Immediate Effects of Calf Muscle Release via Foam Rolling and Active Stretching on Blood Pressure, Heart Rate and the Rate Pressure Product in People with High-Normal Blood Pressure – A Comparative Study

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Abstract

Background and need for the research: High-normal blood pressure (i.e., 130–139/85–89 mmHg) has hazardous ratio for both coronary heart disease and stroke, because of day to day variations in blood pressure; consequently, prevention through lifestyle modification is essential. Although numerous studies have examined stretching and self-myofascial release to lower blood pressure, no consensus has been reached regarding which technique is superior for immediate lowering blood pressure. The aim of this study was to evaluate and compare the immediate effects of self-performed foam rolling and active-stretching on blood pressure and myocardial oxygen demand.

Methods: A total of 98 patients with high normal blood pressure (20–40 years of age) meeting the inclusion criteria were randomly divided into two groups. Group 1 (n = 49) performed foam rolling, and group 2 (n = 49) performed TheraBand-assisted active stretching of the calf muscle. The pre and post blood pressure, heart rate, and the rate pressure product were assessed. Statistical analysis was conducted in SPSS software (version 20.0).

Results: Systolic and diastolic blood pressure significantly decreased in both groups (P < 0.05), and the decrease was greater in the active stretching group than the foam rolling group. In the foam rolling group, the heart rate significantly increased, whereas no changes were observed in the active stretching group. The Rate Pressure Product was not significant within and between two groups.

Conclusion and clinical implications: Active stretching as part of a self-performed daily exercise routine appears safer that immediate blood pressure lowering, without affecting myocardial oxygen demand.

Ethics committee approval: Reference No.: EC/Approval/08/Physio/21/06/2023.

Keywords: Active stretching; Blood pressure; Foam rolling; High normal blood pressure

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Abbreviations: SBP, Systolic Blood Pressure; DBP, Diastolic Blood Pressure; HR, Heart Rate; RPP, Rate Pressure Product; SMR, Self-Myofascial Release; BMI, Body Mass Index; RR, Respiratory Rate.
Introduction

Hypertension is defined as chronic elevation of the systemic arterial pressure above a certain threshold value. Accumulating data suggest that the risk of cardiovascular disease rises logarithmically in response to a blood pressure elevation above 115/75 mmHg [1–6]. The hazard ratios for coronary heart disease and stroke are between 1.5 and 2.0 in people with high normal blood pressure (130–139/85–89 mmHg) compared with a blood pressure <120/80 mmHg [7]. In a large electronic medical record cohort study in 1.25 million patients, those with rather than without hypertension had a higher lifetime risk of cardiovascular disease (63 versus 46%) and, on average, developed cardiovascular disease 5 years earlier [8]. For each 20/10 mmHg increase in systolic blood pressure (SBP)/diastolic blood pressure (DBP), the coronary heart- and stroke-related mortality doubles [9–15].

Empirical data have indicated that increasing physical activity levels can lower blood pressure in individuals with normal (<140/90 mmHg) or high blood pressure [16]. The American College of Sports Medicine position statement recommends engaging in 30 minutes of continuous or cumulative, mostly aerobic, physical exercise at moderate intensity on most days of the week to lower blood pressure [17]; this recommendation is supported by systematic reviews [16]. Consequently, people with hypertension are strongly advised to follow an appropriate exercise regimen. However, according to publicly available data, few people perform exercise sufficient to prevent their blood pressure from rising [18]. According to a 2018 WHO Report [19], 81.0% of adolescents (11–17 years old) do not exercise for more than an hour a day, and 1.4 billion adults (18 years of age or above), or one in four, under exercise. Although evidence has indicated that stretching and myofascial release can aid in controlling blood pressure, which method is most effective for immediately controlling blood pressure is not yet known. Thus, an important goal in people with moderately elevated blood pressure is preventing day to day variations and progression via lifestyle modification, as medications are not yet recommended.

Thus, the aim of this study was to determine which of two methods is most effective in immediate control of blood pressure in people with high normal blood pressure, and to add lifestyle modification to increase treatment effectiveness. We evaluated and compared the immediate effects of two self-exercise techniques, foam rolling (group 1) and active stretching (group 2), on the blood pressure, heart rate, and rate pressure product in individuals with high normal blood pressure.

The objectives of the study were to compare the immediate effects of foam rolling and active stretching exercises on the following parameters in people with high normal blood pressure:

1. Blood pressure
2. Heart rate
3. Rate pressure product
Materials and Methods

This comparative study was conducted at a tertiary cardiac center in Ahmedabad city, India, and was performed with the approval of the institutional ethical committee. Each participant was informed about the purpose and course of the study, and written consent was obtained.

The inclusion criteria were age between 20 and 40 years; high normal blood pressure (SBP: 130–139 mmHg and/or DBP: 85–89 mmHg) in accordance with guidelines [7]; and no medication use. Patients with metabolic disorders, a history of unstable or severe cardiac disease, lower limb DVT, peripheral artery occlusion disease, recent upper limb or lower limb injury, amputation, non-cooperativeness, use of blood pressure and/or diuretic medications, or participation in any other clinical trial were excluded. The termination criteria were pain and inability to continue the study.

The materials required were as follows: pencil, pen, paper, rubber, consent form and assessment form, sphygmomanometer, weighing machine, stadiometer, foam roller, TheraBand, oximeter, mat, stopwatch, and stethoscope.

The patients included in the study were randomly screened for eligibility according to the inclusion criteria. According to the sample size calculation, 116 patients with high normal blood pressure were recruited for the study.

Blood pressure was manually measured according to previously described guidelines [28] with a mercury sphygmomanometer (Diamond mercu- rial blood pressure apparatus, India). Participants relaxed for at least 5 minutes in a quiet environment on a chair, with their feet flat on the floor and an arm resting at heart level. The cuff was wrapped around the left arm above the level of the cubital fossa and fastened properly. The average value was determined from three measurements [29]. Information on sociodemographic characteristics, related comorbidities, and medical conditions were taken. The sociodemographic factors were age, sex, occupation, and residence. The clinical history of recent illness, smoking, acute infection, skin disease, diabetes, medicines, hypertension, musculo-skeletal deformity, and pain, as well as the family history, was obtained. A calibrated scale was used to calculate body weight to the nearest 0.01 kg, and a stadiometer was used to calculate height to the nearest 0.01 m. The body mass index (kg/m²) was calculated according to these values.

A total of 98 of 116 patients were enrolled; 11 did not meet the inclusion criteria, and seven did not provide consent. The participants were random- ized into two groups of 49 patients each – a foam roller group (group 1) and active stretching group (group 2) – with concealed allocation. The groups were determined by the patients, who selected concealed papers bearing the labels “G1” or “G2” from a ballot box. The chief investigator subsequently assigned each patient to either the walking group or control group, on the basis of the label G1 or G2, respectively. In this process, every participant had an equal opportunity of being allocated to either group, thus minimizing systemic bias. Allocation was performed by a physiotherapist who was blinded and unaware of the study’s objectives and procedures. The flow diagram of the study is illustrated in Figure 1.

Intervention Procedure

Group 1: Foam Roller Group (n = 49)

The participants were instructed through a SMR procedure using a commercially available foam roller (DECATHLON, Ahmedabad, India; diameter: 12.6 cm; length: 33 cm). The participants were required to roll the targeted leg muscle, the calf muscle, back and forth over the foam roller for 30 seconds, and rest for 30 seconds, on each side. They were required to cover the entire surface area. An investigator provided continuous feedback to ensure the correct form and rhythm. This protocol was similar to that used by Kim et al. [30]. Each technique was performed as shown in Figure 2A. Legs and arms not engaged in the technique were used to offset weight as required.

Group 2: Active Stretching Group (n = 49)

Participants were instructed to sit in long-legged position and grip the TheraBand as depicted in Figure 2B. A stiff blue (CAUGAR, India) TheraBand was used. Participants stretched the plantar flexors three times on each side, with a 30 second hold duration followed by 30 seconds of
rest. Constant feedback was provided to maintain appropriate stretching for 30 seconds. This protocol was used by Buehler et al. [31].

**Sample Size Estimation**

The sample size was calculated on the basis of the mean and standard deviation of the SBP, at 90% power, with a 95% confidence interval, according to a previous study [32].

**Outcome Measures**

At 5 minutes before the start of an exercise session, the blood pressure, heart rate, and rate pressure product were measured. Blood pressure was measured at the right brachial artery with a sphygmomanometer (Diamond mercurial blood pressure apparatus, India). Heart rate was measured at the right radial artery with a monitoring device (PHILIPS, India). The rate pressure product was calculated with the

**Figure 1**  Flow Diagram of the Study.

**Figure 2**  (A) Self-myofascial release of the calf muscle with a foam roller. (B) Active stretching of the calf muscle with a TheraBand.
The blood pressure, heart rate, and rate pressure product were assessed 5 minutes after the intervention ended. All measurements were conducted on patients in sitting position to control variables. Comparisons between and within groups were made with pre- and post-intervention data.

**Statistical Analysis**

Statistical analysis was conducted in SPSS software (version 20.0). The Shapiro–Wilk test was performed to examine the normal distribution of the data collected. A paired t-test was used to compare all variables before and after intervention. All normally distributed variables, were compared among groups with an independent/unpaired Student’s t-test. The significance level was set at $\alpha \leq 0.05$. All results are presented as mean $\pm$ SD.

**Results**

All participants ($n = 98$) completed the exercise. Participants’ baseline characteristics are presented in Table 1.

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**Figure 3**  Within and between Group Comparisons of Mean Systolic Blood Pressure.

**Figure 4**  Within and between Group Comparisons of Mean Diastolic Blood Pressure.
**Figure 5** Within and between Group Comparisons of Mean Heart Rate.

**Figure 6** Within and between Group Comparisons of the Mean Rate Pressure Product.

**Table 1** Baseline Demographic and Clinical Characteristics.

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Group 1 (n = 49) mean ± SD</th>
<th>Group 2 (n = 49) mean ± SD</th>
<th>P value (P &gt; 0.05)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>30.22 ± 6.32</td>
<td>32.20 ± 6.26</td>
<td>0.12*</td>
</tr>
<tr>
<td>Sex (M/F)</td>
<td>42/7</td>
<td>42/7</td>
<td>0.11*</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.13 ± 4.17</td>
<td>24.19 ± 3.19</td>
<td>0.94*</td>
</tr>
<tr>
<td>RR (breaths per min)</td>
<td>14.29 ± 1.24</td>
<td>14.37 ± 1.20</td>
<td>0.74*</td>
</tr>
<tr>
<td>HR (beats per min)</td>
<td>83.20 ± 15.92</td>
<td>81.90 ± 14.91</td>
<td>0.68*</td>
</tr>
<tr>
<td>SBP (mmHg)</td>
<td>132.18 ± 2.21</td>
<td>132.86 ± 2.40</td>
<td>0.15*</td>
</tr>
<tr>
<td>DBP (mmHg)</td>
<td>86.52 ± 1.44</td>
<td>86.41 ± 1.35</td>
<td>0.71*</td>
</tr>
</tbody>
</table>

*Indicates P > 0.05.

BMI, body mass index; RR, respiratory rate; HR, heart rate; SBP, systolic blood pressure; DBP, diastolic blood pressure.
No statistical difference was observed between groups in terms of baseline demographic and clinical characteristics (P > 0.05), as detailed in Table 1. Table 2 shows the within group effectiveness of exercise, on the basis of pre- and post-intervention data analysis.

A significant decrease in systolic and DBP was observed in both groups (P < 0.05). In the foam rolling group, the heart rate was clear elevated, whereas in the active stretching group, no significant changes were observed. Moreover, no changes in the rate pressure product were observed in both groups (Table 2).

Table 3 shows a between group comparison of the foam rolling group and active stretching group, to determine which technique was more effective.

A more significant decrease in SBP and DBP was observed in the active stretching group than the foam rolling group (P < 0.05). The heart rate and rate pressure product did not differ between the foam rolling and active stretching groups. Active stretching, compared with foam rolling, was associated with significantly lower SBP and DBP when the baseline measurement was used as a covariate and compared with the post-exercise results (Table 3).

### Discussion

This study was conducted to assess and compare the immediate effects of self-myofascial release by foam rolling and active stretching of the calf muscles in patients with high normal blood pressure. Foam rolling and active stretching of the calf muscle were immediately effective in the treatment of high normal or elevated blood pressure, and the active stretching group showed better results than the foam rolling group. Furthermore, no changes in heart rate occurred in the active stretching group. However, a recent meta-analysis by Kato et al. has indicated that stretching workouts decrease the resting heart rate and blood pressure, while also improving endothelial function and decreasing arterial stiffness [32]. The exercises used in this study were self-performed, and no significant changes in RPP were observed. Accordingly, our findings demonstrate a safe method for blood pressure control that does not affect myocardial oxygen demand.

Numerous studies in the literature have reported a decrease in blood pressure, a decrease in arterial stiffness, and improvement in vagal tone with active stretching of the calf muscle, in agreement with

Table 2  Pre- and Post-Data Comparison within Group 1 and Group 2.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Group 1</th>
<th>P value</th>
<th>Group 2</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP Pre</td>
<td>132.18 ± 2.21</td>
<td>0.00*</td>
<td>132.86 ± 2.40</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>125.55 ± 3.92</td>
<td></td>
<td>124.04 ± 3.23</td>
<td></td>
</tr>
<tr>
<td>DBP Pre</td>
<td>86.52 ± 1.44</td>
<td>0.00*</td>
<td>86.41 ± 1.35</td>
<td>0.00*</td>
</tr>
<tr>
<td></td>
<td>81.14 ± 2.77</td>
<td></td>
<td>79.59 ± 2.16</td>
<td></td>
</tr>
<tr>
<td>HR Pre</td>
<td>83.20 ± 15.92</td>
<td>0.00*</td>
<td>81.90 ± 14.91</td>
<td>0.32†</td>
</tr>
<tr>
<td></td>
<td>91.84 ± 14.84</td>
<td></td>
<td>87.22 ± 13.71</td>
<td></td>
</tr>
<tr>
<td>RPP Pre</td>
<td>10,995.90 ± 2104.60</td>
<td>0.19†</td>
<td>10,875.31 ± 1943.17</td>
<td>0.88†</td>
</tr>
<tr>
<td></td>
<td>11,535.51 ± 1932.38</td>
<td></td>
<td>10,819.43 ± 1725.21</td>
<td></td>
</tr>
</tbody>
</table>

*Denotes statistically significant value; P < 0.05 indicates significance, whereas P > 0.05 indicates non-significance. †indicates P > 0.05.

Table 3  Post Intervention Comparison between Group 1 and Group 2.

<table>
<thead>
<tr>
<th>Measures</th>
<th>Group 1</th>
<th>Group 2</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>SBP</td>
<td>125.55 ± 3.92</td>
<td>124.04 ± 3.23</td>
<td>0.04*</td>
</tr>
<tr>
<td>DBP</td>
<td>81.14 ± 2.77</td>
<td>79.59 ± 2.16</td>
<td>0.00*</td>
</tr>
<tr>
<td>HR</td>
<td>91.84 ± 14.84</td>
<td>87.22 ± 13.71</td>
<td>0.11†</td>
</tr>
<tr>
<td>RPP</td>
<td>11,535.51 ± 1932.38</td>
<td>10,819.43 ± 1725.21</td>
<td>0.06†</td>
</tr>
</tbody>
</table>

*Denotes statistically significant value; P < 0.05 indicates significance, whereas P > 0.05 indicates non-significance. †indicates P > 0.05.
our findings indicating immediate improvements in blood pressure with such stretching. Two large cross-sectional studies have evaluated the relationships among flexibility, arterial stiffness, and blood pressure. One study in 1150 adults has not found a correlation between blood pressure and flexibility; however, participants categorized as having “poor” flexibility in a sit-and-reach test – which measures flexibility in the lower back, calf, and hamstrings – had significantly greater arterial stiffness than those classified as having “good” flexibility [33]. In the second study, in 566 adults, those over 40 years of age with poor flexibility had 30% higher arterial stiffness and 5 mmHg higher SBP than those with adequate flexibility [34].

Stretching may be useful in lowering blood pressure through a variety of physiological processes. Similarly to flexibility exercise, muscle stretching opens blood vessels. Stretching muscles, like flexibility training, stretches the blood vessels [35]. Blood vessel structural alterations might result, thereby altering the blood vessel diameter, or decreasing the arterial stiffness and flow resistance, and ultimately lowering blood pressure [36]. Stretching may also affect blood pressure by causing endothelial cells to produce metabolites, which in turn lead to vasodilation, when blood vessels are stretched. Stretching raises nitric oxide synthase levels, thus increasing exercise-induced endothelial-dependent vasodilation and blood flow, while lowering blood pressure [37]. Finally, stretching may influence the blood pressure through effects on the parasympathetic and sympathetic nervous systems. After an acute stretching session, the parasympathetic nervous system is more activated and the sympathetic nervous system is less activated, thus decreasing resistance to blood flow, blood pressure, and vasoconstriction, and increasing vasodilation [38].

The foam rolling group showed a significant decrease in SBP and DBP. The slow, gentle, and gradual stimulation of the calf muscle’s fascia and Ruffini endings is believed to activate the parasympathetic nervous system and consequently decrease blood pressure [39]. Kim et al. [30] have found that cortisol, a stress hormone, decreases after self-myofascial release. This finding has been explained by the fascia relaxing and suppressing the sympathetic nervous system. Thus, the parasympathetic nervous system may be activated, and blood pressure may decrease, as a result of fascia relaxation. Furthermore, Mense et al. have proposed that myofascial release also stretches the deep fascia surrounding the internal organs, thereby releasing neurotransmitters that can affect the cardiovascular system, and that this process regulates the autonomic nervous system’s balance by stimulating mechanoreceptors 3 and 4 [40, 41].

The current study did not identify the precise mechanism responsible for the increase in heart rate in the foam rolling group. However, the mechanical stress of foam rolling was likely to activate the cardiovascular response, thereby increasing the heart rate for a shorter period of time.

Conclusion and Clinical Implications

The present study clearly demonstrated that foam rolling and active stretching of the calf muscle had immediate blood pressure lowering effects in patients with high normal blood pressure, without affecting myocardial oxygen demand. Additionally, active stretching immediately decreased the blood pressure without affecting the heart rate. Therefore, active stretching appears to be safe, and self-performing daily exercise to lower blood pressure, and decrease the morbidity and mortality associated with cardiovascular events, is recommended for all patients with high normal blood pressure.

Limitations and Future Recommendations

The study’s limitations were that no physiological changes in arterial stiffness, vasodilation, or parasympathetic nervous system activation were examined, because doing so would have required clinical testing and precise investigation reports from qualified medical professionals.

The short-term blood pressure, heart rate, and rate pressure product were measured during this investigation. Future longitudinal studies are necessary to determine the long-term benefits of physical stretching in lowering blood pressure and enhancing quality of life. Further research on the effects of active stretching on populations with disease
should be performed, because all our participants were young, healthy adults free of cardiovascular disease. Furthermore, studies using a control group should be performed.

Conflicts of Interest

There are no conflicts of interest.

Data Availability Statement

Data will be made available if required.

Ethical Statement and Consent

The study was approved by our institute’s ethics committee (IEC: EC/Approval/08/Physio/21/06/2023). Written consent for submission and publication of this research was obtained from the patients.

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REFERENCES


