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ESTIMATING THE CUT-OFF SCORES OF DUAL-TASK COST OF TIMED UP AND GO COGNITIVE TO DIFFERENCIATE FALLERS AND NON-FALLERS: A CROSS-SECTIONAL ANALYSIS.

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ABSTRACT

Purpose and Objective: The purpose of the study was to establish the Cut-off scores of Dual-task Costs (DTC) of Motor Component of timed up and go-cognitive test (TUG-Cog) to help to distinguish fallers and non-fallers in elderly; this cut-off score will help to get a holistic idea about their Dual-Task performance and risk of falls which will, in turn, help for identification, planning and prognostic assessment. Method: 101 healthy elderly participants were assessed with help of study tools and divided into 2 groups based on history of fall within the past one year. Single tasks and Dual task TUG-Cog was performed and DTC calculated for all participants. Receiver Operating Characteristics (ROC) Curve was obtained using DTC values against history of fall in the past one year. Sensitivity and Specificity was obtained and cut-off score chosen. Result: The area under the curve (AUC) was 0.663 when ROC curve was plotted with DTC values against previous history of fall. The coordinates of the ROC curve gave cut-off score of motor DTC as 8.02% with a sensitivity of 84.6% and specificity of 30.7%. Conclusion: The Cut-off score of DTC of Motor Component of TUG-Cog test was 8.02% for differentiating Fallers from Non-fallers.

INTRODUCTION:

Accidental falls occur in nearly one-third of those aged more than 60 years, 10% results in serious injuries. This can lead to disability, hospitalizations, and premature death in elderly. (Ganz, 2007 & Baker, n.d.) About 30-55% of older persons acknowledge of having a "fear of fall" and approximately one third of them report of restricting activities because of it. This avoidance of activities and reduced physical fitness is a risk factor for future falls, mortality, dysfunction & premature nursing home admissions & social isolation. (Mann, 2006 & Kannus, 2007) Everyday life consists of numerous situations in which walking is integrated with other activities, such as watching out for vehicular traffic or using a mobile phone. This concurrence of locomotion with another activity is termed as dual-tasking. (Lajoie, 1996 & Neider, 2011) An individual needs intact cognition and physical (motor) ability to carry out dual tasks effectively. Age-related changes affects motor functions such as strength, balance, coordination, flexibility, reaction times, etc., this can lead to decrease in walking speed and stride length, and increase in lateral sway and stride time. (Elble, 1991 & Mills, 2001) Relative change in performance associated with dual-tasking is referred to as dual-task effect (DTE). (Leibherr, 2016 & Werner, 2018) The level to which one performance is affected by such cognitive-motor interference is typically expressed as the dual-task cost (DTC).

When a secondary cognitive task is superimposed on a gait activity, older individuals, may concentrate on one task more to perform better than other or he may compromise on both tasks. Such effect of both tasks on each other is called as dual task interference (DTI), with older individuals with a fall history showing even greater affection. (Guccione, 3rd ed. 2012 & Plummer, 2015) The understanding of cognitive-motor interference in people with high fall risk or concerns about falling during walking under different cognitive dual-task conditions is still quite limited. (Plummer, 2015) Hence, what value of DTC should be considered normal for an elderly individual with a particular cognitive or motor capacity is yet unknown. These values are called the cut-off scores, the values of which, if known, can help for risk estimation, falls screening for those at risk of falls, plan prevention program & assess effect of interventions targeted to improve balance and avoid falls. When walking is combined with a cognitive task it helps to assess dual task function. Timed up and go - cognitive (TUG-Cog) is commonly used dual tasks in most of the studies; hence, it was used as task to assess the dual task skills & focused attention. Thus, considering all the above aspects, current study was planned with the aim of finding out the cut-off scores of DTC for motor component of TUG-Cog dual-tasking in elderly individuals.

Aim & Objectives:

The aim of the current study was to estimate cut-off scores of DTC of TUG-Cog to differentiate fallers and non-fallers in elderly. This study had four objectives – assessing elderly individuals for dual-tasking using TUG-Cog, determining sensitivity and specificity of DTC values using ROC curve, determining cut-off score of motor component of DTC using sensitivity and specificity and determining odd's ratio for cut-off score of motor component of DTC.

MATERIALS AND METHODS:

Institutional ethics committee clearance was obtained. Sample size was calculated according to the available data of Timed up and go (TUG) test for prevalence of balance impairment and Montreal Cognitive Assessment (MoCA) scale for prevalence of cognitive impairment from local population. Prevalence of balance impairment and cognitive impairment was calculated and was found to be 81.72% and 50.55% respectively. The sample size was calculated and found to be 94 using the following formula: (n=sample size, $Z_{/2}$ at =0.05 is 1.96, $Z_{/2}$ at =0.001 is 2.68, p=prevalence of impairment, q=100−p, l=allowable error). Elderly individuals with no depression who are able to read, understand and interpret English having minimum HSC educational qualification, corrected for any visual/auditory impairment and who are community ambulators were selected for the study. Those having a neurological condition, pain (VAS >4), peripheral vascular disease, vestibular processing insufficiency, lower extremity fracture in past 12 weeks and on pharmaceutical agents like antidepressants, etc. which affect cognition or alertness were excluded. All individuals (n=101) were explained the procedure and taken consent from.

Demographic data, medical and surgical history (if any) were taken and history of fall in the past one year was recorded. Participants' performance was recorded for Motor ST (TUG), Cognitive ST (counting backwards by 3) and dual-task (TUG-Cog). The DTC was then calculated using the following formula, DTC=[(Dual task performance-Single task performance)/Single task performace] ×100. After completion of assessments, participants were divided into two groups based on history of fall in the past one year into fallers (n=13) and non-fallers (n=88). Receiver Operating Characteristics (ROC) curve was plotted for Motor component of DTC for TUG-Cog test against the previous history of fall through the SPSS software version 1.0.0.1508; sensitivity and specificity was obtained for the coordinates of the ROC curve. The cut-off value of 8.02% was obtained so as to minimize false negative mistakes (not to falsely state a faller to be a non-faller). The chosen cut-off value was then assessed on odd's ratio to check for its outcome (distinguishing as a faller or non-faller) relative to the exposure (past history of fall). Since the odd's ratio was >1 the outcome was positive, indicating that, the test has positive odds of outcome. Thus, a person who has a Motor DTC score of >8.02% was categorised as a faller. Hence, this test can be a useful test to determine fallers and non-fallers.

RESULTS:

Table 1: Demographic Characteristics Of Participants

Values (Mean ± SD)	Fallers (n=13)	Non-Fallers (n=88)	p-Value	Inference
Age (years)	70.583±6.748	69.333±6.474	0.5309	Not Significant
GDS Score	6.5833±2.065	3.620±2.977	0.0008	Extremely Statistically Significant
BBS Score	53.166±3.040	53.931±2.509	0.7743	Not Significant
MMSE Score	27.833±2.289	28.126±1.878	0.6598	Not Significant

GDS- Geriatric Depression Scale, BBS- Berg Balance Scale, MMSE- Mini Mental State Examination

Table 2: Mean Values Of Single And Dual-task Test Scores

		Motor Component		Cognitive Component	
		Single task (sec.)	Dual task (sec.)	Single task (%)	Dual task (%)
Fallers (n=13)	Mean ± SD	14.0683± 2.9444	19.2691± 4.7172	84.6225± 28.1962	82.275±27.2337
	p-value	0.0002		0.2172	
	Inference	Very statistically significant		Not statistically significant	
Non-fallers (n=88)	Mean ± SD	13.5958± 3.8694	17.2468± 7.7112	90.9514± 15.1522	87.8314± 16.9877
	p-value	<0.0001		0.0816	
	Inference	Extremely statistically significant		Not quite statistically significant	

Values are Mean ± SD; ST= Single task, DT= Dual-task

Table 3: Dual-task Cost and Cut-off Score

		Fallers	Non-Fallers	p-value	Inference
DTC (%)	Motor	38.3025± 29.1090	25.3513± 29.7865	0.1455	Not Significant
	Cognitive	-1.8191± 11.9712	-0.4149± 23.5154	0.8336	Not Significant

Values are Mean ± SD; DTC= Dual-task Cost

Table 4: Area Under The Curve

Area	Asymptotic 95% Confidence Interval	
	Lower bound	Upper bound
0.663*	0.53	0.769

[*The area under the ROC curve is 0.663. This suggests that since the area is greater than 0.5 there is more than just chance possibility that the diagnostic test will have good ability to diagnose the diseased population from the healthy population.]

Table 5: Sensitivity & Specificity For Cut-off Value

	Cut-off Value (%)	Sensitivity (%)	Specificity (%)
DTC Motor	8.02	84.6	30.7

The cut-off score of Motor component of DTC in relation to history of fall was 8.02%.

Table 6: Odd's Ratio Calculation With DTC Cut-off Score Of 8.02%

		History of Fall		
		Yes	No	Total
Motor DTC	Yes	11	61	72
	No	2	27	29
	Total	13	88	101

$$Odd's\ Ratio = \frac{a/c}{b/d} = \frac{ad}{bc}$$

$$Odd's\ Ratio = \frac{11/2}{61/27} = \frac{11x27}{61x2} = 2.4344$$

Therefore,
Odd's Ratio = 2.43

Odd's ratio is >1, thus, the odds of outcome with exposure are higher. This indicates that elderly individuals are more prone to fall if the cut-off score of Dual-task cost of Motor component of TUG-Cog test is greater than 8.02%.

DISCUSSION:

Due to limited availability of literature which mentions Cut-off scores of dual-tasks tests and uses these as a measure to distinguish fallers and non-fallers in the elderly population, main objective of this study was to find the cut-off score of Motor Component of DTC of TUG-Cog test.

Sensitivity and Specificity are concerned with the accuracy of the screening test relative to the reference standard test. The focus is usually the adequacy of the screening test. Also, the main concern is that whether the results on the reference standard test are corresponding with those on the screening test. (Trevethan, 2017) They are inversely proportional, meaning that as Sensitivity increases, Specificity decreases and vice versa. (Parikh, 2008) They indicate the effectiveness of a test with respect to a trusted outside referent.

The cut-off scores of dual task costs have not yet been established as a quantitative measure of distinguishing fallers and non-fallers for the TUG-Cog test. Using the Motor component DTC of TUG-Cog test, the ROC Curve was plotted against a previous history of fall.

The ROC curve is generally used relying on the property that the accuracy of the indices derived is not distorted by the decision criterion. (Hajian, 2013) Thus, there is a lesser probability of getting a biased result.

The area under curve (AUC) is considered to be an effective measure of accuracy. (Hajian, 2013) It is an effective and combined measure of sensitivity and specificity that determines the inherent ability of the test to discriminate between the diseased and healthy population i.e., the validity of the diagnostic test. (Hajian, 2013) The AUC was 0.663 in

current study, indicating that the diagnostic test (TUG-Cog) had a good ability to distinguish diseased and non-diseased population than a mere chance possibility. (Hajian, 2013)

Table 7: Sensitivity & Specificity

		Status of the individual according to "Gold Standard"Status of the individual according to "Gold Standard"		
		Has the condition	Does not have the condition	
Result from the screening Test	Positive	True Positive (a)	False Positive (b)	Row entries for determining Positive Predictive Value
	Negative	False Negative (c)	True Negative (d)	Row entries for determining Negative Predictive Value
		Column entries for determining Sensitivity	Column entries for determining Specificity	

The optimal cut-off point is the most north-western point in the ROC space. It is the cut-off point which has the highest sensitivity and highest specificity. Thus, as a rule, the optimal cut-off point is the one which maximizes True Positive + True Negative (or minimizes False Positive + False Negative). However, this is based on the principle that the cost of making a false positive mistake is equal to the cost of making a false negative mistake. These costs are rarely equivalent. (Pintea, 2009).

A diagnostic test to have a good reliability, must have >80% of Sensitivity and Specificity both. However, the objective of the current study requires to distinguish fallers from non-fallers; thus, if higher value of specificity is chosen then there is a possibility of incorrectly (conducting a false negative mistake) labelling a faller to be a non-faller.

Hence, having an appropriate cut-off value is important for reducing false positive and false negative results. Therefore, the most appropriate value of cut-off score was chosen to be 8.02% for a sensitivity of 84.6% and a specificity of 30.7%. Thus, it was stated that all the individuals having a DTC of Motor component greater than 8.02% on the TUG-Cog test are at a risk of fall.

The study had some limitations, although the two groups were statistically similar on baseline, the data was collected in individuals' homes, where the environmental distractions could not be avoided or standardized for all participants; Retrospective data about history of fall was collected, and hence, there may be chances of recall bias. Some individuals required hints for completion of cognitive component of the dual-task, there was use of preferred language for Cognitive responses by the participant, etc., and hence, there was no standardization of instruction. This may have caused biased data in a few cases. Also, due to difference in number of participants in both groups, fallers (n=13) and non-fallers (n=88), the results may have been influenced. The study is performed only with TUG-Cog test; similar cut-off value may be calculated for other dual-task tests and in disease specific population. Cut-off scores of cognitive component of TUG-Cog may also be calculated with appropriate population. While doing so, influence of external factors such as task complexity, environment, individual preference and individual skills may also be considered carefully.

CONCLUSION:

The cut-off score of Dual-task cost of Motor Component of Timed up and go-Cog test is 8.02% for differentiating Fallers and Non-fallers.

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