Inflammatory Biomarker Responses to Whole-Body Vibration

Subjects: Others

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Inflammation is considered to be a vital defense mechanism for health, acting as a protective response of the immune system through a satisfactory inflammatory biomarker response (IBR). IBR, as well as being beneficial to the organism, can be also responsible for a variety of chronic inflammatory diseases. Whole-body vibration (WBV) exercise is a type of physical exercise that can act on inflammation responses due its capacity for stimulating the sensory components that promote systemic responses.

Keywords: inflammation ; whole-body vibration exercise ; physical and rehabilitation medicine

1. Introduction

Inflammation is considered to be a vital defense mechanism for health, acting as a protective response of the immune system [1][2]. It restores and defends physiological functions when homeostatic mechanisms are not sufficient, by replacing or suppressing incompatible homeostatic controls [1][2]. Thus, inflammatory mediators act by temporarily deactivating normal homeostasis, with a higher physiological priority placed on achieving a satisfactory inflammatory biomarker response (IBR) [1][2]. IBR (acute or chronic) is the protagonist in defending against life-threatening insults, infection, and injury [1][2][3], and can be triggered by several factors (endogenous or exogenous; infectious or non-infectious) [2][3]. IBR, as well as being beneficial to the organism, is also a potential mechanism for the onset of acute pathological states, which can become chronic when the acute form is not controlled, being responsible for a variety of chronic inflammatory diseases [1][2][3][4], such as osteoarthritis [5], obesity [6], type 2 diabetes [7], fibromyalgia [8], cardiovascular disease [9], and chronic obstructive pulmonary disease (COPD) [10]. IBR also can also be found in elderly populations, leading to inflammaging (i.e., chronic low-grade inflammation associated with aging) [11], as well in healthy individuals after physical exercise [12]. Therefore, it is important to identify physiological responses produced by inflammation in subjects with different clinical status, as the persistence or non-resolution of inflammation can cause changes in the defense mechanisms, leading to an excessive or abnormal IBR [4]. Thus, these mechanisms can be used for the development of anti-inflammatory therapies in chronic inflammatory diseases, including physical exercises.

2. C-Reactive Protein (CRP)

CRP has both pro-inflammatory and anti-inflammatory properties; it is synthesized in the liver hepatocytes and—in lesser quantities—by endothelial cells, smooth muscle cells, lymphocytes, macrophages, and adipocytes [13]. It is a blood marker of inflammation that is normally found in chronic systemic inflammation and used in the risk assessment of cardiovascular disease [14]. Physical exercise seems to reduce the CRP levels in individuals with different clinical status. Han et al. [15] showed in a 2019 meta-analysis that physical exercise can be used as a therapy to reverse the low-grade inflammatory state reducing the CRP levels in children and adolescents with overweight or obesity. Fedewa et al. in 2017 [14], suggested that physical exercise and decreases in body mass index are associated with reductions in CRP levels regardless of age or sex. Kohut et al. in 2006 [16], compared aerobic exercises with flexibility/strength exercises and found greater reductions in CRP levels in the former group. This is consistent with the work of Zheng et al. in 2019 [17], which reported that aerobic exercises can have a beneficial effect in reducing the blood markers of inflammation—including CRP levels—in individuals more than 40 years old. Moreover, El-Kader and Al-Jiffri, in 2019 [18], also reported a significant decrease in CRP in obese post-menopausal women who performed aerobic exercise or resistance exercise training. According to the results, the WBV exercise, as along with other modalities of physical exercise, also reduced the CRP levels. Rodriguez-Miguelez et al. in 2015 [19], showed a decrease in the CRP levels in healthy older adults after 8 weeks of WBV exercise (twice a week) using frequencies of 20–35 Hz. On the other hand, a pilot study by Seefried et al. in 2017

[20] observed no significant decline in CRP levels in individuals with end-stage renal disease (i.e., hemodialysis patients) using frequencies of 14–28 Hz along with other exercises, twice weekly for 12 weeks, before or after hemodialysis sessions. Oh et al. in 2019 [21], observed that CRP levels and hepatic stiffness decreased in individuals with nonalcoholic fatty liver disease subjected to WBV exercise (30–50 Hz) twice a week for 6 months, suggesting that a low-intensity WBV program may be considered the best program for patients who have difficulty engaging in exercise.

3. Cytokines

Cytokines are soluble proteins or glycoproteins that regulate the functions of the immune system, and they can increase (pro-inflammatory) or attenuate (anti-inflammatory) the IBR, making them necessary for the homeostasis of the organism [22]. Changes in the concentrations of cytokines can be balanced with interventions such as physical exercises, including WBV exercise, and this can have beneficial effects on IBR in individuals with various clinical status. Di Giminiani et al. in 2020 [23], found an increase in IL-6 in only one session of WBV (30 or 45 Hz) in young males. Neves et al. in 2014 [24], demonstrated an acute increase in IL-6 after high-intensity physical exercises when compared with low-intensity exercises, while IL-10 showed a greater reduction in response to low-intensity exercises. Cerqueira et al. [12], in a 2020 systematic review, investigated the IBR after different intensities of physical exercise and observed increases in TNF-α and IL-10 only after intense exercise, along with greater increases in IL-6, IL-10, and IL-1β with intense than with moderate exercise. TNF-α is a potent pro-inflammatory cytokine that can perform a variety of biological activities, including inflammation [25]. Hazell et al. in 2014 [26], added WBV exercise (45 Hz) to only one session of the physical exercise (using body mass as the resistance) and found significant increases in IL-1β and IL-6, but with no differences between groups (i.e., with and without WBV). In addition, the IL-10 increased more in healthy males subjected to WBV than in those who engaged in exercise without vibration. Lage et al. in 2018 [27], found higher levels of IL-10 in individuals with COPD after only one session of the WBV exercise (35 Hz) compared with their levels at rest. As IL-10 is an anti-inflammatory cytokine [28], this indicates that WBV exercise can exert significant effects on these anti-inflammatory responses. However, one study compared aerobic exercises with flexibility/strength exercises, measuring IL-6, TNF-α, and IL-18 and finding greater reductions in IL-6 and IL-18 in the aerobic exercises group, whereas TNF-α declined in both groups [16]. Similarly, Zheng et al. in 2019 [17], also found reductions in the TNF-α and IL-6 after aerobic exercises. Oh et al. in 2019 [21], also observed that TNF-α was decreased in individuals with nonalcoholic fatty liver disease after 6 months of WBV exercise (twice a week) at frequencies from 30 to 50 Hz.

sTNFR1 and sTNFR2 are distinct receptors of TNF-α [25]. The expression of these receptors may vary between cell types and tissues. sTNFR1 is expressed on every cell type in the body, while the expression of TNFR2 is limited to endothelial cells, nerve cells, and cells of the immune system [25]. Simão et al. in 2012 [29], found significant reductions in the concentrations of sTNFR1 and sTNFR2 after 12 weeks of WBV (three times per week) using frequencies from 35 to 40 Hz, suggesting that the WBV intervention reduces the IBR in elderly knee osteoarthritis patients. In contrast, Ribeiro et al. in 2018 [30], found a decrease in plasma levels of sTNFR1 and increased levels of sTNFR2 in individuals with fibromyalgia, along with an increase in the sTNFR1 plasma levels in healthy women, after only one session of WBV exercise (40 Hz). This could be explained by the fact that plasma levels of sTNFR1 are already higher in individuals with fibromyalgia at rest, showing a probable attempt to control chronic systemic inflammation [30]. Moreover, Marín et al. in 2011 [31], suggested that the physical exercise load can be increased by using a WBV program or by an improvement of resistance. In addition, it is important to consider the findings described by Rodriguez-Miguelez et al. in 2015 [19], which showed a decrease in TNF-α in healthy older adults after 8 weeks of WBV (twice a week) using frequencies from 20 to 35 Hz, supporting the efficacy of WBV in at least partially counteracting inflammaging.

4. Adiponectin and Leptin

Adiponectin and leptin are adipokines (or adipocytokines) produced by the adipose tissue. Adipokines present pro- and anti-inflammatory actions as well as acting in satiety mechanisms and body weight maintenance and presenting pro- and anti-nociceptive properties that modulate pain perception [32][33]. Their reduction is correlated with increased levels of pro-inflammatory cytokines such as IL-6, IL-12, IL-18, and TNF-α [33]. Bellia et al. in 2013 [34], observed a significant increase in adiponectin after an intervention consisting of 8 weeks of WBV exercise (three times per week) at a frequency of 30 Hz in obese individuals; however, they found no difference in the leptin levels. Oh et al. in 2019 [21], observed that adiponectin increased in individuals with nonalcoholic fatty liver disease subjected to WBV exercise, together with decreases in the TNF-α and CRP levels that could be attributed to the remarkable improvement of hepatic stiffness as a result of the WBV program. However, Ribeiro et al. in 2018 [30], found decreased plasma levels of adiponectin in individuals with fibromyalgia after one session of WBV exercise (40 Hz). They also found an increase in leptin levels, concluding that a

single session of WBV exercise can improve the IBR in patients with fibromyalgia, reaching values close to those seen in healthy women.

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