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Pulse pressure findings following upper cervical care: a practice-based observational study

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Introduction: *Pulse pressure is an indicator of cardiovascular health and is the difference between systolic and diastolic blood pressures. An important etiologic consideration is autonomic nervous system balance. The purpose of this study is to observe pulse pressure changes following a six-week course of care utilizing an upper cervical technique.*

Methods: *One hundred and thirty patients presenting in five different clinics were separated into three groups based on initial pulse pressure groups with 40 mmHg considered as normal: low (< 40 mmHg), medium (40-49 mmHg), and high (> 49 mmHg).*

Results: *Pulse pressure reduced by 8.9 mmHg in the high group which was statistically significant (p < 0.01) with a large effects size of 0.8. Changes in the low and*

Introduction : *La tension différentielle est un indicateur de la santé cardiovasculaire et représente la différence entre la tension artérielle systolique et diastolique. L'équilibre du système nerveux autonome est une considération éthologique importante. L'objectif de cette étude est d'observer les changements de la tension différentielle à la suite d'un traitement utilisant une technique des hautes cervicales d'une durée de six semaines.*

Méthodologie : *Cent trente patients se sont présentés dans cinq cliniques différentes et ont été répartis par groupes de trois en fonction des groupes de tension différentielle initiaux avec une pression de 40 mmHg considérée comme normale : faible (< 40 mmHg), moyenne (40-49 mmHg) et élevée (> 49 mmHg).*

Résultats : *La tension différentielle réduite de 8,9 mmHg dans le groupe élevé, ce qui était statistiquement important (p < 0,01) avec une ampleur des effets observés de 0,8. Les changements dans les*

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medium groups were not statistically significant (p < 0.05).

Conclusion: *In this observational study the group displaying the highest pulse pressure demonstrated statistically significant reduction in pulse pressure.*

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KEY WORDS: chiropractic, pulse pressure, cervical spine, autonomic nervous system

groupes faibles et moyens n'étaient pas statistiquement importants (p < 0,05).

Conclusion : *Dans cette étude par observation, le groupe présentant la tension différentielle la plus élevée a démontré une réduction statistiquement importante de la tension différentielle.*

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MOTS CLÉS : chiropratique, tension différentielle, colonne cervicale, système nerveux autonome

Introduction

Pulse pressure is an established clinical measurement that may be useful for health professionals that seek to monitor cardiovascular health. Autonomic dysfunction can lead to essential hypertension and arterial stiffness reflected in elevated pulse pressure.[1,2] Pulse pressure is the difference between systolic and diastolic blood pressures. Elevated pulse pressure is a recognized cardiovascular risk factor and some studies have suggested it to be a marker for pre-clinical cardiovascular disease.[3-5] A meta-analysis involving 8000 patients found that a modest increase of 10 mm Hg in pulse pressure increased the risk of cardiovascular events and mortality by almost 20%.[6] This study also found that pulse pressure was a better predictor of cardiovascular endpoints than systolic pressure alone.

Pulse pressure is an interplay between the cardiac stroke volume and arterial wall compliance. Compliance is predominantly determined by the arterial wall behavior of the aorta and its large vessels. Increased stiffness of the large vessels decreases their compliance and increases pulse pressure.[5] In the case of arteriosclerosis a vicious cycle ensues: stiff arteries increase pulse pressure and an increase in pulse pressure causes mechanical damage to the endothelial lining promoting arteriosclerosis. It can be difficult to determine which is the cause and which is the effect. Regardless, once the cycle begins it can create havoc on the circulatory system.[5]

The literature indicates a pulse pressure of 40 mm Hg is normal. According to Sherazi S, *et al*.,[7] a pulse pressure of >40 mm Hg has a greater magnitude of left ventricular remodeling due to reduction in left ventricular end-systolic volume. The main variable of interest in the current study was the pulse pressure difference in pre- versus post (at six weeks, following the initial upper cervical adjustment). Low pulse pressure has been defined as a pulse pressure lower than 25% of the systolic pressure.[8] Others have defined low pulse pressure as <35 mm Hg.[9] Additionally, increased mortality has been attributed to low pulse pressure in patients with advanced heart failure.[9] With low pulse pressure it is the loss of stroke volume in an already compromised patient that is detrimental.

Elevated pulse pressure is a measure of arterial stiffness.[10-12] It has been linked to cardiovascular end-points[4-7], left ventricular hypertrophy[13], cognitive decline[14-17], diabetes[18], and brain atrophy[15].

There is some evidence that patients with cardiovascular problems such as hypertension sometimes improve following chiropractic adjustments.[19-23] The present study explores the potential usefulness of pulse pressure for monitoring cardiovascular progress (or lack thereof) in a chiropractic setting. The purpose of the study was to observe pulse pressure changes following application of an upper cervical chiropractic technique. Improved pulse pressure is defined as a decrease in pulse pressure following care in these cases with previously elevated pulse pressure. It was theorized that pulse pressure changes may depend on initial values, e.g., normal pulse pressure may not change while lower and higher pulse pressures would show a change toward normal.

Methods

The practice-based study design was approved by the Institutional Review Board at Sherman College of Chiropractic. All participants signed informed consent forms prior to participation.

The study included all new patients entering into any of the five participating clinics and who fit the criteria of consenting to the participation within the dates of March 15, 2014 to December 31, 2014. The five attending chiropractors (one per office) were trained in the knee chest upper cervical specific (KCUCS) chiropractic technique. The technique utilizes the Tytron infra-red scanning technology to assess upper cervical subluxation status on a visit to visit basis along with prone leg check analysis. A three view cervical x-ray series was performed on each case consisting of Anterior-Posterior open mouth full cervical, neutral lateral and base posterior views for the purpose of assessing alignment of the cranio-cervical junction. A knee chest solid head-piece table set at 14-degree angle was employed for the adjusting technique. All of these procedures were consistent with training through KCUCS chiropractic technique.

Prior to the administration of KCUCS chiropractic technique each participant had their brachial blood pressure measured in the supine position using an automatic Omron model BP760. This instrument has been accepted as valid by the European Society of Hypertension International Protocol and Association for the Advancement of Medical Instrumentation.[24-26] The patient was instructed to rest in the supine position in a quiet rest area for 10 minutes prior to blood pressure examination. Following the initial blood pressure examination, the patient's initial upper cervical chiropractic adjustment was administered. Following the post adjustment rest period of between 20 to 60 minutes, the blood pressure was measured again in the same position. Knee chest upper cervical care was provided for a six-week period of time.

The knee chest upper cervical care provided for each subject followed the same protocol in each of the five clinics regarding Tytron infra-red scanning, prone leg check analysis, x-ray analysis and the knee chest adjustments administered. The exception in patient care between the five clinics was in the rest time of between 20 to 60 minutes immediately following each upper cervical adjustment. Early pioneering researchers studying upper cervical chiropractic technique were of the opinion that a rest period immediately following an upper cervical adjustment was essential for improved outcomes.[27] It is thought longer rest periods facilitate stability of the cranio-cervical junction. There are no current data to support the preference of rest period length other than clinical experience.

The specific vectors of adjustment were assessed via x-ray analysis of the upper cervical misalignment. Frequency of upper cervical chiropractic adjustments administered was determined by analysis of Tytron infra-red thermography as well as leg length equality examination. On the six-week follow-up office visit, blood pressure measurements were obtained prior to any care on those visits utilizing the procedure for blood pressure assessment used in the initial blood pressure reading.

Statistical Methods

Data were sorted into three groups, according to initial pulse pressure, based on the assumption that a pressure of 40 is normal[7]: low (< 40), medium (40-49), and high (> 49). The range of 10 mmHg was arbitrarily selected as it was thought to be wide enough to be clinically significant. Paired testing for differences were used in each category, comparing pulse pressures for pre-adjustment versus at six weeks (three tests; one per each of three pulse pressure categories). Probability plots indicated acceptable normality for all six variables (pre versus six week pulse pressure for low, medium, and high categories). Thus, the paired t-test was used, in Stata 12.1 (StataCorp, College Station, TX). Two-tailed p-values less than or equal to the conventional alpha level of 0.05 were considered statistically significant. Effect size, using a pooled standard deviation, was also used to determine the magnitude of pre-post differences that were statistically significant.

Results

There were 130 participants (81 females and 49 males) included in the study. The mean age for the patients was 46.7 years old (standard deviation = 17.2) ranging from eight to 81 years of age. Most patients (n = 97 of the 130) were younger than 60 years of age. Through the course of six weeks care the average number of office visits was 11.5 (SD = 3.4) and the average number of upper cervical chiropractic adjustments was 2.8 (SD = 2.5). Out of 130 patients, 128 cases were adjusted with an atlas listing while two cases were adjusted using an axis listing.

Mean pulse pressure changes (from pre- to six-weeks) were slight and statistically insignificant for the low

Table 1.
Summary data, by pre pulse pressure group, reported as mean (SD). ES = effect size, reported for the main variable of interest in the study, pulse pressure. Initial post is on same visit as initial adjustment. Initial post systolic and diastolic missing for one patient in low pulse pressure group.

Variable	Low (< 40)	Medium (40-49)	High (> 49)
n	54	29	47
Mean age	38.7 (15.6)	48.8 (16.6)	54.5 (15.4)
Female	40	19	22
Male	14	10	25
Pre systolic	107.6 (11.8)	121.2 (10.8)	144.7 (19.9)
Initial post systolic	112.4 (14.7)	121.0 (13.0)	137.1 (15.4)
6w post systolic	108.7 (12.2)	118.1 (14.0)	132.5 (12.6)
6w – pre difference	1.1	-3.1	-12.2
Pre diastolic	76.5 (10.7)	76.4 (10.0)	82.9 (12.2)
Initial post diastolic	77.9 (10.6)	77.7 (9.4)	82.0 (12.8)
6w post diastolic	76.0 (10.4)	75.7 (9.3)	79.4 (10.3)
6w – pre difference	-0.5	-0.7	-3.5
Pre pulse pressure	31.1 (5.8)	44.8 (2.4)	61.9 (12.1)
Initial post pulse pressure	34.5 (7.8)	43.2 (8.2)	55.1 (8.3)
6w post pulse pressure	32.7 (7.1)	42.4 (8.8)	53.0 (9.6)
6w – pre difference	1.6	-1.4	-8.9
p-value for 6w-pre diff	0.13	0.14	< 0.01
Effect size	0.3	0.4	0.8

Legend: n= number, w = week, diff = difference

and medium pulse pressure groups (Table 1). The mean change for the high pulse pressure group was relatively large, where a reduction by 8.9 points was observed, and this change was statistically significant ($p < 0.01$) with a large effect size of 0.8. In the high pulse pressure group similar treatment numbers were observed: the average number of visits were 11.9 and the average number of adjustments was 2.6.

Discussion

Pulse pressure represents the relationship between left ventricle ejection and the properties of the arterial wall. Attributes of the arterial wall determine arterial compliance and the transmission characteristics of the arterial system.[5] The Windkessel model of circulation describes the relationship between stroke volume and arterial compliance of the aorta and large vessels.[28] Windkessel is loosely translated from German to English as 'air chamber'.[29] In regard to circulation it is generally accepted as 'elastic reservoir'. The aorta has remaining blood volume at the end-point of diastole. Upon systole, the left ventricular ejection pumps more blood into the aorta. Compliance is determined by the aorta's ability to accommodate further increases in volume. Although compliance occurs throughout the vascular tree, total systemic arterial compliance is primarily determined by the aorta and its large vessels. Aortic compliance is largely dependent upon the vessels elasticity. As the vessel becomes less elastic, it loses ability to adequately take on more volume upon systole and pulse pressure increases.

There are transmission characteristics of the arterial tree, beyond the Windkessel model, to be considered when evaluating pulse pressure. Circulation depends on a pulse wave initiated by cardiac contraction. Pulse waves travel from the heart to the capillary bed. The forward wave (systolic P1) runs into multiple branch junctions as arteries split into smaller vessels. Each time a wave hits a branch junction there is a wave reflection. A small amount of the wave bounces back toward the heart. The waves reflecting back and having impact on pulse pressure are predominantly from the major branches of the aorta. The reflected wave going back toward the heart can increase aortic systolic pressure, thus pulse pressure, above what is generated via left ventricle ejection. The reflected wave (systolic P2) has an amplifying effect on central pulse pressure. Pulse pressure can be clinically assessed via brachial measurements. Izzo found that brachial systolic blood pressure closely related to centrally measured pressure.[30]

According to Dart and Kingwell [5], there is a common thread between arterial compliance described by the Windkessel model and wave reflection. Both are similarly affected by arterial wall properties. Arteries with compromised elasticity are less compliant and magnify the wave reflection, increasing pulse pressure.

Pulse pressure has a bidirectional effect on cardiovascular disease.[31] Elevated pulse pressure increases mechanical pressure upon the endothelial lining and increases the risk of a CVD event. Mechanical pressure, over time, has a damaging effect on the endothelial lining creating a vicious cycle of further increased arterial stiffness.

Pulse pressure is subject to any factor that affects aortic elasticity. Aging[12] is associated with loss of elasticity in the aorta as is atherosclerosis [32-33]. High homocysteine [34-35] and insulin resistance [36-38] have been found to increase pulse pressure. Pulse pressure improvements have been reported with exercise [39-40] as well as diet modifications [41-42] including n-3 fatty acids.

Vascular smooth muscle tone has a direct impact on arterial elasticity. Vascular smooth muscle is largely determined by the sympathetic nervous system and is subject to autonomic balance. The sympathetic nervous system has significant influence on mean arterial pressure and systemic vascular resistance as it modulates the mechanical properties of muscular arteries.[43] Increased smooth muscle tone can be an explanation for the arterial wall effects seen in elevated pulse pressure.[44]

A number of studies on upper cervical chiropractic techniques have reported improvements in hypertensive patients' systolic pressures following care.[19-23,45-46] One study that included 42 subjects found that hypertensive subjects' blood pressure lowered and hypotensive patients' blood pressure elevated following care indicated a broader normotensive effect.[47]

Other studies have suggested upper cervical chiropractic care as being beneficial for autonomic balance. These studies[19, 48-51] have focused on heart rate variability (HRV) as an indicator of autonomic modulation.[52-53] HRV has been found low in survivors of myocardial infarction (MI) and abnormal HRV patterns precede episodes of life-threatening arrhythmias. Furthermore, HRV is a strong predictor of mortality in patients with MI.[54] Our study adds to the body of literature on a possible association between upper cervical chiropractic care and cardiovascular assessments.

Various studies have confirmed positive post changes with the application of an upper cervical technique.[55-56] One study also reported on positive subjective outcomes and safety of several upper cervical techniques.[57]

Further research (e.g., a randomized clinical trial) seems warranted as a next step toward possibly introducing a novel approach for a safe, natural approach to cardiovascular health. The present study is limited in its generalizability to other patients since it had an observational study design (case series). In addition, the high pulse pressure group's readings may simply be temporary outliers. As this is the first study of its kind, further research is needed before more definite conclusions can be drawn. In further research, our sample size calculations indicate that 20 patients would be needed in a high pulse pressure group such as ours, based on our data in Table 1 for that group (using 80% power and a two-tailed alpha level of 0.05).

Conclusion

In this study we observed, through the application of an upper cervical chiropractic technique, lowered pulse pressure in patients determined to previously have had elevated pulse pressure. It is plausible that these observations are related to improved autonomic function. Further research with improved designs is a reasonable next step in this line of investigation.

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