Association Between Body Mass Index and Cognitive Impairment in Elderly Subjects with Type 2 Diabetes Mellitus: A Cross-Sectional Study

Maria Guia Estrella A. Dela Cruz, MD,[1] Michelle Co, MD,[1] and Carter Rabo, MD[2]

Abstract

Background. Chronic illnesses such as Type 2 diabetes mellitus (T2DM) and obesity have been implicated as risk factors in the development of cognitive impairment (CI), but despite this, definite association between the two conditions in increasing cognitive impairment risk is not well defined.

Objective. This study aims to examine the association between body mass index (BMI) and cognitive impairment (CI) in elderly patients with Type 2 diabetes mellitus.

Methods. This is a cross-sectional study conducted in the outpatient clinics of a private hospital in Manila which included elderly patients with Type 2 diabetes. BMI categories of the subjects were determined using the Asia-Pacific criteria and the Montreal Cognitive Assessment – Philippines (MOCA-P) was administered to subjects who fulfilled the inclusion criteria. Descriptive statistics were used to determine the prevalence of impaired cognition among subjects while risk ratio analysis was used to determine the correlation between BMI and CI. Correlation analysis and linear regression analysis were used to determine the presence of association between cognition (measured by MOCA-P scores) and BMI. For all analysis, a 95% level of significance was used.

Results. A total of 109 subjects from the outpatient clinics were included in the study. A high percentage of the study population (90.83%) had CI based on MOCA-P scores. Subjects that belonged to the extremes of BMI- underweight and obese class 2 had higher incidence of CI compared to the other groups. Underweight subjects had 1.103 (95% CI: 1.038 to 1.172) times likelihood of having impaired cognition (p-value 0.0016), while obese 2 subjects had 1.110 (95% CI: 1.040 to 1.184) times likelihood of having impaired cognition (p-value 0.0016). Regression analysis revealed that in subjects with diabetes of less than 10 years, cognition scores were negatively correlated to BMI (p-value 0.0454). Correlation analysis revealed that at the general population level, regardless of the external factors, increasing or decreasing BMI did not have significant effect on cognition scores.

Conclusion. Subjects who belonged to the extremes of BMI- underweight and obese class 2 – had higher incidence of CI compared to the other BMI groups. Among subjects with T2DM duration of less than 10 years, cognition scores tend to be negatively correlated to BMI.

Keywords. Type 2 diabetes mellitus, cognitive impairment, BMI

Introduction

Type 2 diabetes mellitus (T2DM) and high body mass index (BMI), specifically being overweight and obese are interrelated and often occur together. It may also be considered that high BMI or being overweight or obese may even increase the risk of having T2DM.[1] BMI is one of the important factors to consider in T2DM, especially when it comes to anticipating microvascular and macrovascular complications, as well as other chronic illnesses - such cognitive decline.[2,3] Despite the frequent association of overweight and obesity with T2DM, not all of these individuals are obese and may fall under any of the weight categories. In this light, this study aims to see the relationship of BMI to the risk of having cognitive impairment (CI) among elderly subjects with T2DM.

[1] Section of Endocrinology, Diabetes and Metabolism, Department of Internal Medicine, Chinese General Hospital and Medical Center
[2] Section of Neurology, Department of Internal Medicine, Chinese General Hospital and Medical Center
Corresponding Author: Maria Guia Estrella A. Dela Cruz, MD eMail: guiadelacruzmd@yahoo.com

According to the World Health Organization (WHO) CI is characterized by evidence of lower performance in one or more cognitive domains that is greater than would be expected for a patient's age and educational background. Cognition includes the memory, executive function, attention, language, and visuospatial skills. CI may vary from mild to severe dementia, which is characterized by global and irreversible cognitive decline that can impair daily activities. It affects about 50 million people and cases increase continuously due to the aging population. It has significant social and economic impact and has no remedy; thus, the focus is to identify reduce modifiable risk factors.[3] Among these risk factors, T2DM and obesity are of great concern.

There is an increased risk of decline in cognition and dementia associated with T2DM.[3-6] Studies have associated T2DM with a significantly increased risk and rate of cognitive decline and an increased risk of dementia.[3,4] There is an estimated 73% increase in the risk of all types of dementia, 56% increased risk of Alzheimer dementia and a 127% increased risk of vascular type of dementia compared to other persons without T2DM, which was demonstrated by a meta-analysis done by Gudala et al.[6]

BMI affects the development of CI later in life, although different studies have conflicting findings regarding BMI that may confer risk versus protection against CI. Lower baseline BMI has been linked to rapid decline in mild CI in some studies.[18] On the other hand, West et al. revealed that obesity was associated with an increase in rate of CI in elderly individuals, while BMI was inversely associated.[10] Another study correlated high waist-hip-ratio rather than BMI with increased risk of CI among elderly in those classified to have higher than normal BMI (>25.3 kg/m^2).[9] The obesity paradox in aging even suggests that higher BMI may be protective.[12,19]

T2DM risk is increased with obesity and both conditions have increasing prevalence especially in the aging population.[4-6] Despite this relationship between the two conditions, no study has yet to investigate the relation of BMI on the risk of CI on elderly subjects with T2DM.

Several prospective studies have demonstrated the relationship between deterioration of cognitive function and poor glycemic control among elderly subjects with T2DM.[3-6] Similarly, BMI has been shown to affect the risk for development of CI, although some studies exploring relationships between BMI and CI in the elderly are conflicting.[8-12] High BMI, specifically obesity, is identified as an independent risk factor in the development of CI.[3,11] Evidence suggests that brain changes that are related to the normal aging processes may be exacerbated by obesity.[13]

On the other hand, another study demonstrated that being overweight and obese may even be protective against the development of impairment of cognition and occurrence of dementia in women in the older age group.[16] Low BMI and CI have also been correlated. It has been demonstrated that low baseline BMI was associated with significant decline in cognitive performance in individuals with mild CI over one year.[16]

There are many tests that can be employed to identify early CI. One of these is the Montreal Cognitive Assessment (MOCA) by Nasreddine et al.[16] It is a brief (10–15 minute) 30-point cognitive screening test which aids in identifying subjects with mild CI (MCI) and dementia. It evaluates executive functions: attention and concentration memory, language, visuo-constructional skills, conceptual thinking calculations and orientation.

Unlike the Mini-mental status exam (MMSE), MOCA-P test is readily available and has had adaptations in many languages, including Filipino, thus, making it a suitable tool for use in detection of MCI.[17]

Objectives

General objective: This study aims to examine the association between BMI and CI in elderly subjects with T2DM.

Specific Objectives

1. To determine the prevalence of CI among subjects with T2DM whose ages range from 65 to 80 years old.
2. To determine the prevalence of CI across different BMI categories among elderly subjects with T2DM.
3. To determine if any of the following factors present in the study population had contributed to the risk of having CI among the different BMI classifications:
    - Age
    - Sex
    - Duration of T2DM
    - Highest educational attainment

Methodology

Study Design. This is a cross-sectional study conducted in the outpatient clinics of Chinese General Hospital and Medical Center.

Setting. The study involved 109 subjects from the outpatient charity and private clinics of Chinese General Hospital, seen from August 2019 -January 2020.

Participants. This study included a total of 109 elderly subjects with T2DM aged 65 - 80 years old with no history of any neuropsychiatric illness, who were screened from a total of 150 subjects who were initially invited to join the study. Participants were selected from the charity and private outpatient clinics of Chinese General Hospital.

During enrolment, all eligible subjects were evaluated for evidence of T2DM based on history, physical exam and laboratory findings. All eligible participants were also evaluated for any present or past history of neuropsychiatric illness that may confound the outcomes. Out of the total 150 subjects initially selected for the study only 109 were included due to patient refusal to complete the questionnaire, with unconfirmed history of previous neurologic impairment and presence of other conditions which were stated in the exclusion criteria (specifically heart failure and Parkinson's disease).

Inclusion criteria. The study included elderly subjects with T2DM aged 65-80 years with new or previously diagnosed T2DM. Presence of T2DM was confirmed based on the American Diabetes Association (ADA 2019) Guidelines Diagnostic criteria for T2DM:[1]

- Fasting plasma glucose or sugar (FPG/ FBS) ≥ 126 mg/dL (7.0 mmol/L).
- 2-hour plasma glucose (2h-PG) ≥ 200 mg/dL (11.1 mmol/L) during oral glucose tolerance test (OGTT). The test should be performed using a glucose load that contains the equivalent of 75-g anhydrous glucose in water.
- HbA1c ≥ 6.5% (48 mmol/mol). The test should be done using a method that is certified by the National Glycohemoglobin Standardization Program (NGSP) and standardized to the Diabetes Control and Complications Trial (DCCT) assay
- Subjects who have classic symptoms of hyperglycemia/hyperglycemic crisis, a random blood sugar or random plasma glucose ≥ 200 mg/dL (11.1 mmol/L)

Exclusion Criteria. This study did not include any patient with other types of diabetes such as Type 1 diabetes, autoimmune or monogenic diabetes. Those who have evidence of current or past neurological or psychological conditions that may confound outcomes were also excluded. These conditions include (but were not limited to): Alzheimer's disease, Parkinson's disease, Huntington's disease, Lewy Body, Stroke, Fronto-temporal dementia, Brain metastasis, ALS (Amyotrophic lateral sclerosis), Sleep behavior disorder, Brain tumors, Multiple sclerosis, Head trauma. Depression, Schizophrenia, Heart failure, Substance abuse, and/or HIV (human immunodeficiency virus)

Description of Outcome Measures. Each patient was initially analyzed based on their baseline characteristics: age, sex, highest educational attainment, T2DM duration and level of glycemic control (using available results of fasting blood sugar, 75 g oral glucose tolerance tests/75g OGTT or HbA1c, whichever is available) and BMI (to be calculated from weight in kg and height in meters). A calibrated weighing scale and height chart was used to ensure accuracy of measurements. BMI was calculated by dividing the weight in kilograms by the height in meters squared.

Diagnosis of T2DM mellitus was confirmed based on the ADA diagnostic criteria as mentioned above.[1]

Participants were categorized as underweight (<18.5 kg/m^2), normal weight (18.5–22.9 kg/m^2), overweight (23–24.9 kg/m^2), obese I (25 -29.9 kg/m^2) and obese II (≥30 kg/m^2) using the Asia-Pacific BMI criteria.[21,22]

Included participants were asked to complete the MOCA-P test which was used to assess for the presence of CI. Subjects were classified based on their test scores by grading the severity of CI which were based on the following MOCA score cut-offs:[14,15]

- 18 - 25 = mild cognitive impairment
- 10 - 17 = moderate cognitive impairment
- less than 10 = severe cognitive impairment

Data Sources/Measurement. Data regarding each participant's age, sex, highest educational attainment, and duration of T2DM were obtained directly from the patient by history. Biochemical evidence of T2DM were obtained from medical records of laboratories done in the last three months prior to the interview. Weight and height were measured on the day of enrolment and interview using a calibrated weighing scale and height meter. BMI was calculated by dividing weight in kilograms (kg) by squared meter (m²) manually, then rechecked using Excel®.

MOCA-P test scores were obtained by administering the questionnaire to each participant and by summation of all correct answers. An additional 1 point was added to the total score for those who had less than 12 years of educational attainment as instructed in the MOCA-P questionnaire.

Bias. Participants of this study were obtained from the pool of subjects in the charity OPD and the private outpatient clinics of consultants from the Section of Endocrinology. Purposive sampling was done for both charity and private subjects since the number of participants who fulfill the inclusion criteria and none of the exclusion criteria were limited. To eliminate selection bias, all screened subjects who fulfilled the inclusion criteria were included in the study. Attempt to avoid bias in study management was done by undergoing training and certification to properly administer the MOCA-P test.

Study Size. Using the *OpenEpi* application, sample size was calculated with the following assumptions:

- Population size (for finite population correction factor or fpc) (N): 2051
- Hypothesized % frequency of outcome factor in the population (p): 95% ± 5
- Confidence limits as % of 100 absolute + %) (d): 5%
- Design effect (for cluster surveys-DEFF): 1

Based on these, we targeted 127 participants.

Quantitative Variables. Quantitative variables measured in the study included age, weight, height, BMI, duration of T2DM, latest fasting blood sugar, HbA1c or 75 g OGTT results, highest educational attainment (which was measured using length of education in years) and finally MOCA-P test scores.

Statistical Methods/Statistical Analysis. Descriptive statistics were used to determine the prevalence of CI among elderly subjects with T2DM.

Risk ratio analysis was performed to determine which among the demographic and clinical characteristics were significantly associated with prevalence of CI in the study population. Risk ratios were also computed to describe the expected degree of impact or effect of each level of demographic/clinical characteristics to subjects' risk of having impaired cognition. The interval estimates of the risk ratios also served as basis to interpret whether the demographic/clinical attributes will significantly

Table I. Baseline Characteristics of the Study Population

Age	N (%)
Early Elderly	100 (71.7)
Old elderly	9 (8.25)
Sex (n, %)	N (%)
Male	16 (14.67
Female	93 (85.3)
Highest Educational Attainment	N (%)
(<12 years)	77 (70.6)
(>12 years)	35 (32)
Duration of T2DM	N (%)
< 10 years	57 (52.29)
≥ 10 years	52 (47.7)
Measures of glycemia	Mean (Median, Range)
FBS mg/dl n=50	161.8 (143, 90-280)
HbA1c n = 79	7.5 (7.1, 5-12.6)
BMI	N (%)
Underweight	2 (1.8)
Normal Weight	32 (29)
Overweight	29 (26.6)
Obese 1	38 (34.86)
Obese 2	8 (7.39)

Table II. Overall Prevalence of Subjects with Impaired Cognition

Classification/Diagnosis	Frequency	Prevalence Rate
Normal Cognition	10	9.17%
Impaired Cognition	99	90.83%
Total Number of Subjects	109	

Table III. Cognitive Impairment and Subjects' Body Mass Index

BMI	Total	Cognition Status		Prevalence Rates	
		Normal Cognition	Impaired Cognition	Normal Cognition	Impaired Cognition
Underweight	2	0 (0.00%)	2 (1.83%)	0.00%	100.00%
Normal	32	2 (1.83%)	30 (27.52%)	6.25%	93.75%
Overweight	29	2 (1.83%)	27 (24.77%)	6.90%	93.10%
Obese 1	38	6 (5.50%)	32 (29.36%)	15.79%	84.21%
Obese 2	8	0 (0.00%)	8 (7.34%)	0.00%	100.00%

increase/decrease/have no effect on the risk of a patient to be diagnosed with impaired cognition. If the interval estimate contained the point value of 1 or the p-value is not less than 0.05, then the attribute has no significant effect on the risk of having the impairment. For all analysis, a 95% level of significance was used. Correlation analysis and linear regression analysis were used to determine the presence of association between cognition (measured by MOCA-P scores) and BMI classification if the other factors/variables were controlled as confounders.

Ethical Considerations. Subjects who are eligible to participate in the study will be asked to sign a consent form. Prior to signing the investigator will discuss the study background, study procedure and will inform the subjects regarding the non-disclosure policy. All subject details shall be kept confidential. Each patient will be assigned a number to prevent identification.

Results

Baseline Characteristics. The study enrolled a total of 109 subjects out of the initial 150 who were invited for the study. These subjects were diagnosed with T2DM, ranging from age 65 - 85 years at the time of enrolment. One hundred subjects were categorized as early elderly (from ages 65-74 years) and nine were classified as late elderly (≥75 years) based on the classification mentioned by Orimo et al.[25] The number of female subjects were 93 while male subjects were only nine. A majority (70.6%, 77 out of 109) of subjects attained primary to secondary level of education (<12 years of education) while only 32% or 35 out of 109 were able to reach tertiary level of schooling (≥ 12 years of education). Duration of T2DM ranged from 1 to 30 years among the study population, 52% of subjects had < 10 years of disease duration and the remaining 47.7% had T2DM for > 10 years.

Only 50 subjects had FBS results at the time of evaluation, with values ranging from 90-280 mg/dL, while only 79 out of 109 subjects had available HbA1c results, with values ranging between 5 - 12.6. The average FBS was at 161.8 mg/dL, with a median of 143 mg/dL, while the average HbA1c was 7.5 with a median of 7.1 (*Table I*). Since availability of recent HbA1c and FBS levels were not consistent for the subjects, these variables were only used to confirm the diagnosis of T2DM but were not included in the statistical analysis. All participants had their BMI determined by dividing their weight in kilograms (kg) by their height in meters (m) squared. Majority (34.86%) of them fell under the weight category of Obese class 1 (25 -29.9 kg/m^2).

Statistical Analysis. The prevalence of impaired cognition among elderly subjects with T2DM and its association with BMI and across demographic/clinical attributes was initially analyzed. Summary tables presented indicate the prevalence of impaired cognition among a group of elderly subjects with T2DM. Prevalence rates were also computed across some demographic and clinical characteristics. Risk ratio analysis was performed to determine the association of BMI with the incidence of CI. For all analysis, 95% level of significance was used. It was observed that 90.83% of the 109 subjects (or 9 out of 10) are diagnosed with impaired cognition (*Table II*).

Prevalence rates of impaired cognition across different BMI classifications were also determined. Risk ratio analysis was performed to determine whether BMI classification was significantly associated with CI. The p-values of the risk ratios serve as basis for conclusion; a p-value less than 0.05 implied that there is a significant association between the CI and the demographic/clinical characteristics.

All subjects that belong to underweight and obese 2 groups had MOCA-P scores compatible with impaired

Table IV. Association Between Cognitive Impairment and Patient's BMI

BMI	Risk Ratio Analysis (Impaired: Normal)			
	Risk Ratio (RR)	95% CI		p-value
Underweight	1.103	1.038	1.172	0.0016
Normal	1.046	0.930	1.177	0.4510
Overweight	1.034	0.915	1.170	0.5893
Obese 1	0.892	0.769	1.036	0.1341
Obese 2	1.110	1.040	1.184	0.0016

Table V. Partial Linear Correlation between Cognition Scores (MOCA-P) and BMI Scores (Analyzed by strata: Gender, Age, Disease Duration, Educational Attainment)

Variable (Factor)	Correlation Coefficient	p-value
Sex		
Male	0.46871	0.0671^{ns}
Female	-0.13017	0.2136^{ns}
Age Category		
Early Elderly	-0.04311	0.6686^{ns}
Late Elderly	-0.24366	0.5609^{ns}
Disease Duration		
< 10 years	-0.26608	0.0454*
≥ 10 years	0.12871	0.3632^{ns}
Educational Attainment		
< 12 years	-0.17395	0.1303^{ns}
≥ 12 years	0.25173	0.1646^{ns}

Table VI. Linear Regression Model 1: BMI as the Sole Predictor of MOCA-P scores Among Subjects with T2DM < 10 years.

Variable/(Factor)	Parameter Estimate	p-value
Intercept	21.44156	<0.0001***
BMI	-0.05739	0.6224^{ns}
Simple Linear Regression (One-way Analysis - No Confounder) Dependent Variable: Cognition Scores (MOCA-P) Independent Variable: BMI Scores		
R-square: 0.0023 / Adjusted R-square: -0.0071		

Table VII. Linear Regression Model 2: Association between BMI and Cognition Scores when Other Factors are Considered (Sex, Age, Disease Duration and Educational Attainment)

Variable/(Factor)	Parameter Estimate	p-value
Intercept	40.060342	<0.0001***
BMI	-0.084688	0.4938^{ns}
Sex	0.416080	0.4457^{ns}
Age	**-0.252486**	**0.0387***
Disease duration	-0.015919	0.7727^{ns}
Educational Attainment	0.176915	0.6743^{ns}
Multiple Linear Regression Dependent Variable: Cognition Scores (MOCA-P) Independent Variable: BMI Scores Extraneous variables: Gender, Age, Disease Duration, Educational Attainment (including all extraneous variables, whether significant or not)		
R-square: 0.0493 / Adjusted R-square: -0.0032		

Table VIII. Linear Regression Model 3: (Dependent Variable: Cognition Scores (MOCA-P), Independent Variable: BMI Scores, Extraneous variable: Age

Variable/Factor	Parameter Estimate	p-value
Intercept	38.806848	<0.0001***
BMI	-0.092532	0.4256^{ns}
Age	-0.238956	0.0400*
R-square: 0.0414/ Adjusted R-square: 0.0233		

cognition (both prevalence rates = 100%) (Table III). Risk ratio analysis revealed that the risk of having impaired cognition was only associated with the underweight and obese 2 groups (Table IV). Underweight subjects had 1.103 (95% CI: 1.038 to 1.172) times the likelihood of having impaired cognition as compared to other subjects. On the other hand, obese 2 subjects had 1.110 (95% CI: 1.040 to 1.184) times the likelihood of having impaired cognition as compared to the other patient groups. Results are inconclusive for the other BMI categories.

Correlation analysis and linear regression analysis were used to determine the presence of association between cognition (as measured by MOCA-P scores) and BMI classification if the other factors/variables were controlled as confounders. The regression model was interpreted to examine the effect BMI on the cognition score of the subjects after accounting for the effects of these confounders.

Prior to performing the regression method, correlation analysis was done to examine if there is a linear pattern on the relationship between the BMI scores and cognition scores (MOCA-P) regardless of other external factors. Correlation analysis revealed that there was no significant unconditional correlation or linear trend pattern between the BMI scores and the cognition scores (MOCA-P) of the subjects (correlation coefficient -0.04769 *p = 0.6224*)

Since linear correlation did not exist in the study population, a series of partial correlation analyses was performed to determine whether linear correlation exists between BMI scores and cognition scores on a specific group/collection of subjects (or strata). The results of the partial linear correlation analyses are presented in *Table V*.

Based on the results, significant linear correlation between BMI and cognition scores (MOCA-P) were only observed when the analysis was exclusively performed among those subjects with disease duration of less than 10 years (*Table VI*).

Regression Analysis. The results from partial correlation analysis only yielded significant results for a specific

group, meaning the previous conclusion cannot be generalized to the entire group of subjects under this study. Thus, regression analysis was performed to determine whether BMI and cognition scores are significantly associated in the general population level. Regression analysis was also used to measure the expected effect of BMI and other external factors (possible confounders) on cognition scores (MOCA-P).

Series of linear regression analyses was performed, and different set of models are generated to discover the underlying effect of BMI, with or without the extraneous factors (confounders).

The second regression model was used for the other 4 extraneous factors as additional explanatory variables in addition to BMI. This model examined whether the other factors possibly contributive on the association between BMI and cognition scores.

The results revealed that among the five factors/variables being considered, only age is found to be significantly associated with cognition scores (MOCA-P).

The third regression model (*Table VIII*) included BMI (the primary factor of interest in this study) and age (the sole significant variable from the linear regression model 2). This model determined if BMI had a significant effect on cognition scores after accounting for age.

Similar to linear regression model 2, it was still observed that cognition scores (MOCA-P) is only significantly associated with age and not BMI classification. Further, it can be concluded that as the subjects get older, the cognition scores tend to decrease. Specifically, on the average, a one-year increase on patient' age is deemed expected to lower his/her MOCA-P score by 0.23 points. Therefore, the results of all regression models consistently reveal that cognition scores (MOCA-P) are not significantly associated with BMI numeric scores

Discussion

A total of 109 subjects from the charity and private outpatient clinics of one medical center in Manila were included in the study. Subjects enrolled were classified under the different BMI classifications- ranging from underweight to obese class 2 with majority belonging to obese class 1 group. Aside from BMI, subjects were also classified based on age (early versus late elderly), T2DM duration, and highest educational attainment which may affect MCI incidence.[27,29]

The results of the study revealed that a high percentage of the study population (90.83%) had CI based on MOCA-P test scores, although prevalence rates of impaired cognition across the different categories of BMI tend to differ. This value was observed to be higher in comparison to the study done by Blanquisco et. al. which only revealed that 45% among elderly Filipinos with T2DM mellitus had CI.[27] The disparity between the prevalence of CI among the two studies may be due to the higher cut-off scores for MOCA-P.[14,25] Normal values were given a cut-off of $\geq$ 21 in the previous study, while the cut-off value for normal MOCA-P test used in this study was at $\geq$ 26 which was based on the scores used to define the different levels of CI suggested by Nasreddine.[25] Aside from the score cut-off, this study also enrolled slightly older participants ranging between 65 to 80 years of age.

Subjects that belonged to the extremes of BMI- underweight and obese class 2 were revealed to have a higher incidence of CI compared to the other groups. Similar findings of high incidence of cognitive decline among the underweight elderly were also seen in the study done by Driscoll et al and among elderly with obesity in a different study by Concha-Cisternas et al.[19,28] This observation may be explained by the obesity paradox in aging which suggests that adiposity in later life may be protective to cognitive function.[12,17]

Correlation analysis revealed that at the general population level, regardless of the external factors, increasing or decreasing BMI did not have significant effect on cognition scores. Regression analysis on the other hand revealed that among subjects with a disease duration of < 10 years, cognition scores tend to decrease as their BMI increased. This implied that subjects with higher BMI tend to have lower MOCA-P scores if their T2DM duration is < 10 years, which may mean that risk of CI is no longer associated with BMI among those with longer T2DM duration. Other factors did not significantly affect the relation of BMI and MOCA-P scores. It was also observed that when the possible effects of other factors were disregarded, BMI still had no significant association with cognition scores (MOCA-P).

Limitations. The limitation of the study is the small sample size, wide disparity in distribution of subjects according to age range and BMI, locale, and short amount of time for recruitment. Aside from these, evaluation of glycemic control was not used for analysis since the researchers only made use of available results (FBS, HbA1c or 75 g OGTT). These were taken within a 3-month period from the time of enrolment, performed in different laboratories, and were not standardized. These made these data non-comparable.

Conclusion

Subjects that belonged to the extremes of BMI - underweight and obese class 2 - were revealed to have a higher incidence of CI compared to the other BMI groups. Among subjects with a disease duration of < 10 years, cognition scores tend to decrease as BMI increased.

Recommendations

1. Subjects who had evidence of CI were advised to consult with a neurologist for further evaluation and management.
2. Subjects were advised to follow-up regularly with their attending physicians.
3. A larger number of subjects belonging from the late elderly group should be included in the study to make the population more representative.

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