Original Research

The Effect of Energy Patches on Substrate Utilization in Collegiate Cross-Country Runners

RYAN E. FIDDLER†, DOUGLAS B. SMITH‡, BERT H. JACOBSON‡, CRISHEL D. KLEIN†, ARIC J. WARREN‡, MATTHEW S. O'BRIEN‡, BRENNAN J. THOMPSON†, and K. LEE EVERETT†

Applied Musculoskeletal and Human Physiology Laboratory, Department of Health and Human Performance, Oklahoma State University, Stillwater, OK, USA

‡Denotes professional author, †Denotes graduate student author

ABSTRACT

Int J Exerc Sci 4(2) :113-121, 2011. It is well established that an increased capacity of skeletal muscle to oxidize fatty acids can spare glycogen and delay the onset of fatigue in mild- to moderate-intensity exercise. The purpose of the following study was to examine the effect of LifeWave® energy patches on non-protein substrate utilization in Division-1 cross-country runners. To determine the effect of the patches subjects were pretested to establish baselines and randomly assigned to an experimental (EX) or placebo (PL) group. Twenty-two trained male (n = 11; mean ± SD, age = 21.1 ± 2.6years, height = 179.6 ± 4.2cm, body mass = 71.4 ± 7.4kg, VO_{2max} = 72.6 ± 7.1mL•kg-1•min-1) and female (n = 11; mean ± SD, age = 21.5 ± 2.4years, height = 166.7 ± 5.7cm, body mass = 53.7 ± 3.2kg, VO_{2max} = 63.6 ± 6.9mL•kg-1•min-1) cross-country runners volunteered to participate in the study. Dependent variables included maximal oxygen consumption (VO_{2max}), rating of perceived exertion (RPE), respiratory exchange ratio (RER), maximum heart rate (HRmax), and time to exhaustion (TTE). Results indicated there were no significant differences between the EX and PL groups at posttesting for RPE, TTE, HRmax, or VO_{2max}. RER was found to be significantly higher for the EX group compared to the PL group during stage 1 of the Bruce-protocol graded exercise test (p = 0.02). Based on the limited available research regarding LifeWave® energy patches effect on non-protein substrate utilization during aerobic exercise there appears to be no performance enhancing benefits.

KEY WORDS: Lipid metabolism, glycogen sparing, ergogenic aid, endurance exercise

INTRODUCTION

Substrate utilization during aerobic adenosine triphosphate (ATP) synthesis in human skeletal muscle plays a key role in endurance performance. The utilization of the macronutrients, fat and carbohydrate, can vary greatly during exercise and is largely dependent upon exercise intensity and duration, diet, and environmental factors (24). During low- to moderate-intensity exercise, fat oxidation provides the majority of ATP for working skeletal muscle (33). The primary substrates available for use by the working muscles are muscle and liver glycogen, blood glucose, intramuscular triglycerides and plasma free fatty acids (8, 33). Muscle and

liver glycogen energy supplies are limited, while adipose tissue energy supplies are abundant; an average 80 kg person stores between 90-110 g of liver glycogen and approximately 400 g of muscle glycogen yielding roughly 1500-2000 kcal, and 12,000 g of adipose tissue and 300 g of intramuscular triglycerides yielding approximately 110,700 kcal (12). As exercise intensity increases the relative proportion of fat oxidation increases until around 60%-65% of VO_{2max}, whereby fat oxidation begins to decrease and carbohydrate oxidation begins to increase (24). In addition to exercise intensity, exercise duration affects the relative proportion of substrate utilization with an increased rate of fat oxidation and decreased rate of carbohydrate oxidation during prolonged exercise. Typical fat oxidation rates range between 0.2-0.5 g·min^{-1}, however, rates as high as 1.0-1.5 g·min^{-1} during prolonged running (≈6 hours) have been observed (1). The increase in fat oxidation during prolonged exercise is believed to be due to decreased stores of muscle and liver glycogen to the point that carbohydrate oxidation rates cannot supply the ATP resynthesis demand (24). It is well established that an increased capacity of skeletal muscle to oxidize fatty acids can spare glycogen and delay the onset of fatigue in endurance exercise (16, 17,, 19, 30). The relative contribution of these substrates can be influenced by training status (16, 17, 19, 30), diet (2, 9, 10, 20, 25, 27), and environmental factors (11, 15, 18, 36) and potentially may be influenced by the use of various supplements (22).

LifeWave® energy patches represent a new technology claiming to increase the flow of electrons in the body, leading to increased endurance. The function of LifeWave® energy patches is non-transdermal and therefore no substances enter into the body, which has been confirmed through third-party independent testing (5). The patch technology is said to couple the frequency signature of the substance in the patches with the body's natural magnetic field (31). The resulting frequency modulation due to the interaction between the biomolecular stereoisomers of the patch and the magnetic field of the body stimulates increased beta-oxidation of long-chain fatty acids (31). According to the manufacturers, the LifeWave® patches shift substrate utilization towards lipids as a primary fuel source, sparing carbohydrate. Therefore, the wearer of LifeWave® patches should be able to utilize lipids for energy and spare glycogen depletion, exhibiting a shift in substrate utilization at mild- to moderate-intensity exercise.

Indirect calorimetry can be used to estimate the relative proportion of substrate utilization by determining the ratio of CO_2 (V_{CO2}) produced by O_2 (V_{O2}) consumed, this ratio (V_{CO2}/V_{O2}) is referred to as the non-protein respiratory quotient (RQ) (4). Non-protein respiratory exchange ratio (RER) is an estimate of the RQ. An RER of 0.70 indicates 100% fat utilization, whereas, an RER of 1.0 indicates 100% carbohydrate utilization. Distance running performance is partly dependent upon a runners ability to utilize fat as a fuel source at high work rates (i.e., lower RER), thus, sparing carbohydrates (13). It is unclear whether gender differences in non-protein substrate utilization exist during exercise. Several studies have shown females derive a relatively greater proportion of energy from fat oxidation during exercise than males (14, 21, 29, 35). However, other studies have reported no gender difference in the

non-protein substrate utilization of carbohydrates and fats during exercise (7, 28, 32, 34).

The primary focus of the following study was to assess whether LifeWave® energy patches result in a decreased RER at various intensities during a Bruce-protocol graded exercise test (GXT) compared to a placebo patch in endurance-trained athletes. A secondary purpose of the study was to examine the effect of energy patches on maximal oxygen consumption (VO_{2max}), ratings of perceived exertion (RPE), maximum heart rate (HR_{max}), and time to exhaustion (TTE) in endurance-trained athletes. Although there is limited evidence on the effects of LifeWave® energy patches during aerobic exercise, we hypothesize there will be no difference in RER, VO_{2max}, TTE, HR_{max}, or RPE between groups.

METHODS

Participants

Twenty-two trained male and female collegiate Division-I cross-country runners volunteered for participation in this study which was approved by the Institutional Review Board of Oklahoma State University. Table 1 shows the group-specific demographics. Participants were informed of the experimental procedures and associated risks before providing a written informed consent. Inclusion criteria for participation consisted of being current members of the varsity cross-country teams, 18 years of age or older, cleared for activity by the medical staff, and sign the IRB-approved informed consent document.

Experimental Approach to the Problem

To determine the effect of the LifeWave® patches, trained male and female collegiate Division-I cross-country runners were recruited in the fall semester of the academic year. A randomized, double-blinded, placebo-controlled, between-subjects design was utilized to test the efficacy of the LifeWave® patches. Subjects were pretested to establish baselines and randomly assigned to an experimental (EX, n=12) or placebo (PL, n=10) group with an equal proportion of males and females in each group. This design was chosen over a within-subjects design due to the rigorous nature of maximal oxygen consumption testing. The parallel design required each participate to undergo two VO_{2max} tests, whereas in a within-subjects design each subject serves as their own control and thus would have undergone three VO_{2max} tests. Randomization was performed by a co-investigator who was not present during the testing to ensure the double-blind nature of the study. Dependent variables included measures of RER, VO_{2max}, RPE, HR_{max}, and TTE. Subjects were posttested one week after baseline assessments.

Protocol

On the first day of testing, subjects reported to the training facility and were briefed on the protocol of the study and asked to read and complete the approved IRB consent form. Subjects also completed a personal medical history questionnaire. The protocol was explained to the subjects and all agreed to participate. Height and weight measurements were taken for each subject using a physician's scale with an attached stadiometer (Detecto, Webb City, MO). Subjects were instructed to not alter their diets during the one week between tests. Pretesting was performed to establish baseline measurements for VO_{2max}, RPE, RER, HR_{max}, and TTE using a Bruce-protocol graded exercise test (GXT) (6) on a

motorized treadmill (Trackmaster, JAS Fitness Systems, Newton, KS). A warm-up protocol was performed prior to the maximal treadmill tests; all subjects rode a Monark cycle ergometer at a self-selected resistance and cadence for five minutes and then stretched on their own for approximately five minutes.

One week following baseline testing, subjects again reported to the laboratory. Prior to patch placement, the men's ankles were shaved to optimize patch contact with the skin. Following the recommendations of the manufacturer, the white (positive) patch was placed superior to the right medial malleolus and the tan (negative) patch was placed superior to the left medial malleolus of the EX group subjects. The PL group subjects underwent an identical protocol with patches containing distilled water. Subjects experienced the same warm-up protocol as pretesting; however, the patches were placed on the subjects between the cycling warm-up and the stretching. The GXT occurred in the university exercise physiology laboratory in which the temperature, barometric pressure, and humidity were monitored for consistency during both tests using a wireless monitor (Davis, Perceptions II, Hayward, CA). Laboratory temperature was maintained at 72 °F. Each subject was tested individually and at the same time of day for both baseline and posttesting. During both tests the primary investigator and at least three other co-investigators were present. Verbal encouragement was provided to each subject during the GXT.
VO_{2max}, RER, and TTE were measured and recorded using open circuit spirometry (Parvo-Medics TrueOne® 2400 Metabolic Measurement System, Sandy, UT). RER was recorded by a member of the research team with 15 seconds remaining at the end of each three-minute stage of the Bruce-protocol GXT and upon completion of the GXT. RPE and HR were recorded in the same manner as RER. RPE was measured using the 15-category Borg Perceived Exertion Scale (3). HR was measured using Polar A5 heart rate monitors (Polar Electro, Kempele, Finland). Following the test, subjects were required to cool down by walking on the treadmill for three minutes at 1.5 MPH while all physiological measures continued to be recorded.

Statistical Analysis
Three separate two-way, mixed-factorial ANOVA models (2 x 2; day [baseline vs. posttest] x group [EX vs. PL] were used to analyze HR_{max}, TTE, and VO_{2max} data. Two separate three-way, repeated-measures ANOVA models (3 x 2 x 2; time [stage 1 vs. stage 3 vs. final stage] x day [baseline vs. posttest] x group [EX vs. PL] were used to analyze RER and RPE. When a significant interaction was found, follow-up analyses were performed using two-way or one-way repeated measures ANOVAs with Bonferroni corrections and pairwise comparisons. Due to differences in the total stages completed for each subject's GXT, stages 1, 3, and the final stage completed were chosen so that all subjects had an equal number of stages analyzed. Additionally, independent-sample t-tests were used to determine group mean differences during the baseline testing session. All data processing and statistical analyses were performed using SPSS 18.0 and the level of significance was set at $p < 0.05$.

RESULTS

There were no significant differences ($p < 0.05$) between the EX and PL groups at baseline testing for age, height, body mass, BMI, or VO_{2max} (Table 1).

Table 1. Baseline mean (SD) age, height, body mass, BMI, VO_{2max}.

	Age (yrs)	Height (cm)	Body mass (kg)	BMI	VO_{2max} ($mL \cdot kg^{-1} \cdot min^{-1}$)
EX (n=12)	20.7 ± 2.2	172.9 ± 8.2	63.3 ± 11.8	22.1 ± 2.2	68.0 ± 8.8
PL (n=10)	22.6 ± 2.6	173.5 ± 8.3	61.6 ± 9.7	20.4 ± 2.4	68.3 ± 8.1
	p = 0.18	*p = 0.88*	*p =0.72*	*p = 0.09*	*p = 0.94*

RER

Results of the repeated measures ANOVA indicated a significant time x day x group interaction for RER (p=0.03). Follow up analysis using lower order ANOVA models with Bonferroni corrections and pairwise comparisons revealed a significant time x group interaction during the posttest (p=.003); RER was significantly higher for the EX group (p=0.02) compared to the PL group during stage 1 of the Bruce-protocol GXT (Table 2 and Figure 1).

Table 2. Mean ± SD values during stage 1, stage 3, and final stage for RER.

	Stage 1		Stage 3		Final Stage	
	Base-line	Post-Test	Base-line	Post-test	Base-line	Post-test
EX (n=12)	0.75± 0.07	0.77± 0.03	0.87± 0.06	0.87± 0.04	1.10± 0.04	1.09± 0.05
PL (n=10)	0.74± 0.06	0.73± 0.05* *p = 0.02*	0.87± 0.06	0.89± 0.04	1.09± 0.03	1.12± 0.05

*Indicates a significant (p < 0.05) difference between PL and EX

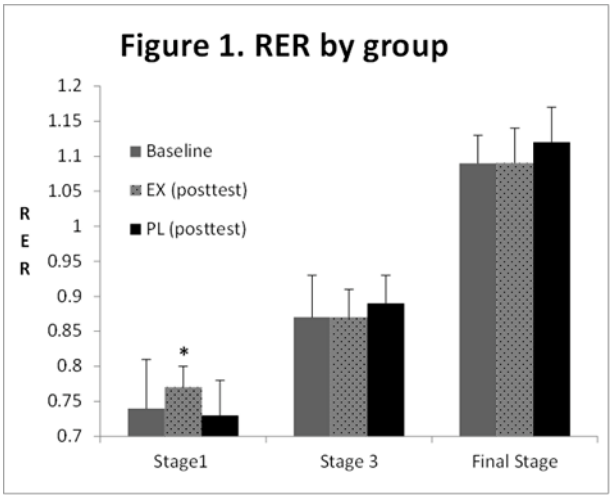

Figure 1. Mean (SD) values for RER at stage 1, stage 3, and final stage of the Bruce protocol VO2max test at baseline and posttest. Baseline data includes both groups combined. * Indicates a significant (p < 0.05) difference between PL and EX.

RPE

Results of the repeated measures ANOVA indicated no significant interactions; time x day x group, p=0.89; day x time, p=0.41; time x group, p=0.35; day x group, p=0.89 (Table 3 and Figure 2). There were no significant differences for the main effects group (p=0.90), or day (p=0.30), however, a main effect was found for time (p=0.001).

Table 3. Mean ± SD values during stage 1, stage 3, and final stage for RPE.

	Stage 1		Stage 3		Final Stage	
	Base-line	Post-test	Base-line	Post-test	Base-line	Post-test
EX (n=12)	7.0± 0.8	7.0± 0.5	10.0± 1.8	11.0± 2.0	17.0± 1.7	18.0± 1.5
PL (n=10)	7.0± 1.2	7.0± 0.9	10.0± 2.4	10.0± 2.0	18.0± 2.0	18.0± 1.8

VO_{2max}, HR_{max}, TTE

There was no day x group interaction for VO_{2max} (p = 0.99) and no main effect for day (p = 0.89) or group (p = 0.94). There was no day x group interaction for HR_{max} (p = 0.85) and no main effect for day (p = 0.92) or

group (p = 0.13). There was no day x group interaction for TTE (p = 0.54) and no main effect for day (p = 0.74) or group (p = 0.92) (Table 4).

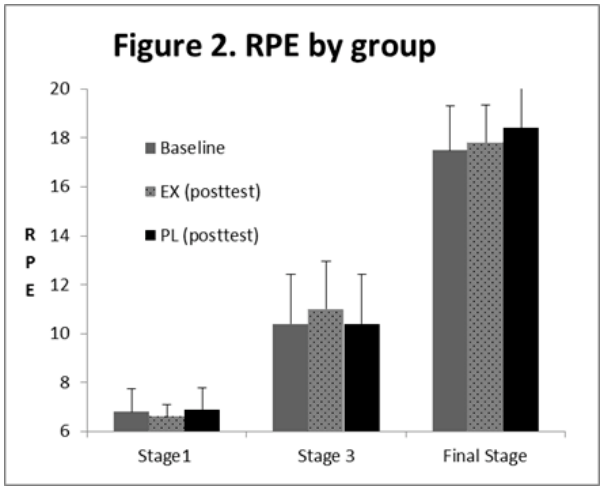

Figure 2. Mean (SD) values for RPE at stage 1, stage 3, and final stage of the Bruce protocol VO_{2max} test at baseline and posttest. Baseline data includes both groups combined.

Table 4. Mean ± SD values from baseline to posttest for HR_{max}, TTE, VO_{2max}.

	HRmax (bpm)		TTE (min)		VO2max (mL•kg-1•min-1)	
	Base-line	Post-Test	Base-line	Post-test	Base-line	Post-test
EX (n=12)	188.0± 7.1	187.0± 6.0	16.2± 2.4	16.1± 2.3	68.0± 8.8	68.1± 9.2
PL (n=10)	193.0± 10.0	193.0± 11.3	16.1± 1.9	16.4± 1.9	68.3± 8.1	68.4± 8.0

DISCUSSION

This is the first study investigating the effect of LifeWave® energy patches on substrate utilization in trained endurance athletes. The major finding in this study was that there were no differences in RER between EX and PL groups during stages 1, 3, and the final stage of the GXT. Only two previously published studies have been conducted to assess the efficacy of LifeWave® energy patches on physical performance (23, 31). Anecdotal and unpublished information exists, however, there is very little empirical evidence to support the claims purported by the manufacturers of the product. In a recent study assessing the effectiveness of the LifeWave® patches on muscle power and endurance there were no significant differences found between placebo and experimental groups completing a 50-repetition leg-extension isokinetic protocol (23). The authors concluded that while only one of eight variables (peak torque during knee extension) reached significance between placebo and patch groups and while two other variables resulted in near-significance, the inconsistency of the overall results did not provide a convincing argument that the energy patches were capable of enhancing performance (23).

Our results indicated no improvements for the EX patch group in non-protein substrate utilization, VO_{2max}, RPE, TTE, or HR_{max}. By contrast, during stage 1 of the Bruce-protocol GXT posttest indicated the EX group had a significantly higher RER (p = 0.02) compared to the PL group. This finding is contrary to the purported benefits of the LifeWave® energy patches. As recommended by Jacobson and colleagues (23), the present study sought to compare the energy patches and placebo under aerobic stress. The fact that no significant differences in any of the variables existed, aside from a higher RER recorded by the EX group compared to the PL group during stage 1 of the posttest, may be attributed to several factors. First, and as suggested by Jacobson et al., specific placement of the patches in relationship to the standard acupuncture meridians has not been established and therefore varied results may be seen with selected patch placement.

Manufacturers of the LifeWave® energy patches suggest placing the patches on one the following four sites; superior to the medial malleolus, anterior wrist, medial to the axilla and inferior to the anterior deltoid, and lateral to the knee near the fibular head. The manufacturers also suggest that different sites can be more effective than others for each individual; however, they also suggest the medial malleolus to be the most effective site for runners. Therefore, we chose to use the medial malleolus as our designated placement site. Future studies may wish to try multiple sites. Secondly, the manufacturers of the patch claim effectiveness is enhanced when subjects consume greater than two liters of water per day, however, we did not assess subject's fluid intake. We instructed our subjects to not alter their diets during the one week between tests. This could be a limitation in the current study. Future studies should monitor fluid intake among subjects. In addition, our subjects were highly trained distance runners; this may have limited any potential ergogenic effect. Future studies may wish to assess LifeWave® energy patches on less-fit subjects. Due to our small sample size we did not control for gender, this could be a limitation to the study and future studies may wish to assess gender-specific responses. Another limitation in our study was that the warm-up protocol was not standardized for everyone, future studies should control for this. Lastly, the duration of the Bruce-protocol GXT may not have been long enough to elicit an improvement in non-protein substrate utilization, future studies may wish to test the effect of the patches on non-protein substrate utilization in recreational endurance athletes (runners, cyclists, swimmers, etc.) during prolonged submaximal aerobic exercise.

Practical Applications

Improving non-protein substrate utilization can prolong fatigue and spare glycogen depletion allowing the athlete to exercise at mild-to moderate-intensities for a longer duration. This can be extremely beneficial for several types of endurance athletes such as cyclists, runners, swimmers, and triathletes. However, the ergogenic aid assessed in this study did not improve non-protein substrate utilization. Based on the results of this investigation, it appears that LifeWave® energy patches have no effect on non-protein substrate utilization.

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