ORIGINAL ARTICLE

Comparison of Gait Performance in Three Attention Demand Tasks During Extended Timed-up and Go Test in Elderly With Diabetic Peripheral Neuropathy

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ABSTRACT

Introduction: : Gait performance deteriorated among the elderlies, who suffered with diabetic peripheral neuropathy (DPN). However, little is known about the relation of gait performance in three attention demanding tasks during extended time up and go test. The aim of this study is to compare the gait performance in three attentional demand tasks, including motor and cognitive during extended time up and go test among elderlies with DPN. **Methods:** Forty-six participants were recruited in this case-control study: 23 with DPN (mean age 70 ± 5.4 years) and 23 without DPN (69 ± 5.5 years). The effects of different attention demands (dual-task) on gait performance during the Extended Timed-up and Go (ETUG) test was determined. Participants underwent three attention demand tasks: (i) single task (normal walking), (ii) dual-motor task (carried a tray with a cup of water), and (iii) subtraction task of a cognitive dual-task (counted backward from 10 to 1 during attempted track completion). Repeated variance analysis measures (ANOVA) were used in analyzing the variables, which also includes attention demand and ETUG scores. **Results:** Participants with DPN walked significantly slower compared to participants without DPN in two ETUG tasks; consecutively, 16.9 seconds vs 14.4 seconds in single task, 20.3 seconds vs 18.6 seconds in dual-motor task and 21.1 seconds vs 24.5 seconds in cognitive dual-task. **Conclusion:** Elderly with DPN have higher tendency of falling and secondary activities could contribute to major effects.

Keywords: Balance, Cognitive, Diabetic peripheral neuropathy, Dual-task, Gait

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INTRODUCTION

According to the International Diabetes Federation (IDF) (1), there has been an increased number of Diabetes mellitus (DM) recent decades worldwide. With the current number of (approximately) 463 million people with diabetes, it is expected to increase the figure up to 700 million by 2045 (1). Previous studies had pointed out that approximately 50% of people with type 2 DM will develop a microvascular complication, specifically diabetic peripheral neuropathy (DPN) (2,3).

DPN gradually affects the distal muscle strength directly and deteriorates normal gaits, as demonstrated by the accelerated loss of motor axons, reduced muscle volume of the intrinsic foot muscle and diminished muscle performance (4). Besides, lower limb diabetic sensory neuropathy has an adverse effect on postural stability and walking and ultimately increases the risk of falling in people with diabetes (5). Elderly with DPN are 23 times more likely to fall and are 15 times more likely to report an injury compared with matched non-neuropathic participants (5).

Among elderly, walking activities may demand a greater quantity of attentional resources and different cognitive mechanisms for maintaining adequate control and performance. Sensorimotor (5), functional balance (6) and attention function (5, 6,7) are the three critical parameters that work together and symbiose to regulate pleasant sensation and balance in gait performance. An elderly with or without DPN may present alterations in these parameters, and these alterations contribute to the deterioration of gait performance. Differences in socio-demographic characteristics, level of physical activity and cognitive status among elderly might impaired their gait, thus increasing the risk of falls and disability (8).

Increased gait variability and postural instability could be associated with executive functioning whilst walking in healthy elderly communities, particularly those performing dual tasks, where a dual task approach is often used to investigate the influence of cognitive need in gait control. A study has been reported a significant impacts of attention demand and dual tasking activities on falls episodes in elderly, who had suffered from mild to moderate cognitive impairments (9). Thus, dual task with cognitive involvement could become an imperative finding in determining the risk of falls, especially among elderly with or without DPN.

Previous studies had been conducted on the effects of multitasking on gait performance among elderly (10,11). However, fewer on the impacts of different attention demands on gait performance in an elderly regardless; with or without DPN in Malaysian population context. There could be a slightly different in between Malaysian and overseas samples due to the population and geographical study. Previous evidence claimed that an insulin usage has a significant impact associated with peripheral neuropathy and Malaysian's elderly use of insulin is often delayed for various reasons. Many patients started their insulin intake reaching the maximum number of oral hypoglycaemic but failed to achieve the target control. Thus, insulin initiation is often delayed leading to more patients with complications.

The gait parameters among elderly with DPN may has an adverse effect from carrying out a particular, dual or more complicated tasks. However the effect on the gait parameters of individuals with diabetes with additional cognitive tasks has not been extensively studied. Hence the objective of this study is to compare the effect of three attention demand in gait performance in elderly with or without DPN.

MATERIALS AND METHODS

This study was a case-controlled cross-sectional study conducted in a community center from April until August 2019. Purposive sampling and physical tests were performed by professional (both trained and qualified) physiotherapist using physical performance-based outcome measures. The informed consents also were provided to those participants who were eligible for the study. The study protocol was approved by the Research Ethics Committee of Universiti Teknologi MARA (600-IRMI (5/1/6). A total of 23 participants met the following criteria: (i) diagnosed with DPN for more than six months and with type-2 diabetes five years before the study, (ii) confirmed diagnosis of DPN using 5.07/10g SWME and 128 Hz tuning fork (performed by an experienced occupational therapist) , (iii) capable of walking for 10-m independently and continually without any walking aids and had scored more than 24/30 on the Mini-Mental State Examination (MMSE) (12). The exclusion criteria were as follows: (i) other neurological problems, severe musculoskeletal issues, disease that causes peripheral neuropathy other than DM, (ii) alcoholism, underlying foot ulcer, presented with a visual deficit, (iii) experienced a cerebral vascular injury during the past six months and (iv) language barrier.

The performance of gait was evaluated using the Extended Time Up and Go (ETUG) test, commonly used in clinical performance-based lower limb function, functionality and fall risk measurements (13). When tested on the same elderly population with reduced mobility, the ETUG showed a good overall intra- and inter rater reliability (14). The standard timed up and go (TUG) was chosen as the 'gold standard' since TUG is well established (14) and was the original test from ETUG was developed. When corrected for attenuation caused by restricted reliability, the study found a correlation of 0.85 for the test and retest between the TUG and ETUG. This is an indication that shows the two tests (TUG and ETUG), were testing the same phenomenon. This is not surprising, since the subtasks are quite similar, only that in the ETUG, subtasks are performed separately, while in the TUG, they are performed as a continuous task. Perhaps, the ETUG test does not require sophisticated and costly equipment that can be easily applied to a large group of elderly living in a community (15). Other variable includes socio-demographic, age, sex, ethnicity, years of education, marital status, employment status and self-reported non-communicable diseases were obtained through structured questionnaires.

Test Procedure

Each participants' possessed and performed two trials of ETUG. This is to ensure that they were familiar with the test. During the test, the researcher stood beside the participant to oversee the process / procedures including safety to both participant and the tool. After five minutes of test, they completed the tasks as follows: (i) sit-to-stand, (ii) 3-m walk at preferred speed, (iii) 180° turn, (iv) 3-m walk at fast speed and (v) turn and sit down. The task require the participant to complete in three attention demands which were; single-, dual-motor (with a tray with a cup of water), and dual-cognitive (with a tray while counting numbers backward from 10 to 1).

Scoring the ETUG

Each sub-task was given the same instructions: "After I count three, two, one, I want you to begin. Are you all set? Start with three, two, one".

Sub-task 1: sit-to-stand

Participants were required to seat on a 46-cm high chair with armrests, their backs against the chair's back. The command was to stand still and rise to an upright position. There was no guidance nor instruction on how to use the armrests, but they were recorded while they were used. The timer began when the participant stood upright and still, and stopped when the participant sat.

Sub-task 2: 3-m walk at preferred speed
The participants were given a task to complete; to walk 6-metres at their desired walking pace and then come to a complete stop without turning. The middle three metres were timed. When the participant's hips/body passed two lines on the floor, one at the beginning and the other at the end of the central 3-m region of the walkway, start and stop times were recorded.

Sub-task 3: 180 turn
The participants stood with their backs against the walkway at the start of the 180° turn. They were timed from the start of the task until they had turned 180 degrees and were standing still, facing the walkway and chair.

Sub-task 4: 3-m walk at fast speed
The participants again were instructed to walk a distance of 6 metres quickly but healthy pace and then come to a complete stop without turning. The middle three metres were timed. When the participant's hips passed two lines on the floor, one at the beginning and the other at the end of the central 3-m region of the walkway, start and stop times were recorded.

Sub-task 5: turn and sit down.
The participants were told to turn and sit down while standing in front of and facing the chair. The participants were timed from the start of the instruction until they sat on the chair.

Total time
The ETUG total time was determined by adding the time for each of the five sub-tasks: sit-to-stand, chosen walking pace, 180° turn, quick walking speed, and turn and sit down. (14).

Statistical analysis
The data were analyzed using version 25 of IBM SPSS statistical tools (IBM, Armonk, NY). For both result factors, descriptive statistics and experiments were carried out for normality. Repeated variance analysis measures (ANOVA) were used to evaluate gait parameters across three tasks involving single-, dual-motor, and dual-cognitive activities. A post hoc Bonferroni comparison was performed when the repeated measure ANOVA test revealed a significant difference (*P* < .05).

RESULTS

Table I reports the participants' characteristics according to DPN status. The participants' mean age was 70.30 ± 5.4 years in DPN group while 68.83 ± 5.5 in without DPN (range: 60 – 80 years). When comparing the characteristics between with and without DPN, no significant differences were found in all variables except age, gender, history of falls, comorbidities, polypharmacy, and BMI (All p> 0.05).

Table 1.0 Characteristics of participants (n=46)

CHARACTERISTICS	DPN STATUS				P - VALUE
	WITH DPN (n=23)		WITHOUT DPN (n = 23)		
	n (%)	Mean ± SD	n (%)	Mean ± SD	
Age (years)		70.30 ± 5.39		68.83 ± 5.47	0.531
Weight (kg)		70.74 ± 8.78		68.61 ± 6.30	0.95
Height (cm)		162.61 ± 8.20		160.57 ± 6.63	0.18
Gender					
Women	11		10		0.606
Men	12		13		
History of falls					
Yes	22		23		**0.030***
No	1				
Fear of falls					
Yes	22		23		**0.042***
No	1				
Duration of DM					
5-10 yrs	6		20		**0.016***
>10 yrs	17		3		

Values are presented as frequency, n (%) or mean ± standard deviation (SD) *: Significant difference at p < 0.05.

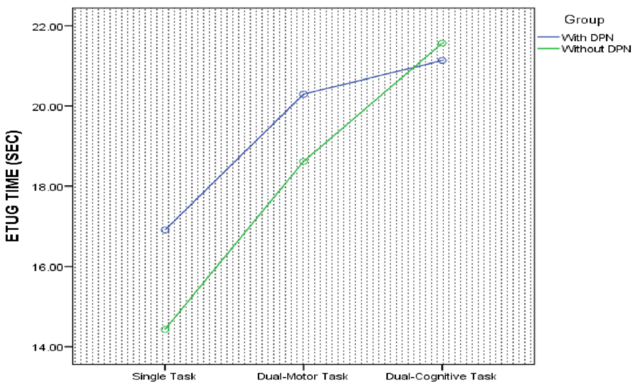

Fig 1: Attentional demands tasks

Meanwhile, on gait performance, Fig.1 shows the time taken to complete the ETUG test under 3 attentional demand tasks shows a significant reduction. It shows a compelling result of time taken to complete the tasks ; (i) single task ETUG, (ii) dual motor task ETUG and (iii) dual cognitive task ETUG were observed in elderly with DPN compared with elderly without DPN (p > 0.05). A repeated measures of variance ANOVA were conducted to explore the impact of different attentional demands on gait performances. The data shows statistically significant main effect for time point [F(2,88)=219.557, p<0.01] with large effect size (partial eta squared=.83). Post-hoc comparisons using the Bonferroni correction revealed that the mean score for each different task differ at single task (M= 15.69, SD= 1.73), dual-task (M= 19.46, SD=2.06) and cognitive dual-task (M= 21.35, SD= 1.75). The main effect was significantly difference for groups [F(1, 44)=11.398, p<0.01]; however small effect size (partial eta squared=.21) and the interaction effect [F(2, 88)=14.811, p<0.01] with small effect size (partial eta squared=.25)

DISCUSSION

Significant effect of time points in the single, dual motor task ETUG and dual cognitive task ETUG were observed in elderly with DPN groups compared with elderly without DPN. The participants with DPN took longer time to complete in two different tasks as compared to participants without DPN (single = 16.9sec vs 14.4 sec, and dual motor = 20.3 sec vs 18.6 sec);a slightly different seen in dual cognitive task (21.1 sec vs 21.5 sec). This is because the participant with DPN had an overall slow velocity, shorter steps, and lower cadence, resulted in high double support time in their gait phase. To support the result, previous studies showed that gait pattern occurred as the elderly with both DM and DPN tends to maintain their dynamic and stability during walking, which required them to plan future stepping action (16–18). Also, Manor and his colleagues in 2012 revealed that elderly with DPN walk with greater variability in stride length and longer double support, more progressively than the same age group without DPN (19). This result might be due to lower grey matter volumes globally and regionally among elderly with DPN, which in turns resulted in delay gait reaction response. In fact, two thirds of the body mass is accounted for, where the upper body, and control of the head and trunk is important especially for balancing performance among elderly people while walking. Adults with diabetes, with or without DPN, have a higher head-trunk correlation during walking (20). Most of them performed head–trunk stiffening strategies to increase confidence and maintain balance while walking (19).

The single task in ETUG also seems very challenging for elderlies with DPN. Reduced somatosensory information from the lower limbs associated with peripheral neuropathy or reduced muscle strength of the ankle plantar flexors or dorsiflexors were the main significant contributors(21,22). For example, motor nerve damage could result in muscle atrophy and fatty infiltration, which in turn could affect dynamic gait movement and cause changes, causing increased early hip and knee bending and extended midstance hip extension moment. (23). This may result in late ankle position dorsiflexion and increase in energy absorption and delayed and truncated final push-off (23). This is consistent with prior studies that also showed a more conservative gait style in DPN with increased flexion of the lower extremity (3). This gait pattern is similar to a mild hemiparesis gait seen in neurological issues and other pathologies that lead to distal weakness, but distinct in etiology (24). Weakness or motor weakness of ankle dorsiflexors can be associated with this result. During walking, the anterior tibialis works concentrically during swing for clearing of the foot and eccentrically during loading reaction for plantarflexion rate control (24). Additionally, an extensive recruiting of synergists, such as toe extensors, may compensate for weakness in this muscle (24). These procedures result in an overall transfer of workload from distal to proximal joints, and therefore gait process takes longer time to complete.

In terms of secondary task, involving motor or cognitive had also shown an effect in gait among elderly with and without DPN. Both groups' participants had poorer performance while walking, and the motor task was performed less adequately in the DPN group, as evidenced by more water spillage compared with the elderly without DPN. This suggests that elderly with diabetes with and without DPN probably used a greater proportion of their attentional demands to maintain their normal gait pattern during motor task. As the gait of those with DPN was more affected by the secondary tasks, it appears that elderly with DPN were less able to focus, and divert their attention, leading to a deterioration in their gait.

Following this, for the cognitive dual task, both groups had shown an increase in time to complete the task as compared to single and motor dual tasking. Possible explanation for the results observed in this study is the lack of sensory information from the periphery in DM resulting in elderlies using their attentional capacity to maintain their gait, thus leaving less reserve capacity for other simultaneous cognitive tasks. In other circumstances, elderlies are able to compensate for a lack of input from one part of the somatosensory system by relying on information from other parts of the system, for example, the visual system. However, elderlies with diabetes may also have impaired sight, for example from diabetic retinopathy or cataracts (25), preventing such compensation from occurring. As old age increases, saccadic latency and declines in the useful field of view are represented (26), and that can affect the ability of an elderly person to easily switch their gazes back and forth between two parallel activities. Furthermore, with advancing age, walking relies progressively on vision (26). The risk may be attributed to decreased proprioceptive and vestibular awareness. This condition can intensify competitiveness between walking and another dual-task activity. In addition, this could be due to high fear of falls among both groups. As reported by Lopes and his colleagues, the incidence of falls in those with diabetes is higher than an age-matched population, where approximately 20%-60% of elderlies had indicated fear of falling and that this fear is always greater in women, especially because they have sedentary lifestyles (24). DM is closely associated with cognitive impairment that impairs the speed, memory and focus of data processing, which attributes the impact on the emotional processing (25),as well as microvascular of blood-brain barrier impairment that may occur because of transient hyperglycemia (26). Alterations in monoamine neurotransmitters synthesis and re-uptake, which are important to the brain, occurs because of changes in insulin availability in the brain (22). These tasks may significantly affect motor performance, resulting in poor gait parameters among elderly with hyperglycemia. Furthermore, hyperglycemia can increase errors and slow down responses in performing basic verbal and mathematical tasks, such as calculating insulin dosing, and work performance and may thus disrupt daily activities (30). In preserving equilibrium in gait performance, cognitive and attention have important functions, as the brain guides limb muscle to regulate the body. Cognitive deficiency can also result in a slow or sluggish reaction during dual-task activities. Consequently, this condition could lead to many harmful effects, such as falls, in cognitively impaired individuals performing dual tasks. Overall, the limitation for this study was using a monofilament in diagnosing the DPN, instead of the gold standard of DPN measurement which is electrodiagnostic studies (e.g., nerve conduction studies). Further studies of elderly with DPN using nerve conduction and dual-task paradigms in more challenging situations are required.

CONCLUSION

In conclusion, elderly with DPN have a more conservative gait pattern with a higher complexity, which is partly maintained by cognitive attention. For both elderlies diagnosed with DM as well as with and without DPN, gait deteriorated when performing secondary tasks. This effect can be seen in elderlies with DPN, possibly putting them at particular risk of falls. It is important that healthcare professionals recognize the potential for falls in those with DPN and implement early preventative strategies.

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