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Reported diabetes mellitus: incidence and determinants in cohort of community dwelling elderly people in São Paulo City, Brazil: SABE study, health, wellness and aging

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Abstract *To verify the association between the incidence of DM and predictors, in a cohort of elderly people. Elderly people (≥ 60 y) were analyzed, of both genders, participants of the SABE Survey, carried out in the city of São Paulo, Brazil, in 2000 (n = 2,143) and 2006 (n = 1,115). The study variables were: DM; demographic (gender, age group, education level, companionship in the residence), nutritional status (risk for obesity, body obesity, and high abdominal fat), clinical (number of reported diseases), and lifestyle (alcohol consumption, smoking, intake of meat and fruit and vegetables). Multiple logistic regression (p < 0.05) was used to verify the association between variables of this study, with the statistical software Stata/SE 10.1. In 2006, 914 subjects, survivors of 2000, were analyzed and 72 were identified as new cases of DM (7.7/1.000 person-years). It was found that body obesity (OR = 1.67, CI = 1.00 to 2.81) and high abdominal fat (OR = 2.32, CI = 1.47 to 3.67) were predictors of the incidence of DM in the elderly (p < 0.000). It was concluded that body obesity and abdominal fat are the variables which contribute to the development of DM in the elderly.*

Key words *Incidence, Diabetes mellitus, Elderly, Predictors*

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Introduction

The aging population has been accompanied by an increase in the incidence and prevalence of non-communicable diseases and disorders (NCDs), which generate a greater burden for individuals, families, and the State, and are the main cause of morbidity, disability, and mortality in the elderly population, in all regions of the world, becoming a challenge for developing countries, such as Brazil[1,2]. Among the most frequent chronic diseases in the Brazilian elderly population, is type 2 diabetes mellitus (DM)[3].

Studies show that the prevalence and incidence of DM present a tendency to increase. Biggs et al[4]. studied a cohort of elderly people (≥ 65 years) with a 12.4-year follow-up and found a DM incidence of 7.1/1000 person-years. According to these authors, the incidence of DM has doubled in the last 15 years and is higher in individuals between 65 and 79 years of age. Wild et al[5]. found that in the countries of Latin America and the Caribbean, the number of elderly (≥ 65 years) with DM will increase by 2030 by 194%. In Brazil, 21% of elderly individuals ≥ 65 years of age reported having DM, according to data from the Surveillance of risk factors and protection for chronic diseases by telephone survey (VIGITEL)[6], representative of Brazilian capitals and the Federal District.

The scientific literature contains evidence regarding the main factors that predispose individuals to the occurrence of DM in the adult population; however, there is still controversy about which determinants are associated with the development of DM in the elderly. Studies show that advancing age *per se* has been considered an independent condition for decreased glucose tolerance and, consequently, for the development of DM in the elderly[7,8]. However, other factors, such as level of schooling, physical inactivity, the presence of other morbidities, inadequate diet, obesity, intra-abdominal fat, smoking, and abusive use of alcoholic beverages are also associated with the risk of DM[8-10].

Knowledge of the main determinants of DM is essential to compose policies and projects aimed at reducing the occurrence of this public health problem in the population, especially in individuals living in the community, a scenario of propitious action to propose preventive actions to control determinants that may contribute negatively to the state of health[11]. According to Silva et al.[12] the presence of chronic disease in this segment of the population is influenced by risk factors that can be avoided or controlled, as long as they are recognized by both the individual and health professionals.

Epidemiological studies on DM in Brazil have been increasing, mainly with the young population and adults. However, studies to establish the incidence of DM, with follow-up of the same population, considering elderly individuals, living at home, are still incipient. Thus, this study aims to verify the determinant factors that contribute to the development of DM, in a cohort of elderly Brazilians living at home.

Methods

Study design and population

This is a longitudinal, association study, using data from the SABE Study: Health, Welfare, and Aging, carried out in the city of São Paulo-SP/Brazil, in 2000 and 2006.

In 2000, the SABE Study was coordinated by the Pan American Health Organization (PAHO), characterized as a multicenter, epidemiological, international, home-based survey in seven Latin American and Caribbean countries (Argentina, Barbados, Brazil, Chile, Cuba, Mexico, and Uruguay), with the objective of evaluating the living conditions and health status of the elderly in Latin America[13].

In Brazil, the study was carried out in the city of São Paulo, in 2000 and 2006, in order to verify changes in the living and health conditions of the elderly and their determinant factors, as a function of time. The survey was coordinated by the Faculty of Public Health (FSP) of the University of São Paulo (USP) and financed by the Foundation for Research Support of the State of São Paulo (FAPESP) and the Ministry of Health[14].

The SABE study population in 2000 consisted of 2,143 elderly (≥ 60 years) of both sexes, living in the city of São Paulo, who agreed to participate. The sampling process of this study was performed in a probabilistic way, using the two-stage cluster sampling method. For the sample of the first stage, the 72 census tracts registered in the Department of Epidemiology of the FSP of the University of São Paulo (USP) were considered, selected according to probability criteria proportional to the number of households, from the 263 census tracts of the National Survey of Household Sample (1995), from urban areas of the municipality of São Paulo, corresponding to 1,568 individuals interviewed[13,14].

The second stage consisted of 575 individuals, who lived near the selected sectors or, at most, within the limits of the districts to which the selected sectors belonged, corresponding to the increase made to compensate for the lower population density of elderly people aged 75 and over, and the higher mortality rate among men, totaling 2,143 household interviews[13,14].

In 2006, the individuals interviewed in 2000 were reevaluated, corresponding to 1,115 elderly (≥ 65 years), who again agreed to participate in the study. The reduction in the number of elderly people in the study period (2000 to 2006) occurred due to deaths (649), refusals (178), non-location (139), change of domicile (51), and institutionalization (11)[14].-

The questionnaire used to collect data for the SABE study was proposed by PAHO, translated and adapted for use in Brazil. Data collection was performed by trained interviewers, in two stages: 1) a home visit, conducted by one interviewer, covering questions about the health status of the elderly; 2) home visit, performed by two interviewers, responsible for anthropometric measurements, and balance, flexibility, and strength tests. The data collected were reviewed by a specialized technical group from FSP/USP[13].

The SABE Study was approved by the National Research Ethics Committee - CONEP and by the Research Ethics Committee - COEP of the FSP of USP. The elderly individuals who agreed to participate signed a Term of Free and Informed Consent, in 2000 and in 2006.

For the present study, of the 2,143 elderly interviewed in 2000, 1,747 reported not having received a diagnosis of DM in the SABE Study. Of those who reported not having received a diagnosis of DM in 2000, 914 were reassessed in 2006, after loss of participants due to death (649) and elderly who had not performed the measures of waist circumference, weight, and height (184).

Study variables

The dependent variable was diabetes mellitus in the 6-year study period (2000-2006), identified by the question "Has a doctor or nurse ever told you that you have diabetes mellitus, that is, high blood sugar levels? ". The response alternatives were: yes, no, do not know, and did not answer; the final two were considered as *missing*.

To verify the determinant factors of the incidence of DM in the study population, sociodemographic, nutritional status, clinical, and lifestyle variables were selected from the SABE study in 2000, which correspond to questions used in the international scientific literature to evaluate the causal hypotheses for the development of this disease. We chose to analyze these variables, prior to the reference to having the disease, in order to verify their effect in the 6-year period.

The sociodemographic variables were sex, age group, schooling, and living with others at home, which were reported by the elderly, identified and categorized in dichotomous variables, respectively, as: What is the sex of the interviewee? (Man and woman); How many full years of age are you? (60 to 74 and ≥ 75 years); What was the last grade you attended at school, did you pass? (< 8 and ≥ 8 years of schooling); and Do you currently live alone or with others? (alone and with others).

Regarding nutritional status and clinical variables, the risk for obesity, body obesity, abdominal fat, and number of diseases (systemic arterial hypertension, heart disease, and stroke) were used, respectively.

The risk for obesity (≥ 28 and < 30 kg/m^2) and body obesity (BMI ≥ 30 kg/m^2) was identified through the body mass index (BMI = weight - kg/height^2 - m) and classified according to PAHO[15], considering these classifications as possible causes for the development of DM. Abdominal fat was identified by the waist circumference values (elevated when WC ≥ 102 cm for men and ≥ 88 cm for women) proposed by the WHO[16]. The number of diseases was reported by the elderly and classified into 0-2 and 3 or more diseases.

Weight was measured using a portable scale (SECA, Germany), with a capacity of 150 kg and sensitivity of 1 kg. Waist circumference was measured using an inelastic tape measure. Measurement techniques were standardized according to Frisancho[17] and measurements were performed in triplicate using the mean values for the analysis.

In relation to the lifestyle variables, we also used the information reported and categorized in dichotomous variables as follows: ingestion of alcoholic beverage in the last three months (yes/no), current smoking (yes/no), at least three meats (beef, pork, poultry, and fish) per week (yes/no), and intake of at least two servings of fruits and vegetables (FLV) per day (yes/no).

Statistical procedures

The population of this study originated from a complex sampling process, and therefore sta-

tistical tests indicated for *surveys* were used. The relative frequency of all variables corresponds to the frequency weighted by the census sector to which the elderly belonged.

To calculate the incidence, the DM reported in 2006 was considered. The observation period (6 years) was determined for the survivors, considering the time between the 1st interview in 2000 (n = 2143) and the last in 2006 (n = 1115) and in a specific way for each case, since there were deaths and losses between the interview periods. The number of deaths that occurred up to the conclusion of data collection of the SABE 2006 study was 649, of which 560 were cases with a known date and 89 with a date attributed to those cases in which the date of death was unknown. There were 379 losses during the period, including 178 individuals who refused to be interviewed (considering the time elapsed between the first interview in 2000 and the date of the second interview in 2006, in which the refusal was given), and 139 individuals who could not be located, 51 individuals were transferred to another municipality and 11 were institutionalized (considering the average number of days between the date of the first interview in 2000 and the second interview in 2006).

The association between the dependent variable and the independent variables was verified by the Rao & Scott test and multiple logistic regression, with a significance level of 5%. The measure of magnitude of effect was verified by *odds ratio* (OR) values, and respective confidence intervals (95% CI).

Through the univariate analysis, the variables with $p < 0.20$, in ascending order of entry, were selected to compose the final multiple regression model, with the variables with $p < 0.05$ remaining, or those that changed by at least 10%, the value of the *odds ratio*. The collinearity was verified by the Variance Inflation Factor (VIF), considering absence of collinearity when the VIF was between 0.19 and 5.30. Sex and age groups were maintained to fit the model, regardless of the p value.

The calculations were performed using the statistical program *Stata Version 10.1 (Stata Corp., College Station, USA)*.

Results

Of the 914 individuals reevaluated in 2006, 842 did not report DM (60% female) and 72 reported having DM (58% female), constituting new cases of the disease (Table 1). The incidence rate of DM in 6 years of study was 7.7/1000 person-years.

Regarding the sociodemographic variables, it was found that of those who developed DM during the study period, 58.1% were women, 85.7% were 60-74 years old, 80.5% reported < 8 years of schooling, and more than 80% lived with others (Table 1).

Regarding the nutritional status, 59.2% of the new cases of the disease presented a risk for obesity, 30.8% were classified as obese, and 67.9% had excess abdominal fat.

According to the clinical and lifestyle variables, it was verified that 71.4% reported having 3 or more chronic diseases, 40% reported ingesting alcoholic beverages, 18.5% were smokers, and 8.9% and 12.9% reported not ingesting meats or fruits and vegetables (FLV), respectively (Table 1).

Of all the analyzed variables, the risk for obesity, body obesity, elevated abdominal fat, and three or more reported diseases were those that presented associations ($p < 0.20$) with the development of DM in the elderly (Table 2).

Through the logistic regression analysis, the variables that remained in the final model and demonstrated a direct and positive association with the incidence of DM were body obesity and elevated abdominal fat, being the determinant variables for the occurrence of this disease in the elderly, regardless of gender and age groups. Obese individuals and those with excess abdominal fat presented 1.67 and 2.33 more odds, respectively, of developing DM in 6 years of study ($p < 0.05$). No multicollinearity was observed among the studied variables (Table 3).

Discussion

The present study was developed to fill a gap in the scientific area, since, despite the existence of programs, policies, and actions aimed at the control and treatment of diabetes mellitus in the Brazilian population, results show a high incidence rate of DM in the Brazilian elderly population, in relation to developing countries[18,19]. The rate, however, is similar or inferior to other studies carried out in developed countries[20,21], according to the country development classification proposed by the *World Economic Outlook Report*[22].

In the present study, the incidence rate of DM in the 6-year study period was 7.7/1000 person-years, corresponding to 72 new cases. A study conducted in Jamaica with 728 adult and

Table 1. Distribution of the elderly according to the year of study, diabetes mellitus, and sociodemographic, nutritional status, clinical, and lifestyle variables. SABE Study, São Paulo-SP/Brazil.

Analyzed Variables	2000	2006	
	Overall (N 1467)	Yes (N 72)	No (N 842)
	%	%	%
Sociodemographic			
Sex			
Male	41.0	41.9	39.6
Female	58.0	58.1	60.4
Age group			
60-74	78.5	85.7	83.2
75 and over	21.5	14.3	16.8
Schooling			
< 8 years	83.3	80.5	77.6
≥ 8 years	16.7	19.5	22.4
Companionship at home			
Lives alone	13.2	15.3	12.6
Lives with others	86.8	84.7	87.4
Nutritional Status			
Risk for body obesity			
Yes	68.2	59.2	67.7
No	31.8	40.8	32.3
Body obesity			
No	79.5	69.2	79.0
Yes	20.5	30.8	21.0
GHigh abdominal fat			
No	54.9	32.1	48.1
Yes	45.1	67.9	51.9
Clinical			
Number of reported diseases			
0-2	39.4	28.6	43.2
3 or more	60.6	71.4	56.8
Lifestyle			
Intake of alcoholic beverages			
No	78.6	60.0	65.8
Yes	21.4	40.0	34.2
Smoker			
No	83.3	81.5	85.0
Yes	16.7	18.5	15.0
IIntake of meat			
Yes	91.9	91.1	92.5
No	8.1	8.9	7.5
Intake of FLV			
Yes	82.5	87.1	82.1
No	17.5	12.9	17.9

Note: SABE – Health, Welfare and Aging; N - number; FLV – fruits and vegetables.

elderly individuals identified 51 new cases of DM in 4 years of study, corresponding to 1.84/1000 person-years[18]. Another study carried out in Costa Rica with 7039 adult and elderly individuals found an incidence of DM of 1.62/1000 person-years[19].

Rockwood et al.[20] analyzed a cohort of 9008 elderly (≥ 65 years), from the *Canadian Study of Health and Aging (CSHA-1)*, and found an incidence rate of DM of 8.6/1000 person-years, in 4.6 years of study, similar to that observed in the present study. However, another study carried out in Germany with 6,012 adult and elderly individuals verified a high number of new cases (401) of DM in 9 years of study[21]. It should be noted that all of these studies considered the re-

Table 2. Univariate analysis of the association between the incidence of diabetes mellitus and variables studied. SABE Study, São Paulo-SP/Brazil.

Variables analyzed	OR	CI (95%)	p
Sex			
Male	1	0.52 - 1. 58	0.739
Female	0.91		
Age group			
60-74 years	1	0.43 – 1.54	0.522
≥ 75 years	0.81		
Schooling			
> 8 years	1	0.95 – 1.08	0.582
≤ 8 years	1.01		
Companionship at home			
Lives with others	1	0.55 – 2.82	0.582
Lives alone	1.25		
Risk for obesity			
No	1	0.89 – 2.32	0.130
Yes	1.44		
Body obesity			
No	1	1.00 – 2.81	0.050
Yes	1.67		
High abdominal fat			
No	1	1.23 – 3.11	0.005
Yes	1.96		
Number of reported diseases			
0 - 2	1	0.96 – 3.73	0.063
3 or more	1.89		
Intake of alcoholic beverages			
No	1	0.68 – 2.15	0.328
Yes	1.18		
Smoker			
No	1	0.70 – 2.32	0.403
Yes	1.29		
Intake of meat			
No	1	0.43 – 3.30	0.712
Yes	1.20		
Intake of FLV			
No	1	0.27 – 1.63	0.376
Yes	0.67		

Note: SABE - Health, Welfare and Aging; OR - odds ratio; CI - confidence interval; FLV – fruits and vegetables; bold p < 0.20. Rao & Scott test[22].

Table 3. Association between diabetes mellitus in 6 years of study and variables of nutritional status. SABE Study, São Paulo-SP/Brazil.

Variables analyzed	OR	CI (95%)	p of the variable	p of the model
Body obesity				
No	1	1.00 – 2.81	0.005	
Yes	1.67			
High abdominal fat				0.000
No	1			
Yes	2.33	1.47 – 3.67	0.001	

Note: SABE - Health, Welfare and Aging; OR - odds ratio; CI - confidence interval; bold p <0.05. Multiple logistic regression adjusted by sex and age groups.

ported information of this disease, as used in the present study.

A meta-analysis study investigated the predictive incidence of DM in 32 studies in adults and elderly people in many countries and found different incidence rates among the regions analyzed. In the present study the new cases of DM were analyzed according to the geometric mean by regions; it is possible to note that the incidence of DM (7.7/1000 person-years) in this study is similar to that of European countries (7.2/1000 person-years), higher than Asian countries (5.2/1,000 person-years), and below rates in the United States (13.5/1000 person-years)[23].

These results are worrying, especially in developing countries such as Brazil and specifically in the elderly, who are more susceptible to health problems and, therefore, less able to address them. According to some studies, the presence of DM may decrease the quality of life and functional capacity for the performance of basic and instrumental activities of daily living, as well as increase the risks of clinical complications, hospitalizations, and even death in this age group[24].

Although no statistical differences were found between sex and age groups in the present study, the incidence rate of DM was higher in women, and in the age group 60-74, for both sexes, as in other studies[18,25]. Some studies found an inverse relationship, verifying a higher incidence of DM in men[26,27]. One of the reasons that may explain this result is that women seek medical assistance more often than men, allowing early diagnosis, in addition to hormonal changes during the menopause period, promoting the use of estrogens and, consequently, increasing body weight and abdominal fat, factors that predispose to the development of this disease[27].

Another possible explanation for the lower incidence of the disease in the group ≥ 75 years may be related to survival bias, since elderly individuals more vulnerable to complications of the disease would be more likely to die prematurely[28]. Lebrão and Duarte[13] found that DM was the only

chronic disease whose frequency decreased with advancing age in elderly people in São Paulo. According to these authors, deaths due to complications of the disease may have contributed to this result.

In the present study, there were no statistical differences between sociodemographic variables and reported DM, indicating that, in this population, the incidence of the disease is not influenced by these variables, as evidenced by other authors[29]. However, Barceló et al. found that the occurrence of diabetes mellitus (15.7%) was positively associated with low levels of education (0 to 6 years of schooling)[30].

It has been verified that the risk for obesity was not associated with DM, similar to other studies performed[29,30]. These results indicate that being over the appropriate weight for height does not constitute a risk for the development of DM in the elderly, despite being a condition predisposing to the occurrence of the disease in adults[31]. Differently, in the present study it was found that obese elderly individuals were more likely to develop DM. This evidence confirms the hypothesis that there are differences in the impact of nutritional status and development of chronic diseases among adult and elderly individuals, yet it is still a poorly studied area, lacking conclusive results and requiring more research to investigate this relationship.

A longitudinal study conducted in Barbados-Caribbean with obese individuals aged 40 to 84 years, using reported information on DM, as in this study, found a positive and significant association between DM and obesity (4th quartile, when BMI ≥ 29.8 kg/m^2), and the risk of developing DM in nine years of study was 3.7 times higher for obese individuals[32]. Although, in Brazil, there are no studies of this nature investigating this relationship, Passos et al.[29] evaluated the elderly from the Bambuí Project (Health and Aging Study) in Minas Gerais and verified that the prevalence of DM may be associated with obesity (≥ 30 kg/m^2).

In the present study it was observed that abdominal fat is a variable that contributes to the increase in the number of DM cases in the elderly, being the variable that presented the greatest risk for the development of this disease in 6 years of study, in the same way as has also been observed in adult individuals, thus representing a common determinant between both population groups[18,23]. A longitudinal study performed with individuals 25 to 74 years old from Jamaica using reported information on DM, as in the present study, verified that elderly individuals with excess abdominal fat presented a higher risk for the development of DM[18].

Few studies have performed this analysis with the elderly. Srikanthan et al.[33], who evaluated a cohort of elderly people participating in *The MacArthur Successful Aging Study*, found that the development of DM occurs specifically in subjects with excess fat in the abdominal region, regardless of gender and age group, as found in the present study. To date, there are no longitudinal studies with Brazilian elderly which present this information, highlighting the importance of the present study as, probably, the first Brazilian study to investigate factors that determine the development of DM in this age group.

One of the methodological limitations of the present study is the fact that the estimates of incidence of DM are based on reported data related to the time of disease development. It is possible that the data on the incidence of DM may be underestimated as it may not have been self-reported, even when present. On the other hand, the reported information on DM, without clinical tests to prove the diagnosis of the disease, is valid and can be used, as already verified by other authors[34].

Another limitation refers to loss of follow-up and lack of knowledge of when data were censored, which may interfere with the estimation of the incidence rate. In addition, it is not possible to establish if there were changes over time, regarding the explanatory variables, since the data of the participants were only obtained at two moments (2000 and 2006). Differences in age, schooling, ethnicity, research design, and BMI and WC reference values are also highlighted, which may interfere in the comparison between studies and make it difficult to identify the real effect of these indicators on the incidence of DM.

However, considering the significant incidence of DM and its negative effects, and given the paucity of information on this condition and associated determinants in the elderly in Brazil, this study makes a relevant contribution to broadening the understanding of DM in this age group and the formulation of future studies to reduce the occurrence of DM in the population.

Preventive measures, such as blood glucose monitoring, body weight control, adequate nutrition, and regular physical activity practice are the main recommendations used in research, clinics, and health centers to avoid the development of DM. However, the identification and follow-up of body variables, such as the presence of body obesity and, especially, abdominal fat, should be

implemented in care protocols for the elderly, in different areas of attention, considering that, in the future, this population group will constitute the Brazilian epidemiological scenario.

Conclusion

Based on the considerations presented, it was possible to verify that the variables body obesity and abdominal fat contributed to the development of DM in the elderly. This information is valid and deserves attention from researchers and professionals in the area, in order to stimulate discussions on whether the strategies implemented contemplate the determinants analyzed and if these strategies are effective and efficient to avoid the development of DM.

Collaborations

MA Roediger proposed this work, and carried out organization and analysis of the data and writing of the manuscript. MFN Marucci, LA Gobbo, DAQS Dourado, JLF Santos participated in the analysis and interpretation of results, and revision and final approval of the manuscript. YAO Duarte and ML Lebrão participated in the revision and approval of the final version of the manuscript.

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