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original article

# Association between time spent sitting and diabetes mellitus in older adults: a population-based study

## *Associação entre tempo sentado e diabetes mellitus em idosos: um estudo de base populacional*

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**Abstract** – By the middle of the last century, changes in the Brazilian economy and society triggered a rapid demographic transition characterized by an increased number of older adults in the population. Thus, Brazil has witnessed population aging, which was accompanied by an increased incidence of non-communicable chronic diseases. Some risk factors for the development of the chronic non-communicable diseases have been well established, such as overweight, tobacco and alcohol consumption, inadequate nutrition, and physical inactivity. Additionally, sedentary behavior has been related to significant deleterious effects on health, such as diabetes mellitus type 2, obesity and mortality. The objective of this study was to investigate the association between sitting time and diabetes mellitus in older adults. A cross-sectional study was conducted in 24 municipalities in the Regional Health Superintendence of Uberaba, MG. Selected subjects answered a structured questionnaire and underwent anthropometric assessment. A total of 3,265 elderly subjects, with a median time spent sitting of 240.00 ($P25^{th}$=137.14 and $P75^{th}$=330.00) minutes/day and a 20.0% prevalence of diabetes mellitus were detected. Adjusted logistic regression analysis showed that a sitting time of more than 330.00 minutes/day was positively associated with diabetes mellitus (OR=1.351, 95%CI: 1.057-1.729). It was concluded that older adults who daily sit for long periods of time have higher chances of having diabetes compared to those who sit for less time.

**Key words**: Aged; Diabetes mellitus; Life style.

**Resumo** – *Em meados do século passado, transformações na economia e sociedade brasileira somaram-se para desencadear uma rápida transição demográfica, que se caracterizou pelo aumento de idosos. Assim, presenciou-se um envelhecimento populacional, que foi acompanhado pelo aumento da incidência de doenças crônicas não transmissíveis. Alguns fatores de risco estão bem estabelecidos para o desenvolvimento das doenças crônicas não transmissíveis, como excesso de peso, consumo de tabaco e álcool, alimentação inadequada e inatividade física. Adicionalmente, o comportamento sedentário mostrou-se relacionado a importantes efeitos deletérios à saúde, como, por exemplo, diabetes mellitus tipo 2, obesidade e mortalidade.O estudo teve como objetivo investigar a associação entre tempo sentado e diabetes mellitus em idosos. Estudo transversal, realizado em 24 municípios integrantes da Superintendência Regional de Saúde de Uberaba, MG. Os indivíduos selecionados responderam um questionário estruturado e foram submetidos à avaliação antropométrica. Foram analisados 3.265 idosos. A prevalência de diabetes mellitus foi de 20,0% e a mediana de tempo sentado de 240,00 ($P25^{o}$=137,14 e $P75^{o}$=330,00) minutos/dia. A análise de regressão logística ajustada demonstrou que o tempo sentado superior a 330,00 minutos/dia associou-se positivamente com a diabetes mellitus (OR=1,329; IC95%: 1,040-1,700). Pode-se concluir que os idosos que ficam sentados por longos períodos diariamente apresentam maior chance de ter diabetes mellitus quando comparados com aqueles que ficam sentados por menor tempo.*

**Palavras-chave**: *Estilo de vida; Diabetes mellitus; Idoso.*

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## INTRODUCTION

In the middle of the last century, changes in the economy and health conditions of Brazilian society jointly triggered a rapid demographic transition characterized by an increased number of elderly people[1]. Thus, population aging was observed, accompanied by an increased incidence of non-transmissible chronic diseases[1]. These diseases are known to involve lifelong expenditures not only with drugs, but also with exams and medical visits, with a consequent considerable onus for health services which tends to increase with population aging[1,2].

Among non-transmissible chronic diseases, particularly outstanding is diabetes mellitus due to its high prevalence[3] and to the fact that it is considered to be a risk factor for morbidity-mortality[4] because of the complications induced by systemic macro- and microvascular injuries[5]. In 2000 there were about 171 million diabetic people in the world and this number is estimated to increase to 366 million by 2030[3]. During this period, this group will grow from 4.6 to 11.3 million in Brazil[3]. The number of persons with diabetes is estimated to exceed 82 million among the elderly living in developing countries. The worldwide increase for this age group will correspond to a 134% prevalence of the disease, with a 194% increase considering only Latin American countries[3]. These data demonstrate a great increase in the prevalence of diabetes mellitus and underscore the importance of public health planning in order to satisfy this increasing demand, especially among the elderly.

Some risk factors for the development of diabetes mellitus have been well established, such as excess weight, inadequate eating habits and physical inactivity[6,7,8]. However, recent evidence has indicated that a sedentary behavior may also be considered a risk factor for this disease[9].

Sedentary behavior is defined as activities performed in the lying or sitting position, with energy expenditure of ≤ 1.5 metabolic equivalents (METs)[10,11]. Specifically among the elderly, the considerable amount of time spent in this behavior, in addition to having negative effects on health such as inducing a higher body mass index (BMI), increased waist circumference (WC) and levels of C-reactive protein and plasma glucose, as well as metabolic syndrome[12], has increased the risk of all-cause mortality[13]. However, its association with diabetes mellitus is still poorly known, with the need for more in-depth studies, especially considering the adjustment by health variables. In this respect, the objective of the present study was to investigate the association between time spent sitting and the presence of diabetes mellitus among the elderly.

## METHODOLOGICAL PROCEDURES

### Population and sample

This was a cross-sectional study belonging to the project "Health profile of the elderly population of the municipalities of the Regional Health Manage-

ment - Uberaba/Minas Gerais", based on a population of 79,924 persons[14] aged 60 years or older residing in 24 municipalities of the Regional Health Superintendence of Uberaba, MG.

Sample calculation was based on the elderly population of each municipality as reference[14], considering the following parameters: 0.05 sampling error, 95% confidence interval and population proportion of each municipality (elderly population of the municipality divided by the total population of the municipality). A simple random sampling process resulted in a minimum sample of 3,198 elderly subjects.

Inclusion criteria were: agreeing to participate in the study by giving written informed consent; reaching the minimum score according to educational level in the Mini Mental State Exam[15,16], and being able to walk even with the aid of a cane or a walker. Exclusion criteria were: being wheelchair bound, having severe hearing or visual impairment causing considerable difficulty of communication, and being temporarily or permanently bedridden.

The selected subjects answered a questionnaire applied in the form of an interview and were submitted to anthropometric evaluation. Data were collected by trained interviewers between May 2012 and April 2013.

## Variables analyzed

The sociodemographic variables analyzed were: sex (male, female), age range (60-69, 70-79 and ≥ 80 years), schooling (with and without schooling; those who never frequented a school were classified as having no schooling and those who frequented a school as having schooling), and family income (≤ 1 minimum wage, > 1 and ≤ 3 minimum wages, and > 3 minimum wages).

The perception of health status during the last 12 months was evaluated as a health indicator, with the reply options being excellent, good, regular and poor. The scale was categorized into two levels: negative perception of health (poor and regular) and positive perception of health (excellent and good). BMI and WC were also obtained. BMI was determined by the formula BMI = body mass/height$^2$, based on the measurement of body mass in kg and height in meters using a digital scale and a portable stadiometer, respectively. BMI values were classified as low weight (BMI < 18.5 kg/m$^2$), normal weight (BMI 18.5 - 24.9 kg/m$^2$) or excess weight (BMI ≥ 25.0 kg/m$^2$)[17]. WC was measured only once at the midpoint between the last rib and the anterosuperior iliac crest and was classified as indicating no risk (WC <80.0 cm and WC < 94.0 cm) or indicating risk (WC ≥ 80.0 cm and WC ≥ 94.0 cm for women and men, respectively)[17].

The presence of diabetes mellitus was determined by self-report based on the reply to the question "Did any doctor ever tell you that you have diabetes?", and the subjects were divided into two groups, i.e., diabetic and nondiabetic.

The following habits were considered: smoking (yes/no), consumption of alcoholic beverages (yes/no), self-report of regular physical activity (yes/

no), and time spent sitting. Total time spent sitting (minutes/day) was determined on the basis of the replies to the questions regarding time sitting on a habitual weekday and on a habitual weekend day of the International Physical Activity Questionnaire[18] validated for the elderly population of Brazil[19,20].

### Data analysis

Data were entered on an Excel® spreadsheet by double entry and then analyzed statistically with the Statistical Package for the Social Sciences (SPSS), version 20.0. Descriptive analysis was applied to all variables. Total time spent sitting was determined based on the weighted mean sitting time value on a weekday and on a weekend day. The subjects were then divided into four groups according to the following percentiles: ≤ P25th, > P25th and ≤ P50th, > P50th and ≤ P75th and > P75th).

Logistic regression was carried out in two steps in order to investigate the association between diabetes mellitus and time spent sitting: 1) in the first step, univariate logistic regression was performed between the presence of diabetes mellitus and the sociodemographic variables, health indicators and habits. 2) In the second, the adjusted odds ratio was calculated between the presence of diabetes mellitus and time spent sitting based on the sociodemographic variables, health indicators and habits which had shown $p < 0.20$ in univariate logistic regression. The odds ratio (OR) and the 95% confidence interval (95% CI) were calculated in all analyses. The level of significance was set at 5%.

### Ethical procedures

The subjects gave written informed consent to participate in the study. The present study obeyed the principles of the Declaration of Helsinki and the research protocols were evaluated and approved by the Ethics Committee for Research on Human Beings of the Federal University of "Triângulo Mineiro" (Protocol No. 1640/2010).

## RESULTS

The study was conducted on 3,265 individuals, 38.5% (n=1.256) of them males and 61.5% (n=2.009) females. The prevalence of diabetes mellitus was 20.0% (n=653). Median total time spent sitting was 240.00 ($P25^{th}$=137.14 and $P75^{th}$=330.00) minutes/day.

Univariate logistic regression between the sociodemographic variables and the presence of diabetes mellitus revealed an association with sex (p=0.000) and age range (p=0.008). Among the health indicators, the variables associated with the presence of diabetes mellitus were health status (p=0.000), BMI (p=0.000) and WC (p=0.000). Among the habits, consumption of alcoholic beverages (p=0.002) and time spent sitting (p=0.003) were associated with diabetes mellitus (Table 1).

**Table 1.** Univariate analysis of association between the presence of diabetes mellitus and the sociodemographic variables, health indicators and habits. Regional Health Superintendence of Uberaba/MG, 2012/2013.

| Variables | Diabetes | | | |
|---|---|---|---|---|
| | n (%) | OR (95% CI) | p | $x^2$ Wald |
| Sex | | | | |
| Male | 192 (29.4) | 1 | 0.000 | 28,000 |
| Female | 461 (70.6) | 1.650 (1.371 - 1.987) | | |
| Age range | | | | |
| 60 to 69 years | 370 (56.7) | 1 | 0.008 | 9.681 |
| 70 to 79 years | 226 (34.6) | 0.872 (0.725 - 1.050) | | |
| 80 years or more | 57 (8.7) | 0.626 (0.462 - 0.849) | | |
| Schooling | | | | |
| No schooling | 182 (27.9) | 1 | 0.408 | 0.685 |
| With schooling | 471 (72.1) | 1.084 (0.896 - 1.311) | | |
| Family income | | | | |
| ≤ 1 MW | 257 (39.4) | 1 | 0.169 | 3.559 |
| > 1 MW and ≤ 3 MW | 305 (46.7) | 0.942 (0.783 - 1.134) | | |
| > 3 MW | 91 (13.9) | 1.217 (0.927 - 1.597) | | |
| Health status | | | | |
| Positive | 234 (35.8) | 1 | 0.000 | 46.357 |
| Negative | 419 (64.2) | 1.852 (1.551 - 2.211) | | |
| Body mass index | | | | |
| Normal weight | 143 (21.9) | 1 | 0.000 | 64.721 |
| Low weight | 8 (1.2) | 0.577 (0.274 - 1.213) | | |
| Excess weight | 502 (76.9) | 2.158 (1.763 - 2.642) | | |
| Waist circumference | | | | |
| No risk | 66 (10.1) | 1 | 0.000 | 81.756 |
| With risk | 587 (89.9) | 3.450 (2.638 - 4.512) | | |
| Alcoholic beverages | | | | |
| Yes | 77 (11.8) | 1 | 0.002 | 9.765 |
| No | 576 (88.2) | 1.511 (1.166 - 1.958) | | |
| Smoking | | | | |
| Yes | 84 (12.9) | 1 | 0.071 | 3.254 |
| No | 569 (87.1) | 1.261 (0.980 - 1.623) | | |
| Regular physical activity | | | | |
| Yes | 372 (57.0) | 1 | 0.958 | 0.003 |
| No | 281 (43.0) | 1.005 (0.845 - 1.195) | | |
| Time spent sitting | | | | |
| ≤ 13714 minutes/day | 159 (24.3) | 1 | | |
| > 137.14 to ≤ 240.00 minutes/day | 181 (27.7) | 0.846 (0.668 - 1.070) | 0.003 | 14.249 |
| > 240.00 to ≤ 330.00 minutes/day | 122 (18.7) | 1.149 (0.082 - 1.498) | | |
| > 330.00 minutes/day | 191 (29.2) | 1.289 (1.017 - 1.634) | | |

MW: minimum wage.

Adjusted regression analysis between time spent sitting and diabetes mellitus revealed association with time spent sitting > 330.00 minutes/day (OR=1,329; 95%CI: 1.040-1.700; p=0.001) after adjustment for sex, age range, family income, perception of health status, BMI, WC, consumption of alcoholic beverages, and smoking (Table 2).

**Table 2.** Adjusted analysis of the association between the presence of diabetes mellitus and time spent sitting. Regional Health Superintendence of Uberaba/MG, 2012/2013.

| Time spent sitting | OR (95% CI)* | p | $x^2$ Wald |
|---|---|---|---|
| ≤ 137.14 minutes/day | 1 | 0.001 | 15.653 |
| > 137.14 a ≤ 240.00 minutes/day | 0.835 (0.655- 1.064) | | |
| > 240.00 a ≤ 330.00 minutes/day | 1.124 (0.856- 1.478) | | |
| > 330.00 minutes/day | 1.329 (1.040- 1.700) | | |

*Adjusted for sex, age range, family income, perception of health status, body mass index, waist circumference, consumption of alcoholic beverages, and smoking.

## DISCUSSION

The present population-based study demonstrated that elderly subjects who reported spending time sitting for a longer time had a greater chance of having diabetes after adjustment for sex, age range, family income, perception of health status, BMI, WC, consumption of alcoholic beverages, and smoking.

Although there are no similar studies regarding the age range of the population and conducted on Brazilian individuals, some studies conducted on adults and elderly subjects have reported a relationship between these two variables. A cross-sectional study of individuals older than 18 years, aged on average 40 years, demonstrated an association between time spent sitting and diabetes when comparing persons reporting a time spent sitting of more than 4 hours/day to persons spending time sitting between one and two hours[21]. In another study conducted on men aged 45 to 64 years, George et al.[22] observed that those who spent more than six hours sitting had a greater chance of having diabetes than those who spent less than four hours sitting, a situation that was maintained after adjustment for physical activity, age, family income, educational level, smoking, BMI, and functional limitation.

Furthermore, some prospective studies have demonstrated an increased risk of developing diabetes mellitus among individuals with sedentary behavior for long periods of time. A study by Hu et al.[23] demonstrated, after 10 years of follow-up, that men aged 40 to 75 years who watched television for more than 40 hours per week had a 2.31 relative risk (95% CI 1.17–4.56, p=0.01) to develop diabetes mellitus than those who watched television less than one hour per week after adjustment for age, time of follow-up, consumption of alcoholic beverages, smoking, level of physical activity, and BMI. These findings were corroborated by Krishnan et al.[6] who followed up Afro-American women for the same period of time and observed that watching television five hours or more per day was associated with the risk to develop the disease.

However, another large prospective study reported that diabetes mellitus and television time were not directly associated. These results indicate that sedentary behavior contributes to a greater risk of obesity, which indeed is a factor that predisposes to the onset of diabetes. When the analysis was adjusted for sociodemographic and life style characteristics and for systolic arterial pressure there was a significant correlation between diabetes mellitus and television time. However, when BMI and WC were added to the adjustment, the association was attenuated and was no longer significant, showing a possible explanation for the mechanisms that link television time to the onset of diabetes[24].

A study on an American population of Latin American origin, with a mean time spent sitting similar to that observed in the present study, also showed that obesity possibly explains the relationship between diabetes mellitus and time spent sitting. However, when the analysis was adjusted for BMI, the association lost significance[21]. On the other hand, in the present study, after multivariable analysis including adjustment for BMI and WC among others, there was no attenuation or change of significance. Thus, it can be seen that there are other mechanisms leading to diabetes mellitus starting from a long time spent sitting.

Several studies have pointed out some of these mechanisms, showing that sedentary behavior is directly linked to metabolic changes that predispose to the onset of diabetes mellitus. Dunstan et al.[25] observed that women who spend more time watching television show changes in blood glucose metabolism. A similar study also detected a positive association between time spent watching television and insulin resistance, β cell activity and fasting insulinemia[26], whose increased level is a strong predictor of the development of diabetes, as reported by Dankner et al.[27].

Other studies have treated changes in metabolism, relating sedentary behavior to changes in enzyme activity and modifications of glucose transporters (GLUTs), which may result in an increased risk of onset of diabetes mellitus. According to Tremblay et al.[28], sedentary behavior reduces the activity of the enzyme lipoprotein lipase (LPL), apparently by interfering with the mechanisms of cellular transcription. This leads to reduced LPL expression on the cell membrane, resulting in impaired tissue uptake of free fatty acids from blood. As a consequence, there is inhibition of insulin-stimulated glucose oxidation, of glucose uptake and of glucogenesis, important effects for the development insulin resistance and type 2 diabetes mellitus[29].

Additionally, muscle immobility, which is a direct result of sedentary behavior, leads to reduced GLUT-4 levels expressed on the membrane of muscle cells, both stimulated by insulin and by physical activity. Conversely, when muscle is stimulated, e.g. by electrostimulation, there is an expressive increase of GLUT-4 and GLUT-1 levels[28]. Thus, muscular activity promotes a greater ability to utilize plasma glucose with a consequent reduction of glycemia, whereas sedentary behavior inhibits glucose uptake and increases glucose concentration in blood.

On this basis, sedentary behavior leads to reduced glucose utilization by the muscles due to reduced glucose uptake (increased insulin resistance) but also due to muscle atrophy since the musculature is less requisitioned[30]. Thus, with reduced expenditure, the energy balance is metabolized by the liver for the production of fat, which will be preferentially stored in central adipose tissue. These adipocytes become more active, leading to a greater production of proinflammatory cytokines. This condition, associated with high plasma glucose concentration, results in hypercoagulability, facilitating platelet aggregation and inflammation, which are risk factors for the development of chronic diseases. Thus, the increased chance of the onset of diabetes mellitus may be a consequence of a long time spent in the sitting position[30].

Several metabolic pathways can be affected by prolonged sedentary behavior, leading to a higher risk of developing diabetes mellitus. The inhibition of LPL and GLUT-4 expression results in a lower tissue response to insulin stimulation[28]. In addition, the systemic inflammatory state induced by chronic immobility and also by obesity leads to changes in the normal metabolism of glucose, such as increased glycemia, fasting insulinemia and glucose tolerance[30]. All of these modifications combine to contribute to a higher risk of developing diabetes mellitus among individuals with high sedentary behavior.

Some considerations should be pointed out regarding the present study. The strong points of the study were: representativeness of the sample, use of the Mini Mental State Exam[15] as a criterion for subject inclusion, evaluation of sedentary behavior based on total time spent sitting[18] and not only on time spent watching television, and the exclusive investigation of the elderly population in view of the rarity of studies associating sedentary behavior and diabetes in this age range. On the other hand, the cross-sectional design of the study, which does not permit to establish a cause-effect relationship, and the evaluation of sitting time by self report may be considered to be limitations of this study, although this strategy has been used in other population-based studies[21].

## CONCLUSIONS

The present study revealed that elderly subjects who spend 330.00 minutes/day or more sitting have a greater chance of developing diabetes than subjects who spend ≤ 137.14 minutes/day sitting even after adjustment for sex, age range, family income, perception of health status, BMI, WC, consumption of alcoholic beverages, and smoking. These findings indicate the importance of devising strategies for the reduction of sitting time in the elderly population in order to prevent diabetes mellitus and its complications.

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## REFERENCES


1. Veras R. Envelhecimento populacional contemporâneo: demandas, desafios e inovações. Rev Saúde Pública 2009;43(3):548-54.
2. Veras RP. Estratégias para o enfrentamento das doenças crônicas: um modelo em que todos ganham. Rev Bras Geriatr Gerontol 2011;14(4):779-86.
3. Wild S, Roglic G, Green A, Sicree R, King H. Global prevalence of diabetes estimates for the year 2000 and projections for 2030. Diabetes Care 2004;27(5):1047-53.
4. Mattos PE, Luz LL, Santiago LM, Mattos IE. Tendência da mortalidade por diabetes melito em capitais brasileiras, 1980-2007. Arq Bras Endrocrinol Metab 2012;56:39-46.
5. Fowler MJ. Microvascular and macrovascular complications of diabetes. Clinical Diabetes 2008;26(2):77-82.
6. Krishnan S, Rosenberg L, Palmer JR. Physical activity and television watching in relation to risk of type 2 diabetes. The Black Women's Health Study. Am J Epidemiol 2009;169(4):428-34.
7. Tyrovolas S, Koyanagi A, Garin N, Olaya B, Ayuso-Mateos JL, Miret M, et al. Diabetes mellitus and its association with central obesity and disability among older adults: a global perspective. Exp Gerontol 2015;64:70-7.
8. Ding D, Chong S, Jalaludin B, Comino E, Bauman AE. Risk factors of incident type 2-diabetes mellitus over a 3-year follow-up: Results from a large Australian sample. Diabetes Res Clin Pract 2015;108(2):306-15.
9. Wilmot EG, Edwardson CL, Achana FA, Davies MJ, Gorely T, Gray LJ, et al. Sedentary time in adults and the association with diabetes, cardiovascular disease and death: systematic review and meta-analysis. Diabetologia 2012;55(11):2895-905.
10. Ainsworth BE, Haskell WL, Whitt MC, Irwin ML, Swartz AM, Strath SJ, et al. Compendium of physical activities: an update of activity codes and MET intensities. Med Sci Sports Exerc 2000;32(9 Suppl):S498-504.
11. Pate RR, O'Neill JR, Lobelo F. The evolving definition of "sedentary". Exerc Sport Sci Rev 2008;36(4):173-8.
12. de Rezende LF, Rey-López JP, Matsudo VK, Do Carmo Luiz O. Sedentary behavior and health outcomes among older adults: a systematic review. BMC Public Health 2014;14:333.
13. Pavey TG, Peeters GG, Brown WJ. Sitting-time and 9-year all-cause mortality in older women. Br J Sports Med 2015;49(2):95-9.
14. IBGE. Instituto Brasileiro de Geografia e Estatística. 2011. Available from: http://www.ibge.gov.br/home/estatistica/populacao/censo2010/resultados_preliminares/preliminar_tab_municipio_zip.shtm. [2013 Aug 03].
15. Folstein MF, Folstein SE, McHugh PR. "Mini-mental state". A practical method for grading the cognitive state of patients for the clinician. J Psychiatr Res 1975;12(3):189-98.
16. Bertolucci PHF, Brucki MWD, Campacci SR, Juliano Y. O Mini-Exame do Estado Mental em uma população geral: impacto da escolaridade. Arq. Neuro-Psiquiatr 1994;52:1-7.
17. World Health Organization. Obesity: Preventing and Managing the Global Epidemic. Report of aWHO Consultation on Obesity, Geneva: World Health Organization, 1998.
18. Rosenberg DE, Bull FC, Marshall AL, Sallis JF, Bauman AE. Assessment of sedentary behavior with the International Physical Activity Questionnaire. J Phys Act Health 2008;5 Suppl 1:S30-44.
19. Benedetti TB, Mazo GZ, Barros MVG. Aplicação do Questionário Internacional de Atividades Físicas para avaliação do nível de atividades físicas de mulheres idosas: validade concorrente e reprodutibilidade teste-reteste. Rev Bras Ciênc Mov 2004;12(1):25-34.
20. Benedetti TRB, Antunes PdC, Rodriguez-Añez CR, Mazo GZ, Petroski ÉL. Reprodutibilidade e validade do Questionário Internacional de Atividade Física (IPAQ) em homens idosos. Rev Bras Med Esporte 2007;13(1):11-6.

21. Heer HD, Wilkinson AV, Strong LL, Bondy ML, Koehly LM. Sitting time and health outcomes among Mexican origin adults: obesity as a mediator. BMC Public Health 2012;12(1):896.
22. George ES, Rosenkranz RR, Kolt GS. Chronic disease and sitting time in middle-aged Australian males: findings from the 45 and Up Study. Int J Behav Nutr Phys Act 2013;10(1):20.
23. Hu FB, Leitzmann MF, Stampfer MJ, Colditz GA, Willett WC, Rimm EB. Physical activity and television watching in relation to risk for type 2 diabetes mellitus in men. Arch Intern Med 2001;161(12):1542.
24. Ford ES, Schulze MB, Kröger J, Pischon T, Bergmann MM, Boeing H. Television watching and incident diabetes: Findings from the European Prospective Investigation into Cancer and Nutrition-Potsda Study. J Diabetes 2010;2(1):23-7.
25. Dunstan DW, Salmon J, Owen N, Armstrong T, Zimmet PZ, Welborn TA, et al. Physical activity and television viewing in relation to risk of undiagnosed abnormal glucose metabolism in adults. Diabetes Care 2004;27(11):2603-9.
26. Dunstan DW, Salmon J, Healy GN, Shaw JE, Jolley D, Zimmet PZ, et al. Association of television viewing with fasting and 2-h postchallenge plasma glucose levels in adults without diagnosed diabetes. Diabetes Care 2007;30(3):516-22.
27. Dankner R, Chetrit A, Shanik MH, Raz I, Roth J. Basal-State Hyperinsulinemia in healthy normoglycemic adults is predictive of type 2 diabetes over a 24-year follow-up. A preliminary report. Diabetes Care 2009;32(8):1464-6.
28. Tremblay MS, Colley RC, Saunders TJ, Healy GN, Owen N. Physiological and health implications of a sedentary lifestyle. Appl Physiol Nutr Metab 2010;35(6):725-40.
29. Kump DS, Booth FW. Alterations in insulin receptor signalling in the rat epitrochlearis muscle upon cessation of voluntary exercise. J Physiol 2005;562(3):829-38.
30. Charansonney OL. Physical activity and aging: a life-long story. Discov Med 2011;12(64):177-85.

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