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Influence of postural misalignment on blood pressure in hypertensive individuals: an exploratory cross sectional study

Influência do desalinhamento postural na pressão arterial de indivíduos hipertensos: estudo exploratório de corte transversal

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RESUMO | INTRODUÇÃO: Sistema nervoso simpático (SNS) tem sido considerado sistema integrador na regulação da Pressão Arterial (PA). Postura também é regulada pelo SNS. Sistemas que regulam a PA atuam no controle postural. **OBJETIVO:** Testar a hipótese que desalinhamentos posturais se associam com PA em indivíduos hipertensos. **METODOLOGIA:** Estudo exploratório, com 40 indivíduos hipertensos, em uso regular de anti-hipertensivos. Todos foram submetidos a Monitorização Ambulatorial da Pressão Arterial (MAPA) e avaliação da postura pelo Software de Avaliação Postural (SAPO). Para associação entre ângulos de postura e variáveis pressóricas, utilizou-se testes t de student e Mann-Whitney, com nível de significância de 5%. Esse estudo está registrado no clinical trials, sob o número NCT02401516. **RESULTADOS:** Para a Pressão Arterial Sistólica (PAS), deslocamento anterior de tronco apresentou menor variação vigília/sono (14,7%vs25,3%, p=0,01), tornozelo em flexão com maiores cargas pressóricas: 21,9%vs7,8% para carga total (p=0,02), 21,8%vs9% para carga durante vigília (p=0,04) e 21,9%vs7,9% para carga durante sono (p=0,02). Para a Pressão Arterial Diastólica (PAD), deslocamento de tronco posterior apresentou maior carga pressórica (24,0%vs16,2%, p=0,04) e deslocamento anterior menor variação vigília/sono (14,4%vs25,5%, p=0,01) e quadril em flexão apresentou maior carga pressórica (29,4%vs18,3%, p=0,02). A partir de Escore de postura, postura alterada apresentou menor variação vigília/sono, tanto para PAS (13,7%vs22,8%, p=0,03) como PAD (11,5%vs23,5%, p=0,01), bem como maior carga pressórica durante sono (28%vs18%, p=0,02). **CONCLUSÃO:** desalinhamentos posturais podem se associar com PA. Três ou mais alterações nos ângulos de postura se associaram com menor variação da pressão vigília/sono e maior carga pressórica diastólica durante sono.

PALAVRAS-CHAVE: Hipertensão. Pressão arterial. Postura.

ABSTRACT | INTRODUCTION: Sympathetic Nervous Sistem (SNS) has been considered as the ultimate integrator of the systems' physiology on Blood Pressure (BP) control. Posture is also regulated by SNS. Systems which regulate BP also act on postural control. **OBJECTIVE:** To test the hypothesis of an association between Postural Misalignments (PM) and BP in hypertensive individuals. **METHODOLOGY:** Exploratory study using a sample of 40 hypertensive individuals, who regularly use antihypertensive drugs. All of them underwent Ambulatory Blood Pressure Monitoring (ABPM) and posture assessment, through Postural Assessment Software (PAS). To test association between posture angles and BP variables, the student's t-test and Mann-Whitney tests were used, at a 5% level of significance. This study is registered at clinical trials, under the number NCT02401516. **RESULTS:** For Systolic Blood Pressure (SBP), anterior trunk shift presented smaller awake/asleep variation (14.7%vs25.3%, p=0.01), and flexing ankle for higher BP loads: 21.9%vs7.8% for total load (p=0.02), 21.8%vs9% for load during the period awake (p=0.04) and 21.9%vs7.9% for load during the period asleep (p=0.02). For Diastolic Blood Pressure (DBP), posterior trunk shift presented higher pressure load (24.0%vs16.2%, p=0.04), and anterior trunk shift presented smaller awake/asleep variation (14.4%vs25.5%, p=0.01) and flexing hip presented higher BP load (29.4%vs18.3%, p=0.02). From posture scores, the PM presented smaller awake/asleep variation for SBP (13.7%vs22.8%, p=0.03) and DBP (11.5%vs23.5%, p=0.01). **CONCLUSION:** PM can be associated with pressure. Three or more alterations in posture angles are associated with smaller awake/asleep BP variation.

KEYWORDS: Hypertension. Blood pressure. Posture.

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Introduction

Systemic Arterial Hypertension (SAH) is one of the main modifiable risk factors for cardiovascular and cerebrovascular diseases[1], whose cost was directly or indirectly estimated as $46.4 billion dollars in the year 2011[2]. Ambulatory Blood Pressure Monitoring (ABPM) is a gold standard examination for BP diagnosis[1]. Parameters obtained through the ABPM made it possible to establish a prognosis of the primary outcomes of the cardiovascular event when compared to BP measurements taken at clinics[1]. Excessive activation of the Sympathetic Nervous System (SNS) seems to play an important role in the generation and maintenance of SAH[3], therefore, it is being considered as the final system integrator of all physiological systems, in the regulation of cardiovascular function[4]. Most vascular nerves of the SNS result in vasoconstriction, and their main transmitter is noradrenaline, it is a highly differentiated tissue, and each subdivision reacts to specific reflexes[4], with the interference of musculoskeletal[5], vestibular, cutaneous[4], endocrine[5] and somatosensorial[6] systems.

Muscle neural control plays an essential role in hemodynamics, through Muscle Sympathetic Nerve Activity (MSNA), which consists of vasoconstrictor impulses modulated from the Central Nervous System (CNS), and many peripheral receptors[4], among which, the Arterial Baroreflex (AB) is the BP modulating receptor[4]. This relationship vary with individuals, can be altered by some factors, such as posture[4], and the acute effects of sudden change in posture, called gravitational stress, is the most studied in BP control[7,8].

Posture can be defined as the shape a body takes at a certain moment to compensate for the gravitational force applied to all the body segments, while keeping stable the positioning of such segments[9]. Even when standing still, individuals present some minute oscillatory movements which are related to postural control, defined as the ability to stand, walk and interact with the environment in a safe and efficient manner[9]. As individuals maintain the same attitude in face of gravity, it tends to become a pattern, with adaptation of body segments to this position[10]. It is important to emphasize that, in order to maintain a good postural control, several physiological systems interact, each one contributing differently, such as the musculoskeletal, somatosensorial, vestibular and cognitive systems[9].

Assuming posture as the attitude the body takes on, when faced with gravity at different moments of the day, and considering the high frequency of postural misalignment (PM) in the current world, the musculoskeletal alterations are expected to be the cause of or consequence of PM[10]. These alterations can increase BP due to their intimate relationship with SNS, either through MSNA, vestibular-sympathetic reflex or another mechanism. Therefore, it is important to understand the possible influence of posture over BP in hypertensive individuals. Thus, this study aimed at analyzing the influence of posture over BP in hypertensive individuals.

Materials and methods

This is an exploratory study, carried out on hypertensive individuals, monitored at the Teaching Clinic of Bahiana School of Medicine and Public Health (EBMSP) and at a primary health care center, between march, 2014 through July, 2015. The participants of the study were individuals diagnosed as having SAH (SBP≥140mmHg and/or DBP≥90mmHg) for at least 2 months, from both genders, aged between 30-60 years, with a Body Mass Index (BMI) of 34.9Kg/m^2, who are regularly on medication for BP control and not on any medication for glycemic control. All participants were oriented to keep their diet pattern and maintain the use of already prescribed medication. Since the objective of this study was to evaluate the influence of posture, while chronic condition, in BP of individuals with hypertension, also a chronic nature, was performed 24 hours assessment of BP and after the test validation, evaluation of posture. Individuals with a history of cerebrovascular diseases and previous cardiovascular episodes, diagnosed with renal disease or peripheral artery disease, neurological, mental, orthopedic or rheumatologic diseases, pregnancy and Diabetes Mellitus (due to association of autonomic dysfunction), were excluded from the study.

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This project has been approved by the Bahiana Ethics Committee, under the protocol ID CAAE 16952113.5.0000.5544. Also, this project is registered at clinicaltrials.gov under the number NCT 02401516. After signing an Informed Consent (IC), participants proceeded to the Cardiovascular Research Laboratory of the EBMSP, in order to undergo 24 hours ABPM according to the V Brazilian Guideline for ABPM use[1]. All examinations were reported by a cardiologist with experience in analyzing such method and who is unaware of the participants' postural profile.

ABPM gives as a result the values of the pressure loads, medium and peak pressures, BP variations between Awake and Asleep period, for both SBP and DBP, presence of other symptoms and conditions such as hypotension and classifies individuals in dipper and non-dipper, depending on the presence or absence of nocturnal dipping of BP during Asleep period, respectively. Pressure load can be defined as the percentage of measures above the reference values for SBP and DBP, being considered during the Awake period, during the Asleep period, and the total load. Variation in pressure between the Awake and Asleep periods measures the extent that pressure during Asleep period varies in relation to the Awake period. It is expected that these values fall at least 10%. When the pressure dip does not occur during Asleep period, it is said that the individual is non-dipper[1].

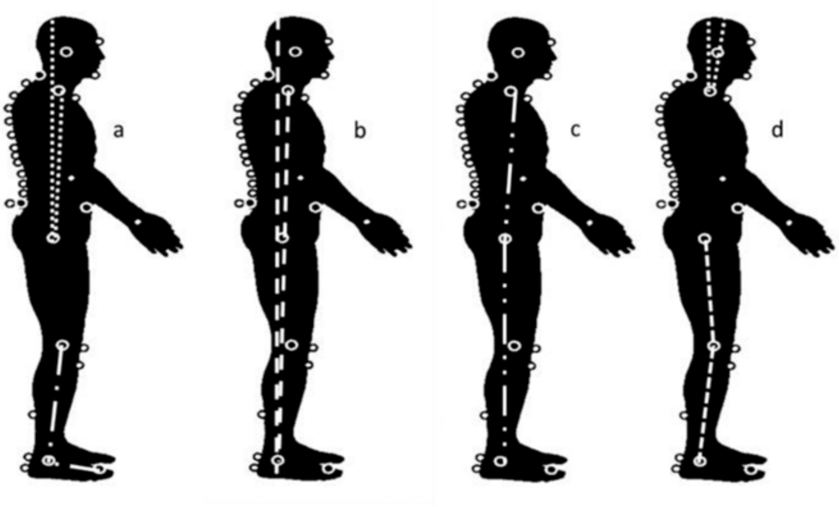
After examination has been validated, the participants filled out the questionnaire based on life habits, health and sociodemographic data. Weight and height were evaluated by a Welmy® (Santa Barbara D'Oeste, SP) manual scale and, abdominal Waist Circumference (WC) was measured according to Barbosa et al[11]. BP at the clinic was assessed according to the VI Brazilian Guideline of Hypertension (VI Diretriz Brasileira de Hipertensão)[12].

Posture assessment: a 25cm diameter styrofoam hemispheres were attached to the main bone surfaces with a double-sided tape (3M brand), according to the Postural Assessment Software protocol[13]. Participants placed their feet on a 30-degree abduction, in order to align and standardize images. Individuals wearing shorts (for men) and a sports bra (women) were positioned over kraft paper with an area of one square meter, near the plumb-line, which was tied to the ceiling, and a marking of 10cm length, in order to calibrate the software images, which were captured by a Sony Cybershot digital camera (model DSC-W570, 16.1 megapixels), supported by a tripod half their height and placed three meters away from the individuals. It was requested that the individuals assume habitual posture and the time between positioning and the capture of the image was enough to make the individuals relaxed, assuming the posture more usual as possible.

The software generates images of both sides, and the Right Side View was raffled. Angles were described as: 1)Vertical Alignment of Head (VAH), which is formed between the tragus, acromion and vertical line; 2) Vertical Alignment of Trunk (VAT), formed between the acromion, greater trochanter and vertical line; 3) Vertical Alignment of Body (VAB), formed between the acromion, lateral malleolus and vertical line; 4) Hip Angle (HA), formed between the acromion, greater trochanter and lateral malleolus; 5) Knee Angle (KA), formed between the greater trochanter, lateral joint line of the knee and lateral malleolus, and 6) Ankle Angle (AA), formed by the lateral joint line of the knee and the lateral and horizontal lines of the lateral malleolus. (Figure 1)

Sample size: Since the identification of subjects with posture alterations was only carried out after they were chosen and it is understood that alterations around 5mmHg are clinically relevant, the standard deviation of the mean BP between groups with altered angles was chosen as 5mmHg, for SBP above 140mmHg and/or DBP above 90mmHg, in order to detect the differences between BP averages of 5mmHg, with a significance level of 5%, power of 80%, in a two-tailed hypothesis, with a total number of 38 individuals, 19 in each group. WinPepi calculator was used and the data was organized and analyzed by the SPSS software, version 14.0 for Windows.

Figure 1. Posture angles at Right Lateral View. **1a-Up:** Vertical Alignment of Trunk (VAT), formed between the acromion, greater trochanter and vertical line; **Down:** Ankle Angle (AA), formed by the lateral joint line of the knee and the lateral and horizontal lines of the lateral malleolus; **1b.** Vertical Alignment of Body (VAB), formed between the acromion, lateral malleolus and vertical line; **1c.** Hip Angle (HA), formed between the acromion, greater trochanter and lateral malleolus; **1d – Up:** Vertical Alignment of Head (VAH), which is formed between the tragus, acromion and vertical line; **Down:** Knee Angle (KA), formed between the greater trochanter, lateral joint line of the knee and lateral malleolus.



Descriptive and inferential analysis:

Sociodemographic variables: Age (years), skin color (Black/White/Brown/Yellow/Indigenous), education (until 4 years of education/5-8 years/9-11 years and 12 years or more), marital status (Married-Stable Union/Single/Widow/Separated-Divorced);

Life habits, health and anthropometric variables: Height (cm), BMI (Kg/m2), Waist Circumference (WC) (cm), smoking (never smoked/smoker/former smoker), alcohol consumption (dichotomous), regular use of medication (dichotomous), kind of medication (category). WC values considered relevant were up to 84cm for women and 88cm for men, validated for the Brazilian population[11]. WC values were categorized as normal and increased;

Clinical variables: Total, Awake and Asleep BP loads (%), Peaks in BP during Awake and Asleep (mmHg) period, medium BP (mmHg), BP Variation between Awake and Asleep (%) period, absence of BP descent (no-dipper), and clinical measures of SBP, DBP and Heart Rate (HR);

Postural variables: VAH, VAT and VAB, categorized as posterior and anterior shift; HA, KA and AA, categorized as increased (hip extension, knee extension and flexing ankle) and decreased (flexing hip, flexing knee and flexing ankle) angle. Negative values mean posterior shift or increased angles. Positive values mean anterior shift or decreased angles. AA had a cut point of 90-degree angle.

Average and standard deviation were used for the descriptive analysis of age, height, BMI, WC, BP peaks and averages as well as the HR variables. For the asymmetrical variables, pressure loads, BP variation between awake and asleep period, median and interquartile range were used. For the categorical variables, the absolute number and proportion were used.

Student's t-test was used in order to identify the association between posture angles and BP peaks and averages; for the association between posture angles and pressure loads, and for the BP variation between awake and asleep period, Mann-Whitney test was used. For the association between posture angles and absence of BP decrease, Fisher test was used. For all tests, the statistical significance level was set at 5%, for a two-tailed hypothesis.

Results

The studied sample presented mean age of 48.7±7.2 years, height of 160.41±8.11cm, a BMI of 29.4±4.4 Kg/m2, WC of 96.8±3.4cm for male participants, considered increased for all men, and 91.7±6.9cm for female participants, being increased in 90% of women. Most frequent characteristics were found in female (75%), married (57.5%), 12 or more years of education (62.5%), and black skin (51.5%). Most of participants have never smoked (77.5%), claimed not to drink alcohol (62.5%), were taking antihypertensive medication (80%), the most frequent one being an angiotensin II receptor blocker (60%), and hypertension was under control in 62.5% of participants. (Table 1)

Table 1. Sample characteristics according to the sociodemographic, anthropometric, clinical, life habits and health data. (n=40)

Variables	Average ±SD
Age (years)	48.7±7.2
Height (cm)	160,41±8,11
BMI (Kg/m²)	29,4±4,4
WC Men(cm)*	96.8±3.4
WC Women(cm)	91.7±6.9
SBP at the clinic (mmHg)	144.5±23.3
DBP at the clinic (mmHg)	86.8±12.2
HR at the clinic (bpm)	76.6±12.0
WC Men (cm) (n=10)	**n(%)**
Increased	10(100.0)
WC Women (cm) (n=30)	
Increased	27(90.0)
Sex	
Female	30(75.0)
Marital Status	
Married/Stable relationship	23(57.5)
Single	12(30.0)
Separated/Divorced	3(7.5)
Widowed	2(5.0)
Education (years)	
Until 4	1(2.5)
5 - 8	5(1.5)
9 - 11	9(22.5)
12 or more	25(62.5)
Skin Color	
Black	21(51.5)
Brown	17(42.5)
White	2(5.0)
Smoking	
Never	31(77.5)
Former smoker	8(20.0)
Smoker	1(2.5)
Alcohol consumption	
No	25(62.5)
Yes	15(37.5)
Use of antihypertensive medication	
Yes	32(80.0)
Types of medication	
Thiazide diuretic	13(32.5)
Beta-blocker	13(32.5)
ACE inhibitor†	2(5.0)
ARB‡	24(60.0)
Calcium channel blockers	4(10.0)
Acetylsalicylic acid (ASA)	4(10.0)
BP classification	
Controlled hypertension	25(62.5)
Non-controlled hypertension	15(37.5)

*Waist Circunference; † ACE inhibitor: Angiotensin-converting-enzyme inhibitors; ‡ARB: angiotensin II receptor blocker

For SBP, individuals with anterior trunk shift presented a smaller variation in SBP between awake and asleep period (14.7%vs25.3%, p=0.01), while the biggest loads presented by the flexing ankle: 21.9%vs7.8% for total load (p=0.02), 21.8%vs9% for load during awake periods (p=0.04) and 21.9%vs7.9% for load during period asleep (p=0.02). (Table 2)

Table 2. Associations between Postural Angles (PAS software) and Systolic Blood Pressure (SBP) variables. (n=40)

SBP variables	Total PL (%)	Awake PL (%)	Asleep PL (%)	Average (mmHg)	Awake/asleep Variation (%)
Postural Angles					
VAT (°)					
Posterior (n=22)	21.8	22.7	20.5	129.6±17.3	25.3*
Anterior (n=18)	18.9	17.9	20.5	125.1±21.4	14.7
HA (°)					
Increased (n=32)	20.1	20.4	19.5	128.1±21.2	21.6
Decreased (n=8)	22.1	21.1	24.6	125.5±6.9	16.3
VAB (°)					
Posterior (n=6)	27.1	28.5	24.6	132.8±14.5	24.8
Anterior (n=34)	19.3	19.1	19.8	126.7±19.9	19.8
KA (°)					
Increased (n=27)	19.8	20.5	18.8	129.0±22.5	22.8
Decreased (n=13)	22.0	20.5	24.0	124.8±9.2	15.7
AA (°)					
Increased (n=8)	7.8†	9.0‡	7.9§	113.0±4.2	24.5
Decreased (n=32)	21.9	21.8	21.9	129.2±19.5	20.1

Pressure Loads (PL) and Pressure Variations: Mann-Whitney; BP Peaks and Averages: Student's t-test.
*p=0,01; †p=0,02; ‡p=0,04; §p=0,02. Other variables not significant.

Considering DBP data, it was possible to notice that posterior trunk shift presented a higher pressure load (24.0%vs16.2%, p=0.04), and the anterior shift presented a smaller variation (14.4%vs25.5%, p=0.01) and it was more frequent among non-dippers (p=0.02). Flexing hips presented a higher DBP during asleep period (29.4%vs18.3%, p=0.02). There was no significant difference between VAH and BP variables. (Table 3)

WC expresses a central obesity[14], and it has been described in literature due to its association with SAH[15] and postural alterations[16], an analysis was carried out in order to identify a possible interference of this variable. When data was stratified by gender, even with elevated WC in most female participants, there was no statistically significant difference, in comparison with posture angles and pressure variables. On the other hand, with male participants, all had elevated WC and, even with a smaller number of participants, when correlated with pressure variables, it was possible to observe a positive relationship for pressure load of DBP during asleep (r=0.63; p=0.05) period and a negative relationship between the SBP and DBP variation during awake/asleep period (r=-0.89; p=0.01 e r=-0.78; p=0.01, respectively). WC showed no association with Posture Score (PS) in either gender.

Table 3. Associations between Postural Angles (PAS software) and Diastolic Blood Pressure (DBP) variables. (n=40)

DBP variables	Total PL (%)	Awake PL (%)	Asleep PL (%)	Average (mmHg)	Awake/Asleep Variation (%)
Postural Angles					
VAT (°)					
Posterior (n=22)	22.3	24.0*	18.7	83.56±9.1	25.5†
Anterior (n=18)	18.3	16.2	22.7	83.3±16.4	14.4
HA (°)					
Increased (n=32)	20.1	20.7	18.3‡	83.3±14.0	22.3§
Decreased (n=8)	22.0	19.9	29.4	83.9±6.2	13.4
VAB (°)					
Posterior (n=6)	18.5	21.2	17.8	81.7±6.7	22.6
Anterior (n=34)	20.9	20.4	21.0	83.7±13.6	20.1
KA (°)					
Increased (n=27)	20.0	21.1	18.2	83.9±14.9	22.8
Decreased (n=13)	21.5	19.3	25.3	82.5±6.7	15.8
AA (°)					
Increased (n=8)	11.8	13.6	10.4	75.0±3.8	26.3
Decreased (n=32)	21.5	21.3	21.6	84.4±13.0	19.9

Pressure Loads and Variations: Mann-Whitney; Pressure Peaks and Averages: Student's t-test; *p=0,04; †p=0,01; ‡p=0,02. Other variables not significant.

From five postural variables which showed an association between bivariated analysis, a Posture Score (PS) was created, namely: anterior trunk shift, posterior body shift, flexing hip, knee and ankle. PS was categorized as minimally altered when there are two PM, and altered, when an individual presented more than two angle alterations. Student's t-test was used for pressure peaks and averages, Mann-Whitney test was used for pressure loads and variations.

Table 4. Associations between Postural Escores (PAS software) and Blood Pressure (BP) variables. (n=40)

BP variables	Total SPL (%)	SBP Average (mmHg)	SBP Awake/Asleep Variation (%)	Total DPL (%)	DBP Average (mmHg)	DBP Awake/Asleep Variation (%)
Postural Escore						
Minimally altered (n=30)	20.1	128.8±21.7	22.8*	20.3	83.6±14.4	23.5†
Altered (n=10)	21.6	124.1±6.8	13.7	21.1	83.1±5.7	11.5

SPL: Systolic Pressure Load; DPL: Dyastolic Pressure Load;
Loads and Variations: Mann-Whitney; Averages: Student's t-test; *p=0,03, †p=0,01.
Other variables not significant.

For SBP, a smaller variation between awake/asleep period was observed in altered group (13.7%vs22.8%, p=0.03). For DBP, the altered group presented a smaller variation between awake/asleep period (11.5%vs23.5%, p=0.01). (Table 4)

Discussion

Anterior trunk shift, posterior body shift, flexing hip, knee and ankle were associated with higher pressure loads and smaller pressure variations during the awake/asleep period, for SBP as well as for DBP. Relating to PS, three or more PM have impacted BP during the asleep period.

To the best of our knowledge, associations between posture angles and ABPM data has not been previously studied, and the hypothesis that these PM could generate and maintain SAH has not been previously explored until this present study. However, it is important to understand the possibles mechanisms involved in this association.

Central obesity, anterior trunk shift and flexing hips favor a forward trunk projection, as a possible attempt of compensating for posterior body shift. All these measurements were associated with higher pressure loads and smaller variations between awake/asleep period. It is possible to propose the theory that anterior trunk shift can have a certain reflex on vestibular system, which has an important role to play in blood distribution adjustment over the body[17,18]. Shift positioning of the head and body can stimulate otolith organs[17], which can stimulate MSNA[18], consequently, increasing Peripheral Vascular Resistance (PVR) and Cardiac Output (CO)[16]. There seems to be an additive interaction between MSNA and BP, when both musculoskeletal and vestibular-sympathetic reflexes are simultaneously activated[18].

Excess on motor activity can lead to higher activation of noradrenergic system[19], increasing stimulus of sympathetic tone, whith maintainance of postural adjustments[20] during awake period. This condition in awake can modify tone regulation program during relaxation, interfering in quality of asleep, consequently increasing pressure. In case this condition is true, hyperstimulation of SNS caused by posture is added to the hyperstimulation of SNS caused by SAH, in which case PM have additional effects.

Flexing ankle was strongly related to the pressure loads in SBP. Alterations in muscle tension state can generate mechanical compressions on the vessel's external wall, while transferring this mechanical force into the vessel's internal wall, which favors liberation, sensitivity and excretion of adrenaline[5] with persistent reduction in perfusion, compromising muscle performance[21]. Sustained muscle contraction can increase muscle tension by stimulating mecanoreceptors[6], and the activation of metaboreceptors[22,23], which provoke and result in an increase in SNS activities[21].

Study on the actions of metaboreceptors were carried out during physical exercise, with sustained contractions of 35% from a Maximum Voluntary Contraction (MVC). Metaboreflex action is directly proportional to muscle mass and to the capacity of arterial occlusion by muscle contraction[22], which means altered posture sustained for a long period of time can stimulate metaboreceptors of great muscle groups, such as: anterior tibialis, triceps surae, harmstring, among others[24], causing an increase in BP, decrease in perfusion pressure, which can bring about premature fatigue and the incapacity of muscle performance[22], as well as cause a systemic action, considering the quantity of the PM.

Having three PM was associated with a smaller pressure control and with smaller variation in BP at night. Under physiological conditions, noradrenergic system seems to be involved in the reduction of motor activity during period asleep, with a reduction in postural tone and sensorimotor responses, mainly during REM or deep asleep period[19]. Noradrenaline provokes activation of the forebrain during the period awake and of other cerebral structures and inhibits neurons that favor the period when one is asleep, thereby, waking the individual[19]. It is assumed that individuals with small pressure variation during period awake/asleep can present an excess of circulating noradrenaline, with a potential vasoconstrictor effect over SNS.

Smallest diastolic pressure variation at night and highest DBP during asleep period were associated with WC in male participants. Central fat gain is associated with dysfunction in the adipocytes, increase in the PVR and the stimulation of SNS[15], alterations in the asleep sync, and nervous modulation that is similar to the awake period[25].

Among the medications used, beta-blocker has direct effect on the CNS, whose action is to reduce sympathetic efferent influx by modulating the response to sympathetic stimulation, regulating BP. Even after the stratification of data, there was no difference between groups with and without beta-blocker. In association, there was no difference between variables in the group of those who make use of beta-blockers.

In this paper, posture is define in a different way it used to be: as the attitude the body takes on when faced with gravity. The idea to find an interconnection between human posture alignment and blood pressure is a new one, and to explore this association, this group choose to work with the ones that had more chance to show the difference: hypertensive individuals rather than controls, turning this in a limitation of the study.

This study was exploratory in nature. Many hypotheses generated will not be confirmed by this study, being necessary others to validate them, such as muscle tone as a possible modifier of PVR and evidence of sympathetic nerve activation by posture. The evaluation of muscle tone demand the use of no tools available at the time, such as electromyography and evaluation of sympathetic nerve activity is done invasively, an option not considered for the current study. The association between postural misalignment and BP is significant because is a new approach at this relationship and also a new perspective to assessment and treating. A comparison of postural misalignment and BP on non-hypertensive individuals should be the next step.

Therefore, we conclude that postural misalignment may influence blood pressure, and a higher number of PM can negatively influence pressure variation during awake/asleep period.

Author contributions

Goes ALB conceived the idea of the manuscript, acquisition, analysis and interpretation of the data and drafted the article; Dias AF, Jesus DM, Negrão MC, Silva TN, Silva TB, Lago VC, Soares VP participated in the acquisition of data; de Souza, LAP analyzed the ABPM, contributing to the acquisition of data; Ladeia AMT revised the manuscript critically for important intellectual content and made the final approval of the version to be submitted.

Competing interests

No financial, legal or political competing interests with third parties (government, commercial, private foundation, etc.) were disclosed for any aspect of the submitted work (including but not limited to grants, data monitoring board, study design, manuscript preparation, statistical analysis, etc.).

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