Research Article

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

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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. 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. Hypertension is a major antecedent of coronary heart disease, renal disease, and stroke. Worldwide, hypertension is the second largest contributor to the burden of disease. 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. 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. Additionally, hypertension carries a large financial burden, with 2009 estimated total costs in the United States reaching $73.4 billion. Unfortunately, only 25%–40% of patients currently taking antihypertensive drug treatments are meeting BP goals. 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. 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 Policy called for additional research and public education on MT. According to a 2014 survey commissioned by the American Massage Therapy...
Association, 77% of individuals claim their primary reason for receiving a massage was medical (54%) or stress (23%) related. 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. 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]; \( P = .005 \)). 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. 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.

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 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 withdrawal along with a corresponding increase in PNS activity. This has been evidenced by several investigations reporting improved heart rate...
variability, an index used to evaluate autonomic nervous system (ANS) control.\textsuperscript{17,43,61,65}

Few descriptive models of MT-induced sympathovagal responses have been proposed. Diego and Field\textsuperscript{17} 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.\textsuperscript{13} The group III afferents are thought to be stimulated by mechanical stimuli such as stretch, contraction, or pressure.\textsuperscript{18} Most group IV afferents are stimulated by metabolic or chemical by-products of contraction, such as potassium and bradykinin.\textsuperscript{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.

\textbf{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.\textsuperscript{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.

\textbf{Increased O₂ Saturation}

Doering et al\textsuperscript{18} demonstrated that manual vibratory massage significantly increased tidal volume after lung
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.

### Table 1

<table>
<thead>
<tr>
<th>Proposed Mechanism</th>
<th>Author</th>
<th>Year</th>
<th>Main Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>MOA 1 sympathovagal balance</td>
<td>Diego and Field</td>
<td>2009</td>
<td>MT engenders sympatholytic effects evidenced by improved HRV</td>
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<tr>
<td>Lindgren et al</td>
<td>2010</td>
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<td>Smith et al</td>
<td>2013</td>
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<tr>
<td>Walchli et al</td>
<td>2014</td>
<td></td>
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<tr>
<td>MOA 2 heart rate</td>
<td>Moraska et al</td>
<td>2008</td>
<td>Systematic review: of 11 studies reporting HR data, 5 discovered significant reductions in HR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>These effects do not persist much beyond the MT session and are not considered clinically significant</td>
</tr>
<tr>
<td>MOA 3 $O_2$ saturation</td>
<td>Doering et al</td>
<td>1999</td>
<td>Increase in tidal volume after manual vibratory massage</td>
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<tr>
<td></td>
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<td>Increased $O_2$ saturation</td>
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<td></td>
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<td>Decreases in central venous pressure</td>
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<td></td>
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<td>Decreases in pulmonary vessel resistance</td>
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<tr>
<td>MOA 4 blood flow</td>
<td>Crane et al</td>
<td>2012</td>
<td>Attenuation of inflammatory cytokines</td>
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<td>Supa’at et al</td>
<td>2013</td>
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<td>Improved endothelial function</td>
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<tr>
<td>Franklin et al</td>
<td>2014</td>
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<td>No significant increases in blood flow attributable to MT</td>
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<tr>
<td>Tidus et al</td>
<td>1995</td>
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<td>Shoemaker et al</td>
<td>1997</td>
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<td>Hinds et al</td>
<td>2004</td>
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<tr>
<td>Ouchi et al</td>
<td>2006</td>
<td></td>
<td>Significant increases in peripheral blood flow</td>
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<tr>
<td>Sefton et al</td>
<td>2010</td>
<td></td>
<td></td>
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<tr>
<td>MOA 5 viscosity</td>
<td>Arkko et al</td>
<td>1983</td>
<td>No changes in hematocrit</td>
</tr>
<tr>
<td>Ernst et al</td>
<td>1987</td>
<td></td>
<td>Reduced blood viscosity, hematocrit, and plasma viscosity</td>
</tr>
<tr>
<td>MOA 6 HPA axis alterations</td>
<td>Ironson et al</td>
<td>1996</td>
<td>Significant reductions in cortisol</td>
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<td>Field et al</td>
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<td>Ouchi et al</td>
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<td>Moyer et al</td>
<td>2004</td>
<td></td>
<td>Systematic reviews including aforementioned studies: mean effect of MT on cortisol is very small or not statistically distinguishable from zero</td>
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<td>Moraska et al</td>
<td>2008</td>
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<tr>
<td>Moyer et al</td>
<td>2011</td>
<td></td>
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<tr>
<td>MOA 7 subjective and objective central changes</td>
<td>Moyer et al</td>
<td>2004</td>
<td>Systematic review: MT recipients showed 77% greater reduction in trait anxiety vs. comparison groups</td>
</tr>
<tr>
<td>Jones et al</td>
<td>1999</td>
<td></td>
<td>Reduced EEG asymmetry</td>
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<tr>
<td>Diego et al</td>
<td>2004</td>
<td></td>
<td>Shift toward left-frontal EEG activation</td>
</tr>
<tr>
<td>Ouchi et al</td>
<td>2006</td>
<td></td>
<td>Increased blood flow to the amygdala and hypothalamus</td>
</tr>
<tr>
<td>Field</td>
<td>2010</td>
<td></td>
<td>Reduced sympathetic outflow after MT is associated with increases in structures within the brain involved in ANS regulation</td>
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</table>

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

### 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.\textsuperscript{27,28,62} The release of histamine may be attributed to tactile stimuli\textsuperscript{5} or by withdraw in sympathetic activity.\textsuperscript{27} Histamine has been shown to be a potent vasodilator that acts on H\textsubscript{1} and H\textsubscript{2} receptors in peripheral vasculature (Powell & Brody 1976).\textsuperscript{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).\textsuperscript{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.\textsuperscript{62,27}

Franklin et al\textsuperscript{27} 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.\textsuperscript{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 al\textsuperscript{27} 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.\textsuperscript{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.\textsuperscript{1} 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,\textsuperscript{26,45} where prolonged exposure to stress results in increased levels of the catecholamines, norepinephrine and epinephrine, and cortisol.\textsuperscript{52} 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.\textsuperscript{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.\textsuperscript{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.\textsuperscript{49–51} Discrepant findings may be attributable to some of the authors reporting within-group analysis\textsuperscript{23} or using percentage of change as the measure of effect,\textsuperscript{24} whereas
other authors converted the results of RCTs into standardized MD effect sizes that compared the effect of MT against control treatment.

Subjective and Objective Central Changes

Of all potentially moderating variables, anxiety has been described most frequently. Moyer et al. 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.

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. 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. Other research has shown that adolescents with greater relative right frontal electroencephalogram (EEG) activation (associated with negative effect) and symptoms of depression demonstrated reduced EEG asymmetry after receiving MT. Others have found that MT involving moderate pressure increases positive effect with a shift toward left-frontal EEG activation. It is conceivable that the reduction in sympathetic outflow that is associated with MT is associated in with increased stimulation of the limbic system, including hypothalamic structures involved in ANS regulation.

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. 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.

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 al. noted increases in SBP and DBP among subjects receiving treatments that included a combination of trigger point therapy and sports massage. Conversely, Delaney et al. 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. Third, endothelial dysfunction is recognized as a major factor in the development of atherosclerosis and has significant prognostic value. 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.

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