Determinants of blood pressure in type 2 diabetic subjects with high occurrence of inadequate glycemic control

Determinantes da pressão arterial em diabéticos tipo 2 com alta ocorrência de controle glicêmico inadequado

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ABSTRACT

Study design: Association study

Objective: To analyze the association between different biological/behavioral risk factors and blood pressure in a sample of type 2 diabetes mellitus patients with poor glycemic control. Methods: A sample of 121 type 2 diabetic patients was selected in the Public Healthcare System in a middle size Brazilian city. Blood pressure was measured using an aneroid device, previously calibrated. Six determinants of blood pressure were taken into count: age, hypoglycemic agents, general obesity, abdominal obesity, eating behaviors and physical activity level. Results: The type 2 diabetic patients presented mean age of 60.1±8.9 years-old and, at least, one risk factor. Eating behaviors (OR_{adj}= 0.31 [0.12-0.75]) and sports practice (OR_{adj}= 0.12 [0.02-0.75]) constituted protective factors associated with lower systolic blood pressure. On the other hand, age was positively associated with high systolic blood pressure (OR_{adj}= 3.81 [1.39-10.38]). Patients with 5-6 risk factors, presented higher values of systolic and (F= 3.857; p= 0.011 [post hoc with p= 0.039]), diastolic blood pressure (F= 4.158; p= 0.008 [post hoc with p= 0.036]) and increased occurrence of hypertension (p= 0.010). **Conclusion:** Our findings indicate that, behavioral variables were important determinants of blood pressure in type 2 diabetic patients with poor glycemic control and clustering of behavioral and biological risk factors increase the hypertension occurrence.

Key words: Physical Activity. Diabetes Mellitus. Blood Pressure. Diet.

Introduction

According to American Diabetes Association[1], type 2 diabetes mellitus (T2DM) is caused by the gradual increase in hepatic and peripheral cellular resistance to insulin, leading the pancreas to produce more insulin, which can induce to gradual pancreatic beta-cell failure. Currently, a complex interaction between unhealthy behaviors (e.g. physical inactivity, smoking and inadequate diet) and risk factors (e.g. general and

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abdominal obesity) has been pointed as cornerstone to the development of T2DM[2,3,4] and, therefore, strategies targeting lifestyle changes and weigh loss are strongly recommended in the treatment of T2DM.

In adults, the presence of T2DM is associated with development of a variety of cardiovascular disorders, including arterial hypertension (AH).[4] Recent studies have identified that, the relationship between T2DM and AH would be based on insulin resistance. Problems in insulin binding to its receptor, decrease nitric oxide production and increase endothelin-1 (vasoconstrictor) leading to reactive oxygen species production and endothelial dysfunction.[4] Thus, glycemic control is an important goal to be achieved by health programs involving diabetic patients[5], because it indicates the effectiveness of the T2DM treatment.

Blood pressure maintenance is hard to be achieved in diabetic patients, especially in those attended by public healthcare system, and it is not clear if lifestyle modifications and weight loss could control blood pressure in T2DM even with poor glycemic control. In fact, the absence of glycemic control contributes to a low effectiveness of the treatment, which can decrease the motivation of patient and physician. On the other hand, even in settings with poor glycemic control, the effectiveness of inexpensive tools, such as lifestyle modification, to control cardiovascular parameters, can stimulate the subjects and be effective in terms of public healthcare system and result in decreased costs for the treatment of diabetes and related diseases.[6]

Then, the purpose of the present study was to analyze the association between different biological/behavioral risk factors and blood pressure values in a sample of T2DM patients with high occurrence of poor glycemic control.

Methods

Sample

Cross-sectional study carried out in the city of Bauru (São Paulo State, Brazil [360,000 inhabitants and human development index of 0.825]) from January to February of 2009. The study was approved by the Ethical Committee Group from the Institute of Bioscience of the Universidade Estadual Paulista - UNESP (Campus of Rio Claro) and all research participants gave written informed consent after receiving a thorough explanation of the research project.

In Brazil, the provincial public healthcare system is formed by Basic Healthcare Units (BHU), which is funded by state government. The BHUs have a variety of health professionals (e.g. dentists, gynecologists, obstetricians, general practitioners, pediatricians, psychiatrists and nurses) and are responsible for monitoring the AH and T2DM patients in a specific geographical region of the city. In the present study, the Provincial Public Healthcare Department granted access to the patients' medical records of two BHUs from a total of 17. Sample size calculation is presented in previous publication[6] and indicated the necessity of, at least, 118 patients (prevalence of physical inactivity among diabetics 47%, error of 10%, power of 80% and significance of 5% [n=130 with 10% of sample loss]). Potential patients were identified through analysis of three inclusion criteria: (i) individuals previously diagnosed with T2DM; (ii) age equal or less than 75 years-old, in order to avoid age-related interference in diabetic neuropathy diagnosis; and (iii) individuals with, at least, one-year of complete medical records in the BHU.

All patients who met the inclusion criteria were contacted by phone (n = 186), from these, 130 agreed to participate, but nine were excluded due to incomplete data (e.g. fail in body composition assessment and age higher than 75years).[6] The total sample of the present study was composed by 121 individuals.

Blood pressure values

Blood pressure assessment followed the recommendations of the I Brazilian Guideline to Diagnose and Treatment of Metabolic Syndrome.[7] Blood pressure values were measured (single measure) in sitting position, in a quiet room at the BHU after a previous period at rest (all measures were done by a health professional previously trained). AH was defined according to the guidelines of the Inter-American Society of Hypertension (Stage 1 systolic blood pressure [SBP] $\geq$ 140 mmHg and/or diastolic blood pressure [DBP] $\geq$ 90 mmHg) using an aneroid device previously calibrated.

Ethnicity, anthropometry and glycemic control

Ethnicity was computed and stratified as: white, black, Asiatic and other. Anthropometric measures including waist circumference (WC) (flexible inelastic metric tape [precision of 1.0 mm]), body weight (digital scale [kg]) and height (wall stadiometer [m]) were measured following standardized techniques.[8] Body mass index (BMI) was also computed (kg/m^2). The more recent fasting glucose test of the medical record was used to indicate glycemic control: <99 mg/dL ([controlled] n= 11; 9.1%); 100-125.9 mg/dL ([poor glycemic control] n= 27; 22.3%); ≥ 126 mg/dL ([poorly controlled] n= 83; 68.6%).

Determinants of blood pressure

Six risk factors were taken into count: age, regular insulin use (hypoglycemic agents), general obesity, abdominal obesity, no dietary recommendation and no sport/physical activity practice. The age of the subjects was stratified as follow: <50 years-old or ≥ 50 years-old. Regular insulin use was treated as categorical variable (yes or no) and assessed throughout self-report and confirmed by medical record. General obesity was assessed by bioelectrical impedance analysis (BIA Analyzer -101Q, RJL Systems, Detroit, EUA) according to standard procedures.[9] Percentage of body fat (%BF) was estimated by the equations proposed by Sun et al.[10] (which have been developed in solid statistical models [men: r^2= 0.90; women: r^2= 0.83] and is recommended to epidemiological studies) and obesity was identified according cutoffs adjusted by sex and age.[11] Abdominal obesity was identified by values of WC (metallic tape with 2m of length and measure made at middle distance between iliac crest and last rib [Men: 102cm and Women: 88cm]).[12] Patients regularly engaged in any dietary recommendation prescribed by nutritionist, were identified (yes or no). Sport/physical activity practice was estimated throughout face-to-face interview, using the Baecke et al.[13] questionnaire. In this study only the second section of the questionnaire was used. The subjects who related any sports practice of moderate to vigorous intensity were considered physically active.

The occurrence of all risk factors was clustered and a categorical variable ranging from 0 (absence risk factor) to 6 (general obesity, abdominal obesity, no sport practice, no dietary recommendation, higher age and regular insulin use) was structured.

Statistical procedures

Numerical variables are presented as mean and standard-deviation. *Student's t-test* for independent samples was used to compare the numerical variables between male and female. Analysis of variance (ANOVA one-way) with Tukey's post hoc test was used to compare numerical variables according the clustered risk factors. Chi-square test was used to compare proportions and a multivariate model for categorical variables was created using logistic regression (odds ratio [OR] and 95% confidence interval [95%CI]). Statistical significance was set at in p< 0.05 and all statistical procedures were performed by SPSS software, version 13.0 (SPSS Inc., Chicago, IL).

Results

The sample was composed by 121 T2DM patients with mean age of 60.1±8.9 years-old and predominantly of white ethnicity (71.9%). All diabetic patients with diagnosis of AH were under antihypertensive therapy. Regular insulin use, dietary recommendation and sports practice were identified in 36.4% (n = 44), 49.6% (n= 60) and 9.1% (n = 11), respectively. General (68.6% [n= 83]) and abdominal obesity (65.3% [n = 79]) were also identified. Table 1 shows the characteristics of the sample according to gender.[6] Female subjects presented higher fasting glucose (p= 0.002) and %BF (p= 0.002) than male. They also presented higher occurrence of general and abdominal obesity (p= 0.001). In the analyzed diabetic group, age (r= 0.25; p= 0.005), regular insulin use (r= -19; p= 0.032), sport/physical activity practice (r= -0.17; p= 0.049), no dietary recommendation (r= -0.19; p= 0.029), %BF (r= 0.24; p= 0.007) and WC (r= 0.24; p= 0.006) presented significant correlation with SBP, but only %BF (r= 0.27; p= 0.003) and WC (r= 0.33; p= 0.001) presented statistical correlation with DBP.

The association between blood pressure and its determinants is showed in Table 2. Dietary recommendation (OR= 0.37 [0.17-0.77]) and sport/physical activity practice (OR= 0.14 [0.02-0.69]) constituted protective factors associated with lower SBP, but not with DBP. General and abdominal obesity were positively associated with high SBP and DBP. Regular insulin use (OR= 0.47 [0.22-1.01]) and age (OR= 2.30 [0.98-5.41]) were marginally associated with high SBP, but not with DBP.

Figure 1 shows the interaction between all determinants and high blood pressure in a multivariate model. Dietary recommendation (OR_{adj}= 0.31 [0.12-0.75]; p= 0.010) and sport/physical activity practice (OR_{adj}= 0.12 [0.02-0.75]; p= 0.024) maintained the significant association with lower occurrence of high

Table 1
Characteristics of the sample stratified according gender.[6]

Variables	Male (N= 49) N (%)	Female (N= 72) N (%)	p
Numerical			
Age ([years] mean±SD)	59.8±9.9	60.2±8.3	0.802
Glucose ([mg/dl] mean±SD)	143±43	179±83	0.002
%BF (mean±SD)	26.1±5.9	41.9±6.7	0.001
WC ([cm] mean±SD)	99.4±11.3	101.7±14.9	0.342
SBP ([mmHg] mean±SD)	137.3±20.5	142.2±23.5	0.242
DBP ([mmHg] mean±SD)	86.1±10.7	88.4±12.6	0.289
Categorical			
Ethnicity (white)	36 (73.5)	51 (70.8)	0.912
Age (e”50 years-old)	35 (71.4)	57 (79.2)	0.446
Insulin use (Yes)	21 (42.9)	23 (31.9)	0.302
Sports practice (Yes)	5 (10.2)	6 (8.3)	0.977
Dietary recommendation (Yes)	26 (53.1)	34 (47.2)	0.656
%BF (Obesity)	21 (42.9)	62 (86.1)	0.001
WC (Elevated)	20 (40.8)	59 (81.9)	0.001
AH (Yes)	31 (63.3)	51 (70.8)	0.499

SD= standard-deviation; AH= arterial hypertension; SBP= systolic blood pressure; DBP= diastolic blood pressure; WC= waist circumference; %BF= body fatness.

Table 2
Determinants of elevated blood pressure in type 2 diabetic patients.

	Blood pressure at rest			
	Systolic (≥ 140 mmHg)		Diastolic (≥ 90 mmHg)	
Determinants	N (%)	OR_{crude} (95%CI)	N (%)	OR_{crude} (95%CI)
Age (years-old)				
< 50	12 (41.4)	1.00	15 (51.7)	1.00
≥ 50	57 (62)	2.30 (0.98-5.41)	52 (56.5)	1.21 (0.52-2.80)
Insulin use				
Yes	20 (45.5)	0.47 (0.22-1.01)	20 (45.5)	0.53 (0.25-1.12)
No	49 (63.6)	1.00	47 (61)	1.00
Sports practice				
Yes	2 (18.2)	**0.14 (0.02-0.69)**	4 (36.4)	0.42 (0.11-1.54)
No	67 (60.9)	1.00	63 (57.3)	1.00
Dietary recommendation				
Yes	27 (45)	**0.37 (0.17-0.77)**	31 (51.7)	0.74 (0.36-1.52)
No	42 (68.9)	1.00	36 (59)	1.00
%BF				
Normal	15 (39.5)	1.00	14 (36.8)	1.00
Obesity	54 (65.1)	**2.85 (1.29-6.31)**	53 (63.9)	**3.02 (1.36-6.71)**
WC				
Normal	16 (38.1)	1.00	17 (40.5)	1.00
Elevated	53 (67.1)	**3.31 (1.51-7.22)**	50 (63.3)	**2.53 (1.17-5.46)**

OR= odds ratio; 95%CI= 95% confidence interval; WC= waist circumference; %BF= body fatness.

SBP (Figure 1, Panel A). Increased age also was associated with high SBP (OR_{adj}= 3.81 [1.39-10.38]; p= 0.009). Abdominal obesity in the multivariate model was not associated with the same outcome. No determinant was associated with high DBP in the multivariate model (Figure 1, Panel B).

In the analyzed sample, all T2DM patients presented, at least, one risk factor. On the other hand, 12.4%, 25.6%, 29.8% and 32.2% presented 1-2, 3, 4 and 5-6 risk factors, respectively. The T2DM patients with 5-6 risk factors, when compared to 1-2 risk factors, presented higher values of SBP (F= 3.857;

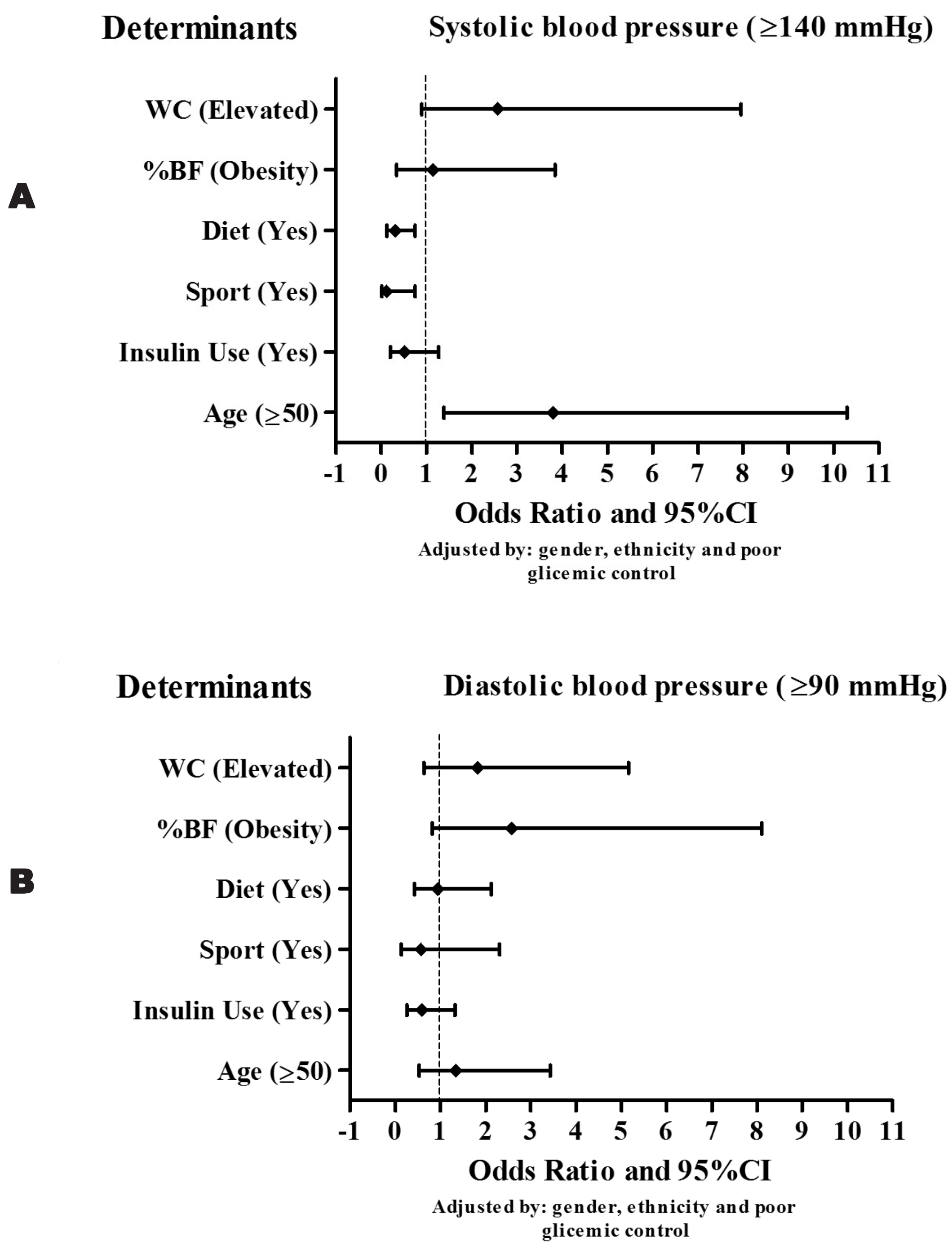
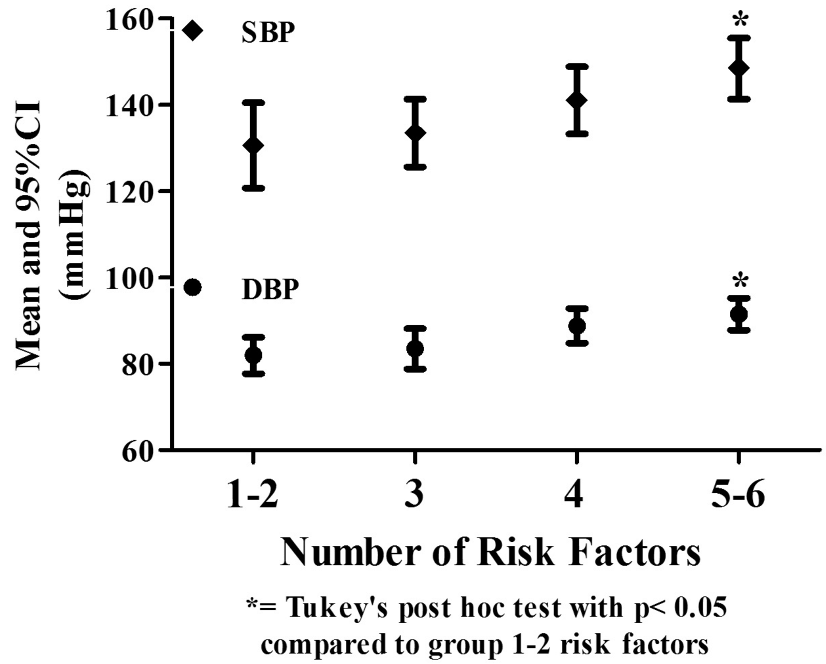


Figure 1. Multivariate model for blood pressure and its determinant in type 2 diabetic patients.
Note. WC= waist circumference; %BF= body fatness

p= 0.011 [post hoc with p= 0.039]), DBP (F= 4.158; p= 0.008 [post hoc with p= 0.036]) and increased occurrence of hypertension (p= 0.010) (Figure 2, Panels A and B).

A



B

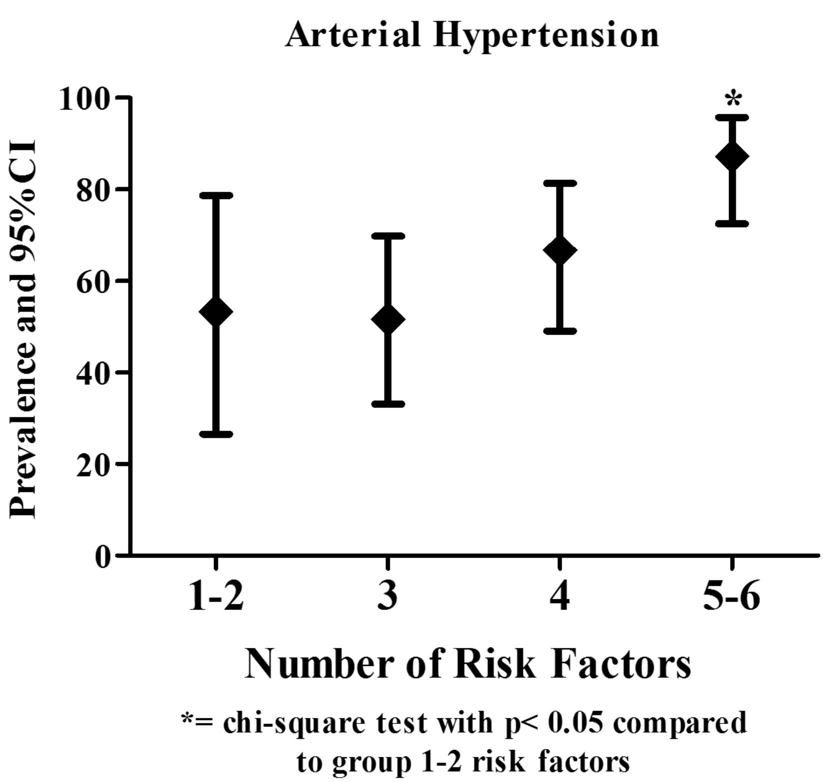


Figure 2. Blood pressure indicators according to clustered risk factors in type 2 diabetic patients.
Note. SBP= systolic blood pressure; DBP= diastolic blood pressure

Discussion

The analyzed sample showed similarities with American diabetic patients attended in San Diego

(Project Dulce; n= 555).[14] In both diabetic groups, there were more women than men, high rate of patients older than 50 years and with high overweight prevalence. Moreover, regular insulin use was similar (36.4% in Bauru and 30.9% in San Diego), but, the American sample presented lower occurrence of AH and the authors suggested that this outcome could be attributed to effectiveness of the preventive program carried out in the Project Dulce. This result indicates that preventive programs are also necessary in Brazil.

Elevated occurrence of AH (80.2%) and poor glycemic control (90.9%) were detected in the patients of the present study. Similarly, large amount of the sample presented both general and abdominal obesity, which were associated with increased blood pressure values. Although these data do not represent a population characteristic (highly elevated occurrence of AH, poor glycemic control and obesity), but a particularity of the analyzed sample, recent studies involving adult subjects also detected positive association between adiposity and blood pressure.[3,15] It is proposed that adipokines released by adipocyte play central role in this inflammatory process responsible for obesity-induced hypertension.[16] The increased amount of adipose tissue results in increased release of fat free acids (FFA) in blood circulation and generates an increased FFA availability, in which the insulin binding is prejudiced in both smooth and endothelial tissue. Vasoconstriction and hyperglycemia are two end products of this insulin resistance.[4] Moreover, adipose tissue of obese individuals releases adipokines related to insulin resistance (tumor necrosis factor-α [TNFα] and interleukine-6) and also present reduced adiponectin expression.[4,16]

In our study, abdominal obesity presented higher burden in the blood pressure than in general obesity. Huang[4] indicated that fat distribution has increased burden in the above mentioned inflammatory process related to obesity, because visceral tissue has increased lipolysis rate and releases increased amount of inflammatory adipokines. Therefore, body composition must be closely monitored in these subjects.

On the other hand, independently of body composition, behavioral variables were associated with lower values of blood pressure. In adults, physical activity practice and supplementation of antioxidant agents are related to both increased nitric oxide production and lower blood pressure.[17,18] The increased blood flow during physical activity practice (shear stress) stimulates the production of nitric oxide and superoxide dismutase (antioxidant agent) by endothelial cell, controlling the production of reactive oxygen species and, in turn, acting on maintenance of the adequate endothelial function.[18,19,20] In fact, physically active subjects have decreased inflammatory status (blood concentration of plasminogen activator inhibitor-1) than sedentary ones.[21] Moreover, in T2DM patients, a yearlong physical activity intervention increased blood concentration of adiponectin and decreased TNFα and interleukine-6.[22] Oral supplementation of soy protein and fish oil can be also source of antioxidant agents and, therefore, enhance organism defenses against oxidative stress.[17] Our results indicate that, the engagement in sport/physical activity during leisure time and dietary control are important factors to the maintenance of blood pressure in T2DM patients with poor glycemic control, even in the absence of weight loss.

Increased age was associated with higher systolic blood pressure, independent of all other determinants analyzed in the present study. In fact, an interaction between biological and behavioral factors could be used to explain our results. Regarding biological factors, a possible explanation would be the natural processes related to ageing, such as autonomous imbalance and vessels stiffening.[23] In relation to behavioral factors, previous studies showed that older people have decreased physical activity practice.[3] Additionally, the benefic effects of adequate food intake are just recently observed in the scientific literature and, therefore, older people might have not experience these effects during their early life.

Previous data indicate that the studied risk factors are related to poor glycemic control[5], but the clustering of them was not analyzed. In our study, several risk factors were not associated with high blood pressure, but when clustered with other risk factors, they strongly increased the blood pressure values. It is noteworthy that, the harmful effect of the clustered risk factors over blood pressure happened independently of glycemic control, indicating that, the pathway by which this clustering affects blood pressure could be other instead of insulin resistance, therefore, more studies are necessary.

The main contribution of our study was to show that, clustering of behavioral and biological risk factors strongly increases blood pressure values in the T2DM population and should be avoided. Another outcome of the present study was to indicate that, in Brazilian public healthcare system, cardiovascular benefits in diabetic patients can be reached with lifestyle changes, independently of body composition and glycemic control.

The cross-sectional design constitutes the main limitation of our study, because it does not support the establishment of a causality relationship between high blood pressure and independent variables. Additionally, two other limitations must be included. First, the identification of poor glycemic control through lasted fasting glucose present bias (e.g. date of the laboratory tests varied among the diabetics; fasting glucose level provides a short-term picture of control) and it is widely recognized that the gold standard to measure glycemic control is the glycosylated hemoglobin A1.[2] In Brazil, public healthcare system use the fasting glucose as a routine exam by physicians (laboratory tests) and, self-monitoring of blood glucose is made by diabetic patients using portable devices.[24]

The second limitation is the absence of detailed information about the type of antihypertensive therapy adopted (e.g. renin inhibitors, β-blockers, diuretic therapy and calcium channel blockers). In our sample, 15 diabetics diagnosed as hypertensive (medical record) presented controlled blood pressure values, but in additional simulation, the exclusion of these diabetics did not change the statistical significant results.

Conclusions

In summary, our findings indicate that behavioral variables and aging were important determinants of blood pressure in T2DM patients with poor glycemic control and that this association happened independent of high general or abdominal body fat. Furthermore, our results evidenced that, clustering of behavioral and biological risk factors increases the likelihood of AH in diabetic patients, independently of poor glycemic control. Finally, due the above mentioned limitations, caution is necessary in the interpretation of the findings and further studies (suppressing the limitations) are necessary to make clearer these associations.

RESUMO

Modelo do estudo: Estudo de associação
Objetivo: Analisar a associação entre diferentes fatores de risco biológicos/comportamentais e pressão arterial in uma amostra de diabéticos do tipo 2 com pobre controle glicêmico. **Métodos:** Uma amostra de 121 diabéticos tipo 2 foi selecionada no sistema público de uma cidade brasileira de porte médio. Pressão arterial foi aferida usando um aparelho aneroide previamente calibrado. Seis determinantes da pressão arterial foram considerados: idade, hipoglicemiantes, obesidade geral, obesidade central, hábitos alimentares e atividade física. **Resultados:** Os diabéticos apresentaram média de idade de 60,1±8,9 anos e ao menos um fator de risco. Hábitos alimentares (OR_{adj}= 0.31 [0.12-0.75]) e prática esportiva (ORadj= 0.12 [0.02-0.75]) constituíram fatores de proteção associados a menor pressão arterial. Por outro lado, idade foi positivamente associada com alta pressão arterial sistólica (OR_{adj}= 3.81 [1.39-10.38]). Pacientes com 5-6 fatores de risco apresentaram maiores valores sistólicos (F= 3,857; p= 0,011 [post hoc com p= 0,039]) e diastólicos (F= 4,158; p= 0,008 [post hoc com p= 0,036]) e maior ocorrência de hipertensão (p= 0,001). **Conclusão:** Nossos achados indicam que variáveis comportamentais foram importantes determinantes de pressão arterial em pacientes com pobre controle glicêmico e a agregação de fatores comportamentais e biológicos aumentaram a ocorrência de hipertensão.

Palavras chaves: Atividade Física. Diabetes Mellitus. Pressão Arterial. Dieta.

References

1. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2010; 33:S62-9.
2. Chien KL, Chen MF, Hsu HC, Su TC, Lee YT. Sports activity and risk of type 2 diabetes in Chinese. Diabetes Res Clin Pract. 2009; 84:311-8.
3. Fernandes RA, Zanesco A. Early physical activity promotes lower prevalence of chronicle diseases in adulthood. Hypertens Res. 2010; 33:926-31.
4. Huang PL. eNOS, metabolic syndrome and cardiovascular disease. Trends Endocrinol Metab. 2009; 20:295-302.
5. Khattab M, Khader YS, Al-Khawaldeh A, Ajlouni K. Factors associated with poor glycemic control among patients with type 2 diabetes. J Diabet Complicat. 2010; 24:84-9.
6. Codogno JS, Fernandes RA, Sarti FM, Freitas Junior IF, Monteiro HL. The burden of physical activity on type 2 diabetes public healthcare expenditures among adults: a retrospective study. BMC Public Health. 2011; 11:275.

7. Brazilian Society of Hypertension. I Brazilian Guideline to Diagnose and Treatment of Metabolic Syndrome. Arq Bras Cardiol. 2005; 84:1s-28s.

8. Lohman, T.G. (Ed.). Anthropometric Standardization Reference Manual. Champaign. IL, Human Kinetics Books, 1988.

9. Heyward VH, Stolarczyk LM. Applied assessment of body composition. São Paulo: Manole, 2000.

10. Sun SS, Chumlea WC, Heymsfield SB, Lukaski HC, Schoeller D, Friedl K, et al. Development of bioelectrical impedance analysis prediction equations for body composition with the use of a multicomponent model for use in epidemiologic surveys. Am J Clin Nutr. 2003; 77:331-40.

11. Pollock M, Wilmore J. Exercise in health and disease: evaluation and prescription for prevention and rehabilitation, Saunders, Philadelphia, 1990.

12. Lean ME, Han TS, Morrison CE. Waist circumference as a measure for indicating need for weight management. BMJ 1995; 311:158-61.

13. Baecke JA, Burema J, Frijters JE. A short questionnaire for the measurement of habitual physical activity in epidemiological studies. Am J Clin Nutr. 1982; 36:936-42.

14. Benoit SR, Fleming R, Philis-Tsimikas A, Ji M. Predictors of glycemic control among patients with Type 2 diabetes: a longitudinal study. BMC Public Health. 2005; 5:36.

15. Yang J, Lu F, Zhang C, Liu Z, Zhao Y, Gao F, et al. Prevalence of prehypertension and hypertension in a Chinese rural area from 1991 to 2007. Hypertens Res. 2010; 33:331-7.

16. Kotsis V, Stabouli S, Papakatsika S, Rizos Z, Parati G. Mechanisms of obesity-induced hypertension. Hypertens Res. 2010; 33:386-93.

17. Simão AN, Lozovoy MA, Simão TN, Dichi JB, Matsuo T, Dichi I. Nitric oxide enhancement and blood pressure decrease in patients with metabolic syndrome using soy protein or fish oil. Arq Bras Endocrinol Metab.2010; 54:540-5.

18. Zaros PR, Pires CE, Bacci MJr., Moraes C, Zanesco A. Effect of 6-months of physical exercise on the nitrate/nitrite levels in hypertensive postmenopausal women. BMC Womens Health. 2009; 9:17.

19. de Moraes C, Davel AP, Rossoni LV, Antunes E, Zanesco A. Exercise training improves relaxation response and SOD-1 expression in aortic and mesenteric rings from high caloric diet-fed rats. BMC Physiol. 2008; 8:12.

20. Zanesco A, Antunes E. Effects of exercise training on the cardiovascular system: pharmacological approaches. Pharmacol Ther. 2007; 114:307-17.

21. Lira FS, Rosa JC, Lima-Silva AE, Souza HA, Caperuto EC, Seelaender MC, Damaso AR, Oyama LM, Santos RV. Sedentary subjects have higher PAI-1 and lipoproteins levels than highly trained athletes. Diabetol Metab Syndr 2010; 2:7.

22. Balducci S, Zanuso S, Nicolucci A, Fernando F, Cavallo S, Cardelli P, et al. Anti-inflammatory effect of exercise training in subjects with type 2 diabetes and the metabolic syndrome is dependent on exercise modalities and independent of weight loss. Nutr Metab Cardiovasc Dis. 2010; 20:608-17.

23. Wichi RB, De Angelis K, Jones L, Irigoyen MC. A brief review of chronic exercise intervention to prevent autonomic nervous system changes during the aging process. Clinics (Sao Paulo) 2009; 64:253-8.

24. Ezenwaka CE, Dimqba A, Okali F, Skinner T, Extavour R, Rodriguez M, Jones-Lecointe A. Self-monitoring of blood glucose improved glycemic control and the 10-year coronary heart disease risk profile of female type 2 diabetes patients in Trinidad and Tobago. Niger J Clin Pract 2011; 14:1-5.