Clinical Applicability of Gait Analysis in the Early Detection of Cognitive Decline: A Cross-Sectional Study.

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Research article

Keywords: Gait, dual-tasking, cognition, community-dwelling, older adults.

Posted Date: November 20th, 2020

DOI: <https://doi.org/10.21203/rs.3.rs-107338/v1>

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Abstract

BACKGROUND Although promising results concerning dual-task gait predicting dementia progression in older adults with Mild Cognitive Impairment have been established, the question remains whether this can also be applied to older adults who are not yet suffering from overt cognitive impairments.

Spatiotemporal gait analysis has proven to be valuable and reliable in this context. Nevertheless, these instruments are not common in clinical environments. This study aims to investigate whether easy applicable, inexpensive instruments can be used in the detection of gait alterations associated with early cognitive decrements.

METHODS Eighty-two healthy community-dwelling older adults (age 60-89) with a MMSE ≥ 27 were enrolled in this study. Gait analyses using 10-meter walk test (10MWT) and GAITRite-instrument were performed under single and dual-task conditions. Performance on MMSE, CDT, MoCA, TMT-A, TMT-B, Digit Span Forward and Digit Span Backward were registered. Based on the tertiles of dual-task costs (DTC), subjects were categorized as “poor walkers” or “good walkers”. Comparative and predictive statistical analyses were conducted.

RESULTS During both types of dual-task 10MWT “poor walkers” performed significantly worse on CDT, MMSECDT, TMT-A and Digit Span Backward compared to “good walkers”. Spatiotemporal gait analysis revealed that temporal DTC resulted in poorer performance on MMSE, CDT, MMSECDT and MoCA orientation whereas spatial DTC showed significantly lower scores on MoCA language, TMT-B and Δ TMT for “poor walkers” compared to “good walkers”. The effort it took to perform either the verbal fluency or the arithmetic dual-task during 10MWT predicted TMT-A and Digit Span Backward outcome. Regarding spatiotemporal dual-task gait analysis, performance on MMSE could be predicted by DTC stride velocity and performance on MoCA language could be predicted by DTC step and stride length.

CONCLUSIONS Poor walking abilities can be associated with early cognitive decrements, even in a very early stage when cognitive performance is still more or less intact. Poor walking performance might therefore be considered a clinical precursor or warning signal for beginning cognitive decline. The subtle cognitive and gait decrements can be identified using inexpensive tools, which are easy applicable in all clinical settings.

Trial registration Not applicable

Background

During the past decades, the famous Latin quotation “Mens sana in corpore sano” has been the object of innumerable studies, even to the extent that it has literally been adopted to the titles of a bunch of scientific research papers. At a time of persistent excessive social demands, stress and pressure to achieve, scientists became more than ever persuaded of the existence of an essential interplay between the (dys)function of one’s body and one’s mind (and by extension brains). Therapies and treatments have

been adjusted accordingly. This assumption might even so create opportunities for early risk detection of mental or cognitive disorders in case of physical dysfunctions, or vice versa.

The use of dual-task paradigms has contributed a lot to the comprehension of human information processing and the cognitive-motor interrelationships. As such, it has been superseded that gait is a purely automated motor activity [1–3]. Nowadays, there is a general consensus that gait relies on higher-level cognitive input [4]. Although there is some evidence that impaired executive functions may actually contribute to gait alterations [5], cause and effect has not been definitively demonstrated [1]. Together with the fact that an altered gait pattern involves an increased risk of falling, this obscurity has inspired many researchers to compare cognitively healthy older adults with cognitively impaired older adults and assess the differences in gait and fall incidence in an attempt to identify high risk populations for falling. Indeed, older adults suffering from Mild Cognitive Impairment (MCI) [6–11] and dementia [6, 12–19] have been associated with hampered gait patterns and increased fall risks.

Oppositely, Verghese et al. was one of the first researchers to demonstrate that quantitative gait parameters can predict the development of dementia, in initially non-demented older adults [20, 21]. These findings were later corroborated by several researchers [22–27]. More than 10 years later, Verghese introduced a term “Motor Cognitive Risk Syndrome” which is characterized by a slow walking speed and subjective cognitive impairment and provides a clinical approach to identify individuals at high risk for dementia [28]. Recently, Montero-Odasso et al. conducted a study with the promising result that dual-task gait test may predict dementia progression in older adults with MCI [22]. However, Darweesh et al. commented that the question remains as to whether dual-task gait also predicts dementia among older individuals who do not yet have overt cognitive impairment [29]. In terms of optimal and early (preventive) interventional strategies, early detection of any clinical signs announcing or indicating beginning cognitive decline is crucial. At this preclinical stage, less advanced and low-cost treatments can indeed easily be implemented. Furthermore, the cognitively asymptomatic individual will have sufficient cognitive abilities to understand and adequately execute training instructions. For the abovementioned reasons a cohort of healthy older adults without cognitive complaints seems an interesting and important target population.

Although sophisticated spatiotemporal gait analysis has been proven to be very sensitive and valuable in experimental settings such as academic research laboratories, these instruments are not common in clinical environments. This study therefore aims to investigate whether easy applicable, inexpensive instruments can be used in the detection of gait alterations in association with early cognitive decrements in healthy older adults.

Methods

Participants

Eighty-two community-dwelling older adults (age 60–89) were enrolled in this study. Participants were recruited through online advertising, flyer distribution and by word of mouth. Older adults with a Mini-Mental State Examination (MMSE) score < 27 or indicating cognitive complaints were excluded since they do not belong to the population of interest of the current study. Also, major neurological or orthopedic disorders likely to directly impact gait, were not eligible. Older adults who were not able to walk independently with or without walking aids were excluded as well. This study was approved by the Ethical Committee of the Ghent University Hospital. Informed written consent was obtained from all participants.

Gait analyses

Spatiotemporal gait analysis was performed using the portable and reliable electronic GAITRite® walkway system (8.3 m x 0.89 m; CIR Systems Inc., Havertown, PA, USA) [30]. All subjects completed (i) one single task at a self-selected normal walking speed and two dual-task conditions: (ii) normal walking while enumerating animal names (verbal fluency task) and (iii) normal walking while counting aloud backwards by 3's from 100 (arithmetic task). The three walking conditions were offered in a randomized order.

Bearing in mind its clinical practice, gait analysis was also performed in a more simple and inexpensive way. Whilst walking under the three conditions described above, time was registered over a distance of 10 meters (10-meter walk test, 10MWT). To eliminate acceleration and deceleration times, subjects started and ended walking 2 meter before and after the actual 10 meters distance. Walking speed was calculated by dividing 10 (meters) by the time registered.

Neuropsychological Assessment Battery

In order to gain more insight in the participants' cognitive status, several neuropsychological screenings were administered. Besides the well-known valid and valuable MMSE [31], Clock Drawing Test (CDT) was conducted as complementary assessment. CDT was scored on the four most reliable and practically useful items as proposed by Thalmann et al. [32]. The scores of the MMSE and CDT (maximum 30 and 7 respectively) were also combined to a single score (MMSECDT) with a maximum of 9 [32]. The Montreal Cognitive Assessment (MoCA) is a cognitive screening instrument that has been developed to screen patients who present with mild cognitive complaints, usually performing in the normal range on the MMSE [33]. Similar to the MMSE, it is scored out of 30 points, with higher scores reflecting better performance. Cognitive abilities that are examined by the MoCA are: visuospatial/executive function, naming, episodic memory, attention, language, abstraction, and orientation. In order to compensate for educational effects, Nasreddine et al. determined that one point should be added to the total MoCA score for individuals with ≤ 12 years of formal education [33]. Executive functioning, cognitive flexibility and working memory were assessed by the Trail Making Test (TMT) [34]. In part A (TMT-A) the subject has to connect the randomly spread numbers from 1 to 25 in consecutive ascending order. In part B (TMT-B) alternating connection between randomly spread numbers (1 to 13) and letters (A to L) has to be made. Participants were instructed to complete each part of the TMT as quickly and accurately as possible. In case of an error, the investigator immediately pointed it so that the subject could correct it and complete

the test without errors (but at the expense of additional time) [35]. Time to complete TMT-A and TMT-B was recorded and represented their respective scores. The calculation of Delta-TMT (TMT-B – TMT-A) removes the potential bias due to the upper extremity motor speed element [35, 36] and is suggested to be a more accurate measure of executive functioning than performance on TMT-B [37]. Finally, working memory was also assessed by use of the Digit Span Test. During the Digit Span Forward, the examiner enumerates digits which need to be recalled in the same order by the subjects. In the Digit Span Backward, series of digits have to be recalled by the subject in reverse order. The length of the series increases each time by one digit (respectively up to 9 and 8 digits). The test ends when the subject is not able to correctly recall the span in two consecutive attempts. The number of the longest span of correctly reproduced numbers represents the score of the tests.

All questionnaires or measures described above are freely available and no license is required in order to administer them.

Statistical Analysis and calculations

All data were analyzed using SPSS version 26 for Windows (Statistical Package for the Social Sciences Inc., Chicago, IL, USA) and statistical significance was assumed at $p < .05$. Descriptive statistics were used to summarize the characteristics of the subjects.

As we were particularly interested in the extra effort induced by the dual-tasks, dual-task costs (DTC) of walking speed (10MWT), stride velocity, step time, step length, stride time and stride length were calculated as follows [38, 39]:

$$DTC = \left(1 - \frac{\text{dual-task spatiotemporal gait parameter}}{\text{single task spatiotemporal gait parameter}} \right)$$

Based on the tertiles of the DTC's, subjects were categorized as 'poor walkers' (highest DTC tertile) or 'good walkers' (lowest DTC tertile). Subjects who ended up as 'intermediate walkers' (mid DTC tertile) were not used for comparative statistical analysis since we assumed that mediocre gait characteristics in this homogeneous healthy population would not be sensitive enough to reveal significant correlations with neuropsychological performance. Comparison of neuropsychological scores between 'poor walkers' and 'good walkers' was performed by the t-test for independent samples. However, if normality assumption was not fulfilled or Levene's test for equal variances was not assumed, the non-parametric Mann-Whitney U test was used.

Separate linear regressions were used to test the cross-sectional association between dual-task gait costs as independent variables and neuropsychological outcomes as dependent variables. The DTC gait parameters and the associated neuropsychological tests from Tables 2 and 3 were entered in the regression models.

Results

Subject characteristics

Characterization of the study population and mean neuropsychological outcomes are shown in Table 1. Mean age of the cohort was 71.1 years old and 40.2% were women. Lower education level was defined as ≤ 12 years of formal education.

As we were interested in the potentially different impact of the two types of dual-task (verbal fluency versus arithmetic), DTC's of the spatiotemporal gait parameters for both dual-tasks were calculated as explained earlier.

Comparative results for verbal fluency DTC

Categorization based on the DTC tertiles for the animal naming task resulted in significant different cognitive abilities when considering the walking speed DTC categorization of the 10MWT. Scores of CDT, MMSECDT, TMT-A and Digit Span Backward were significantly worse in “poor walkers” compared to “good walkers” (Table 2).

Comparative results for arithmetic DTC

Categorization based on the DTC tertiles of several spatiotemporal parameters for the serial subtraction task resulted in significantly different cognitive performance on some neuropsychological tests. 10MWT and spatiotemporal gait analysis revealed that ‘poor walkers’ (highest dual-task cost) significantly performed worse ($p \leq .05$) on MMSE, CDT, MMSECDT, TMT-A, TMT-B, Delta TMT and some MoCA subscores (Table 3).

In order to ensure readability of Tables 2 and 3, it was opted only to include those neuropsychological test results that revealed significantly different scores between poor and good walkers.

Predictive value of DTC

To evaluate the potential predictive value of dual-task gait costs on neuropsychological outcomes, simple linear regression models were calculated for the entire study population.

The effort it took to perform the verbal fluency dual-task during 10MWT predicted TMT-A and Digit Span Backward outcome. Dual-task gait cost (verbal fluency DTC) predicted TMT-A results with a significant linear regression equation ($F(1, 71) = 5.417, p = .023$), with an R^2 of .071. As for Digit Span Backward performance, a significant regression equation was found ($F(1, 71) = 5.662, p = .020$), with an R^2 of .074. As for the other type of dual-task, simple linear regression equation revealed that dual-task gait cost (arithmetic DTC) during 10MWT could similarly predict TMT-A performance [$F(1, 71) = 8.431, p = .005$], with an R^2 of .106] and Digit Span Backward outcome [$F(1, 71) = 5.656, p = .020$], with an R^2 of .074]. Performance on CDT, MMSECDT and MoCA could not be predicted by DTC on 10MWT (regardless of the type of dual-task cost) since significance level of linear regression models was not reached for these neuropsychological test results.

Regarding spatiotemporal dual-task gait analysis, especially the arithmetic DTC's for *spatial* gait parameters were found to have a predictive value to neuropsychological performance. MMSE could be predicted by DTC Stride Velocity since a significant regression equation was found ($F(1,76) = 6.033$, $p = .016$), with an R^2 of .074. DTC for step length predicted MoCA language [$F(1, 76) = 13.340$, $p < .001$], with an R^2 of .149], TMT-B [$F(1,68) = 7.598$, $p = .007$], with an R^2 of .101] and Δ TMT [$F(1,68) = 7.048$, $p = .010$], with an R^2 of .094]. Similarly, DTC for stride length predicted MoCA language [$F(1, 76) = 13.850$, $p < .001$], with an R^2 of .154], TMT-B [$F(1,68) = 7.377$, $p = .008$], with an R^2 of .098] and Δ TMT [$F(1,68) = 6.811$, $p = .011$], with an R^2 of .091].

Discussion

The results of this study suggest that poor walking abilities (based on high dual-task costs) can be associated with cognitive decrements, even in a very early stage when cognitive performance is still more or less intact. Apparently, these subtle cognitive decrements can be identified using inexpensive and time-saving gait analysis, applicable in all clinical settings. The *10-meter walk test* appears to be a valuable instrument to discriminate between older adults with and without early onset in cognitive decline. The dual-task cost for both types of dual-tasks resulted in significantly different scores for CDT, MMSECDT, TMT-A and Digit Span Backward between poor and good walkers. Arithmetic dual-task cost could additionally discriminate performance on MoCA and the visuospatial/executive MoCA-subitem between poor and good walkers. Dual-task gait speed has recently been proven not to be a sensitive predictor of cognitive decline in healthy community-dwelling older adults [40]. However, the extra effort of dual- versus single task gait performance might be a more meaningful measure to use in this context.

Interestingly, *spatiotemporal gait analysis* using the GAITRite electronic walkway only revealed significant differences in cognitive performance when the most challenging dual-task (serial subtraction by threes) was performed. Since more demanding cognitive dual-tasks have been proven to induce higher dual-task costs [41], this may have resulted in stronger categorization in this trial. Besides, verbal fluency mainly depends on semantic memory, whereas backward counting relies on the working memory. As both ambulation and arithmetic dual-tasking rely on the working memory, the increased competitive interaction with executive functions might explain this finding. Still, it is remarkable that categorization based on the 10MWT DTC's for verbal fluency did yield significantly different cognitive performances. Gait velocity has repeatedly been proven to be a sensitive gait parameter for numerous outcomes [42, 43]. The poorer cognitive outcomes for the poor walkers were also seen for GAITRite measured stride velocity DTC for verbal fluency, although it lacked statistical significance. The finding that the 10MWT seemed to be more sensitive, might be attributed to the longer walking distance, eventually producing more reliable and stable gait patterns. Also, it might be expected that a larger sample size would result in significant neuropsychological differences for spatiotemporal gait verbal fluency DTC's as well.

MoCA focuses on executive functions (working memory) and is therefore known to be a more sensitive instrument for identifying MCI than MMSE [44]. The fact that MoCA test results can cautiously be interpreted as a measure of working memory while backward counting also relies on (the same) working

memory, might explain why some MoCA subitems appear to be significantly different when poor and good walkers were identified based on arithmetic DTC and not when they were identified based on verbal fluency DTC. Interestingly, categorization based on DTC of *spatial* gait parameters (step length and stride length) results in significant differences in TMT-B, Delta TMT (assessing cognitive flexibility) and the MoCA-language subscore, whereas categorization based on DTC of *temporal* gait parameters (stride velocity, step time and stride time) yields significant differences in MMSE, CDT, MMSECDT and the MoCA-orientation subscore. Neuropsychological test results of poor and good walkers based on DTC-tertiles of *temporal* gait parameters are very analogous or even identical. Similarly, neuropsychological outcomes for poor and good walkers based on DTC-tertiles of *spatial* gait parameters are very comparable. Since the concerning gait parameters are closely related to each other, calculation of upper and lower tertiles will probably have generated the same subjects in the spatial or temporal gait related “poor” and “good” walker categories, which might explain this finding.

The orientation subitem of the MoCA test is also implemented in MMSE, which may explain that these neuropsychological test scores appear together in statistical analysis. Executive functions are known to play a critical role in gait regulation, especially when dual-task paradigms are introduced [1, 34, 45, 46]. Dual-task gait abilities are even considered to be functional measures of executive functions [47]. Therefore, it might be surprising that distinctions based on dual-task costs could be made not only for TMT and CDT (measuring executive functions) but also for MMSE. However, some executive functions are important to memory implying that executive functions and memory are often not selectively impaired [48]. Besides, dual-task cost has previously been associated with episodic memory performance, confirming that other cognitive domains beyond executive function are involved in gait performance [41, 49–51]. This could contribute to the explanation of the finding that for spatiotemporal gait analysis not only tests specifically investigating executive functions and working memory but also tests more focusing on cognition and memory (like MMSE) are significantly worse when dual-task costs are higher.

Regardless of the type of dual-task, the dual-task cost of 10MWT is able to predict performance on TMT-A and Digit Span Backward (both assessing attention, executive functioning and working memory) in a statistically significant way. As for prediction based on spatiotemporal gait analysis the arithmetic dual-task cost for stride velocity, step length and stride length was respectively able to predict performance on MMSE; MoCA-language; MoCA-language, TMT-B and delta TMT. The largest predictive value could be identified for MoCA-language subscore. Although the predictive values are rather poor, dual-task gait analysis seems to be a promising instrument in predicting early cognitive decrements.

As rightly commented by Darweesh et al. [29] most research in this area is targeting on a population that is known to be prone to develop dementia (i.e. MCI). However, similar to any pathological condition or disease, the preclinical stages of cognitive deterioration are critical and most susceptible for early treatment or intervention strategies. These preclinical stages are characterized by executive dysfunction and working memory impairments [52]. Considering that these disturbances are very subtle in this period, the older individual generally is not aware of them since no discomfort during daily life activities is noticed. When the older adult does experience changes in daily functioning, the cognitive decline might

already be drifted towards a more severe condition, requiring more advanced, expensive and challenging intervention strategies. For this study, we therefore deliberately opted to select a healthy older population not suffering from any subjective cognitive malfunction. For the same reason, clinicians should be encouraged to invest in systematic screening of neuropsychological functioning and walking abilities in the older adult, even if the latter does not experience functional problems so far. In practical terms, older individuals presenting with a poor performance on both neuropsychological screening and walking ability (high dual-task cost), as illustrated by the circular mark in Fig. 1, are suggested to be referred for further investigation as they are expected to be at risk for conversion towards more severe cognitive dysfunctioning.

The findings in this report are subject to some potential methodological weaknesses. Although eighty-two older adults were enrolled, only upper and lower tertiles were used for categorization into “poor” and “good walkers”, resulting in rather small groups to compare. However, for predictive analyses the entire sample was considered. Secondly, due to the non-prospective character of the study, it is impossible to conclude that the ‘poor walking’ subjects, associated with poorer neuropsychological performance, will actually develop cognitive disorders. Executive functions and attentional systems have been associated with prefrontal areas which undergo some structural brain changes during *normal* ageing [35, 53, 54]. The finding that higher dual-task costs represent poorer neuropsychological performance might therefore be not surprising and considered as normal or ‘non-pathological’. However, it is generally accepted that healthy older adults exhibit some ‘normal’ strategies in response to dual-tasking, without widespread changes in the gait pattern [1]. We therefore consciously made categorizations based on several spatiotemporal gait parameters in this study, which all resulted in significantly worse neuropsychological performance. The subtle cognitive decrements of the poor walkers might thus be expected to be precursors of further cognitive deterioration, rather than to be ascribed to normal ageing.

Still, prospective study designs are needed to confirm this suggestion. Besides, it would be interesting to prospectively assess fall incidence within the identified categories based on walking and neuropsychological performances. For future research, it might be recommended to perform brain imaging (fMRI) to identify eventual changes in brain structure rather than using screening instruments only, since deviations in imaging might be determined earlier than its clinical manifestations that can be registered by screening instruments. However, in terms of implementation in clinical practice, it can be considered an advantage that simple neuropsychological screening instruments seem to be valuable alternatives that can be used in this context. Finally, in order to confirm and consolidate the results of this study, we agree with Darweesh et al. [29] that future research should definitely focus on older adults without overt cognitive disabilities, rather than on older adults suffering from MCI (which is known to be a precursor for dementia development).

Conclusion

The aim of the current study was to investigate whether poor clinical walking abilities could be associated with early cognitive decrements in older adults without known cognitive complaints. This

research shows indeed that the effort it takes to complete a cognitive dual-task while walking, can be related to early cognitive decrements in healthy older adults. Poor walking ability might thus be considered a clinical precursor or warning signal for beginning cognitive decline. Backward counting appeared to be the most sensitive type of dual-task in signaling subtle cognitive decrements. Neuropsychological instruments, especially those assessing executive functioning and working memory, seem to be sensitive in case of high dual-task gait costs. To our knowledge, this is one of the few studies demonstrating that high dual-task gait costs can be related to early cognitive decrements, even in a healthy older population without overt cognitive impairment. Furthermore, this study shows that both cognitive and gait alterations are valuable when measured with inexpensive tools, which are easily applicable in all clinical settings. These findings therefore suggest a potential role for clinicians in early detection strategies which are of utmost importance in the early initiation of interventional approaches to monitor eventual further cognitive deterioration in older adults. After all, individuals have a huge potential to reduce their dementia risk, even in later life [55].

List Of Abbreviations

MCI, Mild Cognitive Impairment; MMSE, Mini-Mental State Examination; 10MWT, 10-meter walk test; CDT, Clock Drawing Test; MMSECDT, combined score of MMSE and CDT; MoCA, Montreal Cognitive Assessment; TMT, Trail Making Test; TMT-A, Trail Making Test part A; TMT-B, Trail Making Test part B; DTC, Dual-Task Cost; BMI, Body Mass Index.

Declarations

Ethics approval and consent to participate

The study protocol was approved by the Ethical Committee of the Ghent University Hospital and all participants signed an informed consent.

Consent for publication

Not applicable.

Availability of data and materials

The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

Funding

This study was funded by the Special Research Fund, Bijzonder Onderzoeks Fonds (BOF), of the Ghent University [05v00608]. This grant had no role in study design, data collection, data analysis, data interpretation, or writing of the manuscript.

Authors' contributions

DC and TRdM had the study idea. TRdM collected, analyzed and interpreted the data and was the major contributor in writing the manuscript. PD and DC interpreted the results and substantively revised the manuscript. All authors read and approved the final manuscript.

Acknowledgements

Not Applicable.

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Tables

Table 1
Clinical characteristics of the subjects and neuropsychological outcomes

	Healthy older adults (N = 82)
Age (<i>yrs</i>)	71.1 ± 7.4
Male : Female (%)	40.2 : 59.8
BMI	27.2 ± 3.8
≥ 1 fall past year (%)	30.5
Lower education level (%)	53.1
MoCA [max 30]	25.93 ± 2.52
Visuospatial/executive [max 5]	4.19 ± 0.94
Naming [max 3]	2.90 ± 0.34
Attention [max 6]	5.64 ± 0.68
Language [max 3]	2.32 ± 0.83
Abstraction [max 2]	1.52 ± 0.50
Delayed Recall [max 5]	2.99 ± 1.27
Orientation [max 6]	5.84 ± 0.46
MMSE [max 30]	28.96 ± 0.99
CDT [max 7]	6.51 ± 1.07
MMSECDT [max 9]	8.72 ± 0.62
TMT-A (<i>s</i>)	43.55 ± 16.99
TMT-B (<i>s</i>)	110.38 ± 60.61
Delta TMT	66.82 ± 49.11
Digit Span Forward	5.42 ± 0.82
Digit Span Backward	3.97 ± 0.87
BMI, Body Mass Index; MoCA, Montreal Cognitive Assessment; MMSE, Mini-Mental State Examinations; CDT, Clock Drawing Test; MMSECDT, combined score MMSE and CDT; TMT-A, Trail Making Test Part A; TMT-B, Trail Making Test Part B; Δ TMT, TMT-B – TMT-A.	

Table 2

Poor walkers (based on verbal fluency DTC for 10MWT) show subtle though significantly worse cognitive performances.

	poor walker	good walker	<i>p-value</i>
DTC 10MWT	6.17 ± 1.31	6.83 ± 0.82	.009
CDT	8.58 ± 0.65	8.92 ± 0.41	.009
MMSECDT	52.16 ± 21.64	39.44 ± 14.09	.043
TMT-A (<i>s</i>)	3.54 ± 0.72	4.25 ± 0.90	.004
Digit Span Backward			
DTC, Dual-Task Cost; 10MWT, 10-meters walk test; CDT, Clock Drawing Test; MMSECDT, combined score Mini-Mental State Examination and CDT; TMT-A, Trail Making Test Part A.			

Table 3
Poor walkers (based on arithmetic DTC's) show subtle though significantly worse cognitive performances.

	poor walker	good walker	<i>p-value</i>
DTC 10MWT			
CDT	5.96 ± 1.40	6.85 ± 0.53	.004
MMSECDT	8.37 ± 0.84	8.93 ± 0.27	.002
MoCA	24.78 ± 3.19	26.41 ± 1.95	.041
MoCA visuospatial/ executive	3.81 ± 1.11	4.41 ± 0.75	.025
TMT-A (<i>s</i>)	51.83 ± 19.42	38.47 ± 12.44	.014
Digit Span Backward	3.67 ± 0.70	4.17 ± 0.96	.046
DTC Stride Velocity	28.54 ± 1.27	29.36 ± 0.81	.015
MMSE	6.31 ± 1.12	6.84 ± 0.55	.040
CDT	8.54 ± 0.76	8.92 ± 0.28	.020
MMSECDT			
MoCA orientation	5.65 ± 0.69	5.96 ± 0.20	.025
DTC Step Time	28.54 ± 1.27	29.36 ± 0.81	.015
MMSE	6.38 ± 1.10	6.84 ± 0.80	.033
CDT	8.58 ± 0.76	8.92 ± 0.40	.016
MMSECDT			
MoCA orientation	5.69 ± 0.68	5.96 ± 0.20	.049
DTC Step Length	2.00 ± 0.94	2.69 ± 0.47	.005
MoCA language	124.86 ± 76.27	87.22 ± 25.77	.016
TMT-B (<i>s</i>)	77.37 ± 63.72	48.77 ± 18.79	.018
Δ TMT (<i>s</i>)			
DTC Stride Time			
MMSE	28.54 ± 1.27	29.36 ± 0.81	.015

DTC, Dual-Task Cost; 10MWT, 10-meter walk test; MMSE, Mini-Mental State Examinations; CDT, Clock Drawing Test; MMSECDT, combined score MMSE and CDT; TMT-A, Trail Making Test Part A; TMT-B, Trail Making Test Part B; Δ TMT, TMT-B – TMT-A.

	poor walker	good walker	<i>p-value</i>
CDT	6.38 ± 1.10	6.84 ± 0.80	.033
MMSECDT	8.58 ± 0.76	8.92 ± 0.40	.016
MoCA orientation	5.69 ± 0.68	5.96 ± 0.20	.049
DTC Stride Length			
MoCA language	2.04 ± 0.96	2.69 ± 0.47	.010
TMT-B (<i>s</i>)	124.50 ± 76.47	88.01 ± 26.05	.026
Δ TMT (<i>s</i>)	76.44 ± 64.22	48.97 ± 19.18	.038
DTC, Dual-Task Cost; 10MWT, 10-meter walk test; MMSE, Mini-Mental State Examinations; CDT, Clock Drawing Test; MMSECDT, combined score MMSE and CDT; TMT-A, Trail Making Test Part A; TMT-B, Trail Making Test Part B; Δ TMT, TMT-B – TMT-A.			

Figures

Figure 1

Black boxplots represent categorization based on verbal fluency DTC; grey boxplots represent categorization based on arithmetic DTC. Circular mark represents individuals likely to be at risk for further cognitive decline.

Figure 1

Black boxplots represent categorization based on verbal fluency DTC; grey boxplots represent categorization based on arithmetic DTC. Circular mark represents individuals likely to be at risk for further cognitive decline.