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Validity, test-retest reliability, sensitivity to change and feasibility of motor-cognitive dual task assessments in patients with dementia

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ABSTRACT

Objective: To investigate validity, test-retest reliability, sensitivity to change, and feasibility of dual task (DT) assessments in patients with dementia.
Design: Validation study.
Setting: Post ward-rehabilitation.
Participants: Geriatric patients (n = 105) with dementia (age 82.7 ± 5.9, MMSE score 21.9).
Main outcome measures: Psychometric quality of DT performance of different DT-tests. Analyses were performed for motor and cognitive performance, and relative DT costs (DTCs).
Results: Spearman's rank correlations (r_s) between examined DT-tests were moderate-high for motor tasks (r_s = 0.29–0.90), small-high for cognitive tasks (r_s = 0.12–0.55) and small-high for relative DTCs (motor DTCs r_s = 0.02-0.61, cognitive DTCs r_s = −0.19 to 0.06, combined DTCs r_s = −0.11 to 0.31). Correlations with external assessment were moderate-high for motor tasks (r_s = 0.25–0.84), small-moderate for cognitive tasks (r_s = −0.10 to 0.46) and small-moderate for relative DTCs (motor DTCs r_s = −0.09 to 0.17, cognitive DTCs r_s = −0.03 to 0.21, combined DTCs r_s = −0.07 to 0.26).
Test-retest reliability was excellent for motor tasks (ICC = 0.75–0.96), fair-excellent for cognitive tasks (ICC = 0.51–0.88) and poor-good for relative DTCs (motor DTCs ICC = 0.10–0.74, cognitive DTCs ICC = 0.05–0.65, combined DTCs ICC = 0.15–0.71).
Sensitivity to change was acceptable-excellent for trained DT-tests ($p \leq 0.01$). Effect sizes were small-large for gait parameters (SRM = 0.30–1.12), large for cognitive tasks (SRM = 0.82–0.95) and small-large for relative DTCs (motor DTCs SRM = 0.15–0.77, cognitive DTCs SRM = 0.56-0.98, combined DTCs SRM = 0.40–1.10).
Completion time ranged from 13.1 to 16.9 min.
Conclusions: All DT-tests showed acceptable-excellent psychometric properties in patients with dementia with highest quality for the gait-based tests 'Walking & Counting' and 'Walking & reciting ABC'.
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1. Introduction

The ability to perform multiple tasks simultaneously (dual tasking = DT) decreases with age and is severely impaired in dementia (Baddeley, Bressi, Della Sala, Logie, & Spinnler, 1991; Della Sala, Baddeley, Papagn, & Spinnler, 1995; Verghese et al., 2002) because of limited attentional resources and constrictions in executive functions (EF) (Perry & Hodges, 1999). Deficits in attention-related DT performances show a faster decline compared to the loss of basic functional performances (Baddeley et al., 1991; Sala & Logie, 2001) in patients with dementia and are strongly related to motor dysfunctions (Beauchet et al., 2009). This reveals that DT deficits are sensitive and specific indicators for cognitive decline with the potential to be a diagnostic tool and to evaluate the effectiveness of intervention strategies (Baddeley et al., 1991;

Abbreviations: AD, Alzheimer's disease; CERAD, Consortium to Establish a Registry for Alzheimer's Disease; CG, control group; CI, confidence interval; CIRS, Cumulative Illness Rating Scale; cm, centimeter; EF, executive functions; DT, dual task; DTC, dual task costs; GDS, Geriatric Depression Scale; ICC, Intra-Class Correlation Coefficient; IG, intervention group; min., minutes; MMSE, Mini-Mental State Examination; NAI, Nürnberger-Alters-Inventar; N, Newton; OR, odds ratio; POMA, Performance Orientated Mobility Assessment; s, seconds; SF-12, short form (12); ST, single task; TUG, Timed up and Go-test; WWT, walking while talking; ZN-G, Zahlen-Nachsprechen-G (Repeating-Number-Test); ZVT-G, Zahlen-Verbindungs-Test-G (age-adjusted Trail Making Test).

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Muir et al., 2012; Sala & Logie, 2001). Despite this, no methodological gold standard has been established to assess DT deficits.

Frequently used DT combinations have been walking while performing a simultaneous cognitive task [e.g. walking while talking (Lundin-Olsson, Nyberg, & Gustafson, 1997), walking and an arithmetic task (Beauchet et al., 2007, 2008a, 2008b, 2011; Gimmon, Jacob, Lenoble-Hoskovec, Büla, & Melzer, 2013; Hartmann, Murer, De Bie, & De Bruin, 2009; Hofheinz & Schusterschitz, 2010; Muhaidat, Kerr, Evans, & Skelton, 2013a; McCulloch, Mercer, Giuliani, & Marshall, 2009; Montero-Odasso et al., 2009; Muhaidat, Kerr, Evans, & Skelton, 2013b; Muhaidat, Kerr, Evans, Pilling, & Skelton, 2014; Nordin, Moe-Nilssen, Ramnemark, & Lundin-Olsson, 2010; Schwenk, Zieschang, Oster, & Hauer, 2010; Sheridan, Solomont, Kowall, & Hausdorff, 2003; Shumway-Cook, Brauer, & Woollacott, 2000; Tang, Yang, Peng, & Chen, 2015; Yamada et al., 2011; Yang, He, & Pang, 2016; Yogev et al., 2005), walking with a visuo-spatial working memory task (Schott, 2015), or walking with a verbal fluency (VF) task (Beauchet, Dubost, Gonthier, & Kressig, 2005; Camicioli, Oken, Sexton, Kaye, & Nutt, 1998; Gimmon et al., 2013; Hollman et al., 2010; Liu-Ambrose, Katarynych, Ashe, Nagamatsu, & Hsu, 2009; McCulloch, Shubert, & Giuliani, 2006; McCulloch et al., 2009; Muhaidat et al., 2013a, 2013b, 2014; Nordin et al., 2010; Verghese et al., 2002; Yang et al., 2016)] or postural control combined with cognitive tasks (Condron and Hill, 2002; Hauer et al., 2003; Makizako et al., 2010; Melzer, Shtilman, Rosenblatt, & Oddsson, 2007; Moghadam et al., 2011; Swanenburg, De Bruin, Favero, Uebelhart, & Mulder, 2008; Swanenburg, De Bruin, Uebelhart, & Mulder, 2010; Szturm et al., 2015). Combinations with other motor tasks, although rarely used, showed high discriminative validity (e.g. arithmetic task with maximal strength; Hauer, Marburger, & Oster, 2002), and hold option to test less automated motor performances.

While a large number of DT assessment tools are available, examining their psychometric properties is essential. Adequate validity and reliability are necessary for the evaluation of patients' performance. Responsiveness of a measurement tool is required for detecting changes in DT performance over the time and for assessing intervention effectiveness (Ashford, Slade, Malaprade, & Turner-Stokes, 2008).

So far, the mentioned studies focused on validity [predictive validity (Beauchet et al., 2007, 2008a, 2008b; Makizako et al., 2010; Muhaidat et al., 2014; Nordin et al., 2010; Schott, 2015; Shumway-Cook et al., 2000; Swanenburg et al., 2010; Tang et al., 2015; Verghese et al., 2002; Yamada et al., 2011; Yang et al., 2016), construct validity (McCulloch et al., 2009; Szturm et al., 2015), concurrent validity (Condron & Hill, 2002; Gimmon et al., 2013; Yang et al., 2016), convergent validity (Gimmon et al., 2013; Hofheinz & Schusterschitz, 2010; Liu-Ambrose et al., 2009; Schott, 2015)] and test-retest reliability (Beauchet et al., 2011; Condron & Hill, 2002; Gimmon et al., 2013; Hartmann et al., 2009; Hofheinz & Schusterschitz, 2010; Hollman et al., 2010; Makizako et al., 2010; McCulloch et al., 2009; Melzer et al., 2007; Moghadam et al., 2011; Montero-Odasso et al., 2009; Muhaidat et al., 2013a; Shumway-Cook et al., 2000; Swanenburg et al., 2008; Szturm et al., 2015; Tang et al., 2015; Yang et al., 2016). Only two studies examined feasibility (McCulloch et al., 2006; Muhaidat et al., 2013b) and none investigated responsiveness.

Except for some studies (McCulloch et al., 2009; Muhaidat et al., 2013a, 2013b, 2014; Nordin et al., 2010; Schott, 2015; Yang et al., 2016), investigations only analyzed psychometric properties of the outcomes derived from the motor but not of the cognitive tasks (Yang, Liao, Lam, He, & Pang, 2015). Outcome measures were declared for single task (ST) and DT conditions but rarely for relative DT costs [DTCs, (McCulloch et al., 2009; Muhaidat et al., 2013a, 2013b, 2014; Nordin et al., 2010; Schott, 2015; Yang et al., 2016)] which is recommended for DT performance, because it considers differences in baseline ST performance and provides a measure of actual DT changes (Muhaidat et al., 2013a; Riby, Perfect, & Stollery, 2004).

Validation studies predominantly included community-dwelling healthy elderly and excluded patients with cognitive impairments. A possible reason for excluding patients with dementia could be the challenge in testing because of impairments in cognitive and motor-functional domains (Boyle, Cohen, Paul, Moser, & Gordon, 2002) as well as behavioral and psychological symptoms (Aalten et al., 2007), that could have strong influence on test performance (Hauer & Oster, 2008).

Only two studies examined test-retest reliability of quantitative gait variables under DT in older adults with a diagnosis of mild cognitive impairment (diagnosis cp. Petersen et al., 1999) but excluded patients with diagnosed dementia (Montero-Odasso et al., 2009) and test-retest reliability of stride time variability while DT in patients with frontotemporal dementia (Beauchet et al., 2011). But no validation study has been comprehensively investigated DT assessments in patients with dementia.

In summary, common DT assessment strategies in older adults are insufficiently evaluated for comprehensive biometrical quality and for comparison between different tests. No previous study has performed validation of DT assessment in patients with dementia. Therefore, the aim of this study was to assess construct validity respectively convergent validity, test-retest reliability, sensitivity to change, and feasibility of different DT-tests and to compare those tests in people with dementia.

2. Materials and methods

2.1. Study design and participants

Validation study was part of a randomized controlled intervention trial (RCT) to improve motor-cognitive performance in geriatric people with dementia. The RCT was performed according to the Helsinki declaration and the study protocol was approved by the ethics committee of the University of Heidelberg.

Participants were recruited consecutively at a geriatric rehabilitation ward, from nursing homes and community-dwelling persons. Predefined inclusion criteria were: age >65 years; no severe cardiovascular, neurological (e.g. Parkinson's disease) or psychological disease; ability to walk 10 m without a walking aid; residence within 15 kilometers of the study center and written informed consent. Only a small percentage of the participants had legal representatives. In those cases for the written informed consent legal representatives were included in the ethical consent procedure.

Eligible participants were screened for cognitive function using the Mini-Mental State Examination (MMSE; Folstein, Folstein, & McHugh, 1975). In those with a MMSE score of 17–26 a comprehensive neuropsychological assessment was applied based on an established neuropsychological test battery (Consortium to Establish a Registry for Alzheimer's Disease [CERAD]; Morris, Mohs, Rogers, Fillenbaum, & Heyman, 1988), a modified, age-adjusted Trail Making Test (ZVT-G; Oswald & Fleischmann, 1997), and a digit-span test (ZN-G; Oswald & Fleischmann, 1997). Only individuals meeting internationally established CERAD criteria for probable dementia (cognitive performances in CERAD subtests in lower 10% percentile of the sample corresponding to a z-value of −1.3, cf. Barth, Schönknecht, Pantel, & Schröder, 2005; Fisseni, 1990) were included in the study.

2.2. Measurements

2.2.1. Participant characteristics

Demographic and clinical characteristics of participants including age, gender, years of educational and professional training,

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