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Evaluating the use of gas discharge visualization to measure massage therapy outcomes

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Abstract

Background—The purpose of this study was to evaluate the short-term effects of massage therapy using gas discharge visualization (GDV), a computerized biophysical electrophoton capture (EPC), in tandem with traditional self-report measures to evaluate the use of GDV measurement to assess the bioenergetic whole-person effects of massage therapy.

Methods—This study used a single treatment group, pre–post-repeated measures design with a sample of 23 healthy adults. This study utilized a single 50-min full-body relaxation massage with participants. GDV measurement method, an EPC, and traditional paper-based measures evaluating pain, stress, muscle tension, and well-being were used to assess intervention outcomes.

Results—Significant differences were found between pre- and post-measures of well-being, pain, stress, muscle tension, and GDV parameters. Pearson correlations indicate the GDV measure is correlated with pain and stress, variables that impact the whole person.

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Author contributions

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Conclusions—This study demonstrates that GDV parameters may be used to indicate significant bioenergetic change from pre- to post-massage. Findings warrant further investigation with a larger diverse sample size and control group to further explore GDV as a measure of whole-person bioenergetic effects associated with massage.

Keywords

complementary therapies; massage; outcome measures

Introduction

Massage therapy has gained recognition for having therapeutic effects for individuals, including those with a diverse range of conditions. Throughout the field of massage, practitioners commonly recognize a change that occurs in the person after receiving a massage treatment; often referred to as an “energetic” change. Therapists and clients commonly refer to this therapeutic effect of massage, yet research has yet to capture the essence of this change using traditional outcome measures. There is growing evidence to suggest massage has significant effects on outcomes in diverse populations. The majority of literature on massage therapy focuses on associated outcomes supporting pain and tension reduction [1–11], stress and anxiety reduction [1, 3, 4, 8, 12–15], alleviating depressive symptoms [1, 2, 12, 16, 17], and general well-being/quality of life [3, 4, 10, 14, 18]. Fewer studies have evaluated additional outcomes including immune function [19, 20], blood flow [10], nausea management [3], and quality of sleep [6, 13, 21].

Subjective self-reports are most commonly reported to demonstrate massage outcomes for symptoms related to perceptions of pain, tension, stress, anxiety, and well-being [1, 3–5, 16, 20, 22]. To support the validity of findings, previous research has relied on objective biomarkers to demonstrate effects of massage. Psychological outcome measures have been used to demonstrate changes in cortisol [12, 13, 16, 17, 22], norepinephrine [13], and serotonin levels [16]. Physiological objective measures have focused on impacts on electrocardiogram (EKG) [23] and electroencephalogram (EEG) patterns [15], respiratory rate [4, 22], pulmonary function [22], blood glucose [24], serum insulin and IGF-1 levels [24, 25], natural killer cells [19, 20], white blood cells [26], and neutrophil counts [26]. The reports of these outcome measures provide an indication of the mechanisms of therapeutic massage on individual biosystems (e.g., cardiovascular, immune, etc.); however, little research has adequately demonstrated the whole-person bioenergetic effects (i.e. the person as a whole-complex system) of massage therapy that is commonly seen in practice.

This research was designed to evaluate the bioenergetic effects of massage therapy in a healthy population using the gas discharge visualization (GDV) device, an electrophoton capture (EPC) measure that theoretically measures the biophoton emissions surrounding the finger tips, as an indication of one’s energetic field [27–29]. The GDV device provides a potential computerized biophysical screening of the psychophysiologic state of an individual [29]. The GDV uses modern optics, electronics, and computer processing for analyzing photon emission stimulated by a pulsed electromagnetic field [29]. Theoretically, GDV imaging and analysis process measures quantify the biophoton emissions surrounding the

finger tips [29], such that energy photons are emitted from the corona discharge formed as a result of the ionization of air molecules surrounding the fingertip (see Figure 1). Theoretically, it is these energy photons which cause the resultant image, and as such represent the individual's bioenergetic field.

A recent review of research suggests the GDV device can be used for evaluating the impact of various treatment procedures, suggesting numerous correlations between GDV parameters and patients' states post-treatment [29]. While many outcome measures focus on a single biological system, GDV focuses on the overall bioenergetic evaluation of the state of the whole person as a single complex system.

In an attempt to find innovative ways to explore the impact of massage therapy, the goal of this study is to examine if the GDV device provides a sensitive bioenergetic measure of change pre–post-massage treatment; and if the GDV device correlates with traditional self-report measures that represent the biological, psychological, and emotional aspects of an individual. The objectives of this study were to (1) evaluate the physical (pain and tension), psychological (stress) and emotional effects (well-being) of massage therapy using traditional self-report measures; (2) evaluate the use of the GDV electro-photographic device to assess the bioenergetic whole-person effects of massage therapy; and (3) determine the correlation of GDV parameters with traditional self-report outcome measures. The hypotheses for this study were (H1) self-report measures will indicate improvement in physical (pain and tension), psychological (stress), and emotional well-being using traditional self-report measures; and (H2) GDV electrophotography device will effectively assess the bioenergetic whole-person effects of massage therapy. The exploratory research question for this study was (RQ1) What GDV parameters will be correlated with traditional self-report outcome measures?

Providing data about the use of the GDV device to measure basic Swedish massage outcomes in the general population will provide a foundation of knowledge to inform the future evaluation of the potential use of GDV measurement in patient populations and specialized massage and bodywork modalities.

Materials and methods

This study used a single treatment group, pre–post-repeated measures design with a sample of healthy adults. This within-sample design was selected to minimize confounding influences and measure change throughout the protocol process to assess use of traditional paper-based self-report measures and use of the GDV device to measure the effects of massage. The study was approved by the University of Arizona Institutional Review Board, Project No. 09-0089-01 (Evaluating the Use of Electro-Photography for Measuring Whole Person Changes Associated with Massage Therapy).

Recruitment

Recruitment was completed through use of posters displayed at a university campus. Interested participants called the researcher to schedule a single visit to participate in the study. The participant provided written informed consent. Verbal explanations were provided

if the participant did not understand any part of the consent form. All participants were voluntary and treated according to the ethical standards of the American Psychological Association code of conduct [30].

Sample

Twenty-three healthy volunteer participants were recruited to receive a single massage therapy treatment. Inclusion criteria were adults aged 18 and older, with no current health conditions to contraindicate massage treatment. Participant exclusion criteria were pregnancy; history of seizures, epilepsy, anaphylactic shock, heart conditions, deep vein thrombosis; asthma; severe allergies; current cancer tumors or lymphoma; any sort of metal or electrical implant; hemophilia; damaged blood vessels; or weakened bones. Self-reports were used to determine participant eligibility.

Massage therapists

Four massage therapists licensed in the state of Arizona, with five or more years of professional experience, provided massage therapy treatments to participants. Each therapist was provided with a study protocol training session before participating in the study. Therapists were instructed to follow a semistructured treatment protocol to ensure consistency across the intervention.

Massage therapy treatment

Massage therapy treatments included a 50-min full body relaxation massage. Using a Swedish massage technique, a commonly used modality, the treatment began with the participant in the prone position and turning to the supine position halfway through the massage treatment. The massage protocol did not include massaging the hands to avoid soiling the hands, which could potentially contaminate data collection with the GDV device.

Participant measures

The participants provided information on gender, age, race, education, comfort receiving massage, and how often they received massage. These measures were treated as independent variables in this project.

Self-report-dependent measures included a series of standardized single-item measures to assess a range of physical and psychological aspects of health and well-being: (1) Visual Analogue Scales/Numeric Rating Scale - single-item visual analogue scales using a numeric rating scale (0–5, with 0 indicating no pain) for pain, muscle tension, and stress [31–33]; and the (2) Arizona Integrative Outcomes Scale (AIOS)-(0–5; 0=worst you have ever been) a single item visual analogue assessment of overall well-being [34], along with a modified version to assess change in participant well-being pre- and post-massage treatment. AIOS which uses a continuous scale, measures overall well-being; we also measured physical, mental, emotional, social, and spiritual well-being [35].

The GDV was also used as a dependent measure in this study. The GDV device is an EPC measurement that produces a computerized biophysical measure screening of one's psychophysiologic state and functional activity [27–29]. Theoretically, this complex imaging

process is based on the concept of a meridian system, commonly used to explain and predict outcomes associated with traditional mind–body interventions [36]. The meridian system describes the pathways of energy or signal flow that corresponds to the high electrical conductance points on the body surface [36]. The meridian system theory has developed over many years, and explains observations in complementary and alternative modalities such as qigong, yoga, and acupuncture, as well as predicts results of conventional therapies [36]. The meridian system theory is accepted as acupuncture nomenclature by the World Health Organization [37].

Theoretically, images produced by the GDV device are derived from the emission of biophotons surrounding the fingertip that result from the energy pathways through the meridians. This electron movement results in collision and ionization of the gas molecules surrounding the finger [27–29]. To collect the GDV data, each fingertip from both hands is placed on a dielectric plate and a 10 μA signal (the pulse duration is 1 ms – high voltage; high frequency; low current) is passed through the fingertip – producing a "tingling effect." Essentially, the image is capturing the displacement of gas particles in the chamber beneath the charged fingertip. There is no known risk associated with the taking of GDV measurements [27, 29].

The GDV device captures the emissions as data that is stored as digitized images, which typically appear as images of branch-like patterns surrounding the fingertip. The GDV software analyzes the density and biophoton discharge to produce data for statistical analysis. The GDV device also produces quantitative data that is analyzed using algorithms based on the meridian system; this produces images that represent a measure of the individual's bioenergetic field. The GDV image is influenced by the nervous-humoral status of all organs and systems. The GDV device includes specialized software that registers these readings into parameters that provide indicators of an individual's well-being [29, 38].

The GDV screening output theoretically represents the energy flow of the meridian lines, and is derived from four front projection subscales, including the area, symmetry, entropy, and form coefficient, which are resultant from 12 right [6] and left [6] projection subscales, including area; entropy; form coefficient; integral area; root mean square (RMS) of integral area; and integral entropy. These are the subscales of what is commonly referred to as the right and left JS Integer scores which are the basis for the GDV images. The "front projection" subscales inform the frontal GDV image and reflecting the measure of symmetry and area of energy flow. Likewise, the "right" subscales inform the right side GDV image, and the "left" subscales inform the left side image – these images represent energy flow indicating the balance of meridians. Notably, a "symmetry" value is quantified as an indication of the GDV images, representing a quantifiable value of the balance depicted in the GDV imagery. As with other previous studies, in this research the GDV images represent the level of balance of energy flow of the meridians for each participant before and after their massage treatment. In general, GDV measures are not very well defined regarding their meaning; perhaps this study represents an initial attempt to understand what correlations with more commonly defined outcomes (e.g. pain, stress, tension, well-being) mean.

Data collection

Once consented, self-report measures were completed and then the participant provided GDV device images of each fingertip from both hands, starting with the thumb of the right hand to the pinky and then the left hand from thumb to pinky finger. After the GDV images were taken, the self-report measures were immediately completed a second time. Each participant then received a brief consultation with a massage therapist; after the consultation each participant received a 50-min massage. After the massage, each participant provided self-reported data a third time. Then, the GDV images were taken a second time. Finally, each participant provided self-reported data one last time. In total, each participant provided responses to the wellness and pain, stress, and tension scales four times (see Figure 2).

Statistical analysis

Descriptive statistics were completed on all variables. All outcome measures were considered continuous in nature and normally distributed. To test H1 and evaluate pre- and post-massage on self-report measures, a within-subject repeated measure of F-test statistical analysis was completed. This repeated measure analysis allows the authors to determine if collecting GDV data had any impact on the self-report measure. To test H2 and examine GDV differences, paired t-tests were calculated. Statistical significance was set a priori at $p < 0.05$.

To explore RQ1 and assess the relationship between self-report and GDV measures, Pearson correlation coefficients were calculated. Scores for both sets of variables were converted to change scores (post minus pre), and then the correlation coefficients were calculated for each change in GDV and change in self-report pair (between time points 2 and 3). Due to the small sample size of this pilot study and the exploratory nature of this analysis, statistical significance for correlation coefficients was expanded from the a priori level of $p < 0.05$ to $p < 0.10$ and results are presented as exploratory rather than hypothesis confirming or rejecting.

The data analysis for this paper used SPSS® software, Version 19 (IBM SPSS Statistics, v. 19, Chicago, IL).

Results

There were 23 participants in the study. All participants had previously received a massage and reported being comfortable receiving massage therapy. Demographic data are provided in Table 1.

No significant differences existed between self-report data collected before and after each GDV measurement (time 1 vs. 2; time 3 vs. time 4), indicating no effects resulted from collecting the GDV measure itself (see Table 2).

H1: Self-report measures will indicate improvement in physical (pain and tension), psychological (stress), and emotional well-being using traditional self-report measures.

Significant differences were found between pre- and post-massage measures (time 2 vs. time 3) for pain, stress, and muscle tension. Significant differences were also found in all AIOS measures pre- and post-massage (time 2 vs. time 3) (see Figures 3 and 4).

H2: GDV electrophotography device will effectively assess the bioenergetic whole-person effects of massage therapy.

Paired t-test analyses of GDV measures suggested significant changes from pre- to post-massage measures for front projection area, symmetry, entropy, and form coefficient; right projection area, projection entropy, projection form coefficient, integral area, and RMS of integral area; and the left projection area, projection form coefficient, integral area, and integral entropy. There were no significant differences found between pre- and post-measures for right integral entropy, left projection entropy, or left RMS of integral area. Minimum and maximum values, pre- post means, standard deviations and p-values are presented in Table 3.

RQ1: What GDV parameters will be correlated with traditional self-report outcome measures?

To conduct this exploratory analysis we examined the Pearson correlation matrix relating all 16 GDV parameters to the 9 self-report measures (144 coefficients). Nine correlations were significant at $p < 0.05$ ($r>0.40$), slightly more than were expected by chance. The significant correlations focused in the physically-oriented measures: pain [4], stress [2], tension [2], and the physical subscale of AIOS [1]. Similarly, the significant correlations were clustered in the projection entropy variables [5] and projection form coefficients [3]. When expanding the criterion to $p <0.10$ ($r > 0.36$), the pattern became more striking. At this criterion, the GDV variable left projections entropy had correlated significantly with five out of nine self-report measures.

Figure 5(a) and 5(b) provides before and after GDV images, referenced by the front projection symmetry values, for a typical participant in the study. Notably, front projection symmetry values were significantly different pre- to post-massage. These images suggest qualitative changes in the bioenergetic field around the body are affected from pre- to post-massage. The patterns of change in front projection symmetry pre- and post-massage of each participant, in order by magnitude of change, are illustrated in Figure 6. This figure illustrates the change from pre- to post-massage is not unidirectional, as measured by the GDV.

Discussion

Previous research has demonstrated that massage therapy affects both physiological and psychological outcome measures and provides an indication of the biological systems affected by massage therapy. However, these measures evaluate the effects of massage on different systems in the body in a somewhat fragmented manner when viewed from a complex systems perspective. Practitioners and researchers alike seek innovative ways to understand the energetic whole-person effects of massage therapy commonly seen in practice with clients and patients after receiving massage treatments. This study sought to

investigate the bioenergetic effects of massage in a sample of healthy adults using the GDV device in tandem with traditional self-report paper-based measures to determine if the GDV device can effectively address more global, whole-person outcomes.

This study contributes several findings regarding use of GDV to evaluate whole-person outcomes of massage therapy. First, the protocol of this study was successfully completed with all participants; demonstrating the acceptability of using GDV measurement with healthy participants. All participants were able to complete the GDV measure process without issue. Second, consistent with previous research, data findings supported H1 and H2, suggesting that massage therapy has beneficial effects on well-being, pain, muscle tension, and stress using traditional measures and GDV measurement. Outcomes of the analysis to explore RQ1 indicated significant correlations between the paper-based measures and the GDV measures. Standard deviations for GDV correlations were high; however, this is expected in cases when there is high variation among participants, as in this study sample. The significant correlations between the GDV and self-report measures of pain and stress support the theoretical hypothesis that the GDV device produces a whole-person-oriented psychophysiologic measure that indicates one's bioenergetic field [27–29].

Findings also indicate that the GDV measure of one's bioenergetic field is not unidirectional. These data support the notion of energetic "balance," something that has been hypothesized but not rigorously supported through a biological marker such as GDV in this field of study. This notion of balance as measured by the "symmetry" value change as seen in Figure 6 is a quantifiable representation of the participants' GDV change patterns [example provided in Figure 5(a) and 5(b)]. Generally speaking, some individuals may need to relax during a massage, while others experience rejuvenation; and others may come in a balanced state, and thus experience little change as measured by the GDV. This observation converges with observations made by massage therapists in practice with healthy clients and those with health conditions. This variability in valence of change in symmetry suggests an individualized bioenergetic treatment effect from massage therapy. The potential clinical relevance of this observation is that massage therapy can promote bioenergetic balance, resulting in person-specific treatment effects. These data warrant more investigation that focuses on individualized participant data analysis to understand and explore individualized treatment effects.

While the study is small, it provides several results that can inform future research. GDV subscale measures are correlated with traditional self-report measures of pain and stress; and the GDV is sensitive to changes pre- and post-massage. Outcomes of this early phase research indicate the GDV electrophotographic imaging process is an acceptable approach for collecting data in the general population, and may also be acceptable for use in patient populations. The GDV's potential to measure whole-person bioenergetic outcomes may also have implications for other complementary and alternative modalities, such as acupuncture, acupressure, meditation, yoga, etc. Future validation of this alternative measure of effectiveness could also be added with other accepted physiological measure protocols, such as electroencephalography.

In summary, findings of this study confirm previous research, suggesting massage is an effective treatment to immediately reduce pain, stress, tension, and increase physical and mental well-being in the general population. Findings indicate the GDV device may hold the potential for demonstrating the complex system bioenergetic effects associated with receiving massage. Using healthy individuals with varying levels of physical, mental, and emotional wellness as a sample with a minimal dosage of Swedish massage provides a preliminary demonstration of the sensitivity and feasibility of using the GDV device. These data also provide a preliminary indication the GDV devise may also be appropriate to use with diverse populations, such as individuals with health conditions, regardless of technique and dosage. One might hypothesize individuals reporting higher levels of symptomology (i.e. pain, stress, tension, anxiety, etc.) may have more significant changes in their bioenergetic levels, from pre- to post-treatment, as measured by the GDV device.

However, study findings should be interpreted with acknowledgment of study limitations. First, this pilot study relied on a small convenience sample of health individuals with limited diversity, and no comparison group. Measurements of GDV were taken only pre- and post-massage. Second, biases in self-reports could exist due to expectancy or social desirability effects, however changes in the objective GDV measure indicate this is not the case. Future research should include larger sample sizes and control groups to evaluate the GDV device as an instrument for evaluating the effects of massage therapy, and should include patient samples seeking massage for the alleviation of health problems. Without additional data on patient samples, it is impossible to know whether such samples would show more or less variability in direction of GDV change. Larger sample sizes would allow for more robust complex multivariate statistical analyses and, potentially, a broader generalization of findings. In addition, attention to individualized analysis of data may aid understanding of how individuals respond to massage therapy. Finally, a study that explores multiple measures of effectiveness, including but not limited to GDV, will provide opportunities to compare GDV measurements to other biological measures, beyond those relying on self-report.

Conclusions

Findings from this exploratory study demonstrated the effects of massage therapy using the GDV device and biopsychoemotional self-report measures; and demonstrated how GDV parameters correlate with traditional self-report outcome measures in a healthy sample of participants. Findings suggest the GDV device provides a bioenergetic whole-person-oriented measure, sensitive to outcomes traditionally associated with massage therapy. Consistent with findings from self-report measures, this study shows that GDV parameters may be used to indicate significant change from pre- to post-massage. Findings warrant further investigation with a larger sample size, control group, multiple physiological measures, and diverse populations in regard to health status, to further explore the GDV device as a bioenergetic measure of the effects associated with massage.

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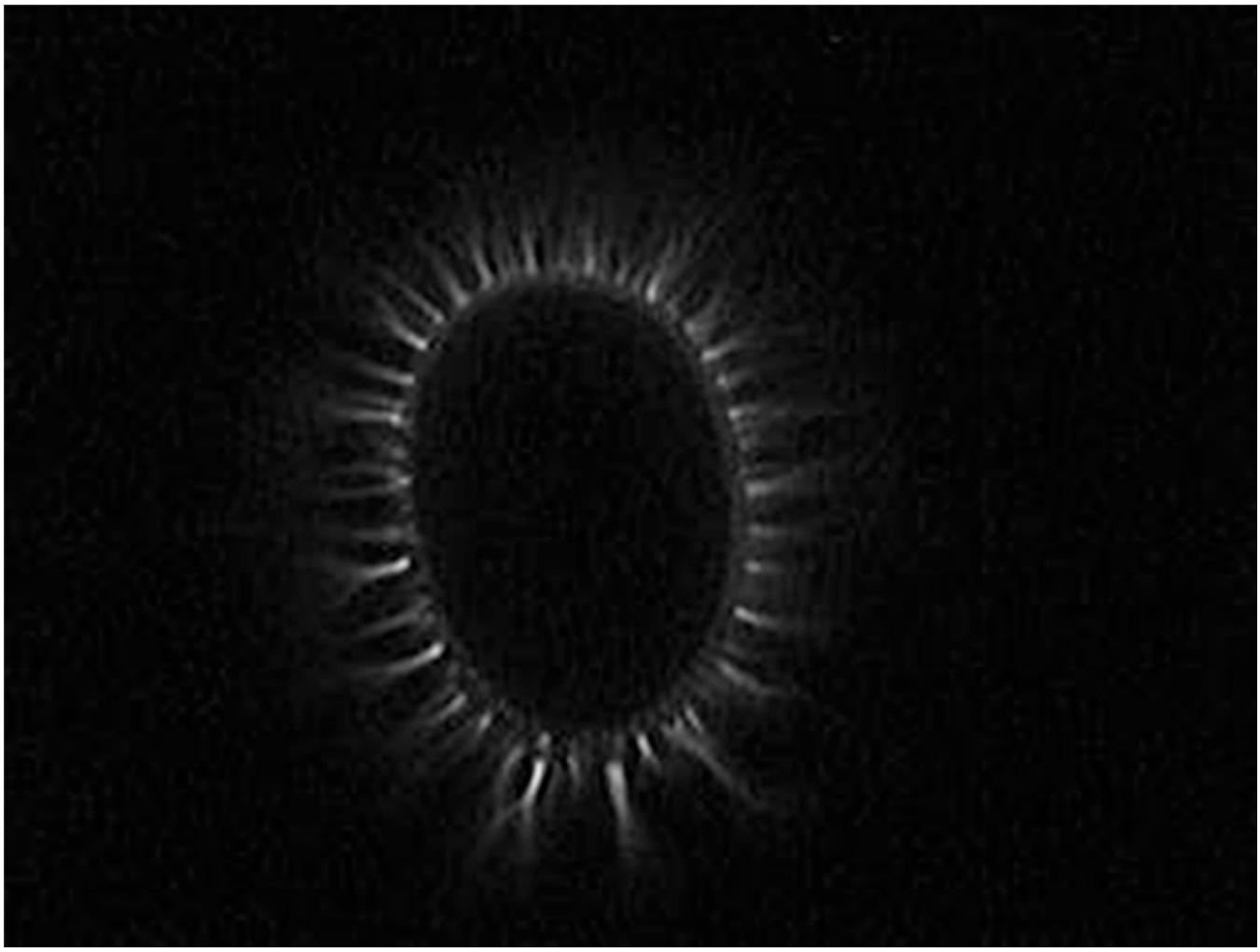

Figure 1.
Example of GDV image of fingertip. GDV image of the ionization of air molecules surrounding the fingertip.

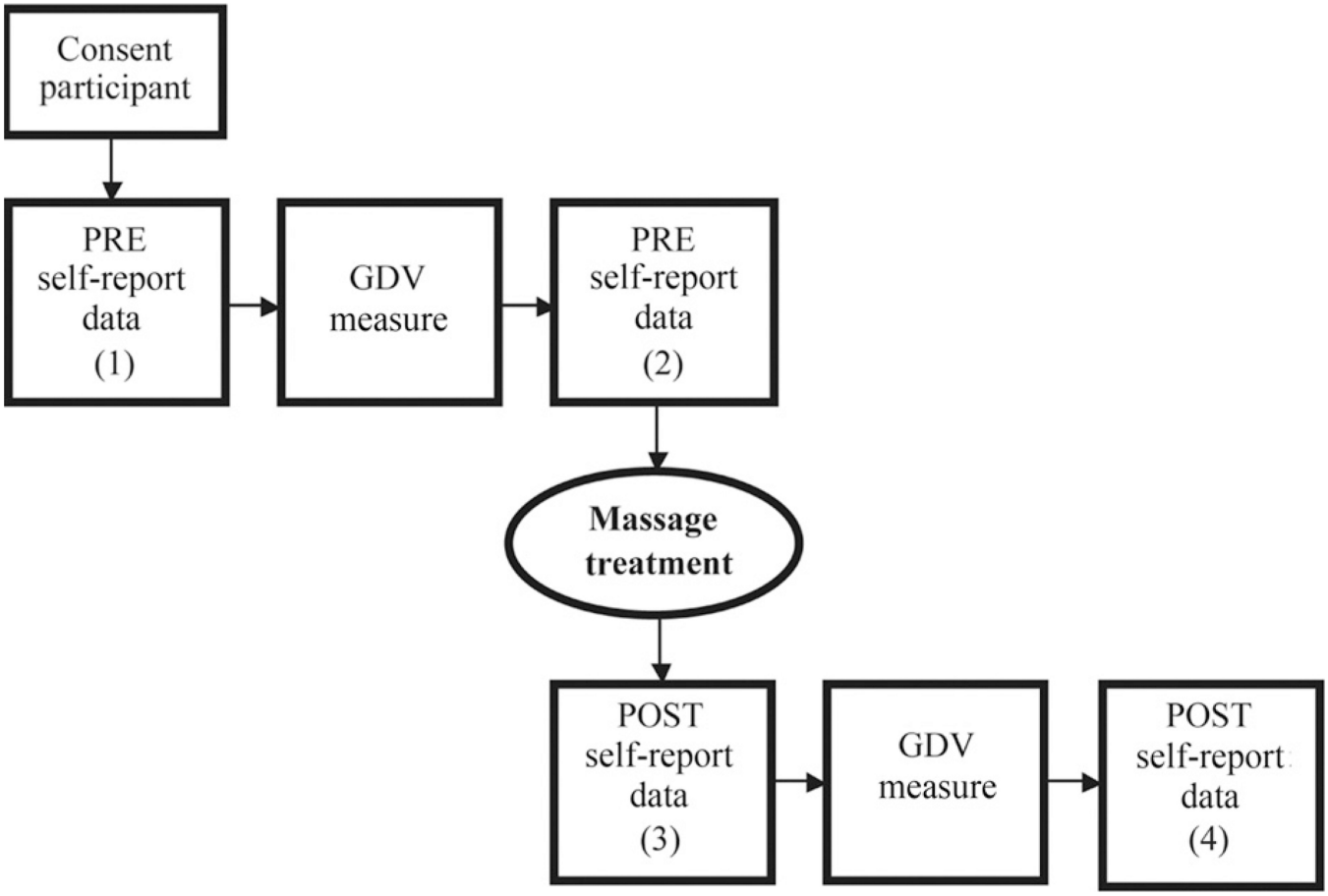

Figure 2.
Study protocol flow chart. Protocol process followed for each study participant.

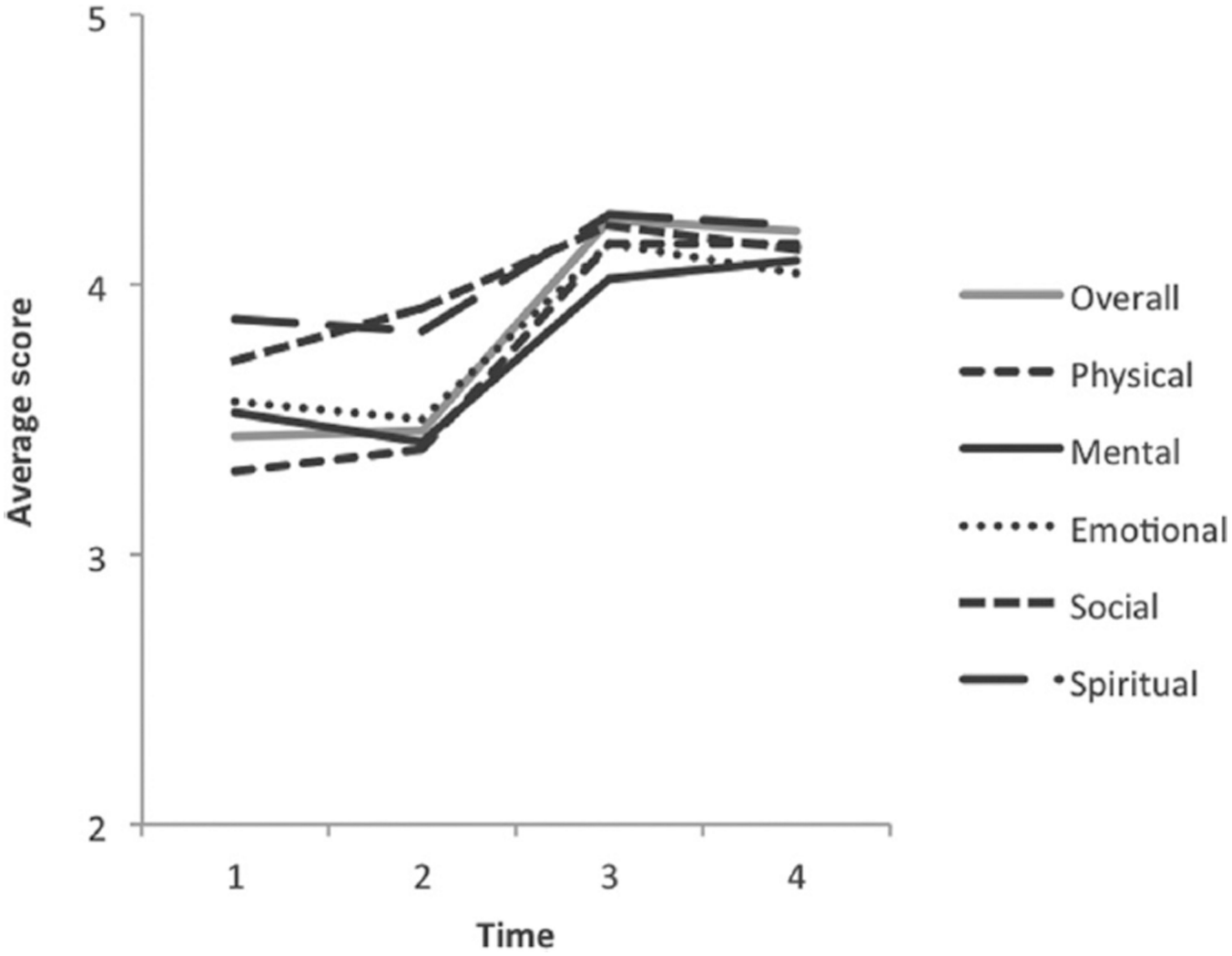

Figure 3.

Within subject repeated measures for self-reports of well-being. Changes in self-reports of well-being across four repeated measures pre- and post-massage session, with the GDV measure occurring between time points 1 and 2 and 3 and 4, and the massage session occurring between time points 2 and 3.

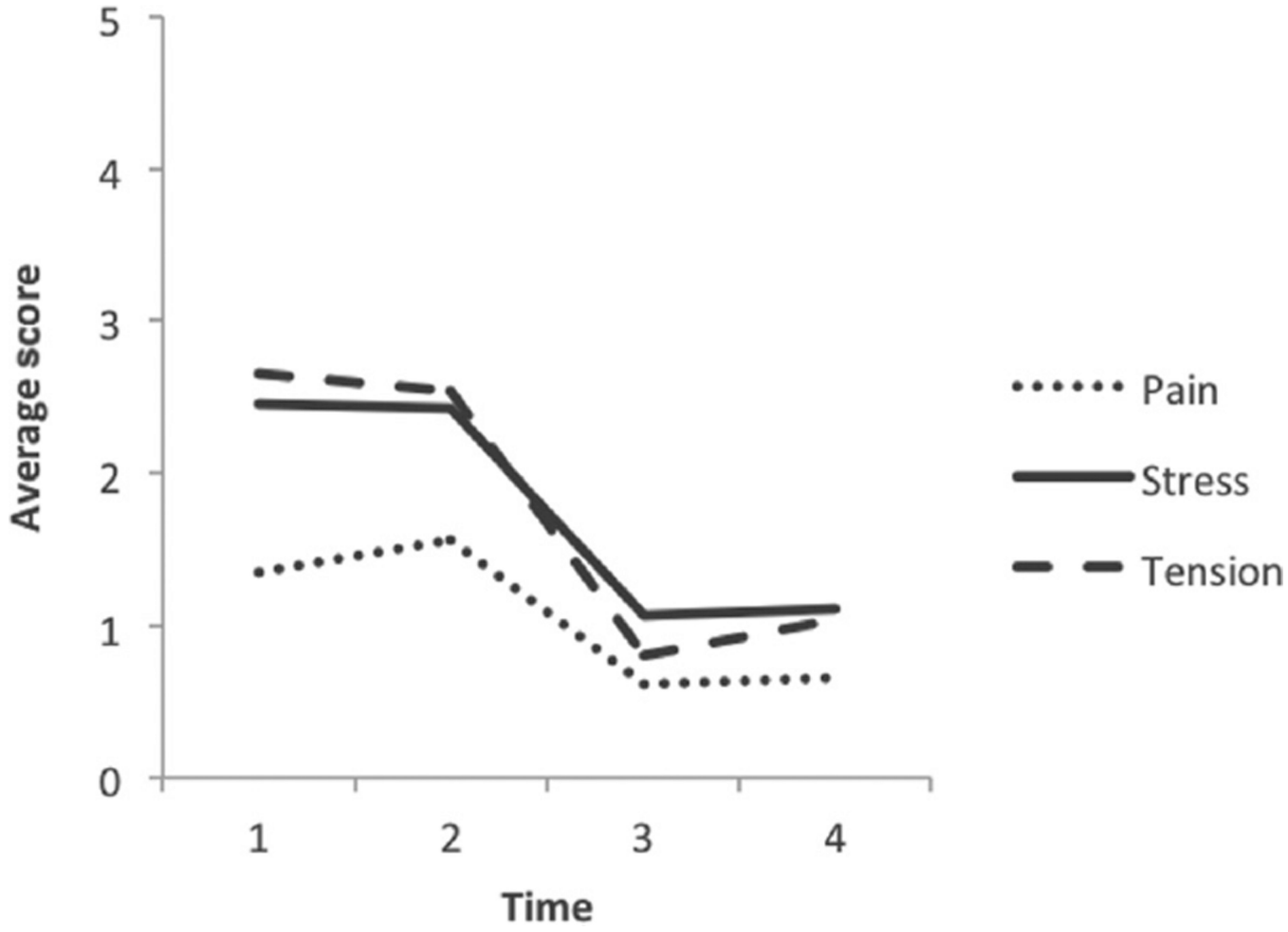

Figure 4.

Within subject repeated measures for self-reports of pain, stress and tension. Changes in self-reports of pain, stress, and tension across four repeated measures pre- and post-massage session, with the GDV measure occurring between time points 1 and 2 and 3 and 4, and the massage session occurring between time points 2 and 3.

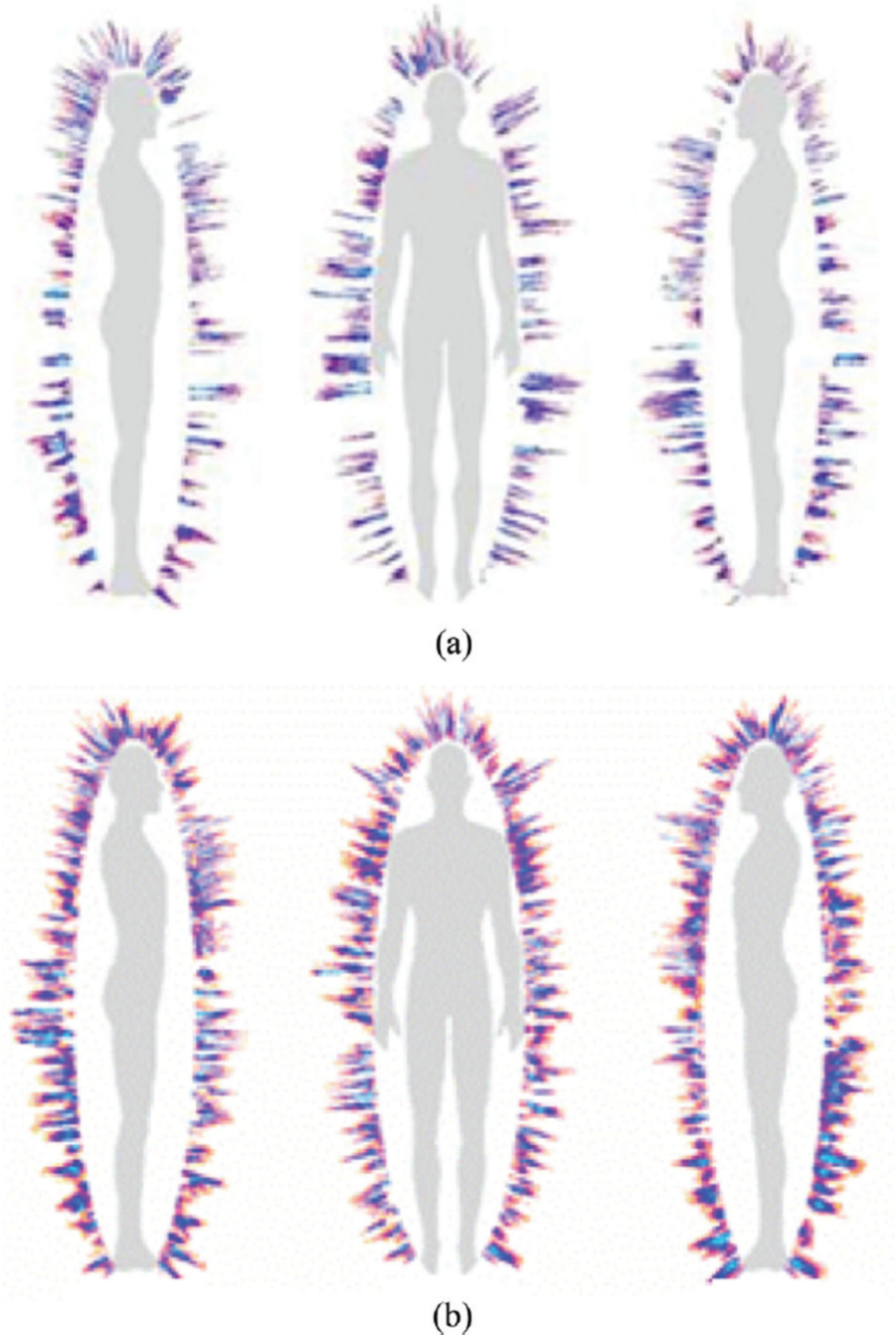

Figure 5.

GDV images before and after massage. (a) Example GDV image before massage. GDV image produced from an algorithm based on GDV subscale measures (as seen in Table 3) for a single participant before his/her massage session. (b) Example GDV image after massage. GDV image produced from an algorithm based on GDV subscale measures (as seen in Table 3) for the same participant represented in (a), after his/her massage session.

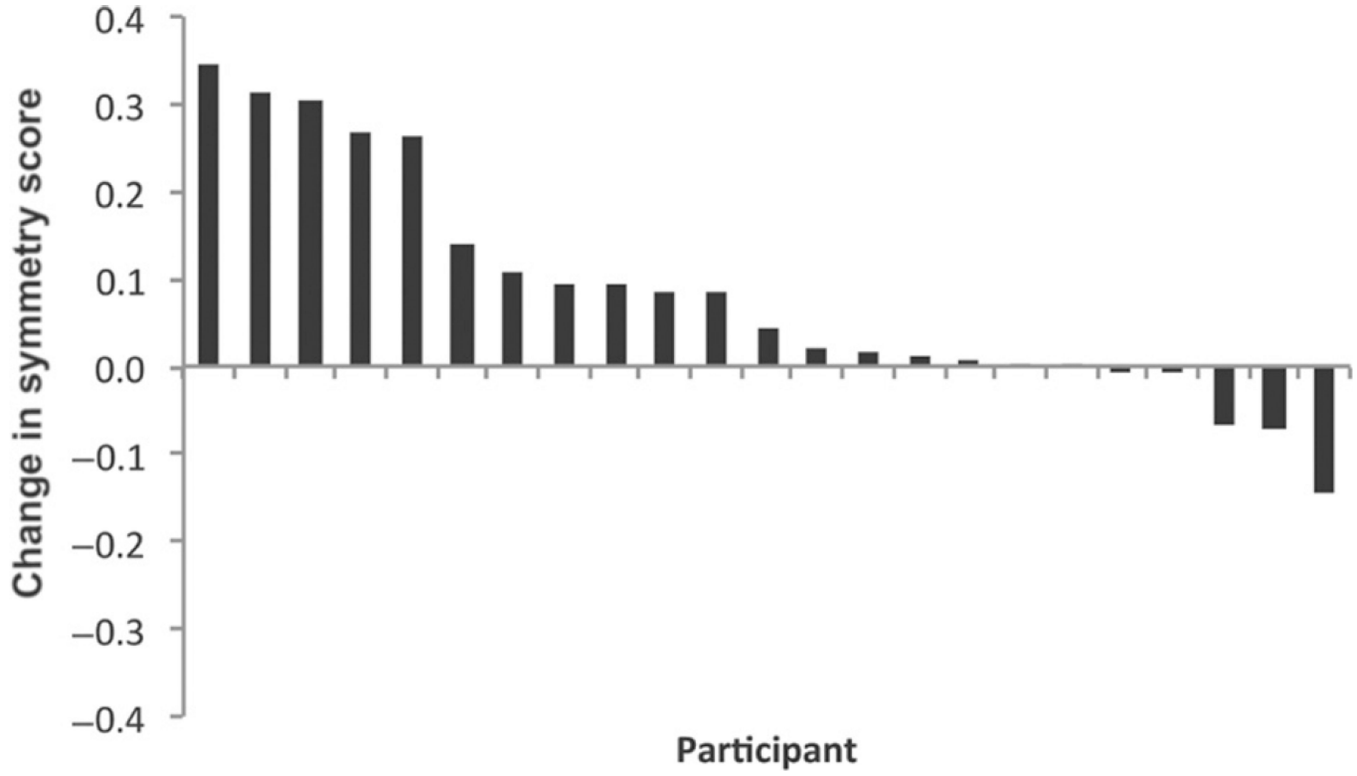

Figure 6.

GDV changes in symmetry from pre- to post-massage. Illustration of individual change patterns from pre- to post-massage for each study participant.

Note: Minimum and maximum values are inclusive of pre- and post-scores for GDV parameters. Each column represents a study participant, inclusive of participants who experienced little to no change pre- to post-massage.

Table 1

Demographical distribution by age, gender, education, and ethnicity.

Demographical variables	
Age	
Average	38.3 (SD = 10.9)
Gender, n (%)	
Male	10 (43.5)
Female	13 (56.5)
Elementary school (lst-6th grade)	–
Middle school (7th-8th grade)	–
High school (9th-12th grade)	–
Some college/vocational school	15 (65.2)
College degree (4-year degree)	5 (21.7)
Graduate degree	3 (13.0)
Ethnicity, n (%)	
African American/Black	1 (4.4)
Asian American	–
Caucasian/White	18 (78.3)
Hispanic/Latino	3 (13.0)
Hawaiian/Pacific Islander	–
Native American, Alaskan Native	–
Other	1 (4.4)

Table 2

Within-subject repeated measure of F-test statistics for outcome measures.

Measure	Time 1	Time 2	1 vs. 2 p	Time 3	2 vs. 3 p	Time 4	3 vs. 4 p
Arizona Integrative Outcomes Scale							
Overall wellness	3.48 (0.90)	3.50 (0.92)	0.665	4.26 (0.65)	<0.001	4.24 (0.80)	0.680
Physical wellness	3.35 (0.86)	3.39 (0.78)	0.406	4.17 (0.56)	<0.001	4.17 (0.51)	1.000
Mental wellness	3.59 (0.95)	3.48 (0.99)	0.396	4.07 (0.73)	0.001	4.13 (0.69)	0.328
Emotional wellness	3.63 (0.94)	3.54 (0.89)	0.503	4.20 (0.72)	0.001	4.09 (0.73)	0.203
Social wellness	3.80 (0.73)	3.98 (0.53)	0.071	4.26 (0.64)	0.023	4.17 (0.68)	0.295
Spiritual wellness	3.87 (0.89)	3.85 (0.83)	0.539	4.28 (0.72)	0.001	4.26 (0.72)	0.492
Pain level	1.39 (1.41)	1.63 (1.42)	0.242	0.61 (0.77)	0.003	0.67 (76)	0.678
Stress level	2.37 (1.54)	2.46 (1.53)	0.680	1.02 (1.06)	<0.001	1.02 (1.37)	0.740
Tension level	2.70 (1.50)	2.57 (1.54)	0.266	0.76 (0.81)	<0.001	1.04 (1.05)	0.045

Lower score is better for pain, stress, and tension scales, higher score is better for AIOS wellness scales.

Table 3

Paired t-test statistics for GDV outcome measure.

GDV measure parameters	Minimum value	Maximum value	Pre-Mean (SD)	Post Mean (SD)	p
Front projection area	2139	17364	8315.26 (3803.86)	9655.13 (3930.89)	0.011
Front projection symmetry	0.27	0.91	0.65 (0.21)	0.74 (0.17)	0.007
Front projection entropy	1.79	4.03	3.43 (0.66)	3.63 (0.42)	0.037
Front projection form coefficient	27.99	184.55	79.37 (39.63)	68.22 (31.84)	0.020
Right projection area	2775	18583	9552.48 (4105.78)	10739.96 (4175.63)	0.018
Right projection entropy	2.07	4.16	3.52 (0.66)	3.76 (0.28)	0.018
Right projection form coefficient	24.53	162.89	68.85 (39.31)	57.34 (23.31)	0.040
Right integral area	−1.56	1.24	0.07 (0.74)	0.31 (0.58)	0.003
Right RMS of integral area	0.14	0.96	0.44 (0.23)	0.36 (0.16)	0.016
Right integral entropy	1.52	2.21	1.96 (0.19)	1.97 (0.15)	0.797
Left projection area	1621	18318	9362.04 (4082.72)	10926.57 (4017.10)	0.009
Left projection entropy	1.73	4.13	3.60 (0.54)	3.71 (0.30)	0.161
Left projection form coefficient	23.93	169.74	65.15 (34.93)	53.36 (23.79)	0.011
Left integral area	−1.88	1.41	0.13 (0.75)	0.39 (0.58)	0.004
Left RMS of integral area	0.12	1.10	0.40 (0.22)	0.33 (0.12)	0.080
Left integral entropy	1.42	2.26	2.04 (0.14)	1.88 (0.18)	0.002

Minimum and maximum values are inclusive of pre- and post-scores for GDV parameters.