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ORIGINAL ARTICLE

Relationship of Cognition and Dual Task Performance in Sedentary Middle Aged Obese Adults: A Cross Sectional Study

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ABSTRACT

Background: Obesity is the over accumulation of fat in the body and represents a major priority for healthcare systems due to its social, clinical and economic burdens. The prevalence of obesity in India is 40.3% which is increasing faster than the world average and it is higher among middle aged adults over 40 than under 40, where as in Kerala the prevalence rate is about 40.7% with a female preponderance. Midlife obesity is associated with decrements in cognitive function as well as motor function, and this could potentially compromise a person's memory, attention, concentration and decision-making abilities that impacts daily functioning. Dual task involves the simultaneous incorporation of cognitive as well as motor components and it is found to be affected in obese adults. So there may exist a scope of association between the cognition and dual task performance of obese patients, and thus this study aims to find out the association between cognition and dual task performance in sedentary middle aged obese adults.

Objective: To find out the linear relationship between cognition and dual task performance in sedentary middle aged obese adults**.**

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Methods: Community dwelling sedentary middle aged obese individuals with MoCA score between 18 - 30 were recruited for the study. They were instructed to perform two single tasks: six-meter self-selected walking speed test and the timed up and go test. Each single task was then repeat under two dual task conditions: self-selected walking speed test and verbal fluency test, self-selected walking speed test and serial 3 subtraction test, timed up and go test and verbal fluency test, and timed up and go test and serial 3 subtraction test. Dual task cost was calculated for each dual task to explore the percentile decline in dual task performance. ((difference between dual task and single task motor performance)/single task motor performance] ×100)

Results and Discussion: Regression analysis was done and found a significant linear relationship of cognition with dual task performance and dual task cost in sedentary middle aged obese adults ($p<0.05$). Moderate linear relationship ($\beta=0.65$) was found for timed up and go serial 3 subtractions which was the most difficult task and a weak linear relationship ($\beta=0.22$) for self-selected walking speed verbal fluency the simplest one. The results concluded that as the task complexity increases dual task cost increases which indicates a direct relationship between cognition and dual task performance. The prefrontal cortex plays a major role during single and dual-task gait functions and this activation corresponds to the complexity of the task. Reduced brain volume, grey matter atrophy, impaired synaptic plasticity, all of which may contribute to changes in cognitive and motor domain. These evidence may correspond to the linear relationship exists between cognition with dual task performance and dual task cost in the current study.

Conclusion: Findings of this study implies that there is a linear relationship between cognition and dual task performance in sedentary middle aged obese adults.

KEYWORDS

• Cognition • Single task • Dual task • Dual task performance • Dual task cost • Task complexity • Sedentary middle aged obese adults

INTRODUCTION

Obesity is a condition characterized by increase in the size and amount of fat cells in the body. It is a chronic disorder that is officially classified as a disease by the World Health Organization (WHO), and also by several other national and international organizations.[1] The WHO defines obesity as body mass index (BMI) ≥ 30.[2] Globally in the year 2016, more than one-third of adults were living with overweight and about 13% with obesity.[3] According to the WHO (2021), over 1.9 billion adults (39% adults) were overweight among which more than 600 million (13% adults) were obese.[2] According to a national survey conducted in 2021 prevalence of obesity in India is 40.3% and it is higher among women than men (41.88% vs 38.67%), and among middle aged adults over 40 than under 40 (45.81% vs 34.58%).[4] In the South Asian population, there has been a more than 20% increase in the prevalence of obesity in women compared to men.[5] National family health survey report (2022) reports that one in every 4 Indians is now obese.[6] Overall prevalence of obesity and overweight in Kerala was 40.7% and 24% respectively which was found to be more among females (33%) than males (17%).[7]

Obesity is related to a range of health-related problems, such as diabetes, heart disease, hypertension, and cancer. Some of these health related comorbidities are themselves associated with adverse cognitive effects, where evidence from recent research suggests that adiposity has a specific association with cognitive function.[8] An association between obesity and cognitive health is receiving increasing recognition. In addition to an increased risk of an accelerated trajectory of cognitive ageing, evidence suggests early to mid-adulthood obesity may have an immediate detrimental impact on cognitive functioning.[9] Overweight and obesity are usually related to poorer cognition across lifespan.[10] Based on BMI data, individuals who are overweight or obese fall in the lowest quartile of global cognition, verbal fluency, delayed recall, immediate logical memory, and intelligence.[11]

Obese individuals are found significantly slower in gait speed compared to persons with normal BMI.[12] Recently, potential obesity-related differences in neural activity during ambulation in adults were reported.[13] The prefrontal cortex (PFC) plays a major role in gait functions in obese adults and its activation is found to be significantly higher in obese than in non-obese during ambulation. Studies have reported dual-task conditions, namely precision gait and decision-making tasks, were associated with greater PFC activity compared to the single-task condition in older adults.[14]

Obese people are at increased risk of decline in functional independence as they age. Community-dwelling obese adults, lose 10% independence each year, as measured by activities of daily living.[15] Studies have shown that obese patients have significant reduction in dual task performance.[14] Dual-task performance involves the execution of a primary task, which is the major focus of attention, and a secondary task conducted at the same time. The motor and cognitive systems act reciprocally to ensure successful motion.[16] In the present study walking is considered as the motor component of dual task performance, because daily activities often requires the ability to divide one's attention between tasks such as walking and talking concurrently.[17]

There exists a dual task paradigm for evaluating interactions between cognition and dual task motor performance. The purpose of this study is to find the relationship between cognition and dual task performance in sedentary middle aged obese adults.

MATERIALS AND METHODS

An analytical cross-sectional study was conducted with convenience sampling technique for a duration of six months among community dwelling obese subjects in Ernakulum and Thrissur district to estimate the relationship between cognition and dual task performance in sedentary middle aged obese adults.

After obtaining approval from the Scientific Committee and Institutional Review Board, 60 community dwelling obese subjects fulfilling all the inclusion criteria were recruited for the study. Informed consent was taken prior to study. Both male and female aged 40 to 60 years with BMI ≥ 30 having MoCA score 18 – 30 with minimum educational qualification of 10th standard and those who are able to walk independently without assistance were included in the study. Subjects with Subjects with hypertension and diabetes mellitus for more than 5 years since onset those performing regular physical exercise for at least 3 months before the study, medically unstable subjects, psychiatric and non-cooperative patients, those with vestibular dysfunction, recent fractures and surgeries, visual and hearing impairment, degenerative and inflammatory musculoskeletal disorders, inflammatory, infective, degenerative and demyelinating diseases of central nervous system, not willing to participate in the study were excluded from the study.

PROCEDURE

Sedentary middle aged obese adults with MoCA score between 18 and 30 were instructed to perform two single tasks (ST): six-meter self-selected walking speed test (SSWS) for which the self-selected walking speed (SSWS) was calculated in meter per seconds and the timed up and go test (TUG) for which the time to complete the test was recorded in seconds. Each single task was then repeat under two dual task conditions: SSWS+VF and TUG + VF and SSWS +S3S and TUG +S3S.

- Dual-task cost (DTC) was calculated for each DT as follows:
- [(difference between DT and ST motor performance)/ST motor performance] ×100

RESULTS

The obtained data was analysed using IBM SPSS Version 20.00. Baseline homogeneity was established using test for linearity. A p-value less than 0.05 was considered as statistically significant. The statistical analysis of the data showed that all of the variables were normally distributed. Thus regression was used for the analysis.

The β value for cognition in relation to SSWSVF and SSWSS3S is 0.394 and 0.384. The positive value of β indicated a direct relation between the 2 variables. As subjects MoCA score decreases there is proportionate reduction in gait speed. The value of β is between 0.21 -0.50 which indicates a weak direct relationship of cognition on SSWSVF and SSWSS3S in

sedentary middle aged obese adults. The β value for cognition in relation to TUGVF and TUGS3S is -0.429 and -0.354. The negative value of β indicated an inverse relation between the 2 variables. As subjects MoCA score decreases there is proportionate increase in time taken for completion of TUG. The value of β is between -0.21 to -0.50 which indicates a weak inverse relationship of cognition on TUGVF and TUGS3S in sedentary middle aged obese adults.

The β value for cognition in relation to dual task cost 1,2,3 and 4 (DTC1, DTC2, DTC3, DTC4) is -0.224, -0.263, -0.58 and -0.65 The negative value of β indicated an inverse relation between the 2 variables. The value of β is between 0.21 -0.50 which indicates a weak inverse relationship of cognition on DTC1 and DTC2 in sedentary middle aged obese adults. The β value for cognition in relation to DTC3 and DTC4 is between 0.51-0.80 which indicates a moderate linear relationship. As MoCA score decreases dual task cost increases.

The β value for cognition in relation to SSWS is 0.434. The positive value of β indicated a direct relationship between the 2 variables. As subjects MoCA score decreases there is proportionate reduction in the gait speed. The value of β is between 0.21- 0.50 which indicates a weak direct relationship between cognitions SWS. The β value for cognition in relation to TUG is -0.422. The negative value of β indicated an inverse relationship between the 2 variables. As subjects MoCA score decreases there is proportionate increase in the time taken for TUG. The value of β is between 0.21- 0.50 which indicates a weak inverse relationship between cognition TUG.

When comparing the magnitude of DTC between tasks, results showed that magnitude of DTC was most higher for TUGS3S, which suggests that as task complexity increases dual task cost(DTC) increases.

Regression analysis was performed to determine the relationship of cognition and dual task performance in sedentary middle aged obese adults. At 95% confidence interval and degrees of freedom 59 with level of significance 5% table value t=2.000 and calculated t statistic value for SSWSVF, SSWSS3S, TUGVF and TUGS3S are 3.262,3.166,3.614,2.883 respectively which is greater than table value. Therefore, rejecting the null hypothesis (H_{01}) and accepting the alternate hypothesis (H_{A1}) such that there is a linear relationship between cognition and dual task motor performance in sedentary middle aged obese adults.

At 95% confidence interval and degrees of freedom 59 with level of significance 5% table value t=2.000 and calculated t statistic value for Dual task cost 1,2,3,4 (DTC1, DTC2, DTC3, DTC4) on cognition are 2.171,3.739,7.913,2.416 which is greater than table value. Therefore, rejecting the null hypothesis (H_{02}) and accepting the alternate hypothesis (H_{A2}) such that there is a linear relationship between cognition and dual task cost for motor performance in sedentary middle aged obese adults.

At 95% confidence interval and degrees of freedom 59 with level of significance 5% table value t=2.000 and calculated t statistic value for SSWS and TUG on cognition are 3.674 and 7.885 which is greater than table value. Therefore, rejecting the null hypothesis (H_{03}) and accepting the alternate hypothesis (H_{A3}) such that there is a linear relationship between cognition and single task motor performance in sedentary middle aged obese adults.

Thus from the obtained results it can be inferred that there is a significant relationship between cognition and dual task performance in sedentary middle aged obese adults.

Table 1: Demographic representation of age

Age	Frequency	Percentage (%)
40-45	26	42.6%
46-50	22	36.1%
50-55	8	13.1%
56-60	4	6.6%
Total	60	100%

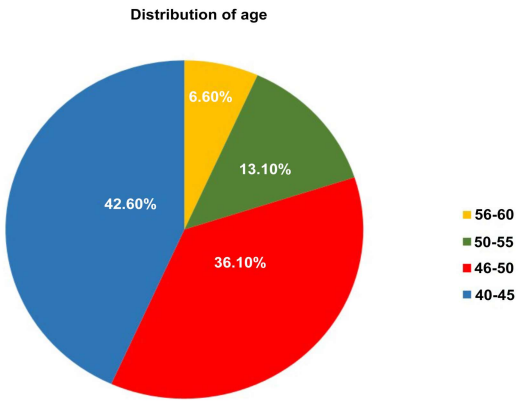


Figure 1: Demographic representation of age

Table 2: Dempgraphic representation of gender

Gender	Frequency	Percentage(%)
Female	49	80.3%
Male	11	18.0%
Total	60	100%

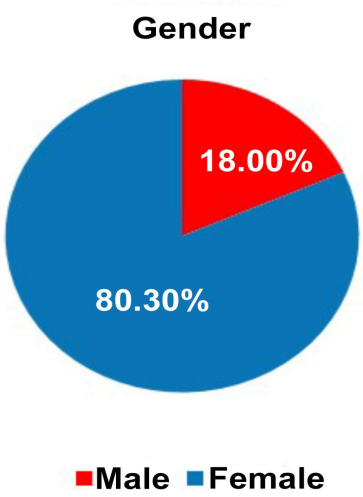


Figure 2: Demographic representation of gender

Table 3: Demographic representation of BMI(kg/m2)

Obese Class	BMI(kg/m2)	Frequency	Percentage (%)
Obese Class 1	30 – 34.9	29	47.5%
Obese Class 2	35- 39.9	25	41.0%
Obese Class 3	Above 40	6	9.8%
Total		60	100%

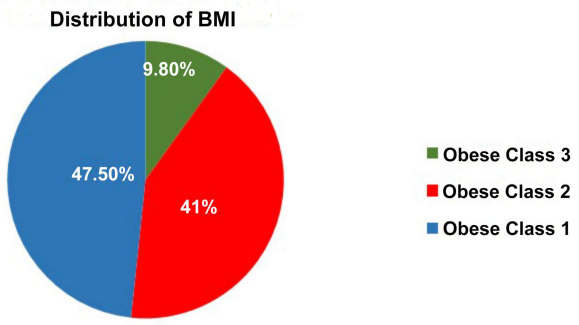


Figure 3: Demographic representation of BMI(kg/m2)

Table 4: Representing the scores on MoCA of the subjects in the study

MoCA	Frequency	Percentage(%)
18 – 25	58	96.6%
26 – 30	2	3.4%
Total	60	100%

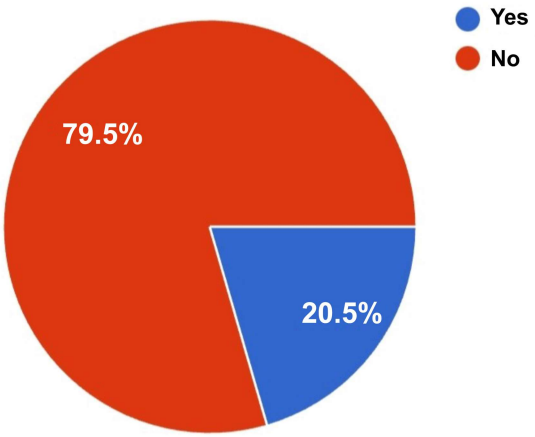


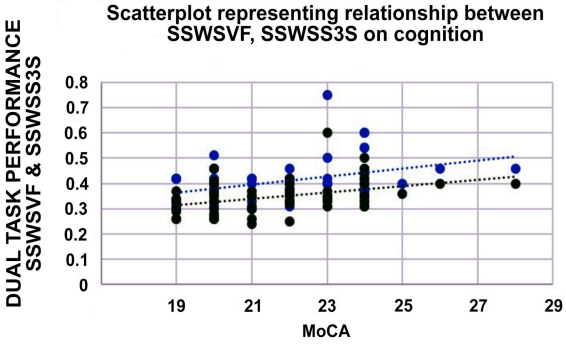
Figure 4: Representing the scores on MoCA of the subjects in the study

Table 5(a): Regression analysis of SSWSVF on cognition

Linear Regression Model	Standardized coefficient	t	Sig.
	Beta		
Self-selected walking speed verbal fluency (SSWSVF) Cognition	0.394	3.262	.002

Table 5(b): Regression analysis of SSWSS3S on cognition

Linear Regression Model	Standardized coefficient	t	Sig.
	Beta		
Self-selected walking speed serial 3 subtraction (SSWSS3S) Cognition	0.384	3.166	.002



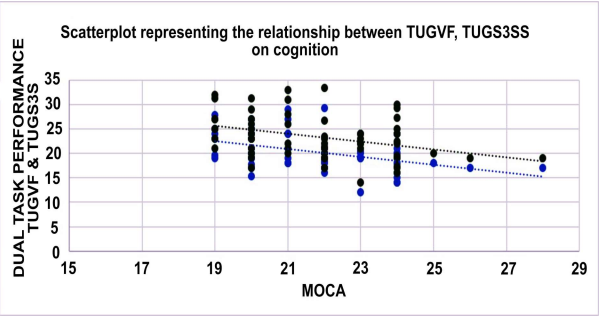
Graph 1: Regression analysis of SSWSVF, SSWSS3S on cognition

Table 5(c): Regression analysis of TUGVF on cognition

Linear Regression Model	Standardized coefficient	t	Sig.
	Beta		
Timed up and go Verbal fluency (TUGVF) Cognition	-0.429	-3.164	.001

Table 5(d): Regresion analysis TUGS3S on cognition

Linear Regression Model	Standardized coefficient	t	Sig.
	Beta		
Timed up and go serial 3 subtraction (TUGS3S) Cognition	-0.354	-2.883	.000



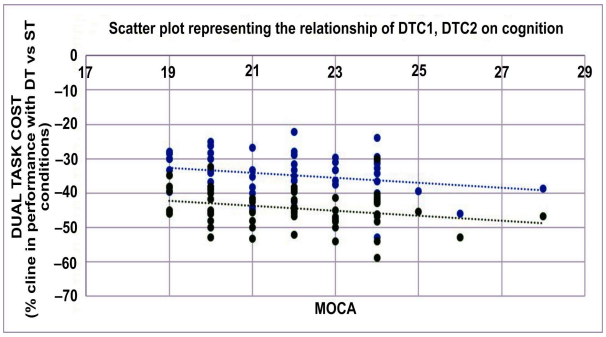
Graph 2: Regression analysis of TUGVF, TUGS3S on cognition

Table 6(a): Regression analysis of DTC1 on cognition

Linear Regression Model	Standardized coefficient	t	Sig.
	Beta		
Dual task cost (DTC1) Cognition	-0.224	-2.171	0.034

Table 6(b): Regression analysis of DTC2 on cognition

Linear Regression Model	Standardized Coefficient	t	Sig.
	Beta		
Dual task cost2 (DTC2) Cognition	-0.263	-3.739	.000



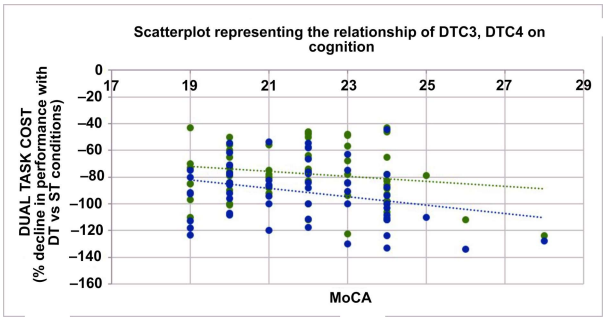
Graph 3: Regression analysis of DTC1, DTC2 on cognition

Table 6(c): Regression analysis of DTC3 on cognition

Linear Regression Model	Standardized Coefficient	t	Sig.
	Beta		
Dual task cost (DTC3) Cognition	-0.58	7.913	.000

Table 6(d): Regression analysis of DTC4 on cognition

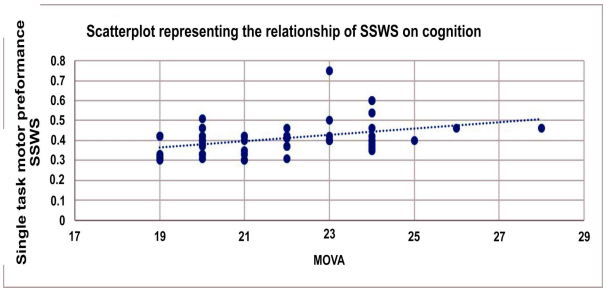
Linear Regression Model	Standardized Coefficient	t	Sig.
	Beta		
Dual task cost 4 (DTC4) Cognition	-0.65	2.416	.019



Graph 4: Regression analysis of DTC3, DTC4 on cognition

Table 7(a): Regression analysis SSWS on cognition

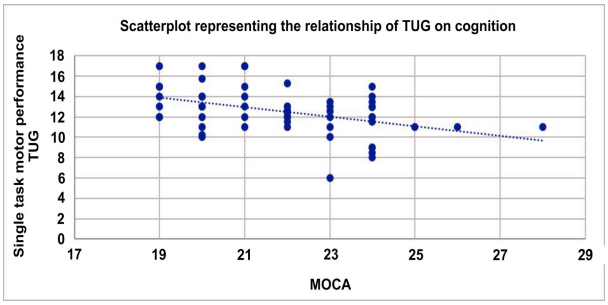
Linear Regression Model	Standardized coefficient	T	Sig.
	Beta		
Self-selected walking speed (SSWS) Cognition	0.434	3.674	.001



Graph 5: Regression analysis of SSWS on cognition

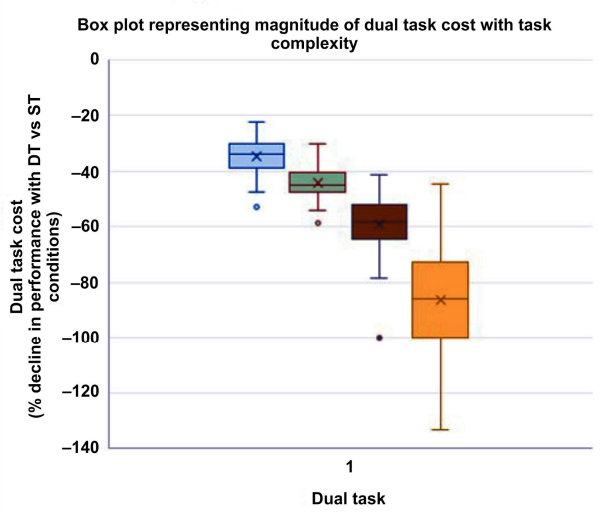
Table 7(b): Regression analysis of TUG on cognition

Linear Regression Model	Standardized Coefficient	t	Sig.
	Beta		
Timed up and go (TUG) Cognition	-0.422	7.885	.000



Graph 6: Regression analysis of tug on cognition

Magnitude of Dual Task Cost with Task Complexity



Box Plot 1: Representing magnitude of dual task cost with task complexity

DISCUSSION

The results of this study reveals that there is a significant linear relationship between cognition and dual task motor performance in sedentary middle aged obese adults. With regression analysis of SSWSVF, SSWSS3S, TUGVF, TUGS3S respectively on cognition, it shows that there is a direct linear relationship between SSWSVF, and SSWSS3S on cognition and an inverse linear relationship between TUGVF, and TUGS3S on cognition. This finding revealed that as the MoCA score decreases, there is a proportionate reduction in gait speed and increase in time required for completion of TUG.

Antonio G Lentoor *et al* (2022) and K. Decker *et al* (2017) found a significant inverse correlation between BMI and MoCA on neurocognitive tasks of attention, memory, and executive function.[18,19] Overweight and obesity are usually related to poorer cognition across lifespan.[10] Based on BMI data, individuals who are overweight or obese fall in the lowest quartile of global cognition, verbal fluency, delayed recall, immediate logical memory, and intelligence.[11] Elevated BMI has been correlated with reduced volume in a number of brain region (ventral diencephalon and brainstem) and grey matter atrophy in the frontal lobe (left superior frontal and right medial orbitofrontal cortex), temporal lobe, post-central gyrus, middle frontal gyrus, anterior cingulate gyrus, hippocampus, thalamus, midbrain and reduced integrity of white matter throughout the brain.[20-22] Medial orbitofrontal cortices, hippocampus, and cerebellum are involved in reward-based learning, memory, motor control and learning, structural alterations in these regions may be associated with deficits in cognitive and motor domains.[23-25]

Midlife obesity potentially compromises a person's memory, learning, and executive functions.[26] Cognitive domains involved in learning, memory, and executive function are mainly sub served by the hippocampus and prefrontal cortex. Long-term potentiation (LTP) is considered to be the major cellular mechanism that contributes to learning and memory.[27] High fat levels impair hippocampal LTP in the dentate gyrus and it also diminish hippocampal long-term synaptic potential maintenance.[28]

Obesity in mid-life was correlated with lower blood brain barrier (BBB) integrity.[29] Obese individuals usually have increased levels of circulating plasma amyloid proteins and it can impair BBB integrity.[30,31] Furthermore, active transport of consummatory regulatory hormones such as leptin and ghrelin through the BBB was impaired in obese individuals which will inhibit their positive roles in synaptic plasticity through actions in the hippocampus.[29]

Neurotrophins, such as Insulin like growth factor-1 (IGF-1) and Brain derived neurotropic factor (BDNF), can mediate obesity's effects on cognition and behaviors. IGF-1 exerts its effect to stimulate cell growth and proliferation and promote β-amyloid clearance in the brain. Obese individuals usually show IGF-1 resistance, degrading their capability to prevent β-amyloid deposition and contributes to neurodegeneration.[32-34]BDNF promotes neuronal differentiation, survival, neurogenesis, and brain plasticity.[35]High fat diet reduces BDNF level in the hippocampus, and the impaired hippocampal synaptic plasticity and cognition are possibly through BDNF's effects on dendritic spines.[36]

Furthermore, obese individuals possess more adipose tissues for fat storage. Adipose tissue produces adipokines and cytokines which are crucial components of metabolism. Elevated level of adipokines and cytokines , can in turn leads to structural brain abnormalities.[37,38]

Leptin an inflammatory cytokine can influence neuronal excitability in the brain, neurogenesis, axonal growth and synaptogenesis, obese individuals exhibit leptin resistance and is associated with cognitive deficits.[39-42] Interleukin-1 is another cytokine produced by the adipose tissue, which can cross the blood brain barrier and affect cognitive function through neuroinflammation.The researcher assumes that these are the possible reasons for the inverse relationship between BMI and MoCA found in this study.

As a prerequisite for finding out whether a linear relationship exists between cognition and dual task motor performance study sought to found out whether a linear relationship exists between cognition and single task motor performance in sedentary middle aged obese adults. Similar to the findings of Karine Peres etal (2020) and Jae Joon Lee *et al* (2017) the present study found an inverse relationship between obesity and gait speed (m/s) and a direct relationship between obesity and timed up and go duration (secs), which are the single tasks incorporated in this study. The results evidenced that obese individuals will demonstrate slower gait speed and longer TUG duration.[12,43] The inclusion of subjects with varying levels of cognition in the present study reveals that the varying cognitive level among the subjects may have an influence over decrement in gait speed and longer TUG duration in obese individuals, as the results supports.

The study revealed that there is a linear relationship between cognition and dual task motor performance in middle aged obese adults which indicates that as MoCA score decreases dual task motor performance also decreases. In line with the findings of Olufunmilola *et al* (2016) our findings also evidenced that there is a decline in an individual's motor performance in dual task conditions relative to single task conditions, which states that obese subjects are at increased risk of fall when performing dual task.[14] Studies reported that obese individuals have inability to effectively allocate attention appropriately to the two tasks in dual-task contexts which may also be a possible reason for the relationship the researcher found in this study.[44,45]

In order to explore the extent of decline in dual task performance the dual task cost (DTC) was calculated. Dual task cost for motor performance is the percentile decline in the motor performance in the dual task conditions relative to single task conditions. A greater positive value for DTC indicated a greater performance deterioration under the dual-task condition compared with the single-task condition.[75,76] In the current research DTC was higher for the Timed up and go$_+$ Serial 3 subtraction which is having more complexity amongst of all other tasks used in this study.

Regression analysis of dual task costs (DTC) on cognition in the study, apparently founds that there is an inverse linear relationship between dual task cost and cognition. Thus as subjects MoCA score decreases, dual task cost increases. The possible mechanism for this inverse linear relationship may be due to the involvement of prefrontal cortex which plays a major role during single- and dual-task gait functions in obese adults, and this activation corresponds to the complexity of the task.[22]

According to Lenoir and Gentier *et al* (2013) additional recruitment of neural resources from the PFC is required to maintain the desired gait performance in obese individuals to compensate for obesity-related decrements in proprioception and informational processing speeds.[77,78] Thus it can be inferred that in the current study, additional recruitment of neural resources from the PFC to maintain the desired gait performance was due to the task complexity element which we introduced, and it may be a possible reason for the linear relationship found between cognition and DTC.

In the present research, while comparing the magnitude of dual task cost with task complexity results apparently shows that as task complexity increases dual task cost increases. Considering the median values of DTC1, DTC2, DTC3, DTC4 respectively it shows that DTC was greater for the 4th task (TUGS3S), which suggests that as task complexity increases dual task cost increases.

Obese individuals may experience difficulty when performing dual task as obesity cause decline in cognitive and motor performance as well. But it is unclear how obese classes (1,2,3) are related to dual task performance particularly with tasks of varying levels of difficulty. The present study shows that there is a relationship between obese class and dual task performance. Thus an individual in obese class 3 will demonstrate a greater decrement

in dual task performance when compared with the performance of an individual in obese class 1 and 2. The same trend can be seen in the relationship between cognition and dual task cost. This decrement in the dual task performance is associated with problems in executing and sustaining activities of daily living.

The findings of this study implies that there is a linear relationship between cognition and dual task performance in sedentary middle aged obese adults.

Limitations

- Equal distribution of subjects was not obtained in all obese classes
- Equal gender distribution was not obtained

Suggestions for Future Studies

Future studies can be conducted:

- To find the impact of cognitive motor interference during complex motor task
- To find the effect of dual task exercise training on improving dual task mobility, reducing the falls and fall related injuries.
- Other adiposity measures can be used as indicators of obesity like Waist hip ratio.
- Other cognitive domains like reaction time, problem solving can be used in the dual task testing paradigm.
- Studies can be done on different age groups including children.

CONCLUSION

The purpose of the study was to find out the relationship of cognition and dual task performance in sedentary middle aged obese adults. In the current research there exists a weak to moderate linear relationship of cognition with dual task performance and dual task cost and the strength of this relationship was greater for more challenging task. These findings provide resources for future studies regarding designing of dual task exercise training strategies to improve dual task performance, reducing falls and fall related injuries in middle aged obese adults. Moreover, it also provides implications for considering task complexity as the best parameter in the designing of dual task training programs for obese individuals in improving their dual tasking capability and thus the quality of life.

LIST OF ABBREVATIONS

BBB: Blood brain barrier

BDNF: Brain derived neurotrophic factor

BMI: Body mass index

DT: Dual task

DTC: Dual task cost

GS: Gait speed

IGF: Insulin like growth factor

IL: Interleukin

S3S: Serial 3 subtraction

SSWSVF: Self-selected walking speed + Verbal fluency

SSWSS3S: Self-selected walking speed + Serial 3 subtraction

ST: Single task

TUG: Timed up and go

TUGVF: Timed up and go + Verbal fluency

TUGS3S: Timed up and go + Serial 3 subtraction

VF: Verbal fluency

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