



EFFECTS OF A WEARABLE MICROVIBRATIONAL DEVICE ON MUSCLE MECHANICAL PROPERTIES AND POSTURAL CONTROL: A PILOT OBSERVATIONAL STUDY

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ABSTRACT

Wearable technologies are increasingly being integrated into postural re-education approaches. However, little is known about the effects of continuously wearable microvibrational devices on muscle mechanical properties and postural control. This pilot observational study investigated whether the use of a Wearable Microvibrational Device (WMD) is associated with changes in myofascial rheological properties and postural performance in recreational athletes undergoing a postural exercise program. Forty recreational athletes were retrospectively evaluated and allocated to either a WMD cohort (n=20) or a matched Control cohort (n=20). Both cohorts completed a 15-day postural re-education protocol, but only the WMD cohort used the wearable device. Assessments were performed at base-line (T0), after 15 minutes (T1), and after 15 days (T2). Muscle stiffness (S), tone (Frequency, F), and logarithmic decrement (D) were measured instrumentally and bilaterally in the tibialis anterior, gastrocnemius, and upper trapezius muscles. Postural control was assessed through the baropodometric Postural Biometric Index (PBI), while perceived bio-physical dysfunction was evaluated using the Bio-Postural Questionnaire (BPQ). The WMD cohort demonstrated progressive reductions in S and F, accompanied by significant increases in D across all investigated muscles. In contrast, the Control cohort showed a tendency toward increased S and F following exercise, without significant D modifications. Only the WMD cohort exhibited a significant improvement in PBI scores, whereas BPQ scores improved significantly in both cohorts. These preliminary findings suggest that the integration of a WMD into a postural exercise program may favor adaptive modifications of muscle rheological properties and objective postural performance. Larger controlled studies are warranted to clarify the underlying physiological mechanisms and confirm the clinical relevance of these observations.

KEYWORDS: *Wearable electronic device, ultrasonic wave, vibration, postural balance, muscle*

Received: 23 June, 2026

Accepted: 30 July, 2026

ISSN 2279-5855 print / 3103-7364 [online]

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INTRODUCTION

Extensive scientific literature establishes postural expression as a complex, dynamic phenomenon emerging from the functional convergence of biomechanical alignment, neuromuscular activity, and multisensory integration- encompassing somatic, visceral, and emotional inputs (1-4). From a neurophysiological perspective, posture may be interpreted as a reflex expression of spinal convergence and facilitation processes driven by central nervous system demands, whereby multiple afferent inputs converge at the metameric level, generating coordinated somatic motor responses (5). Consequently, qualitative and quantitative shifts in muscle tone, stiffness, and elasticity constitute pivotal factors in the destabilization of the postural system (6,7). These myofascial alterations often mirror the cumulative impact of convergent afferent inputs on spinal segments, which may induce facilitation phenomena within the somatic musculature, and such dysfunctions are robustly correlated with musculoskeletal impairments, chronic pain syndromes, diminished functional capacity, and a subsequent decline in quality of life (8).

Specifically, impairments in myofascial viscoelasticity may compromise force transmission efficiency and mechanical plasticity, thereby precipitating compensatory loading across articular and fascial networks (9). Prior research has established robust correlations between objective biomechanical metrics and patient-reported outcomes, advocating for multimodal assessment frameworks that synthesize instrumental and clinical data within rehabilitative contexts. Such an integrative paradigm is essential for elucidating the interplay between localized tissue aberrations and systemic adaptations in postural and autonomic regulation. Nevertheless, a significant gap persists regarding non-invasive therapeutic modalities capable of concurrently modulating muscular mechanical properties and postural stability through robust physiological pathways, especially via low-intensity stimulation. Within this framework, non-invasive wearable technologies provide substantial utility; following recent bio-technological advancements, they are increasingly pivotal in modern healthcare paradigms (10,11). Various wearable devices have been proposed and tested with varying levels of success in the postural field: from classic bites (12) to advanced wearable necklace sensors (13), based on proprioceptive and exteroceptive feedback, to therapeutically active tools such as adhesive patches based on the emission of photons (14,15).

A physical agent that could combine the possibility of stimulation via a wearable device and the need to mechanically stimulate the muscles for the purpose of myofascial and postural rheological correction would be ultrasound microvibrational stimulation, which appears to have mechanical, thermal and neuromodulation properties capable of influencing the neuromuscular and postural systems in the human body (16-18). However, to date there are no studies available on the role of any continuously wearable devices based on the physical principle of vibrational stimulation.

Therefore, this research sought to preliminarily assess whether the use of a Wearable Microvibrational Device (WMD) correlates with favorable shifts in postural orientation and the viscoelastic properties of myofascial tissues in a cohort of recreational athletes.

MATERIALS AND METHODS

This is a small-scale, retrospective, practice-based, controlled pilot study carried out from September to December 2025 at the “Center for Physiotherapy, Rehabilitation and Re-Education – Ce.Fi.R.R.” located in the facilities of the “Gabriele d’Annunzio” University of Chieti-Pescara in Chieti (Italy). It monitored a convenience cohort of recreational athletes who underwent a routine postural training protocol, comparing those who were independently prescribed the use of a non-invasive WMD paired with a non-rehabilitative postural re-education exercise protocol (WMD group) with a well-matched control group of subjects undergoing a postural re-education exercise protocol only (Control group). Subjects in the WMD group presented at our facility already equipped with the device, which was independently indicated by an external specialist in posturology prior to admission. The present study was conducted in accordance with the ethical principles outlined in the Declaration of Helsinki (19), as well as in accordance with the STROBE guidelines applicable to the specific study design. As a proactive demonstration of clinical and scientific rigor, this study was conducted under the UNI EN ISO 9001:2015 certification for observational research, issued to the leading institution by the National Accreditation Body, ACCREDIA (Certificate No. IT15/0304) (21). This framework ensures the highest standards of data integrity and operational rigor. Following institutional protocols, informed consent was secured from all subjects upon first access to the facility of the study. This consent authorizes the utilization of anonymized clinical data for subsequent investigative efforts and retrospective research, ensuring full compliance with ethical and privacy standards. The observed procedures were entirely non-invasive and involved no pharmacological intervention. All methodologies were executed in full compliance with the prevailing national healthcare regulatory framework. Data considered for the study were recovered from the assessment record of subjects routinely collected during repeated standard postural assessments.

The regulatory framework governing the ethical oversight of retrospective, non-pharmacological research is currently

marked by a lack of national clarity, particularly regarding jurisdictional competencies and approval criteria (20), therefore, in the presence of pre-collected data under valid informed consent and in the presence of a retrospective non-pharmacological design, the standard ethical approval was waived.

The study population consisted of a consecutive series of individuals who presented to the facility during the observation period and met the eligibility criteria for a postural re-education protocol. In accordance with institutional guidelines, subjects were excluded from the analysis if they presented with major confounding conditions, including neoplasms, pacemakers or electronic implants, active infections, severe neurological or cognitive deficits, and severe cardiovascular disorders. Additional exclusion criteria comprised severe spinal disc herniation or stenosis, advanced osteoporosis, fever, history of seizures, pregnancy, substance abuse, systemic inflammatory musculoskeletal diseases, tissue necrosis, thrombosis or phlebitis, and hematological or coagulation disorders. Minors (under 18 years of age) were also excluded unless written informed consent was provided by a legal guardian. Applying these criteria led to the retrospective selection and extraction of clinical data from the medical records of 40 subjects (13 females, 27 males; mean age 49.6 ± 19.0 years).

Given the retrospective and preliminary nature of this investigation, a quota sampling strategy was utilized. This approach was chosen to minimize potential selection and analysis biases between the cohorts, as an a priori randomized allocation was not feasible. Initially, a consecutive sampling method was used to screen all recreational athletes admitted to the center during the reference period who held an external indication for a postural re-education protocol integrated with a WMD. This process yielded a preliminary WMD cohort of 20 individuals (4 females, 16 males; mean age 49.2 ± 19.1 years). Concurrently, to establish a balanced comparative framework for assessing postural outcomes based on the presence or absence of the WMD, an equally sized active control group was assembled. This Control cohort was formed by retrospectively selecting a consecutive series of 20 subjects (9 females, 11 males; mean age 50.0 ± 19.4 years) who had undergone a conventional postural re-education exercise program. To maximize comparability between the two interventions, the control group inclusion was strictly restricted to patients prescribed a training protocol identical in both duration and frequency to that of the WMD cohort.

The observed subjects were evaluated at the following times:

- T0: first assessment, for which subjects in both the WMD and Control cohorts were required to not wear the device.
- T1: immediate re-test, applied 15 minutes after T0, in which patients in the WMD cohort group were asked to wear the bracelet they usually used on pre-existing therapeutic indications, while patients in the Control cohort were always re-evaluated without wearing any device.
- T2: follow up at 15 days, in which patients from both cohorts were re-evaluated with the same conditions applied at time T1.

Assessment tools used were the following methods:

- Myoton PRO: a hand-held, smartphone-sized, non-invasive, and quantifiable tool for digital palpation of soft tissues (Myoton AS, Tallin, Estonia) (22). The instrument is equipped with a small, movable tip with a 7.1 mm deformation area delimited by a green visual indicator that indicates the starting point of the percussion. It is aimed perpendicularly at the target tissue with a pre-compression of 0.18 N, percussing it three consecutive times in approximately 3 seconds with pulses of 0.4 N of pressure and a duration of 15 ms. The instrument then records the acceleration signal in relation to the pulses delivered to the tissue, returning tissue rheological values of tone (Frequency = F) measured in Hz, resistance to deformation (Dynamic Stiffness = S) measured in N/m, and the inverse function of elasticity (Logarithmic Decrement = D) consisting of a pure number. These parameters were detected in subjects observed bilaterally on the bellies of the tibialis anterior, gastrocnemius, and upper trapezius muscles; their tension state is directly correlated with the overall postural position (23,24). These parameters were collected at each measurement time (T0, T1, and T2).
- Bio-Postural Questionnaire (BPQ): a multidimensional screening tool designed for the rapid quantification of systemic health status. This instrument represents an optimized iteration of a previously validated questionnaire, refined for use within the host institution (25). It systematically evaluates five primary domains: musculoskeletal (e.g., localized pain, edema, joint instability), visceral (gastrointestinal, renal, cardiovascular, and genito-hormonal functions), perceptual (visual, auditory, and somatosensory systems), psycho-emotional (anxiety, cognitive attention, and stress levels), and lifestyle factors (tobacco use, physical activity, and clinical history). The BPQ consists of 57 self-reported items, primarily scored on a 3-point Likert scale (0: absence of dysfunction; 2: maximum dysfunction), with two specific items capped at a maximum value of 1. The aggregate score, ranging from 0 to 112, serves as a global index of bio-physico-metric and postural dysfunction. As a self-administered tool, the BPQ streamlines anamnestic data collection and enables longitudinal monitoring of the patient's functional burden. Such broad-spectrum assessment frameworks are increasingly pivotal in the clinical

management of posture, where identifying concurrent bio-psycho-social determinants is essential for comprehensive rehabilitation (26). These parameters were collected at times T0 and T2.

- Digitized Baropodometric Assessment: postural stability and plantar pressure distribution were evaluated using a high-resolution baropodometric platform (Bioredix S.r.l., Rome, Italy). The primary outcome measure was the Postural Biometric Index (PBI), a multidimensional composite score automatically calculated by the proprietary software of the platform. The PBI synthesizes a comprehensive array of stabilometric and baropodometric variables, including Center of Pressure (CoP), bipodalic and retro-forefoot load symmetry, CoP angle, podalic angle, the anatomical location of the maximum pressure point, support surface symmetry, and the Center of Gravity (CoG) deviation relative to the CoP (25). For clinical interpretation, PBI values within the 0-10 range are classified as a physiological postural state, while values exceeding 10 indicate postural dysfunction (25). Observed subjects were instructed to stand on the platform for a 5-second acquisition period, maintaining a fixed gaze on a visual target positioned on the opposite wall. To ensure reproducibility and compliance, the feet were placed parallel and shoulder-width apart, according to a configuration recognized as one of the best for stabilometric evaluations (27). These parameters were collected at each measurement time (T0, T1, and T2).

During the observation period, subjects belonging to the WMD group cohort wore a device named RYB (ONAM S.r.l., Livorno, Italy) consisting of a bracelet equipped with a low-amplitude microvibrations generator working at an ultrasonic frequency of 90 kHz, positioned approximately at the dorsal level of the styloid area of the wrist joint on the individual dominant upper limb. The bracelet produces a vibration that is generally imperceptible or, at most, minimally perceptible depending on the individual tactile sensitivity of the wearer subject. The vibration generator is equipped with a rechargeable battery. Observed subjects wearing the WMD maintained a continuous 24-hour wearing schedule for 15 days, excluding periodic short charging breaks.

The postural re-education exercise protocol underwent by both the WMD and Control cohorts consisted of individual 45-minute sessions of total-body strengthening, stretching, and proprioceptive exercises. These exercises were tailored to each participant and performed three times a week over a 15-day period (with approximately 48 to 72 hours between sessions).

Given the small sample size and the exploratory intent of the observation, the considered data were analyzed using nonparametric tests, following a conservative approach regarding the distribution and robustness of the datasets. Specifically, for both the WMD and Control cohorts, the variables monitored on three times (T0, T1, and T2) were analyzed by Friedman test for repeated measures, followed by a post-hoc analysis with Nemenyi test; the BPQ values, detected only at times T0 and T2, were instead analyzed by Wilcoxon signed rank test. The comparison between the WMD and Control cohorts was conducted on a purely quantitative and descriptive basis, evaluating the trend of variations that emerged from the respective intragroup analyses, without the use of intergroup statistical inference. Each variable was reported as median with interquartile range (IQR). The statistical significance values considered for the tests conducted were $p < 0.05$. The comparability analysis of the observed cohorts was conducted by means of a Mann Whitney U test applied to the variables of age, weight, and height of the subjects; for this analysis, the data reported were standardized test statistic (Z), test statistic (U) and standardized effect size ($Z/\sqrt{(n1+n2)}$). For the analyses conducted with the Friedman test, the values of the test statistic (χ^2) and effect size (W) were also reported. The p value was reported also for the post-hoc analyses conducted with Nemenyi test. For analysis conducted with Wilcoxon test, the data reported were standardized test statistic (Z) and effect size (r). All analyses were conducted using the online calculation software Statistics Kingdom (<https://www.statskingdom.com>).

RESULTS

Patient demographics and cohort comparability analysis

The main demographics (age, weight, and height) of the observed WMD and Control cohorts are reported, along with their comparability analysis in Table I (Table I).

Table I. Demographic parameters of the observed cohorts and related comparability analysis.

Variable	Cohort	No.	Median	IQR	p	Z	U	$Z/\sqrt{(n1+n2)}$
Age (years)	WMD	20	53.50	59.75 - 30.00	0.70	-0.38	185.50	0.06
	Control	20	57.50	63.50 - 40.25				
Weight (Kg)	WMD	20	63.00	78.25 - 55.75	0.20	-1.27	152.50	0.20
	Control	20	70.00	86.00 - 60.75				
	WMD	20	164.00	167.75 - 160.00	0.48	-0.71	173.50	0.11

Height (cm)	Control	20	168.00	172.50 - 160.00				
Legend: No. = Number of Patients								

On the basis of the analysis conducted on the demographics of the patients observed, it is shown that there are no significant differences between the WMD and Control cohorts, arguing in favor of a comparability of the two cohorts in terms of demographic variables. It should be noted, however, that the gender distribution between the two cohorts tended to be dissimilar in the Females/Males ratio (4/16 in WMD; 9/11 in Control).

Myoton S data analysis

The observation of the measurements of the S value carried out at times T0, T1, and T2 showed overall significant variations in both cohorts, although with opposite directions in terms of decrease for the WMD cohort and increase for the Control cohort, with variable levels of effect size (Table II).

Table II. *Myoton S omnibus data analysis.*

Muscle	Side	Cohort	Time	Median	IQR	p	χ^2	W
Tibialis Anterior	Right	WMD	T0	454.00	486.75 - 417.50	<0.01	38.10	0.95
			T1	393.00	459.50 - 356.75			
			T2	366.00	425.50 - 331.75			
		Control	T0	393.00	449.75 - 344.25	<0.01	12.03	0.30
			T1	421.50	486.75 - 369.75			
			T2	448.00	495.75 - 416.25			
	Left	WMD	T0	453.50	486.75 - 411.50	<0.01	32.40	0.81
			T1	399.00	459.00 - 367.50			
			T2	366.00	413.50 - 331.75			
		Control	T0	393.00	448.75 - 349.75	<0.01	11.68	0.29
			T1	424.00	491.25 - 373.75			
			T2	465.00	495.75 - 410.25			
Gastrocnemius	Right	WMD	T0	312.50	338.50 - 275.75	<0.01	40.00	1.00
			T1	270.50	299.50 - 254.25			
			T2	250.00	260.25 - 239.50			
		Control	T0	283.00	318.75 - 263.75	<0.01	12.87	0.32
			T1	294.50	354.00 - 256.50			
			T2	301.00	342.00 - 283.75			
	Left	WMD	T0	312.50	338.50 - 275.75	<0.01	38.10	0.95
			T1	270.50	299.50 - 254.25			
			T2	250.00	260.25 - 239.50			
		Control	T0	279.00	305.50 - 257.25	<0.01	17.87	0.45
			T1	297.50	335.50 - 270.75			
			T2	305.50	342.00 - 288.25			
Upper Trapezius	Right	WMD	T0	392.50	482.25 - 375.25	<0.01	40.00	1.00
			T1	367.00	407.25 - 342.00			
			T2	309.50	375.25 - 276.75			
		Control	T0	368.00	416.00 - 316.75	<0.01	17.36	0.43
			T1	379.00	455.25 - 342.00			
			T2	415.00	459.00 - 383.25			
	Left	WMD	T0	391.50	482.25 - 380.75	<0.01	38.10	0.95
			T1	367.00	407.25 - 342.00			
			T2	309.50	375.25 - 276.75			
		Control	T0	384.00	427.25 - 316.75	<0.01	14.75	0.37

			T1	384.50	455.25 - 350.75			
			T2	425.50	459.00 - 389.00			

Post-hoc analysis of the observed data showed that while the WMD cohort experienced a significant decrease in S-value in the comparisons between all three assessment times, the Control cohort experienced a significant increase in S mostly between times T1 and T2 (Table III).

Table III. *Myoton S post-hoc data analysis.*

Muscle	Side	Cohort	Times Compared	<i>p</i>
Tibialis Anterior	Right	WMD	T0-T1	<0.01
			T1-T2	<0.01
			T0-T2	0.01
		Control	T0-T1	0.25
			T1-T2	<0.01
			T0-T2	0.16
	Left	WMD	T0-T1	0.01
			T1-T2	<0.01
			T0-T2	0.01
		Control	T0-T1	0.33
			T1-T2	<0.01
			T0-T2	0.14
Gastrocnemius	Right	WMD	T0-T1	<0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.76
			T1-T2	<0.01
			T0-T2	<0.01
	Left	WMD	T0-T1	0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.06
			T1-T2	<0.01
			T0-T2	0.16
Upper Trapezius	Right	WMD	T0-T1	<0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.14
			T1-T2	<0.01
			T0-T2	0.08
	Left	WMD	T0-T1	0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.19
			T1-T2	<0.01
			T0-T2	0.12

Myoton F data analysis

The observation of the measurements of the F value carried out at times T0, T1, and T2 showed overall significant variations in both cohorts, although with opposite directions in terms of decrease regarding the WMD cohort and increase regarding the Control cohort, and with variable levels of effect size (Table IV).

Table IV. *Myoton F omnibus data analysis.*

Muscle	Side	Cohort	Time	Median	IQR	<i>p</i>	χ^2	W
Tibialis Anterior	Right	WMD	T0	21.30	22.225 - 19.725	<0.01	34.33	0.86
			T1	20.35	21.50 - 18.70			
			T2	19.00	20.00 - 16.75			
		Control	T0	20.25	22.675 - 18.875	<0.01	13.63	0.34
			T1	21.10	22.80 - 19.725			
			T2	22.10	23.80 - 19.90			
	Left	WMD	T0	21.30	22.225 - 19.725	<0.01	34.33	0.86
			T1	20.35	21.50 - 18.70			
			T2	19.00	20.00 - 16.75			
		Control	T0	20.40	23.325 - 18.875	0.03	6.91	0.17
			T1	21.40	23.55 - 19.775			
			T2	22.30	24.15 - 19.975			
Gastrocnemius	Right	WMD	T0	16.80	18.65 - 15.15	<0.01	32.38	0.81
			T1	16.15	17.825 - 14.175			
			T2	14.50	16.40 - 13.00			
		Control	T0	16.25	18.475 - 15.225	<0.01	12.83	0.32
			T1	17.70	19.125 - 14.85			
			T2	17.90	18.85 - 16.175			
	Left	WMD	T0	16.80	18.65 - 15.15	<0.01	32.38	0.81
			T1	16.15	17.825 - 14.175			
			T2	14.50	16.40 - 13.00			
		Control	T0	16.85	18.50 - 14.80	0.02	8.08	0.20
			T1	17.55	19.20 - 15.425			
			T2	17.35	18.55 - 15.975			
Upper Trapezius	Right	WMD	T0	20.85	22.425 - 20.25	<0.01	38.10	0.95
			T1	19.75	20.125 - 18.675			
			T2	17.25	19.00 - 16.00			
		Control	T0	19.75	22.4 - 17.80	<0.01	19.16	0.48
			T1	21.25	23.125 - 18.80			
			T2	22.00	23.625 - 20.40			
	Left	WMD	T0	20.65	23.25 - 19.95	<0.01	38.10	0.95
			T1	19.15	20.25 - 18.475			
			T2	17.00	19.00 - 16.00			
		Control	T0	20.00	22.6 - 18.10	<0.01	20.08	0.50
			T1	21.25	23.275 - 20.30			
			T2	22.00	23.7 - 21.00			

Post-hoc analysis of the observed data showed that while the WMD cohort experienced a significant decrease in F-value in the comparisons between all three assessment times, the Control cohort experienced a significant increase in F mostly between times T1 and T2 (Table V).

Table V. *Myoton F post-hoc data analysis.*

Muscle	Side	Cohort	Times Compared	<i>p</i>
Tibialis Anterior	Right	WMD	T0-T1	0.03
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.46

			T1-T2	<0.01
			T0-T2	0.04
	Left	WMD	T0-T1	0.03
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.33
			T1-T2	0.02
			T0-T2	0.46
Gastrocnemius	Right	WMD	T0-T1	0.07
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.51
			T1-T2	<0.01
			T0-T2	0.06
	Left	WMD	T0-T1	0.07
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.29
			T1-T2	0.02
			T0-T2	0.41
Upper Trapezius	Right	WMD	T0-T1	0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.19
			T1-T2	<0.01
			T0-T2	0.04
	Left	WMD	T0-T1	0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.16
			T1-T2	<0.01
			T0-T2	0.03

Myoton D data analysis

The observation of the measurements of the D value carried out at times T0, T1, and T2 showed an overall significant variation in the values only in the WMD cohort; furthermore, while in the WMD a linear trend of increase in the D value was observed, in the Control the values appeared with more random variations, with variable effect sizes (Table VI).

Table VI. Myoton D omnibus data analysis.

Muscle	Side	Cohort	Time	Median	IQR	p	χ^2	W
Tibialis Anterior	Right	WMD	T0	0.84	1.01 - 0.77	<0.01	36.40	0.91
			T1	0.96	1.2325 - 0.84			
			T2	1.19	1.57 - 1.015			
		Control	T0	0.89	0.9775 - 0.7925	0.56	1.14	0.03
			T1	0.845	0.985 - 0.7575			
			T2	0.83	0.9075 - 0.7675			
	Left	WMD	T0	0.895	0.9975 - 0.8075	<0.01	36.40	0.91
			T1	1.00	1.1825 - 0.87			
			T2	1.19	1.57 - 1.015			

Gastrocnemius	Right	Control	T0	0.82	1.00 - 0.7475	0.51	1.35	0.03
			T1	0.87	1.00 - 0.7275			
			T2	0.80	0.9375 - 0.73			
		WMD	T0	1.225	1.30 - 1.115	<0.01	39.52	0.99
			T1	1.455	1.7625 - 1.24			
			T2	1.565	1.84 - 1.335			
		Control	T0	1.44	1.64 - 1.1525	0.08	4.94	0.12
			T1	1.345	1.64 - 1.15			
			T2	1.20	1.48 - 1.00			
Gastrocnemius	Left	WMD	T0	1.24	1.3325 - 1.115	<0.01	39.52	0.99
			T1	1.485	1.77 - 1.2775			
			T2	1.565	1.84 - 1.3325			
		Control	T0	1.395	1.70 - 1.16	0.07	5.30	0.13
			T1	1.32	1.6475 - 1.195			
			T2	1.275	1.3625 - 1.075			
Upper Trapezius	Right	WMD	T0	1.17	1.27 - 1.0175	<0.01	39.52	0.99
			T1	1.27	1.3925 - 1.1475			
			T2	1.42	1.5375 - 1.2475			
		Control	T0	1.20	1.3625 - 0.975	0.82	0.39	0.01
			T1	1.205	1.455 - 1.00			
			T2	1.30	1.40 - 0.965			
	Left	WMD	T0	1.19	1.2725 - 1.04	<0.01	39.52	0.99
			T1	1.30	1.3925 - 1.1725			
			T2	1.42	1.5375 - 1.2475			
		Control	T0	1.24	1.335 - 0.96	0.82	0.39	0.01
			T1	1.20	1.4 - 1.00			
			T2	1.30	1.385 - 0.965			

Post-hoc analysis of the observed data showed that while the WMD cohort experienced a significant increase in D-value in the comparison between all three assessment times, the Control cohort showed no significant variations between times (Table VII).

Table VII. Myoton D post-hoc data analysis.

Muscle	Side	Cohort	Times Compared	p
Tibialis Anterior	Right	WMD	T0-T1	0.03
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.76
			T1-T2	0.97
			T0-T2	0.61
	Left	WMD	T0-T1	0.03
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.51
			T1-T2	0.84
			T0-T2	0.84
Gastrocnemius	Right	WMD	T0-T1	<0.01
			T1-T2	<0.01
			T0-T2	<0.01

		Control	T0-T1	0.37
			T1-T2	0.12
			T0-T2	0.80
	Left	WMD	T0-T1	<0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.61
			T1-T2	0.08
			T0-T2	0.46
Upper Trapezius	Right	WMD	T0-T1	<0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.92
			T1-T2	0.99
			T0-T2	0.84
	Left	WMD	T0-T1	<0.01
			T1-T2	<0.01
			T0-T2	<0.01
		Control	T0-T1	0.92
			T1-T2	0.84
			T0-T2	0.99

PBI data analysis

The observation of the PBI value detected at times T0, T1, and T2 showed an overall significant variation in the values only in the WMD cohort (Table VIII).

Table VIII. PBI omnibus data analysis.

Cohort	Time	Median	IQR	<i>p</i>	χ^2	W
WMD	T0	15.5	20.25 - 14.00	<0.01	30.91	0.77
	T1	14	15.25 - 11.75			
	T2	9.5	11.00 - 8.50			
Control	T0	16	18.25 - 13.00	0.35	2.10	0.05
	T1	14.5	18.00 - 9.00			
	T2	15	18.00 - 12.75			

Post-hoc analysis of the observed data showed that while the WMD cohort experienced a significant decrease in the PBI value in the comparison between times T1-T2 and T0-T2, the Control cohort showed no significant variations between times (Table IX).

Table IX. PBI post-hoc data analysis.

Cohort	Times Compared	<i>p</i>
WMD	T0-T1	0.16
	T1-T2	<0.01
	T0-T2	<0.01
Control	T0-T1	0.33
	T1-T2	0.76
	T0-T2	0.76

BPQ data analysis

The observation of the BPQ score detected at times T0 and T2 showed an overall significant variation in the values for both cohorts (Table X).

Table X. *BPQ data analysis.*

Cohort	Time	Median	IQR	<i>p</i>	<i>Z</i>	<i>r</i>
WMD	T0	29.50	35.25 - 17.50	<0.01	-3.90	-0.87
	T1	18.00	27.50 - 12.50			
Control	T0	23.50	37.00 - 18.00	<0.01	-3.54	-0.83
	T1	23.00	32.25 - 17.50			

DISCUSSION

The preliminary findings of this observational study suggest that the integration of the WMD modulates baseline postural and muscular rheological properties, although these observations must be interpreted with caution given the relatively small sample size of recreational athletes evaluated. Most notably, despite the pilot nature of this cohort, the WMD group exhibited an immediate reduction in muscular S and F upon device application at T1. This initial response appeared to be maintained even when combined with the active exercise protocol at T2. In parallel, a progressive and significant increase in the D parameter was observed across all three time points (T0 to T2) within the WMD cohort. These patterns contrast sharply with the behavior of the Control cohort, which demonstrated a counter-trend characterized by an increase in S and F values, reaching statistical significance only at T2, after the implementation of physical exercises, and a non-significant tendency toward a reduction in D. Furthermore, the WMD cohort achieved a significant reduction in the PBI score following the implementation of the rehabilitation protocol (T1-T2 and T0-T2), whereas the Control group showed no meaningful variations. Interestingly, despite these muscular and rheological discrepancies, both cohorts demonstrated a significant mitigation of bio-physical postural dysfunction, as reflected by the reduction in BPQ scores. While these preliminary data are encouraging, these divergent mechanical behaviors might pose some questions about the underlying physiological mechanisms.

Since F measures the intrinsic tension of muscle, while S indicates myofascial resistance to deformation, the significant decrease in these parameters observed in subjects using the WMD might indicate mechanical myofascial release or proprioceptive inhibition associated to the use of the device. Since the microvibration produced by the WMD is effectively a proprioceptive stimulus, potentially involving the Pacinian corpuscles and other vibration-sensitive mechanoreceptors, this could have induced a change in the observed parameters (18,28). Furthermore, since proprioceptive vibratory stimuli are perceived rapidly but transiently in an application-dependent manner (29), the fact that the WMD is a long-lasting device could have made the proprioceptive stimulation effective over the long term, with effects that persisted until the end of the observation, with the device acting as a possible "facilitator" reducing compensatory hypertonicity before exercise even begins. The fact that, in the control cohort, S and F significantly increased after implementing postural exercise represents a possible pattern of acute muscle fatigue or standard motor activation, which has been widely documented in the literature (29).

Furthermore, the fact that only the WMD cohort experienced a significant increase in D value highlights that it is possible that proprioceptive reprogramming possibly due to the use of the device could have favored an adaptive plastic remodeling of the muscular rheological properties, which could have a preventive effect on the establishment of altered tension states and tissue fibrosis (30).

The observation of the BPQ variable, which quantifies the biophysical postural dysfunction perceived by the subject, highlights how postural exercise alone has a perceived short-term clinical efficacy, with significant changes observed regardless of whether or not the WMD was used in the subjects studied. However, the drop in PBI in the WMD cohort alone would seem to indicate that the addition of the device achieves this clinical benefit through a real and profound objective restructuring of the rheological properties of the muscles. The Control cohort appears to improve the perception of their own functionality in the short term, probably due to the many psychological and anti-stress benefits associated with physical activity (31); the WMD group, on the other hand, appears to associate the subjectively perceived benefit with an objective biomechanical normalization, confirmed by the trends in Myoton and PBI values.

The preliminary results observed in this study appear to be consistent with current evidence in the literature, which demonstrates a potential therapeutic effect, albeit weak and rapidly evolving from a technological and applicative point

of view, of wearable proprioceptive stimulation systems, even those based on perceptible or imperceptible vibratory stimuli (32,33).

Although the preliminary findings of this study provide encouraging evidence regarding the efficacy of the WMD, several methodological limitations must be acknowledged, which constrain the robustness and generalizability of these results. First, the retrospective, observational nature of the design led to a relatively small and heterogeneous sample size within each cohort, thereby limiting the statistical power of the analysis. Furthermore, the participants did not present a well-defined pathological condition characterized by strict diagnostic criteria; rather, they exhibited a general postural dysfunction that was professionally but subjectively assessed outside the primary data collection site. This lack of clinical standardization inherently hindered the homogenization of the cohorts.

Given these constraints, the influence of a placebo effect associated with the WMD, or the confounding role of spontaneous chronological evolution within individual subjects, cannot be entirely ruled out. Similarly, statistical artifacts, such as regression to the mean, particularly in subjects presenting with highly dysfunctional baseline values, must be considered. Conversely, the retrospective observational design may have mitigated the impact of a true Hawthorne effect during the protocols. This is further supported by the fact that only the BPQ instrument relies on subjective self-reporting, whereas the Myoton and PBI evaluations utilize objective physical measurement tools. While these objective assessments are substantially less prone to participant bias, they remain partially examiner-dependent; nonetheless, this potential variance was minimized in the present study by utilizing a single, consistent investigator across all subjects and time points.

Despite these limitations, this study offers valuable insights by investigating the real-world application of the WMD in postural re-education, benchmarking its utility as a possible complementary approach to be paired with traditional targeted physical exercise protocols. In particular, the divergent trajectories observed in muscle rheological parameters between the WMD and Control cohorts suggest that the biomechanical interaction of such devices is highly complex. These preliminary outcomes underscore the necessity for subsequent, more rigorous investigations. Future research should employ larger, finely stratified samples investigated within controlled experimental designs, utilizing multi-dimensional evaluation tools to fully elucidate the underlying physiological mechanisms.

CONCLUSIONS

In conclusion, while the preliminary and exploratory nature of this study warrants caution, the present field observations open new and intriguing perspectives on the integration of wearable technology in sports and recreational physical activity. The divergent biomechanical responses observed between the cohorts suggest that devices like the WMD do not merely complement traditional exercise but may fundamentally alter the neuro-mechanical and rheological state of myofascial tissues during movement. This introduces a shifting paradigm in postural re-education: moving from a model focused solely on active motor retraining to one that leverages immediate, device-mediated tissue compliance to maximize exercise efficiency.

Moving forward, these insights highlight the critical need to transition from real-world observations to highly controlled experimental frameworks. To confirm and expand upon these initial trends, future research must prioritize randomized controlled trials utilizing larger, well-stratified cohorts. Specifically, future protocols should investigate whether these acute rheological modifications translate into long-term structural adaptations and stable clinical outcomes. Additionally, incorporating advanced multi-dimensional assessment tools, such as high-density electromyography or dynamic elastography, could help fully map the physiological mechanisms driving this supposed device-tissue interaction. Ultimately, this line of research holds the potential to refine personalized re-education protocols, establishing a more synergistic bond between targeted physical exercise and advanced biomechanical wearables.

Conflict of interest

The authors declare that they have no conflict of interest.

Funding

The study was conducted without external funding.

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