Suboccipital dermatomyotomic stimulation and digital blood flow

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The effect of gentle, soft tissue manipulation in the suboccipital region on digital blood flow, as a measure of sympathetic nervous system activity, was studied. Digital strain gauge plethysmography was used to measure the changes in pulse contour during (1) a normative test period with the subject in the supine position, (2) after a control interval (placebo) during which the investigator placed his hands under the suboccipital region, and (3) after an interval during which the investigator's fingers applied slow, steady, circular kneading in the suboccipital triangle region. Twenty-five studies were performed in a crossover design with the patient as his or her own control. Total pulse amplitude (*Y*) and the height from the dicrotic notch to the peak (*X*) were measured. Examination of the total data of all subjects revealed the occurrence of a significant change in *X* and *Y* with simply touching the suboccipital region with the hands. An even more favorable response ensued when suboccipital manipulation was applied. Those subjects reporting comfort or neutral responses had larger significant changes with manipulation when compared with the group reporting the experience as uncomfortable. The response within each group suggests that favorable autonomic changes (sympathetic dampening) occur with specific suboccipital manipulation as well as, indeed, the simple touching of the suboccipital triangle.

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This study was designed to evaluate the effect of gentle, soft tissue manipulation in the suboccipital region (suboccipital dermatomyotomic stimulation, SDS) on human digital blood flow (DBF) as a measure of sympathetic nervous system (SNS) activity. Considerable literature is available to indicate that the DBF dynamics are primarily a function of the SNS.[1-4] A number of studies have attempted to assess the physiologic effects of manipulative techniques[5-10]; however, we could find no literature addressing neurovascular effects from SDS. We therefore wished to know if measurable changes are identifiable in the autonomic periphery during manipulation of a dermatome unrelated to the area being measured.

Subjects and methods

A total of 25 studies were done on 19 women and 6 men. Subjects, ranging in age from 18 to 42 years, were recruited from the medical campus of Ohio University College of Osteopathic Medicine, Athens, Ohio. All studies were approved by the Institutional Review Board and Human Subjects Research Committee, and subjects gave informed consent. A brief interview was conducted to screen for the presence of vascular or neurologic disease that may affect autonomic reflexes. Exclusions also included chronic musculoskeletal pain syndromes of the head or neck (or both) and medications that influence autonomic tone.

The subjects were studied in the O'Bleness Memorial Hospital Vascular Laboratory, Athens, Ohio . The subjects lay supine in a room maintained at constant temperature (25°C). All studies were performed by the same examiner (J.J.F.). A strain gauge plethysmographic device with recorder was attached to the distal phalanx of the subject's left index finger. After a normative period of 10 minutes, a baseline plethysmographic recording was made (*Figure 1, top left*). The examiner then followed either protocol A (placebo) or protocol B (SDS), determined by random selection.

During protocol A, the investigator placed his hands flat under the subject's head in the suboccipital region for 120 seconds during which a continuous plethysmographic recording was made (*Figure 1, top right*). During protocol B, the investigator placed his fingers specifically in the suboccipital triangle region bilaterally and performed slow, circular kneading for 120 seconds. Recordings similar to those in protocol A were made (*Figure 1, bottom right*). A 10-minute normative period was allowed before the subject was crossed over to the alternate protocol. The subject was asked to report whether the experience during either protocol was uncomfortable (scored as -1), subjectively neutral (scored as 0), or relaxing (comfortable, scored as 1).

Data were obtained by averaging five representative pulse contours from each interval and analyzing them for changes from the respective normative baseline in total pulse amplitude (Y) and distance from the dicrotic notch to peak amplitude (X). The patients acted as their own controls in the treatment arm (protocol B) versus the placebo arm (protocol A). Statistical significance in the change of X and Y from the baseline values, measured before the beginning of each protocol, was tested using the paired t-test, with t considered significant at a P level of less than .05. Baseline values measured before each protocol were compared as well (*Table 1*).

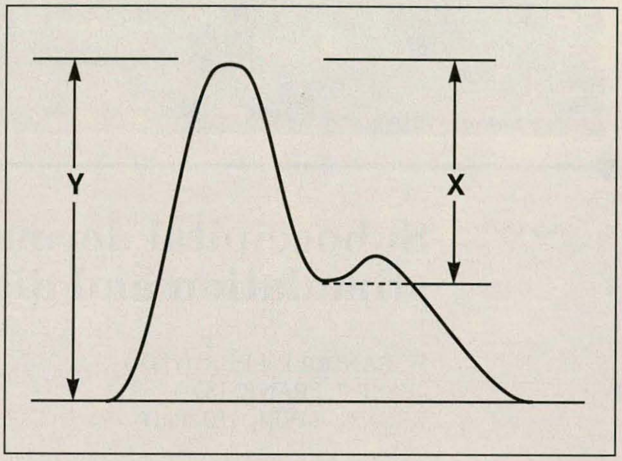

Figure 2. *Digital pulse contour.* Y = *total pulse amplitude;* X = *height from dicrotic notch to peak;* X/Y = *relative dicrotic position.*

Results

Analysis of the data of all subjects taken together (*Table 2*) shows a significant change in X (-2.08 mm, $df=24$, $t=-3.60$, $P=.0014$) and Y (-5.52 mm, $df=24$, $t=-4.89$, $P<.0001$) with protocol A (hand touching only). When suboccipital manipulation was performed, a larger significant change resulted in both X and Y ($X=-2.28$ mm, $df=24$, $t=-2.73$, $P=.01$; $Y=-6.08$ mm, $df=24$, $t=-5.01$, $P<.001$).

Those subjects who reported comfortable responses did not have a significant change in X in either protocol A or B (protocol A, -1.38 mm; protocol B, -1.54 mm). Subjects experiencing comfort had a significant change in Y with the placement of hands

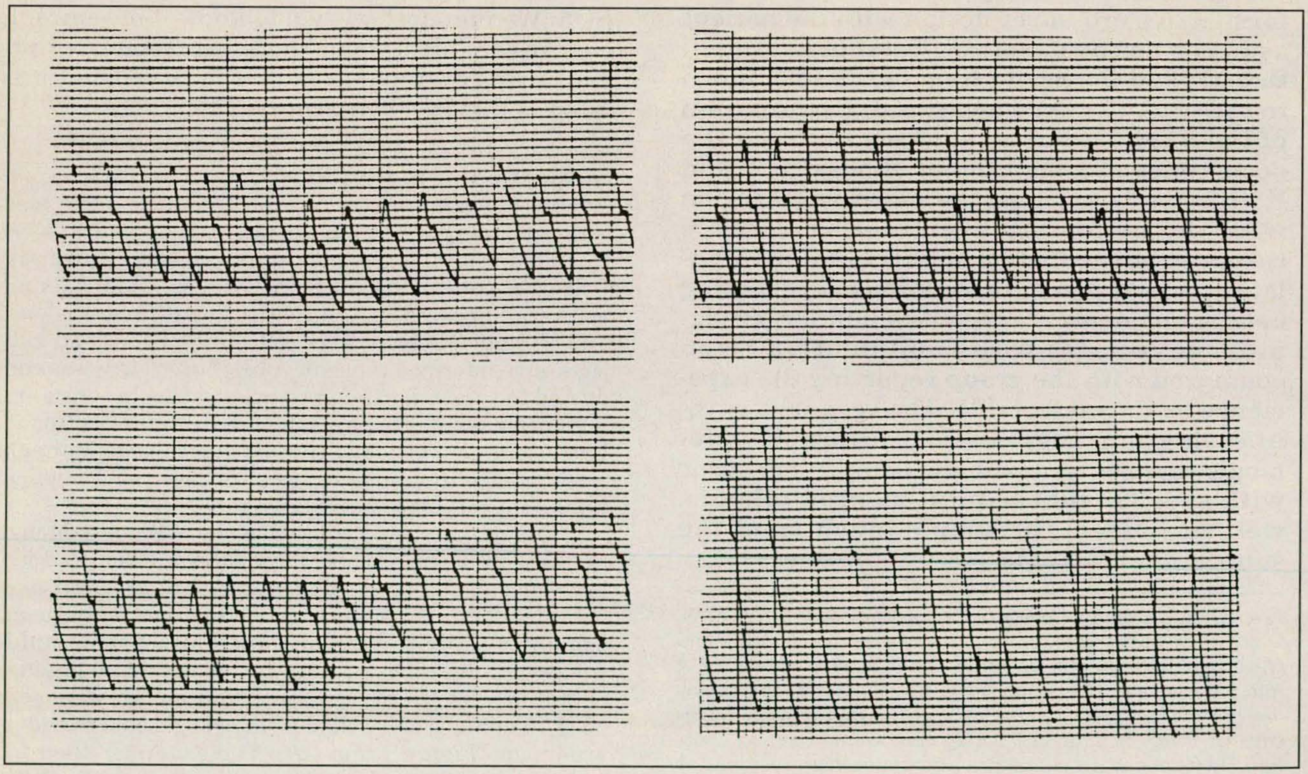

Figure 1. *Case study plethysmographic recordings.* Top, left: *Baseline,* X=*5 mm;* Y=*13 mm;* X/Y *ratio=0.38 mm.* Top, right: *Control,* X=*9 mm;* Y=*22 mm;* X/Y=*0.40 mm.* Bottom, left: *Baseline,* X=*5 mm;* Y=*15 mm;* X/Y *ratio=0.33 mm.* Bottom, right: After osteopathic manipulative procedure, X=*16 mm;* Y=*36 mm;* X/Y *ratio=0.44 mm.*

Table 1
Original Data

Subject No.	Sex	X/Y* ratio (mm) Baseline 1	Protocol A	Baseline 2	Protocol B	Comfort level†
1	M	15/29	13/29	12/29	13/32	1
2	F	14/28	25/47	12/25	23/50	1
3	F	6/14	6/14	2/7	4/12	−1
4	F	6/11	6/15	5/10	5/14	1
5	M	3/8	5/23	6/21	9/28	−1
6	F	11/15	16/28	13/25	16/33	−1
7	M	3/19	6/25	9/29	12/39	1
8	F	19/30	23/35	14/22	26/38	0
9	F	8/15	10/20	15/26	20/37	0
10	F	8/18	11/24	5/15	8/23	1
11	F	4/8	3/10	5/12	2/13	1
12	F	7/22	12/38	10/27	11/34	0
13	F	4/23	5/22	5/24	8/40	0
14	M	11/23	12/29	11/22	7/21	1
15	M	6/12	7/15	5/9	6/14	0
16	F	6/16	11/26	10/16	10/21	0
17	F	16/24	15/28	8/18	6/21	1
18	F	6/12	9/19	7/15	12/22	1
19	F	10/18	10/20	8/18	19/19	0
20	F	6/10	6/10	2/5	4/8	0
21	F	4/11	3/10	2/6	2/6	1
22	F	15/25	14/23	10/17	10/17	1
23	F	12/34	15/36	4/15	8/20	1
24	F	20/40	25/50	17/33	14/36	−1
25	F	4/8	8/15	11/20	10/20	−1

*X = Distance from the dicrotic notch to peak amplitude; Y = normative baseline in total pulse amplitude. X/Y = relative dicrotic position.
†The comfort level was a subjective analysis of each individual, with 1 = relaxing; 0 = neutral; and −1 = uncomfortable.

to the suboccipital region (−4.07 mm, df=12, t=−2.78, P=.018), and an even larger significant change in Y with suboccipital manipulation (−5.23 mm, df=12, t=−2.78, P=.017).

An interesting finding was that those subjects reporting neutral responses, while having only minimal significant changes in X and Y with the hands touching the suboccipital region (X=−2.25 mm, df=7, t=−3, P=.017; Y=−5.0 mm, df=7, t=2.52, P=.040), had the largest significant change in X and Y in response to suboccipital manipulation (X=−4.73 mm, df=7, t=−2.66, P=.033; Y=−8.0 mm, df=7, t=−3.95, P<.006).

Those subjects who reported the suboccipital manipulation to be uncomfortable had the largest significant changes in X and Y in response to touch only (X=−3.32 mm, df=4, t=−3.3, P=.03; Y=−9.0 mm, df=4, t=−3.45, P=.027). No significant change occurred in X with manipulation in the group reporting uncomfortable experience (change in X, −0.8 mm). All groups had significant changes in the amplitude of Y with protocol B. The smallest significant change was in the group reporting the experience as uncomfortable (Y=−4.6 mm, df=4, t=−3.2, P=.033).

The baseline plethysmographic recordings of all subjects before each protocol were compared to assure that each subject had returned to baseline before the crossover protocol. Comparison of baseline recordings showed no significant change in X or Y (X=0.65 mm, df=24, t=0.77, P=.45; Y=0.28 mm, df=24, t=0.18, P=.85).

Table 2
Group Results*

Group	Protocol A (Touching only) Mean ± SD, mm	Protocol B (OMT†) Mean ± SD, mm
■ Entire study group (N=25)		
X change from baseline	−2.08±−2.89	−2.28±−4.17
Y change from baseline	−5.52±−5.64	−6.08±−6.00
■ Group reporting (n=12) experience as comfortable		
X change from baseline	−1.38±−3.34	−1.54±−3.91
Y change from baseline	−4.07±−5.38	−5.23±−6.78
■ Group reporting experience as neutral (n=8)		
X change from baseline	−2.25±2.12	−4.73±−4.66
Y change from baseline	−5.00±5.61	−8.00±−5.73
■ Group reporting experience as uncomfortable (n=5)		
X change from baseline	−3.20±−2.17	−0.80±−2.68
Y change from baseline	−9.00±−5.87	−4.60±−3.21

*An average change from the baseline in total pulse amplitude (X) and height from dicrotic notch (Y) and standard deviations (SD) were calculated for the entire experimental group and each subjective comfort level group per protocol.
†OMT = osteopathic manipulative treatment.

Discussion

This study provokes consideration of the implications of changes in the digital pulse contour (*Figure 2*) as well as a review of neurovascular pathways and a look at potential clinical issues.

The digital pulse amplitude is altered by several variables. Principally involved are dynamics in the capacitance vessels (venomotor tone) and arteriolovenous shunts. Variations in amplitude can be caused by changing limb position, deep inspiratory effort, systemic and local temperature change, as well as spontaneous fluctuations. Startling, unpleasant as well as pleasant stimuli have been reported to alter the pulse volume.[11-15]

If the preceding factors are taken into account, variations in pulse amplitude can be used as a relatively direct and immediate index of vasomotor tone of the dermal arterioles. With digital plethysmography, only the cutaneous vascular reactions are measured as compared with forearm blood flow. As the innervation of the digital vessels is entirely derived from the SNS and no dilator nerve fibers are present in the skin, vasoconstriction and vasodilation in the digits depend primarily on the stimulation or withdrawal of activity of the SNS nerves, respectively. It further appears that α_2-adrenoreceptors are predominantly responsible for mediating such activity.[16] Variations, then, in pulse amplitude reflect a sympathetic response to stimuli.

Furthermore, the contour of the digital waveform and position of the dicrotic notch are principally under the influence of resistance vessels, that is, the arterioles. Evaluation of these variables may offer an even more specific guide to neurovascular hemodynamics. In other words, it is thought that elevation of the dicrotic notch implies a relatively vasoconstricted state, whereas depression suggests vasodilation.

Manipulation in the suboccipital triangle region affects the C1 nerve. If pain is elicited, then the lateral spinothalamic tract on the opposite side becomes involved and connects with the thalamus. Simple touch involves the anterior spinothalamic center. From here, thalamocortical fibers are recruited, leading to the parietal somatesthetic region of the postcentral gyrus. Descending communication starts with corticothalamic circuits, which then cascade to the hypothalamus and ultimate in sympathetic outflow to the periphery.[17,18]

An alternative neuroanatomic route may involve, via mechanical pressure, a perturbation of the cerebrospinal fluid (as implied in the craniosacral manipulative technique of fourth ventricle compression), the dynamics of which have an effect on the reticular activating system, which in turn may produce a sympathetic response.

It should be noted that the specific, simple manipulative procedure applied in this study is similar to the described occipitoatlantal technique of Sutherland.[19] Because of its simplicity, SDS should be reproducible from examiner to examiner.

Potential clinical applications of the simple SDS procedure applied in our study might include differentiating patients with cold sensitivity of the hands (Raynaud's disease) in terms of whether the disease is functional (primary Raynaud's disease) or obstructive (secondary Raynaud's disease).[20] That is, labile pulse contour changes would be consistent with the primary form. Acute stroke syndromes have been described after cervical head-turning manipulations. A presumed mechanism is vaso-spasm of the vertebral arteries. If, as a screening instrument, SDS elicited an uncomfortable response, further high-velocity manipulation may be deferred. The implication would be that vasoconstriction (three-fifths of our patients had a decrement in X/Y) tends to occur in the periphery of those subjects registering a response of pain, and, by inference, because of a more generalized vasospasm (because the observed response is not segmentally related) possibly in the vertebral arteries as well.

In addition, if the simple manipulative technique used in our study proves to be a tool for reducing sympathetic tone, it may be applicable to the treatment of entities such as an acute panic attack, migraine syndrome, or other hyperautonomic states for which immediately controlling autonomic nervous system activity would be beneficial.

Comment

Although the herein reported significant differences between our selected placebo and treated groups were measured, it should be recognized that the placebo was not inert. Both groups consistently demonstrated amplitude changes consistent with specific neurovascular activity. As such, it is believed that SDS as well as, indeed, the time-honored, simple touching may, with further study, prove to be rather important avenues for "balancing" autonomic tone.

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