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RESEARCH ARTICLE

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Effects of focal vibration on changes in sports performance in amateur athletes: A randomized clinical trial

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Abstract

The aim of this study was to evaluate the effectiveness of a focal vibration protocol added to an activation protocol with active muscle contractions and to see what repercussions it has on sprint, countermovement jump (CMJ), and lower limb isometric strength. A double-blind randomized clinical trial was conducted in the Functional Anatomy Laboratory and the sample consisted of 70 athletes. The main outcome measures were knee extension force, CMJ, sprint, and surface electromyography. Repeated-measures analysis of variance revealed significant improvements. They were found in the within-group analysis for the Experimental Group in the isometric extension force ($p < 0.001$; $\eta^2 = 0.368$), CMJ ($p < 0.001$; $\eta^2 = 0.301$) and 30 m sprint ($p < 0.001$; $\eta^2 = 0.376$). In the electromyography, there are changes in the Sham Group in all muscles, in CMJ and Sprint tests, and no differences in the Experimental Group, except for the RF muscle. In the between-group analysis, statistically significant differences were found only in favor of the Experimental Group in CMJ ($p = 0.017$; $\eta^2 = 0.81$) and 30 m sprint ($p < 0.001$; $\eta^2 = 0.152$). These results confirm a significant improvement in the sprint, CMJ performance, and quadriceps strength, after a focal vibration protocol, added to a muscle active contraction, compared to a focal vibration sham protocol. Therefore, our results suggest that the focal vibration can be a very useful tool in sports involving high-powered actions.

KEYWORDS
focal vibration, knee extension force, muscle activity, sprint, vertical jump

1 | INTRODUCTION

Sports performance is a complex mix of biomechanical functions and functional capacities that allow the athlete to perform or practice a sport effectively. Performance in an athletic context has a popular connotation of representing the pursuit of excellence, where an athlete measures his or her performance as a progression toward excellence or achievement.[1] Among other functional capacities, high-power actions such as sprinting, jumping, and lower limb muscular strength have a huge influence on sports performance.[2,3]

Short-duration sprinting (<10 s duration) and explosive vertical jumping are determinant and even decisive in many sports. Elite soccer players spend ~11% of the game sprinting short distances.[4,5] Vertical jumping is a fundamental skill in different sports such as

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handball, soccer, volleyball, and basketball.[6–9] In the past Olympic Games, celebrated in Tokyo 2021, data showed that large differences in the classification are however due to minimal differences in tenths and centimetres. The difference between first and sixth in the 100 m sprint final was less <2 tenths; and in the high jump event, there was a triple tie for first place and only 4 cm separated the gold from the seventh.[10,11]

Sprinting and vertical jumping are actions performed at high power and they are directly related to the strength of the lower limb.[5] Several studies have investigated the relationship between sprint and vertical jump performances and strength, demonstrating that, in general, stronger athletes perform better during both actions.[12,13]

To increase strength, and consequently improve actions such as vertical jump and sprint, several methods such as short-term periodization training,[14] eccentric-overload training,[15] blood flow restriction training,[16] resisted sprint training,[17] or whole-body vibration training[18] have been applied.

Regarding whole-body vibration, there is controversy in the literature about its effect and sports performance. On the one hand, some authors enhance its potential to manage some diseases and enhance athletic performance due to the effects on the musculoskeletal and neural systems.[18,19] Furthermore, previous reviews[20,21] observed the advantages of whole-body vibration, producing significant results, especially increasing lower limb muscle strength and flexibility compared to traditional methods.

On the other hand, other bibliography results[18,22,23] reflect that the efficacy in producing significant improvement in performance-related muscle parameters in elite athletes is still in doubt, showing results without significant differences in strength, power, and flexibility variables. In addition, whole-body vibration propagates through all the tissues of the body and can reach frequencies and amplitudes that could pose a risk, such as increased average blood flow, problems with knee or hip prostheses, bone injuries, or spinal cord implications.[24–26]

To increase treatment efficacy and safety for the athlete, focal vibration has been developed. This type of vibration, using high frequencies (>100 Hz), has been shown to modify corticomotor excitability, associated with muscle contraction.[27–29] In addition, focal vibration allows to allocate a more localized stimulus to a single muscle or specific muscular group, and with more possibilities to be applied during a sport than whole-body vibration.

Focal vibration has shown improvements in muscle strength[27,30] and countermovement jump (CMJ)[31] in athletes. The effect of focal vibration application on sprint performance has not been studied yet.

For this reason, it was hypothesized that adding focal vibration in lower limb muscles during a warm-up would have the greatest effects on sprint, CMJ, and lower limb isometric strength in amateur athletes.

This study aimed to evaluate the effectiveness of a focal vibration protocol added to a warm-up protocol with active muscle contractions on sprint, CMJ, and lower limb isometric strength.

2 | METHODS

2.1 | Design and participants

A double-blind (evaluator and participants) randomized clinical trial design was carried out. The study was conducted in March 2023, in the Faculty of Medicine and Health of the Universitat Internacional de Catalunya. This study was approved by the local ethics committee with the code Ceim-UIC-Barcelona; study code: FIS-2022-05. The study procedures were conducted following the Declaration of Helsinki.[32] Informed consent was obtained from all participants. The protocol of the study was registered in ClinicalTrials.gov (NCT05757661). Consolidated Standards of Reporting Trial guidelines were followed throughout the study.

The Experimental Group received focal vibration treatment and the Sham Group received the same treatment without contact with the patient's skin.[33] Inclusion criteria were as follows: (a) healthy athletes in a sport involving sprint tasks and training at least 3 times a week; (b) age between 18 and 40 years; and (c) to have signed the informed consent. Exclusion criteria included the following: (a) having ever received focal vibration treatment; (b) volunteers who have suffered a sports injury during the last 2 months or are unable to perform physical activity; (c) subjects presenting neurologic or orthopedic problems during the last year; (d) having received any lower limb surgical interventions during the last 6 months; and (e) not understanding the orders provided by the investigators. The randomization was carried out using the computer program Ramdom.org, which generates a random list for the Experimental and Sham Group.

The anthropometric variables were age, sex, lower limb dominance, height, weight, and hours of training per week. These are represented in Table 1. Limb dominance was assessed by self-reported preferred kicking limb.

2.2 | Sample size

The sample size was calculated using the GRANMO 7.12 program, performing a two-sided test analysis, and assuming an α risk of 0.05 and a

TABLE 1 Demographic characteristics of the sample.

	Experimental Group (*n* = 35)	Sham Group (*n* = 35)
Age (years)	21.7 ± 3.41	21.37 ± 4.76
Sex	24 (68.6%) Men 11 (31.4%) Women	23 (65.7%) Men 12 (34.3%) Women
Dominance	26 (74.3%) Right 9 (25.7%) Left	31 (88.6%) Right 4 (11.4%) Left
Height (cm)	175.5 ± 9.15	174.83 ± 8.93
Weight (kg)	69.7 ± 12.02	68.5 ± 12.26
Hours of sport per week	7.5 ± 2.69	7.8 ± 3.67

β risk of 0.20. The common standard deviation and the minimum differences to be detected between the groups (focal vibration and sham) were determined based on a pilot study with 20 subjects. We used the outcome 30 m sprint (s) as the main outcome. A common standard deviation of 0.89 s and a minimum difference to be detected of 0.6 s were used. According to this pilot study, a total of 70 subjects (35 for each group) was calculated.

2.3 | Procedures

The primary outcome measure in this study was the performance in the 30 m sprint. The secondary outcome measures were CMJ and the last one was maximal voluntary isometric quadriceps strength. During all of them, the surface electromyography (sEMG) in the rectus femoris (RF), vastus lateralis (VL) and vastus medialis (VM) was registered. The muscle activity of the maximal voluntary isometric contraction (MVIC) was used to determine the peak value for each muscle, and then, for the dynamic variables assign the activation percentage.

2.3.1 | Sprint

The subjects performed a 30 m sprint test measured with photocell beams (Chronojump Boscosystem)[34] placed on the starting line and 30 m away. Photocell beams are formed by a double reflector and a tripod, and when the subject crosses the line between these two points, the chronometer starts or ends the measurement marking each subject's total sprint seconds. Subjects were instructed to sprint with maximal effort. The participants performed two maximal sprints at the pre-intervention and postintervention tests with the goal of achieving the fastest outcome. The sprint test was conducted outdoors on an athletic track (Figure 1).

2.3.2 | CMJ

CMJ is a type of vertical jump starting from an upright position with full knee extension, the feet approximately in line of shoulder and hands positioned on both iliac crests. Following the methodology of Balsalobre et al.,[35] the participants jumped from this position as high as possible and landed in the same position in which they took off. The mobile phone application My Jump 2 was used to measure the CMJ, using the camera to perform a frame-by-frame analysis to calculate the height of the jump (cm). High reliability and accuracy of My Jump 2 compared to the gold standard (force plate) has been reported.[35] The participants repeated the jump 3 times, and the mean was registered (Figure 1).

2.3.3 | Quadriceps strength

The quadriceps strength was analyzed during 5 s of maximal isometric contraction, registered in Newtons. Attraction dynamometer (PCE Ibérica S.L.) with an accuracy of 5.0 Nm and a range of 20.0 N was used. The subject was placed in a seated position, 90° of knee flexion and with a webbing in the distal and anterior side of the leg. The subject was asked to perform a knee extension movement and a maximum isometric force for 5 s, kicking the webbing as strongly as possible. The patients repeated the test three times on his dominant leg and the mean was registered (Figure 1).

2.3.4 | Electromyography

sEMG was used to evaluate the muscle activity of the quadriceps during the sprint and CMJ tasks. The reliable and validated sEMG mDurance® system (mDurance Solutions SL) was used to record muscle activity

FIGURE 1 Variables. (A) Sprint. (B) Countermovement jump (CMJ). (C) Quadriceps strength.

during a functional task (intra-class correlation coefficient = 0.916; 95% confidence interval= 0.831–0.958).[36] The muscles assessed were VM, VL, and RF. Data were obtained from the dominant limb. The mDurance® system (mDurance Solutions SL) consists of three parts as follows: (a) a Shimmer3 sEMG unit (Realtime Technologies Ltd). This unit is a bipolar sEMG sensor for the acquisition of muscle activity. Each Shimmer3 has two channels, with a sampling rate of 1024 Hz. Shimmer3 applies a bandwidth of 8.4 Hz and the sEMG signal resolution is 24 bits, and has an overall amplification of 100–10,000 V/V;[36] (b) the mDurance Android application which receives the data from the Shimmer3 and sends it to a cloud service;[36] (c) the mDurance cloud service where the data is stored, filtered, and analyzed.[36] For the processing and filtering of the raw data, both isometric and dynamic tests were filtered using a fourth-order Butterworth bandpass filter with a cut-off frequency of 20–450 Hz. The signal was smoothed using a window size of 0.025 s root mean square (RMS) and an overlapping of 0.0125 s between windows.[36] The MVIC was calculated using the peak of the RMS signal during an isometric test. The principal variable recorded for muscle activity was mean RMS expressed as %MVIC.

The subject's skin was cleaned with alcohol and dried before the electrodes were placed. If hair impeded the correct adhesion of the electrodes to the skin, the particular site was shaved. Self-adhesive 5 × 5 cm Valutrode® surface electrodes were placed on the muscle bellies according to the SENIAM project recommendations[37] and with an interelectrode distance of 20 mm.[36] VM electrode was placed at 80% on the line between the anterior superior iliac spine and the joint space in front of the anterior border of the medial collateral ligament of the knee, with an orientation almost perpendicular to this same line for the belly muscle. VL electrode was placed between the line from the anterior superior iliac spine to the lateral side of the patella, they were placed 2/3 s of the way through in the direction of the muscle fibers for the belly muscle. Finally, the electrodes for the RF were also placed on the midpoint between the anterior superior iliac spine and the patella midpoint for the belly muscle. Reference electrodes were placed at the patella midpoint and anterior superior iliac spine.

Before the sprint and CMJ dynamic tests, a MVIC test was performed to normalize the data. The subjects carried out a 5 s maximal contraction of knee extension against webbing fixed from a sitting position with a 90° knee flexion, with their arms folded and close to the chest.[38]

2.3.5 | Intervention

The baseline and post-intervention measurements were taken by a researcher, and the intervention was carried out by another physical therapist familiar with the focal vibration machine. Both have a physical therapy experience of more than 10 years. The intervention was provided individually in the facilities at the Universitat Internacional de Catalunya. Participants in both groups received a single 20 min session.

The Experimental Group received a single treatment with the focal vibration machine (V-Plus Wintecare®), at the same time that the subject carried out active contractions in lower limb muscles. The positioning of the vibration heads was determined by the type of exercise, and those were fixed by a webbing designed by the manufacturer to keep the vibration head stable in the muscle. The vibration program was set to a predeterminate mode of 10 s of vibration and 3 s of rest. The frequency increases automatically in 10 Hz steps from 100 Hz to 180 Hz, and then progressively decreases again, in a cyclical way. The patient's perception of pain was monitored throughout the treatment, stopping the treatment if the patient complained of pain.

The first application with focal vibration consisted of a unilateral exercise performing three sets of 10 repetitions of the last 30° of knee extension, at the beginning of the exercise an isometric contraction for 5 s and then complete the full knee extension. The subject rested for 15 s between sets and when the first leg finished the 3 sets, it rested for 1 min (time in which the contralateral leg was doing the same exercise). Three focal vibration channels were placed on the muscle bellies of the RF, VM, and VL.

The second application with Focal Vibration consisted of a unilateral exercise of three sets of 10 repetitions of hip flexion in a 90° flexion position. The exercise was an isometric contraction during 5 s, with physiotherapist resistance. The subject rested for 15 s between sets and when the first leg finished the three sets, it rested for 1 min (time in which the contralateral leg was doing the same exercise). Two focal vibration channels were placed on the proximal muscle belly of the RF muscle, fixed by the straps, and one fixed manually by the therapist on the iliopsoas muscle.

Finally, the last application of focal vibration consisted of three sets of 10 dynamic bilateral squats, focusing on the final part of the hip extension at the maximum possible speed. The subject rested for 1 min between sets. Two focal vibration channels were placed on the muscle belly of each VM, fixed by the straps, and the other two channels, on each gluteus maximus, manually fixed by the therapist (Figure 2).

For the Sham Group, the same procedures were performed as in the Experimental Group, same active exercises, same physiotherapist procedures and same placement of focal vibration channels. The model of Toscano et al.[33] was followed to apply it as a placebo. The focal vibration channels were placed without the vibrating head, close to the muscle belly but without touching the skin. The focal vibration machine was turned on, so in this condition, patients were only subject to the faint buzzing sound of the vibrator.

2.3.6 | Statistical analysis

Statistical analysis was conducted with the SPSS 23.0 package (IBM). There was no loss of follow-up in the study. The mean and standard deviation were calculated for each variable. The Kolmogorov–Smirnov test was used to determine a normal distribution of quantitative data. Within and between-group differences were analyzed using repeated-measures of analysis of variance (ANOVA) and one-way ANOVA. If the assumption of sphericity was violated, the Greenhouse–Geisser correction was utilized for the interpretation. Effect sizes (ES) were calculated using partial η^2. Considering an ES >0.140 as large; around 0.060 as medium; and <0.039 as small.[39] Exclusions after randomization are

FIGURE 2 Focal vibration applications. (A) Application 1. (B) Application 2. (C) Application 3.

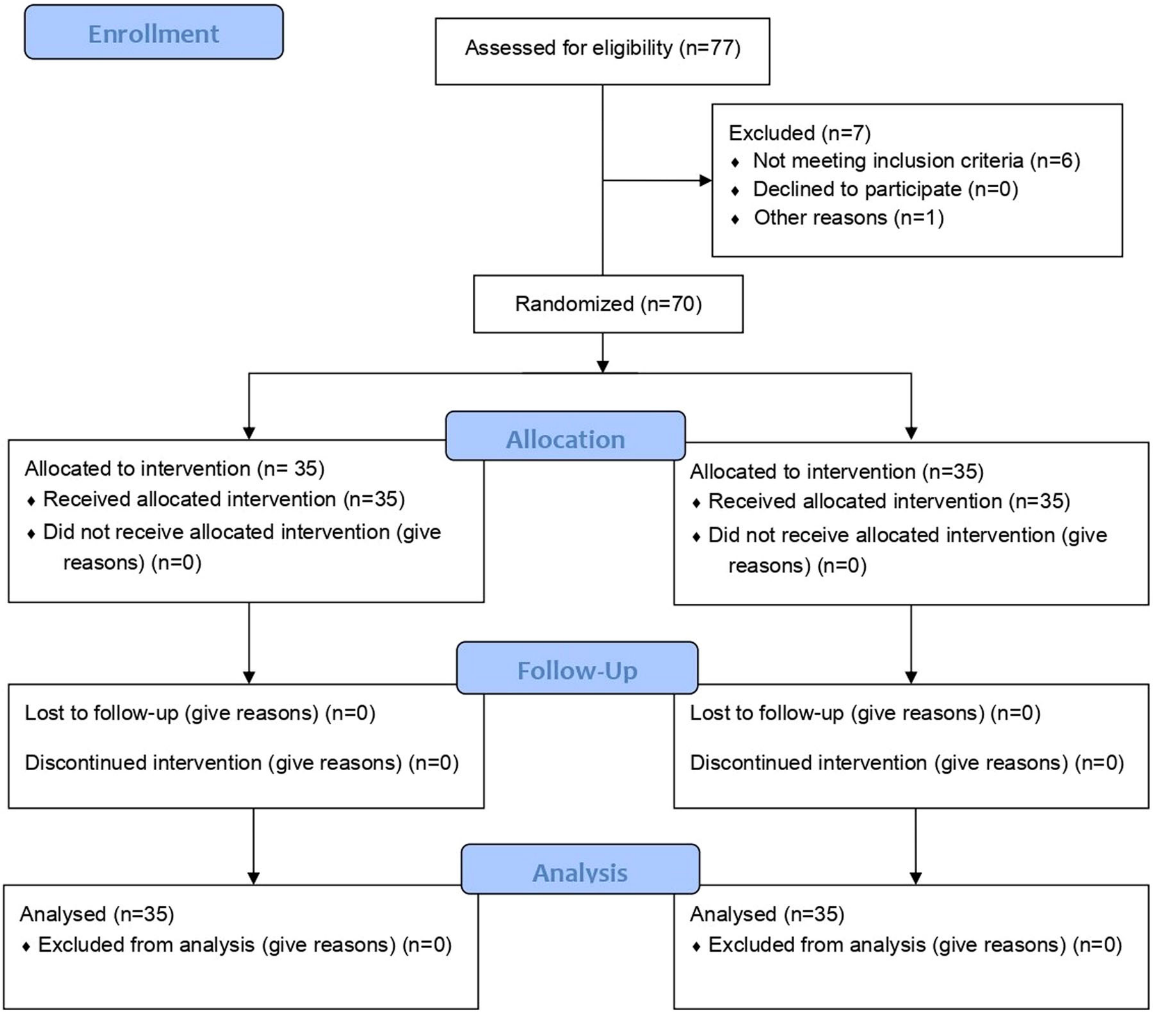

FIGURE 3 Consolidated Standards of Reporting Trial (CONSORT) flow diagram.

explained in Figure 3. All subjects enrolled originally were included in the final analysis as planned. The level of significance was set at $p < 0.05$.

3 | RESULTS

In March 2023, 70 participants (35 in the Experimental Group and 35 in the Sham Group) were recruited. The 70 participants met all eligibility criteria and agreed to participate. Then, the participants were randomly assigned to each group and received their assigned treatment.

Statistically significant improvements were found in the within-group analysis (Table 2) for the Experimental Group in the isometric extension force ($p < 0.001$; $\eta^2 = 0.368$), which showed a 17.46% more force than baseline, CMJ ($p < 0.001$; $\eta^2 = 0.301$) with an increase of a 4.89% and 30 m sprint ($p < 0.001$; $\eta^2 = 0.376$) improving a 3.75%. In the Sham Group, a statistically significant improvement was found only in the isometric extension force ($p = 0.018$; $\eta^2 = 0.154$) with 11.34% more force than baseline.

In the between-group analysis, statistically significant differences were found only in favor of the Experimental Group in CMJ ($p = 0.017$; $\eta^2 = 0.081$) increasing a 4.53% more than the Sham Group and in the 30 m sprint ($p < 0.001$; $\eta^2 = 0.152$) improving a 4.75% more than the Sham Group.

The changes found in the electromyography values can be seen in Table 3.

Statistically significant changes were found in the within-group analysis (Table 3) for the Experimental Group in the RF CMJ RSM ($p < 0.046$; $\eta^2 = 0.112$) (−25.2%) and in the RF 30 m sprint RMS ($p < 0.001$; $\eta^2 = 0.354$) (−56.01%). In the Sham Group, statistically significant differences were found in all muscles in both tests: RF CMJ RSM ($p = 0.026$; $\eta^2 = 0.138$) (−22.81%); RF 30 m sprint RMS ($p < 0.001$; $\eta^2 = 0.284$) (−61.64%); VL CMJ RSM ($p = 0.017$; $\eta^2 = 0.156$) (−28.51%); VL 30 m sprint RMS ($p = 0.009$; $\eta^2 = 0.184$) (−29.17%); VM CMJ RSM ($p = 0.014$; $\eta^2 = 0.165$) (−59.28%); and VM 30 m sprint RMS ($p < 0.001$; $\eta^2 = 0.272$) (−68.82%).

In the between-group analysis, there was no statistically significant difference for any electromyography variable.

4 | DISCUSSION

The aim of this study was to evaluate the effects of a focal vibration protocol added to the warm-up protocol with active muscle contractions, in the sprint, CMJ, and maximal isometric quadriceps strength.

Comparing the variables before and after treatment, a statistically significant improvement in all functional variables was found in the Experimental Group, and only in the isometric extension force for the Sham Group. Similarly, sEMG showed a statistically significant decrease in the Sham Group for all muscles in all tests and for the RF muscle in the Experimental Group. Comparing the results between both groups, statistically significant improvements in the CMJ and sprint tasks were observed in favor of the Experimental Group.

Our results showed a statistically significant increase in the maximum isometric strength variable for both, the Experimental Group and the Sham Group. However, the focal vibration group achieved an ES more than twice than the Sham Group (Table 2). According to Fattorini et al.[40] and Brunetti et al.,[41] focal vibration might improve motor control by inducing selective plastic modifications in the central nervous motor system. The findings could be attributed to plastic changes in proprioceptive processing, leading to

TABLE 2 Within-group comparison of isometric extension force, countermovement vertical jump and 30 m sprint.

Outcome/group	Pretreatment	Posttreatment	Within-group
Isometric extension force (Newtons)			
Experimental Group	321.82 ± 165.42	378.02 ± 186.21	$p < 0.001$ $\eta^2 = 0.368$
Sham Group	330.81 ± 160.06	368.33 ± 207.17	$p = 0.018$ $\eta^2 = 0.154$
Countermovement vertical jump (Cm)			
Experimental Group	31.31 ± 7.67	32.92 ± 7.46	$p < 0.001$ $\eta^2 = 0.301$
Sham Group	32.61 ± 7.05	32.73 ± 8.03	$p = 0.788$ $\eta^2 = 0.002$
30 m sprint (s)			
Experimental Group	4.98 ± 0.64	4.80 ± 0.63	$p < 0.001$ $\eta^2 = 0.376$
Sham Group	4.92 ± 0.59	4.97 ± 0.64	$p = 0.329$ $\eta^2 = 0.028$

TABLE 3 Electromyography values in the RF, VL, and VM muscles during the countermovement vertical jump test and 30 m sprint.

Outcome/group	Pretreatment	Posttreatment	Within-group
RF RMS in CMJ (%)			
Experimental Group	58.61 ± 33.44	46.81 ± 19.63	$p = 0.046$ $\eta^2 = 0.112$
Sham Group	58.67 ± 25.69	47.77 ± 15.72	$p = 0.026$ $\eta^2 = 0.138$
VL RMS in CMJ (%)			
Experimental Group	72.83 ± 35.26	66.47 ± 28.04	$p = 0.298$ $\eta^2 = 0.32$
Sham Group	79.09 ± 36.36	61.54 ± 22.84	$p = 0.017$ $\eta^2 = 0.156$
VM RMS in CMJ (%)			
Experimental Group	66.89 ± 42.18	54.91 ± 21.56	$p = 0.099$ $\eta^2 = 0.078$
Sham Group	82.75 ± 64.05	51.95 ± 21.33	$p = 0.014$ $\eta^2 = 0.165$
RF RMS in sprint (%)			
Experimental Group	218.28 ± 145.22	139.91 ± 102.59	$p < 0.001$ $\eta^2 = 0.354$
Sham Group	237.75 ± 147.59	147.08 ± 97.15	$p < 0.001$ $\eta^2 = 0.284$
VL RMS in sprint (%)			
Experimental Group	251.98 ± 170.92	227.94 ± 158.19	$p = 0.507$ $\eta^2 = 0.013$
Sham Group	281.27 ± 174.01	217.75 ± 160.96	$p = 0.009$ $\eta^2 = 0.184$
VM RMS in sprint (%)			
Experimental Group	212.16 ± 150.70	160.10 ± 115.63	$p = 0.106$ $\eta^2 = 0.075$
Sham Group	232.46 ± 194.06	137.69 ± 92.92	$p < 0.001$ $\eta^2 = 0.272$

Abbreviations: RF, rectus femoris; RMS, root mean square; VL, vastus lateralis; VM, vastus medialis.

an improvement in knee joint control, improving the alignment of force production and justifying the improvement of quadriceps isometric strength. This change has been documented since focal vibration causes cortical excitability changes.[28]

Similar to Pamukoff et al.,[42] our study found similar results in the isometric strength, but it is not completely comparable to other studies measuring.[43] This showed how peak torque improved immediately after an application of focal vibration and argued that this increase in maximal isometric strength is accompanied by an increase in the central activation ratio and a decrease in the motor activation threshold, similar to the literature discussed above.[40,41]

Moreover, to studying isometric force, there are several studies that evaluate dynamic force in relation to the effects of focal vibration. Drummond, et al.[44] studied the dynamic and isometric strength of the flexor muscles of the upper limb, between a group with focal vibration and a Sham Group. Similar to our study, they found statistically significant differences in both groups. In contrast, Iodice et al.[30] found no statistically significant differences in both, the focal vibration and the Sham Groups, in maximal isometric strength assessed after the intervention on the dominant limb, but did find statistically significant differences after more than one session of focal vibration on both limbs.

In addition, there are also studies in other types of populations that evaluate isometric strength, some authors have demonstrated the advantages of focal vibration in elderly patients.[29,45] Regarding the mechanism that makes a significant improvement in motor performance, applied focal muscle vibration is considered a highly selective stimulus for Ia spindle afferents. According to Matthews and Watson,[46] the high frequency can activate the spindle receptors in muscles through vibration causing a prolonged increase in their activity. This increase in activity can lead to long-term changes in the central nervous system, resulting in the reorganization of neural circuits.[29]

Similar to the literature that supports the strength improvement with focal vibration intervention, and considering that the increase of strength is associated with better sports performance,[2,47] our study showed that by adding focal vibration, athletes were able to perform a higher CMJ compared to themselves before the treatment, and also compared to other athletes who did not receive focal vibration. Also, the ES was large in both, within-group and between-group comparisons. These results are similar to Lin et al.[48] and Couto et al.,[49] proving that only with the intervention after the vibration the athletes can improve their CMJ.

Regarding the electrical activity of the quadriceps muscle in CMJ and sprint, we found a statistically significant decrease for all muscles in the Sham Group. According to Pamukoff[42] and Zinke,[50] in the Experimental Group, there were no statistically significant differences between pre and post-measurements, except for the RF muscle. Furthermore, there were no differences between the Sham Group and the Experimental Group, as in the study of Cattagni et al.[52] and the latest Cochrane review.[51]

A possible explanation for the greater decrease in RF muscle activation in the Experimental Group is the biarticular action of this muscle. A previous study of Hanon et al.[53] compared the different muscle activation of the biarticular and monoarticular quadriceps muscles and observed that the RF had a greater influence on the 30 m sprint and consequently fatigued earlier than the monoarticular muscles.

Similarly, during sprint performance, the Experimental Group improved statistically with a large ES after the focal vibration intervention and compared with the Sham Group. There are no previous studies that relate the application of focal vibration to sprint performance. However, with the effects of the focal vibration described above and the results of increased strength and improved CMJ, we could expect an improvement in sprint performance.[12,13]

The main clinical implication from our study is that adding a high-frequency focal vibration protocol to a warm-up with active muscle contractions produces statistically significant improvement in amateur athletes in the sprint, the results show an ES more than 13 times higher in the Experimental Group ($\eta^2 = 0.376$) than in the Sham Group ($\eta^2 = 0.028$), the same clinical implications for the vertical jump, a statistically significant improvement with a large ES in the Experimental Group (0.301) and a small ES in the Sham Group (0.002).

This study has different limitations because the study was conducted in a controlled laboratory environment, and the findings may not necessarily apply to real-life athletic situations. Also, as the study participants engaged in a variety of sports and spent varying amounts of time practising each week, it may be difficult to generalize the results to a specific sport or training regime. Another limitation of this study that should be noted is that high muscular dynamic contraction velocity of the muscle could alter the stability of the electrodes and muscle interaction and therefore the recording of sEMG.[54]

As future lines of research, it could be interesting to propose studies where the aim is to explore the effects of a more prolonged protocol, consisting of multiple sessions over several days, on athletes' sprint performance and evaluate how the focal vibration affects in different lengths such as 60, 100, or 200 m.

5 | CONCLUSION

Adding a focal vibration protocol to a muscle activation protocol makes a significant improvement in the sprint time, CMJ performance, and quadriceps strength, compared to a focal vibration sham protocol in amateur athletes. Therefore, our results suggest that the focal vibration could be useful in improving performance in sports involving high-powered actions.

AUTHOR CONTRIBUTIONS

Max Canet-Vintró: Investigation, methodology, project administration, resources, writing—original draft, writing—review and editing. **Jacobo Rodríguez-Sanz**: Investigation, methodology, project administration, resources, supervision, writing—original draft, writing—review and editing. **Carlos López-de-Celis**: Data curation, formal analysis, writing—original draft, writing—review and editing. **Enric Campañá-Arnal**: Investigation, writing—review and editing. César Hidalgo-Garcia: Investigation, writing—review and editing. **Albert Pérez-Bellmunt**: Investigation, methodology, project administration, resources, supervision.

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CONFLICT OF INTEREST STATEMENT

The authors declare no conflict of interest.

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