

Effects of Therapeutic Calf Massage on Cardiac Autonomic Function in Healthy Volunteers—a Pilot Study

A. V. Siva Kumar, PhD,¹ A. Krishna Sri Lahari, BPT,² K. N. Maruthy, MD,¹ S. K. Kareem, MSc,¹ K. MaheshKumar, PhD^{3*}

¹Dept. of Physiology, Narayana Medical College and Hospital, Nellore, Andhra Pradesh, ²Narayana College of Physiotherapy, Nellore, Andhra Pradesh, ³Dept. of Physiology, Govt. Yoga and Naturopathy Medical College & Hospital, Chennai, Tamilnadu, India

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Background: Calf massage is a therapeutic intervention that improves circulation and relieves us from pain & tightness. The calf massage also improves autonomic performance by modulating the vagal tone of the cardiovascular system. Therefore, the current study was intended to determine therapeutic calf massage on cardio autonomic activity in healthy subjects.

Objective: To assess the immediate effect of a single 20-min session of calf massage on cardiac autonomic modulation through heart rate variability (HRV) measurement.

Materials & Methods: In this study, 26 apparent healthy female participants aged between 18 and 25 years participated. Massage over the calf muscles on both legs for 20 min was performed, and resting cardiovascular parameters and HRV parameters were measured at baseline, immediately after the massage, and during the recovery periods (10 and 30 min after the massage). Data were analyzed using one-way ANOVA followed with post hoc analysis.

Results: Immediately after the massage intervention, heart rate (HR), systolic (SBP), and diastolic (DBP) blood pressure were decreased ($p < .01$), and the reduction was persisted at 10 min and 30 min of the recovery period ($p < .01$). In HRV parameters, the root mean square of successive differences (RMSSD) and high-frequency

normalized unit (HF n.u.) increased, and low frequency (LF n.u.) decreased after the massage, and at the 10 and 30 min of the recovery period.

Conclusion: The present study reports suggest a significant reduction in heart rate and blood pressure after the massage therapy. A drop in sympathetic tone and raise in parasympathetic tone can also attribute to the therapeutic effect.

KEYWORDS: massage; blood pressure; autonomic balance; tissue mechanics

INTRODUCTION

Cardiovascular autonomic neuropathy (CAN) is a disease-related impairment of cardiovascular autonomic function. CAN increases the risk of cardiac arrhythmias, silent myocardial ischemia, and sudden death. Furthermore, patients with a recent myocardial infarction and irregular heart rate variability have a high mortality rate.⁽¹⁾ As a result, it may limit exercise capacity and is linked to an amplified risk of adverse cardiovascular events during exercise. Various pharmacological modalities have been employed to reduce deterioration of cardiac autonomic function which needs to be directed with lifestyle modifications.⁽²⁾ However, immobilized patients may not be able to perform regular exercise to restore their cardiac activity.

One of the simplest techniques of alternate medicine is therapeutic massage that involves applying pressure manually on soft tissues, which can have positive mechanical, physiological, neurological, and psychological benefits.⁽³⁾

One of these scientific treatments is calf massage, a traditional therapeutic technique that targets the calf muscles to enhance circulatory dynamics.⁽⁴⁾ Commonly, massage is given to healthy people before or after physical activity to reduce the risk of injury, enhance performance recovery, and increase soft tissue flexibility.⁽⁵⁾ In addition, it has therapeutic benefits in conditions like muscle spasms, hyperemia, and local analgesia which are significantly reduced when massage is applied to the restricted reactions in the area.^(6,7) The gastrocnemius and soleus muscles in the calf are exceptionally strong muscles that can exert a great deal of force during sprinting and jumping.^(6,8) When participating in short sprints and other sports like tennis and soccer, the calf muscles are vulnerable to rupturing or being damaged.⁽⁹⁾

Previous studies reported that leg tightness and pain in persons who have been wounded can be reduced with calf massage therapy.^(10,11,12) However, very few studies have demonstrated their impact on reduction in heart rate and blood pressure.^(13,14) Therefore, every new report from that field can extend our knowledge of how to control blood pressure safely and efficiently.

There is sparse data available on effect of massage therapy and it is uncertain as to how comprehensive massage therapy affects physiological changes in autonomic balance. Therefore, the current study aimed to determine the therapeutic calf massage on cardiac autonomic function in healthy volunteers.

METHODS

Participants

The Ethics Committee has reviewed and approved this within subject study design protocol by the host institution (REF: IEC -22/JAN/20/19). The protocol was also registered and accepted in the clinical registry of India (CTRI/2020/06/026206). Twenty-six healthy female students from the Narayana Medical College and Hospital who were familiar with the lead investigator (the sample size for the pilot trial was

not determined) were recruited for this study. Each participant received a thorough description of the study before they took part, and they all signed the consent form. Participants were deemed healthy if they had a body mass index (BMI) of less than 25 kg/m², had never received massage therapy, and did not take any medications for any illnesses. All study participants underwent screening and were excluded if they had any history of metabolic disorders, were under medication, had an acute illness, or had any systemic non-communicable diseases. The study was carried out during the year 2020–2021.

Intervention

In this study, massage therapy to calf muscles on both sides was given for 20 min with olive oil as the lubricant during working days between 8:00 a.m. and 10:00 a.m. The gastrocnemius, soleus, and plantaris muscles located in the lower half of the leg were focused on during this study's massage therapy. The massage techniques are a combination of petrissage/kneading (5 min), tapotement/beating/hacking/cupping (2–3 min), and effleurage or long strokes (5 min). These techniques are applied at medium pressure with standard protocol as per the traditional textbook descriptions to apply the massage movements.⁽¹⁵⁾ The subjects were requested to lie prone with both legs exposed for application massage movements.

Outcome Measurement

All participants were invited to the research lab of the Department of Physiology in the host institute. As the study was altered by assessing autonomic activity, the influences that could disturb the autonomic responses were restricted. The basic demographic variables were collected from all participants. The resting cardiovascular parameters including heart rate and blood pressure were obtained after 5 min of rest in a supine position. Later, the subject underwent a lead II ECG for 5 minutes to analyze short-term heart rate variability (HRV).

Blood Pressure (BP) and Heart Rate (HR)

Subjects reported a day before the intervention, and the procedure was explained with demonstrations. Supine brachial SBP, DBP, and HR were obtained using a

semi-automated blood pressure monitor (OMRON, Kyoto, Japan) for better sensitivity and accuracy before the intervention. Two sequential readings were measured, and the mean values were used. After 15 min of supine rest, baseline BP and HR were measured at baseline, immediately after massage therapy in a prone position with minimal clothing. It was repeated in 10 min and 30 min of the recovery period. During the recovery period, subjects were not allowed to move or rise from the bed.

Estimation of Short-Term HRV

For the recording of short-term HRV, a recommendation of the Task Force on HRV was followed. For this purpose, limb lead II ECG was acquired at 8000 samples/sec during supine rest using ECG analog amplifier (AD converter). Raw RR interval data were obtained from the AD converter and were stored in the system separately.⁽¹⁶⁾ HRV analysis was done using Kubios HRV analysis software version 2.2 (Kubios, Kuopio, Finland). In the time domain, the root mean square of successive differences (RMSSD) reflects the vagal tone and is free of respiratory influence.⁽¹⁷⁾ In the frequency domain, the high-frequency (HF) band, also frequently called the respiratory band (0.15 and 0.40 Hz), which reflects the vagal tone, was used in this study.

Statistical Analysis

Datasets were expressed as mean \pm standard deviation (SD). Shapiro-Wilk test was used for the normality assessment of the variables. A repeated measure analysis of variance (ANOVA) was used for within-group (time) changes followed by a post hoc test (Tukey's HSD). *P* values were corrected for Bonferroni by multiplying all pairwise *p* values with each variable's number of comparisons. R statistical software version 3.4.1 (<https://www.r-project.org/>) was used for the analysis.

The study protocol was reviewed and sanctioned by the Institutional Ethics committee of Narayana Medical College & Hospital, Nellore.

RESULTS

All registered participants have completed the study and none of them reported any adverse events. The baseline

characteristics of the study participants are summarized in Table 1.

HR decreased immediately after massage therapy and the reduction was sustained at 10 min and 30 min of the recovery period compared to baseline ($p < .05$). The SBP decreased immediately from 126.87 ± 3.89 mmHg to 116.34 ± 5.89 mmHg after the massage therapy, and sustained around 119.85 ± 5.23 mmHg at 10 min and 123.56 ± 9.56 mmHg at 30 min of the recovery period. Similarly, DBP decreased significantly ($p < .05$) after massage therapy at 10 min and 30 min of the recovery period compared with the baseline (Table 2).

The changes of RMSSD (vagal tone) after the massage, at 10 min and 30 min of recovery period showed an improvement. Same improvement was noted for HF (n.u) immediately after massage, and at the 10 and 30 min of recovery period from baseline. LF power (n.u) significantly reduced immediately after massage and at the 10 (-9.78 ± 3.4) and 30 min (-10.80 ± 4.5) of the recovery period, as shown in Table 2.

DISCUSSION

The current study investigated a single session of therapeutic leg massage on cardiac ANS activity among healthy female volunteers. The findings of our study showed that 20 min of leg massage session effectively increases the HRV and decreases heart rate, SBP, and DBP. Our findings were consistent with previous studies done on calf muscles after aerobic exercise.⁽¹⁸⁾ There are a wide variety of postulated biological mechanisms for reducing cardiac autonomic variables after the intervention of calf massage. A simple drop in heart rate

TABLE 1. Baseline Characteristics of the Study Participants

Demographic Parameters	Mean \pm SD [range]
Age (yrs)	18.80 \pm 2.50 [14.23-19.74]
Body weight (kg)	52.32 \pm 8.80 [44.45-58.81]
Body mass index (kg/m ²)	20.58 \pm 2.98 [18.23-24.56]
Systolic blood pressure (mmHg)	110.7 \pm 5.21 [107.56-119.55]
Diastolic blood pressure (mmHg)	72.88 \pm 6.20 [64.56-79.80]
Resting HR (beats/min)	73.16 \pm 4.80 [68.20-78.80]

TABLE 2. Changes in Resting Cardiovascular and Short-Term HRV Parameters

Variables	Intervention Group				Analysis of Variance Between Groups
	At Baseline	At Immediately After	At 10 min	At 30 min	F value / P value
HR bpm	77.82±4.546	69.85±3.28 ^a	71.56±4.10 ^a	72.60±2.89	4.35/0.03
SBP mmHg	126.87±3.89	116.34±5.89 ^a	119.85±5.23 ^a	123.56±9.56	9.28/0.04
DBP mmHg	82.45±3.99	75.23±4.55 ^a	76.69±2.89 ^a	75.87±4.71 ^a	13.56/0.05
RMSSD (msec)	47.56±10.25	54.69±12.56 ^a	56.87±9.56 ^a	52.56±8.87 ^a	18.25/0.01
HF (n.u)	51.92±4.56	57.89±8.51 ^a	52.69±7.23	56.87±9.36	9.92/0.04
LF (n.u)	49.86±8.73	43.30±8.80 ^a	42.89±7.89 ^a	41.87±6.70 ^a	5.58/0.03

^ap<.05 [post hoc test]; comparison with baseline.

may be reflected as a sign of relaxation even though the precise mechanisms triggering the decline would be indefinite. Therapeutic massage research by Ouchi et al.⁽¹⁷⁾ studied the effect of massage and noted a significant decline in heart rate, perhaps due to the stress-free state of an individual during the intervention and the increase in vagal dominance induced by massage. There is a reciprocal decrease in sympathetic activity on cardiovascular dynamics resulting in a drastic fall in heart rate, and SBP.⁽¹⁹⁾ Massage causes the blood vessels, particularly arterioles, to react by releasing a number of local vasodilators. Other than a fall in sympathetic tone, this could be the possible reason for a decrease in DBP. This was reinforced by Diego and Field⁽¹⁴⁾ whose study had revealed that massage increases the HF component of HRV, reflecting an increase in vagal activities.⁽¹⁴⁾ The calf massage intervention is extremely effective in cumulative HRV and cardiac parasympathetic activity in normal subjects. This is demonstrated in the time domain by a decrease in heart rate and an increase in SDNN, RMSSD, and also pNN50. This was supported by Delaney et al.⁽¹⁹⁾ who demonstrated similar results in response to massage therapy.⁽¹⁹⁾ Furthermore, there was a decrease in the LF, indicating a change from sympathetic activities to parasympathetic activities. Our results are in agreement with Yamamoto et al.⁽²⁰⁾

Numerous neurohumoral mechanisms culminate in the changes in cardio autonomic variables. Regarding the quality of life events, participants conveyed a perception of hypotonia and significant enhancement in mood following calf

massage therapy. These outcomes are most likely due to an increased relaxation response and a whole reduction in the defense-arousal response, and are perhaps arbitrated for parasympathetic activity.^(21,22) The current study has provided new insights into a therapeutic massage on different systematic responses apart from pain relief and muscular spasms. It could be more effective along with allopathic medicine to improve the cardio autonomic response of the patient. There are a few limitations in the current study protocol. The study was a within-subject design that does not have a control group. The sample size was very small, and the recruitment of the participants was not randomized. Therefore, the results cannot be generalized to the desired population.

Implications

The authors would like to extend the study to a large population to assess autonomic balance using dynamic pupillometry which could be more sensitive to reflect autonomic status along with heart rate variability and pulse rate variability.^(23,24)

CONCLUSION

The study's main finding was that the effect of therapeutic calf massage could significantly alter the cardio autonomic parameters and improve the vagal tone. The reduction of cardiovascular variables can be attributed to decreased sympathetic and increased parasympathetic tone.

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CONFLICT OF INTEREST NOTIFICATION

The authors declare there are no conflicts of interest.

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Corresponding author: K. MaheshKumar, Dept. of Physiology, Govt. Yoga and Naturopathy Medical College & Hospital, Chennai, Tamilnadu-600106, India
E-mail: doctor.mahesh1985@gmail.com