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Vibration Training in Elite Sport: Effective Training Solution or Just Another Fad?

Marco Cardinale and Julie A. Erskine

The use of vibration as a training intervention has been suggested for more than a decade. Following the initial promising studies, a large number of investigations have been conducted to understand the acute and chronic effects of this novel training modality mainly using special populations, sedentary, physically active, and aged individuals. There is a small number of studies involving athletes. For this reason it is at the moment very difficult to provide safe and effective training guidelines to athletes. We discuss the current findings related to the effectiveness on elite athletes and provide some guidance on practical applications. Vibration is without a doubt an interesting intervention; however, more needs to be done to understand the physiological mechanisms involved in the adaptive responses to vibration exercise. Furthermore, more studies are needed to establish a dose-response relationship to vibration training to provide indications on safe and effective vibration training prescriptions.

**Keywords:** sinusoidal stimulation, strength training, force modulation

Vibration training was introduced more than 10 years ago as an alternative method to improve strength, power, and flexibility.\(^1,2\) Vibration is a mechanical stimulus characterized by an oscillatory motion. The magnitude of the vibration stimulus depends on the amplitude of the oscillations, the frequency, and the resulting acceleration transmitted to the body or parts of it. A large number of scientific studies have been conducted in the past with the aim of studying the negative effects of vibrating tools and whole body vibration (WBV) on workers exposed to such stimuli for long hours during their working tasks. Vibration stimulation became a novel idea in the 1980s and 1990s thanks to the work of Nazarov\(^3\) and Issurin\(^1,4\) who suggested the use of vibrating pulley machines during strength and flexibility training and vibrating devices to be applied directly to the body or while the athlete was performing strengthening exercises. Previous work has suggested that vibration exposure elicits small but rapid changes in muscle length producing reflex muscle activity in an attempt to dampen the vibratory waves.\(^5\) This reflex muscle activation is likely to be similar to the tonic vibration reflex (TVR).\(^6\) Because muscle spindle
primary endings are most responsive to vibration and thus responsible for the TVR, most of the studies have focused on understanding neuromuscular responses to WBV exercise. Due to the potential of vibration to affect the neuromuscular system, our group introduced the concept of whole body vibration hypothesizing the possibility of improving force and power production. Since then, numerous studies have followed, which tried to analyze and understand how vibration could be used as a training intervention not only in elite athletes, but also as an alternative exercise modality in various populations ranging from disabled children, aged individuals and adults with cerebral palsy. Furthermore, different technologies have been developed to provide vibration exercise devices similar to the typical gym equipment. There is no current consensus on the effectiveness of vibration exercise. Some authors are suggesting that there is no evidence for whole body vibration to improve strength and power in the lower limbs, some others in a systematic review seem to suggest strong to moderate evidence of the positive effects of whole body vibration exercise in untrained people and elderly women. Unfortunately, the aggressive and unscrupulous marketing of many companies has taken over the process of research and many devices are currently sold without proper and safe advice provided to the user and, most of all, without a scientific validation of their safety and effectiveness. It is very important to highlight that most of the studies investigating the effectiveness or use of vibration training have been conducted on noncompetitive athletes, sports science students, and/or injured and aged individuals. The extrapolation of such findings to an athletic population is dangerous, as everyone who works in elite sports knows the difference between an Olympic level athlete and a physical education student or a sedentary individual.

The aims of this commentary are 1) to summarize some evidence of the effectiveness of vibration in athletes and 2) provide suggestions for future studies. Where appropriate, we will provide the name of the equipment used in the studies cited to better inform the readers. Due to the format of this commentary, we are aware of not being able to be exhaustive in discussing the vibration training phenomenon; for this reason we suggest the reader consider some recent reviews of vibration exercise for a more comprehensive analysis of this novel training modality and for further insights on the physiological aspects connected to how vibration affects various structures in the body.

Vibration Training Is Not Only About Vibrating Platforms

Vibration had been used in the 1980s mainly by Russian scientists as an alternative way of improving strength and flexibility in gymnasts. Unfortunately, limited information written in English exists on the effectiveness of such a method. However, reports suggested this modality of exercise as quite successful. Following these initial indications, Issurin et al developed a pulley-like device to train strength and flexibility and suggested that such a modality of exercise was particularly effective in improving strength, power, and flexibility in elite athletes. Our group began to study the use of vibrating platforms to provide vibration training to the lower limbs and showed promising initial results with simple research studies followed up by better designed ones to understand the possible mechanisms of the observed effects.
on muscle function and the neuroendocrine system.\(^7\)\(^9\)\(^10\)\(^17\) Many studies followed using different types of vibrating plates: tilting vs. whole plate oscillating. Since then numerous manufacturers have appeared on the market producing both types of systems with few actually trialed and presented in scientific publications. A vibrating dumbbell was also studied which showed promising results (acute increases in power output during an arm flexion task) in elite boxers,\(^8\) but to date no other studies have been conducted using this vibration training modality. Recent work from Mischi et al\(^\text{14}\) has shown promising results while using vibrating devices applied to typical gym strength training equipment. Furthermore, applying vibration to barbells was shown to increase peak and average power output during bench pressing exercises.\(^18\) Finally, gymnasts have been shown to improve flexibility using a novel vibrating tool to allow them to perform flexibility training with vibration, suggesting another means of using vibration as a training stimulus.\(^19\) Direct application of vibration to muscles and tendons has been studied extensively and will not be discussed in this commentary.

### Acute Effects of Vibration in Athletes

The acute effects of vibration exercise have been studied mainly with the aim of identifying the most appropriate combination of frequency and amplitude able to affect strength and power performance. Furthermore, considering the observed effects on muscle perfusion,\(^20\) the interest in understanding the acute responses to such stimuli is increased with the view of using vibration as some form of training aid/warm-up/preconditioning procedure. Few studies have been conducted using athletes competing in national and/or international level competitions. Bosco et al\(^9\) showed an acute shift to the right of the Force/Velocity and Power/Velocity relationship in the vibrated leg of elite female volleyball players after 10 sets of 1 minute of static squatting on one leg performed on a Galileo 2000 (Novotec, Pforzheim, Germany; frequency (F) = 26 Hz, peak-to-peak (p-t-p) displacement = 10 mm). Elite female field hockey players were also shown to increase vertical jumping ability and hamstrings flexibility after 5 minutes of WBV (squat) performed on a Galileo Sport Machine (Novotec, Pforzheim, Germany), F = 26 Hz; p-to-p displacement 6 mm). We have previously suggested that WBV exercise increased electromyographic (EMG) activity of the leg extensor muscles in elite female volleyball players by 34% as compared with just squatting in no-vibration condition.\(^10\) For this reason and due to the resemblance of such response to the tonic vibration reflex, we have suggested a “muscle tuning” response aimed at controlling active damping in the soft tissues as one of the mechanisms leading to the observed performance enhancements.\(^5\) The highest EMG activity was observed at 30 Hz frequency on a NEMES Boscosystem (OMP, Rieti, Italy) which had the whole plate oscillating with a p-to-p displacement of 4 mm. This increase in EMG activity has been later observed by other authors in nonathletic populations.\(^21\) However, despite the accepted evidence of higher neuromuscular activation during WBV, the local metabolic demand in leg extensors while performing static squats on a whole plate oscillating device (Fitwave, Medisport, Italy; F = 30 Hz, p-to-p displacement = 4 mm\(^22\)) as compared with squatting without vibration does not seem to be so markedly different. To our knowledge, the aforementioned studies are the only ones where elite/well trained
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athletes were studied. In light of this, it seems clear that further studies are needed to understand how to make best use of WBV exercise if acute effects are sought. Vibrating dumbbells have also shown some promise in increasing power output acutely due to a large increase in EMG activity in elite boxers (Galileo, Novotec, Pforzheim, Germany;1,8). Finally, performing stretching on vibrating devices has been shown to increase flexibility in gymnasts more than conventional stretching19 and increase flexibility without affecting explosive abilities when combined with stretching.23

Regular programs of vibration training have been studied in a wide range of subjects suggesting a lot of benefits. When we analyze the effectiveness of such programs in athletes, the evidence does not seem to be very strong. A 5-week training period characterized by progressive WBV training of frequencies ranging from 35 to 40 Hz and amplitudes of 1.7 to 2.5 mm produced no significant improvements in vertical jumping ability, isometric and dynamic muscle strength, and maximal knee extension velocity in well trained sprinters (Power plate platform, the Netherlands;24). Young elite skiers were shown to benefit from a resistance exercise program supplemented by WBV (F = 24 to 28 Hz, amplitude 2 to 4 mm; Fitvibe, Gymnauniphy, Belgium) showing greater improvements in vertical jumping ability and isokinetic knee and ankle measures than the resistance exercise only group.25 Eight weeks of WBV training (Nemes LC, Boscosystem, Italy; 5 × 40 s, with 1 min rest; 30 Hz, 5g magnitude) produced a significant improvement in vertical jumping ability and knee extensor strength in ballerinas.26

In our experience, it is unlikely that vibration exercise alone using the currently available technologies (vibrating platforms with frequencies ranging from 10 to 60 Hz and amplitudes ranging from <1 mm to 10 mm) can benefit athletes. The added benefit of such technology would come only if resistance exercise could be performed in combination with vibration stimulation and/or vibration applied to preexisting high levels of muscle activation. Performing resistance exercise on the currently marketed WBV plates can be a risky business. Firstly the surface limits the stance of the athlete (if squatting is the exercise of choice). Secondly and most importantly, because of the poor manufacturing and the cheap choice of components, many vibrating plates cannot sustain heavy loads. In our experience also, many commercially available plates vary frequencies and amplitudes (and hence magnitudes) and directions of vibration in a stochastic manner when someone tries to perform strengthening exercises on them.

Safety Considerations

When using WBV devices it is important to recognize that body posture and type of vibrating plate used27 affect transmissibility of vibration to the spine and the head when exercises are performed standing on the plate. Lying on the plate and/or sitting on the plate should be discouraged as transmission to the head is quite high and would put the athlete at risk of spinal degeneration, visual and vestibular damage, hearing loss, and other health risks.28 Hand-held vibrating exercise devices
### Table 1  Summary of Studies Conducted Using Vibration Training Modalities in Athletes

<table>
<thead>
<tr>
<th>Author</th>
<th>Athletes</th>
<th>Duration and characteristics of vibration training</th>
<th>Results</th>
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<tbody>
<tr>
<td>Bosco et al (1999)</td>
<td>National team volleyball players (6 ♂)</td>
<td>10 × 1 min (1 min rest between reps) vertical sinusoidal vibrations @ 26 Hz; 10 mm p-t-p amplitude delivered with Galileo 2000 device</td>
<td>↑ average force, velocity &amp; power (~6%; <em>P</em> &lt; .05-0.005) of experimental leg during leg press exercise immediately after vibration exercise</td>
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<tr>
<td>Bosco et al (1999)</td>
<td>National team boxers (12 ♂)</td>
<td>5 × 1 min (1 min rest between reps) vertical sinusoidal vibrations @ 30 Hz; 6 mm p-t-p amplitude delivered with Galileo 2000 device</td>
<td>↑ average mechanical power (14%) during arm flexion of experimental arm &amp; decrease EMG/P ratio immediately after vibration exercise (<em>P</em> &lt; .001 mechanical power; <em>P</em> &lt; .01 EMG:P)</td>
</tr>
<tr>
<td>Issurin &amp; Tenenbaum (1999)</td>
<td>National team level power-trained athletes (14 ♂)</td>
<td>Explosive bilateral biceps curl exercise with superimposed vibration @ 44 Hz; 3 mm p-t-p amplitude transmitted by a specially designed vibratory stimulation device (Issurin et al, 1994)</td>
<td>↑ maximal power by 10.4% &amp; mean power by 10.2% for second set with superimposed vibratory stimulation vs. first set without vibratory stimulation</td>
</tr>
<tr>
<td>Cardinale &amp; Lim (2003)</td>
<td>Professional volleyball players (16 ♂)</td>
<td>1 min @ 0, 30, 40, 50 Hz; 10 mm p-t-p amplitude applied with Nemes Bosco-system</td>
<td>↑ EMG activity by 34% during 30 Hz vibration vs. baseline (<em>P</em> &lt; .001)</td>
</tr>
<tr>
<td>Cochrane &amp; Stannard (2005)</td>
<td>Elite field hockey players (18 ♂)</td>
<td>5 min @ 26 Hz; 6 mm p-t-p amplitude during 6 different exercises performed on Galileo Sport device</td>
<td>8% ↑ vertical jump height &amp; 8% ↑ hamstrings flexibility tested within 15 s of cessation of vibration</td>
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<tr>
<td>Study</td>
<td>Participants</td>
<td>Protocol Description</td>
<td>Immediate Effects</td>
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<tr>
<td>Kinser et al (2008)</td>
<td>Young competitive gymnasts (22♂)</td>
<td>4 × 10 s (5 s rest) @ 30 Hz; 2 mm p-t-p amplitude using custom built device producing sinusoidal vibrations applied at 4 sites during forward split stretching</td>
<td>18% ↑ flexibility immediately after vibration; No change in explosive strength</td>
</tr>
<tr>
<td>Delecluse et al (2005)</td>
<td>Sprinters (6♂, 4♀) with mean 100 m sprint times of 11.45 ± 0.42 s for males, 12.46 ± 0.59 s for females</td>
<td>9–18 min (intermittent application) @ 35–40 Hz; 1.7–2.5 mm p-t-p amplitude during 6 exercises using Power Plate vibration platform; 3 d/wk for 5 wks</td>
<td>No change in isometric &amp; dynamic strength, maximal knee extension velocity, vertical jump performance or sprint running velocity after 5 weeks of training</td>
</tr>
<tr>
<td>Mahieu et al (2006)</td>
<td>National level competitive skiers (11♂, 6♀)</td>
<td>Up to 14 min (intermittent application) @ 24–28 Hz; 2–4 mm p-t-p amplitude during 8 exercises using Fitvibe device; 3 d/wk for 6 wks</td>
<td>↑ repeated vertical jump performance (+13.5 repetitions) &amp; isokinetic knee &amp; ankle strength (+24% and +27%) after 6 weeks training</td>
</tr>
<tr>
<td>Sands et al (2006)</td>
<td>Young highly trained gymnasts (10♂)</td>
<td>4 min @ 30 Hz; 2 mm p-t-p amplitude using custom built vibration device producing sinusoidal vibrations applied during 4 different stretching positions; 5 d/wk for 4 wks</td>
<td>Acute ↑ flexibility R &amp; L legs immediately after vibration (r = +5.5–7.5 cm; P &lt; .05); Chronic ↑ flexibility R leg only after 4 weeks of training (+6 cm; P &lt; .01)</td>
</tr>
<tr>
<td>Annino et al (2007)</td>
<td>Italian National Ballet School Ballerinas (11♀)</td>
<td>5 × 40 s (60 s rest) @ 30 Hz; 5 mm p-t-p amplitude using Nemes LC device producing vertical sinusoidal vibrations; 3 d/wk for 8 wks 100 kg after 8 weeks of training</td>
<td>6% ↑ CMJ performance &amp; ↑ average force, velocity &amp; power (P &lt; .05–0.001) during leg press exercise at external loads of 50, 70, and</td>
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</table>
or the use of vibrating dumbbells, cables and barbells should be used with caution as prolonged use of similar tools has been linked to degeneration of soft tissues, reduction in vascularization and bone and articular damage.28

**Future Research Activities**

In light of the current state of knowledge of the effectiveness of vibration exercise, it is clear that more studies are needed to understand its mechanisms of action and its safety and effectiveness in improving strength, power, and flexibility in elite athletes. The potential of vibration to affect muscle temperature and muscle perfusion20,22,29 should also be investigated with the view of using vibration as a warm/up-recovery tool. In general, we do not know a dose-response relationship to various vibration exercise modalities; hence we cannot provide effective prescriptions. Finally, considering the recent findings on the effectiveness of combining vibration with strengthening exercises to reduce muscle atrophy in bed-rest models,30 more studies are needed to evaluate the possibility of using similar modalities in the rehabilitation of the most common athletic injuries of the lower limbs.

**References**


