Journal of the Formosan Medical Association (2014) 113, 94–101

Available online at www.sciencedirect.com

SciVerse ScienceDirect

journal homepage: www.jfma-online.com

ORIGINAL ARTICLE

Physiologic and behavioral effects of papoose board on anxiety in dental patients with special needs

Hsin-Yung Chen [a,†], Hsiang Yang [b,c,†], Huang-Ju Chi [a], Hsin-Ming Chen [b,c,d,e,f,*]

[a] *Department of Occupational Therapy & Graduate Institute of Behavioral Sciences, Medical College Chang Gung University, Taoyuan, Taiwan*
[b] *Oral Health Care for Special Needs, National Taiwan University Hospital, Taipei, Taiwan*
[c] *Department of Dentistry, National Taiwan University Hospital, Taipei, Taiwan*
[d] *Department of Dentistry, National Taiwan University, Taipei, Taiwan*
[e] *Graduate Institute of Clinical Dentistry, National Taiwan University, Taipei, Taiwan*
[f] *Graduate Institute of Oral Biology, National Taiwan University, Taipei, Taiwan*

Received 19 February 2012; received in revised form 10 April 2012; accepted 12 April 2012

KEYWORDS
anxiety;
autonomic nervous system;
dentistry;
electrodermal activity;
heart rate variability;
special needs

Background/Purpose: Anxiety induced by dental treatment can become a serious problem, especially for patients with special needs. Application of deep touch pressure, which is a sensory adaptation technique, may ameliorate anxiety in disabled patients. However, few empiric studies have investigated the possible links between the clinical effects of deep touch pressure and its behavioral and physiologic aspects. Equally little progress has been made concerning theoretical development. The current study is a crossover intervention trial to investigate the behavioral and physiological effects of deep touch pressure for participants receiving dental treatment.
Methods: Nineteen disabled participants, who were retrospectively subclassified for positive trend or negative trend, were recruited to receive the papoose board as an application of deep touch pressure. Quantitative analyses of behavioral assessments and physiological measurements, including electrodermal activity and heart rate variability, were conducted. We sought to understand the modulation of the autonomic nervous system and the orchestration of sympathetic and parasympathetic (PsNS) nervous systems.
Results: Behavioral assessments reported that higher levels of anxiety were induced by the dental treatment for participants with both groups of positive and negative trends. Although no significant differences were found in the SNS activity, physiologic responses indicated that

Conflicts of interest: The authors have no conflicts of interest relevant to this article.

* Corresponding author. Department of Dentistry, National Taiwan University, Number 1, Changde Street, Jhongjheng District, Taipei City 100, Taiwan.
E-mail address: hmchen51@ntuh.gov.tw (H.-M. Chen).

† H.-Y. Chen and H. Yang contributed equally to this work.

0929-6646/$ - see front matter Copyright © 2012, Elsevier Taiwan LLC & Formosan Medical Association. All rights reserved.
doi:10.1016/j.jfma.2012.04.006

significantly changes of PsNS activity were observed under the stress condition (dental treatment) when deep touch pressure intervention was applied, especially for participants in the group of positive trend.
Conclusion: Our results suggest that the PsNS activation plays a critical role in the process of ANS modulation. This study provides not only physiologic evidence for the modulation effects of deep touch pressure on stressful conditions in dental environments but also the evidence that the application of papoose board, as a sensory adaptation technique, is not harmful for dental patients with special needs.
Copyright © 2012, Elsevier Taiwan LLC & Formosan Medical Association. All rights reserved.

Introduction

Anxiety is physiologic phenomenon that occurs when a person encounters stress, which may derive from unpredictable or novel events, medical treatment, or an uncomfortable experience.[1] Anxiety associated with dental treatment is one such stressor, which poses a challenge not only for children but also for adults and may cause the patient to avoid dental consultations.[2,3] Although people of all ages and backgrounds are affected by anxiety, studies have noted that people with special needs are especially susceptible to dental challenges.[4,5] Although certain psychometric questionnaires provide good reliability and validity to investigate patients' anxiety status,[6,7] little research has been conducted regarding disabled populations.

Most dental treatments are well agreed to be involved an invasive procedures with inherent risk of substantial harm inside the oral cavity. Therefore, dental patients displaying uncontrolled, impulsive, and aggressive behavior may endanger both themselves and dental staff. To prevent potential risks, healthcare professionals must know and apply behavioral anxiety management techniques for patients with special needs.[4,5] Several strategies have been used to manage anxiety during dental treatment. Practical strategies include, but are not limited to, cognitive behavioral techniques, medication and pain control, and sensory adaptation techniques (SATs).[8–10] However, cognitive behavioral techniques might be difficult to apply to patients with poor cognitive and communicative abilities. Although general anesthesia is also a possibility, clinical administration thereof is limited by restrictions in the clinical setting and the qualified professional staff.[2,5] When neither cognitive nor anesthetic strategies are appropriate, SAT may provide a useful method of anxiety management by applying multisensory inputs of vision, hearing, and deep touch pressure. Deep touch pressure is a form of tactile input that may act as a calming agent, potentially increasing the activity of the parasympathetic division of the autonomic nervous system (ANS).[11] To our knowledge, however, systematic theoretical research illustrating the contribution of deep touch pressure to ANS modulation is limited.

The papoose board is a SAT device that provides deep touch pressure to stabilize and calm patients with special needs during anxiety-provoking conditions. The papoose board is also used as a calming tool for pediatric patients in certain medical situations. It significantly assists medical staff in managing uncooperative or anxious patients and reduces the difficulties and risks during interventions.[11] Studies have indicated that use of papoose board for deep touch pressure has a significant effect in allowing participants to feel secure, and reduce their level of anxiety.[12,13] Therefore, papoose board may be considered a noninvasive, easily applied technique that does not require a high level of cognitive ability in clients. However, for special needs patients requiring dental treatment, application of papoose board was misconstrued as a form of constraint, abuse, or deception. Although evidence-based results have highlighted the anxiety-reducing effect of papoose board, its use as a behavioral management technique remains controversial. Overall, the empirical and theoretical information and guidelines on papoose board are as yet relatively indistinct.[14,15]

Theoretical reports have suggested that the allostasis of the ANS, including the activation of the sympathetic nervous system (SNS) in association with the parasympathetic nervous system (PsNS), plays a crucial role in anxiety and stress.[16,17] Over the past few decades, many physiological measures have been used to investigate responses to anxiety, including blood pressure, heart rate, skin conductance, and cortisol level.[18,19] Among these quantitative methods, electrodermal activity and heart rate variability are the most convenient methods to investigate the physiologic correlates of emotions.[20–22] The electrodermal activity refers to modifications in skin conductivity associated with sweat gland activity innervated by the SNS. The tonic-measuring skin conductance level in electrodermal activity provides an indirect method to assess the performance of the SNS[21,23] in identifying anxiety during dental treatment.[3]

Although sympathetic modulation is well understood, less attention has been focused on the contribution of parasympathetic activity during allostatic modulation of the ANS. Because the heart rate (HR) is influenced by both sympathetic and parasympathetic activity, the index demonstrating parasympathetic performance is greater during stress.[24] Both bioelectrical (electrocardiography) and bio-optical (photoplethysmography) methods are used to analyze the interbeat intervals of regular HR waveforms and investigate ANS control.[25] High correlation ($r = 0.998$) have been confirmed between the time and frequency domains in analyses of heart rate variability derived from either the R-R intervals of electromyography or the pulse-pulse interval (P—P) of blood volume pulse from photoplethysmography sensor.[26] Although electromyography is the gold standard for estimation of heart rate variability, blood volume pulse obtained from photoplethysmography is general acceptable to provide valuable information to explore the responses of autonomic cardiovascular system in applications where electromyography is not available.[26–28] For the frequency domain of heart rate variability, rhythms in the low- and high-frequency ranges constitute markers to detect sympathetic and parasympathetic activities, respectively. The same rhythms can be used to assess the balance of ANS modulation.[20,30,31] To our knowledge, however, few integrated studies on anxiety have been based on the concept of the orchestration of SNS and PsNS.

The aims of the present study were (a) to investigate the effects of deep touch pressure, induced by papoose board, on ANS modulation in participants who experienced anxiety during dental treatments; for this assessment we used both physiological and behavioral measures, and (b) to identify the effect of deep touch pressure between the treatment phases, with focus on the modulation of SNS and PsNS.

Materials and methods

Participants

A total of 19 participants were recruited by word-of-mouth from the Special Care Clinic for Disabled Patients in the Dental Department, National Taiwan University Hospital (NTUH), Taiwan. The inclusion criteria were as follows: (a) no previous trauma to the fingers of the hand (to enable electrode use in that hand), (b) prior experience with using papoose board, and (c) lack of participation in any experimental rehabilitation or drug studies. Participants were excluded if they met any of the following criteria: (a) the original treatment plan required anesthetic or sedation, (b) patients with medicine usage or caffeine intake on the day of the treatment, (c) history of asthma, seizure, or restrictions in circulation over the past 3 months, and (d) excessive agitation or behavioral struggle before treatment. Informed consent was obtained prior to participation, and the experimental protocol was approved by the Human Research Ethics Committee of NTUH.

Experimental design and procedures

Because of the characteristics of our disabled participants, most patients could not undergo dental treatment unless their anxiety was well managed. Therefore, the papoose board was applied during all phases of the entire dental intervention. The testing was performed in the morning to prevent the influences of physiological and physical fatigue of subjects. The temperature of the recording environment was controlled at $21 \pm 2.0\,^{\circ}C$, and the relative humidity was maintained at approximately 40%$\sim$50% to prevent from artifacts in data acquisition.

Prior to the testing, the caregiver of each participant was invited to fill in the checklist for overnight sleeping quality and anxiety questionnaires based on her or his understanding of the participant's condition. Physiological measurements were acquired continually with the participants in the identical supine position to reduce the posture effects throughout the 4 treatment phases. In heart rate variability analysis, standard recommendations for the R wave to R wave interval (R—R) analysis include a minimum of 256 beats to perform a spectral analysis. For an adult, physiologic normal resting HR ranges from 60—100 beats a minute. Since HRe variability measurement requires an adequate sampling window and window size has been established in this manuscript, the average heart rate of normal human is 72 beats/minute, which multiplied by the minimum window (72 beats/minute $\times$ 4 minutes = 288 beats) for adequate data length. To include a safety margin, and suggestion from previous studies,[28,29] we used a 5-minute sampling window (60 beats/minute $\times$ 5 minutes = 300 beats) in each phase of this study. In the baseline phase, the participant remained lying down on the dental chair for 5 minutes to enable recording of the baseline data. Then, during the pretreatment phase, the participant was wrapped into the papoose board to receive deep touch pressure, but with no active dental intervention for the next 5 minutes. The treatment phase began when a handpiece was placed inside the participant's mouth for dental treatment. According to each participant's clinical needs, treatment was performed for approximately 5—20 minutes, with several pauses for rest if necessary. After the treatment was finished, the participant was kept lying on the dental chair with deep touch pressure for the post-treatment phase, which lasted 5 minutes. During this time, the caregiver was encouraged to fill in an anxiety questionnaire (to gather data on the participant's behavioral performance during treatment and post-treatment phases for later analysis). The entire process lasted approximately 40—50 minutes.

Apparatus

The papoose board, a 150 $\times$ 45 cm foam-padded device, was used during dental treatment in the present study. Four sets of Velcro straps were used to firmly secure the participant to a rigid board at the level of shoulders, upper trunk, pelvis, and thighs, to provide sustained deep touch pressure. The procedure of fastening was performed by a trained occupational therapist, and the straps made firm contact with the participants' body parts without any deformation of the skin surface.

Physiologic measures

To record the signals of physiological parameters, electrodes were connected to a Bluetooth-based bioamplifier (Nexus-10; Mind Media B.V., Roermond-Herten, Netherlands), which provides an elegant alternative to replace the cabled system. The sampling rate was 128 Hz.

Electrodermal activity

The electrodermal activity was recorded with silver-silver chloride electrodes, with a diameter of 5 mm. The electrodes were wrapped to the volar surface of the middle phalanges of the third and fourth fingers of the participant's left hand. The electrodermal activity was determined by fluctuations in micro-Siemens (μS), with increases reflecting raised skin conductance. Higher skin conductance level scores indicate greater SNS activation, thus showing greater anxiety.[12]

Heart rate variability

Using the photoplethysmography, clipped to the left second finger of the participant, the inter-pulse interval (IPI) of BVP was processed in the frequency domain by Biotrace^{+} software (Mind Media B.V., Netherlands) through fast Fourier transformation. The specific frequency bands demonstrating ANS activity included the low frequency band (0.04—0.15 Hz) corresponding mainly to SNS; in contrast, the high frequency band (0.15—0.4 Hz) is related to PsNS.[22] Moreover, low frequency percentage and high frequency percentage are the percentages of low frequency band and low frequency band across the entire spectrum, and indicate SNS and PsNS activities respectively. The low frequency-high frequency ratio was calculated as the ratio of the low frequency and high frequency components, yielding a measure of sympathetic/parasympathetic balance.

Behavioral assessments

The present study combined the Numeric State Anxiety Scale and the Children's Fear Survey Schedule-Dental Subscale to investigate the participants' behavioral status.

Numeric state anxiety scale

The participants' caregivers were invited to describe the participants' emotional status during the baseline, treatment, and post-treatment phases. The Numeric State Anxiety Scale is a numeric ordinal scale, with the score represented on an abscissa line reflecting level of anxiety. A score of 0—1 represents "not at all"; 2—4 denotes "little"; 5—7 denotes "medium"; 8—9 denotes "a lot"; and 10 denotes "worst imaginable." The scale is easy to administer and quickly quantifies a person's level of anxiety, and lends itself to use with patients who have speech or language difficulties. The reliability and validity of the Numeric State Anxiety Scale are adequate for clinical evaluation of levels of anxiety.[32]

Children's fear survey schedule-dental subscale

The caregivers were asked to fill in the Chinese version of the Children's Fear Survey Schedule-Dental Subscale before the dental treatment, to evaluate the subjective level of anxiety of the participants at baseline. This psychometric scale consists of 15 items, with the score for each item ranging from 1 (not afraid) to 5 (very afraid). Distinct aspects of dental and medical situations are presented, to assess the level of dental fear. The Children's Fear Survey Schedule-Dental Subscale has demonstrated high internal reliability, indicating that the scale is a highly sensitive and specific instrument for detecting anxiety.[7,33] Scores equal to or exceeding 38—42 points have been reported to be associated with dental fear, thus predicting anxiety during dental treatment.[34,35] Given the lack of behavioral assessment tools for anxiety among disabled participants, who may have similar limitations in language expression and comprehension as those of young children, the Children's Fear Survey Schedule-Dental Subscale was selected to evaluate the participants' level of anxiety in the present study.

Statistical analysis

The data from the demographic survey were analyzed for the mean and standard deviations among all participants, and the results were presented as descriptive statistics. The non-parametric Kruskal-Wallis test and Mann-Whitney *U* test were used to investigate the distinct phases and main effects of electrodermal activity and heart rate variability. The scores of Numeric State Anxiety Scale and each item in Children's Fear Survey Schedule-Dental Subscale were represented by a percentage and analyzed with the independent *t*-test to compare the differences. All statistical tests were two-tailed, with the significance level (α) being set at 0.05. All analyses were performed using SPSS version 12.0 (SPSS Inc., Chicago, IL, USA).

Table 1 Demographic characteristics of the participants in the present study ($N = 19$).

Characteristics	Total	Positive trend	Negative trend	*p* value
N	19	10	9	0.819
Sex (*N*)				
Men	12	5	7	0.405
Women	7	5	2	0.257
Age, y	24.58 (8.71)	24.10 (5.86)	25.11 (11.47)	0.809
Level of disability				
Profound	10 (52.63%)	6 (60.00%)	4 (44.45%)	0.527
Severe	5 (26.32%)	2 (20.00%)	3 (33.33%)	0.655
Moderate	3 (15.79%)	2 (20.00%)	1 (11.11%)	0.564
Mild	1 (5.26%)	0 (0.00%)	1 (11.11%)	—
Classification of disability				
Multiple	8 (42.11%)	6 (60.00%)	2 (22.22%)	0.157
MR	11 (57.89%)	4 (40.00%)	7 (77.78%)	0.366
Dental treatment				
Dental cleaning	11 (57.89%)	6 (60.00%)	5 (55.56%)	0.763
Cleaning and filling	7 (36.85%)	4 (40.00%)	3 (33.33%)	0.705
Root canal treatment	1 (5.26%)	0 (0.00%)	1 (11.11%)	—

$p < 0.05$.
MR = mental retardation.

Results

The effects of deep touch pressure induced by papoose board were evaluated by physiological and behavioral measurements. Because different trends emerged for ANS response, we divided the 19 participants into two subgroups, based on their Z-score in slope tendency of low frequency-high frequency ratio between the baseline and pre-treatment phases. Subjects with a positive Z-score (>0) were assigned to the group of positive trend ($N = 10$), and participants with a negative Z-score (≤ 0) were assigned to the group of negative trend ($N = 9$). We found no statistical differences for level of disability, classification of disability, and other demographic characteristics between the groups of positive and negative trends (Table 1).

Analysis of the physiologic measurements

Table 2 presents the means and standard deviations for all physiological parameters of the group of positive trend. No statistically significant differences emerged for any of the raw physiological data across the phases. However, the normalized high frequency percentage at baseline (1.00 ± 0.00) was significantly higher than at pretreatment (0.74 ± 0.14, $p = 0.028$) or post-treatment (0.81 ± 0.27, $p = 0.028$), as shown in Fig. 1. For normalized low frequency-high frequency ratio, the value at baseline (1.00 ± 0.00) was significantly lower than at pretreatment (1.77 ± 0.67, $p = 0.028$) or post-treatment (1.81 ± 0.97, $p = 0.045$).

For the group of negative trend, no statistically significant differences emerged for any of the raw physiologic data across the phases (Table 3).However, for the normalized physiologic parameters of the group of negative trend, significant differences were observed between each phase. As indicated in Fig. 2, the normalized skin conductance level at baseline (1.00 ± 0.00) was significantly lower than at post-treatment (1.62 ± 0.76, $p = 0.045$). For normalized low frequency-high frequency ratio, the value at baseline (1.00 ± 0.00) was significantly higher than at pretreatment (0.57 ± 0.26, $p = 0.013$).

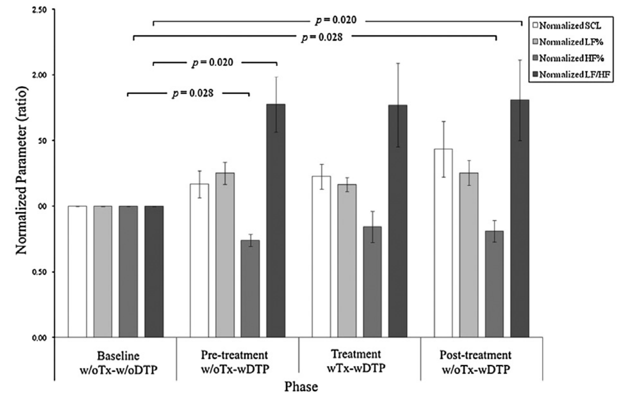

Figure 1 Comparisons of the normalized physiological parameters (response) of positive trend group ($N = 10$) at 4 phases: baseline (w/oTx-w/oDTP), pretreatment (w/oTx-wDTP), treatment (wTx-wDTP), and post-treatment (w/oTx-wDTP). The positive trend group showed higher normalized values of high frequency percentage at baseline compared to those of pretreatment and post-treatment ($p < 0.05$). Significantly higher normalized values of low frequency-high frequency ratio for treatment and post-treatment were noted, compared with baseline. Bars represent differences between one standard deviation. w/oTx-w/oDTP = without treatment and deep touch pressure; w/oTx-wDTP = without treatment but with deep touch pressure; wTx-wDTP = with treatment and deep touch pressure.

Analysis of the behavioral assessments

Before the dental treatment, most participants revealed higher scores, indicating a state of anxiety, on Numeric

Table 2 Statistical analysis for positive physiologic parameters of disabled participants under four phases.

Parameter	N	Phase				p value
		Baseline (w/oTx-w/oDTP)	Pretreatment (w/oTx-wDTP)	Treatment (wTx-wDTP)	Post-treatment (w/oTx-wDTP)	
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
SCL (μS)	10	1.53 (0.92)	1.82 (1.15)	1.84 (1.05)	2.11 (1.34)	0.673
Normalized SCL	10	1.00 (0.00)	1.17 (0.33)	1.23 (0.30)	1.43 (0.67)	0.055
LF%	10	42.22 (6.47)	52.11 (10.67)	48.37 (4.39)	52.43 (13.30)	0.085
Normalized LF%	10	1.00 (0.00)	1.25 (0.27)	1.16 (0.16)	1.25 (0.30)	0.085
HF%	10	41.59 (12.40)	30.93 (11.21)	32.05 (10.71)	33.36 (13.81)	0.298
Normalized HF%	10	1.00 (0.00)	0.74 (0.14)	0.84 (0.38)	0.81 (0.27)	0.028*
LF/HF	10	1.14 (0.50)	1.98 (0.98)	1.71 (0.70)	2.01 (1.33)	0.200
Normalized LF/HF	10	1.00 (0.00)	1.77 (0.67)	1.77 (1.01)	1.81 (0.97)	0.020*

*$p < 0.05$ between phase factor in Kruskal-Wallis test comparisons.
HF% = high frequency percentage, higher HF% values indicate greater parasympathetic nervous system (PsNS) activity; LF% = low frequency percentage, higher LF% values indicate greater sympathetic nervous system (SNS) activity; LF/HF = low frequency-high frequency ratio; SCL = skin conductance level, higher SCL scores indicate greater SNS activity; w/oTx-w/oDTP = without treatment and deep touch pressure; w/oTx-wDTP = without treatment but with deep touch pressure; wTx-wDTP = with treatment and deep touch pressure.

Table 3 Statistical analysis for negative physiologic parameters of disabled participants under four phases.

Parameter	N	Phase				*p* value
		Baseline (w/oTx-w/oDTP)	Pretreatment (w/oTx-wDTP)	Treatment (wTx-wDTP)	Post-treatment (w/oTx-wDTP)	
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	
SCL (μS)	9	1.68 (1.33)	1.65 (1.52)	2.62 (2.64)	2.83 (3.19)	0.573
Normalized SCL	9	1.00 (0.00)	0.97 (0.34)	1.53 (0.62)	1.62 (0.76)	0.045*
LF%	9	56.41 (8.35)	44.57 (5.62)	49.76 (7.50)	50.91 (12.70)	0.056
Normalized LF%	9	1.00 (0.00)	0.80 (0.14)	0.90 (0.19)	0.92 (0.26)	0.100
HF%	9	22.16 (10.04)	35.55 (16.47)	32.89 (9.82)	35.41 (15.68)	0.130
Normalized HF%	9	1.00 (0.00)	1.84 (1.23)	1.87 (1.13)	2.28 (2.48)	0.088
LF/HF	9	3.29 (2.14)	1.73 (1.28)	1.67 (0.64)	2.17 (2.13)	0.060
Normalized LF/HF	9	1.00 (0.00)	0.57 (0.26)	0.71 (0.52)	0.84 (0.70)	0.013*

*$p < 0.05$ between phase factor in Kruskal-Wallis Test comparisons.
HF% = high frequency percentage, higher HF% values indicate greater parasympatheic nervous system (PsNS) activity; LF% = low frequency percentage, higher LF% values indicate greater sympathetic nervous system (SNS) activity; LF/HF = low frequency-high frequency ratio; SCL = skin conductance level, higher SCL scores indicate greater SNS activity; w/oTx-w/oDTP = without treatment and deep touch pressure; w/oTx-wDTP = without treatment but with deep touch pressure; wTx-wDTP = with treatment and deep touch pressure.

State Anxiety Scale at the baseline phase (70% in positive trend and 88% in negative trend groups). Higher levels of anxiety during the treatment phase were also observed for scores of Numeric State Anxiety Scale, especially in the group of positive trend. In the post-treatment phase, approximately 10% of participants remained in a state of anxiety higher than medium.

Comparison between phases indicated that high levels of anxiety were present during the treatment phase, and more than 90% of participants in the positive trend group felt anxious, with scores of Numeric State Anxiety Scale

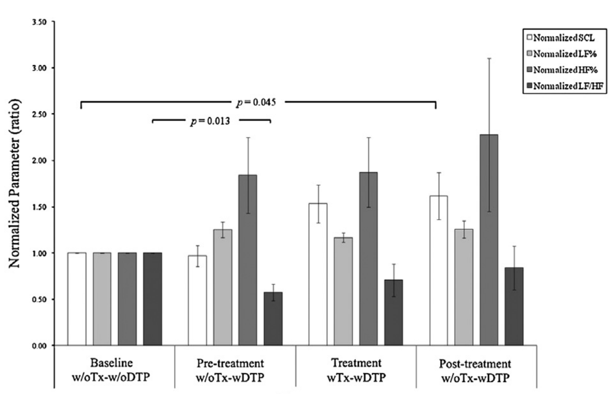

Figure 2 Comparisons of the normalized physiological parameters (response) of negative trend group ($N = 9$) at 4 phases: baseline (w/oTx-w/oDTP), pretreatment (w/oTx-wDTP), treatment (wTx-wDTP), and post-treatment (w/oTx-wDTP). The negative trend group showed higher normalized values of skin conductance level at post-treatment compared with baseline ($p < 0.05$). Significantly lower normalized values of low frequency-high frequency ratio for pre-treatment compared with baseline were noted. Bars represent differences between one standard deviation. w/oTx-w/oDTP = without treatment and deep touch pressure; w/oTx-wDTP = without treatment but with deep touch pressure; wTx-wDTP = with treatment and deep touch pressure.

ranging from medium to worst imaginable. The Children's Fear Survey Schedule-Dental Subscale identified dental fear in 8 participants (scale $\geq$ 38), of whom two were female. Five of the eight anxious participants were mentally retarded, and three had multiple disabilities (level of disability: four profound, two severe, one moderate, one mild). The proportion of participants with scores of Children's Fear Survey Schedule-Dental Subscale $\geq$ 38 was 42.11%. For all participants, the most feared items were dental injections, the dentist drilling, the sight of the dentist drilling, the noise of the dentist drilling, choking, and having somebody put instruments in their mouth. The results for the groups of positive and negative trends indicated no significant difference between the two subgroups, either for total score of Children's Fear Survey Schedule-Dental Subscale or for item scores.

Discussion

This study was the first to investigate the use of papoose board in alleviating the anxiety of patients with special needs during dental treatment. Physiologic parameters were measured and the results consistently demonstrated distinct ANS modulation patterns for the effects of deep touch pressure induced by papoose board, for both groups of positive and negative trends of patients. The sequence effect of original variables was not found to be significant, but the benefit of deep touch pressure in orchestrating the status of participants' behavior was found for normalized variables. Behavioral assessments completing by caregivers indicated that participants felt anxious even with the deep touch pressure intervention during dental procedures. However, the results, which might be partially attributed to caregivers' subjective impression, were not consistent with the relative information from physiological measurements.

No significant difference was found for skin conductance level, low frequency percentage, high frequency percentage, and low frequency-high frequency ratio, indicating that dental treatment together with deep touch pressure might not influence ANS activity for these specific parameters. However, the effects of ANS modulation should be considered not only the individualized functions of SNS and PsNS, respectively, but also the orchestration between the interactions of contextual factors with the entire system. The normalized parameters provide clearer information to show the synchronized performance of ANS modulation which accessed accompany with the baseline condition between phases.[13] We also suggest that ANS response should be generalized into normalized parameters to appropriately illustrate the effects of specific factors that influence the modulation status of participants.

In the group of positive trend, higher normalized values of low frequency-high frequency ratio were observed for conditions both with and without deep touch pressure. This finding indicated that for participants of the group of negative trend, SNS activity was dominant relative to PsNS when participants were experiencing behavior disturbances. To maintain the consistency of ANS status, the responses of the SNS and PsNS tended to co-vary as the participant adjusted to stress. These findings indicated the important role of PsNS in ANS modulation for the group of positive trend. Thus, when noticeable alternation was not observed in the SNS activation, the deep touch pressure intervention may have interacted with lower PsNS response to harmonize ANS function in the group of positive trend. Previous research has indicated that lower PsNS activity may be a biomarker for sensory modulation difficulties.[36] Given the consistency of results, we hypothesize that poor ANS modulation may be attributed to poor sensory modulation characteristics in participants of the group of positive trend. Thus the deep touch pressure provided by papoose board might enable those participants to properly regulate their modulation functions and adapt to challenges in the dental environment.[1,13]

For the group of negative trend, the normalized low frequency-high frequency ratio also remained steady among the phases. However, the relatively low normalized values of low frequency-high frequency ratio indicated that PsNS activity was the dominant response in the group of negative trend. With the application of deep touch pressure, significantly higher PsNS activity played a critical role in modulating the ANS toward a more stable and comfortable status during conditions of anxiety. The application of deep touch pressure evidently activated PsNS reaction. Compared with the group of positive trend, appropriate ANS modulation enabled the group of negative trend to cope and adapt to the anxiety condition with fewer difficulties during dental treatment.

In both groups of positive and negative trends, neither the reactivity nor the response of SNS was evoked between the application of deep touch pressure without and with the dental treatments. When participants received dental treatment, their SNS activity peaked and this led to anxious emotions. By contrast, participants in both the groups of positive and negative trends in the current study showed no significant increase in SNS firing, for any of the physiological parameters, after the application of papoose board. This finding indicated that deep touch pressure intervention provided special needs participants with the opportunity to regulate their ANS activity and to modulate allostasis, thereby promoting the fluency and quality of dental procedures.[14,37] These results support the claims of previous studies for the benefits of deep touch pressure intervention in dental treatment.[11,38,39] However, as mentioned earlier, deep touch pressure intervention applied by papoose board should not be misconstrued as an apparatus to constrain, abuse, or deceive participants with special needs.

In addition, although the higher values of normalized low frequency-high frequency ratio were observed in the group of positive trend, in contrast with lower values in the group of negative trend (Tables 2 and 3), the values were still maintained in steady among the phases through modulation of PsNS activity under deep touch pressure intervention. These results support the effects of deep touch pressure to balance the ANS function under anxious challenge. The results also indicated that the group of positive trend was possibly the population with greater special needs, who would require more deep touch pressure or other supportive techniques during novel and threatening situations. An additional interpretation from these data is that when participants are faced with novel circumstances, multiple patterns of ANS modulation probably exist, two of which showed up as trends in the current research. For the group of positive trend, increased SNS activation during the post-treatment phase may have been caused by the awareness that dental treatment had ended, accompanied by preparation for dealing with the next novel condition. Thus, deep touch pressure intervention might not be completely effective in inhibiting SNS activity when strong drives are triggered under novel circumstances. The group of negative trend seemed to be PsNS dominant, and for these participants the effects of deep touch pressure may have continued after the end of dental treatment, when the participants were preparing to deal with further novel conditions.

To conclude, this study offered physiologic evidence for the modulation effects of deep touch pressure in stressful conditions in dental environments. It also provided evidence that the application of papoose board, as a sensory adaptation technique, is not harmful for people with special needs. While this study had its limitations, we hope that it will serve as a basis for further research into the physiological mechanisms of deep touch pressure, and the application of deep touch pressure for managing stress in various conditions and populations.

Acknowledgments

This project was partially supported by grants from the National Science Council, Taiwan (NSC 99-2320-B-182-002-MY3) and Hsueh-Wan Kwan Research Scholarships.

References

1. DiMatteo MR, Lepper HS, Croghan TW. Depression is a risk factor for noncompliance with medical treatment meta-analysis of the effects of anxiety and depression on patient adherence. *Arch Intern Med* 2000;**160**:2101–7.
2. Bennett CR. Delivery of dental care to persons with disabilities and other special populations. *Work* 1999;**12**:239–43.
3. Caprara HJ, Eleazer PD, Barfield RD, Chavers S. Objective measurement of patient's dental anxiety by galvanic skin reaction. *J Endod* 2003;**29**:493–6.

4. Gordon SM. Dental fear and anxiety as a barrier to accessing oral health care among patients with special health care needs. *Spec Care Dentist* 1998;**18**:88—92.
5. Lyons RA. Understanding basic behavioral support techniques as an alternative to sedation and anesthesia. *Spec Care Dentist* 2009;**29**:39—50.
6. Corah NL, Gale EN, Illig SJ. Assessment of a dental anxiety scale. *J Am Dent Assoc* 1978;**97**:816—9.
7. Lee CY, Chang YY, Huang ST. The clinically related predictors of dental fear in Taiwanese children. *Int J Paediatr Dent* 2008; **18**:415—22.
8. Havelka C, McTigue D, Wilson S, Odom J. The influence of social status and prior explanation on parental attitudes toward behavior management techniques. *Pediatr Dent* 1992; **14**:376—81.
9. Berggren U. Long-term management of the fearful adult patient using behavior modification and other modalities. *J Dent Educ* 2001;**65**:1357—68.
10. Lahmann C, Schoen R, Henningsen P, Ronel J, Muehlbacher M, Loew T, et al. Brief relaxation versus music distraction in the treatment of dental anxiety: a randomized controlled clinical trial. *J Am Dent Assoc* 2008;**139**:317—24.
11. Shapiro M, Melmed RN, Sgan-Cohen HD, Eli I, Parush S. Behavioural and physiological effect of dental environment sensory adaptation on children's dental anxiety. *Eur J Oral Sci* 2007;**115**:479—83.
12. Mullen B, Champagne T, Krishnamurty S, Dickson D, Gao RX. Exploring the safety and therapeutic effects of deep pressure stimulation using a weighted blanket. *Occup Ther Ment Health* 2008;**24**:65—89.
13. Shapiro M, Sgan-Cohen HD, Parush S, Melmed RN. Influence of adapted environment on the anxiety f medically treated children with developmental disability. *J Pediatr* 2009;**154**: 546—50.
14. Adair SM, Durr DP. Modification of papoose board restraint to facilitate airway management of the sedated pediatric dental patient. *Pediatr Dent* 1987;**9**:163—5.
15. Frankel RI. The papoose board and mothers' attitudes following its use. *Pediatr Dent* 1991;**13**:284—8.
16. Benjamins C, Schuurs AH, Hoogstraten J. Skin conductance, marlowe-crowne defensiveness, and dental anxiety. *Percept Mot Skills* 1994;**79**:611—22.
17. Sequeira H, Hot P, Silvert L, Delplanque S. Electrical autonomic correlates of emotion. *Int J Psychophysiol* 2009;**71**:50—6.
18. Noteboom T, Barnholt KR, Enoka RM. Activation of the arousal response and impairment of performance increase with anxiety and stressor intensity. *J Appl Physiol* 2001;**91**:2093—101.
19. Maldonado EF, Trianes MV, Cortés A, Moreno E, Escobar M. Salivary cortisol response to a psychosocial stressor on children diagnosed with attention-deficit/hyperactivity disorder: differences between diagnostic subtypes. *Span J Psychol* 2009; **12**:707—14.
20. Malik M. Heart rate variability: standards of measurement, physiological interpretation, and clinical use. *Circulation* 1996; **93**:1043—65.
21. Miller LJ, McIntosh DN, McGrath J, Shyu V, Lampe M, Taylor AK, et al. Electrodermal responses to sensory stimuli in individuals with fragile x syndrome: a preliminary report. *Am J Med Genet* 1999;**83**:268—79.
22. Li Z, Snieder H, Su S, Ding X, Thayer JF, Treiber FA, et al. A longitudinal study in youth of heart rate variability at rest and in response to stress. *Int J Psychophysiol* 2009;**73**:212—7.
23. Boucsein W. *Electrodermal activity*. NYC, NY: Plenum; 1992.
24. van Lang NDJ, Tulen JHM, Kallen VL, Rosbergen B, Dieleman G, Ferdinand RF. Autonomic reactivity in clinically referred children attention-deficit/hyperactivity disorder versus anxiety disorder. *Eur Child Adolesc Psychiatry* 2007;**16**:71—8.
25. Cervantes Blásquez JC, Rodas Font G, Capdevila Ortís L. Heart-rate variability and precompetitive anxiety in swimmers. *Psicothema* 2009;**21**:531—6.
26. Lu G, Yang F, Taylor JA, Stein JF. A comparison of photoplethysmography and ECG recording to analyse heart rate variability in healthy subjects. *J Med Eng Technol* 2009;**33**: 634—41.
27. Omboni S, Parati G, Frattola A, Mutti E, Di Rienzo M, Castiglioni P, et al. Spectral and sequence analysis of finger blood pressure variability: comparison with analysis of intra-arterial recordings. *Hypertension* 1993;**22**:26—33.
28. Selvaraj N, Jaryal A, Santhosh J, Deepak KK, Anand S. Assessment of heart rate variability derived from finger-tip photoplethysmography as compared to electrocardiography. *J Med Eng Technol* 2008;**32**:479—84.
29. Lin GH, Chang YH, Lin KP. Comparison of Heart Rate Variability Measured by ECG in Different Signal Lengths. *J Med Biol Eng* 2005;**25**:67—71.
30. Stein PK, Reddy A. Non-linear heart rate variability and risk stratification in cardiovascular disease. *Indian Pacing Electrophysiol J* 2005;**5**:210—20.
31. Cohen H, Benjamin J. Power spectrum analysis and cardiovascular morbidity in anxiety disorders. *Auton Neurosci* 2006; **128**:1—8.
32. Crandall M, Lammers C, Senders C, Savedra M, Braun JV. Initial validation of a numeric zero to ten scale to measure children's state anxiety. *Anesth Analg* 2007;**105**:1250—3.
33. Lee CY, Chang YY, Huang ST. Prevalence of dental anxiety among 5- to 8-year-old Taiwanese children. *J Public Health Dent* 2007;**67**:36—41.
34. Cuthbert MI, Melamed BG. A screening device: children at risk for dental fears and management problems. *ASDC J Dent Child* 1982;**49**:432—6.
35. Berge MT, Veerkamp JSJ, Hoogstraten J, Prins PJM. The dental subscale of the children's fear survey schedule: predictive value and clinical usefulness. *J Psychopathol Behav Assess* 2002;**24**:115—8.
36. Schaaf RC, Benevides T, Blanche EI, Brett-Green BA, Burke JP, Cohn ES, et al. Parasympathetic functions in children with sensory processing disorder. *Front Integr Neurosci* 2010;**4**: 1—11.
37. Kupietzky A, Ram D. Effects of a positive verbal presentation on parental acceptance of passive medical stabilization for the dental treatment of young children. *Pediatr Dent* 2005;**27**: 380—4.
38. Champagne T, Stromberg N. Sensory approaches in inpatient psychiatric settings: innovative alternatives to seclusion & restraint. *J Psychosoc Nurs Ment Health Serv* 2004;**42**:34—44.
39. Olson LJ, Moulton HJ. Occupational therapists' reported experiences using weighted vests with children with specific developmental disorders. *Occup Ther Int* 2004;**11**:52—66.