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Assessment of the Dynamic Gait Index with and without Cognitive Load in Elderly Non-fallers

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Abstract

Aims: Most of the rehabilitation assessments concentrate on a unidimensional approach which focuses on challenging and measuring either the executive function (cognitive) components of the task or on its motor components of fallers. This study aimed to assess dynamic balance tasks with and without cognitively load in elderly non-fallers.

Methods: Totally 30 elderly participants with age of 65.57 ± 4.00 were included in the study. Non fallers were be screened with the help of Timed Up and Go – Cognitive test. After the screening, dynamic balance was assessed using Dynamic Gait Index on two consecutive days, without and with cognitive task. The Cognitive load was given by Controlled Oral Word Association Test.

Results: The results showed that there was significant difference ($p<0.01$) with the scores of dynamic gait index with cognitive load.

Conclusion: The dynamic balance will be significantly affected when elderly non-fallers are cognitively loaded.

Keywords: Fallers; Non-fallers; Cognitive Load; Dynamic Balance; Dynamic Gait Index

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Introduction

Ageing is a dynamic, progressive, and physiological process accompanied by functional, morphological, biochemical, and psychological changes. As India is undergoing a demographic shift, with a significant rise in life expectancy contributing to an increase in the elderly population is expected to touch 324 million by 2050 [10]. With age, individuals become increasingly prone to various health challenges, among which accidental falls emerge as a prevalent and concerning issue. Studies suggests that one-third of elderly over 60 years of age develop a fear of falls leading to restrictions on daily activities and thereby compromising their independence [1, 10].

Postural control is a core concept of fall risk management that is based on sensory input, cortical processing of information, and active motor responses involving muscles, joints, and reflexes. Disruptions at any of these levels increase the fall risk. The impact of falls on elderly individuals is reduced physical activity, compromised social life, increased fear of falling, and recurrent falls that lead to depression and decreased quality of life [9, 18]. Maintaining dynamic balance is a critical aspect of motor function, enabling individuals to navigate uneven terrain, negotiate obstacles, and perform activities requiring coordinated movement in different environmental conditions [9]. The age-related changes in balance control, particularly among older adults, have consistently demonstrated a decline in the ability to react on time and effectively to challenges during a dynamic task, resulting in slower reaction times and hence impaired dynamic postural adjustments [9].

Cognitive decline, especially with tasks requiring divided attention or simultaneous performance of motor and cognitive tasks presents significant challenges for the elderly [12]. With aging, structural changes in brain, including neuronal loss and reduced synaptic contribute to slower processing speed and difficulties in multitasking [6, 15]. While young and middle-aged adults commonly manage multitasking like walking and planning simultaneously, older adults experience significant challenge with the same. This phenomenon is known as 'dual-tasks costs', reflects the diminished ability to perform two activities concurrently due diminished central processing or impaired sensory-motor coordination.

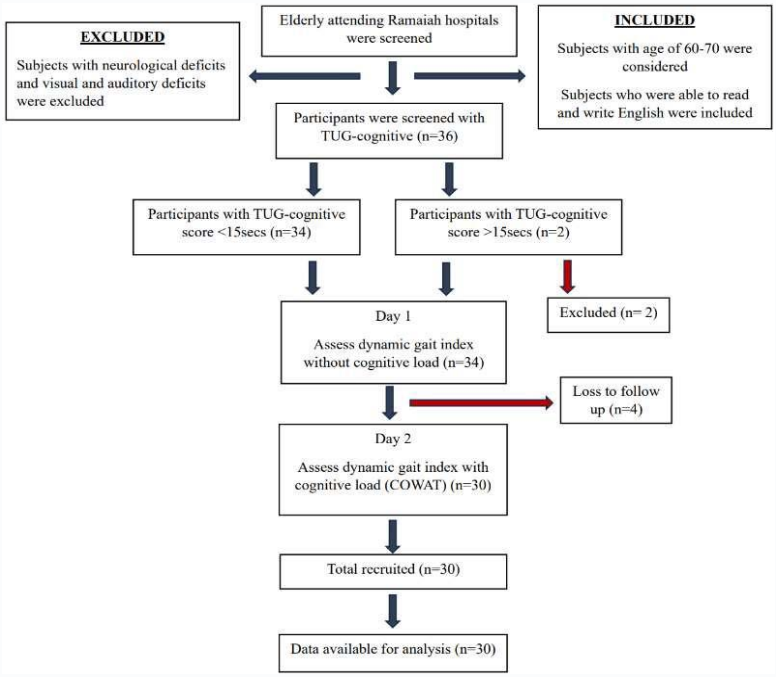

Figure 1: Methodology flowchart.

Dynamic balance and cognition is closely linked many studies demonstrate that cognitive load, can negatively impact the balance and heighten the risk of falls among the elderly [15]. To move around in controlled motor patterns, one must have the ability to determine which tasks need more attention. Automated movements requiring little conscious effort like walking may shift to at a cognitive process in the elderly, disrupting postural control mechanisms [1, 5, 9]. The progressive decline in postural stability with advancing age compounds the challenges to maintaining balance, exacerbating fall risks across successive decades of life [16].

Most studies in this field categorize the elderly as "faller" and "non-fallers" often overlooking the cognitive decline that the non-fallers experience which can affect the balance [1, 6, 9]. Elderly fallers under cognitive load condition have gait disruptions of but appears to have no effect on non-fallers and young people. The cognitive load can still impact the dynamic balance suggesting that even those not classifies as fallers could be at risk. The literature around the dual task performance in non-fallers is limited particularly when examining how cognitive tasks affect their ability to maintain dynamic balance [2, 6, 12]. The addition of a verbal fluency task during a fast-paced walking seemed to alter the results where the walking speed of all age groups reduced and the diminution of the walking speed was around 3.5% larger in the elderly [8, 17].

This study seeks to address the gap by exploring how elderly non-fallers, perform on a dynamic balance task under cognitive load. The study also aims to determine whether individuals may face heightened risk of falls, who traditionally do not fit the faller category. By identification of subtle balance deficits early, this research hopes to contribute to development targeted interventions that could preserve mobility, enhance quality of life, and reducing the incidence of falls among the ageing population.

Material and Methods

This was a cross-sectional study conducted between July 2023 to June 2024 at Centre of Rehabilitation, Ramaiah Memorial Hospital, Bangalore. The ethical clearance from the Institutional Ethics committee was obtained (MSRMCMC/EC/PG-07/06-2023). The study included 30 based on a precious study having a precision of 80% power and 95% confidence level and with effect size of 0.53.

The Inclusion criteria was participants in the age group of 60-70 years, TUG-Cognitive score for non-fallers <15 seconds, being able to read and speak English and able to walk 3m unaided. Exclusion criteria included participants with any known neurological condition affecting balance and gait, recent fractures of lower limb, severe auditory deficits and severe vision deficits.

Data collection was commenced after obtaining the ethical clearance from the Institutional Ethics committee. Thirty older adults between the age of 60-70 visiting Ramaiah Hospitals were recruited considering the inclusion and exclusion criteria. Each participant was explained about the study and informed consent was taken. Demographic data, age and gender was taken.

Screening Process

Timed up and go test with cognitive (TUG-Cognitive) is a useful to assess walking balance under dual task condition (serial subtraction task) performed to screen for "faller" or "non faller" being the outcome of interest. The best of three trials was taken and subjects with score of < 15 seconds were classified as non-fallers were included in the study.

Dynamic Gait Index without Cognitive Load

Post the screening process, the assessment was spread over two days as performing Dynamic gait Index (DGI) tasks twice in the same day might cause the subject to have a learning effect. Giving the gap in between the two DGI assessment was to have a washout period. The participants were made to perform the 8 tasks of Dynamic Gait index (DGI) without giving any cognitive load and the scores were recorded on the first day. The tasks of the DGI are graded on an ordinal scale

ranging from 0 being considered as severely impaired to 3 being considered as normal, which gives of a total score of 24. A DGI score of 19 or less would be used as a cut-off value for categorizing fallers from non-fallers (Chiu et al. 2006). Each subject was given one trial performance.

Dynamic Gait Index with Cognitive Load

On the second day, DGI while giving a cognitive load i.e., using the Controlled word Association task was scored. During each of the eight tasks, different letters were given. To keep it standardized the letter per task was common for every individual. The letters were C, R, W, P, F, L, A, S. The COWAT was scored by the number of suitable words told of the each of the letters during the task performance. The errors that are considered as that begin with the wrong letter, are proper nouns, or words that differ from a previous response by tense, plurality, or grammar usage and repeated words are not scored. The reason to choose this test was as the test is for executive functioning domain, and as executive functioning is closely related to gait. The words subjects could say were recorded in a voice recorder during the tasks (Figure 1).

Statistical Analyses

Data from the 30 participants will be analysed using SPSS 27.0. Descriptive statistics will summarize demographic data. A Shapiro-Wilk test was used to test normality, following which Paired Sample t-test was used to compare DGI scored with and without CL.

Results

The study recruited 30 participants with a mean age of 65.57 ± 4.0 years. The population included 16 (53.3%) males and 14 (46.7%) females. The minimum age of the participants were 60 years and maximum age was 70 years. The below table summarises the results of the assessed parameters within the study population (Table 1).

Paired t test analysis was performed to compare the scores of DGI with and without cognitive load. The mean difference between the two scores were 2.067 ± 1.680, and was statistically significant ($p<0.01$). This demonstrates that a significant difference exist between the two scores of DGI with and without cognitive load.

Discussion

Our study findings found that the elderly non-fallers, when cognitively challenged, showed a significant difference ($p<0.01$) during dynamic balance with cognitive load. This implies that the NF could fall under the category of fallers during CL. The first day, the scores of DGI without the CL had a mean and SD of 21.37 ± 1.95 and on the second day, with the CL the subjects had a mean and SD of 19.30 ± 2.53. The participants were assessed on two different days to avoid any learning effect.

Interestingly, even though all the participants who were categorized as non-fallers in our study based on TUG-cog scores <15seconds, one of the participants still fell into the faller category based on the performance of DGI without any cognitive load (score of 17). This will need further more studies in this fields to understand if which of the two is more specific to fallers identification.

Table 1:

VARIABLE	MEAN AND STD. DEV
TUG-Cognitive Score	12.19 ± 1.79 seconds
DGI without Cognitive load	21.37 ± 1.95
DGI with Cognitive load	19.30 ± 2.53
COWAT	30.63 ± 10.10

The analysis of male and female showed that there were 47% of male and 53% male of the 30 participants. And there was no much significant difference between the scores on DGI with cognitive load. The categorization age into two strata, i.e. from 60-64 years and 65-70 years. We estimated that with aging the scores of DGI would decrease and the 60-64 years would perform better than the 65-70 years on the second day. We had expected that the older age group could have higher scores indicating them to be fallers. But the intergroup testing showed that there was no much significance.

The scores of DGI seemed to alter with tasks involved and the most variation that patients showed was during task 5 consisting of stepping over an obstacle. This implies that the cognitive load provided during stepping over can cause chances of fall. This can be attributed to the higher attentional demands needed during stepping over and upon that doing a cognitive task during the activity can lead to chances of fall. The specific associations observed in this study also align with earlier studies [3, 4] showing that executive functions and verbal memory are important predictors of decline in balance this could be attributed to various contextual factors that can affect as people age. Executive functions maybe be relevant to ADLS as they are important for planning, regulation of behaviour, and organization and implementation of tasks in everyday life. Fallaci IV et. al. (2022) presented that the verbal fluency can also decline due to reduced ADL performance this may be related as the role of initiation on functional abilities are present [14, 19]. Earlier studies have showed that the decline in verbal fluency, verbal memory is associated with multiple falls especially during dual task conditions. Effective balance requires integration of sensory information (visual, vestibular, proprioceptive) and motor control. The motor control systems, including those in the brainstem and cerebellum, rely on timely and accurate sensory inputs to make adjustments for balance. Pichierri G et. al. (2011) tested that Cognitive tasks can interfere with the brain's ability to process these inputs and execute appropriate motor responses. These executive functions decline not only pose as a challenge to the balance but also indicate that higher cognitive process negatively affected the dynamic balance. The chance of falls can occur without history of falls, when elderly come across difficult environments and distractions. This suggests that falls are part of more intrinsic impairment and poor sensorimotor processing and our results support previous findings that executive functions and frontal lobe integrity are crucial to execute ADL which can decline with age [11].

This study demonstrates how cognitive load can significantly affect ADLs and highlights the needs to consider cognitive tasks when assessing functional performance in the elderly. High cognitive load can detract from the ability to process and integrate these sensory inputs effectively, which may disrupt balance and coordination. Cognitive load can impact motor control systems responsible for gait and postural stability. As studies aligned with our findings that high cognitive demands can lead to less efficient or less coordinated movement patterns [7, 13]. For instance, walking while engaged in a complex cognitive task may result in a more hesitant gait or less precise movements. The importance then has been on incorporating a balance program with an additional cognitive task in elderly. As we determined in this study that after 60 years of age even with having no indication to fall, the elderly require some rehabilitation in dual task that is with a dynamic balance task with cognitive task. This can further improve the balance and ADLs as most of our everyday

activities involve a multitask condition.

One of the limitations to our work was not being able to get the scores of COWAT for a whole minute as each of the dynamic tasks wasn't taking a one whole minute. Hence, the study faced the limitation of not having values to compare against the normative score. This could've have given us a clearer insight to the amount of cognitive load imposed. This could also help us to determine if there was any task prioritization with either balance or the cognitive components. Further studies could also incorporate virtual reality to create real life simulations and test them under cognitive load conditions.

Conclusion

Results of this study demonstrated that there was significance ($p<0.01$) with the scores of dynamic gait index with cognitive load. From this study we can imply that the dynamic balance will be significantly affected when elderly non-fallers are cognitively loaded (COWAT).

Clinical Trial Registration

Clinical trial registration was done from Clinical Trials Registry -India (CTRI), National Institute of Medical Statistics, ICMR New Delhi (Trial REF/2023/10/074250).

Ethical Clearance

The ethical clearance from the Institutional Ethics Committee was obtained prior to the study (MSRMCMC/EC/PG-07/06-2023).

Author Contributions Statement

- **Meghana Mukesh:** Conception and design, Analysis and interpretation of the data, Drafting of the paper, Revising it critically for intellectual content
- **S Nandakumar:** Conception and design, Drafting of the paper, Revising it critically for intellectual content
- **Tittu Thomas James:** Analysis and interpretation of the data, Drafting of the paper, Revising it critically for intellectual content

All authors approve the final version to be published and all authors agree to be accountable for all aspects of the work.

Declaration of Interest

The authors report there are no competing interests to declare.

Statement of Consent

Any patient, service user, or participant (or that person's parent or legal guardian) in any type of qualitative or quantitative research, has given informed consent to participate in the research.

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