MEDICAL ACUPUNCTURE
Volume 29, Number 2, 2017

DOI: 10.1089/acu.2017.1214

Detailed Autonomic Nervous System Analysis of Microcurrent Point Stimulation Applied to Battlefield Acupuncture Protocol

Kelly Armstrong, OTR/L, SIPT, MPP,[1] Raman Gokal, MBChB, MD, FRCP, FASN,[1]
Joe Durant, BA(Psy), LMT, MPP,[2] Todd Todorsky, LMT, MPP,[3]
Antoine Chevalier, PhD, LMT, MPP,[4] and Bruce FaShong, DAc, MPP[3]

ABSTRACT

Introduction: This is a detailed comparative analysis of the effects of direct-current (DC) microcurrent point stimulation (MPS) on the autonomic nervous system, when applied in the Battlefield Acupuncture (BFA) protocol for 8 patients with histories of pain.
Methods: Evaluations entailed a standard baseline visual analogue scale (VAS) for pain, saliva cortisol, and a baseline status of 27 autonomic nervous system (ANS) functions, for a total of 29 markers, all repeated prior to and following electrotherapy on this cohort of patients.
Results: The ANS response to microcurrent point electrical nerve stimulation reflected a statistically significant pre–post improvement in 8 of the 29 markers collected: (1) pain on the VAS scale was reduced by 63% (2.0625 points; 95% CI [confidence interval]: 1.2745–2.8505; $P = 0.0001$); (2) heart rate variability improved by 42% (662.375 points; 95% CI: −1273.675 to −51.075; $P = 0.037$); (3) high frequency–vagal tone improved by 56% (231.25 points; 95% CI: −430.42 to −31.58); $P = 0.029$); (4) exercise tolerance increased by 22% (9.500 points; 95% CI: −16.747 to −2.253; $P = 0.017$); (5) parasympathetic activity improved by 38% (14.000 points; 95% CI: −23.202 to −4.798; $P = 0.009$); (6) stress was reduced by 27% (39.125 points; 95% CI: 1.945–76,305); $P = 0.042$); (7) the PTGi [photoplethysmography index] cardiac marker of endothelial function, arterial blood flow, and ANS regulation improved by 48% (21.5125 points; 95% CI: −35.441754 to 7.5832461; $P = 0.008$); (8) cardiac marker PTGVLFi [Photoplethysmography very low frequency index]—an ANS regulation marker of endothelial function and an indicator of ß-cell activity had a statistically significant reduction of 36% (9.250 points; 95% CI: 1.062–17.438; $P = 0.032$). Salivary cortisol decreased by 14% (0.08286 points; 95% CI: −0.1182 to 0.28384; $P = 0.352$).
Conclusions: The positive and impressive results in this study showed significant improvement in several parameters of ANS function and reduction in pain and cortisol levels. If replicated, this study paves the way for use of DC MPS applied to the BFA protocol for other pathologies that are known to be affected by sympathetic nervous system activation.

Keywords: Battlefield Acupuncture, Microcurrent Point Stimulation, Heart Rate Variability (HRV), Vagal Tone (HF), Stress

[1]St. Augustine, FL.
[2]Brunswick, GA.
[3]Jacksonville, FL.
[4]University of Natural Health, Indianapolis, IN.

INTRODUCTION

Battlefield Acupuncture (BFA) was developed by Col. Dr. Richard C. Niemtzow, (MD, PhD, MPH) of Andrews Air Force Base, as a standardized protocol to provide a simple, easy to apply, nonpharmaceutical solution for the Military's pain-management needs in the clinical and battlefield settings.[1–3]

The protocol involves the applications of a stimulus to five key acupuncture ear (auricular) points that isolate the autonomic nervous system (ANS) and central nervous system's (CNS) role in the chronic/acute pain cycle. When these points are treated collectively, it has been reported that a wide variety of neuromyofascial pain syndromes can be relieved effectively on a timely basis.

Acupuncture has been practiced for thousands of years and is commonly used for treating many types of chronic pain.[4–7] Electroacupuncture (EA) has been used as an adjunctive to pain management in acupuncture therapy for decades.[8] EA has been reported to outperform traditional acupuncture needles analgesically.[9] Science has long hypothesized with respect to a scientific explanation of the analgesic successes of acupuncture or EA. Literature supports that acupuncture relieves pain by regulating the ANS,[10] activating the release of ß-endorphins,[11] regulating the CNS,[12] and producing local effects on the peripheral nervous system.[13]

It is widely accepted in science that imbalances of the parasympathetic (rest/healing/calming) and sympathetic (flight/fight/stress) branches of the ANS are directly linked to wide variety of pain and diseases.[14–20] The sympathetic nervous system (SNS) is designed to facilitate short-term survival by creating a cascade of neurophysiologic responses, and persistent tone or upregulation of the SNS is a precipitator of ill health and disease.[21,22] Real-time analysis of sympathetic upregulation may be now accurately measured in two ways, heart rate variability (HRV)[17] and cortisol levels.[23,24]

It is well-established that low HRV values (sympathetic overactivity) are implicated in cardiac pathology, morbidity, reduced quality-of-life (QoL), and precipitous mortality.[14–20] Optimal HRV values are associated with improved exercise tolerance, cardiovascular health, improved ANS control, better emotional regulation, and enhanced neurocognitive processing.[25] In addition to health benefits, optimal HRV has been shown to improve neurocognitive performance by enhancing focus, visual acuity, and readiness, and by promoting emotional regulation needed for peak performance.[26]

Emerging evidence also supports the neurophysiology of acupuncture as modulating the imbalances created by sympathetic and parasympathetic activities, in order to alleviate autonomic disorders.[10,27]

Microcurrent therapies involve applying weak direct currents (80 μA–1 mA), and are now being recognized increasingly as adjuncts for pain relief and ANS regulation.[28–31] However, there is no consensus in the literature identifying the best practice measures for application of BFA to patients who have chronic pain or stress. Although sufficient evidence supports the application of acupuncture needles for autonomic regulation, there is limited evidence in literature to support the use of electrotherapies for the same purpose. The aim of this pilot study was to assess the impact of microcurrent point stimulation (MPS) on the autonomic nervous and endocrine systems in a sample of patients with chronic pain.

METHODS

Subjects

A diffuse range of patients with neuromyofascial pain syndrome from both sexes was recruited for this study. A total of 8 patients (5 females, 3 males; mean age: 37.75 years; standard deviation [SD]: 18.18) with chronic nonspecific pain (3 with neck pain, 2 with foot pain, and 1 each with shoulder pain, back pain, and fibromyalgia), with a mean pain duration average of 4.855 years (SD 6.13), presented to the current authors for therapy to address their problems. (Table 1) Inclusion criteria was simple: patients who were currently suffering from soft-tissue chronic pain for >3 months, with a recorded 3+/10 visual analogue scale (VAS) for pain score. The diagnoses of pain, location, severity, sex, and previous interventions or surgeries were not considered to be exclusion criteria.

Methodology

MPS was applied to the BFA protocol, using[28,29,32] a single Dolphin™ Neurostim device (Center for Pain & Stress Research, Ontario, Canada). This is a U.S. Food and Drug Administration (FDA)–approved device that is used to apply low-frequency, concentrated, microcurrent stimulation (at 10K Ohms) for the relief of chronic pain.[32,33] MPS application time was 30 seconds per point, for a total of 10 points in both ears. The device was set to negative polarity (–). The BFA protocol includes the following points: Omega 2; *Shen Men*; Point Zero; Thalamus; and Cingulate Gyrus (Fig 1).

Table 1. Breakdown of Pain Location/Diagnosis of N = 8 Pain Sample

	Descriptive statistics				
Factor	*N*	*Minimum*	*Maximum*	*Mean*	*SD*
Age (years)	8	10	57	39.75	18.18752
Duration of pain (years)	8	0.08	16.00	4.855	6.13738
Initial pain levels (0–10)	8	1	6	3.25	1.8322
Post-treatment pain levels (0–10)	8	0	4	1.1875	1.4126

SD, standard deviation.

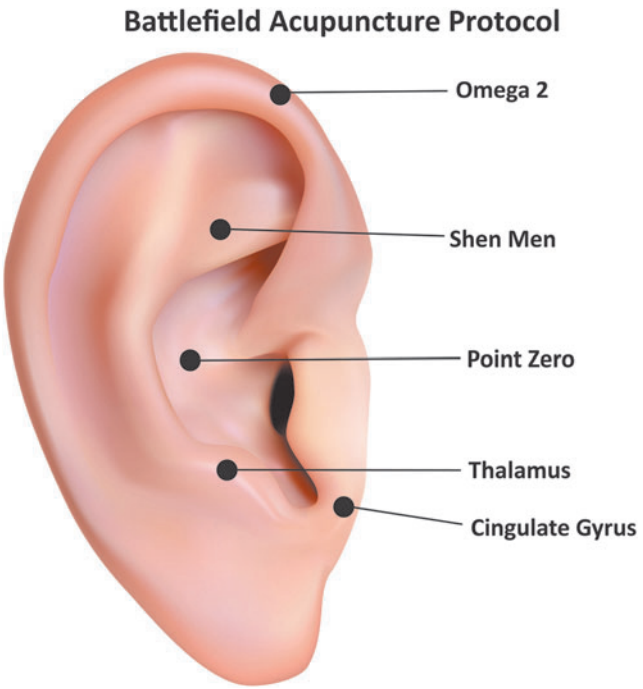

FIG. 1. Battlefield Acupuncture protocol points: Omega 2; *Shen Men*; Point Zero; Thalamus; and Cingulate Gyrus.

Autonomic nervous system assessments. These assessments were performed immediately before and after electrostimulation with the ANS1 (Biosensor Equipment LLC, Houston TX), a sophisticated FDA-approved electrocardiogram device that measures HRV, sympathetic, parasympathetic, adrenergic, and cardiovagal functions. The device utilizes a multimodal approach to assess the SNS, parasympathetic nervous system, and galvanic skin response functions through an autonomic nerve assessment, an arterial assessment, and an assessment of cardiometabolic markers.[17,34] Included are measurements of 27 physiologic ''markers,'' placing each patient measurement categorically into abnormal, borderline, and optimal goal columns. The seven ANS markers with 95% CI are:

(1) *HRV: Total power*—Total power has been determined to be the main indicator of ANS activity and is reflective of variations in time intervals between heart beats, known as HRV. Lower than normal HRV values are associated with negative outcomes in heart disease and increased risk for diabetic neuropathy.[18,19] High vales (≥ 780) are associated with health and vigor.[35]

(2) *HF: High frequency indicator of parasympathetic vagal nerve activity*—Vagal tone is an internal biologic process referring to the activity of the vagus nerve, which serves as the key component of the parasympathetic branch of the ANS. Research suggests that decreased vagal activity or tone is associated with increased stress vulnerability and poor health.[35–37] A low value (< 220), suggests sympathetic system predominance and the possibility of stress or mental anxiety.[38]

(3) *Exercise tolerance: Standard deviation of all normal-to-normal R–R intervals (SDANN)*—SDANN is an indicator of both sympathetic and parasympathetic function and, therefore, is an indicator of ANS activity overall in addition to VO_2 (maximum oxygen consumption in the muscles). High numbers (≥ 40) are usually seen in athletes, and improvement in this value would indicate an improved ANS response and exercise tolerance.[35,39]

(4) *Parasympathetic activity: Root mean square of successive normal sinus R–R interval difference (RMSSD)*—RMSSD is an indicator of parasympathetic activity and reflects the electrical stability of the heart.[40]

(5) *Stress Index*—The Stress Index measures cardiac muscle oxygen demand related to heart work. The Stress Index is correlated to C-reactive protein (CRP) and is a marker of sympathetic failure.[41] CRP is produced by the liver and increases with inflammation. HRV reflects the adaptability of the body to daily internal and external stressors that influence ANS function directly, as well as reflecting the stress the body is experiencing at the present time. High values (≥ 180) indicate a risk for heart disease.[42]

(6) *Cardiac marker PTGi*—PTGi is a cardiac marker of endothelial function, arterial blood flow, and ANS regulation. Endothelial dysfunction, ANS dysfunction, and artery blood flow are known risk factors for diabetes and atherosclerosis.[43]

(7) *Cardiac marker: Photoplethysmography very low frequency index (PTGVLFi)*—PTGVLFi is an ANS regulation marker of endothelial function and an indicator of ß-cell activity. ß-Cells are insulin producing cells located in the pancreas, and this is a marker for glucose intolerance and microcirculation complications.[20] Studies have shown very high correlation with the oral glucose tolerance test and the PTGVLFi.[44] High numbers (≥ 33) indicate a risk for diabetes.[45,46]

Visual analogue scale. A VAS was used to evaluate each patient's pain. The VAS is an 11-point scale from 0 to 10, with 0 being no pain and 10 being the most intense pain imaginable.[47–49] The patient verbally selects a value that is most in line with the intensity of the pain that he or she has experienced in the last 24 hours or is often reported as a rating during a specific movement pattern or functional task. The VAS has good sensitivity[49,50] and excellent test–retest reliability.

Saliva cortisol. Salivary cortisol evaluations were conducted pre–post MPS sessions with all 8 patients. Access Medical Labs (Jupiter, FL), one of the nation's largest full service medical laboratories, received and processed the pre–post saliva cortisol tests. Cortisol is a well-known endocrine stress marker.[51]

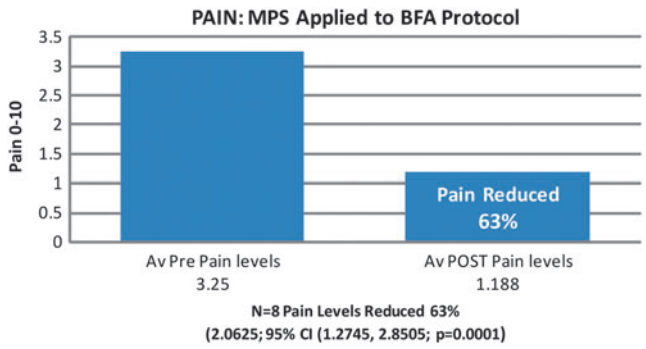

FIG. 2. Pre–post pain levels with minimum, maximum, mean average, and standard deviation (SD) of $N = 8$ pain sample. Visual representation of pain statistics measures of mean, the sample size, and a measure of dispersion in standard deviation. This graph shows the average pain level before therapy is 3.25 (95% confidence interval [CI]: 1.72–4.78; $P = 0.002$), compared to the average pain level post application of 1.188 (95% CI: 0.07–2.368; $P = 0.002$). Pain reduced 2.0625 points or 63% (95% CI: 1.2745–2.8505; $P = 0.0001$). MPS, microcurrent point stimulation; BFA, Battlefield Acupuncture; Av, average.

Purpose for collecting objective data. The objective data collection was aimed at revealing:

(1) If MPS, when applied to the BFA protocol, can modulate any variables within the ANS and VAS pain scale for these patients
(2) If MPS is a valid option for the nonpharmacologic pain management of pain- or stress-related conditions.

RESULTS

The overall responses in this cohort of patients following microcurrent point electrical nerve stimulation to ANS parameters, pain, and cortisol levels reflected a statistically significant pre–post improvement in the following 8 of the 29 markers collected:

(1) *Pain on the VAS scale*—This was reduced by 63% (2.0625 points; 95% CI: 1.2745–2.8505; $P = 0.0001$; Fig. 2 and Table 2).

Table 2. ANS1: Pre–Post Chart Results of Indicators of Pain, Cortisol, and ANS Functioning; MPS Applied to BFA Protocol (N = 8).

Comparison	*Marker of*	*Normal level*	*Average levels pre- vs. post treatment*	*Difference in mean levels & SD*	*Percentage change in mean levels*	*95% CI/ P-value*
(HRV) total power pre–post (ms^2)	Overall ANS activity	≥780	Pre = 1577.38 Post = 2239.75	662.375 ± 731.201	+42%	Yes/$P = 0.037$
Vagal tone (HF) pre–post (ms^2)	Parasympathetic activity	≥220	Pre = 412.25 Post = 643.25	231.00 ± 238.534	+56%	Yes/$P = 0.029$
SDANN pre–post (ms)	Sympathetic activity/ Exercise tolerance/VO_2 max to muscles	≥40	Pre = 43.38 Post = 52.88	9.500 ± 8.668	+22%	Yes/$P = 0.017$
RMSSD (ms)	Parasympathetic activity	≥35	Pre = 36.75 Post = 50.75	14 ± 11.006	+38%	Yes/$P = 0.009$
Stress pre–post (%)	Sympathetic activity	≤180	Pre = 145.88 Post = 106.75	−39.125 ± 44.473	−27%	Yes/$P = 0.042$
PTGi pre–post (Vs)	Arterial & homeostatic marker	≥40	Pre = 44.9 Post = 66.413	21.5125 ± 16.6614	+48%	Yes/$P = 0.008$
PTGVLFi pre–post ($ms^2/\mu Si$)	Autonomic nerve marker & endothelial function	≤33	Pre = 25.38 Post = 16.13	9.250 ± 9.794	−36%	Yes/$P = 0.032$
Pain pre–post (0–10)	Pain	N/A	Pre = 3.25 Post = 1.188	2.0625 ± .9425	−63%	Yes/$P = 0.0001$
Cortisol levels	Sympathetic activity	N/A	Pre = 0.5743 Post = 0.4914	−0.08286 ± 0.21731	−14%	No/$P = 0.352$

Notes: ANS1, Biosensor Equipment LLC, Houston TX.
HRV—Total power or HRV; normal range >780 ms^2.
Vagal tone (HF)—Vagal tone-high frequency; normal range >220 ms.
SDANN—Standard deviation of all normal-to-normal R–R intervals; normal range: 40–80 ms.
RMSSD—Root mean square of successive normal sinus R–R interval difference; normal range: 35–65 ms.
PTGi—Photoplethysmography index of the spectral analysis components; normal range: >40 vs.
PTGVLFi—Photoplethysmography very low frequency index; normal range: <33 $ms^2/\mu Si$.
ANS, autonomic nervous system, MPS, microcurrent point stimulation; BFA, Battlefield Acupuncture; SD, standard deviation; CI, confidence interval; HRV, heart rate variability; NA, not applicable.

Table 3. Numeric Representation of One Sample *t*-Test for Initial Pain Levels of $N=8$ Patient Sample

	Test value = 0					
					95% CI of the difference	
Factor	*t*	*df*	*Sig. (2-tailed)*	*Mean difference*	*Lower*	*Upper*
Initial pain levels (0–10)	5.017	7	0.002	3.250	1.72	4.78

df, degrees of freedom; sig., significance; CI, confidence interval.

(2) *ANS results*—HRV improved by 42% (662.375 points; 95% CI: −1273.675 to −51.075; $P=0.037$).
(3) *HF-vagal tone*—This improved by 56% (231.25 points; 95% CI: −430.42 to −31.58; $P=0.029$).
(4) *Exercise tolerance*—SDANN increased by 22% (9.500 points; 95% CI: −16.747 to −2.253; $P=0.017$).
(5) *Stress*—Stress was reduced by 27% (39.125 points; 95% CI: 1.945–76,305; $P=0.042$),
(6) *Cardiac marker PTGi*—This was improved by 48% (21.5125 points; 95% CI: −35.441754 to −7.5832461; $P=0.008$).
(7) Parasympathetic activity—RMSSD improved by 38% (14.000 points; 95% CI: −23.202 to −4.798; $P=0.009$.
(8) Autonomic nervous and endothelial function marker PTGVLFi had a statistically significant 36% improvement after MPS treatment (95% CI: 9.250 points; 1.062–17.438; $P=0.032$; Table 2.)

Salivary cortisol decreased by 14% (0.08286 points; 95% CI: −0.1182 to 0.28384; P = 0.352; Table 2).

DISCUSSION

The data in this case study clearly shows that the application of MPS applied to the BFA protocol provided significantly improved autonomic regulation in the sample of patients studied. MPS applied to the BFA protocol not only provided significant pain relief to all study subjects but also resulted in widespread physiologic improvements throughout the various nervous systems. There was marked improvement in HRV, vagal tone, exercise tolerance, stress levels, cardiac health, and parasympathetic activity post application. It was noteworthy that these changes were reflected within the endocrine system with a decrease in stress hormone cortisol.

Table 4. Numeric Representation of One Sample *t*-Test for Post-Treatment Pain Levels of $N=8$ Patient Sample

	Test value = 0					
					95% CI of the difference	
Factor	*t*	*df*	*Sig. (2-tailed)*	*Mean difference*	*Lower*	*Upper*
Post-treatment pain levels (0–10)	2.378	7	0.049	1.1875	0.007	2.368

df, degrees of freedom; sig, significance; CI, confidence interval.

The ANS is a fast component-signaling system controlling whole-body metabolic homeostasis by coordinating different organs and tissues, aimed to match oxygen demand and supply precisely in response to external challenges. Persistent sympathetic upregulation often results in stress and pain, which can make patients' daily lives miserable and can lead to significantly impaired physical health.[52,53] Both can be difficult to understand and, up to now, were even harder to measure. Technology, such as advanced autonomic testing, can now provide real-time scientific evidence on the inner workings of the human body's nervous systems in ill-health and disease,[54,55] permitting the collection of quantifiable data for the purposes of science and education.

CONCLUSIONS

This pilot study showed that MPS provided statistically significant overall improvements in pain reduction, HRV, vagal tone, exercise tolerance, parasympathetic activity, and stress reduction when applied to a BFA protocol. Recognizing that this portable, noninvasive procedure had an application time of <5 minutes per patient, these consistent improvements in stress markers suggest a possible significant future role for both MPS applied to BFA for managing pain or stress-related diseases outside of the clinical setting.

Chronic pain can limit QoL, and restrict work and social engagements, and is often blamed for the development of drug dependencies of various forms. The changes produced in the ANS functions help validate the potential application of MPS to the BFA protocol as an option to clinicians treating patients with chronic pain- and stress-related diseases. However, further investigation is warranted with a much larger focus group to confirm these results and to assess their duration.

It is suggested that low-amplitude DC current mimics human biocellular communications, and application of this current may create a shift or change in cellular membrane configuration, resulting in a body-wide therapeutic effect. These biochemical processes may provide a plausible explanation for the autonomic modulation after concentrated DC microcurrent, and is an area where future research is required.

ACKNOWLEDGMENTS

Statistical analyses were done by a third-party freelance statistician, using a paired sample *t*-test in SPSS software, a widely used program for statistical analysis in social and medical science. (Tables 3 and 4)

AUTHOR DISCLOSURE STATEMENT

None of the authors have any commercial associations that create a conflict of interest in connection with the submitted manuscript.

REFERENCES

1. Niemtzow RC, Litscher G, Burns SM, Helms JM. Battlefield Acupuncture: Update. *Med Acupunct*. 2009;21(1):43–46.
2. Pock AR. Acupuncture in the U.S. armed forces: A brief history and review of current educational approaches. *Med Acupunct*. 2011;23(4):205–208.
3. Niemtzow RC. Battlefield Acupuncture. *Med Acupunct.* 2007;19(4):225–228.
4. Vickers AJ, Cronin AM, Maschino AC, et al. Acupuncture for chronic pain: Individual patient data meta-analysis. *Arch Intern Med*. 2012;172(19):1444–1453.
5. Hinman RS, McCrory P, Pirotta M, et al. Acupuncture for chronic knee pain: A randomized clinical trial. *JAMA*. 2014; 312(13):1313–1322.
6. Witt C, Brinkhaus B, Jena S, et al. Acupuncture in patients with osteoarthritis of the knee: A randomised trial. *Lancet*. 2005;366(9480):136–143.
7. Vas J, Perea-Milla E, Méndez C, et al. Efficacy and safety of acupuncture for chronic uncomplicated neck pain: A randomised controlled study. *Pain*. 2006;126(1–3):245–255.
8. Zhang R, Lao L, Ren K, Berman BM. Mechanisms of acupuncture–electroacupuncture on persistent pain. *Anesthesiology.* 2014;120(2):482–503.
9. Inoue M, Nakajima M, Hojo T, Kitakoji H, Itoi M. Spinal nerve root electroacupuncture for symptomatic treatment of lumbar spinal canal stenosis unresponsive to standard acupuncture: A prospective case series. *Acupuncture Med.* 2012; 30(2):103–108.
10. Li QQ, Shi GX, Xu Q, Wang J, Liu CZ, Wang LP. Acupuncture effect and central autonomic regulation. *Evid Based Complement Alternat Med*. 2013;2013:267959.
11. Chang RS, Pomeranz B. Electroacupuncture analgesia could be mediated by at least two pain-relieving mechanisms: Endorphin and non-endorphin systems. *Life Sci*. 1979;25(23):1957–1962.
12. Wu MT, Hsieh JC, Xiong J, et al. Central nervous pathway for acupuncture stimulation: Localization of processing with functional MR imaging of the brain—preliminary experience. *Radiology*. 1999;212(1):133–141.
13. Schröder S, Liepert J, Remppis A, Greten JH. Acupuncture treatment improves nerve conduction in peripheral neuropathy. *Eur J Neurol.* 2007;14(3):276–281.
14. Vinik AI, Maser RE, Ziegler D. Autonomic imbalance: Prophet of doom or scope for hope? *Diabet Med.* 2011;28(6):643–651.
15. Marsland AL, Bachen EA, Cohen S, Rabin B, Manuck SB. Stress, immune reactivity and susceptibility to infectious disease. *Physiol Behav*. 2002;77(4–5):711–716.
16. Hayano J, Yamada A, Mukai S, et al. Severity of coronary atherosclerosis correlates with the respiratory component of heart rate variability. *Am Heart J*. 1991;121(4[pt1]):1070–1079.
17. Bigger JT Jr, LaRovere MT, Steinman RC, et al. Comparison of baroreflex sensitivity and heart period variability after myocardial infarction. *J Am Coll Cardiol.* 1989;14(6):1511–1518.
18. Carney RM, Saunders RD, Freedland KE, Stein P, Rich MW, Jaffe AS. Association of depression with reduced heart rate variability in coronary artery disease. *Am J Cardiol*. 1995;76(8): 562–564.
19. Spallone V, Ziegler D. Freeman R, et al.; Toronto Consensus Panel on Diabetic Neuropathy. Cardiovascular autonomic neuropathy in diabetes: Clinical impact, assessment, diagnosis, and management. *Diabetes Metab Res Rev*. 2011;27(7): 639–653.
20. Lewis JE, Lantigua L, Atlas SE, et al. A cross-sectional assessment to detect type 2 diabetes with endothelial and autonomic nervous system markers using a novel system. *J Diabetes Metab Disord.* 2014;13(1):118.
21. Lymperopoulos A, Rengo G, Funakoshi H, Eckhart AD, Koch WJ. Adrenal GRK2 upregulation mediates sympathetic overdrive in heart failure. *Nat Med*. 2007;13(3):315–323.
22. Bruno RM, Ghiadoni L, Seravalle G, Dell'Oro R, Taddei S, Grassi G. Sympathetic regulation of vascular function in health and disease. *Front Physiol.* 2012;3:284.
23. Stalder T, Evans P, Hucklebridge F, Clow A. Associations between the cortisol awakening response and heart rate variability. *Psychoneuroendocrinology*. 2011;36(4):454–462.
24. Gozansky WS, Lynn JS, Laudenslager ML, Kohrt WM. Salivary cortisol determined by enzyme immunoassay is preferable to serum total cortisol for assessment of dynamic hypothalamic–pituitary–adrenal axis activity. *Clin Endocrinol (Oxf).* 2005;63(3):336–341.
25. Conder RL, Conder AA. Heart rate variability interventions for concussion and rehabilitation. *Front Psychol.* 2014;5:890.
26. Alderman BL, Olson RL. The relation of aerobic fitness to cognitive control and heart rate variability: A neurovisceral integration study. *Biol Psychol*. 2014;99:26–33.
27. He W, Sheng Z-M, Wang L, Gaischek I, Litscher G. Modulation of autonomic nervous system during and after acupuncture treatment of lumbosacral pain in women: A preliminary clinical observational study. *Med Acupunct*. 2013;25(3):209–215.
28. Armstrong K. Electrotherapy Exposed. Rehab Management, January 22, 2016. Online document at: www.rehabpub.com/2016/01/electrotherapy-exposed Accessed February 1, 2017.
29. Chevalier A, Armstrong K, Norwood-Williams C, Gokal R. DC electroacupuncture effects on scars and sutures of a patient with postconcussion pain. *Med Acupunct*. 2016;28(4): 223–229.
30. McMakin C. Microcurrent therapy: A novel treatment method for chronic low back myofascial pain. *J Bodyw Movement Ther*. 2004;8:143–153.
31. Cheng N, Van Hoof H, Bockx E et al. The effects of electric currents on ATP generation, protein synthesis, and membrane transport in rat skin. *Clin Orthop Relat Res*. 1982;(171): 264–272.
32. Aguel F, Department of Health & Human Services. Re: K133789: Trade/Device Name: Dolphin Neurostim OTC [letter to Richard Keen, Acumed Medical, LTD]. Online document at: www.accessdata.fda.gov/cdrh_docs/pdf13/K133789.pdf Accessed February 1, 2017.

33. Chevalier A, Armstrong K, Gokal R. Microcurrent point stimulation applied to acupuncture points for the treatment of non-specific lower back pain. *J Altern Complement Integr Med*. 2016;2(2):016.
34. Antelmi I, de Paula RS, Shinzato AR, Peres CA, Mansur AJ, Grupi CJ. Influence of age, gender, body mass index, and functional capacity on heart rate variability in a cohort of subjects without heart disease. *Am J Cardiol*. 2004;93(3):381–385.
35. Aubert AE, Seps B, Beckers F. Heart rate variability in athletes. *Sports Med.* 2003;33(12):889–919.
36. Rubio A, Pellissier S, Picot A, Dantzer C, Bonaz B. The link between negative affect, vagal tone, and visceral sensitivity in quiescent Crohn's disease. *Neurogastroenterol Motil.* 2014; 26(8):1200–1203.
37. Friedman B. An autonomic flexibility–neurovisceral integration model of anxiety and cardiac vagal tone. *Biol Psychol.* 2007;74(2):185–199.
38. Agorastos A, Kellner M, Baker DG, Stiedl O. Diminished vagal and/or increased sympathetic activity in post-traumatic stress disorder. In: Martin CR, Preedy VR, Patel V, eds. *Comprehensive Guide to Post-Traumatic Stress Disorders.* New York & Philadelphia: Springer; 2016;1277–1295.
39. Gore R. What it takes to build the unbeatable body. *National Geographic*. 2000;198(3):2.
40. DeGiorgio CM, Miller P, Meymandi S, et al. RMSSD, a measure of vagus-mediated heart rate variability, is associated with risk factors for SUDEP: The SUDEP-7 Inventory. *Epilepsy Behav.* 2010;19(1):78–81.
41. Yudkin JS, Kumari M, Humphrie SE, Mohamed-Ali V. Inflammation, obesity, stress and coronary heart disease: Is interleukin-6 the link? *Atherosclerosis.* 2000;148(2):209–214.
42. Dimsdale JE. Psychological stress and cardiovascular disease. *J Am Coll Cardiol.* 2008;51(13):1237–1246.
43. Gandhi PG, Rao GH. The spectral analysis of photoplethysmography to evaluate an independent cardiovascular risk factor. *Int J Gen Med*. 2014;7:539–547.
44. Maarek A, Gandhi PG, Gundu P, Rao HR. Identifying autonomic neuropathy and endothelial dysfunction in type II diabetic patients. *EC Neurology* 2015;2(2):63–78.
45. Action to Control Cardiovascular Risk in Diabetes Study Group. Effects of intensive glucose lowering in type 2 diabetes. *N Engl J Med.* 2008;358(24):2545–2559.
46. Pop-Busui R, Evans GW, Gerstein HC, et al. Effects of cardiac autonomic dysfunction on mortality risk in the Action to Control Cardiovascular Risk in Diabetes (ACCORD) trial. *Diabetes Care.* 2010;33(7):1578–1584.
47. Krebs EE, Carey TS, Weinberger M. Accuracy of the pain numeric rating scale as a screening test in primary care. *J Gen Intern Med.* 2007;22(10):1453–1458.
48. Williamson A, Hoggart B. Pain: A review of three commonly used pain rating scales. *J Clin Nurs*. 2005;14(7):798–804.
49. Jensen MP, McFarland CA. Increasing the reliability and validity of pain intensity measurement in chronic pain patients. *Pain*. 1993;55(2):195–203.
50. Hawker GA, Mian S, Kendzerska T, French M. Measures of adult pain: Visual analog scale for pain (VAS pain), numeric rating scale for pain (NRS Pain), McGill Pain Questionnaire (MPQ), Short-Form McGill Pain Questionnaire (SF-MPQ), Chronic Pain Grade Scale (CPGS), Short Form-36 Bodily Pain Scale (SF-36 BPS), and Measure of Intermittent and Constant Osteoarthritis Pain (ICOAP). *Arthritis Care Res (Hoboken)*. 2011;63(S11):S240–S252.
51. Hellhammer DH, Wüst S, Kudielka BM. Salivary cortisol as a biomarker in stress research. *Psychoneuroendocrinology.* 2009;34(2):163–171.
52. Porges SW. Vagal tone: A physiologic marker of stress vulnerability. *Pediatrics.* 1992;90(3[pt2]):498–504.
53. Kuo LE, Czarnecka M, Kitlinska JB, Tilan JU, Kvetnanský R, Zukowska Z. Chronic stress, combined with a high-fat/high-sugar diet, shifts sympathetic signaling toward neuropeptide Y and leads to obesity and the metabolic syndrome. *Ann N Y Acad Sci*. 2008;1148:232–237.
54. Molina PE. Neurobiology of the stress response contribution of the sympathetic nervous system to the neuroimmune axis in traumatic injury. *Shock.* 2005;24(1):3–10.
55. Ravits JM. AAEM minimonograph #48: Autonomic nervous system testing. *Muscle Nerve.* 1997;20(8):919–937.

Address correspondence to:
Kelly Armstrong, OTR/L, SIPT, MPP
216 Baracoa Court
St. Augustine, FL 32086

E-mail: k.armstrongot@gmail.com