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Artigo Original

Lifestyle changes counseling reduces central blood pressure in pre-hypertensive individuals: an intervention study

Aconselhamento sobre mudanças no estilo de vida reduz a pressão arterial central em indivíduos pré-hipertensos: um estudo de intervenção

Luiz Tadeu Giollo-Junior[§1] MSc; Luciana Neves Cosenso-Martin[1] ; Days Oliveira de Andrade[1] PhD; Letícia Aparecida Fernandes-Baruffi, MSc[1]; Juan Carlos Yugar-Toledo, PhD[1]; José Fernando Vilela-Martin, PhD[1]

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Abstract

Introduction: Lifestyle changes (LC) influence peripheral blood pressure (BP) in pre-hypertensive (PH) individuals; the behavior of central systolic BP (CBP) in respect to LC is not fully known. However, pre-hypertension cardiovascular risk is similar to mild hypertension and can be associated with changes in the endothelial function thereby altering the CBP.

Objective: Thus, to demonstrate the influence of LC on the peripheral and the central blood pressure in PH individuals.

Methods: Fifty-six PH patients were studied before and after three months of LC (Dash diet and aerobic exercises). The CBP was measured by tonometry of the radial artery before and after LC.

Results: The mean age of the study population was 48 ± 10.8 years. There were significant reductions in peripheral systolic pressure (127±8.1 vs. 122 ± 9.2, P=0.003), in the body mass index (29.0±4.6 vs. 28.5±4.6, P=0.001) and the waist-hip ratio(0.91 ± 0.07 vs. 0.89 ± 0.06, P=0.0007) and also in the central systolic pressure (113±10.7 vs. 107±10.9, *P*=0.0001) after three months of LC.

Conclusion: Lifestyle changes promote improvement in peripheral and central BP in PH individuals.

Keypoints

- Twelve weeks of lifestyle chances counseling promoted significative reductions on:

- Central and peripheral systolic pressure; and

- Body mass index and in waist-hip ratio.

Keywords: blood pressure, lifestyle, arterial stiffness, pre-hypertension, DASH diet.

Pontos Chave Destaque

- Doze semanas de aconselhamento para mudanças no estilo de vida promoveram reduções significativas em:

- Pressão sistólica central e periférica; e

- Índice de massa corporal e relação cintura-quadril.

Resumo

Introdução: Aconselhamento para modificação no estilo de vida (MEV) influencia diretamente a pressão arterial periférica em indivíduos pré-hipertensos. O comportamento da pressão sistólica central (PSC) em relação à MEV não está plenamente conhecido. Além disso, a pré-hipertensão (PH) oferece risco cardiovascular semelhante ao de um hipertenso leve e pode estar associado com alterações da função endotelial alterando a PSC.

[§] Corresponding Author: Luiz Tadeu Giollo Junior – e-mail: ltgg@hotmail.com
Affiliations: [1]Hypertension Clinic - Internal Medicine Department, State Medical School of São José do Rio Preto (FAMERP), São Paulo, Brazil.

Objetivo: Demonstrar a influência da MEV com exercício físico e dieta alimentar em parâmetros antropométricos e hemodinâmicos, incluindo a PSC, em indivíduos pré-hipertensos.
Métodos: Foram estudados 56 pacientes com PH antes e após 3 meses de MEV. A PSC foi avaliada utilizando-se um sistema de tonometria da artéria radial antes e após a MEV.
Resultados: A média de idade da população estudada foi 48±10,8 anos. Houve redução significativa na PAS (127±8,1 para 122±9,2; p=0,003), PAD (75±7,4 para 72±7,7; p=0,003), PAM (92±7,0 para 89±7,6; p=0,002), IMC (29,0±4,6 para 28,5±4,6; p=0,001) e na relação C/Q (0,91±0,07 para 0,89±0,06; p=0,0007) após 03 meses de MEV. Também se observou redução da PSC (113±10,7 para 107±10,9; p=0,0001) após três meses de MEV.
Conclusão: A MEV promoveu melhora pressão arterial periférica e central de indivíduos pré-hipertensos.

Palavras-chave: pressão arterial, estilo de vida, rigidez arterial, pré-hipertensão, dieta DASH.

Lifestyle changes counseling reduces central blood pressure in pre-hypertensive individuals: an intervention study

Introduction

Systemic arterial hypertension (SAH) is the main risk factor in the development of cardiovascular disease (CVD), a major cause of mortality worldwide(1). Furthermore, pre-hypertension has a similar cardiovascular risk to mild hypertension(2,3,4) and increases the subject's chance of becoming hypertensive within a 10-yearspan(5).

Although the peripheral arterial pressure is used more in the clinical practice to define both hypertension and pre-hypertension(6,7), these measures do not reflect the central aortic pressure(8). Recent evidence shows that the central blood pressure (CBP) has greater significance as a predictor of cardiovascular complications than the peripheral blood pressure (BP) measured in the brachial artery(9,6). The importance of evaluating the CBP increased substantially with the publication of the Conduit Artery Function Evaluation study (CAFE). Under physiological conditions, the CBP is normally lower than the peripheral BP and many studies have demonstrated a consistent relationship between the CBP and cardiovascular mortality(10, 9). However, few studies demonstrate the behavior of the CBP in pre-hypertensive individuals. In turn, the augmentation index (AI) is another parameter used for evaluating the central hemodynamic. It is also able to predict clinical outcomes for detecting the wave pulse reflection in the arterial tree(11,12). The current standard measure to assess the central hemodynamic involves the non-invasive evaluation of the

Abbreviations
LC – Lifestyle changes
BP – Blood pressure
PH – Pre-hypertensive
CBP – central blood pressure
SAH – Systemic arterial hypertension
CVD – Cardiovascular disease
CAFE – Conduit artery function evaluation study
AI – Augmentation index
DASH – Dietary approaches to stop hypertension
BMI – Body mass index
TC – Total cholesterol
HDLc – High-density lipoprotein cholesterol
TG – Triglycerides
GFR – Glomerular filtration ratio
MDRD – Modification of diet in renal disease
CKD-EPI – Chronic kidney disease epidemiology collaboration
LDLc – Low-density lipoprotein cholesterol
SBP – Systolic blood pressure
DBP – Diastolic blood pressure
CSP – Central systolic pressure
MS – Metabolic syndrome
MAP – mean arterial pressure
GLUT-4 – Glucotransporters
NO – Nitric oxid

radial artery by applanation tonometry, including the CBP and an analysis of the AI, which represents the increase in CBP due to reflected waves. Thus, the greater the amplitude of reflected waves, the greater the overload on the left ventricle and consequently higher CBP(13-16).

On the other hand, lifestyle change (LC) is considered a therapeutic approach to treat hypertension. The two main LC action points are represented by the DASH (Dietary Approaches to Stop Hypertension) diet and physical exercise, which act by improving metabolic parameters and endothelial function(17-20, 2).

Studies have shown that aerobic exercise flow in moderate intensity for 30 minutes, at a frequency of at least five times per week, significantly reduces the peripheral and central BP and significantly improve endothelial function in hypertensive patients(21,22). However, the effects of LC in the AI and CBP need to be better investigated in pre-hypertensive subjects. Thus, the present study sought to demonstrate the influence of LC on the anthropometric, hemodynamic (peripheral and central) and biochemicals parameters of prehypertensive individuals.

Methods

Study design and sample

This was a cohort, randomized, paired, prospective study. Sample was randomly taken from the patients followed on the hypertension outpatient clinic of the School of Medicine of São José do Rio Preto. The inclusion criteria were to be prehypertensive and aged between 30 and 70 years. The exclusion criteria were low life expectancy, previous use of antihypertensive medications, cardiovascular disease and pregnancy. All study participants completed a standard questionnaire to assess risk factors and were extensively informed about the nature of the study.

Prehypertension was defined by office BP values between 120 and 139 mmHg for systolic blood pressure (SBP) and/or between 80 and 89 mmHg for diastolic blood pressure (DBP). For this characterization was considered the mean of three BP measurements(2). From the cohort, 56 prehypertensive patients were invited to participate in the study.

Ethical aspects

The study was approved by the Ethics Committee of São José do Rio Preto Medical School/SP - protocol 2205/2009 and all participants gave their written informed consent.

Study variables

The outcome variables were anthropometric, hemodynamic (peripheral and central) and biochemical parameters and the exposure variable was the counseling on LC. Sample characteristics variables were age (years), sex (♂ / ♀) and skin (Caucasian/Afro-descendant), smoking habit (yes/no), alcohol consumption (yes/no), physical exercise (yes/no) were collected at the time of the study inclusion.

Clinical evaluation

All volunteers underwent clinical evaluations, physical examinations and an investigation of their living habits. Participants were instructed not to use any medication and not to ingest alcoholic beverages within 24 hours leading up to the evaluation.

Anthropometric parameters

Anthropometric parameters were height (m), waist and hips circumferences (cm), weight (kg). From such measures, body mass index (BMI), weight divided by height squared(kg/m2), and waist/hips ratio (cm) were calculated. A calibrated digital scale was used to measure the weight. The height and waist circumferences were measured in centimeters using a tape measure; measurement of the waist was performed at the mid-point between the anterior superior iliac crest and the lowest rib at the end of expiration(23,24).

Hemodynamic (peripheral and central) parameters

Pre-hypertension was defined by office BP values between 120 and 139 mmHg for systolic blood pressure (SBP) and/or between 80 and 89 mmHg for diastolic blood pressure (DBP). For this characterization was considered the mean of three BP measurements. Blood pressure was measured in the office using a digital sphygmomanometer according to the VII

Brazilian Guidelines on Hypertension Treatment(2).Hemodynamic parameters examined were peripheral and central. Peripheral parameters were systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), pulse pressure (PP), heart rate (HR).Central parameters were arterial stiffness – measured by the augmentation index (AI and AI-75 value normalized to a pulse rate of 75) and central systolic pressure (CSP).

Biochemical parameters

Blood samples were drawn after 12 hours of fasting to measure total cholesterol (TC), high-density lipoprotein cholesterol (HDL-c), triglycerides (TG), glycemia, glycated hemoglobin, uric acid, serum creatinine and potassium. Microalbuminuria was also evaluated from urine samples collected for 24 hours and determined using the nephelometric method. The glomerular filtration ratio (GFR) was estimated using the MDRD (Modification of Diet in Renal Disease) and CKD-EPI (Chronic Kidney Disease Epidemiology Collaboration) formula(25,26).

Serum cholesterol was evaluated according to the Brazilian Guidelines for Dyslipidemias(20). Low-density lipoprotein cholesterol (LDLc) was calculated using the Friedewald formula for patients with triglycerides levels below 400 mg/dL (LDLc = TC − HDLc − TG/5)(2).

Lifestyle change counseling protocol

Lifestyle change (LC) counseling protocol included the DASH diet (major food groups, proper portions and reduced sodium)(2), physical activity – mainly aerobic: aerobic exercise (walking) for 30 minutes / 5 times weekly)(2) and healthy life habits (smoking cessation, reduced alcohol consumption and guidelines involving the adequate control of blood pressure) for 12 weeks. Guidance on the DASH diet was performed by a nutritionist and for physical activity program was the recommended exercise prescription model of the Brazilian Society of Cardiology(2) used by a physiotherapist.

Research Protocol

Blood for biochemical tests was drawn from patients who met the study criteria and were submitted for peripheral (SBP and DBP) and central (CSP and AI) hemodynamic assessments. CSP and AI measurements were carried out by a non-invasive technique using applanation tonometry of the radial artery (HEM9000AI device, OMRON Healthcare Co. Kyoto, Japan).

The patient was instructed to fast (no alcohol or any kind of stimulant, or smoking) for at least four hours before arriving at the office. Moreover, the subject's bladder should be empty. The patient was placed in a quiet, comfortable environment (temperature between 21°C and 24°C), and the parameters measurement was taken in the setting position after 5 to 10 minutes of rest prior to the test(2).

Analysis of CBP and AI was performed simultaneously with verification of the peripheral blood pressure, using a calibrated device and a correct size of pressure cuff, which should have an appropriate width to arm circumference ratio of 1:2. As table blood pressure is required before starting applanation tonometry. Stability was confirmed when the differences between two consecutive blood pressure measurements did not exceed 10 mmHg and 5 mmHg for SBP and DBP, respectively. The core parameters (CBP and AI) were assessed once pressure stability was obtained. For this, the left forearm was supported on the equipment and the radial artery was palpated. Subsequently, a pressure sensor was placed on the artery and the hemodynamic parameters were read three times at three-minute intervals. For the test to be considered reliable, the standard deviation of the three tests should not exceed 10%. Functional hemodynamic tests and guidance on the LC were carried out in a specialized outpatient clinic.

After biochemical and functional hemodynamic evaluations, individuals received guidance regarding LC, which included the DASH diet (major food groups, proper portions and reduced sodium), physical activity (mainly aerobic) and healthy life habits (smoking cessation, reduced alcohol consumption and guidelines involving the adequate control of blood pressure). After 12 weeks of counseling on LC, repeat biochemical, and peripheral and central hemodynamics (CSP and AI) evaluations were performed in order to verify the influence of LC on these parameters.

The recommendations carried out aimed at minimizing the possible intervention in the daily food and physical life of the patients, so that they expressed the reality with the modification of the lifestyle in only one visit.

Statistical analysis

The sample size was calculated using the GraphPadStat Mate 2.0 program. The calculated sample size using a p-value of 0.05 and statistical power of 80% to detect a difference in central systolic pressure before and after LC of 6.06 mmHg was 50 individuals.

The descriptive statistical analyses of qualitative and quantitative variables were calculated from measures of central tendency, dispersion and frequency. Inferential analyses were performed by applying the Kolmogorov-Smirnov normality test and homoscedasticity Levene test. The paired t-test was used considering the nature of the data. Correlation analyses were performed using the Pearson method. Multiple logistic regression was used to check possible associations between hemodynamic and anthropometric responses and CSP. The Prism statistics program was used to perform the analysis. An alpha error of 5% was considered acceptable.

Results

The baseline demographic characteristics and habits are described in Table 1. Mean of age was of 50.1(±10.9) years. There was a predominance of males and Caucasians, with most pre-hypertensive individuals consuming alcohol and reporting routine physical exercise.

Table 2 shows the anthropometric parameters and the peripheral and central hemodynamic values before and after LC. Statistically significant reductions in BMI and waist-hip ratio were observed. Note the statistically significant reductions in the systolic, diastolic and mean blood pressures and the CSP in pre-hypertensive patients after three months of LC (Table 2 and Graph 1). The AI and AI-75% reduced but not significantly (Graph 2). Moreover, reductions in the levels of glycated hemoglobin and plasma HDL-c were observed (Table 2). There were no statistically significant changes in respect to the other biochemical variables.

Figure 1 presents results before and after LC. The multivariate correlation between the MAP and the CSP showed a moderate correlation between the two measurements before and after LC, which demonstrates that central blood pressure is directly influenced by peripheral hemodynamics.

Table 1 – Sample characteristics and lifestyle habits (n=56)

Characteristics	Pre-hypertensive
Gender (♂ / ♀) (n)	37 / 19
Caucasian/Afro-descendente (n)	51 / 5
Smoker (%)	15
Alcohol consumption (%)	70
Physical exercise (%)	71

Discussion

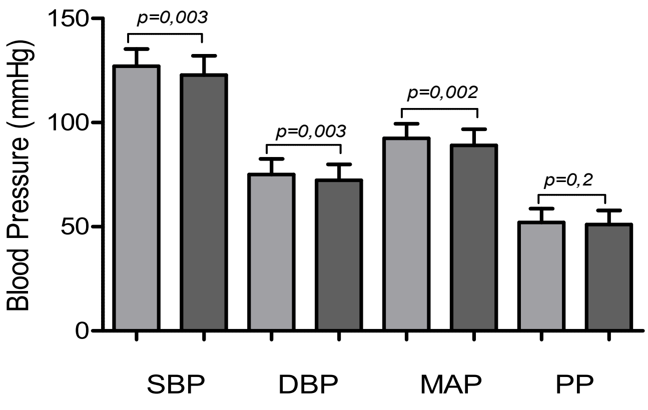
In this study, pre-hypertensive subjects had reductions in BMI, waist-hip ratio and CSP, showing that the intervention on counseling protocol for LC on diet and physical exercise was effective in improving the anthropometric profile and thus reducing cardiovascular risk(27) and the risk of developing metabolic syndrome(28-30). Different types of physical exercise and diet (DASH) offer significant benefits to pre-hypertensive and hypertensive individuals(31,32,2,29). Our LC intervention proposed physical exercise predominantly aerobic and results are in line with literature. Guimarães et al.(33) tested different types of aerobic exercises (interval and continuous) supervised for a period of four months in 43 sedentary mild hypertensive subjects. those, 16 were allocated to the interval exercise group, 16 to the continuous exercise group and 11 to the control group. Although maximum reductions in blood pressure and peripheral arterial stiffness, as demonstrated by an analysis of the pulse wave velocity, were seen mainly in the interval exercise group, the continuous aerobic exercise group was benefited as well. Those benefits can be found mainly in arterial stiffness, and according to our findings, the CSP (Table 2 and Figure 1).

The BMI and waist/hip ratio, a part from being inexpensive techniques as initial

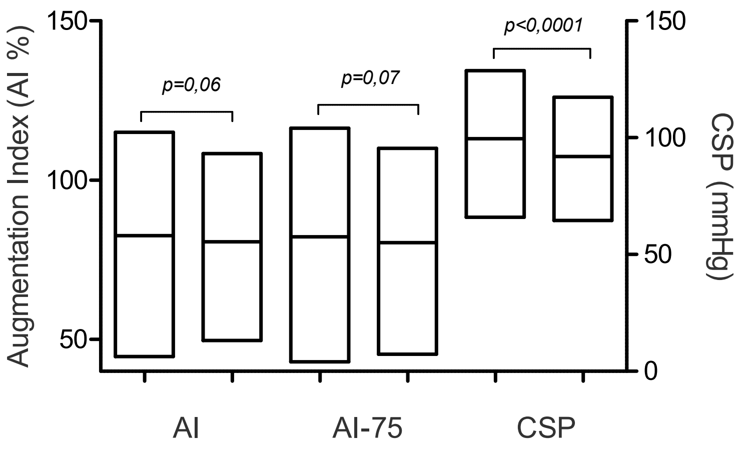
Table 2 – Anthropometric parameters, peripheral and central hemodynamic responses and biochemicals and renal function before and after lifestyle changes in pre-hypertensive patients (n=56)

Variables	Before LC		After LC		
	Mean	± SD	Mean	± SD	***P***
Weight *(kg)*	81,00	± 14,90	80,20	± 14,50	0,208
BMI *(kg/m²)*	29,00	± 4,60	28,50	± 4,60	0,001
Waist *(cm)*	103,50	± 9,10	102,90	± 9,20	0,213
Hips *(cm)*	103,60	± 8,80	103,00	± 8,90	0,206
Waist/Hips *(cm)*	0,91	± 0,07	0,89	± 0,06	<0,001
Hemodynamic parameters					
Peripherals					
SBP *(mmHg)*	127,00	± 8,17	122,00	± 9,25	0,003
DBP*(mmHg)*	75,00	± 7,47	72,00	± 7,72	0,003
MAP*(mmHg)*	92,00	± 7,09	89,00	± 7,65	0,002
PP*(mmHg)*	52,00	± 6,57	51,00	± 6,77	0,284
HR*(bpm)*	73,00	± 11,20	73,00	± 10,60	0,927
Central					
AI*(%)*	82,00	± 14,70	80,00	± 14,60	0,060
AI-75(%)	82,00	± 14,40	80,00	± 14,70	0,076
CSP*(mmHg)*	113,00	± 10,70	107,00	± 10,90	<0,001
Biochemical parameters					
Fasting glycemia *(mg/dL)*	92,00	± 13,20	91,00	± 14,00	0,635
HbA1c *(%)*	5,60	± 0,45	5,30	± 0,44	0,041
Total Cholesterol *(mg/dL)*	205,00	± 31,50	199,00	± 33,70	0,469
HDL cholesterol (mg/dL)	51,00	± 9,77	45,00	± 11,20	0,024
LDL-cholesterol *(mg/dL)*	127,00	± 30,70	126,00	± 33,60	0,838
Triglycerides *(mg/dL)*	130,00	± 55,50	151,00	± 132,10	0,350
Creatinine (mg/dL)	0,93	± 0,20	2,70	± 12,70	0,338
Potassium *(mEq/dL)*	4,40	± 0,46	4,60	± 0,67	0,165
Uric acid *(mg/dL)*	5,40	± 1,37	5,90	± 1,63	0,219
Microalbuminuria*(mg/24h)*	20,00	± 63,12	7,63	± 6,35	0,391
Glomerular Filtration Rate					
CKD-EPI*(mL/min)*	90,50	± 12,70	93,50	± 17,90	0,479
MDRD*(mL/min)*	90,30	± 17,00	97,00	± 35,20	0,342

Values are expressed as means ± **SD** (standard deviation). **P**: p-value from paired *t*-test; **LC**: lifestyle changes; **BMI**: body mass index; **SBP**: systolic blood pressure; **DBP**: diastolic blood pressure; **MAP**: mean arterial pressure; **PP**: pulse pressure; **HR**: heart rate; **AI**: augmentation index; **AI-75**: AI value normalized to a pulse rate of 75; **CSP**: central systolic pressure. **HbA1c**: glycated hemoglobin; **HDL**: high density lipoprotein; LDL: low density lipoprotein; **CKD**-EPI - collaboration of epidemiological chronic kidney disease; **MDRD** - diet modification in renal disease.



Graph 1 – Comparison of peripheral hemodynamic responses (SBP, DBP, MAP, PP) before and after lifestyle changes (LC) intervention in pre-hypertensive patients; **SBP**: systolic blood pressure; DBP: diastolic blood pressure; MAP: mean arterial pressure; PP: pulse pressure.



Graph 2 – Comparison of the central hemodynamic response (CSP) and arterial stiffness (AI and AI-75) before and after lifestyle changes (LC) intervention in pre-hypertensive patients. The middle bar represents the mean value. CSP: central systolic pressure; AI: augmentation index; AI-75: AI value normalized to a pulse rate of 75.

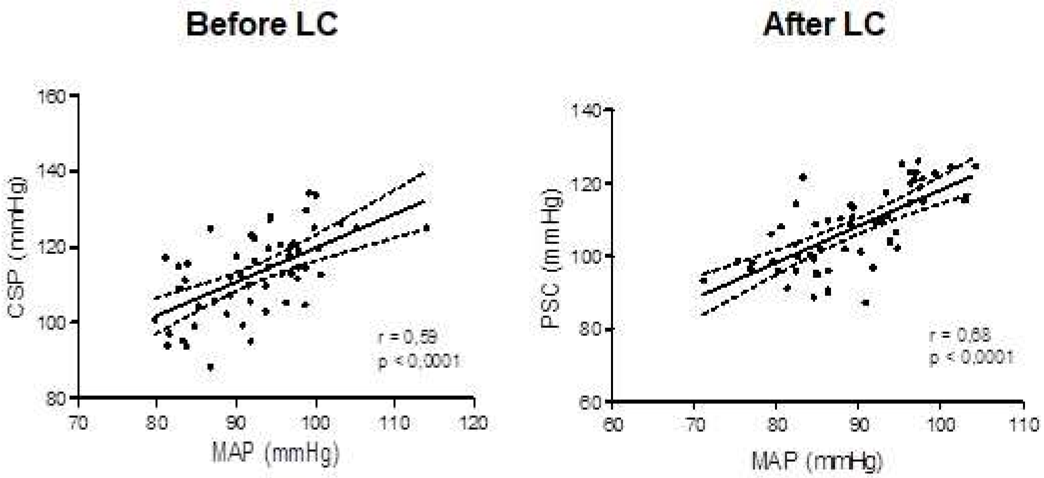


Figure 1 – Analysis of the Pearson multivariate correlation between CSP and MAP before and after lifestyle changes (LC). CSP: central systolic pressure. MAP: mean arterial pressure.

examinations, are indicators of visceral adiposity, insulin resistance and hepatic steatosis(31). LC, in particular exercise and diet, are the first non-pharmacological treatment options to control blood pressure and metabolic syndrome variables in pre-hypertensive patients(2,29).The results of this study demonstrate reductions in peripheral blood pressure of pre-hypertensive patients submitted to LC, which are consistent with literature(34, 35, 2, 29). Márques-Celedonio et al. studied 81 pre-hypertensive patients for six months, only 38 of whom were submitted to LC (diet, physical exercise and counselling to strengthen LC).The group submitted to LC had reductions of 9 mmHg and 14 mmHg in SBP at the end of three and six months of follow-up, respectively and the DBP decreased by 8 mmHg and 11 mmHg, respectively(36). One can observe that those participants were followed up for six months, while in the current study, subjects were submitted to LC for only three months, with no subsequent follow-up visits. This suggests that a longer period of LC with counseling to strengthen the LC must be necessary to obtain greater benefits. In addition, the participation of a multidisciplinary team with monitoring and periodic reinforcement would increase the chance of maintaining the changes over a longer period.

Diet and exercise are very important parts of the lifestyle and, according to our findings, intervention can promote healthier habits into individual's life. Similar to food habit, exercise has a dose-dependent effect on the blood pressure. In addition, the effects of exercise on blood pressure are directly dependent on the recruited metabolic pathway. Aerobic exercises are considered effective in reducing peripheral and central blood pressures and resistance exercises also reduce blood pressure in pre-hypertensive individuals(35). Beck et al.(35) analyzed 43 pre-hypertensive patients subjected to resistance training (opposing force) and endurance exercises (aerobic - 65% to 85% of maximum heart rate for a long time) three times a week for one hour per day over two months. There were no changes in the peripheral or central parameters of the control group. However, reductions of up to 9 mmHg in peripheral SBP and 8 mmHg in the peripheral DBP were recorded for the group that performed resistance training. Moreover, reductions of 10 mmHg were obtained for the aortic systolic pressure and 7 mmHg for the aortic diastolic pressure. Reductions of 12 and 11 mmHg in the central and peripheral systolic pressures, respectively and 7 mmHg for both central and peripheral diastolic pressures were obtained in the group performing endurance exercises. In addition to the pressure coefficients, there was an improvement in arterial stiffness evidenced by a 10% reduction in carotid-radial pulse wave velocity and 11% in the femoral-artery, both in the resistance training and endurance groups(35). The present study also demonstrated reductions in the CSP however the pulse wave velocity was not evaluated. The reduction in CSP can be explained by a possible reduction in peripheral arterial resistance generated by an increase in nitric oxide bioavailability and, consequently, greater vasodilation(37). The vasodilator effect caused by the increase in NO bioavailability can be achieved regardless of any decrease in arterial stiffness, as longer time of LC with a correct variety of physical exercise and diet is required to observe reductions in arterial stiffness. The same effects can also be observed with antihypertensive agents with vasodilator properties(38).

So even with the limitations of duration of LC (three months), they were effective in reducing not only the peripheral pressure parameters (SBP, DBP and MAP), but also the CSP. Reductions of up to 2 mmHg in the peripheral SBP may reduce the risk of mortality from coronary ischemia by 7% and cerebrovascular disease by 10%.1 Moreover, the evaluation of CSP is important because it provides better risk assessment of cardiovascular morbidity and mortality equal to or better than the peripheral SBP(9).This is because the CSP is mainly influenced by structural, and microvascular and macrovascular functional conditions(39).The CSP is influenced directly by arterial stiffness or peripheral resistance and if it is altered, it increases cardiac work by increasing the after load in the left ventricle, favoring the development of myocardial hypertrophy and, consequently, heart failure, ischemic cardiac disease and arterial vascular remodeling(40).

In the present study another arterial stiffness parameter assessed by AI did not show significant changes in the pre-hypertensive group before and after LC. These results are similar to those obtained by Monteiro et al.(34) who conducted a meta-analysis of 14 studies involving prehypertensive and hypertensive patients. The authors found no changes in the behavior of arterial stiffness before and after aerobic exercises over four weeks or more.

The central blood pressure may be strongly influenced by the peripheral vascular resistance (microvessels), causing a reduction in arterial stiffness in pre-hypertensive patients. Yet, structural changes in the arterial wall would be required before observing changes in the AI(34). A longer period of LC with a variation in the dosage of exercise would be needed to see changes in the arterial wall structure. However, in this study, although the AI was not reduced, the decrease in CSP was evident, which is a protective factor for hypertensive individuals. It is known that the disproportion between the peripheral and central blood pressures can be a cardiovascular risk regardless of other risk factors for cardiovascular disease(39,41).

The pre-hypertensive group had reductions in the glycated hemoglobin levels only, with the other biochemical parameters remaining unchanged. This positive change could be attributed to factors such as increased sensitivity to insulin, the GLUT-4 expression in the liver(42), capillary density(43) and ability to oxidize free fatty acids(44). In fact, Qiu et al. evaluated 16 studies involving glycemic behavior with aerobic resistance exercise and found that only walking was able to reduce glycated hemoglobin significantly(45).

The BMI and waist/hip ratio are inexpensive techniques for initial examinations and are good indicators of visceral adiposity, insulin resistance and hepatic steatosis(31). Literature shows that LC, in particular exercise and diet, are the first non-pharmacological treatment options to control blood pressure and metabolic syndrome risk factors in pre-hypertensive patients(2,29).

Strong points and limitations of the study

One strong point of the present study was that in despite of the lack on monitoring of the LC without corrections in the doses of exercise or diet, our findings pointed out that any dose of intervention on exercise and diet promoted cardiovascular and biochemical health.

This study has several limitations. These included the lack of a control group in the study design, the duration of LC and monitoring of LC. The lack of a control group, in our view, was the main limitation. However, we used the study group as a control of itself. Another limitation refers to the duration of LC. Perhaps, if patients were exposed to LC for more time, we would have observed changes in the AI of pre-hypertensive patients.

Conclusions

Changes in the lifestyle through implementing DASH diet and aerobic physical exercise non monitored was effective in reducing the BMI, the waist-hip ratio and peripheral (SBP, DBP, MAP) and central blood pressures in pre-hypertensive individuals.

Other studies should be conducted with control group and exposing patients to longer time on LC to clarify intervention’s effects on AI in pre-hypertensive patients.

Conflicts of interest

The authors of this study state no conflict of interests.

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