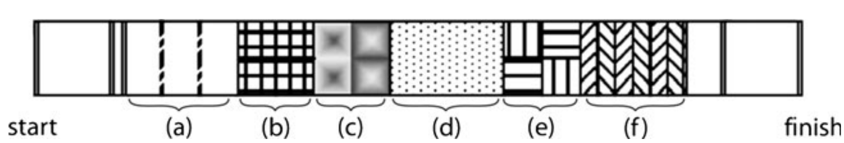

Fig. 1 Layout of the MSOT. **a** kerbs, 1st flat (10 cm), 2nd high (15 cm), **b** round pebble stones, **c** Terrasensa® plates, **d** carpet, **e** wooden plates, **f** stairs

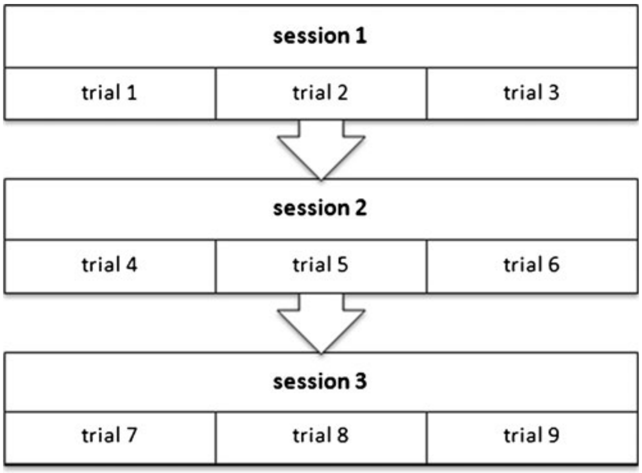

Fig. 2 Procedure: the three sessions with three trials at each session

of a potential familiarization session, three sessions were executed. As a result, additional information about the consistency of older adults in their test performance should be assessed. Total test duration was approximately 20 min per participant for the six trials. The rest between trials was 60 s. A researcher (a sport scientist) was trained by the lead researcher, in this case, the primary author, in measuring the participants with the MSOT for each trial and was specifically instructed in the sequential arrangement by the lead researcher of the MSOT.

Statistical analysis

According to Hopkins [14] and based on an a priori power analysis, a sample size of 27 participants was estimated to detect a size effect of 0.5 with a power of 0.8118, an alpha of <.05, and a critical t of 1.71. Power analyses were performed with the software GPower (GPower, v3.1.3, University of Dusseldorf, Germany). In the field of reliability research, the used significance level and power are the commonly applied ones [16]. Conducting a study with three measurement days and a sample size of 30 participants, a standardized error of measurement (SEM) would be assumed in a range of SEM ×/÷ 1.2 (the lower limit is the observed value divided by 1.20 and the upper limit is the observed value times 1.20), which is equivalent to the 95 % confidence interval [14]. The smallest detectable difference (SDD) was estimated on the basis of the coefficient of variation (CV) [3, 26].

The normal distribution (Shapiro–Wilk test), homoscedasticity (Levene test) of the data, and Spearman's correlation coefficient (r_s) were calculated with the statistical software IBM SPSS Statistics 19.0 for Windows (International Business Machines Corporation, Armonk, NY, USA). If no normal distribution and/or homoscedasticity were provable, a logarithmic transformation was calculated. The calculations for reliability were conducted with the excel spreadsheet “xrely.xls” (Hopkins, 2011, Auckland, New Zealand) in Microsoft Office Excel 2007 (Microsoft Corporation, Redmond, USA). An alpha ≤0.05 was considered statistically significant.

To test the reliability between the specific trials and between sessions, the relevant parameters for absolute reliability [14, 15] were: mean difference (MD), CV, standardized MD (sMD), and standardized standard error of measurement (sSEM) and for relative reliability [1]: intraclass correlation coefficient ($ICC_r(2,1)$) and r_s. Objectivity is given if there is good reliability and low changes between the three sessions, so that a subjective influence of the testing person is excluded. Additionally, a comparison of the single three trials in one test session and also between the sessions was used. Therefore, ANOVA with repeated measurements or a Friedman test was conducted. If there was no sphericity given, the Greenhouse-Geisser correction was used. Significant differences were examined with Bonferroni post hoc test.

Results

All integrated obstacles and ground surfaces were executed safely by the participants and no falls occurred. In conclusion, the MSOT was executed within the specific target group of untrained older adults.

The descriptive statistics showed a relative consistent scheme over the different trials on each testing session and also between the different sessions (cf. Table 1). Between the first and second trials of each testing session is a greater difference than between the second and third trials.

MDs, CV, sMDs, and sSEM for time were very low (cf. Table 2) at all three sessions. The CV were overall <5 %. The MDs and sMDs were usually reduced regarding the variation

Table 1 Values of the measured time on the MSOT for all three sessions (session 1: trials 1–3; session 2: trials 4–6; session 3: trials 7–9); N=29

Trial	M ± SD	MIN–MAX
1	9.00±1.62	5.75–13.40
2	8.49±1.46	6.18–12.03
3	8.43±1.51	5.72–11.72
4	8.50±1.53	5.97–11.84
5	8.20±1.45	5.97–11.16
6	8.14±1.43	5.84–11.03
7	8.48±1.68	6.19–12.59
8	8.19±1.56	5.85–11.68
9	8.12±1.53	5.94–11.53

M mean, *SD* standard deviation, *MIN* minimum, *MAX* maximum

Table 2 Values of intertrial reliability of the measured time on the MSOT for all three sessions. Comparisons between first and second, and second and third trials at each session and between sessions

Comparison	MD (%)[a]	CV (%)[a]	sMD[a,b]	sSEM[a,b]	ICC_r[a]	r_s
s1: tr2–tr1	−5.52	4.19	−0.32±0.10	0.23	.95	.92*
s1: tr3–tr2	−0.85	4.54	−0.05±0.11	0.25	.94	.94*
s2: tr5–tr4	−3.53	3.31	−0.20±0.08	0.18	.97	.96*
s2: tr6–tr5	−0.69	2.57	−0.04±0.06	0.14	.98	.98*
s3: tr8–tr7	−3.39	2.72	−0.18±0.06	0.14	.98	.98*
s3: tr9–tr8	−0.71	2.57	−0.04±0.06	0.14	.98	.98*

s*x* session *x*, tr*x* trial *x*, *MD* mean difference, *CV* coefficient of variation, *sMD* standardized mean difference, *sSEM* standardized standard error of measurement, ICC_r intraclass correlation coefficient, r_s Spearman's correlation coefficient

[a] Computed with logarithmic transformed data

[b] 95 % confidence interval: ×/÷1.25

* $p<.001$

between the second trial and third trial at every session. Significant ($p<.001$) ICC_r of .94 to .98 were identifiable; r_s were also a high ICC_r.

Regarding the variations (test–retest reliability) between the different sessions, there was a similar trend (cf. Table 3). The CV was, in all cases, <5 % (with exception of one comparison). In MD and sMD, a reduction between comparison 1 (session 1 and session 2) and comparison 2 (session 2 and session 3) was apparent. ICC_r were very high, and r_s showed an analogical trend. The reliability values for

Table 3 Values of test–retest of the measured time on the MSOT for the different sessions. Comparisons between only the first, second, and third trials on each session; the means of the first two or second two trials in each session; and the best trials (out of three, the first two and the second two trials)

Comparison	MD (%)[a]	CV (%)[a]	sMD[a,b]	sSEM[a,b]	ICC_r[a]	r_s[a]	SDD[a] (%)
tr1; s2-1	−5.70	5.65	−0.31±0.11	0.31	.91	.89*	15.65
tr1; s3-2	−0.51	4.52	−0.03±0.08	0.24	.95	.94*	12.52
tr2; s2-1	−3.61	4.77	−0.20±0.12	0.27	.93	.95*	13.21
tr2; s3-2	−0.36	4.13	−0.02±0.09	0.22	.95	.96*	11.44
tr3; s2-1	−3.44	4.54	−0.19±0.11	0.25	.94	.94*	12.58
tr3; s3-2	−0.38	3.56	−0.02±0.08	0.20	.96	.96*	9.86
mtr1-3; s2-1	−4.32	4.28	−0.24±0.10	0.24	.95	.94*	11.86
mtr1-3; s3-2	−0.42	3.34	−0.02±0.08	0.21	.97	.96*	9.25
mtr1-2; s2-1	−4.69	4.89	−0.26±0.11	0.27	.93	.92*	13.55
mtr1-2; s3-2	−0.44	3.78	−0.02±0.09	0.20	.96	.95*	10.47
mtr2-3; s2-1	−3.56	4.14	−0.20±0.10	0.24	.95	.95*	11.47
mtr2-3; s3-2	−0.37	3.36	−0.02±0.08	0.18	.97	.96*	9.31
besttr1-3; s2-1	−2.64	3.90	−0.15±0.14	0.22	.96	.96*	10.80
besttr1-3; s3-2	−0.27	3.15	−0.01±0.11	0.17	.97	.98*	8.73
besttr1-2; s2-1	−3.67	4.48	−0.20±0.12	0.25	.94	.95*	12.41
besttr1-2; s3-2	−0.35	3.84	−0.02±0.10	0.21	.96	.96*	10.64
besttr2-3; s2-1	−2.45	4.06	−0.14±0.11	0.23	.95	.95*	11.24
besttr2-3; s3-2	−0.23	3.13	−0.01±0.09	0.17	.97	.97*	8.67

s*x* session *x*, tr*x* trial *x*, *besttr* best trial, *mtr* mean of the trials, *MD* mean difference, *CV* coefficient of variation, *sMD* standardized mean difference, *sSEM* standardized standard error of measurement, ICC_r intraclass correlation coefficient, r_s Spearman's correlation coefficient, *SDD* smallest detectable difference

* $p<.001$

[a] Computed with logarithmic transformed data

[b] 95 % confidence interval: ×/÷1.25

test–retest for different considerations (only the first, second, and third trials of each session; mean out of all three trials and two trials and the best trial out of two or three trials) can be seen in Table 3. The SDD indicated that a relative change of 8–16 % (dependent on the chosen test protocol) must occur to reveal a genuine change in performance in the MSOT.

The measured time was found to be significant ($p<.05$). MDs could be observed between the single trials and the sessions (cf. Table 4). Post hoc tests detected MDs between trial 1 and trial 2 at sessions 1, 2, and 3. Reviewing the different sessions, the significant MD was between sessions 1 and 2.

The means of cadence were between 106.86±13.37 and 113.10±14.45 steps/min and showed MDs of −0.12 to 3.17 %, CV of 3.01 to 4.52 %, and significant ICC_r of .87 to .95. Concerning the variations (test–retest reliability) between the different sessions, MDs of 0.69 and 1.69 %, CV between 3.71 and 3.94 %, and correlation coefficients of .89 to .91 were observed.

Discussion

Time measurements with the MSOT were reliable in the tested sample of older adults between 60 and 80 years. The absolute reliability with overall values of CV <5 % (with one exception) is very high both between the individual trials and the different sessions. This is clearly under the prevalent limit of 10 % (for CV) in sport sciences [1]. Values for MD between −3.4 % and −5.5 % for comparison of the first and second trials on each session increase this issue. The view on the second trial compared with the third trial shows that the MD was much lower with −0.7 % to −0.9 %.

With ICC_r and r_s from .92 to .98, the relative reliability is positive. This kind of result could also be seen concerning test–retest reliability; both absolute and relative reliability are very good. Due to the high reliability values and the very low changes in the mean, we conclude that the objectivity of the MSOT is given. This is confirmed by the results of the ANOVA because of the significant differences between the first and second trials; therefore, the recommendation is to establish the first trial as an example trial for familiarization.

Table 4 Values of the comparisons of the means between the single trials and between the different sessions

Comparison	*N*	F/χ^2	df	$\eta_{par}{}^2$	*p*
s1: tr1 − tr3	29	15.108	1.603	.350	<.001*
s2: tr1 − tr3	29	20.589	2	–	<.001**
s3: tr1 − tr3	29	14.000	2	–	<.001**
s1 − s3	29	6.383	2	–	.041***

s*x* session *x*, tr*x* trial *x*, *df* degrees of freedom

* tr1 − tr2, $p<.05$ and tr1 − tr3, $p<.05$

** tr1 − tr2, $p<.05$

*** s1 − s2, $p<.05$

The significant differences for time between session 1 and session 2 argue for one session for familiarization with the MSOT before measurements commence. Minimal mean changes and no significant differences between the last trials and sessions support objectivity of the MSOT. The considerations of different calculated values from a series of three trials have led to the conclusion that after one example trial, one more trial is sufficient for reliable measurement because MDs, CV, and correlation coefficients were very similar. However, reliability could be further improved by adding additional trials. As seen in Table 3, reliability values could be improved if three trials (instead of two) are conducted and the best trial out of trial 2 and trial 3 (after one example trial) is taken into account. If the second trial is used for analysis or to study intervention effects, an improvement of at least 12 % argues for a real change in performance in the MSOT. The low SDD revealed that a small improvement is enough to detect changes in performance in the MSOT. These results may help clinicians and researchers when interpreting responses to a particular training intervention between test sessions for an individual older adult.

Preceding studies with comparable courses showed high intraclass correlations, for example, .74 to .99 [9]. However, additional studies utilized an extension comprising of 12 stations, reporting an intraclass correlation of .98 (CV= 5.2 %), which examined videotape analysis, with eight participants and 2 weeks between the data analysis of the same recorded trials [22]. Subsequently, the results from previous studies have shown how a variety of tasks or stations in their courses requires more than a single track similar to that of the MSOT.

There are initially two benefits to utilizing the MSOT in conjunction with multiple tasks and everyday movements and these are minimal space and time for the execution of the measurement. Data concerning validity and reliability in previous studies are available but are not as comprehensive as favored to evaluate the measurement instrument or eliminate measurement errors or systematic failures. This study provides substantial data concerning reliability with different parameters used in sport sciences to present a credible conclusion with a sample of 29 older adults over a period of 3 weeks.

The aim of the new MSOT was to integrate different everyday movements and challenging surface conditions from real-life environments into one single track. This purpose was fulfilled on the common distance in the often conducted gait analysis distance. A course with different stations, which needs substantial space and material, has only limited applicability [22, 23, 29] though it might provide a greater understanding, especially when information is separated for the different obstacles and surfaces.

Another key aspect is to enlarge the measured gait parameters by wearable systems [8, 12, 34]. Therefore, a portable gait analysis system is a more suitable approach to usability in practice. At this point, the user must assess the pros and cons of relevance for given questions and situations: high technical solutions for (only) scientific requests or a practical assessment tool with adequate methodology and quality tested criteria that would take into consideration a more practical bearing. Additional aspects need to be considered: the cost effectiveness and the test economy of the applied tool. The latter could be ensured by the MSOT.

There are several areas concerning future work for the MSOT, which will be discussed in detail. The first consideration is to conduct a series of experimental studies focusing on dual-task conditions during the MSOT. For example, the older adults would be provided with an additional cognitive or transport motor task during the walk on the track. These additional tasks reflect closely to everyday situations in the life of older adults. This kind of dual-task analysis attained rising importance in attention tasks. Different changes with increasing age influence more the dual-task conditions in contrast to the graduation of a single track. The second consideration could assess and examine the differences between fallers and nonfallers between subgroups because one limitation of the current study is the exclusion of fallers. This means the presented results will not be ascertained for the overall population (including fallers). The third consideration would be to conduct the MSOT in an outdoor environment that could then be compared to the indoor analysis of the MSOT measurement. The fourth consideration is to take a prospective approach to replace some or all of the surface grounds/obstacles and replace with a different set of surfaces. This could enable the analysis of different sensory challenges by older adults in connection with the MSOT. The penultimate consideration is to validate the MSOT in regards to the assessment of the relationship between correlations and standardized measurements such as TUG, Chair Stand Test (CST), or maximum step length test. It is suggested by conducting this assessment; it could assist in the deployment of one measure as opposed to a combination of three measures in future studies relating to this area of interest. Finally, in relation to fall prevention, the MSOT could be utilized to categorize prospective participants as fallers and nonfallers, thus enabling the MSOT to be a prediction tool for falling.

In reference to evidence-based diagnostics [11], the next step will be to conduct a study with a larger sample size to examine several influences: age, sex, physical activity, past falls, exposure to medication, and time of day. Future steps in this research are to execute phases II to IV that aim to determine the diagnostic accuracy and clinical consequences [11]. It is suggested that consecutive standards and reference data in conjunction with a large representative sample size should be recruited and implemented. Thereafter, the risk of older adults for deficits in the mobility and performance in everyday movements could be detected, respectively.

A randomized controlled trial will be conducted to examine the difference between tested and not tested participants. The researchers will consider a variety of setting (retirement homes, nursing homes, sports clubs and gyms) that will enable the MSOT to be evaluated further. It is anticipated that by integrating the MSOT into future studies, the measurement will act as either a prediction or training tool to aid older adults with the management of their daily movements.

There are limitations to this study, which include widening the target groups that could provide greater understanding and contribution to data collection illustrating a more substantial representative data of the population. One final limitation of this study is the participant feedback that was primarily subjective. In future studies, this could be reevaluated and amended accordingly to collect a substantial amount of feedback in conjunction with a student intern observing each participant and recording the execution of the MSOT.

The MSOT has the ability to be employed as a measurement tool to evaluate the affects of gait within an aging cohort via intervention studies. The results could lead to a series of training programs with specific surfaces to enable older adults to perform tasks that in turn, will allow them to progress on to the following programs. It is suggested that by doing this, the MSOT will reduce falls and relevant risk factors.

Conclusions

In conclusion, the integration of multisurfaces and different functional movements from real-life environments experienced by older adults in the form of the MSOT in a single distance track of 10 m was suitable and positive. The time on the MSOT is measurable with high reliability in a target group of untrained, healthy older adults between 60 and 80 years.

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Conflict of interest None.

Appendix

Instructions for the Multisurface Obstacle Test for older adults (MSOT)

"In front of you, you see a yellow marked line followed by a 10 m track. In between this 10 m there are different surfaces and obstacles to walk over (point to the track). Your task will be to complete the track three times. You start with (point to the yellow starting line on the ground) both feet in parallel stance with toes behind the starting line. At the command 'Please gear up for the start of the measurement', you should be ready to start, on the command 'go' you start walk. The velocity you walk should be safe and comfortable and in your habitual gait velocity. There is no other demand how to walk over the different surfaces and obstacles. After 10 m there is another yellow line marked on the ground. Please finish your walk with toes behind this second yellow line again with both feet in parallel stance like in the starting position. After each trial there is a short break, you go back beside the track and gear up for the next trial. The rest interval is 60 s. I will walk slightly behind you, just for safety reasons. Do you have any questions?—so let us start with the first trial."

Fig. 3 Profile of the MSOT

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