

Research Article

Massage therapy: understanding the mechanisms of action on blood pressure. A scoping review



Nicole L. Nelson, MSH, LMT*

Clinical and Applied Movement Sciences, Brooks College of Health, University of North Florida, Jacksonville, FL, USA

Manuscript received June 17, 2015 and accepted July 20, 2015

Abstract

Massage therapy (MT) has shown potential in reducing blood pressure (BP); however, the psychophysiological pathways and structures involved in this outcome are unclear. The aims of this scoping review were twofold. (1) To summarize the current knowledge of the mechanisms of action of MT on BP. (2) To highlight the research gaps and challenges that researchers must overcome to further elucidate how MT attenuates BP. A scoping review was conducted to examine the evidence regarding the mechanisms of action of MT on BP. This review included the thematic analysis of 27 publications that considered the influence of MT on BP. Based on this analysis, six potential BP mediating pathways were identified. Current theories suggest that MT exerts sympatholytic effects through physiologic and psychological mechanisms, improves hypothalamus–pituitary–adrenocortical axis function, and increases in blood flow, which, in turn, may improve endothelial function. Future study is needed, using more scientifically rigorous methodology, to fully elucidate the mechanism of action of MT. *J Am Soc Hypertens* 2015;9(10):785–793. © 2015 American Society of Hypertension. All rights reserved.

Keywords: Blood pressure; hypertension; massage therapy; prehypertension.

Introduction

According to the American Heart Association, nearly one in three American adults are estimated to have high blood pressure (BP), with nearly two-thirds of those older than the age of 65 being classified as having hypertension.¹ Hypertension is a major antecedent of coronary heart disease, renal disease, and stroke.⁴⁴ Worldwide, hypertension is the second largest contributor to the burden of disease.⁶⁷ The average age-adjusted death rate attributed to hypertension increased from 1996 to 2006 by 28.7%, with a 17.8% overall death rate in 2006.¹ Those with BP in the prehypertensive range have been found to be three to seven times more likely to become hypertensive and two times as likely to develop cardiovascular disease.⁶⁴ Additionally, hypertension carries a large financial burden, with 2009 estimated total costs in the United States reaching \$73.4 billion.⁴⁴

Unfortunately, only 25%–40% of patients currently taking antihypertensive drug treatments are meeting BP goals.⁹ For these reasons, it has become increasingly crucial to explore alternative methods to reduce hypertension.

The Clinical Utility of Massage

Massage therapy (MT), one of the oldest forms of medicine known to man, is a generalized term that encompasses techniques involving the manual manipulation of soft tissue.⁵⁸ For the purposes of this review, MT will be broadly defined as a profession in which the practitioner applies manual techniques and may apply adjunctive therapies, with the intention of positively affecting health and well-being of the patient. Although treatment pressure, duration of treatment, and strokes can vary, the coalescing factor is generally considered some type of soft tissue manipulation via a licensed therapist's touch.

MT has become increasingly recognized as a complementary tool in assisting with medical conditions across the scientific community, governmental agencies, and consumers. In 2002, the White House Commission on Complementary and Alternative Medicine Policy⁶⁶ called for additional research and public education on MT. According to a 2014 survey commissioned by the American Massage Therapy

Conflict of interest: The author has no financial conflicts of interest.

*Corresponding author: Nicole L. Nelson, MSH, LMT, Clinical and Applied Movement Sciences, Brooks College of Health, University of North Florida, 1 UNF Drive, Jacksonville, FL 32224-2673. Tel: 904-716-2972; Fax: 904-620-2848.

E-mail: nicole.nelson@unf.edu

Association, 77% of individuals claim their primary reason for receiving a massage was medical (54%) or stress (23%) related.² Additionally, medical providers ranked MT the highest among alternative and complementary practices that are perceived as always or usually effective.

Several randomized controlled trials (RCTs) have demonstrated significant reductions in systolic blood pressure (SBP) and diastolic blood pressure (DBP) of individuals classified as prehypertensive or hypertensive.^{29,30,34,48,54,62} Additionally, a recent systematic review and meta-analysis of 24 studies involving 1962 individuals with essential hypertension concluded that, when combined with antihypertensive medication, MT is more effective than antihypertensive drug treatment alone in lowering SBP (mean difference [MD], -6.92 [-10.05 , -3.80]; $P < .0001$) and DBP (MD, -3.63 [-6.18 , -1.09]; $P = .005$).⁶⁸ Although these reductions may appear small, it is well recognized that even modest reductions in BP are associated with significant reduced risk for hypertension complications.⁴⁰ It has been estimated that a 2 mm Hg reduction of SBP results in a 6% reduction in stroke mortality and a 4% reduction in coronary heart disease mortality, whereas a 5 mm Hg results in 14% and 9% reductions, respectively.¹²

The BP modulating effects of massage involve a series of complex psychophysiological processes across varying time scales. As such, it is vital to gain a better understanding of these mechanisms when considering the inclusion of MT to any treatment plan. This review aimed to summarize the existing literature regarding how MT influences BP. Based on the findings, a basic schematic representation of the effects of MT on BP modulating pathways was proposed and is presented in the graphical abstract. In addition, this review attempted to describe the gaps in research and identify future research needs. To the author's knowledge, this present review is the first to explicitly explore the possible means by which MT may reduce BP.

Methods

A scoping review method was used based on the framework detailed by.⁴ In addition to summarizing and mapping existing literature within a complex study area, a scoping review is designed to identify core methodological issues and research gaps. The process consisted of the following steps: (1) the research question was clearly identified; (2) search strategy was defined; (3) the inclusion and exclusion criteria were described; (4) relevant studies were selected; (5) the key items of information were charted; and (6) the results were summarized in a narrative format. [Figure 1](#) summarizes the various stages of the scoping process.

Research Question

What is the current evidence regarding the mechanisms of action of MT on BP?

Literature Search Outline

A search of MEDLINE, CINAHL, and PubMed was performed up to June 15, 2015, for relevant publications. The search strategy combined two sets of keywords using the Boolean operator “AND,” whereas an “OR” strategy was used to combine the keywords within each group. Keywords included the following: massage therapy, high blood pressure, hypertension, prehypertension, nitric oxide, hypothalamus-pituitary-adrenocortical axis, cortisol, blood flow, endothelial function, relaxation response, affect, and sympathetic nervous system activity. Reference lists were hand searched for additional relevant articles. The search initially yielded 625 potentially relevant publications.

Inclusion and Exclusion Criteria

The retrieved abstracts and references were screened to identify documents that reported the effects of MT on any potential BP modulating pathway. All study designs were included (eg, systematic reviews, RCTs, quantitative studies, qualitative studies, or mixed methods). Articles were excluded if it was not subject to peer review and if it was not in English. Of the original 625 abstracts and references, 27 were considered relevant for this review.

Charting the Data

Key items of information from the 27 articles were charted based on outcome measures and proposed mechanisms of BP reduction ([Table 1](#)).

Results

A thematic analysis of the 27 eligible articles revealed six primary mechanisms of action: (1) mediation of sympathovagal balance, (2) reduced heart rate, (3) increased O₂ saturation, (4) increased blood flow, (5) decreased blood viscosity, (6) alterations in hypothalamus–pituitary–adrenocortical (HPA) axis activity, and (7) subjective and objective central changes.

Potential Mechanisms of Action

Mediation of Sympathovagal Balance

The balance of sympathetic and parasympathetic nervous system (PNS) activity is one mechanism by which the body regulates BP. Specifically, increased activation of the sympathetic nervous system (SNS) is characterized by rises in heart rate, myocardial contractility, and cardiac output as well as vasoconstriction and elevation of peripheral resistance, which ultimately increases BP. It has been proposed that MT promotes SNS withdraw along with a corresponding increase in PNS activity.⁵⁰ This has been evidenced by several investigations reporting improved heart rate

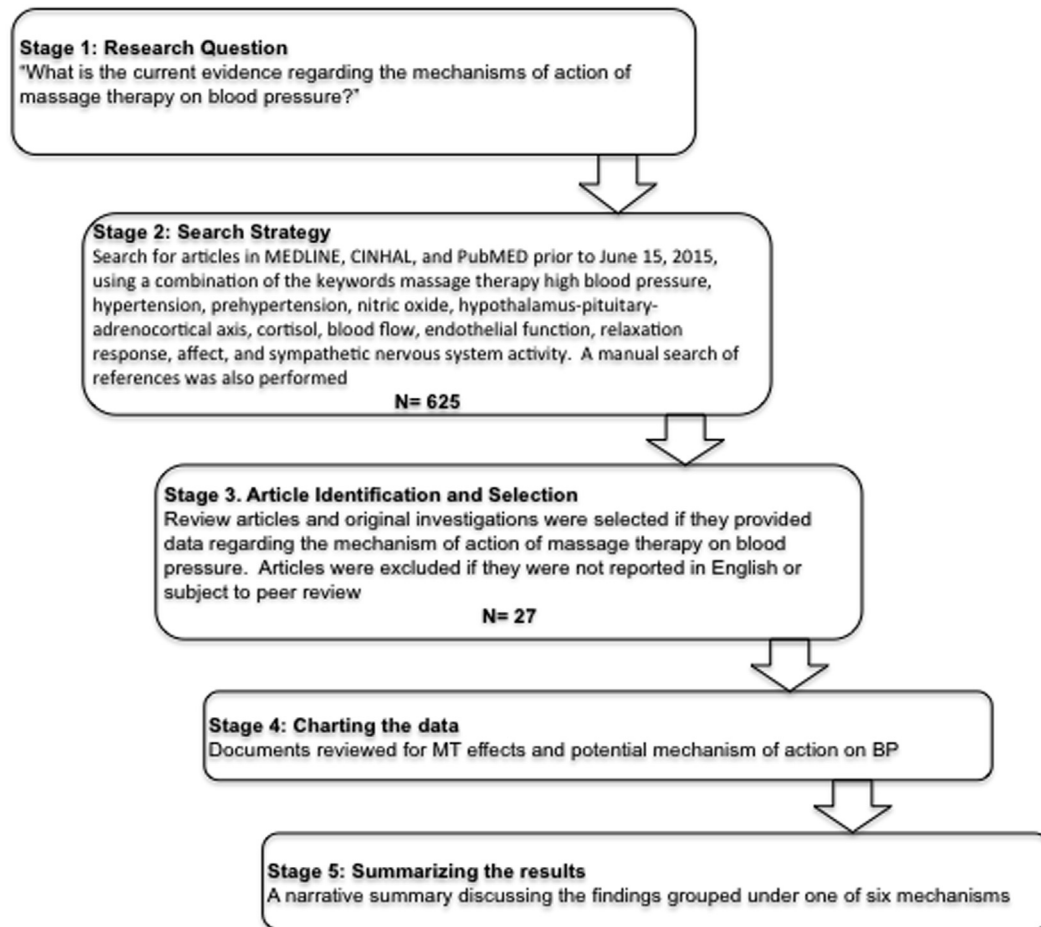


Figure 1. Flow of the scoping process. BP, blood pressure; MT, massage therapy.

variability, an index used to evaluate autonomic nervous system (ANS) control.^{17,43,61,65}

Few descriptive models of MT-induced sympathovagal responses have been proposed. Diego and Field¹⁷ have suggested that moderate pressure may increase activity in the PNS by activating pressure receptors in the skin. Stimulation of myelinated (group III) and unmyelinated (group IV) afferents are known to cause cardiovascular responses.¹³ The group III afferents are thought to be stimulated by mechanical stimuli such as stretch, contraction, or pressure.³⁸ Most group IV afferents are stimulated by metabolic or chemical by-products of contraction, such as potassium and bradykinin.^{37,47} Theoretically, stimulation of these receptors could occur by two means. First, massage may increase circulation and thus induce changes to the metabolic milieu. Second, the afferents may be directly stimulated through the massage strokes on the skin.

Heart Rate

Mean arterial pressure is a product of cardiac output (a product of heart rate (HR) and stroke volume) and total

peripheral resistance; therefore, decreases in HR, without a concomitant increase in total peripheral resistance, would result in reductions in BP. Increases in HR are considered a physiological expression of the SNS response to stress. Assuming MT elicits an increase in vagal tone, we could predict attenuation of HR and by nature of the HR and BP relationship, a drop in BP. Despite this logic, a 2008 meta-analysis revealed among 11 studies reporting HR data, only five discovered significant reductions in HR either during or after the massage treatment.⁴⁹ Furthermore, the reviewers concluded that although small decreases in resting HR are generally observed immediately after MT, the effects do not persist much beyond the MT session. Additionally, the immediate decreases that have been found, although statistically significant, are not likely clinically significant. To this end, it is unlikely that the transient decrease in HR significantly contributes to reductions in BP.

Increased O₂ Saturation

Doering et al¹⁸ demonstrated that manual vibratory massage significantly increased tidal volume after lung

Table 1

Summary of key findings

Proposed Mechanism	Author	Year	Main Findings
MOA 1 sympathovagal balance	Diego and Field	2009	• MT engenders sympatholytic effects evidenced by improved HRV
	Lindgren et al	2010	
	Smith et al	2013	
	Walchli et al	2014	
MOA 2 heart rate	Moraska et al	2008	• Systematic review: of 11 studies reporting HR data, 5 discovered significant reductions in HR • These effects do not persist much beyond the MT session and are not considered clinically significant
MOA 3 O ₂ saturation	Doering et al	1999	• Increase in tidal volume after manual vibratory massage • Increased O₂ saturation • Decreases in central venous pressure • Decreases in pulmonary vessel resistance
MOA 4 blood flow	Crane et al	2012	• Attenuation of inflammatory cytokines • Improved endothelial function
	Supa'at et al	2013	
	Franklin et al	2014	
	Tiidus et al	1995	
	Shoemaker et al	1997	• No significant increases in blood flow attributable to MT
	Hinds et al	2004	
	Ouchi et al	2006	
	Sefton et al	2010	
MOA 5 viscosity	Arkko et al	1983	• No changes in hematocrit
	Ernst et al	1987	• Reduced blood viscosity, hematocrit, and plasma viscosity
MOA 6 HPA axis alterations	Ironson et al	1996	• Significant reductions in cortisol
	Field et al	1996	
	Field et al	1998	
	Hernandez-Reif et al	2000	
	Hernandez-Reif et al	2001	• Systematic reviews including aforementioned studies: mean effect of MT on cortisol is very small or not statistically distinguishable from zero
	Field et al	2005	
	Ouchi et al	2006	
	Moyer et al	2004	
	Moraska et al	2008	• Systematic review: MT recipients showed 77% greater reduction in trait anxiety vs. comparison groups
	Moyer et al	2011	
MOA 7 subjective and objective central changes	Moyer et al	2004	
	Jones et al	1999	
	Diego et al	2004	• Reduced EEG asymmetry
	Ouchi et al	2006	• Shift toward left-frontal EEG activation
	Field	2010	• Increased blood flow to the amygdala and hypothalamus • Reduced sympathetic outflow after MT is associated with increases in structures within the brain involved in ANS regulation

ANS, autonomic nervous system; EEG, electroencephalogram; HPA, hypothalamus–pituitary–adrenocortical; HRV, heart rate variability analysis; MOA, mechanism of action; MT, massage therapy.

or heart transplant by 30% ($P = .008$). Other outcome measures of this study included significant increases in oxygen saturation from 92% to 93.6% ($P = .002$), significant decreases in central venous pressure ($P = .04$), and pulmonary vessel resistance were reduced by 18.3% ($P = .001$). Taken together, these effects may play a role in attenuation of the renin–angiotensin pathway, the long-term regulator of BP. Although the outcomes of this study are encouraging for transplant patients, these results may not be generalizable to hypertensive populations.

Blood Flow

MT has been reported to increase local blood flow through vasodilatory mechanisms induced by the mechanical pressure applied during MT.^{14,27,56,59,62} The increase in peripheral conductance, coupled with no increase in cardiac output, results in reductions in BP. It should be noted that although several MT investigations have observed increases in blood flow, this finding is controversial and may be dependent on the type of stroke used.^{32,60,63}

Massage treatments may cause vessels to dilate by a few mechanisms. First, it has been speculated that the release of

vasoactive substances, including histamine and nitric oxide (NO), occurs during MT.^{27,28,62} The release of histamine may be attributed to tactile stimuli⁵ or by withdrawal in sympathetic activity.⁵⁷ Histamine has been shown to be a potent vasodilator that acts on H₁ and H₂ receptors in peripheral vasculature (Powell & Brody 1976).⁵⁷ Although it is theoretically plausible that histamine contributes to massage hyperemia, red blood cells actively take up histamine, which makes direct measurement challenging.

Factors released from endothelial cells (eg NO and prostacyclin) also may play a role in massage-induced hyperemia. Specifically, increasing blood flow rate creates shear stress, which is the stimulus for the endothelial production of vasodilating substances such as NO and prostaglandin. Because this effect is initiated by an increase in blood flow, this process is termed flow-mediated dilation (FMD). In addition to inducing vasodilation, NO regulates inflammation by preventing leukocyte activation and adhesion and inhibits vascular smooth muscle proliferation (Landmesser et al 2004).³⁹ Collectively, these effects lead to reductions in both SBP and DBP. It is worth mentioning that increases in metabolic demand, as in the case of cardiovascular exercise, are likely a more relevant contributor to increases in blood flow and long-term improved endothelial function compared to passive treatments such as MT; however, two recent investigations have demonstrated displays of transient improvement in endothelial function after participants received a massage treatment.^{62,27}

Franklin et al²⁷ demonstrated improved brachial artery endothelium-dependent FMD for up to 48 hours among subjects receiving a single 30-minute lower extremity massage treatment compared with subjects not receiving MT. Results of this study suggest that MT does have systemic effects on blood flow in young healthy adults. This phenomenon, known as conducted vasodilation, is characterized by vasodilation in distal vessels spreading through the vasculature. Conducted vasodilation is currently understood to occur through cell-to-cell communication between smooth muscle cells and endothelial cells, between adjacent smooth muscle cells, and between adjacent endothelial cells.^{7,19}

Massage may also have a mechanical mechanism that contributes to increases in blood flow. Mechanical forces imparted to the vasculature during massage may result in a pumping effect (aptly termed the skeletal muscle pump), where venous return is enhanced. Although relatively unexplored in the realm of MT, the skeletal muscle pump is a well-established effect during rhythmic muscular contraction. It has been proposed that the squeezing effect of massage strokes elicits a similar stimulus as muscular contraction, whereby forces compress the veins, squeezing blood through venous circulation toward the heart. This squeezing action also may empty the veins, such that venous pressure is reduced, resulting in an increase in the pressure gradient across capillary beds and a subsequent increase in blood flow. In a similar fashion, arteries may

be temporarily occluded by certain massage strokes. This occlusion transiently reduces blood flow, with a subsequent increase in blood flow on release of pressure.

The role of vasodilation and the muscle pump has been well studied in response to muscle contraction during exercise. Within the context of MT, although plausible, little data support the roles of vasodilation and the muscle pump in initiating and maintaining increases in blood flow. Although the results of the Franklin et al²⁷ investigation did reveal increases in brachial artery FMD after young, healthy adults received a MT to the lower body, large experimental studies using FMD are needed among prehypertensive and hypertensive individuals to determine if MT has any effect in these populations. Moreover, it is unclear how long these effects may last or whether these effects would be potent enough to have any relevant impact on blood flow.

Viscosity

Viscosity is a determinant of blood flow, where decreases in viscosity are indicative of increases in blood fluidity. Little is currently known about MT effects on viscosity; however, one investigation reported study participants receiving one 20-minute full body massage showed a significant drop in blood viscosity.²⁰ After a series of six 20-minute massages over a period of two weeks, blood viscosity, hematocrit, and plasma viscosity were reduced. Others have found no change in hematocrit and related variables after MT.³ Unfortunately, to the author's knowledge, no recent investigations have studied whether MT induces alterations in blood parameters.

Activation of the HPA Axis—Implications for Endothelial Function

The association of hypertension and alterations of the HPA axis has been well described,^{26,45} where prolonged exposure to stress results in increased levels of the catecholamines, norepinephrine and epinephrine, and cortisol.⁴² One function of cortisol is to assist in the maintenance of BP by increasing the sensitivity of vessels to catecholamines; where in the absence of cortisol, vasodilation occurs. Additionally, chronically elevated levels of catecholamines and cortisol have been implicated in reductions in NO levels and vascular endothelial function.^{46,53} These functional vascular alterations have led massage researchers to reason that if MT reduces cortisol excretion rates, this will lead to reductions in BP. Several reviews and original investigations have reported decreases in cortisol after subjects have received MT.^{22–24,30,31,33,55} It is worth noting, however, that several quantitative reviews have found that MT's mean effect on cortisol is very small or not statistically distinguishable from zero.^{49–51} Discrepant findings may be attributable to some of the authors reporting within-group analysis²³ or using percentage of change as the measure of effect,²⁴ whereas

other authors converted the results of RCTs into standardized MD effect sizes that compared the effect of MT against control treatment.^{50,51}

Subjective and Objective Central Changes

Of all potentially moderating variables, anxiety has been described most frequently.^{8,25,51} Moyer et al⁵⁰ reported that trait anxiety among study participants receiving several massage treatments demonstrated the largest effect sizes among several measured variables including pain, cortisol levels, and HR. The average MT participant experienced a reduction of trait anxiety of more than 77% compared with control subjects. An important consideration that often goes unrecognized from a research perspective is that anxiety reduction during or after a massage treatment hinges on whether the client is able to relax during the session. The lack of the achieving a relaxed physiological state among some recipients unfamiliar with massage may explain some of the contradictory outcomes seen across MT studies. Moreover, trust, belief, and expectation may be of relevance.²¹

Positive effect and reduced feelings of stress are established correlates of activation of limbic activity and neural structures involved in attention and control of the ANS.^{41,52} Although the exact physiological and molecular effects are unclear, researchers have discovered increased blood flow to the amygdala and hypothalamus among participants receiving MT in the prone position.⁵⁵ Other research has shown that adolescents with greater relative right frontal electroencephalogram (EEG) activation (associated with negative affect) and symptoms of depression demonstrated reduced EEG asymmetry after receiving MT.³⁶ Others have found that MT involving moderate pressure increases positive affect with a shift toward left-frontal EEG activation.¹⁶ It is conceivable that the reduction in sympathetic outflow that is associated with MT is associated with increased stimulation of the limbic system, including hypothalamic structures involved in ANS regulation.²⁵

Descriptive Model of the Mechanisms of Action

Based on the findings of this scoping review, a preliminary schematic representation of the integrated effects of MT has been developed (Graphical Abstract). It is worth noting that although this review is based on well-founded principles of cardiovascular physiology, the precise effects of MT have not been fully elucidated. To this end, further research is warranted to refine and continue development of this basic paradigm.

Discussion

Twenty-seven studies were included in the thematic analysis, where six potential BP-mediating mechanisms were identified. As is often the case with scoping reviews, we

are left with more questions than answers. However, this review has successfully “mapped” existing evidence and revealed specific research gaps and future research needs.

Overall, the strength of evidence across massage research is limited by the lack of scientific rigor.^{8,11,35,49} For example, although the authors of recent systematic reviews concluded that various forms of MT do seem to have a BP lowering effect, the reviewers also acknowledged most of included studies were of poor methodological quality, citing lack randomization or reporting of randomization, inconsistent reporting of medication use, and other lifestyle factors that mediate BP (eg, decreases in weight loss, participation in physical activity), failure to report statistical test results for between-group differences at the end of treatment, small sample sizes, and absence of control groups.^{35,51,68}

Currently, the etiology of essential hypertension is not well understood; where it is likely that multiple biopsychosocial factors contribute, in differing degrees, to the elevation of BP over time. To strengthen the evidence regarding massage mechanisms, future research will require adjustment for potential effect modifiers and covariates of high BP (eg, chronically insufficient sleep, occupational stress, chronic pain, age, sex, and physical activity levels). Furthermore, it is a common finding that individuals with higher baseline BPs benefit more than those with lower baseline BPs in exercise interventions. It follows that subgroup analyses should be performed for the different stages of hypertension.

Cardiovascular responses to MT may be determined by the massage protocol used. For example, Cambron et al¹⁰ noted increases in SBP and DBP among subjects receiving treatments that included a combination of trigger point therapy and sports massage. Conversely, Delaney et al¹⁵ demonstrated a decrease in BP using trigger point therapy; however, the protocol also included linear stroking to the sternocleidomastoid muscles, which could have stimulated the carotid sinus, eliciting a drop in BP. These discrepant findings indicate the depth of pressure, type of strokes, and duration of the treatment influence the cardiovascular system in varying ways. Accordingly, MT researchers will need to develop experimental protocol guidelines in an effort to establish whether longer treatments or treatments involving certain strokes amount to a more effective dose or whether the specific hemodynamic effect is deeper pressure rather than time dependent. Additionally, MT likely elicits different outcomes based on factors such as the recipient's beliefs and expectations of the treatment. Future MT investigations will have to determine the independent effects of these variables and attempt to contain these effects with appropriate placebo controls.

To better identify the mechanisms of action involved in BP reduction, certain objective measures may be of use. First, the advent of brain imaging and EEG creates the opportunity for direct observation of any physiologic changes associated with MT in different regions of the brain.

Second, continuous monitoring of BP, using ambulatory 24-hour BP, not only tends to be more reproducible and relatively free of placebo effects, but also records BP regularly over a prolonged period in the subjects' natural environment, thereby providing a more reliable measure of overall BP.⁶ Third, endothelial dysfunction is recognized as a major factor in the development of atherosclerosis and has significant prognostic value.⁶⁹ Accordingly, the use of FMD would be of great value in studying whether MT offers any protective vascular effects against the prolonged strain of essential hypertension. Although preliminary evidence indicates that MT improves blood flow and endothelial function in healthy individuals, further experimental trials are needed to determine if blood flow changes incurred during various massage treatments actually improve long-term endothelial function in those with hypertension and prehypertension.

Limitations

This scoping review is not without limitations. First, it is likely that research describing the effects of MT used variable terminology, whereby potentially relevant articles could have been missed. Second, only one reviewer was involved in establishing the inclusion and exclusion criteria and data extraction; therefore, the selection of articles and content was subject to bias. Finally, many of the included studies had varying study populations (eg, healthy subjects, children/adolescents, and back pain patients); therefore, the postulated mechanisms of action may not be fully generalizable to the hypertensive or prehypertensive patient.

Conclusions

This scoping review indicates that MT-associated BP reductions are likely the result of a complex integration of central and peripheral mechanisms across physiological and psychological domains. Additional methodically robust clinical trials are necessary to clarify the relative contributions of these mechanisms on BP regulation.

Acknowledgments

The author thanks David Wilson for his graphical expertise.

References

1. American Heart Association. Heart disease and stroke statistics—2012 update: a report from the American Heart Association. *Circulation* 2012;125(1):e2–220.
2. American Massage Therapy Association. Massage therapy for regular health maintenance. Available at: <https://www.amtamassage.org/research/Consumer-Survey-Fact-Sheets.html>. Accessed June 15, 2015.
3. Arkko P, Pakarinen A, Kari-Koskinen O. Effects of whole body massage on serum protein, electrolyte and hormone concentrations, enzyme activities, and hematological parameters. *Int J Sports Med* 1983; 4(4):265–7.
4. Arskey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol Theory Pract* 2005;8:19–32.
5. Atkinson T, White M, Kaliner M. Histamine and serotonin. In: Gallin JI, Goldstein I, Snyderman R, editors. *Inflammation: basic principles and clinical correlates*. 2nd ed. New York: Raven Press; 1992. P. 193–209.
6. Barnes V, Treiber F, Johnson M. Impact of transcendental meditation on ambulatory blood pressure in African-American adolescents. *Am J Hypertens* 2004; 17(4):366–9.
7. Bartlett L, Segal SS. Resolution of smooth muscle and endothelial pathways for conduction along hamster cheek pouch. *Am J Physiol* 2000;278:H604.
8. Bauer B, Cutshall S, Wentworth L, Engen D, Messner P, Wood C, et al. Effect of massage therapy on pain, anxiety, and tension after cardiac surgery: a randomized study. *Complement Ther Clin Pract* 2010;16:70–5.
9. Burnier M. World Health Organization/International Society of Hypertension, Guidelines: blood pressure control and the implementation of guidelines in clinical practice: can we fill the gap? *J Hypertens* 2002;20(7): 1251–3.
10. Cambron J, Dexheimer J, Coe P. Changes in blood pressure after various forms of therapeutic massage: a preliminary study. *J Altern Complement Med* 2006; 12(1):65–70.
11. Cawley N. A critique of the methodology of research studies evaluating massage. *Eur J Cancer Care (Engl)* 1997;6(1):23–31.
12. Chobanian A, Bakris G, Black H, Cushman W, Green L, Izzo J. National High Blood Pressure Education Program Coordination Committee. Seventh report of the Joint National Committee on Prevention, Detection, Evaluation and Treatment of High Blood Pressure. *Hypertension* 2003;42:1206–52.
13. Coote J, Hilton S, Perez-Gonzalez J. The reflex nature of the pressor response to muscular exercise. *J Physiol* 1971;215:789–804.
14. Crane J, Ogborn D, Cupido C, Melov S, Hubbard A, Bourgeois JM, et al. Massage therapy attenuates inflammatory signaling after exercise-induced muscle damage. *Sci Transl Med* 2012;4:119ra113.
15. Delany J, Leong K, Watkins A, Brodie D. The short-term effects of myofascial trigger point massage therapy on cardiac autonomic tone in healthy subjects. *J Adv Nurs* 2002;37:364–71.
16. Diego M, Field T, Sanders C, Hernandez-Reif M. Massage therapy of moderate and light pressure and

- vibrator effects on EEG and heart rate. *Int J Neurosci* 2004;114:31–44.
17. Diego M, Field T. Moderate pressure massage elicits a parasympathetic nervous system response. *Int J Neurosci* 2009;119(5):630–8.
18. Doering T, Fieguth H, Steuemagel B, Brix J, Konitzer M, Schneider B, et al. External stimuli in the form of vibratory massage after heart or lung transplantation. *Am J Phys Med Rehabil* 1999;78:108–10.
19. Emerson G, Segal S. Electrical coupling between endothelial cells and smooth muscle cells in hamster feed arteries: role in vasomotor control. *Circ Res* 2000;87:474–9.
20. Ernst E, Matrai A, Magyarosy I, Liebermeister R, Eck M, Breu M. Massages cause changes in blood fluidity. *Physiotherapy* 1987;73:43–5.
21. Esch T, Guarna M, Bianchi E, Zhu W, Stefano G. Commonalities in the central nervous system's involvement with complementary medical therapies: limbic morphogenic processes. *Med Sci Monit* 2004;10:MS6–17.
22. Field T, Grizzle N, Scafidi F, Schanberg S. Massage and relaxation therapies' effects on depressed adolescent mothers. *Adolescence* 1996;31:903–11.
23. Field T, Hernandez-Reif M, Hart S, Theakston H, Schanberg S, Kuhn C. Elder retired volunteers benefit from giving massage therapy to infants. *J Appl Gerontol* 1998;17:229–39.
24. Field T, Hernandez-Reif M, Diego M, Schanberg S, Kuhn C. Cortisol decreases and serotonin and dopamine increase following massage therapy. *Int J Neurosci* 2005;115:1397–413.
25. Field T. Pregnancy and labor massage. *Expert Rev Obstet Gynecol* 2010;5(2):177–81.
26. Filipoovsky J, Ducimetiere P, Eschwege E, Richard J, Rosselin G, Claude J. The relationship of blood pressure with glucose, insulin, heart rate, free fatty acids and plasma cortisol levels to the degree of obesity in middle-aged men. *J Hypertens* 1996;14:229–35.
27. Franklin N, Ali M, Robinson A, Norkeviciute E, Phillips S. Massage therapy restores peripheral vascular function after exertion. *Arch Phys Med Rehabil* 2014;95:1127–34.
28. Goats G. Massage-the scientific basis of an ancient art: Part 2. Physiological and therapeutic effects. *Br J Sports Med* 1994;28(3):153–6.
29. Givi M. Durability of effect of massage therapy on blood pressure. *Int J Prev Med* 2013;4(5):511–6.
30. Hernandez-Reif M, Field T, Krasnegor J, Hossain Z, Theakston H, Burman I. High blood pressure and associated symptoms were reduced by massage therapy. *J Bodyw Mov Ther* 2000;4(1):31–8.
31. Hernandez-Reif M, Field T, Drasneger J, Theakston H. Lower back pain is reduced and range of motion increased after massage therapy. *Int J Neurosci* 2001;106:131–45.
32. Hinds T, McEwan I, Perkes J, Dawson E, Ball D, George K. Effects of massage on limb and skin blood flow after quadriceps exercise. *Med Sci Sports Exerc* 2004;36(8):1308–13.
33. Ironson G, Field T, Scafidi F, Kumar M, Patarca R, Price A, et al. Massage therapy is associated with enhancement of the immune system's cytotoxic capacity. *Int J Neurosci* 1996;84:205–18.
34. Jefferson L. Exploring effects of therapeutic massage and patient teaching in the practice of diaphragmatic breathing on blood pressure, stress, and anxiety in hypertensive African-American women: an intervention study. *J Natl Black Nurses Assoc* 2010;21(1):17–24.
35. Jones J, Thomson P, Irvine K, Leslie S. Is there a specific hemodynamic effect in reflexology? A systematic review of randomized controlled trials. *J Altern Complement Med* 2013;19(4):319–28.
36. Jones N, Field T. Massage and music therapies attenuate frontal EEG asymmetry in depressed adolescents. *Adolescence* 1999;34:529–35.
37. Kaufman M, Longhurst J, Rybicki K, Wallach J, Mitchell J. Effects of static muscular contraction on impulse activity of groups III and IV afferents in cats. *J Appl Physiol* 1983;55:105–12.
38. Kaufman M, Rybicki K. Discharge properties of group III and IV muscle afferents: their responses to mechanical and metabolic stimuli. *Circ Res* 1987;61(4 Pt 2):160–5.
39. Landmesser U, Hornig B, Drexler H. Endothelial function: a critical determinant in atherosclerosis? *Circulation* 2004;109(21 Suppl 1):II27–33.
40. Law M, Morris J, Wald N. Use of blood pressure lowering drugs in the prevention of cardiovascular disease: meta-analysis of 147 randomised trials in the context of expectations from prospective epidemiological studies. *BMJ* 2009;338:b1665.
41. Lazar S, Bush G, Gollub R, Fricchione G, Khalsa G, Benson H. Functional brain mapping of the relaxation response and meditation. *Neuroreport* 2000;11:1585.
42. Lee Y, Park BN, Kim SH. The effects of heat and massage application on autonomic nervous system. *Yonsei Med J* 2011;52(6):982–9.
43. Lindgren L, Rundgren S, Winso O, Lehtipalo S, Wiklund U, Karlsson M, et al. Physiological responses to touch massage in healthy volunteers. *Auton Neurosci* 2010;158(1):105–10.
44. Lloyd-Jones D, Adams R, Carnethon M, De Simone G, Ferguson T, Flegal K, et al. Heart disease and stroke statistics—2009 update: a report from the American Heart Association Statistics Committee and Stroke Statistics Subcommittee. *Circulation* 2009;119:e21–181.
45. Litchfield W, Hunt S, Jeunemaitre X, Fisher N, Hopkins P, Williams R, et al. Increased urinary cortisol: a potential intermediate phenotype of essential hypertension. *Hypertension* 1998;31:569–74.

46. Mallamaci F, Tripepi G, Maas R, Malatino L, Boger R, Zoccali C. Analysis of the relationship between norepinephrine and asymmetric dimethyl arginine levels among patients with end-stage renal disease. *J Am Soc Nephrol* 2004;15(2):435–41.
47. Mense S, Meyer H. Different types of slowly conducting afferent units in cat skeletal muscle and tendon. *J Physiol* 1985;363:403–17.
48. Moeini M, Givi M, Ghasempour Z, Sadeghi M. The effect of massage therapy on blood pressure of women with prehypertension. *Iran J Nurs Midwifery Res* 2011;16(1):61–70.
49. Moraska A, Pollini R, Boulanger K, Brooks M, Teitlebaum L. Physiological adjustments to stress measures following massage therapy: a review of the literature. *Evid Based Complement Alternat Med* 2008;7(4):409–18.
50. Moyer C, Rounds J, Hannum J. A meta-analysis of massage therapy research. *Psychol Bull* 2004;130(1):3–18.
51. Moyer C, Seefeldt L, Mann E, Jackley LM. Does massage therapy reduce cortisol? A comprehensive quantitative review. *J Bodyw Mov Ther* 2011;15(1):3–14.
52. Newberg A, Alavi A, Baime M, Pourdehnad M, Santanna J, d'Aquili E. The measurement of regional cerebral blood flow during the complex cognitive task of meditation: a preliminary SPECT study. *Psychiatry Res* 2001;106:113–22.
53. Nickel T, Deutschmann A, Hanssen H, Summo C, Wilbert-Lampen U. Modification of endothelial biology by acute and chronic stress hormones. *Microvasc Res* 2009;78:364–9.
54. Olney C. The effect of therapeutic back massage in hypertensive persons: a preliminary study. *Biol Res Nurs* 2005;7(2):98–105.
55. Ouchi Y, Kanno T, Okada H, Yoshikawa E, Shinke T, Nagasawa S, et al. Changes in cerebral blood flow under the prone condition with and without massage. *Neurosci Lett* 2006;407(2):131–5.
56. Portillo-Soto A, Eberman L, Demchak T, Peebles C. Comparison of blood flow changes with soft tissue mobilization and massage therapy. *J Altern Complement Med* 2014;20(12):932–6.
57. Powell J, Brody M. Participation of H₁ and H₂ histamine receptors in physiological vasodilator responses. *Am J Physiol* 1976;231:1002–9.
58. Rubik B, Pavek R, Ward R, Greene E, Upledger J, Lawrence D, et al. Manual Healing Methods. In *Alternative Medicine: Expanding Medical Horizons*. A Report to the National Institutes of Health on Alternative Medical Systems and Practices in the United States Chantilly, VA NIH Pub No. 94-066.1994:113–157.
59. Sefton JM, Yarar C, Berry JW, Pascoe DD. Therapeutic massage of the neck and shoulders produces changes in peripheral blood flow when assessed with dynamic infrared thermography. *J Altern Complement Med* 2010;16(7):723–32.
60. Shoemaker J, Tiidus P, Mader R. Failure of manual massage to alter limb blood flow: measures by Doppler ultrasound. *Med Sci Sports Exerc* 1997;29(5):610–4.
61. Smith S, Lux R, Haley S, Slater H, Beechy J, Moyer-Mileur L. The effect of massage on heart rate variability in preterm infants. *J Perinatol* 2013;33(1):59–64.
62. Supa'at I, Zakaria Z, Maskon O, Aminuddin A, Nordin N. Effects of Swedish massage therapy on blood pressure, heart rate, and inflammatory markers in hypertensive women. *Evid Based Complement Alternat Med* 2013;2013:171852.
63. Tiidus P, Shoemaker J. Effleurage massage, muscle blood flow and long-term post-exercise strength recovery. *Int J Sports Med* 1995;16(7):478–83.
64. Vasan R, Larson M, Leip EP, Evans JC, O'Donnell CJ, Kannel WB, et al. Impact of high-normal blood pressure on the risk of cardiovascular disease. *N Engl J Med* 2001;345:1291–7.
65. Walchli C, Saltzwedel G, Kruerke D, Kaufmann C, Schnorr B, Rist L, et al. Physiologic effects of rhythmic massage: a prospective exploratory cohort study. *J Altern Complement Med* 2014;20(6):507–15.
66. White House Commission on Complementary and Alternative Medicine Policy. White House Commission on Complementary and Alternative Medicine Policy: final report. Available at: <http://govinfo.library.unt.edu/whccamp/finalreport.html>. Accessed June 15, 2015.
67. World Health Organization (WHO). The World Health Report 2002. Reducing Risks, Promoting Healthy Life. Geneva: Switzerland; 2002.
68. Xiong X, Li S, Zhang Y. Massage therapy for essential hypertension: a systematic review. *J Hum Hypertens* 2015;29:143–51.
69. Yoshida T, Kawano H, Miyamoto S, Motayam T, Fukushima H, Hirai N, et al. Prognostic value of flow-mediated dilation of the brachial artery in patients with cardiovascular disease. *Intern Med* 2006;45(9):575–9.