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THE EFFECT OF ISOMETRIC HANDGRIP TRAINING ON BLOOD PRESSURE

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ABSTRACT

The aim of this study was to determine the effect of single-bout isometric handgrip training on systolic (BPS) and diastolic blood pressure (BPD). Healthy normotensive (BP<120/80 mmHg) (n=6) and prehypertensive (BPS 120–139 mmHg and/or BPD 80–89 mmHg) (n=6) women with mean age of 47.3±14.0 years, who did not take antihypertensive medicine, participated in the study. Blood pressure (BP) was measured with aneroid sphygmomanometer Riester Precisa N (Germany). Thereafter with the JAMAR hydraulic hand dynamometer (USA) maximal isometric contraction (MVC) was recorded. After a rest of 3 min, the subject was asked to perform the isometric contraction at 30% of MVC for 2 min and that was repeated for four times with rest of 1 min after each bout of contraction. BP was measured again after a rest of 3 min and 3 hrs. **3 min** after isometric exercise no statistically significant changes in BPS and BPD was observed. But clinically meaningful BPS decrease was observed and confirmed by subgroup analysis with decrease in BPS among prehypertensive subjects. **3 hrs** after isometric exercise BPS and BPD were significantly reduced and the decrease in BPS was also clinically meaningful. Subgroup findings showed among normotensive significant and clinically meaningful reduction in BPS and BPD, respectively, as well as clinically meaningful reduction in BPS among prehypertensive subjects. According to this study we suggest that isometric handgrip training could be considered as BP lowering training method.

Keywords: *isometric handgrip training, blood pressure*

INTRODUCTION

The prevalence of hypertension among adults of 25 years and above is approximately 40% and hypertension is the most important risk factor for cardiovascular disease [6]. *World Health Organization* states that cardiovascular diseases take the lives of 17.9 million people every year [29]. For example, in China in the majority of patients with hypertension, BP is not effectively controlled. 80% of all the patients the hypertension is not effectively controlled [25]. Currently, the recommended exercise programme for blood pressure management in adults is dynamic endurance aerobic exercise of at least 150-min moderate intensity, 75-min vigorous intensity, or an equivalent combination of both each week, as well as at least 2 days of muscle strengthening [21]. The adherence to recommended exercise criteria is generally poor worldwide, so recently isometric handgrip training has gained attention as there is some evidence about its BP lowering effect. Handgrip training is easily applicable (i.e. easy to use and can be performed anytime and anywhere), inexpensive, hence accessible to the global population, and may be preferred by individuals who find physical activity non pleasant and could offer a valuable new therapeutic adjunct in the overall approach for treating hypertension [3,8].

The process of progression from normotensive or prehypertension to hypertension can be delayed or prevented by proper and timely clinical interventions [24]. Isometric handgrip training could serve as a prophylactic intervention for those at risk of developing hypertension and as a nonpharmacological treatment option for those already suffering from hypertension.

Participants in this study were normo- and prehypertensive women, who were not on antihypertensive medications and our goal was to find out the effect of single isometric handgrip training on their BP values.

MATERIALS AND METHODS

Subjects

Normotensive (BP<120/80 mmHg) (n=6) and prehypertensive (BPS 120–139 mmHg and/or BPD 80–89 mmHg) (n=6) women aged 21–65 years were selected from Tartu Health Care College and the National Archive of Estonia by convenience sampling. Exclusion criteria were consumption of antihypertensive medications, carpal tunnel syndrome, wrist/finger joint arthritis, diabetes, chest pain, vertigo or loss of consciousness during physical activity, cardiac disease, asthma, epilepsy. Written informed consent was obtained from participants. Approval for this study was given by the Research Ethics Committee of the University of Tartu (protocol number: 277/T-19).
Participants' eligibility was determined by health status questionnaire and BP level, taken by researcher. Anthropometric data are presented in Table 1.

Table 1. Description of the participants.

Variable	Mean±SD
Age (years)	47.3±14.0
Height (cm)	168.0±6.3
Body mass (kg)	64.5±0.7
Body mass index (kg/m^2)	22.9±1.8

Study design

Study was conducted in Tartu Health Care College February-March 2018. Baseline BP measurements and handgrip training was performed between 9:00–12:00. BP was measured with aneroid sphygmomanometer Riester Precisa N (Germany) on dominant arm based on *American Heart Association* guidelines [12] (Figure 1).

Figure 1. Measuring of blood pressure.

After that the handle of the JAMAR hydraulic hand dynamometer (USA) was compressed, keeping arm adducted, elbow flexed 90°, the forearm and wrist in neutral position, with maximal effort for 5 s and isometric contraction was recorded. Three attempts were given with a pause of 30 s between each attempt. Mean of these three readings was taken as maximal voluntary contraction (MVC) (Figure 2). It was not allowed to smoke, drink coffee, tea, energy drinks and alcohol, to eat big meal 30 min before BP measurements and not to have sports activities on the same day. Each time BP was measured twice, and the average value was calculated. The interval between two measurements was 1 min.

After a rest of 3 min, the subject was asked to perform the isometric contraction at 30% of MVC with the dominant arm for 2 min (Figure 3). Subject sat on a chair and faced mirror to monitor the readings on the dial of dynamometer to keep required 30% MVC. Exercise was repeated for four times with rest of 1 min after each bout of contraction. Participant was instructed to perform normal respiration during exercise to limit any Valsalva effect. BP was measured again after a rest of 3 mins and 3 hrs.

Figure 2. Measuring maximal voluntary isometric grip strength.

Figure 3. Isometric handgrip training.

Statistical analysis

The data were analyzed using Microsoft Excel 2010 software. All data are expressed in mean and standard deviations (Mean±SE). Comparative analysis was carried out using Student t-test (statistical significance was set at $p<0.05$).

RESULTS

Changes in Systolic blood pressure (BPS)

The mean baseline BPS was 121.8±3.7 mmHg. We observed statistically significant ($p<0.01$) decrease in BPS (5.1 mmHg) from baseline 3 hrs after training (Figure 4).

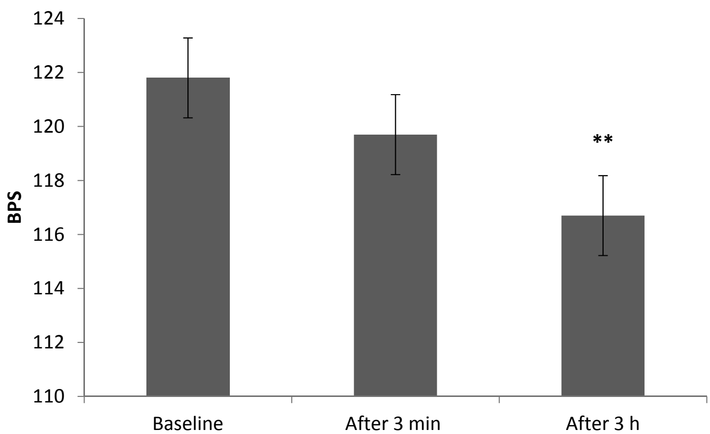

Figure 4. Systolic blood pressure (BPS) at baseline, 3 minutes (min) and 3 hours (h) after isometric handgrip training (Mean±SE), **significantly different compared to baseline; $p<0.01$.

Changes in Diastolic blood pressure (BPD)

The mean baseline BPD was 76.1±2.3 mmHg. Three hrs after training BPD was significantly ($p<0.05$) decreased (1.58 mmHg) compared with baseline (Figure 5).

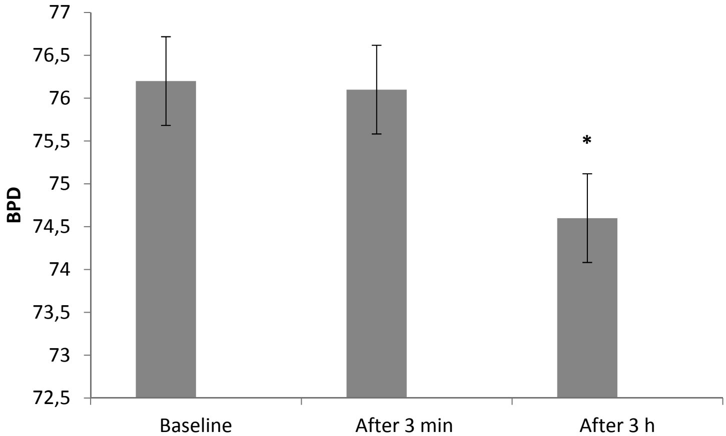

Figure 5. Diastolic blood pressure (BPD) at baseline, 3 minutes (min) and 3 hours (h) after isometric handgrip training (mean±SE); *significantly different compared to baseline; p<0.05.

Blood pressure (BP) changes in subgroups of normo- and hypertensive subjects

Subjects were divided into two groups based on their baseline BP values: normo- and prehypertensive. Subjects were classified as normotensive (n=6), if their BP was <120/80 mmHg and as prehypertensive (n=6) with BP 120-139/80-89 mmHg.

Normotensive subjects

The mean baseline BPS in a group of normotensives was 111.6±1.3 mmHg and BPD 71.5±2.8 mmHg. Three hrs after isometric handgrip training significant ($p<0.05$) decrease in BPS (6.7 mmHg) was observed compared with baseline and data obtained 3 minafter training (7 mmHg) ($p<0.01$) (Figure 6).

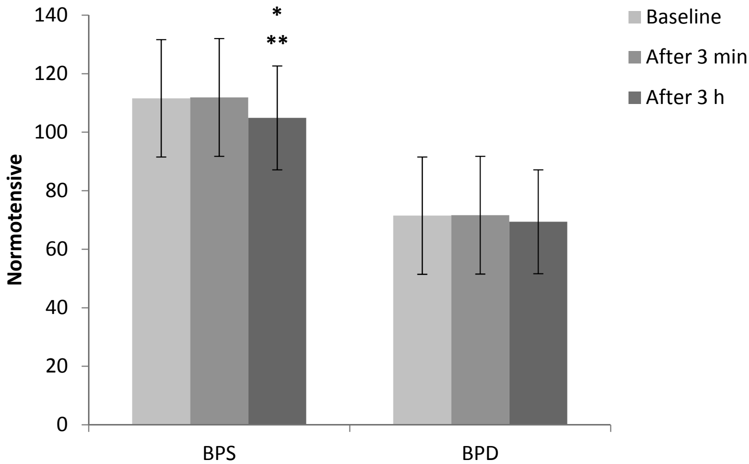

Figure 6. Systolic blood pressure (BPS) and diastolic blood pressure (BPD) of normotensive subjects at baseline, 3 minutes (min) and 3 hours (h) after isometric handgrip training (mean±SE); *significantly different compared to baseline; p<0.05; **significantly different compared to data obtained 3 minutes after training; p<0.01.

Prehypertensive subjects

The mean baseline BPS in a group of prehypertensive was 132±4 mmHg and BPD 80.8±2.7 mmHg. There were no statistically significant changes in BPs during study (Figure 7).

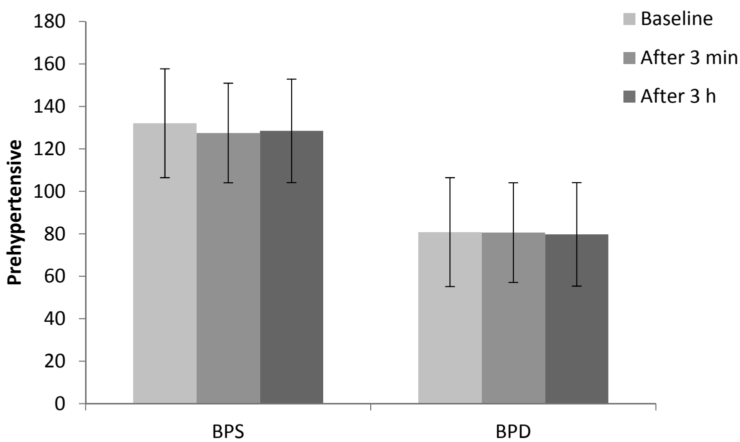

Figure 7. Systolic blood pressure (BPS) and diastolic blood pressure (BPD) of prehypertensive subjects at baseline, 3 minutes (min) and 3 hours (h) after isometric handgrip training (Mean±SE). There were no statistically significant changes in BPs during study; p>0.05.

DISCUSSION

Hypertension is a major risk factor for cardiovascular disease, affecting 1 billion people worldwide [9]. Numerous studies have investigated the effects of aerobic training on BP, and since the effect of isometric training has been studied less, it hasn't yet been accepted as BP lowering treatment strategy [10]. Hypothetically, if single handgrip exercise could help to lower BP even for couple of hours, the patient could exercise several times a day, and regularly to get more pronounced and longer lasting effect on BP, because training takes only couple of minutes and can be performed literally everywhere. This could potentially prevent and decrease the risk problems related to high blood pressure [26].

Unilateral handgrip training protocol (4x2 min, 30% MVC, separated by 1 min of rest between sets) was used. Similar protocol has been used as well by McGowan et al. [17, 18], Badrov et al. [2], Carlson et al. [6], van Assche et al. [26], Ash et al. [1], Goessler et al. [14]. The main consideration choosing similar protocol to van Assche et al. [26] was that a short-term statistically significant BP lowering effect was observed in their study. The methodical difference was that van Assche et al. [26] performed bilateral handgrip training. We preferred to use unilateral intervention, since based on a meta-analysis and systematic review [16] it has been shown to have the greatest BP lowering effect.

It is well known that while performing isometric exercise, the BP increases [27]. To find out how fast is the recovery after isometric handgrip training, we first measured BP 3 min after training. Van Assche et al. [26] demonstrated that 1 min after handgrip exercise, BP was still statistically significantly increased compared to baseline. Olher Rdos et al. [22] reported, that 5 minafter training BP had returned to pre-training values.

We observed 3 min after training clinically meaningful decrease in BPS (2.1 mmHg). In between groups comparison revealed that BP in normotensive did not change, but in prehypertensive clinically meaningful decrease in BPS (4.6 mmHg) was noticed. Post-exercise hypotension (PEH) is commonly observed following aerobic and dynamic resistance training. PEH has been demonstrated as well in prehypertensive [28] and hypertensive [23] subjects after isometric handgrip training and studies have indicated that persons with higher baseline BP demonstrate more pronounced PEH [14]. Meanwhile Bond et al. [4] detected that 7 min after isometric exercise BP among prehypertensive women was statistically significantly higher compared with normotensive. These contradictory results can be attributed to the fact that Bond et al. [4] assessed the effect of only single exercise (1×3 min), but Souza et al. [23], Williams III [28] and current study measured changes in BP after several squeezes. In addition, in the study of Bond et al. [4] participants were African-Americans, among whom prevalence of hypertension is higher, related to genetic and environmental factors [11]. Their mean BP is higher and the likelihood for daily ambulatory BP reduction is smaller [21]. Therefore, their vascular adaptation to isometric training might be somewhat different [4].

Van Assche et al. [26] assessed the effect of training again 7 hrs, Olher Rdos et al. [22] and Souza et al. [23] 1 hrs after training. Olher Rdos et al. [22] did not notice any significant changes in BP, but in other studies statistically significant reduction in BP was detected. It is difficult to explain the differences in the results between the studies by Olher Rdos et al. [22] and Souza et al. [23]. Results could have been influenced by the age, since the subjects in the study of Souza et al. [23] were elderly (^{3}71 years) with hypertension, and in the other studies the subjects were significantly younger. In current study we noticed that 3 hours after isometric training BPS and BPD were statistically significantly reduced (5.1 mmHg and 1.6 mmHg, respectively) and the decrease in BPS was also clinically meaningful. Subgroup findings revealed among normotensive statistically significant and clinically meaningful reduction in BPS (6.7 mmHg) and BPD (2.1 mmHg), respectively. As well clinically meaningful reduction in BPS (3.6 mmHg) among prehypertensive subjects was noticed, meanwhile the reduction in BPD can't be considered as clinically meaningful (1.1 mmHg). Mortimer et al. [20] described BP lowering effect to the same extent among middle-aged women. Hypertension increases progressively the risk for having cardiovascular disorders. BPS increases almost linearly with age, with 90% probability developing hypertension [7, 14]. The reduction in BPS and BPD ≥2 mmHg is considered clinically meaningful, since it is associated with significant risk reduction in the incidence of heart failure among normo- and hypertensive individuals [15]. 2 mmHg reduction in BPS decreases stroke and coronary heart disease deaths rate by 6% and 4%, respectively; reduction of 5 mmHg will further cause reductions of 14% and 9%, respectively [26]. And the decrease in BP even only for couple of hours during a day is already important for cardiovascular diseases risk reduction.

In summary, systematic reviews and meta-analyses have demonstrated BP reductions after isometric training: 6.7/3.9 mmHg [5], 5.2/3.9 mmHg [16] that corresponds to findings in our study. *US Food and Drug Administration* has approved hand dynamometers for BP reduction (Figure 8), that could be used at home [8].

Although the mechanisms responsible for BP reduction remain to be fully clarified, improvements in conduit and resistance vessel endotheliumdependent dilation, oxidative stress, and autonomic regulation of heart rate and BP have been reported [19].

Isometric handgrip exercise training involves a markedly smaller time commitment compared with traditional aerobic exercise training recommendations [19] and could serve as an alternative to aerobic training. Limitations of this study were small sample size, lack of randomization and control group. Future research should concentrate on the long-term training effectiveness of regular isometric handgrip training for the reduction of resting BP.

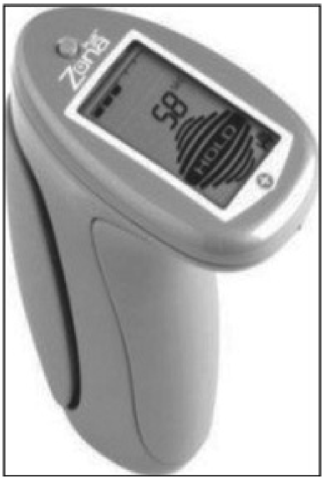

Figure 8. Zona plus hand dynamometer (Zona Health, Boise, ID) [8].

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