EFFECTS OF AUTOMATED ELECTRONIC MASSAGE CHAIRS ON AUTONOMIC CONTROL IN NON-HYPERTENSIVE ADULTS

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in

Kinesiology: Exercise Physiology

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CERTIFICATION OF APPROVAL

I certify that I have read *Effects of Automated Electronic Massage Chairs on Autonomic Control in Non-Hypertensive Adults* by Ty Allan Craig, and that in my opinion this work meets the criteria for approving a thesis submitted in partial fulfillment of the requirement for the degree Master of Science in Kinesiology: Exercise Physiology at San Francisco State University.

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The purpose of this study was to examine the acute effects of automated electronic massage chairs (AEMC) on heart rate (HR), blood pressure (BP), and heart rate variability (HRV) after a single-dose treatment session, compared to a control group. Thirteen participants (age: 46.8 ± 4.6 years) completed two treatment protocols: (1) a 20-min single session of AEMC treatment to the back, neck, and shoulders, and (2) a 20-min single relaxation session control condition. HR, BP and HRV were recorded pre-treatment and at 5, 15, and 30-mins post-treatment for both conditions. HR, BP and HRV data was analyzed using repeated measures MANOVA, and a Bonferroni post hoc test with significance set at $p < 0.05$. EKG was analyzed for HRV for both time and frequency domains. A main effect of time was observed for HR and mean arterial pressure (MAP) in both groups from pre-treatment through 30-min post-treatment ($P < 0.05$); no main effect of condition was observed. None of the measures for HRV were significant and no main effect of condition observed ($P < 0.05$). In conclusion, both the AEMC and control condition protocols elicited similar acute reductions in HR and MAP, and occurred in the absence of changes in autonomic control between conditions.

I certify that the Abstract is a correct representation of the content of this thesis.

_______________________________ 5/10/17
Chair, Thesis Committee Date

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Introduction

High blood pressure, clinically known as hypertension, is one of the most common medical disorders in the United States, and is associated with an increased incidence of all-cause and cardiovascular disease mortality (14). Hypertension affects more than 58 million Americans, has associated costs of more than $70 billion annually, and is considered one of the most important risk factors for development of cardiovascular disease (6, 18, 31). Blood pressure can be affected by gender, smoking, obesity, diabetes, job stress, family history, and other environmental and sociocultural factors, although the exact pathophysiology of hypertension remains unclear (12, 16). Lifestyle modification, medications, and exercise are commonly prescribed for the prevention and treatment of this dangerous chronic disease, though massage therapy has recently become more popular as an alternative method to prevent and control high blood pressure (21).

Massage therapy is described as the manual manipulation of soft tissue by a skilled professional, and has been shown to promote a plethora of health benefits including reductions in pain, stress, depression, fatigue, heart rate, blood pressure, and anxiety (24). One of the oldest forms of treatment in the world, many ancient cultures including the Chinese, Greeks, and Romans used massage as a treatment or medicinal practice (13). Manual massage therapy (MMT) has become increasingly popular, with consumers spending over $6 billion annually in pursuit of the benefits, and is also being used across multiple disciplines including nursing, kinesiology, psychology, and corporate wellness (24, 11).

The autonomic nervous system plays a central role in maintaining cardiovascular homeostasis by monitoring heart rate (HR), blood pressure (BP), blood volume, and receptor signals. Autonomic nervous system activity can be measured via a variety of techniques including heart rate variability (HRV), which is an index of the beat-to-beat fluctuations in HR. Low HRV can be an indicator of hypertension and increased risk of cardiovascular disease, while high HRV is a predictor of better long-term health outcomes (1, 20). Chronically elevated sympathetic nervous sytem activity coupled with decreasing arterial baroreflex sensitivity increases BP, causing hypertension (15). There is a growing body of evidence that suggests MMT has the ability to decrease sympathetic activity, thereby lowering HR and BP (3, 23, 24). Delaney et al. conducted a study in which one session of 20-minutes of trigger point massage therapy to the head, neck and shoulders increased HRV, and reduced HR and BP (9). The commonly proposed mechanism responsible for these changes is the external stimulation of the baroreceptors located in the carotid arteries of the neck (7, 9, 23, 24).

The influence of MMT on HR has continuously shown promise, but has not always offered clear predictions. HR has shown to be reduced directly after a single session of manual massage treatment (8, 9, 24, 26). Multiple-dose treatment protocols have also reported similar result, with reductions in HR post MMT (2, 22). Although these reductions were not sustained, the research shows that the decreases are repeatable. In addition, studies have reported that the decrease in HR was associated with an increase in HRV, which suggests the mechanism behind HR reduction is increasing parasympathetic tone (7, 9).

Similarly, the relationship between MMT and blood pressure has offered positive results, but offers no consistent evidence. A landmark study by Kaye et al. focused solely on BP and HR responses to a single, deep-tissue massage session lasting 45-60-minutes. The study included 263 participants, and resulted in an average SBP reduction of 10.4 mmHg, a DBP reduction of 5.3 mmHg, a mean arterial pressure (MAP) reduction of 7.0 mmHg, and an average HR reduction of 10.8 bpm, respectively (21) More studies have shown similar results and therefore it is commonly suggested that single-treatment MMT has ability to reduce both systolic blood pressure (SBP) and diastolic blood pressure (DBP) after a massage intervention, and is consistent with an increase in parasympathetic activity (5, 17, 23, 24). Furthermore, results have shown that multiple-dose MMT has reduced BP in individuals who already have hypertension (17, 25). Although an ideal duration, frequency, dose, style, and intensity have yet to be determined, the results of these studies and others indicate that MMT can reduce both SBP, DBP, and MAP in hypertensive, and non-hypertensive individuals.

Based on the current literature and research available, MMT has shown promise as an alternative care method. In addition to traditional MMT, the use of automated electronic massage chairs (AEMC) has also gained popularity. These unique devices are electronically controlled, offer a variety of different massage styles, and may be useful in producing similar health related benefits. Furthermore, there are a number of reasons why the use of AEMC's may be beneficial for saving time, money, and other resources. Currently, there is no research that involves the use of AEMC's and to our knowledge, no studies that examine the effect of AEMC's on the cardiovascular system.

For the current study, we monitored HR, BP, and HRV in non-hypertensive individuals before and after a single, 20-minute AEMC intervention to examine any short-term changes in the cardiovascular system. Our hypothesis was that HR and arterial blood pressure would decrease significantly, while HRV would increase significantly versus a control condition. Lastly, we hope the results of this study can serve as a reference model for future studies, and ultimately contribute to the advancement of the fields of health and wellness, medicine, and massage therapy.

Methods

Participants

Participants ($n = 13$) who were apparently healthy adults from the San Francisco Bay Area who were non-hypertensive; males ($n = 8$) and females ($n = 5$) between the ages of 40 and 55 years old (age: 46.8 ± 4.6 years [mean ± SD]) were included (See Table 1). Participants were excluded if they had a history of hypertension (or were on antihypertensive medications), presence of cardiovascular disease, musculoskeletal injuries, skin rashes, or any other medical condition that may preclude them from participation (i.e. claustrophobic or migraine headaches). Additionally, participants were required to be employed, working 5 days/week and spend an average of 4 hours/day at a computer or desk. Participants abstained from alcohol, heavy exercise, or abnormal daily activities 12-hours prior to tests.

Study design

A randomized control trial using a crossover design consisting of a pre-/post-test was implemented, where participants served their own control. On visit 1, participants arrived at the Nextspace co-working office located at 28 2nd street, San Francisco, CA, and were instructed to review and sign the informed consent form. After completing the informed consent, each individual was fitted with the HR and BP monitor and electrocardiogram (EKG), and placed in the AEMC. Each participant underwent a single treatment intervention per day, either the massage condition or the control condition. The participants were then directed to the AEMC where they rested quietly for 5-minutes while baseline HR, BP and EKG measurements were taken. Once the initial rest period was completed, the 20-minute intervention was initiated, and the participant was encouraged to relax as much as possible. After completion of the 20-minute intervention, participants remained in the AEMC for another 30-minutes while post-treatment measurements of HR, BP, and EKG were collected at 5-minutes, 15-minutes, and 30-minutes post-treatment.

Following a minimum of 24 hours later, the participant returned to the same location to receive the alternate experimental condition that was not received on visit 1. The protocol was done in the same manner, beginning by resting quietly in the AEMC for 5-minutes while the baseline HR, BP and EKG measurements were taken. The alternate 20-minute intervention was then administered, and the corresponding post-treatment measurements were taken at the same 5-min, 15-min, and 30-min post-treatment time intervals. The research participant was free to go once both experimental conditions were completed.

Automated electronic massage chair and control condition

During the AEMC condition, the AEMC was preprogrammed to deliver moderate-intensity massage therapy, focused on the back, neck and shoulder areas in a continuous and harmonized manner. The program used was "Unique 2" and incorporated a series of rollers, air bags, and kneading devices. Although the program intensity setting was moderate, different perceptions of strength and intensity exist. Therefore, participants subjectively chose what intensity they thought to be "moderate" on a scale of 1-3 to determine the correct pressure, and the program settings were adjusted accordingly with the participant giving verbal conformation that the pressure was adequate. All measurements were administered with the participant in the "zero-gravity" position, where the individual is seated with the head and upper body supported, the hips and knees flexed at 90 degrees or more, and the entire AEMC reclined so the spine is almost parallel to the floor, and the legs and feet are at the level of the heart.

The control condition was 20-minutes of quiet relaxation while seated in the AEMC and also in the zero-gravity position, but not receiving massage treatment. Participants were encouraged to remain as quiet, still, and calm as possible for the duration of the protocol.

During all conditions, the research environment was a quiet office space with low light and limited noise and distractions. Participants remained fully clothed, removed all personal items prior to beginning, and no phones, music, or other external distractions were allowed during the protocol.

Heart Rate, blood pressure and heart rate variability

The HR and BP were measured using a non-invasive, 2-in-1 automated blood pressure cuff and heart rate monitor (Omron HEM-7120). Measurements were collected at baseline during the initial rest period, 5-min post-treatment, and 15-min post-treatment and 30-min post-treatment. Each measurement was taken once, in the last minute of the each measurement interval. BP was recorded as systolic (SBP) and diastolic pressure (DBP), and mean arterial pressure (MAP) was further calculated by the equation: $MAP = DBP + 0.33(SBP - DBP)$.

HRV was obtained by analyzing the continuously recorded 3-lead EKG (collected at 1000 Hz) connected to a Biopac MP150 data acquisition system (BIOPAC Systems Inc., Goleta, CA). Each EKG was scanned for ectopic beats, which if found, were removed prior to analysis. The RR intervals from the EKG were exported as a text file, which was imported into specialized software (Kubios, version 2.2, Biomedical Signal Analysis Group, Department of Applied Physics, University of Kuopio, Finland). HRV was reported in the time domain as the percentage of successive RR intervals differing by >50% (pNN50). Spectral indices were reported as total (TP), low-(LF), and high-frequency power (HF). Furthermore, LF/HF was reported as a measure of autonomic balance. HRV measurements were reported at baseline, 5-min post-treatment, 15-min post-treatment, and 30-min post-treatment to assess autonomic control.

Statistical analysis

IBM SPSS version 23.0 was used for all analyses. The Shapiro-Wilk test was used to check normality and the data that was not normally distributed was natural log (ln) transformed.

A 2 x 4 repeated measures MANOVA using a Bonferroni adjustment was conducted to examine main and interaction effects of time and condition for the variables, HRV pre-treatment, 5-min post-treatment, 15-min post-treatment, and 30-min post-treatment. Statistical significance was set at $P < 0.05$.

Results

Thirteen non-hypertensive middle-aged (age: 46.8 ± 4.6 years) individuals completed all of the study protocols. Participant characteristics are detailed in Table 1. The EKG of 5 participants could not be analyzed due to artifact/abnormal beats.

Heart rate

There was no significant time*condition interaction or main effect of condition on HR ($P > 0.05$). However, there was a main effect of time on HR (Fig. 1, $P < 0.05$). HR decreased from pre-treatment (MAS: 75.23 ± 16.9 bpm; CON: 74.0 ± 15.4 bpm) to 5-min post-treatment (MAS: 66.69 ± 13.85 bpm; CON: 66.54 ± 12.56 bpm), and through 15-min post-treatment (MAS: 65.54 ± 12.73 bpm; CON: 66.46 ± 13.26 bpm), and 30-min post-treatment (MAS: 65.62 ± 12.22 bpm; CON: 67.08 ± 12.75 bpm). Data for all HR variables pre-treatment, 5-min post-treatment, 15-min post-treatment, and 30-min post-treatment are presented in Table 2.

Blood pressure

A main effect of time was found for SBP, with no differences between the groups (Fig. 3A, $P < 0.05$). Post-hoc analysis showed that all post-treatment periods were lower than baseline. SBP decreased from pre-treatment (MAS: 125.4 ± 14.11 mmHg; CON: 123.3 ± 15.61 mmHg) to 5-min post-treatment (MAS: 113.6 ± 14.62 mmHg; CON: 115.8 ± 12.39 mmHg) and through 15-min post-treatment (MAS: 113.5 ± 14.83 mmHg; CON: 117.7 ± 12.47 mmHg) and 30-min post-treatment (MAS: 114.5 ± 16.06 mmHg; CON: 115.6 ± 13.07 mmHg). In contrast, there were no main effects of time or condition on DBP and no time*condition interaction (Table 2, $P > 0.05$). Although not statistically significant, DBP decreased from pre-treatment (MAS: 77.5 ± 7.39 mmHg; CON: 75.1 ± 10.28 mmHg) to 5-min post-treatment (MAS: 70.5 ± 10.98 mmHg; CON: 71.8 ± 8.96 mmHg) and through 15-min post-treatment (MAS: 72.2 ± 12.33 mmHg; CON: 70.8 ± 7.59 mmHg) and 30-min post-treatment (MAS: 72.9 ± 12.18 mmHg; CON: 72.5 ± 8.25 mmHg).

A main effect of time was found for MAP, which decreased from pre-treatment (MAS: 93.4 ± 2.22 mmHg; CON: 91.2 ± 3.13 mmHg) to 5-min post-treatment (MAS: 84.9 ± 3.30 mmHg; CON: 86.5 ± 2.70 mmHg) and through 15-min post-treatment (MAS: 85.9 ± 3.54 mmHg; CON: 86.5 ± 2.30 mmHg) and 30-min post-treatment (MAS: 86.8 ± 3.69 mmHg; CON: 86.9 ± 2.67 mmHg). In contrast, there was no time*condition interaction or main effect of condition on MAP (Fig. 2, $P > 0.05$). Data for all HR, SBP, DBP, and MAP variables pre-treatment, 5-min post-treatment, 15-min post-treatment, and 30-min post-treatment are presented in Table 2.

Heart rate variability

There was no main effect of time on pNN50 and no effect of condition or time*condition interaction. Additionally, there were no main effects or interactions on any of the variables for the spectral measures (HF, LF, LF/HF, and TP) of HRV during the MAS and CON conditions. Data for all HRV variables pre-treatment, 5-min post-treatment, 15-min post-exercise, and 30-min post-treatment are presented in Table 3.

Table 1. Participant characteristics. Values represent means ± SD.

Characteristic	Value
N	13 (male = 8, female = 5)
Age (years)	46.8 ± 4.6 years)

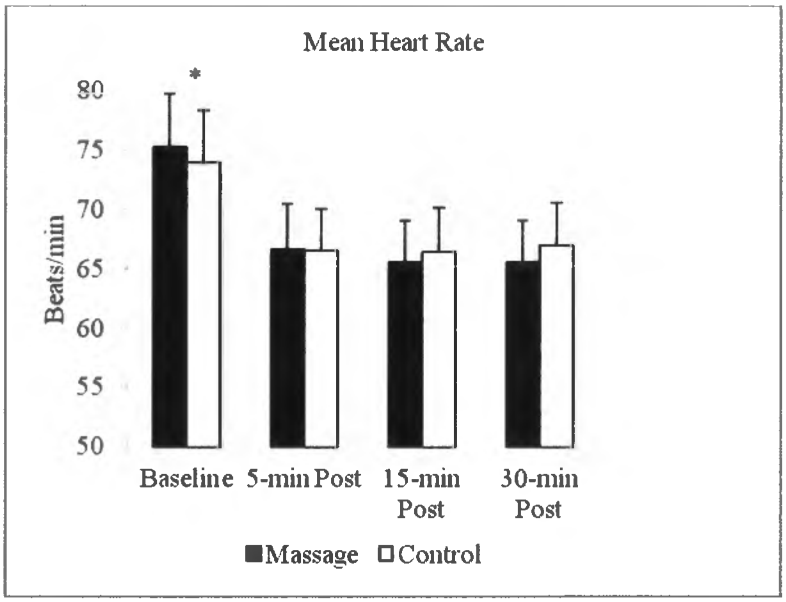

Figure 1. Effects of both MAS and CON treatment protocols on HR pre-treatment, 5-min post-treatment, 15-min post-treatment, and 30-min post-treatment (N=13). Values represent mean ± SEM. *, $P < 0.05$ vs. Baseline.

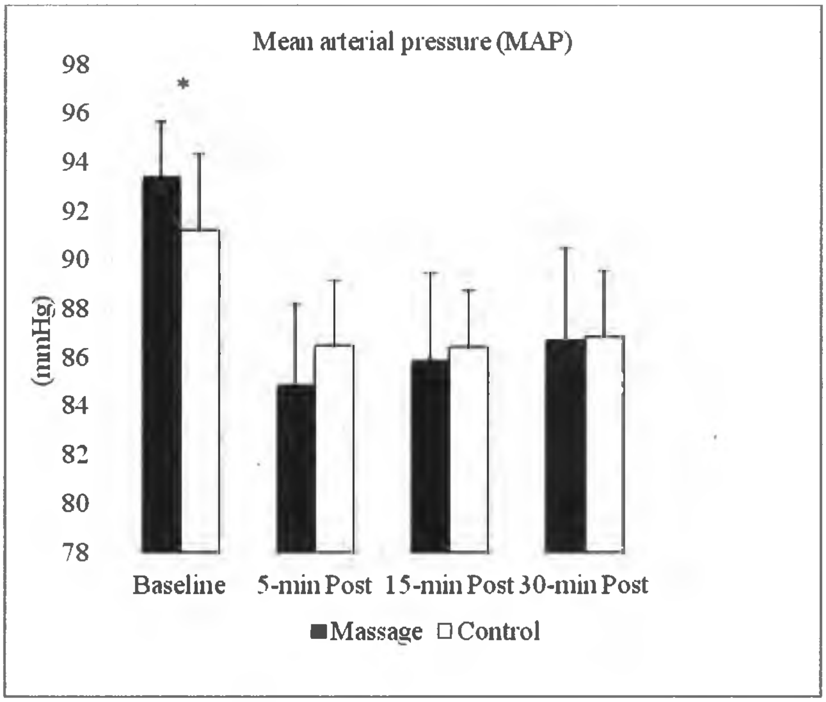

Figure 2. Effects of both MAS and CON treatment protocols on MAP pre-treatment, 5-min post-treatment, 15-min post-treatment, and 30-min post-treatment (N=13). Values represent mean ± SEM. *, main effect of time ($P < 0.05$).

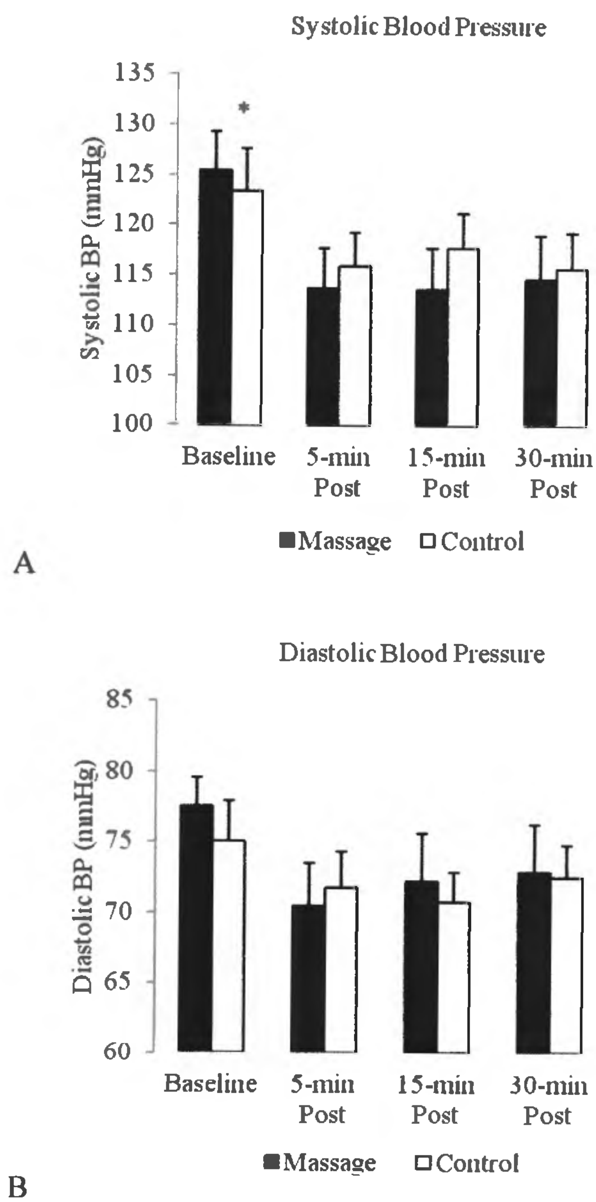

Figure 3. Effects of both MAS and CON treatment protocols on systolic BP (A), and diastolic BP (B) pre-treatment, 5-min post-treatment, 15-min post-treatment, and 30-min post-treatment (N=13). Values represent mean ± SEM. *, main effect of time ($P < 0.05$).

Table 2. Heart rate (HR), systolic blood pressure (SBP), diastolic blood pressure (DBP), and mean arterial pressure (MAP) responses to both MAS and CON treatment protocols (N=13). Measurements were taken at pre-treatment, 5-min post-treatment, 15-min post-treatment. Values represent mean ± SD.

	Pre	5-Min Post	15-Min Post	30-Min Post
Mean HR (bpm)				
Massage	75.23 ± 16.9	66.69 ± 13.85	65.54 ± 12.73	65.62 ± 12.22
Control	74.0 ± 15.4	66.54 ± 12.56	66.46 ± 13.26	67.08 ± 12.75
Mean SBP (mmHg)				
Massage	125.4 ± 14.11	113.6 ± 14.62	113.5 ± 14.83	114.5 ± 16.06
Control	123.3 ± 15.61	115.8 ± 12.39	117.7 ± 12.47	115.6 ± 13.07
Mean DBP (mmHg)				
Massage	77.5 ± 7.39	70.5 ± 10.98	72.2 ± 12.33	72.9 ± 12.18
Control	75.1 ± 10.28	71.8 ± 8.96	70.8 ± 7.59	72.5 ± 8.25
Mean MAP (mmHg)				
Massage	93.44 ± 2.22	84.88 ± 3.30	85.93 ± 3.54	86.78 ± 3.69
Control	91.19 ± 3.13	86.47 ± 2.70	86.45 ± 2.30	86.88 ± 2.67

Table 3. Heart rate variability responses to both MAS and CON treatment protocols. Measurements were taken at pre-treatment, 5-min post-treatment,15-min post-treatment, and 30-min post-treatment (N=8). Values represent mean. *pNN50* (percent of pairs of successive NN intervals that differ by more than 50 ms), *lnLF* low-frequency, *lnHF* high-frequency, ln*Total* (total power), *lnLF/lnHF (*low-frequency/high-frequency ratio). *(ln = Natural log)*

	Pre	5-Min Post	15-Min Post	30-Min Post
pNN50 (%)				
Massage	14.4 ± 10.2	15.66 ± 10.4	15.09 ± 10.8	16.79 ± 8.84
Control	14.85 ± 11.9	13.83 ± 11.2	12.79 ± 9.97	16.75 ± 11.7
lnLF (ms^2)				
Massage	6.37 ± 1.04	6.98 ± 0.89	7.13 ± 1.07	7.3 ± 1.27
Control	7.11 ± 1.18	7.32 ± 0.87	6.57 ± 1.10	7.67 ± 2.36
lnHF (ms^2)				
Massage	6.14 ± 0.83	7.96 ± 2.13	7.74 ± 2.33	6.98 ± 1.64
Control	7.72 ± 2.59	7.51 ± 2.19	6.06 ± 0.65	8.85 ± 3.97
lnTotal (ms^2)				
Massage	7.5 ± 0.98	8.91 ± 1.47	8.9 ± 1.67	8.4 ± 1.28
Control	8.85 ± 1.95	9.01 ± 1.43	7.74 ± 0.91	9.88 ± 3.21
lnLF/lnHF (ms^2)				
Massage	1.04 ± 0.11	0.91 ± 0.17	0.96 ± 0.15	1.06 ± 0.11
Control	0.97 ± 0.19	1.02 ± 0.18	1.08 ± 0.12	0.92 ± 0.19

Discussion

The aim of this study was to observe the acute effects of AEMCs, on HR, BP, and HRV in non-hypertensive adults. Several studies have shown that single session and multi-session manual massage therapy (MMT) can elicit improvements in HR, BP, and autonomic control (9, 24). However, these results have mostly been unpredictable and inconsistent. Furthermore, there is a lot of variation in massage style, intensity, duration, and frequency in most MMT studies, making it difficult to determine proper dosage, practical implications, and clinical relevance. The use of AEMC's allows for more control over the treatment, and provides some consistency by eliminating certain variables, such as the element of human touch. As of now, this is the only study to observe the effects of HR, BP, and autonomic control using AEMC as the treatment modality. Furthermore, this research could be beneficial to others looking to use AEMC treatment protocols to elicit health related benefits.

This study found that both the MAS condition and the CON condition elicit comparable reductions in HR. A main effect of time was observed for HR, without a significant time*condition interaction or condition effects. Post-hoc analysis showed that HR during all post-condition periods was lower than baseline. While this study observed reductions in both MAS and CON conditions, it is unclear whether the reductions are due to the massage treatment itself, or just simply a result of the individual relaxing. However previous studies have observed reductions in HR after a single-session of MMT that were significantly different than the control group (7, 9, 26). There is also speculation that the zero-gravity position allows for less stress on the heart and cardiovascular system because the feet and legs are elevated to the level of the heart, reducing the workload. Although the duration of the HR decrease is unknown and the degree of change is unreliable, this study and others show that the decreases are repeatable (24). Perhaps if the duration of the study were extended to 45-min or 60-min post-treatment, there would be a significant difference in HR between MAS and CON groups. Furthermore, if the sample size was larger, that also might have an effect of the statistical significance. Finally, it would be interesting to see if multiple-sessions of AEMC treatment would have an effect on resting HR, the degree of HR reduction, or the duration of the reduction.

Both protocols elicited similar BP responses during post-treatment measurements. There was a main effect of time on SBP. Post-hoc testing revealed that SBP was lower during all post condition periods. Although there was no significant time*condition interaction, this interaction approached significance ($P = 0.061$). Table 2 shows a slight trend towards higher values in the CON condition, than the MAS condition in all 3 post-treatment measurement intervals. As mentioned earlier, potential reasons for this could be that the participants in both the MAS and CON conditions were more relaxed than they were when they started, as well both conditions using the zero-gravity position. There is also potential that the massage treatment itself was able to influence blood vessel vasodilation, as well as the possibility of modulated nervous system activity.

While the results of the effects of AEMC's on SBP showed some promise, there was no statistical significance when analyzing DBP. There were no significant main effects of time or condition, or a significant interaction. Although DBP was lower than baseline during all post-treatment condition periods, the large amount of variability in DBP likely prevented significant findings.

Mean arterial pressure (MAP) was also calculated, and similar to SBP, there was a main effect of time found but with no significant time*condition interaction or condition effects. This is highly correlated with the reductions found in SBP, as the pre-treatment measurements were higher than all of the post-treatment measurements (Fig. 2, $P < 0.05$).

These findings are not inline with the results of other studies that found BP was reduced significantly using a variety of different MMT protocols (21, 25). Although, the duration, degree of change, and mechanisms remain unclear, prior studies suggest the primary mechanism for changes in BP is the stimulation of the baroreceptors in the carotid arteries, which increases parasympathetic tone resulting in HR and SBP reductions (9). Exercise is a highly recommended treatment strategy that has shown a lot of promise in reducing hypertension and also provides a plethora of other health benefits. Exercise has been shown to be effective in producing post-exercise hypotension in both normotensive and hypertensive individuals (27, 28). There is evidence that acute exercise treatment that elicits significant post-exercise hypotension can predict improvements in resting BP with training (10). If the acute hypotensive effects of AEMC's are shown to elicit similar persistent improvements in resting BP, individuals may have more information and data to make in informed decisions when selecting a treatment strategy for hypertension. Additionally, the focus of our AEMC treatment was to the upper back, neck and shoulders in order to target the baroreceptors as a possible mechanism. Had the AEMC treatment been administered on the lower extremity (feet, legs, and hips), perhaps the degree and/or duration of change would be different.

The results of the HRV measurements were not as promising, and were highly variable. For the time domain variable (pNN50), no main effect of time or significant time*condition interaction was found (Fig. 4, $P < 0.05$). The spectral measures of HRV that were examined (low frequency, high frequency, total power and LF/HF ratio) showed no effects or interactions in either condition (Table 3). These findings did not support our hypothesis that the HR and BP would decrease as a result of an increase in parasympathetic tone. In fact, the post-treatment reductions in SBP with no change in HRV observed in this study may be attributed to peripheral mechanisms with little to no modulations in nervous system outflow. Alterations in the cardiovascular system are prompted by signals from a variety of sources including hormonal, and hemodynamic responses (19, 29, 30). Therefore, there's a possibility that HR and BP may be altered by one of these mechanisms, and is independent of HRV. The discrepancy in the mechanisms eliciting improved HR and BP between populations may be explained by the tendency for HRV to modulate throughout the lifespan. As age increases, cardiac vagal modulation progressively decreases (4). This study population consisted of individuals aged 40-55, making the sample population more inclined to be less sensitive to changes in HRV.

Another possible source for the inconsistent HRV data could be the sample size of only 8 participants. 5 of the original 13 participants had electrocardiogram (EKG) readings that were too poor, and were not reliable enough to use in the final HRV analysis. Perhaps the HRV results could have been more favorable given a larger sample size. Being the researchers first time conducting HRV measurements, the protocol could have been controlled better. Having a razor to remove hair for better electrode connection, and minimizing participant movement during the massage treatment may assist in more readings that were more consistent. Another factor that may be considered is the fact that the HR and BP measurements were taken on one device, while the HRV measurements were taken on a separate device. This could also be why the HRV readings did not correlate with the changes in HR and BP.

Limitations and future studies

There were several limitations associated with this study. First, the sample population was small, and may have limited the statistical significance of the results. Furthermore, the participants were asked to come in during the evening hours, assuming they were done with work. However, this also made the scheduling somewhat irregular, and not having the same exact time for each individual, per condition. This may have affected the measurements due to the variation in time of day. Also, what the participants were doing in between sessions was uncontrolled, and relied upon their honesty. Additionally, the population was very specific and consisted of healthy individuals who may not have shown as much of an effect as someone who was hypertensive or diseased. The testing environment was an open co-working space, and which did have some external distractions that may have altered the measurements. However, the researchers wanted to conduct the experiment in an environment that would be identical to a real-life setting. And most importantly, the limited experience of the researchers could have played a roll in both the execution of the protocol, and the analysis of the results.

Future studies should include a larger sample population, as well as subjective psychological measurements to allow participants to communicate what they felt the largest perceived health benefit is to them. Also, using a protocol that included the lower extremity or the entire body, and not just targeting a specific area. And finally, having more control over the testing environment, and research protocol would also help reduce variations.

Conclusion

While further research is certainly justified, as of now, this is the only study to observe the effects of AEMC's on HR, BP and HRV in non-hypertensive adults. In addition, there is no research using AEMC's for any health related intervention, making this research the first of its kind. That being said, the protocols and methods used in this study are pioneering, and certainly leave room for improvement. There was no difference between conditions according to the data. No time by condition interactions, and no statistically significant data were found. The results did not show any significant results for HRV response to AEMC treatment, and no other significant differences between conditions. Furthermore, there was no interaction between the HR and BP reductions, and the HRV results, suggesting the changes in HR and BP were influenced by other mechanisms. However, there was a main effect of time for HR, SBP, and MAP but with no time*condition interaction. In closing, this study offered some valuable results that will hopefully contribute to the overall body of massage therapy research, but did not find any conclusive evidence that offers any concrete evidence supporting the use of AEMC's. Furthermore, the use of a more controlled protocol and the addition of the subject's psychological response to the massage chair could offer an insight into additional health related benefits.

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Appendix A

Hypertension is, and continues to be, a prevalent chronic disease in the United States, affecting more than 58 million Americans (Chobanian et al. 2003). Considered one of the most important risk factors for cardiovascular disease, high blood pressure can be controlled using a variety of methods. Traditional manual massage, performed by humans, has been shown to elicit a number of positive health benefits (Moyer et al. 2004). Decreased muscle stiffness (Sunshine et al. 1997) lower levels of stress (Moraska et a. 2008), and decreased work on the cardiovascular system (Field et al. 1998) are just a few of the many areas in which massage has shown promise both as an adjunct health treatment and as a preventative care method. Currently, there is no research that sufficiently supports the use of automated electronic massage chairs on any of these health related benefits. Furthermore, there are a number of reasons why the use of automated electronic massage chairs may be beneficial for saving time, money, and other resources. For this study, we will be monitoring heart rate, blood pressure, and heart rate variability in normotensive and prehypertensive individuals before and after one, 20-minute automated electronic massage chair intervention to examine any short-term changes in the cardiovascular system. Our hypothesis is that heart rate and systolic blood pressure will decrease, while heart rate variability will increase versus the control group. To our knowledge, there are no other studies that examine the effect of automated electronic massage chairs on the cardiovascular system, and hopefully this study will yield results that can serve as a reference model for future studies, and ultimately contribute to the advancement of the fields of health, wellness, and massage therapy.

Literature Review

High blood pressure, clinically known as hypertension, is one of the most common medical disorders in the U.S., and is associated with an increased incidence of all-cause and cardiovascular disease mortality (Franklin et al. 2004). Traditional methods for treatment and control of hypertension include prescription medication, and/or lifestyle modifications such as diet and exercise. Recently, alternative methods such as massage have gained popularity and have shown promise as a successful way to control hypertension (Olney et al. 2005).

Hypertension

High blood pressure is associated with elevated anxiety, stress and stress hormones, hostility, depression, and catecholamines. Hypertension is a prevalent chronic disease and is considered one of the most important risk factors for cardiovascular disease (Chobanian et al. 2003). According to the American Heart Association, over 58 million Americans have high blood pressure (Hunt et al. 2005). However, hypertension remains a major public health problem in the United States. Adult hypertension is classified as having a systolic blood pressure (SBP) of over 140 mmHg and/or a diastolic blood pressure (DBP) of over 90 mmHg, or being on antihypertensive medication (ACSM, AHA). A new classification of "prehypertension" has recently been introduced to the public to stress the importance of reducing blood pressure (BP) and preventing hypertension through healthy lifestyle interventions. Prehypertension is classified as having a SBP of 120-139 mmHg and/or a DBP of 80-89 mmHg, while normal BP should be a SBP <120 mmHg and a DBP of <80 mmHg (ACSM, AHA). Table 1 shows a classification of BP for adults over 18 that was produced by the National Heart Lung and Blood institute, and is used by all health and medical professionals (Panel et al. 1998).

Table 1.

Category	Systolic Blood Pressure	Diastolic Blood Pressure
Normal	<120	<80
Pre-hypertension	120-139	80-89
Hypertension-Stage I	140-159	90-99
Hypertension-Stage II	≥160	≥100
Hypertensive Urgency	>180	>120
Hypertensive Emergency	>180	>120 and target organ damage
Adapted from Chobanian, 2003.		

BP increases linearly with age, with SBP continuing to increase throughout adult life, whereas DBP tends to plateau, and even decrease in the later years. Hypertension is more common in males than females at younger ages, but the reverse is true in older individuals. BP may also be affected by gender, smoking, obesity, diabetes, job stress, family history, and other environmental and sociocultural factors (France et al. 1996). Furthermore, studies have shown that patients with hypertension show greater anxiety, stress and depression, more anger and hostility, and more marked cardiovascular reactions to situational stressors (Walton et al. 1995, Ditto et al. 1990). Most importantly, hypertension is associated with an increased incidence of all-cause and cardiovascular mortality including stroke, coronary heart disease, heart failure, peripheral arterial disease, and renal insufficiency (Franklin et al. 2004, Sarnak et al. 2003). Recently, investigators from the Framingham Heart Study reported that participants that were classified as High Normal BP (SBP 130-139 mmHg or DBP 85-89 mmHg) had higher rates of cardiovascular events as compared with those with Optimal levels (SBP <120 mmHg and DBP <80mmHg) (Franklin et al. 1999). Finally, the American College of Sports Medicine's Position Stand on Exercise and Hypertension sites a study that the positive relationship between cardiovascular disease risk and BP, occurs with a BP as low as 115/75 mmHg and doubles for each 20/10 mmHg increase. A person with normal BP at 55 years of age has a 90% lifetime risk of developing hypertension (Vasan et al. 2002).

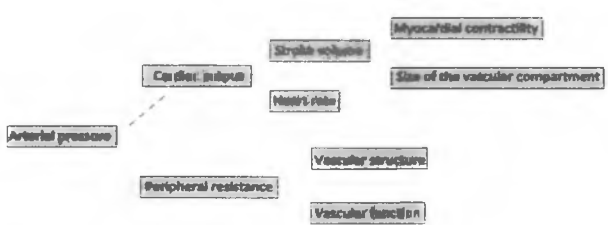
The simple fact is, that if left uncontrolled, hypertension can lead to a myriad of chronic diseases which can severely affect ones overall health and wellbeing. Just as the mechanisms for the cause of essential hypertension vary, so do the treatment methods themselves. Although the first treatment strategy of choice is lifestyle modification such as dietary changes, increasing physical activity, smoking cessation, and reducing body fat, the majority of Americans take medications to control their hypertension; but, not all can or are willing to take prescribed medications. Some forms of medications include beta-blockers, calcium channel blockers, diuretics, ACE inhibitors, and alpha-receptor blockers. Exercise, both aerobic training and resistance training, is also a highly recommended treatment strategy that has shown a lot of promise in reducing hypertension (Williams et al. 2007, ACSM), and also provides a plethora of other health benefits. A single session of aerobic or resistance exercise reduces BP during the recovery period, which is called post-exercise hypotension. Aerobic training is mostly recommended, but resistance training has been shown to be effective in producing post-exercise hypotension in both normotensive (Rezk et al. 2006) and hypertensive (Queiroz et al. 2014) individuals. Although to be clinically relevant, the BP reductions must have a significant magnitude and duration (Kenney et al. 1993). However, recognizing that BP is determined by multiple factors, complementary approaches may be needed to evaluate, treat, and prevent hypertension (Hernandez-Reif et al. 2000).

Mechanisms

Hypertension can be classified as either essential or secondary. Essential hypertension indicates that no specific medical cause can be found to explain a patient's condition. About 90-95% of hypertension is essential hypertension. Secondary hypertension indicates that the high BP is a result of another underlying condition, such as kidney disease or tumors (Oparil et al. 2003). While most mechanisms leading to secondary hypertension are well understood, the pathophysiology of essential hypertension is still a very active area of research with different links to many risk factors, and many theories to consider.

Many factors contribute to the regulation of BP, as BP itself is a product of cardiac output, and total peripheral resistance. Cardiac output and total peripheral resistance are the two determinants of arterial pressure, while total peripheral resistance is determined by functional and anatomical changes in the small arteries and arterioles. Cardiac output is determined by stroke volume and heart rate (HR). The stroke volume is related to the contractility of the heart, and to the size of the vasculature compartment. Figure 1 shows a diagram of the factors affecting arterial pressure.

Figure 1.



Alterations in the cardiovascular system and the autonomic nervous system occur as a result of chronic hypertension. Abnormalities affect specific systems related to the homestasis of BP, and togther they set-up a "vicous cycle" of high BP maintenance that continually stresses the hemodynamic and autonomic responses of cardiovascular system. Such alterations include increased renin-angiotensin system activitiy (Sakata et al. 2002), increased systemic vascular resistance (Ting et al. 1996), and a decrease in endothelial function (Iiyama et al. 1996). The renin-angiotensin system regulates fluid volume and peripheral resistance, while enodthelial dysfunction is an upset balance between vasocontrictors and vasodilators which affects vascular tone. The autonomic nervous system plays a central role in maintaining cardiovascular homeostasis, by monitoring pressure, volume, and receptor signals. Hypertension directly affects the vicous cycle of hypertension by decreasing the arterial baroreflex sensitivity of HR, and increasing sypathetic nervous sytem activity (Grassi et al. 1998). Although they are all involved in the pathophysiology of hypertension, for this particular study, we will be focusing on the autonomic nervous system, specifically, the barorecptors and parasympathetic (vagal) tone.

Massage

Massage therapy, the manual manipulation of soft tissue intended to promote health and well being, is one of the oldest forms of treatment in the world dating back to 2000 B.C. Many ancient cultures including the Chinese, Egyptian, Greeks, and Romans used massage as a treatment or medicinal practice. However, in Western cultures, the association between massage and medicine has been diminished as pharmaceuticals have taken over American medicine (Fritz et al. 2000). Now considered an alternative treatment method, the use of manual massage therapy (MMT) has become increasingly popular, as many people are finding that the associated health benefits are extremely valuable; in particular, the ability to reduce heart rate, blood pressure, and overall cardiac work performed by the heart. In addition, the use of automated electronic massage chairs

(AEMC) has also gained popularity and may be useful in producing similar health related benefits, while also presenting it's own set of advantages.

Interest continues to grow in the United States, as massage therapy is one of the fastest growing areas in the complementary and alternative medicine movement. Visits to massage therapists increased 36% between 1990 and 1997, with consumers now spending between $4 and $6 billion annually in pursuit of the associated health benefits (Eisenberg et al. 1998). The use of MMT also continues to spread across multiple research fields including nursing, kinesiology, and psychology (Moyer et al. 2004). The widespread benefits of MMT such as decreased stress and anxiety, pain reduction, increased circulation, and enhanced relaxation allow for a variety of applications for many different subpopulations. The American Massage Therapy Association (AMTA) has also put out numerous position statements advocating for the scientific and medical research that supports the efficacy of massage therapy (AMTA). One of the strongest characteristics of massage is the ability to use different techniques to adapt to individual needs. Deep-tissue, trigger-point, and sports massage are more aggressive styles and are designed to reach the deep layers of muscle and connective tissue. Swedish massage is considered the most traditional form, and uses compression, kneading and gliding. Thai and Swedish massages are less intense, and focus more on relaxation and increasing circulation (Cambron et al. 2006). With a long list of potential benefits, and an increasing body of positive research to back it up (Field et al. 1998, Moraska et al. 2008, Moyer et al. 2004), MMT continues to grow and show promise as an effective treatment or therapy for a range of health related issues. Furthermore, it would be advantageous for many to expand the field from private practices, into the realm of nursing homes, hospitals, psychological treatment centers, sports performance centers, and workplaces.

Increases in HR, BP, and respiration are all physiological manifestations of the sympathetic nervous system's response to stressful events. Stressful situations in the workplace, for example, can raise HR and BP, which could subsequently contribute to cardiovascular disease. One argument is that MMT may ameliorate these symptoms of stress by promoting parasympathetic activity (Moraska et al. 2008).

Heart Rate

The influence of MMT on HR has continuously shown promise, but has not always offered clear predictions, especially with the limited amount of research available. Two studies were able to report reductions in HR after multiple-dose protocols, done over a period of 10 total sessions, and using pre-post measurements (Anderson et al. 2004, McKechnie et al. 1983). Cowen et al. found that a single 90-minute Swedish massage significantly reduced HR in healthy subjects (Cowen et al. 2006). Another study found that 20-minutes of myofacial trigger-point therapy reduced HR immediately after the session (Delaney et al. 2002). A single-dose massage treatment was also reported to lower HR in examining MMT with a variety of health issues, however these reductions were not sustained following the treatment (Field et al. 1998, Lawler et al. 2006, Okvat et al. 2001). Even though the duration of the HR decrease is limited, the research shows that the decreases are repeatable. In addition, studies have reported that the decrease in HR was associated with an increase in heart rate variability, which suggests the mechanism behind HR reduction is increasing parasympathetic tone (Cottingham et al. 1998, Delaney et al. 2002). Therefore, it is commonly accepted that single applications of MMT reduce HR (Moyer et al. 2004).

Blood Pressure

Similar to the relationship between MMT and HR, there is a limited amount of research examining BP responses to MMT. Also similar, is the fact that the BP measurements that are available, are commonly taken from studies that measured BP as a secondary or tertiary response, and not the primary objective. However, one landmark study by Kaye et al. focused solely on BP and HR responses to one, deep-tissue massage session lasting 45-minutes to 60-minutes. The study included 263 participants, and resulted in an average SBP reduction of 10.4 mm Hg ($p < 0.06$), a DBP reduction of 5.3 mm Hg ($p < 0.04$), a mean arterial pressure reduction of 7.0 mm Hg ($p < 0.47$), and an average heart rate reduction of 10.8 beats per minute ($p < 0.0003$), respectively (Kaye et al. 2008). A study by Aourell et al. that looked specifically at BP responses found that 4 weeks of 2/week 30-minute Swedish massage to the back and neck resulted in minor decreases in blood pressure, possibly due to sympathetic inhibition in normotensive participants (Aourell et al. 2005). A meta-analysis by Moyer et al. found 5 different studies that met their inclusion criteria that examined BP as part of their analysis. The authors concluded that although predictions are not always offered, most commonly MMT is expected to reduce BP, consistent with a parasympathetic response of the ANS (Moyer et al. 2004). A different meta-analysis by Moraska et al. identified 8 more studies that reported single treatment effects of MMT on BP, with 4 of them showing reductions. The same meta-analysis identified 7 studies that reported on changes in BP after multiple treatments or at a long-term follow-up. The results suggest that multiple treatments reduce DBP, but not SBP (Moraska et al. 2010).

In terms of the current research question, there are 3 studies that highlight the use of MMT, with individuals with prehypertension and hypertension. One of the most cited and popular studies was done by Hernandez-Reif et al., in 2000, and indicates that MMT may be effective in reducing both SBP, DBP and symptoms associated with hypertension. This study examined 30 adults of mixed ethnicities with medically diagnosed hypertension for the last 6- months, before and after they received 2, 30-minute full body massages per week, for 5 consecutive weeks. When compared to the control group, the MMT group had a decrease in DBP, as well as reductions in cortisol, a stress hormone, after the massage intervention (Hernandez-Reif et al. 2000). Another study that looked at hypertensive individual responses to MMT used 15 men and women with clinically diagnosed hypertension for 1-year, and 10 total sessions of 10-min back massage. When the pre and post measurements were compared to the control group, the

MMT group showed reductions in both SBP and DBP, with only DBP being statically significant (Olney et al. 2005). Finally, a study examined the use of different styles of MMT using 150 current adult massage clients with a BP lower than 150/95. BP was measured before and after the single session of the randomized MMT treatment, which lasted from 30-minutes to 60-minutes. The results show that participants who received the Swedish style MMT had reductions in SBP, while those who were treated with the more aggressive trigger point therapy and sports massaged showed increases in both SBP and DBP (Cambron et al. 2006). Although an ideal duration, frequency, style, and intensity have yet to be determined, the results of these studies and others, indicate that there is strong evidence that MMT can reduce BP, both SBP and DBP, after single and multiple treatments.

Mechanisms

It is commonly accepted that the primary mechanism responsible for these changes is the external stimulation of the baroreceptors located in the carotid arteries of the neck. These receptors sense pressure that is exerted on the vessel wall, and relays the information back to the brain. The brain then sends a signal to the heart indicating if the pressure exerted on the vessel wall by the blood is adequate, or needs to be adjusted. Evidence has shown that "resetting" these baroreceptors at a lower threshold, has a direct affect on reducing the amount of sympathetic nervous system activity to the heart. The vagus nerve is responsible for the regulation of HR via parasympathetic input. The extrinsic control of the heart by the vagus nerve is first activated by the stimulation of the baroreceptors. If the baroreceptors are reset at a lower threshold, the vagus nerve can then act on the heart sooner and signal a decrease in HR because the BP is too high. Delaney et al. conducted a study in which one session of 20-minutes of trigger point therapy to the head, neck and shoulders reduced HR, SBP, DBP, and increased parasympathetic tone. (Delaney et al. 2002). Finally, both meta-analysis reference the autonomic nervous system as a possible mechanism for the reductions in HR and BP (Moraska et al. 2008, Moyer et al. 2004).

Corporate Wellness Programs

The use of AEMC has been fairly limited to high-end retail stores and personal use. By examining the efficacy of using AEMC to help with preventative care, and chronic disease intervention, we are looking to increase the awareness of the benefits that AEMC provide, as well as increase the availability and usage of these devices in small businesses or large corporations.

Companies and businesses routinely pay extremely high healthcare costs for their employees, and constantly deal with employee absenteeism, resulting in a loss of productivity. It has been suggested that the development and implementation of a strategic Health and Wellness plan may help to decrease overall associated healthcare costs, and help to limit employee sick days. Furthermore, this type of program can increase company productivity, and act as a catalyst for further lifestyle modification, leading to happier and healthier employees, and an increased bottom line and financial outcome for the company.

Methods

The experimental method to be used in this research will be a randomized control trial using a crossover design, consisting of a pre-test/post-test. Each participant will undergo both the AEMC intervention, and the control intervention. On the first day, individuals will be randomly assigned to receive either 20-minutes of AEMC intervention, or they will be assigned to the control condition that will rest quietly for 20-minutes. The participants will undergo 1 treatment intervention per day, and have their measurements taken at baseline and at 5-minutes, 15-minutes, and 30-minutes post-treatment. The participants will then return on a different day and undergo the treatment intervention that was not done on the first day. We are anticipating a total time of 3-hours to complete each participant's protocol, 2 days at 1.5 hours/day.

Participants

The participants that will be recruited and used for this study will be normotensive and prehypertensive men and women, ages 40-55, and must have had some exposure or experience with receiving massage, either automated or manual. I am hoping for 20-30 participants to ensure adequate statistical power. The participants must also work at a desk job 4+ hours/day total, for $\geq$5 days/week, for the last year, since we are examining the non-ambulatory working population.

The inclusion criterion excludes individuals with pulmonary disease, cardiovascular disease, or any other acute or chronic conditions that may affect the measurements. The participants should have also been relatively disease free, have no open wounds or sores, no rashes or skin irritation, and may not have any current musculoskeletal injuries. Participants will be allowed to continue their normal medication regimen (where applicable), excluding individuals who are currently taking any medications used to treat hypertension or that may affect the outcome of the measurements including beta-blockers, calcium channel blockers, diuretics, ACE inhibitors, and alpha-receptor blockers.

The participants will be recruited from the Northern Bay Area of California including Petaluma, Santa Rosa, Sonoma and San Francisco and will be asked to provide their own transportation to and from the research location. Online advertisements, local flyers and signs, as well as business-to-business communications will all be used to recruit participants. The location of the research study will be held at the eMassagechair main office, located in Petaluma, Ca. The participants will be encouraged to wear clothing that is comfortable, and not restrictive. Socks are required for the massage chairs, and participants will remain clothed during the entire experiment, including post treatment. Participants are to follow their normal daily routine, with the exception of no exercise or physical exertion prior to the treatment. Also, we're not controlling for diet, however participants will be directed not to ingest any caffeine or any other stimulant prior to the treatment on both the first and second trial days.

Measurables

The basis for this experiment is to see whether or not AEMC can in fact, increase parasympathetic tone, thereby reducing the amount of work placed on the cardiovascular system, and if so, by what degree. Parasympathetic activity will be measured using 3 different measurable variables including heart rate, measured in beats per minute, blood pressure (systolic/diastolic), measured in millimeters mercury (mmHg), and heart rate variability (HRV). The HR and BP will be taken using a 2-in-1 automated blood pressure cuff, and heart rate monitor (Omron HEM-7120) that will take measurements at baseline, and at pre-selected post-treatment intervals. The HRV will be measured using a Biopac MP150 EKG (BIOPAC Systems Inc., Goleta, Ca) machine, which contains a 3-lead EKG reading. The R-R interval on the EKG will be continuously monitored from the baseline reading, to the final 30-minute post treatment reading.

Procedures

Using a randomized design, each individual will undergo both the control intervention, and the AEMC intervention over. The participants will arrive at their predetermined appointment time, and will be directed to sit and rest quietly for 10 minutes while completing the health history questionnaire and informed consent, and also becoming familiar with the protocol and answering any questions that may arise. I am hoping to concentrate the treatments on weekdays (Tuesday, Wednesday, and Thursday) between the hours of 8am and 12pm in an attempt to create some consistency. After the 10-minute rest period, the lead researcher will then randomly assign an AEMC for the participant, or direct them to the control intervention, which will be a non-operational AEMC. Once the individual has been placed in either the control group, or the AEMC group, a 3-lead EKG will be attached to the participant to begin continuously monitoring of HRV from baseline to the final post-treatment measurement. Baseline measurements of HR, BP, and HRV will be taken at this time in the upright-seated position, on the right arm, along with a brief verbal explanation of the experimental protocol and directions. The initial HR and BP measurements will be taken in triplicate, and averaged together to find the baseline. The participants must empty their pockets, and set any media devices, reading material, or other personal belongings outside of the treatment area. The participants will be told not to talk, get up from the chair, or do anything else that may compromise the measurements. The AEMC treatments will concentrate on the back, neck, shoulders and arms with the specific pressure and intensity specific to the targeted region. Each chair uses its own particular series of rollers, balls and airbags to accurately massage certain areas of the body. The preprogrammed AEMC allows for consistent patterns and routines to control for any inter-massage intervention variability in style, strength, or region. The chairs are preprogrammed to apply a certain amount of pressure and intensity for that particular setting. For our experiment we will use the Swedish setting, which is the least intense protocol, along with light to medium pressure for everyone. Although different perceptions of strength and intensity may exist, they will not be adjusted unless the participant requests to terminate the protocol. Each chair is located in a quiet room, separate from the offices. The treatment area will be set-up with 2-4 research areas, separated by 10 x 10 temporary dividers to ensure privacy and isolation from external distractions. There will be music playing throughout the duration of the intervention, loud enough so that both the experimental group, and the control group will have equal volume. Hopefully, this will drown out any noise from the AEMC, and should also assist in the relaxation of the control group, which is instructed to sit quietly and relax as best as possible. The room will be set at a comfortable temperature and the lights will be kept low and dimmed throughout the experiment.

Following the 20-minutes of treatment, the participants will be instructed to remain seated in the quiet research area, with no distractions for a total of 5-minutes after the massage has finished, and before the follow-up measurements are taken. The post treatment measurements will be taken in the same seated position as the baseline measurements, using the same right arm and while the participant is still in their assigned AEMC. The participants will be discouraged to talk and interact with one another in order to control for other variables. Post-treatment measurements will be taken at 5-minutes, 15-minutes, and 30-minutes, and all will include HR, BP, and HRV. Finally, after the last measurement is completed, the participants will be instructed to slowly recover by walking around and drinking water before leaving the testing facility.

When the experimental procedure is completed, each participant will be asked to schedule their follow-up treatment session, in which they will return after at least a 24-hour break, to complete the treatment intervention that was not received on the first day. The same experimental procedures will be followed from start to finish on the second day; regardless of what treatment intervention they received first.

Statistical Analysis

Pre-test and post-test measurements will be analyzed using a 2 x 4 repeated measures ANOVA to examine the differences between pre and post test, as well as the control versus the experimental groups. I will also use a Duncan post hoc test to examine the HR, SBP, DBP, RPP and HRV values.

Staff

I, Ty Craig, will act as the primary researcher, while my colleague Matthew Marceau will assist me. My collaborators are Dr. Matt Lee, Dr. Marialice Kern, and Dr. Marilyn Mitchell.

Goals

The main goal of this research is to determine if the use of AEMC is effective in increasing heart rate variability (HRV), and lowering heart rate (HR), blood pressure (BP), and rate pressure product (RPP) in normotensive and prehypertensive individuals after 20-minutes of treatment, versus a control group. This will also be used as a preliminary study for testing the efficacy of using AEMC for other health related benefits.

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