Investigating the Physiological Performance Benefits of HAELO Symphonic Pulsed Electromagnetic Field (sPEMF) Therapy Measured by the Biostrap Wrist-Worn Photoplethysmography Device.

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Abstract

Background: Pulsed Electromagnetic Field (PEMF) therapy is a safe and non-invasive type of frequency therapy which has been shown to affect a number of cellular and biological functions to support the management or treatment of various health conditions. However, the research related to athletic performance has been primarily limited to self-reported improvements. Due to a lack of federal regulation in the $4.2 trillion global health and wellness industry, product and service providers often make wellness and performance claims without adequate scientific validation or proof of efficacy.

Objective: This study aimed to evaluate the immediate and lasting physiological performance benefits of two (2) weeks of consistent HAELO Symphonic PEMF (sPEMF) application in a group of healthy adults regularly engaging in high-volume athletic training.

Methods: Participants were recruited based on responses to digital surveys. Measurements collected on 5 healthy participants, age 30-38, using the Biostrap wrist-worn photoplethysmography (PPG) device with in-application prompts for intermittent and daily survey responses for five weeks. Following a two-week baseline, participants were guided through specific sPEMF protocols based on their daily training. Participants were monitored for one additional week of discontinued use to measure the lasting benefits of sPEMF therapy. Participants were instructed to maintain consistent training type and volumes throughout study duration.

Results: A total of approximately 175 days of biometric data were analyzed from 5 participants who maintained compliance throughout the 5-week study duration. Analysis of data throughout study phases showed improvements in nocturnal vitals, deep sleep duration, deep sleep percentage, average sleep disturbances, overall sleep score, and overall recovery score for the majority of participants. Additionally, all participants reported improvements in perceived performance and quality of life.

Conclusions: Consistent use of HAELO Symphonic Pulse Electromagnetic Field (sPEMF) Therapy provides quantitative improvement in various health and performance biometrics. Further investigation is required to understand the physiological benefits of sPEMF therapy.

Background

PEMF therapy is a safe and non-invasive type of frequency therapy designed to generate a magnetic field. PEMF has been shown to affect a number of cellular and biological functions to support the treatment of various health conditions, but the research related to athletic performance has been primarily limited to self-reported improvements in energy and performance in physical activities with decreased pain and improved recovery. In a recent study, researchers found experimental evidence that PEMF improves blood flow, enhances oxygen consumption, and boosts ATP production by facilitating electron transport through mitochondrial electron transport chain, thereby increasing skeletal muscle cellular energy potential[1].

These findings support PEMF applications for athletic performance, primarily in the realm of endurance athletics. Improvements in blood flow to skeletal muscle may enhance oxygen and nutrient delivery for improved cardiorespiratory function and energy output. Improvements in mitochondrial respiratory function and density related to PEMF application are comparable to physiological adaptations observed in prolonged interval exercise training[2].

Additional research has focused on the therapeutic sleep applications of PEMF therapy. In a 4-week double blind, placebo-controlled study of PEMF, researchers found significant improvements in sleep latency, frequency of sleep interruptions, sleepiness after rising, daytime sleepiness, and difficulty with concentration[3]. As elite athletes are known to get less total sleep and have longer sleep latency than non-athletes regardless of sport type[4-5], these validated sleep applications have the potential to significantly impact recovery and performance.

Prior studies have documented the effects of poor sleep quality in athletes including key performance indicators such as decreased reaction time, strength and endurance, and cognitive function[6-7]. According to the findings of a recent study published in Medicine & Science in Sports & Exercise, improvements in sleep quality and duration can have an immediate impact on perceived exertion and endurance performance during time-trials.[8]

Designed to mimic Earth's naturally occurring symphony of frequencies, HAELO is the only PEMF device that simultaneously delivers an orchestra of electromagnetic frequencies to potentially deliver a synergistic effect with cumulative benefits over time.

The safety of PEMF treatments has been thoroughly studies and well established to produce no adverse side effects when exposure time and intensity level are properly regulated.

Methods

Recruitment

Participants were recruited based on responses to digital surveys and pre-screened for inclusion criteria. An additional screening was performed to assess for contraindications and other exclusion criteria. Selected participants were required to complete an Informed Consent document and attend a comprehensive onboarding session.

Table 1. Participant Inclusion & Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
18+ years old	Pacemaker
Resident of the United States	Insulin Pump
Engage in regular physical activity averaging >30 miles per week	Cochlear Implants
	Electrical Implants or Devices
	Vagal Nerve Stimulator
	Breastfeeding
	Stomach or Surgical Staples
	Ferrous Metal Implants
	Immunosuppression Therapies
	History of Organ Transplant
	Recent or Planned Major Medical Procedure

Biometric Data Collection

The Biostrap is a non-invasive, wrist-worn sensor utilizing clinical-grade sensors to capture high-fidelity raw photoplethysmography (PPG) waveforms and analyzing each pulse wave for 29 parameters in a cloud-based pulse engine to ensure data integrity. Biostrap actively and passively captures data. Participants were instructed to wear the device during nightly sleep sessions, physical activity, and during manual data collection episodes. Participants were provided with comprehensive device training, hygiene protocols, and ongoing support to ensure proper usage.

- **Nocturnal vitals**: heart rate, heart rate variability, respiratory rate, oxygen saturation, second waveform derivative analysis of arterial and peripheral elasticity
- **Comprehensive sleep analysis**: duration, sleep stages (light vs. deep), efficiency, latency, awakenings, and movement. Overall sleep quality is additionally summarized as a 0-100 Sleep Score.
- **Recovery analysis**: The recovery analysis was based on a daily biometric assessment compared to a training baseline period to assess physiological recovery after controlled application of physical stress. Overall recovery is summarized as a 0-100 Recovery Score.
- **Physical activity**: daily steps, active duration, sedentary periods, distance traveled, and activity pace (miles/hour). This data was utilized to assess protocol compliance.

Figure 1. The Biostrap wrist-worn wearable is a configurable red/IR photoplethysmography (PPG) and motion detecting device which collects raw pulse wave signals to estimate vital signs, sleep parameters, and physical activity.

Surveys

Participants were instructed to complete surveys and questionnaires through Typeform software integrated in the Biostrap user application of email communications.

- **Demographics Form:** This form collected demographic and other lifestyle history of the research participant.
- **Sleep Quality:** The Pittsburgh Sleep Quality Index (PSQI) is an effective instrucment used to measure the perceived quality and patterns of sleep in adults. This 9-item Likert scale is a validated scoring system which differentiates "poor" from "good" sleep quality by measuring seven areas including subjective sleep quality, sleep latency, sleep duration, habitual sleep efficiency, sleep disturbances, use of sleep medications, and daytime dysfunction. The PSQI survey was administered one week before and after the study phase.
- **Program Satisfaction:** *Was it Worth it Questionnaire (WIWI)*[13]. This satisfaction survey will be administered to the participants prior to debriefing at the end of the study, probing their satisfaction with the research study. This data is utilized to assess the feasibility of the intervention by asking the participant if the entire research experience was worth it for them.
- **Daily Survey**: A brief daily survey was administered to assess perceived recovery, pain, discomfort, soreness, and sleep quality.

Participant Protocol

Phase	Baseline	Intervention	Wash-Out	Analysis
Week	1-2	3-4	5	Post-Study

Baseline Phase **Weeks 1-2**

During this baseline phase, participants were instructed to complete a daily survey, complete a manual pulse report on Day 1 & 8, and continue with normal exercise behaviors. Participants received their HAELO Symphonic PEMF device during the second week of the baseline phase.

Intervention Phase **Weeks 3-4**

The intervention phase included daily survey and structured HAELO Symphonic PEMF protocols for training and non-training days. Daily protocols included morning, post-exercise and pre-sleep frequency set recommendation.

Figure 2. The HAELO device consists of a Symphony One unit and coil with recommended placement on the abdomen, chest, or specific areas of muscle soreness or injury.

Table 2. Training Day Protocol

Component	Frequency Set	Duration (min:sec)	Manufacturer Description
Morning	Power	7:14	Turbo charged power not for the faint of heart! Feel like a winner and boost energy with up-leveled blood circulation, cell hydration and muscle endurance to excel physically, emotionally, and mentally.
Post-Training	Recover	22:32	Deep recovery of muscles, bones, ligaments, and fascia after strenuous workout or competition that typically produces soreness, stiffness, and pain. Supports a quick recovery for regular and consistent routines.
Pre-Sleep	Calm	7:20	Calms the mind and provides stability and grounding to center the mind, body, and energy field. Supports hormones and the nervous system. Targets stress reduction and reinforces peace and harmony.
	Defense	7:48	Comprehensive immune defense that supports white blood cells and provides optimal protection against a wide array

			of nasties. Supports colon and gut health for optimum balance.

Table 3. Non-Training Day Protocol

Component	Frequency Set	Duration (min:sec)	Manufacturer Description
Morning	Level Up	7:18	Powerful initiation of endorphins, serotonin, oxytocin, and dopamine triggering a wave of strength, endurance, and motivation to support a healthy mindset and stamina to go the distance and level up in all situations.
Afternoon	Relief	22:32	Gentle soothing relief to areas that are tight or sore. Relieves physical body tension accelerating recovery. Supports optimal gut health, a sound mind and overall positive attitude to keep routines on track.
Pre-Sleep	Calm	7:20	Calms the mind and provides stability and grounding to center the mind, body, and energy field. Supports hormones and the nervous system. Targets stress reduction and reinforces peace and harmony.
	Defense	7:48	Comprehensive immune defense that supports white blood cells and provides optimal protection against a wide array of nasties. Supports colon and gut health for optimum balance.

Wash-Out Phase **Week 5**

To assess for lasting physiological effects, users were instructed to discontinue all use of HAELO Symphonic PEMF. During the wash-out phase, users continued wearing the Biostrap device, completed daily surveys and maintained normal exercise habits.

Results

Data analysis was performed based on changes in participant daily and weekly averages for each study phase and summarized as weekly population averages below (Tables 4-6). All study participants showed an improvement in nocturnal heart rate, heart rate variability RMSSD, and arterial elasticity with average biometric changes of 1.47 bpm (3%), 1.30 ms (2%), and 3.16 (5%), respectively. The majority of participants experienced minor improvements in nocturnal oxygen saturation levels.

Table 4. Nocturnal Vitals

Category	Baseline (Week 1-2)	Intervention (Weeks 3-4)	Wash-Out (Week 5)	Change BL: Intervention	%Change
Resting Heart Rate	52.19	50.72	50.85	-1.48	-3
Heart Rate Variability	72.87	74.17	73.14	1.30	2
Respiratory Rate	14.45	14.69	14.46	-0.24	-2
Oxygen Saturation	96.75	97.02	96.86	0.28	0
Arterial Elasticity	67.39	70.56	71.78	3.16	5
Peripheral Elasticity	81.75	82.49	83.05	0.74	1

Among the most notable changes in all study participants was a significant increase in deep sleep with an average increase of 17.92 minutes per sleep session, despite a relative decrease in total sleep duration. Participants experienced 0.73 less awakenings (11%) each evening, with an average improvement in the Biostrap Sleep Score of 4.84 points (7%), which accounts for sleep parameters including duration, latency, sleep stages, awakenings, movement, and nocturnal biometric trends. As a result, all participants recognized an average increase of 6.62 points (11%) for the Biostrap Recovery Score. Theis algorithm includes an assessment of nocturnal heart rate, heart rate variability, sleep duration, and sleep efficiency on a relative basis, comparing daily values to a trailing baseline period.

Table 5. Sleep Parameters

Category	Baseline (Week 1-2)	Intervention (Weeks 3-4)	Wash-Out (Week 5)	Change BL: Intervention	%Change
Sleep Duration	529.39	522.58	523.01	-6.81	-1
Sleep Efficiency	86.89	87.60	87.56	0.72	1
Deep Sleep (mins)	119.43	137.36	133.65	17.92	15
Deep Sleep (%)	0.23	0.27	0.26	0.04	18
Sleep Disturbances	6.84	6.10	6.72	-0.73	-11
Sleep Score	71.32	76.16	71.53	4.84	7
Recovery Score	61.58	68.20	54.80	6.63	11

Although participants were instructed to maintain consistency in physical activity throughout this study, an increase in total step count, active duration, and Biostrap Activity Score were found. On average, participants increased daily step count by 975.26 steps and were active for 12.62 minutes per day, representing 11% and 12% increases, respectively.

Table 6. Daily Physical Activity

Category	Baseline (Week 1-2)	Intervention (Weeks 3-4)	Wash-Out (Week 5)	Change BL: Intervention	%Change
Step Count	9217.59	10192.85	9906.442	975.26	11
Active Duration (mins)	108.35	120.97	126.37	12.62	12
Activity Score	61.47	68.24	63.17	6.77	11

Despite the improvements in nocturnal biometrics, sleep quality and overall recovery, participants did not perceive significant changes in daily survey responses. However, an average increase in perceived recovery was recognized within three days of sPEMF intervention and maintained relatively consistent throughout the study duration.

Table 7. Survey Responses

Category	Baseline (Week 1-2)	Intervention (Weeks 3-4)	Wash-Out (Week 5)	Change BL: Intervention	%Change
Perceived Sleep Quality	7	7	7	0	0
Perceived Pain	1	1	0	0	0
Muscle Soreness	2	2	1	0	0
Perceived Recovery	6	7	7	1	16

*All survey responses were scored on a 0 to 10 Likert scale.

Additionally, 100% of participants reported improved quality of life (QoL) and perceived performance following participation in this study. Overall study satisfaction was reported as 8 out of 10 with all participants stating that they would recommend this product to others.

Discussion

Pulsed Electromagnetic Field (PEMF) technologies has been shown to improve biological functions safely and effectively by emitting specific frequencies, one at a time. Designed to mimic Earth's symphony of frequencies, the HAELO sPEMF device simultaneously delivers a synergistic orchestra of targeted frequencies to potentially provide enhanced therapeutic and performance benefits. To assess the utility of Symphonic Pulsed Electromagnetic Field (sPEMF) therapy for competitive endurance athletes, this structured intervention study investigated various nocturnal biometric trends and sleep parameters that have been shown in literature to be associated with athletic recovery, injury prevention, and overall performance.

Sleep Quality

Sleep quality is among the most important yet overlooked component in modern athletic training. Athletic recovery and adaptation involve multiple sleep-dependent processes including cognitive, emotional, musculoskeletal, behavioral, immune, metabolic, endocrine and glymphatic systems[9-10]. However, research in athletic populations has shown that various aspects of stress often lead to disrupted sleep [11-13] which is a critical component of athletic recovery and performance optimization[14-15]. Sleep reactivity, defined as the propensity to exhibit sleep disturbances in response to stress[16], has been shown to be elevated in athletes, particularly as they approach an upcoming competition[16]. The results of this study indicated a notable improvement in overall sleep efficiency and the quantity and duration of sleep disturbances, despite a relative decrease in overall sleep duration. Addressing sleep quality in competitive athletes has been shown to improve key aspects of performance including reaction time, strength, endurance, cognitive function, and perceived exertion. [6-8]

Additionally, an important component of sleep quality in competitive athletes is the amount of restorative sleep achieved. It is well established that growth hormone release from the pituitary gland, up to 95% of which occurs during slow-wave or deep sleep, is necessary for muscular recovery, growth, and repair[17]. Studies have shown that individuals with sleep-deprivation related decreases in deep sleep duration have a 1.7 greater likelihood of training-related injuries[18]. This study demonstrated a significant increase in average deep, restorative sleep in all athletic participants which was associated with an increased in perceived recovery, quality of life, and performance.

Arterial Compliance

When the aortic heart valve closes after ejecting its stroke volume, the decay of blood pressure prior to the next beat describes a waveform which is dependent on the stiffness or elasticity of the arterial system into which the oxygen- and nutrient-rich blood has been delivered. The morphological changes of the pulse wave can be detected via Biostrap photoplethysmography to measure arterial elasticity or compliance, which has emerged as an independent risk factor of cardiovascular disease and associated with an increased likelihood of hypertension, left ventricular hypertrophy and other age-related conditions[19-20]. Unsurprisingly, researchers have found that competitive endurance athletes have demonstrated greater arterial elasticity than their non-exercise-trained or sedentary, age-matched peers[21]. These favorable arterial elasticity properties may explain this population's greater cardiovascular functional capacity and lower risk of cardiovascular disease[22]. While additional research is required to confirm the relationship, the observed improvements in arterial elasticity may, in part, help to explain the improvements in blood flow to skeletal muscle, oxygen consumption, and ATP production found in previous PEMF experiments[1]. These findings support potential sPEMF applications for endurance performance.

Conclusions

Based on the results of this preliminary investigation, as well as high protocol compliance by competitive athletic study participants, this study demonstrates that consistent use of the HAELO Symphonic Pulse Electromagnetic Field (sPEMF) device may provide benefit to competitive endurance athletes including overall performance, recovery, and injury prevention through improved sleep quality and cardiovascular functional capacity biometrics.

Study Limitations

The sample size and targeted population included in this study (N=5) limits the statistical power of outcomes but provides preliminary evidence of efficacy for future investigation with larger population sizes and participant diversity.

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