Journal of Bodywork & Movement Therapies (2013) 17, 291—296

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INTRACRANIAL PRESSURE RESPONSES CRANIAL MANIPULATION

Changes in alpha band activity associated with application of the compression of fourth ventricular (CV-4) osteopathic procedure: A qEEG pilot study

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Received 19 May 2012; received in revised form 30 September 2012; accepted 4 October 2012

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1360-8592/$ - see front matter
http://dx.doi.org/10.1016/j.jbmt.2012.10.002

KEYWORDS
Absolute alpha power;
CV-4;
Osteopathy;
qEEG

Summary The compression of the fourth ventricle (CV-4) is one of the more well known procedures in the cranial manipulation curriculum and practice. Cranial manipulation has received criticism because of the subtle, difficult to learn techniques, controversy over whether or not cranial bone structures move, and what if any clinical effects have been shown. The aim of this study was to measure the effects of CV-4 in 10 healthy subjects through quantitative electroencephalography (qEEG), specifically in alpha band. Participants were randomly distributed in control, sham-CV4 and CV4 conditions using a cross-over design. qEEG activity was recorded for each of the 10 subjects in each of the 3 conditions. There was a significant increase in the alpha absolute power between pre and post in the CV-4 condition. There appears to be potential for understanding the effect of the CV-4 if these finding are replicated in further clinical trials.

Introduction

The procedure known as the compression of the fourth ventricle (CV-4) has been taught and practiced for over 80 years by students of the originator of osteopathy in the cranial field (OCF) William Garner Sutherland (King, 2011). In the last two decades the CV-4 has been adopted and become part of the curriculum of several manual therapy professions such as craniosacral therapy (Upledger and Vredevoogd, 1983), physical therapy (Hanten et al., 1999) and body workers (Chaitow, 2001). The CV-4 is possibly the most well-known of the cranial manipulation procedures originated by Sutherland (Magoun, 1966) and has been shown to reduce sleep latency (Cutler et al., 2005), reduce tension-headache symptoms (Hanten et al., 1999), change blood flow velocity (Nelson et al.,, 2006) and lower cerebral tissue oxygenation (Shi et al., 2011) A recent systematic review of clinical cranial manipulation results concluded that the results were mixed and more research was needed (Jäkel and von Hausenchild, 2011) The present study attempts increase the research base on clinical effects of OCF.

The CV-4 is one of the more well known procedures in the cranial manipulation curriculum and practice. Cranial manipulation has received criticism because of the subtle, difficult to learn techniques, and controversy over whether or not cranial bone structures move in accordance the theory of the primary respiratory mechanism (PRM) postulated by Sutherland (Magoun, 1966). That cranial bones are capable of motion and do not necessarily fuse has been shown (Sabini and Elkowitz, 2006) and apparent calvarial structure position changes suggestive of motion have been shown (Ueno et al., 2003; Moskalenko et al., 1999; Crow et al., 2009). Besides the clinical benefits of the CV-4 described above, cranial manipulation has been shown to possibly benefit children with cerebral palsy (Wyatt et al., 2011), reduce the symptoms of infantile colic (Hayden and Mullinger, 2006), reduce the symptoms of otitis media in children (Mills et al., 2003), improve urinary tract function in patients with multiple sclerosis (Raviv et al., 2009), and improves balance and equilibrium in healthy elderly patients (Lopez et al., 2011).

The findings of Cutler et al. (2005), Nelson et al. (2006), Lopez et al. (2011), and Shi et al. (2011) suggest an impact on brain and cranial nerve function of the CV-4 cranial manipulation. One well known and commonly used clinical technology which might demonstrate effects of the CV-4 in monitoring changes in brain state is quantitative electroencephalography (qEEG). Since the invention of EEG, attempts have been made to assign a functional meaning of the brain's oscillatory neural activity. The recording of frequency spectrum of scalp EEG is a traditional method of analysis based on the frequency domain, and range among several frequency bands. Each band has been typically attributed to a certain brain state such as the level of consciousness or the degree of cognitive or perceptual activity, respectively. Thus, absolute power, defined as total energy intensity of an electrode on a certain region at different frequency bands (Machado et al., 2007), is a potential measure to investigate the influence of CV4 on qEEG activity. As contrasted with standard EEG assessment, the qEEG is a technique of analyzing the brain wave signal that allows a detailed two and three dimensional electrical picture of a subject's brain to be generated with the help of a sophisticated statistical computer program.

We choose alpha band because it is related to physical relaxation, awake and idle state (i.e., a standby state that allows the system to return more rapidly to goal oriented function when needed) (Niedermeyer and Lopes da Silva, 1999). The current study aims to directly measure the effects of CV-4 in absolute alpha power in the occipital areas in healthy subjects. Our hypothesis is that the CV-4 application will produce greater changes in absolute alpha power between pre and post qEEG assessment than in a sham a sham CV-4 or no-treat control conditions.

Methods

Sample

Ten healthy (6 male and 4 female; mean age: 28, SD: 3) subjects were recruited. These subjects were not familiar with cranial manipulation or the CV-4 technique. Inclusion criteria were: 1) absence of mental impairment determined by obtaining a score of $\geq$27 on the Mini Mental State Examination (MMSE) (Oskarsson et al., 2010; Williams et al., 2009) no history of psychoactive or psychotropic substance use (screened by a previous anamnesis and a clinical examination). Exclusion criteria were: 1) any local or systemic pain condition, 2) dizziness, 3) prior or current vascular disease, 4) no history of hypertension, 5) no history of recent headaches, 6) subjects were not included if they had less than 6—8 h of sleep prior to the experiment, 7) subjects were not included if they had caffeine 48 h prior to the experiment. All subjects were made aware of the entire experimental protocol and signed a consent form before participating in this study. This study was approved by the Ethics Committee at Augusto Motta University Center. The study was carried out in the Federal University of Rio de Janeiro (Brazil) in compliance with rules provided for research on human subjects contained in the Resolution of the National Health Council.

Experimental design

Each of the 10 subjects received the CV-4, sham CV-4 and no-treat control conditions in a random order, once a week. Some subjects received the CV-4 in the first week, some in the second week, and others in the third week of the study. At each visit a baseline resting EEG acquisition with eyes closed was obtained before and after each condition for 5 min.

Experimental conditions

CV-4 Procedure: The CV-4 palpatory contact and other cranial phenomena associated with the CV-4 procedure were administered according to definitions currently established by the osteopathic medical profession (ECOP, 2009). The CV-4 is "a cranial technique in which the lateral angles of the occipital squama are manually approximated slightly exaggerating the posterior convexity (Fig. 1 medially directed arrows) of the occiput and taking the cranium into sustained extension (Fig. 1 posteriorly directed arrow) (ECOP, 2009)." This procedure was performed until there was a reduction in the cranial rhythm (cranial bone motion clinically palpated at various rates idiosyncratic to a given person, but typically described as from 4 to 12 cycles per minute) to an apparent motionless state described as a "still point" which can last from a few seconds to a minute. The "still point" was maintained until the subject's cranial rhythm resumed which was palpated by pressure on the operator's thenar eminences. The CV-4 to a "still point" was repeated until the 10 min experimental procedure time expired (Upledger and Vredevoogd, 1983; Chaitow, 2001) (Fig. 2).

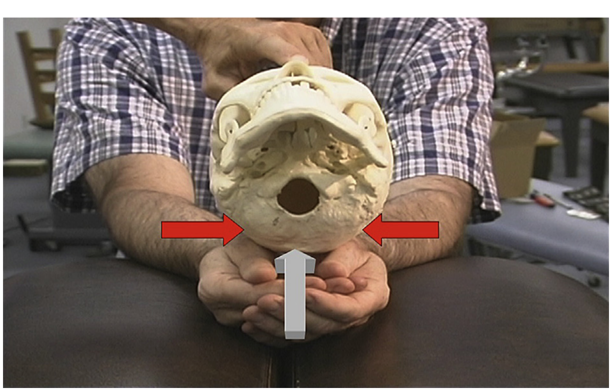

Figure 1 Hand contact medial to occipito-mastoid sutures.

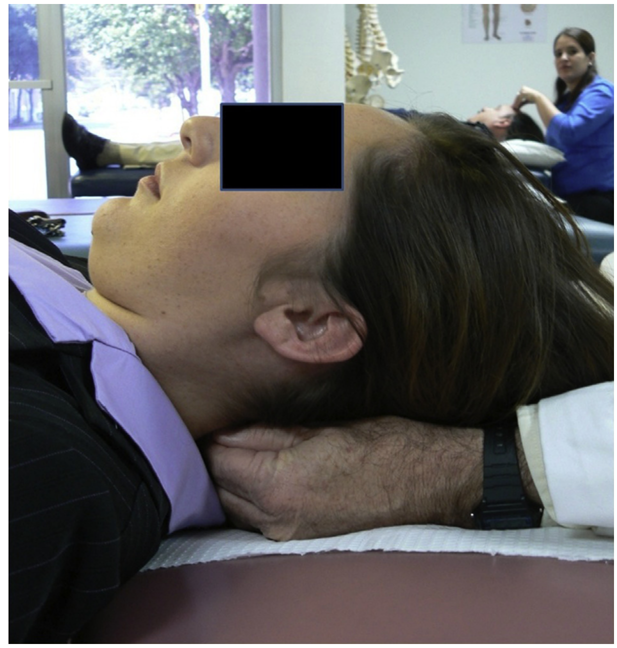

Figure 2 CV-4.

Sham CV-4 Procedure: The subject was supine with the operator at the head of the treatment table with forearms resting on table. The operator overlapped the hands so that the thumbs formed a "V." The apex of the "V" formed by the thumbs was placed at the level of the spinous processes of the second or third cervical (C2—C3) vertebrae. The operator's thenar eminences contacted the occiput very lightly well below the positioning used in the CV4 procedure but did not press on the occiput between the occipito-mastoid sutures. Once placement was achieved the operator's hands remained motionless for 10 min.

No-Touch Procedure: The subject was supine on the treatment table with no contact by the operator, who was present for 10 min.

EEG acquisition

Subjects were seated on a comfortable chair in a darkened and sound-protected room in order to minimize sensory interference (Thakor and Tong, 2004). The International 10/20 System for electrodes (Jasper, 1958) was used (Fig. 3) with the 20-channel EEG system Braintech-3000 (EMSA-Medical Instruments, Brazil).

The 20 electrodes were arranged in a nylon cap (ElectroCap Inc., Fairfax, VA, USA) yielding monopole derivations referred to linked earlobes (Niedermeyer and Lopes da Silva, 1999). Caps of different sizes were used, depending on the head circumference of each subject. The caps were removed for the CV-4, sham-CV4 and no-touch conditions. They were used before and after each experimental procedure, i.e., removed for the administration for the CV-4, sham-CV-4 and no touch conditions.

In addition, two 9-mm diameter electrodes were attached above and on the external corner of the right eye, in a bipolar electrode montage, for eye-movement (EOG)

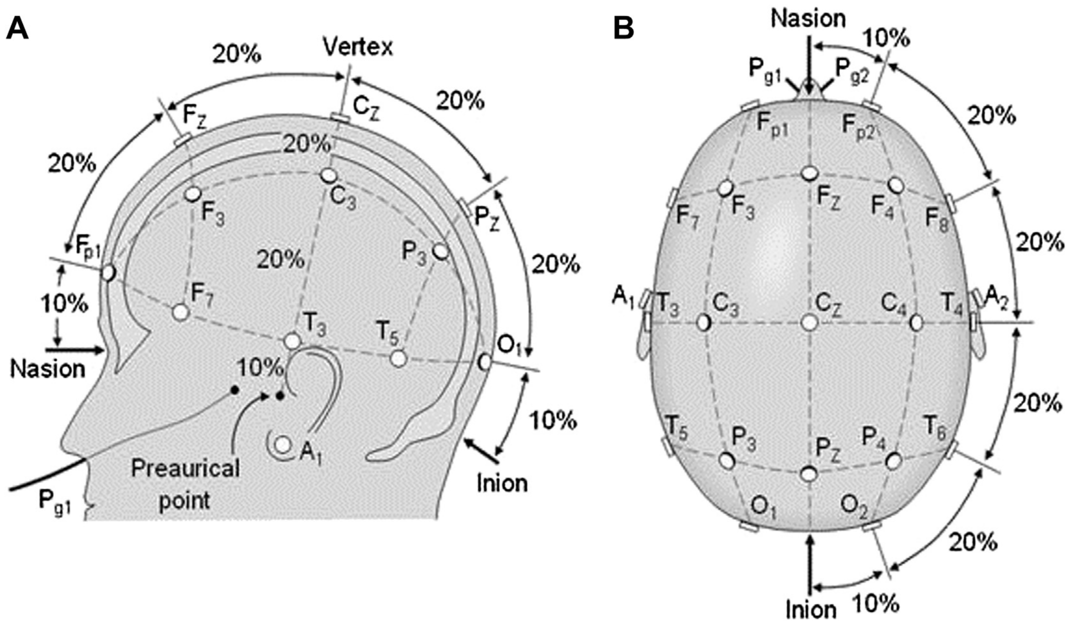

Figure 3 International 10/20 system for electrodes. (A) Lateral view of the electrodes montage. (B) Superior view of the electrodes montage.

artifacts monitoring. Impedance of EEG and EOG electrodes were kept under 5—10 kΩ. The data acquired had total amplitude of less than 100 μV. The EEG signal was amplified with a gain of 22.000, analogically filtered between 0.01 Hz (high-pass) and 100 Hz (lowpass), and sampled at 240 Hz. The software Data Acquisition (Delphi 5.0), developed at the Brain Mapping and Sensorimotor Integration Laboratory was employed to filter the raw data: notch (60 Hz), high-pass of 0.3 Hz and low-pass of 100 Hz.

Data analysis and processing

First, by visual inspection, and then independent component analysis (ICA) possible sources of artifacts (i.e., blink, muscles and saccade-related artifacts) were evaluated. We removed those portions of the EEG record that clearly showed a blink-related artifacts "influence" by visual inspection and we removed the components that showed blink-related artifacts "contamination" using ICA. The data were collected using the bi-auricular reference and they were transformed (re-referenced) using the average reference after we conducted the artifact elimination using ICA. A classic estimator was applied for the power spectral density (PSD), or directly from the square modulus of the FFT (Fast Fourier Transform), which was performed by MATLAB 5.3 (Mathworks, Inc.). We extracted quantitative EEG parameters within a time window between 4 s before and after the treatment. Thereafter, all raw EEG trials were visually controlled and trials contaminated with ocular or muscle artifacts were discarded. The FFT resolution was 1/4s—0.25 Hz. To examine a stationary process, the "Run-test" and "Reverse-Arrangement test" were applied. Specially, the stationary process was accepted for each 4 s (epoch's duration in this period). In this manner, based on artifact-free EEG epochs, the threshold was defined by the mean plus three standard deviations with epochs showing a total power higher than this threshold not being included into the analysis.

Statistical analysis

Absolute alpha power was the dependent variable of interest. The statistical analysis of absolute alpha power was performed using the software SPSS 16. Data were Log_{10} transformed for approximation of the normal distribution (Bucci et al., 2004). A paired *T*-test in order to compared pre and post treatment moments of each condition, with a significance level of $p \leq 0.05$. Specifically, the analysis was limited to three topographically representative electrode sites of occipital cortex (i.e., O1, Oz, O2).

Results

We analyzed absolute alpha power levels for the three experimental conditions of treatment. The statistical analyses did not show significant differences between pre and post absolute power levels for the control and Sham CV4 conditions. With respect to CV4 condition, the statistical analysis revealed a significant difference between absolute power levels ($p = 0.0002$). An increase in the alpha absolute power was noted when compared the moments pre (mean = 29.40; SD = 7.61) and post (mean = 37.18; SD = 2.70) treatment (Fig. 4).

Discussion

This study aimed to measure the effects of CV-4 on absolute alpha power in the occipital areas in healthy subjects. Our hypothesis that the effects of CV-4 application on absolute alpha power would be increased by application of the CV-4 when compared to the other experimental conditions

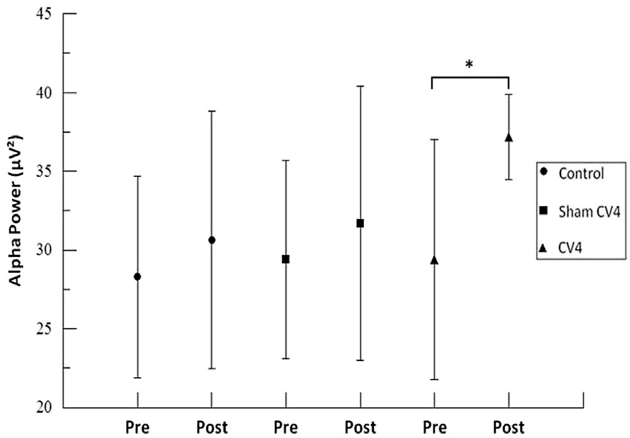

Figure 4 Mean and standard deviation of absolute alpha power (μV^2) at occipital electrodes O1—Oz—O2 for each experimental condition at pre and post treatment. The figure illustrates the combination among occipital electrodes. The statistical analysis revealed a main effect of electrode ($p = 0.0002$).

appears to be supported by data produced in this pilot study.

The data suggested an impact of the osteopathic CV4 procedure on alpha band activity. This is consistent with the clinical reports by many patients that when CV4 is administered a state of relaxation is generally readily perceived. This finding may be related to those of Lagopoulos et al. (2009), who demonstrated significant increases in alpha band activity in posterior cortical regions after non-directed meditation, which is possibly related to the process of relaxation.

Results of the present study may be related to the findings of Shi et al. (2011) and elaborated by Liem (2009) who suggested that the compression of the lateral occipital bone impacts the tentorium cerebelli and changes the pressure inside the fourth ventricle and subsequently the whole intracranial fluid pressure. Any changes in intracranial pressure may induce increased movement and dynamics of cerebrospinal fluid leading to more fully perfused cortical regions especially in smaller areas of its distribution, such as the neural veins and neural sheath, fascia microtubules, and intracellular and extracellular spaces. Such possible intracranial fluid pressure changes may be related to the osteopathic concept that the body is self regulating in so far as suggesting a mechanism by which cerebral and brain stem control areas may be stimulated.

Any speculation such as suggested in this discussion is dependent on further research on both healthy subjects and subjects with identified disorders which may be impacted by intracranial fluid and brain wave activity changes induced by the CV-4.

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