Perspectives Mechanisms of Underlying Post-Exercise Hypotension

Nasim Habibzadeh

Department of Sport Science, University of Guilan, Rasht, Iran

Abstract: Post-exercise hypotension is defined as a reduced resting blood pressure, sympathetic neural activity and systemic vascular resistance in the minutes and hours following exercise. The mechanisms underlying post-exercise hypotension have not been well established; however, a balance of multiple interacting mechanisms including neural, humoral and vascular mechanisms has the potential to impact on it. In fact, based on experimental researches the magnitude of the post-exercise hypotension can be translated into prevention and/or treatment of hypertension. So it is important to know the mechanism underlying post-exercise hypotension as a tool to tackle the cardiovascular disease associated with a sedentary lifestyle such as hypertension.

Key words: Post-Exercise Hypotension • Sedentary Lifestyle • Hypertension

INTRODUCTION

Physical activity is considered to be a non-pharmacological strategy for control of hypertension [1, 2] in the form of phenomenon which is called post-exercise hypotension (PEH). It characterizes with reduction in resting blood pressure, sympathetic neural activity (SNA) and systemic vascular resistance (SVR) in the minutes and hours following an exercise bout [3-5]. Literature based on experimental research indicates that the magnitude of the PEH can be translated into prevention and/or treatment of hypertension [6]. The mechanisms underlying post-exercise hypotension have not been well established; however, a balance of multiple interacting mechanisms including neural, humoral and vascular mechanisms has the potential to impact on PEH [7, 8].

In terms of neural mechanism, consistent finding affirmed that decreased post-exercise sympathetic nerve activity is a hallmark observation in post-exercise hypotension [9-12]. Sympathetic stimulation during exercise releases norepinephrine (NE) which acts predominantly on peripheral α-receptors causing vasoconstriction and increase vascular resistance [13]. Measurement of plasma noradrenaline rate ‘spill over’ from sympathetic nerve activity determine sympathetic neural outflow in bloodstream [14]. Meredith et al. [15] found reductions in plasma NE after endurance training were related to decreased spillover and not increased clearance, suggesting a decrease in sympathetic nerve activity (SNA). More recently, Brown et al. [16] stated that training-induced decreases in blood pressure in older mild hypertensive subjects which were associated with reduced NE release rate.

Regarding to humoral mechanism, evidence suggested post-exercise hypotension represents a homeostatic mechanism in part of the cardiovascular response to an acute bout of exercise [17]. To support this mechanism Hayes et al.[18] have shown PEH facilitates lymph return which enhances plasma water retention through enhanced the protein influx into the blood plasma during recovery period. Collins et al. [19] one year later have demonstrated injections of a vasopressin V_1 receptor antagonist have been shown to attenuate PEH. Released endogenous arginine vasopressin (AVP) enhances the arterial and cardiopulmonary baroreflex inhibition of sympathetic nerve activity as well as reduces the gain of the linear portion of the baroreflex curve and shifts the operating point of the arterial baroreflex to a lower blood pressure after a single bout of dynamic [20]. Blanchard et al. [21] also stated hypertensive patients with three or more polymorphisms associated with the renin-angiotensin-aldosterone system showed greater decreases in post-exercise ambulatory blood pressure. It is known that increase in sympathetic activity is responsible for an increase in renin-angiotensin-aldosterone secretions and a decrease in effective blood volume through vasoconstrictor system [22] thus a fall in...
sympathetic activity following an acute exercise would result in a decline in renin-angiotensin-aldosterone release which influences on vascular volume homeostasis in blood pressure reduction [23].

Vascular mechanism is typified by a rise in systemic vascular conductance in exercise and non-exercise skeletal muscle limbs during PEH that is not always offset by increases in cardiac output [24, 25]. For example in endurance-trained men as well as in elderly people [26] post-exercise hypotension has been shown to attribute by reduction in cardiac output rather than rise in peripheral vasodilation. In general, despite these exceptions, the changes in vascular responsiveness related to PEH in most individual are associated with decreased transduction of sympathetic outflow to vascular resistance and subsequently the release of local vasodilator substances induced by muscle contraction to augment muscle blood flow [27, 28]. The local endothelium-dependent vasodilators secrete some powerful vasorelaxant factors such as substance P, histamine, nitric oxide in which change in vessel diameter and facilitate peripheral vasodilation by the rise in shear stress occurring during PEH [29-31]. Rao et al. [32] reported the reduced a-adrenergic responsiveness after exercise in male spontaneously hypertensive rats may be attributed to nitric oxide. Recent studies by Barrett-O’Keefe et al. [33] also showed post-exercise vasodilatation and PEH following 60 minutes of moderate intensity unilateral dynamic knee-extension exercise is abolished by histamine antagonism in human.

Central Mechanism Underlying Post-Exercise Hypotension: The occurrence of post-exercise hypotension requires a function of baroreflex and activation of muscle afferents suggesting that some interactions in the central neural networks regulating exercise and blood pressure result in this fall in blood pressure [34, 35]. The principal mechanism suggested for this fall in blood pressure is a centrally mediated decrease in sympathetic nerve discharge, the most salient feature of PEH (Figure 1) indicating the involvement of central nervous system (CNS) pathways in both human and rodents [36].

The central neural mechanisms contributing to PEH appear to involve the modulation of barosensitive neurons within the brain stem involving the nucleus tractus solitarius (NTS), caudal ventral lateral medulla (CVLM) and the rostral ventral lateral medulla (RVLM) as an important components in central pathways [37].

The nucleus of the solitary tract is the primary medullary site in which receives signals from both baroreceptors and muscle afferent fibres making it an ideal site for integrating cardiovascular responses to exercise [38,39]. Relatedly, NTS possesses an array of synaptic machinery, such as a complex network of synaptically connected excitatory and inhibitory interneurons, neurotransmitters and peptidergic receptor subtypes in central network to coordinate sympathetic nerve activities and blood pressure changes [40,41].

Within the NTS, α-aminobutyric acid (GABA) inhibitory neurotransmission plays an important role in development of PEH. This effect of GABA inhibition is mediated by GABA<sub>A</sub> receptors [42]. GABAergic inhibition of central neurons can result in pressor or depressor responses depending upon which central site is activated. Pressor responses are often assumed to be the result of GABAergic inhibition of neurons that reduce sympathetic discharge [43]. The pressor effect of GABA neurotransmission appeared to be modulated by substance P-releasing (SPergic) inputs to the NTS [44]. Substance P peptidergic reset blood pressure by shifting the synaptic excitability in the NTS through its interaction with GABAergic synaptic transmission which altered sympathoinhibitory pathways [45]. Substance P has been shown to release from intrinsic SPergic neurones that were synaptically driven by converging neural input from skeletal muscle receptors and arterial baroreceptors onto NTS [46]. Localized microinjection of substance P in the NTS has been reported to evoke hypotension and bradycardia in rats [47]. The later evidence has been demonstrated that a neuropeptide such as substance P, acting on neurokinin 1 receptor (NK1-R) subtype as an exercise pressor in the NTS to trigger PEH after a single bout of dynamic exercise in conscious SHR rat [48].

During exercise, the arterial baroreflex is reset to operate at higher pressures [49]. Simultaneously, thinly myelinated group III (predominantly mechanically sensitive) and unmyelinated group IV (predominantly metabolically sensitive) muscle afferent fibres are activated in response to muscle contraction or stretch and acidification [50,51]. These changes in arterial baroreflex function along with mechanically and metabolically skeletal muscle afferent stimulation, release the extraneuronal of substance P in a cardiovascular-related region of the NTS [52]. Following that, the exogenous substance P at neurokinin -1 receptors (NK-1R) excites cardiovascular related GABA interneurons onto GABA<sub>A</sub> receptors on second order barosensitive neurons [53] through glutamatergic neurotransmitter in the caudal NTS [54, 55]. The second order barosensitive neurons afterward convey information from baroreceptor afferents to the caudal ventrolateral medulla which in turn inhibit the activity of GABAergic neurons in the rostral ventral lateral medulla, the major output neurons controlling cardiovascular sympathetic vasomotor efferent nerve activity [56]. Decreased GABA inhibitory transmission in RVLM results in greater firing of sympathetic vasoconstrictor neurons output that reset blood pressure to a higher level in response to exercise pressor during exercise [57].

As exercise continues, the feedback from skeletal muscle receptors reduce the binding of substance P, released from muscle afferent fibers, to NK1-R on GABA interneuron [58]. The GABAergic neurons then inhibit NTS second order neurons receiving baroreceptor inputs to reset the reflex function curve [59]. Disinhibition of the NTS neurons in the baroreflex pathway could translate to a higher excitatory output from NTS to CVLM and a greater inhibition to the RVLM leading to a lower sympathetic activity. This contributes to an overall decrease in blood pressure immediately after exercise resulting in post - exercise hypotension [60]. Thus it can be simply speculated that blunted sympathoexcitation contributes in part to the reduced incidence of cardiovascular disease associated with a sedentary lifestyle such as hypertension[61].

REFERENCES


