An Initial Analysis of the Effects of Pulsed Electromagnetic Frequency (PEMF) Therapy on Recovery from Strenuous Exercise in College-Aged Men and Women

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ABSTRACT

Recovery from intensive exercise is essential for athletes. Consequently, many use novel modalities to aid this process. One example is pulsed electromagnetic field (PEMF) therapy, which involves a device that emits low frequency electromagnetic currents that may affect cell function. **PURPOSE:** To detail whether PEMF therapy enhances recovery after fatiguing exercise. **METHODS:** Thirty-three (19 men, 14 women) college-aged subjects were allocated to one of three groups: PEMF (subjects received 22:32 min:s of PEMF therapy while holding the device); PLAC (placebo; subjects held a device that was not on for 22:32 min:s); and CONT (control; subjects sat for 22:32 min:s). Fatigue was induced by a 3-stage Yo-Yo running protocol. Recovery interventions were provided immediately after the fatigue protocol (0 hours), and 24, 48, and 72 hours post-fatigue protocol. Recovery was measured quantitatively by a 6-s peak power (PC) and cadence (PC) test on a cycle ergometer; vertical jump (VJ); and isometric leg/back dynamometer strength (LBD). These were taken at baseline (prior to fatigue protocol), immediately after the 0-hour recovery intervention, and after the interventions at 24, 48, and 72 hours. Qualitative recovery was measured by visual analogue and Likert scales pre and post each recovery intervention. A 3 (PEMF, PLAC, CONT) x 5 (baseline, 0, 24, 48, 72 hours) repeated measures ANOVA, with sex as a covariate, derived any between-group differences. Change scores relative to the baseline were calculated, and analyzed by a 3 x 4 (0-baseline, 24-baseline, 48-baseline, 72-baseline) repeated measures ANOVA. Paired samples t-tests compared the qualitative measures pre and post recovery intervention. A 3x8 and 3x4 repeated measures ANOVA calculated any differences in perceived recovery and the pre-post change scores. **RESULTS:** There were no significant time by group ANOVAs. The main effects for time for PP and PC, and the change scores, were significant. PP ($p \leq 0.005$) and PC ($p < 0.001$) at 0 hours were generally lower than at all other times. The PP and PC 0-baseline change scores were lower compared to change scores from the other time points ($p < 0.001$). Although not significant, the PEMF group had greater change scores for PP, VJ, and LBD compared to the other groups, especially at 24 hours (Figure 1). There was a significant decrease ($p = 0.003$; $d = 0.707$) in the PEMF group Likert scale score at 24 hours. **CONCLUSIONS:** Although no significant differences in recovery between the groups were observed, change score and qualitative data suggested that the device used by the PEMF group had a positive influence on recovery and PP, VJ, and LBD performance 24 hours post fatigue protocol. Large standard deviations in the data suggest variation in individual responses. **PRACTICAL APPLICATIONS:** PEMF therapy may be beneficial to help with recovery from strenuous exercise among some individuals. Research is needed to ascertain mechanisms for how PEMF therapy could affect recovery.

INTRODUCTION

- Recovery from intensive exercise is essential for athletes. Consequently, many use novel modalities to aid this process. One example is pulsed electromagnetic field (PEMF) therapy. PEMF therapy involves using a device that emits slow frequency electromagnetic currents with an extended range of frequencies that may increase cell membrane permeability and stimulation of many intracellular functions (1).
- PEMF therapy may be used to facilitate healing from injuries. As an example, PEMF therapy has been used to stimulate bone healing, in that it can stimulate the bone in a similar manner to mechanical loading (3). Angiogenesis (creation of new blood vessels controlled by signals from chemicals in the body) and vasodilation (phenomenon in which the blood vessels widen, thus increasing blood flow) can also occur with the use of PEMF therapy, and may facilitate the treatment and management of post-surgical wounds, edema, and pain (7).
- The anecdotal recommendations for PEMF therapy in the optimization of recovery from intensive activity have been linked to factors such as improved blood circulation, muscle oxygen uptake, and removal of waste products resulting from exercise (6). if PEMF therapy could influence blood circulation, it could be surmised that it may encourage similar positive effects on recovery from exercise as those seen for massage therapy (8) and intermittent pneumatic compression (4). A starting point for investigating PEMF therapy would be to ascertain whether performance in high-intensity activities (e.g., actions requiring maximal strength and power) are recovered quicker following bouts with this modality.
- The purpose of this study was document whether PEMF therapy enhances recovery after fatiguing exercise.

METHODS

- Thirty-three (19 men, 14 women) college-aged subjects were allocated to one of three groups: PEMF (subjects received 22:32 min:s of PEMF therapy while holding the device); PLAC (placebo; subjects held a device that was not on for 22:32 min:s); and CONT (control; subjects sat for 22:32 min:s).
- For the treatment group, they used a PEMF device (HAELO, Encino, CA, USA) that consisted of a Symphony One unit and magnetic coil (5) (Figure 1). The size of the unit was 0.26 m x 0.20 m x 0.08 m, with a mass of approximately 2.5 kg. The device had a frequency range of 3-11875 Hz and a coil rating of 1.01 Ohm. The researcher used an app (HAELO, Encino, CA, USA) to drive the device from their phone, which paired via Bluetooth. A frequency set called '*Recover*' was utilized.

Figure 1. The PEMF device.

- Fatigue was induced by a 3-stage Yo-Yo running protocol (2). Recovery interventions were provided after the fatigue protocol (0 hours), and 24, 48, and 72 hours post-fatigue protocol. Recovery was measured quantitatively by a 6-s peak power (PC) and cadence (PC) test on a cycle ergometer; vertical jump (VJ); and isometric leg/back dynamometer strength (LBD). These were taken at baseline (prior to fatigue protocol), immediately after the 0-hour recovery intervention, and after the interventions at 24, 48, and 72 hours. Qualitative recovery was measured by visual analogue and Likert scales pre and post each recovery intervention.
- A 3 (PEMF, PLAC, CONT) x 5 (baseline, 0, 24, 48, 72 hours) repeated measures ANOVA, with sex as a covariate, calculated between-group differences. Change scores relative to the baseline were derived and analyzed by a 3 x 4 (0-baseline, 24-baseline, 48-baseline, 72-baseline) repeated measures ANOVA. Paired samples t-tests compared the qualitative measures pre and post recovery intervention. A 3x8 and 3x4 repeated measures ANOVA calculated differences in perceived recovery and the pre-post change scores.

RESULTS

- There were no significant time by group ANOVAs for the performance tests (Table 1). The main effects for time for PP and PC, and the change scores, were significant. PP ($p \leq 0.005$) and PC ($p < 0.001$) at 0 hours were generally lower than all other times. The PP and PC 0-baseline change scores were lower compared to change scores from the other time points ($p < 0.001$). Although not significant, the PEMF group had greater change scores for PP, VJ, and LBD compared to the other groups, especially at 24 hours (Figure 2).
- There was a significant decrease ($p = 0.003$; $d = 0.707$) in the PEMF group Likert scale score at 24 hours (Table 2). The change in VAS and Likert scores at 24 hours for the PEMF group was approximately 200-600% larger than that for PLAC and CONT groups (Figure 3), although these differences were not significant.

Table 1. Descriptive (mean ± SD) data for peak power (PP), peak cadence (PC), vertical jump (VJ), and leg/back dynamometer (LBD) strength recorded at baseline, and immediately after (0 hours), 24 hours, 48 hours, and 72 hours post-fatiguing protocol for college aged men and women who received pulsed electromagnetic therapy (PEMF), a placebo (PLAC), or control (CONT) recovery conditions.

	PEMF (n = 9)	PLAC (n = 12)	CONT (n = 12)	All (N = 36)
PP Baseline (watts)	916.56 ± 312.21	892.79 ± 226.25	844.67 ± 329.54	881.77 ± 283.19*
PP0 (watts)	871.17 ± 299.38	854.21 ± 203.96	800.88 ± 281.35	839.44 ± 254.64
PP24 (watts)	989.50 ± 325.53	938.17 ± 233.24	871.71 ± 287.81	928.00 ± 275.60*
PP48 (watts)	988.11 ± 321.62	930.71 ± 200.11	903.54 ± 317.09	936.49 ± 274.51*§
PP72 (watts)	994.11 ± 327.70	950.96 ± 188.45	878.25 ± 264.14	936.29 ± 255.58*§
PC Baseline (revolutions)	146.78 ± 17.33	140.88 ± 14.50	135.50 ± 11.99	140.53 ± 14.74
PC0 (revolutions)	148.39 ± 18.08	138.96 ± 13.86	134.42 ± 10.18	139.88 ± 14.67
PC24 (revolutions)	152.06 ± 20.97	145.25 ± 16.07	139.42 ± 10.93	144.99 ± 16.29*§
PC48 (revolutions)	151.39 ± 17.62	147.50 ± 16.27	140.63 ± 10.70	146.06 ± 15.09*§
PC 72 (revolutions)	150.72 ± 17.14	143.32 ± 18.85	139.83 ± 11.18	144.07 ± 16.06
VJ Baseline (cm)	45.95 ± 12.45	37.77 ± 7.22	37.40 ± 9.47	39.95 ± 10.10
VJ0 (cm)	44.26 ± 12.02	36.50 ± 6.88	36.52 ± 9.03	38.69 ± 9.64
VJ24 (cm)	49.53 ± 12.61	38.52 ± 6.41	36.53 ± 9.72	40.93 ± 10.80
VJ48 (cm)	45.27 ± 11.45	39.40 ± 7.20	37.98 ± 10.01	40.56 ± 9.69
VJ72 (cm)	45.77 ± 12.67	39.97 ± 7.35	38.00 ± 8.83	40.93 ± 9.79
LBD Baseline (kg)	125.01 ± 32.83	133.25 ± 35.90	119.44 ± 28.01	125.98 ± 31.91
LBD0 (kg)	123.67 ± 38.79	133.10 ± 37.12	121.95 ± 26.20	126.47 ± 33.35
LBD24 (kg)	147.44 ± 60.33	139.24 ± 36.44	128.61 ± 32.10	137.61 ± 42.18
LBD48 (kg)	142.35 ± 50.94	137.69 ± 32.84	132.80 ± 34.93	137.18 ± 38.13
LBD72 (kg)	139.69 ± 39.27	146.54 ± 41.58	133.62 ± 33.29	139.97 ± 37.31

* Significantly different from 0 hours. § Significantly different from baseline.

Table 2. Descriptive (mean ± SD) data for pre- and post-recovery intervention for the visual analogue scale (VAS) and Likert scale immediately after (0 hours), 24 hours, 48 hours, and 72 hours post-fatiguing protocol for college-aged men and women who received pulsed electromagnetic therapy (PEMF), a placebo (PLAC), or control (CONT) recovery conditions.

	PEMF (n = 9)				PLAC (n = 12)				CONT (n = 12)			
	Pre	Post	p	d	Pre	Post	p	d	Pre	Post	p	d
VAS												
Baseline-0	2.97 ± 2.09	3.17 ± 2.52	0.757	1.819	2.46 ± 2.04	2.67 ± 1.45	0.692	1.777	2.15 ± 1.75	1.88 ± 1.30	0.482	1.310
24 Hours	2.61 ± 1.62	1.97 ± 1.54	0.060	0.876	1.58 ± 1.87	1.83 ± 1.56	0.465	1.143	2.20 ± 1.51	2.11 ± 1.29	0.750	1.409
48 Hours	2.08 ± 1.29	1.89 ± 1.19	0.646	1.223	1.31 ± 1.19	1.17 ± 1.05	0.409	0.588	1.98 ± 1.49	1.96 ± 1.20	0.889	1.045
72 Hours	2.08 ± 1.57	1.94 ± 1.62	0.468	0.547	1.10 ± 1.11	0.88 ± 0.91	0.119	0.470	2.00 ± 2.00	1.75 ± 1.71	0.432	0.543
Likert												
Baseline-0	1.67 ± 2.18	1.56 ± 1.94	0.842	1.616	2.33 ± 1.56	2.00 ± 1.13	0.368	1.231	2.33 ± 1.67	1.74 ± 1.40	0.228	1.607
24 Hours	2.67 ± 1.23	1.67 ± 0.87*	0.003	0.707	1.83 ± 1.47	1.67 ± 1.23	0.551	0.937	2.17 ± 1.40	1.83 ± 1.12	0.339	1.155
48 Hours	2.00 ± 1.23	1.78 ± 1.20	0.447	0.833	1.67 ± 1.30	1.75 ± 1.22	0.777	0.996	1.67 ± 1.16	1.92 ± 1.08	0.463	1.138
72 Hours	1.56 ± 1.01	1.33 ± 1.00	0.347	0.667	1.17 ± 0.72	1.00 ± 0.95	0.504	0.835	1.58 ± 1.44	1.58 ± 1.31	1.000	0.739

* Significantly ($p < 0.05$) different from the session pre-recovery protocol value.

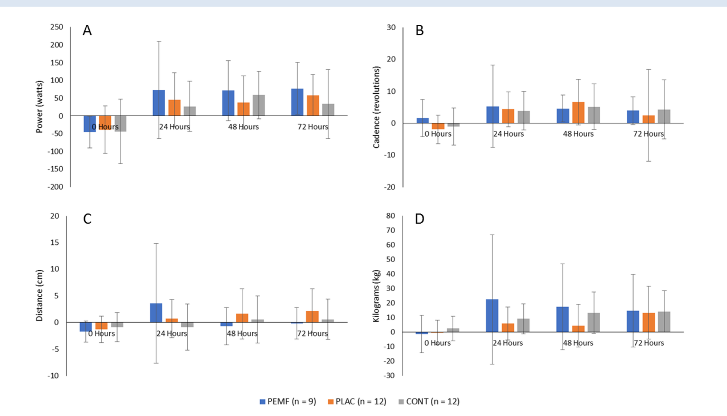

Figure 2. Descriptive (mean ± SD) data for change scores relative to baseline for peak power (A), peak cadence (B), vertical jump (C), and leg/back dynamometer strength (D) recorded at 0 hours, 24 hours, 48 hours, and 72 hours post-fatiguing protocol for college aged men and women who received pulsed electromagnetic therapy (PEMF), a placebo (PLAC), or control (CONT) recovery conditions.

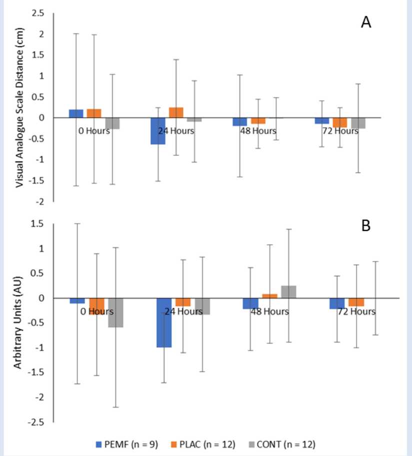

Figure 3. Descriptive (mean ± SD) data for change scores within each session for visual analogue scale (VAS; A) and Likert scale (B) values recorded at 0 hours, 24 hours, 48 hours, and 72 hours post-fatiguing protocol for college aged men and women who received pulsed electromagnetic therapy (PEMF), a placebo (PLAC), or control (CONT) recovery conditions.

CONCLUSIONS

- Although no significant differences in recovery between the treatments, larger, non-significant improvements in PP from a 6-s cycling sprint test, VJ and LBD performance for the PEMF group. While not statistically significant, these small changes may mean the difference in more effective training, in addition to success in in competition and should not be quickly dismissed. Change score and qualitative data suggested that the device used by the PEMF group had a positive influence on recovery and PP, VJ, and LBD performance 24 hours post fatigue protocol.
- The reduction in perceived soreness, measured by a VAS or Likert scale, tended to greater for the PEMF group 24 hours post the fatiguing exercise protocol. There was a significant decrease in the PEMF group Likert scale score at 24 hours.
- Large standard deviations in the data suggest variation in individual responses. Some people may be high or low responders to recovery treatments from a PEMF device.

PRACTICAL APPLICATIONS

- PEMF therapy may be beneficial to help with recovery from strenuous exercise among some individuals. Although more research is needed to ascertain mechanisms for how PEMF therapy could affect recovery following strenuous exercise, the current results show potential for using PEMF devices as part of a recovery protocol for athletes, especially in the first 24 hours post-strenuous exercise.

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