journal homepage: vibmecbio.com/bjmvb

BJMVB 2024, 2(1):25-33

*Review*

# Efficacy of whole-body vibration exercise on inflammatory biomarkers, clinical, functional and biological aspects in women with fibromyalgia: A narrative review

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## Abstract

**Introduction**: The Whole-Body Vibration (WBV) exercise has been widely applied in clinical practice. Thus, the current review aimed to provide an updated investigation of the current literature on the effects and efficacy of WBV on clinical, functional, and biological parameters in women patients with fibromyalgia (FM). **Methods**: For the purpose of this study databases on PubMed, Cochrane Central Register of Controlled Trials, and Physiotherapy Evidence Database (PEDro) were identified and selected. Articles including single or multiple WBV sessions were recognised. **Results**: Five papers were included in this review (2 case-control studies and 3 RCTs). The sample size ranged from 17 to 20 participants, involving only women diagnosed with FM. The identified outcomes were pain, balance, quality of life, fatigue, disability, and FM-related inflammatory biomarkers. **Conclusions**: Despite the fact that WBV treatment appears to be safe and feasible, there is limited evidence to support the application of WBV in clinical practices in patients with FM. We emphasized on the importance of further studies addressing mechanobiomodulation in FM.

**Keywords**: Systemic vibratory therapy, fibromyalgia, inflammatory markers.

## 1. Introduction

The cause of the chronic illness fibromyalgia (FM) is yet unknown. The FM is defined by widespread inflammatory pain and tenderness which can last up to three months or more, and the presence of the at least 11 out 18 specific tender spots. About 2-3% of people in the general population have FM, and 90% of them are women (1-2). Fatigue, disturbed sleep, decreased cognition, reduced functional ability, headaches, arthritis, muscle spasms, tingling, and balance issues are just a few of the impairments and activity limits linked to FM (3). Ankylosing spondylitis and rheumatoid arthritis are two conditions often linked to FM (4-5).

Finding evidence indicating responses triggered by inflammation is becoming crucial, thereby giving opportunities to potential explanations for the clinical condition of FM patients. As advanced information emerges, it provides a crucial avenue for investigating FM and its

Received 10 February 2024 / Revised form 17 March / Accepted 9 April
ISSN - 2965-9671 

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biological aspects (6-10). In this regard, numerous biological markers that may contribute to this illness have been extensively studied (10).

The development of laboratory tests that enable accurate diagnosis can stem from the isolation of an infectious agent or toxin responsible for the disease. However, until further investigation to uncover the disease's root cause, specific treatments may not be feasible. In the meantime, the management of FM involves a combination of pharmacological and non-pharmacological strategies (11, 12).

Non-pharmacological therapies for FM include physical interventions such as yoga, tai chi, walking, and whole-body vibration (WBV) exercises (13,14). In WBV exercises, individuals are positioned on a platform to which stimuli are transmitted throughout the body. The intensity of the stimulus is determined by factors such as peak-to-peak displacement, amplitude, frequency, and acceleration of the oscillation (15–17). There are some action mechanisms to justify the effects of the WBV exercise, such as vibratory tonic reflex and mechanobiomodulation (18-22). Although there have been seven reviews on the effects of WBV exercise on FM-associated symptoms, current studies published in the last five years have highlighted the need for an updated analysis of the available evidence (23,24). Furthermore, due to the limited methodological quality of previous studies, the effectiveness of WBV in the FM population is still not well-established due to the limited methodological quality of previous studies. Yet, research findings support the hypothesis that WBV therapy may improve balance, discomfort, and fatigue (25-28) (Figure 1).

Bear in mind that we stress the importance of evaluating studies that address the effects of biological parameters related to the inflammatory profile in FM and the relationship with WBV. Therefore, in an effort to bridge the existing gaps, the present review aimed to investigate recent evidence and provided an up-to-date analysis on the effects and efficacy of WBV, either alone or combined with exercise, in patients with FM.

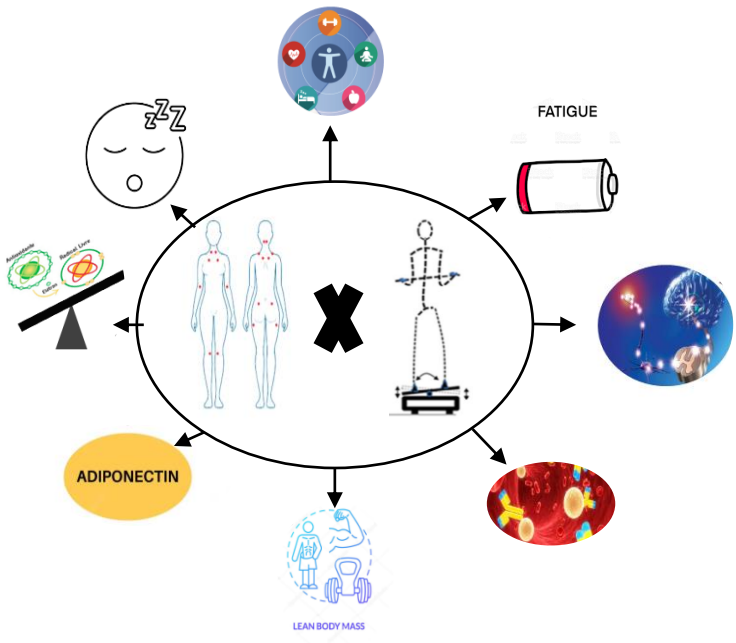


**Figure 1.** Exploring the potential benefits of whole-body vibration exercise for fibromyalgia management.

## 2. Material and methods

### 2.1 *Electronic database searches and selection strategy*

A search was conducted over the last five years as new studies published over the have highlighted the need for an up-to-date review of available evidence in the Cochrane Library, the Physiotherapy Evidence Database (PEDro), and the PubMed database up till June 2023. The search strategy utilized keywords such as "fibromyalgia" and "whole body vibration". Experts in the field of WBV in FM supervised these activities. Our search strategy was structured using the P.I.C.O components (Patients/Population, Intervention, Comparison, Outcomes) to establish the elements. The inclusion criteria for the articles were: (a) focus on WBV therapy, (b) inclusion of a study cohort comprising solely people with FM, and (c) no language restrictions. One of the authors manually removed duplicate articles. A flow chart depicting the complete selection process was included in the systematic review (Figure 1). Two independent evaluators carried out the selection process. The search was concluded on June 20, 2023, with no submission deadline imposed.

### *2.2 Types of participants*

We included research that examined adults with FM and performed WBV exercise. In addition, we selected articles that used published criteria for diagnosis (or classification) of FM. Up till the year 1990, the American College of Rheumatology (ACR) criteria served as the standard for classifying individuals having FM. That was once they experienced widespread pain lasting longer than three months and when pain can be elicited at 11 out of 18 specific tender points on the body with 4 kg tactile pressure (29). The newer preliminary diagnostic tool — ACR 2010 — does not rely upon the physical tender point examination and is available as both a clinician-administered tool and a survey questionnaire (30).

Measure includes a Widespread Pain Index (19) areas representing anterior and posterior axes and limbs) and a Symptom Severity Scale containing items related to secondary symptoms such as fatigue, sleep disturbance, cognition, and somatic complaints. Scores on both measures are used to determine whether a person qualifies as meeting a "case definition" of FM. This tool has been used to classify 88.1% of cases that meet ACR 1990 criteria, and it permits ongoing monitoring of symptom change in people with a current or previous diagnosis of fibromyalgia (1). Although measurements focusing on tender point counts have been widely applied in clinical and research settings, methods described by Wolfe 2010 and Wolfe 2011 promise to classify people with fibromyalgia more efficiently. This occurs while allowing improved monitoring of disease status over time. Despite the facts that differences among published fibromyalgia diagnostic/classification criteria are known, we considered all published criteria to be acceptable and comparable for the purposes of this review.

### 2.3 *Types of interventions*

We examined trials that studied WBV exercise interventions (e.g., moving or holding a standing position while on an oscillating platform) regardless of the frequency, duration, or intensity of exercise sessions. Appendix 2 provided an example of a WBV exercise intervention. We categorized interventions by the duration of the program (e.g., “short” < seven weeks; “intermediate” seven to 12 weeks, “long” > 12 weeks) and by frequency of training per week (e.g., once per week, twice per week, and three or more times per week). Comparative interventions included control (e.g., placebo or sham intervention).

### 2.4 *Data extraction*

Data were extracted from the selected articles by one of the authors. A second author checked this extraction. Any disagreement was discussed and ultimately resolved by a third author if contact with the original author of the article could not be established.

For each selected article, the following data were extracted: (a) the sample and protocol characteristics, namely, the sample size, age, and activity of the control and WBV groups (Table 1), and (b) the vibration therapy details, namely, the device and its oscillation (acceleration, frequency and amplitude), the duration of the intervention, the number of WBV sessions, the number of vibration series, the rest period, and the exposure duration in each series (Table 2).

### 2.5 *Synthesis and data analysis*

Studies published in the last five years (2018 - 2023) exclusively in adults with a clinical diagnosis of FM were included. A descriptive analysis of WBV effect measures was performed on each selected outcome.

## 3. Results

### 3.1 *Article Selection*

A total of 31 articles were found in the electronic search of Cochrane (8 articles), PubMed (11 articles), and PEDro (12 articles) databases. After checking for duplicates, eleven articles remained and were selected, of which five were reviews and one article was excluded (the study clearly did not meet the inclusion criteria). Finally, five articles were included in our review, with two different study designs (e.g., randomized or control case), and two types of intervention (e.g., single session or multiple sessions) (Figure 2).

### 3.2 *Study Characteristics*

The characteristics of the studies using the PICO (Patients, Intervention, Control, Outcomes, and Study design) approach are summarized in Table 1. All five studies were performed with adult women with FM and the sample size varied from 20 to 40 participants.

#### 3.2.1 *WBV Parameters*

*WBV Equipment*

One study used the Galileo vibratory platform (32), and four studies used the FitVibe platform (23, 24, 33, 34). The Galileo vibratory and FitVibe platforms produce a vertical sine-wave vibration.

*Frequency and amplitude*

The studies differed in terms of amplitude and frequency of vibration. Four studies used vertical synchronous stimulus vibration employing an amplitude of 4 mm and a frequency of 40 Hz, and one study used vertical synchronous vibration stimulus employing an amplitude of 3 mm and a frequency of 30 Hz. (Table 1).

*Performance on the platform*

In the five studies, the subjects maintained a dynamic posture on the platform during the vibration. All works specified that both feet were always supported on the platform during the vibration. The knee angle varied between 90º and 180º (Table 1).

*Key measurements and effects*

The outcomes with the highest level of conclusion were pain, quality of life and biological aspects related to FM that characterize the modeling of the inflammatory profile (Table 2).

Pain is the most important symptom in FM, but it was specifically assessed in only one study, which reported improvement in pain (Effect Size = 0.97), in the post-treatment (32).

*Balance*

One study evaluated the effects of WBV therapy on balance, specifically dynamic and static balance. In the study it was shown that WBV significantly improved the dynamic balance (Effect Size = 0.57) and the static balance (Effect Size = 0.87) in the WBV group (32).

*Inflammatory profile*

Four studies examined the biological aspects associated with FM, specifically focusing on the modeling of the inflammatory process.

Two studies demonstrated that a single session of WBV resulted in the modulation of the inflammatory profile in women with FM. One study reported a decrease in plasma levels of adiponectin and sTNFR1, along with an increase in levels of sTNFR2. Significant interactions were observed in plasma levels of adiponectin ($p$=0.0001), sTNFR1 ($p$=0.000001), and sTNFR2 ($p$=0.0052) (33). In the second study, improvements were observed in all oxidant and antioxidant parameters, indicating a greater adaptation to stress response in women with FM. This was evidenced by a reduction in TBARS ($p$<0.001), an increase in FRAP ($p$<0.001), and CAT ($p$=0.005), and an increase in SOD levels ($p$=0.019) (34).

Two studies revealed that multiple WBV sessions led to modulation of the inflammatory profile in women with FM. In one study, WBV therapy was found to increase blood levels of BDNF ($p$=0.045), accompanied by improvements in aspects related to the biological rhythm (23). Another study demonstrated that WBV therapy resulted in increased levels of irisin (p=0.01) and reduced levels of TBARS ($p$=0.001) and visceral adipose tissue mass ($p$=0.001) in women with FM. These findings indicate a reduction in cellular damage and a more pronounced oxidative balance (24).

*Effects of a single WBV session*

Researchers investigated the acute effects of a single WBV session (Figure 2), on inflammatory biomarkers in FM patients and matched healthy people using experiments with 40 participants (33,34). Thus, with just one vibration session, the data showed an improvement in the inflammatory profile. As a result, FM patients attained results equivalent to those of healthy people who shared the same anthropometric traits. Exercise-induced regulation appears to be the mechanism underlying this neuroendocrinological response, resulting in improved stress response in FM patients.

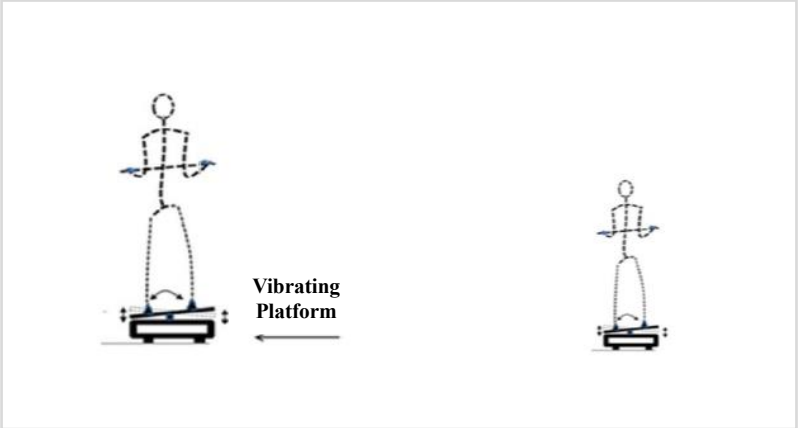


**Figure 2.** Possible position to be adopted during the whole-body vibration exercise. (acute effect: single session of WBV).

Effects of multiple WBV sessions

Three studies, involving 60 participants, examined the effects of multiple WBV sessions (Figure 3), with a training period lasting approximately 6-12 weeks. Significant findings from these studies included improvements in dynamic balance and static balance (32), reduction in pain, improvement in disability and quality of life assessed through QIF (23,32), enhancement of muscle strength and functional performance (23,32), as well improvements in balance and reduction of the inflammatory profile (23,24).

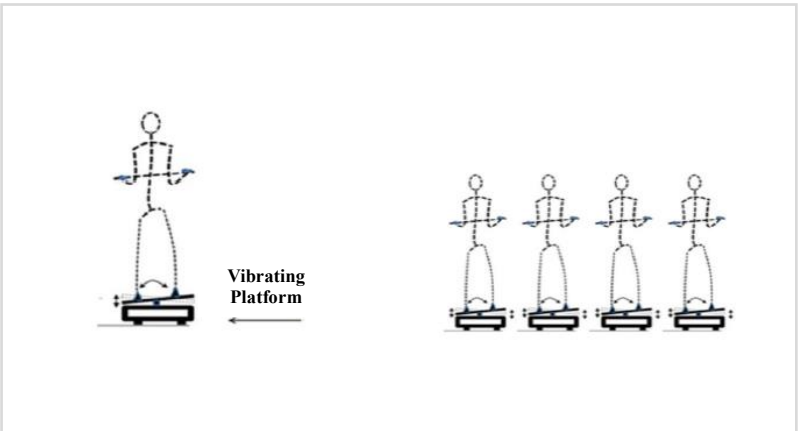


**Figure 3.** Possible position to be adopted during the whole-body vibration exercise. (chronic effect: multiple sessions of WBV).

## 4. Discussion

This review aimed to assess the potential benefits of WBV for women with FM. A total of five studies, encompassing 100 participants, were analyzed and exhibited a sound methodological foundation. It is worth noting that all participants had a confirmed FM diagnosis by a Rheumatologist, which enhances the reliability of the results. The findings of this review indicate that WBV therapy has the potential to improve various FM symptoms, including inflammatory parameters, disability, pain, quality of life, and balance issues (23,24,32,33,34).

Scientific evidence supports the benefits of WBV in FM, including improvements in muscle power and strength, sleep quality, peripheral blood circulation, functionality, balance, postural control, quality of life, and body composition, as well as decreased pain and muscle fatigue and risk of falling, in conjunction with increases in bone mineral density and muscle fiber recruitment. Moreover, remains a gap in the association between WBV and inflammatory markers in FM (35-37). In this analysis, we discovered four papers that discussed how WBV led to patient adjustments and modulation of the inflammatory profile. According to a recent narrative review, it is imperative to research on the application of systemic vibration therapy to mechanobiomodulation components as potential biological effects. Considering current findings about biological responses to mechanical vibrations (38).

Recognizing that diffuse and persistent pain is a primary symptom of FM, often leading to limitations in daily activities for patients (2,5), exercise and physical activity have been found to play a crucial role in promoting analgesia. This occurs through modulation of the immune system, both locally and systemically, as well as within the central nervous system. Such modulation triggers the release of anti-inflammatory cytokines, which reduce the activity of nociceptors and the central nervous system to alleviate pain. Regular exercise has been shown to increase the levels of anti-inflammatory cytokines in the spinal cord while decreasing glial activation and inflammatory cytokines in the central nervous system. It further enhances the transcription of factors that regulate IL-1 (interleukin 1 beta), NFk (nuclear factor kappa beta), and NLPP3 (NOD-type receptor with pyrin domain 3), all possibly known to be reduced with regular exercise. By restoring neuroimmune signaling in the central nervous system, exercise can help prevent the development of hyperalgesia. These mechanisms contribute to importance of therapeutic improvements and positively influence the quality of life for individuals with FM (39).

Importantly, a recent study has revealed that central sensitization and inflammation, despite having distinct physiological mechanisms, exhibit numerous similarities. This includes the notion that multiple biomarkers, rather than a single gold standard, are required to explain the diverse clinical and biological manifestations. Furthermore, both central sensitization and inflammation display crucial roles in various clinical conditions and diseases, with their clinical presentations varying significantly among patients (40). Given this overall context, the significance of research that comprehensively examines the adaptive responses to different exercise modalities becomes even more pronounced. Such research considers both the biological context related to biomarkers and the somatosensory context to enhance our understanding of the complex interplay between exercise, the body's adaptive responses, and the broader clinical implications.

According to the review (42), the choice of protocol and exercise modality can have an impact on the evaluation of the effects of WBV on FM symptoms. Therefore, it is crucial to conduct a comprehensive and systematic analysis to determine the appropriate protocol for each study. Additionally, standardized language is imperative in WBV investigations as different studies utilize various concepts and terminologies, such as the platform and the mode of vibration (synchronous, asynchronous, and alternating). This variation in terminology makes it challenging to understand and replicate the protocols employed in different studies (28,29,43). Finally, this

review has provided valuable insights into the benefits of WBV for FM. We highlighted the potential connection between mechanobiomodulation and disease-related biological responses. These perspectives suggested that a comprehensive understanding of mechanobiomodulation will contribute to unraveling the underlying mechanisms behind the biological effects of WBV in FM. The research findings discussed in this review, encompassing both functional and biological factors, can significantly enhance the utilization of WBV in FM. Ultimately improve the quality of life for patients affected by this clinical approach.

While this review provides valuable insights, it is important to acknowledge its limitations. These include: (i) the limited number of studies available on the use of WBV in FM, (ii) the significant variation in vibration protocols across the included studies, and (iii) the diverse range of outcomes evaluated. Additionally, the literature search was conducted in three electronic databases (the Cochrane Library, the Physiotherapy Evidence Database (PEDro and PubMed), which may have resulted in the omission of some relevant studies. It is worth noting that we periodically update the search to ensure comprehensive coverage.

## 5. Conclusion

Whole Body Vibration (WBV) therapy indeed shows promising potential as a primary treatment for Fibromyalgia (FM) based on the mentioned benefits, such as regulating the inflammatory profile and improving quality of life, balance, functional limitations, and fatigue (as shown in Figure 4). The positive effects of WBV on FM patients have sparked optimism among researchers.

However, the use of WBV in FM is still an emerging field, and studies investigating its efficacy over the past five years have been limited. Specifically, there is a need for further research to understand the underlying biomechanomodulation mechanisms and to develop more effective treatment strategies. Despite the current limitations in research, the authors remain hopeful about the potential benefits of WBV for FM patients, especially when tailored to individualized treatment approaches.

## Conflicts of Interest

The authors declare no conflicts of interest.

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