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Important Mechanisms of Reducing Blood Pressure following Isometric Handgrip Exercises in Hypertensive Women

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Cardiovascular diseases are known to be the leading cause of death around the world, accounting for more than 17 million deaths annually. The main cause of this type of disease is high blood pressure. Prevention and treatment of hypertension are of great importance given the high prevalence and side effects of high blood pressure. Research has shown that high blood pressure (BP) is a major risk factor for cardiovascular diseases)1(. Hypertension (HTN), or a chronic increase in arterial blood pressure, affects one billion people all over the world annually and is the main factor for mortality of about 7 million people globally, which imposes a significant financial and public burden on societies. That said, 33% of adults in the world are afflicted with HTN, whose incidence of course increases with age (2). In Iran, the highest risk of cardiovascular disease events is attributed to high blood pressure; in 2005, about 6.6 million Iranians aged 25 to 64 had high blood pressure. According to the latest statistics, in 2019, about 27% of women had hypertension and 45% had prehypertension. As a result, the study of the disease in women is believed to be crucial (3). In addition, the high incidence of HTN could lead to a significant increase in mortality and disability among people (4).

A low 2-mm Hg decrease in blood pressure, even in a healthy person, can prevent 67,000 (4%) and 3400 (6%) premature deaths from cardiovascular diseases and stroke per year, respectively, which indicates the importance of maintaining blood pressure in the natural healthy range (4). As a result, alternative therapeutic options are required for HTN treatment. However, the efficacy of drug therapy is often incongruous and up to 50% of hypertensive patients who consume antihypertensive drugs may still have high levels of arterial blood pressure. Although certain antihypertensive medications are affordable, they have adverse effects imposing financial burden and an unpleasant cultural nuisance that has inhibited their use in several countries. Lifestyle changes, such as diet modification and exercise interventions, are non-drug treatments suggested for hypertension (1). On the other hand, exercise is as non-pharmacological method for treating hypertension and according to previous studies, isometric exercise activity of the handgrip has caused the greatest reduction in blood pressure.

The initial recommendations to regulate blood pressure have been mentioned as aerobic exercises since it reduces blood pressure, improves the quality of life, and the pathophysiological factors involved in hypertension (5). However, it has been shown that dynamic and static (isometric) resistance training programs are effective as anti-hypertensive sports models (6). A higher level of blood pressure decrease has been reported in isometric exercises (9.10 mmHg in systole BP (SBP) and 2.6 mmHg in diastole BP (DBP)) compared with dynamic resistance exercises (8.1 mmHg in systole and 2.5 mmHg in diastole) and aerobic exercises (5.3 in systole and 7.3 in diastole) (5).

Compared to aerobic exercises, physiological isometric exercises are associated with a lower myocardial oxygen demand (due to a slight increase in heart rate and diastolic blood pressure increase in contrast to aerobic exercise) as well as increased coronary blood flow (6). Moreover, the addition of isometric exercises to dynamic aerobic exercise can decrease the drop in ST segment (an interval between ventricular depolarization and ventricular repolarization) in the electrocardiography and the occurrence of myocardial ischemia (5). Spontaneous respiratory depression without the use of Valsalva maneuver (respiration under pressure from closed

glottis) is another indication of a proper and safe blood pressure response during isometric exercises (7).

Studies have reported a significant decrease in resting blood pressure in people with normal blood pressure (8, 9), pre-hypertension (6, 10, 11), high blood pressure (12, 13), young people (9), old people (10, 12, 13), men (8-10), and women (5, 13). Handgrip exercises, including four two-minute contractions with 20-50% maximum voluntary contraction with 1 to 5 minutes of rest between the turns and a total time of 20 minutes, have been reported as the most common isometric protocols used to lower blood pressure in healthy people and hypertensive patients (10, 12, 13).

In general, exercise program is one of the most important non-pharmacological strategies for reducing the risk of cardiovascular diseases owing to its simplicity, low cost, and most importantly, non-interference with other treatments (5).

Since aerobic exercise (traditional) often requires an open free environment or special equipment with significant energy consumption to lower blood pressure, it also requires a high consumption time, which may usually be less adherent to such exercises and some studies have identified time constraints as one of the barriers (1, 4).

In conclusion, Isometric Handgrip (IHG) exercise has been recommended since it could be done anywhere and anytime with relatively inexpensive and simple equipment. It is also noteworthy that the pressure it puts on the cardiovascular system is not the same as that of aerobic activities. Certain studies have indicated the greatest effect of these exercises on lowering blood pressure and assumed it as a very useful and effective approach to the treatment, management, and improvement of various health indicators of HTN disease (12, 14).

In the present study, the mechanisms responsible for decreasing blood pressure in Isometric Handgrip (IHG) exercises were as follows:

1. **Improved Antioxidant Capacity:** Overproduction of Reactive Oxygen Species (ROS) relative to the antioxidant capacity of cells plays an important role in vascular damage and HTN pathophysiology (6). Research has shown an increased production of superoxide anions (14), reduced nitric oxide synthesis, and decreased bioavailability of antioxidants in HTN patients (13). Decreased systolic blood pressure (SBP) (13 mmHg) following isometric exercises in the study of Peters and colleagues (6) was reported to be a function of endothelium-dependent dilatation via the increase in nitric oxide (NO) production and antioxidant capacity (+61%), as well reduced oxidative stress (-266 %).

2. Improved Endothelial Function: On the other hand, HTN is associated with impaired endothelial function, decreased NO production, vasodilation, and pro-inflammatory factors in the vasculature (12). The decrease in the formation or bioavailability of NO disrupts the endothelial-dependent vasodilatation, the main causes of which are as follows: 1) decreased concentration of L-arginine (the amino acid required for NO synthesis); 2) reduced synthesis of nitric oxide enzyme (eNOS, required for synthesis); 3) impaired eNOS4 activation; 4) increased oxidative stress (ROS production through NO degradation); 5) increased formation of endothelial-derived constricting factors (13, 14).

McGowan and colleagues evaluated the effect of both acute IHG exercises in young and healthy people with high and normal resting blood pressures and reported that the increase in shear stress through blood pressure responses enhanced the release and discharge of NO; thus, the endothelial-dependent vasodilation was improved, which reduced the overall peripheral resistance and rest blood pressure (12, 15). The improvement of endothelial-dependent vasodilation is one of the mechanisms responsible for a decrease in resting arterial BP. After acute rhythmic IHG in older people with high blood pressure, there was an increase in the mean blood flow, shear rate, conduction strength, in addition to decreased endothelial-dependent vasodilator resistance and capacity (13, 15).

3. **Altered Activity of Autonomic Nervous System (ANS):** Negative changes are observed in sympathovagal balance (overactivity of sympathetic activity) in HTN (13). These results directed the researchers to consider the autonomic nervous system (ANS) activity assumptions, as a mechanism responsible for decreased blood pressure following an IHG exercise. Taylor and co-workers reported a decrease in SBP and the mean arterial BP. They also suggested that a change in ANS activity might contribute to blood pressure-lowering effects of IHG (16).

4. **Change in Cardiac Output (CO) and Peripheral Resistance:** Finally, it could be stated that the reduced blood pressure induced by isometric exercises is mediated by variations in peripheral

vascular resistance. A limited number of studies have attributed the hypotension due to these exercise types to the reduction in sympathetic vascular tone (13); for example, the mean arterial blood pressure is determined by Total Peripheral Resistance (TPR) and cardiac output (CO); therefore, any reduction in BP is related to either or both of these factors. CO does not commonly change following this type of exercise and the decrease in BP is likely to be dependent upon decreased TPR; however, the change in CO cannot be ignored (8). CO is obtained by Heart Rate (HR) and Stroke Volume (SV) and the decrease in CO may be associated with a decrease in HR. Decreased HR following Isometric Exercises training is related to ANS changes (increased parasympathetic activity and decreased sympathetic activity) (6). It has been also reported that an improved heart rate indicates the activation of post-exercise parasympathetic neural activity (13, 15).

In summary, Handgrip exercises (rhythmic and isometric) improve the local endothelium-dependent vasodilation by improving shear stress and antioxidant activity. Changes in vascular structure and ANS activity increase endothelial-independent dilatation in healthy people and those with hypertension. Isometric exercise, which is important to improved antioxidant capacity, and endothelial function may change the autonomic nervous system and cardiac output.

Conflict of interest: None declared.

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