Study Report
The Effects of Physiclo Pro Resistance Technology on Exercise and Recovery Energy Expenditure

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A. EXECUTIVE SUMMARY AND INTERPRETATION

This study was designed and executed to test the efficacy by which the Pro Resistance Technology of the Physiclo lower body exercise garment increases the metabolic demand and therefore energy expenditure of exercise in NCAA collegiate student athletes. We collected concurrent (time-synced) metabolic, heart rate, and ventilation data continuously throughout a workout consisting of treadmill running, stationary cycling, plyometrics, loaded back squats, and loaded lunges, performed in the listed order. Based on our analysis of those readings, we conclude that the use of the Physiclo garment enhances the metabolic demand of an exercise bout as demonstrated by the data acquired from the present study. Below is an outline summary of the findings:

1. When examining the data in aggregate (over the entire workout) the Physiclo garment increased oxygen consumption (VO_2) and energy expenditure by 15%, ventilation rate by 22%, and heart rate by 18% during an entire bout of exercise in comparison to non-specialized sports garments. Statistical analysis revealed these changes to be significant ($p<0.05$).

2. Female athletes exhibited an increase of 17% in VO_2, 18% in energy expenditure, 29% in ventilation, and 18% in heart rate when using the Physiclo garment compared to non-specialized sports garments. Statistical analysis revealed these changes to be significant ($p<0.05$).

3. Male athletes exhibited an increase of 12% in VO_2, 12% in energy expenditure, 12% in ventilation, and 18% in heart rate when using the Physiclo garment compared to non-specialized sports garments. Statistical analysis revealed these changes to be significant ($p<0.05$).

4. There was no statistically significant sex- or task-specific differences in the improvement of any measure. In other words, the improvement in VO_2, energy expenditure, ventilation and heart rate was statistically equivalent between sexes and among each exercise task.

5. Post-workout recovery measures for VO_2, energy expenditure, ventilation, and heart rate did not differ between Physiclo and Control conditions.

B. SPECIFIC AIMS

A.1. Specific Aim

In 16 healthy male (n=8) and female (n=8) NCAA student athletes we examined:

Aim 1: the effects of lower-limb compression through proprietary resistive garments on metabolic demand across a number of structured laboratory-based exercises.

Aim 2: the effects of lower-limb compression through proprietary resistive garments on post-workout energy expenditure.

C. BACKGROUND AND SIGNIFICANCE

Runners at various levels of performance and competition specializations have adopted the use of compression garments, such as socks, sleeves, shorts, and/or tights, in efforts to enhance performance and facilitate recovery (2). In terms of performance, previous research has shown some level of efficacy by which compression garments improve time trial performance (1, 3, 4), running economy (5), and physiological parameters (e.g. VO_2 maximum, blood lactate accumulation) (6). Recovery from exhaustive exercise has also shown to be facilitated by the use of compression garments especially in the lower body (7). For instance, compression garments have attenuated delayed onset of muscle soreness and increased the rate by which muscular contractile kinematics were restored (2). However, the overall body of research related to the use of compression garments have failed to evaluate its full complement of potential applications in sport and exercise. Physiclo with their Pro Resistance Technology has innovated a new line of compression garments that may apply added resistance to physical movements ranging from every day activities to high intensity athletic training. In turn, the purported benefits include facilitated performance and body composition improvements due the added metabolic demand and musculoskeletal stress. There is limited empirical information regarding the effects of such class of compression garments on energy expenditure across various exercise modes. Therefore, the purpose of this investigation is to examine the effects of Physiclo garments and their Pro Resistance Technology on exercise and recovery energy expenditure.

D. RESEARCH DESIGN AND METHODS (ABBREVIATED)

C.1. Experimental Overview

This was a prospective study of NCAA student athletes. Participants visited the Cal Poly Pomona (CPP) Human Performance Research Laboratory on 3 separate occasions each separated by 48 hours. The 2 latter visits incorporated differential experimental treatments and therefore were implemented in a randomized, counterbalanced order. During the first visit, subjects underwent standard body composition assessments and familiarization of the testing procedures which included indirect calorimetry and exercise protocols. During the subsequent 2 experimental visits, subjects initially performed 10 minutes of a light warm-up protocol that was identical across both experimental visits. Afterwards, subjects wore either the Physiclo compression garment (Experimental; EXP) or general exercise attire (Control; CTL). Subjects then performed a series of exercises while simultaneously undergoing indirect calorimetry for oxygen consumption and other metabolic measures. A wireless electrocardiograph (ECG) system was used to measure heart rate throughout the exercise protocol. The subjects were instructed to perform tasks 1-3 below for 5 minutes and tasks 4-6 with the prescribed sets and repetitions (reps). The post-workout recovery period was 5 minutes. A 5-minute rest period was implemented between each task.

1. **Rest:** Participants sat comfortably and still

2. **Running:** Participants ran at a self-selected pace on a standard commercial grade motorized treadmill (> 6.0 mph)

3. **Cycling:** Participants cycled on a cycle ergometer at a constant workload of 120 watts (workload controlled and made constant by cycle ergometer system)

4. **Step Ups:** Participants stepped up and down laterally a 24 inch plyo box at cadence of 1 step per second for 3 sets of 25 reps. A 30-second rest was provided between sets. A metronome was set at 92 bpm which was used for step cadence, i.e. 1 step per beat.

5. **Back Squats:** Participants performed 3 sets of 15 reps of back squats using a self-selected load pre-determined during the familiarization visit. A 1-minute rest was provided between each set. A metronome was set at 92 bpm which was used for exercise cadence, i.e. eccentric portion for 2 beats, concentric portion for 1 beat, and pause at the top of lift for 1 beat.

6. **Alternating Lunges:** Participants performed 3 sets of 20 reps of weighted alternating lunges using a self-selected load pre-determined during the familiarization visit. A 1-minute rest was provided between each set. A metronome was set at 92 bpm which was used for exercise cadence, i.e. eccentric portion for 2 beats, concentric portion for 1 beat, and pause at the top of lift for 1 beat.

7. **Recovery:** Participants rested in a seated position for 5 minutes.

Outcomes measures included: Overall, exercise task-specific and recovery VO_2, energy expenditure, ventilation rate, and heart rate

C.2. Data Analysis

Mean differences between treatments (Control vs. Physiclo) were analyzed using a dependent student t-test with significance set at $p<0.05$.

E. RESULTS

E.1 Descriptive Measures

Table 1. Mean age, body weight, and height of participants.

Variable	Aggregated	Female Subjects	Male Subjects
Age (years)	22.0 ± 0.7	21.4 ± 0.9	22.8 ± 1.1
Body Weight (kg)	66.9 ± 5.4	55.4 ± 3.8	83.1 ± 7.1
Height (cm)	169.6 ± 3.7	161.0 ± 3.3	181.7 ± 1.8

E.2. Aggregated Data Analysis

Table 2. Mean values for VO_2, energy expenditure, total energy expenditure, ventilation, and heart rate for Control and Physiclo treatments with percent change and p-values.

Variable	Control	Physiclo	Δ (%)	p-value
VO_2 (ml/kg/min)	14.5 ± 0.4	16.6 ± 0.5	14.8 ± 2.7	0.004
Energy Expenditure (kcals/min)	4.7 ± 0.3	5.4 ± 0.4	15.1 ± 2.5	0.0002
Total Energy Expenditure (kcals)	296.0 ± 21.0	338.2 ± 24.9	14.6 ± 2.8	0.0002
Ventilation (l/min)	22.6 ± 2.1	26.4 ± 2.3	21.5 ± 10.6	0.009
Heart Rate (bpm)	117.3 ± 3.6	137.9 ± 4.0	17.7 ± 1.5	0.001

E.3. Sex-Specific Data Analysis

Table 3. Results of Female Subjects

Variable	Control	Physiclo	Δ (%)	p-value
VO_2 (ml/kg/min)	14.8 ± 0.5	17.3 ± 0.8	16.5 ± 4.5	0.009
Energy Expenditure (kcals/min)	4.0 ± 0.3	4.7 ± 0.4	17.5 ± 3.7	0.005
Total Energy Expenditure (kcals)	252.7 ± 16.4	290.0 ± 18.5	15.4 ± 4.3	0.009
Ventilation (l/min)	18.2 ± 1.5	22.2 ± 1.3	28.7 ± 18.1	0.09
Heart Rate (bpm)	118.5 ± 5.1	139.3 ± 5.1	17.8 ± 2.0	0.01

Table 4. Results of Male Subjects

Variable	Control	Physiclo	Δ (%)	p-value
VO_2 (ml/kg/min)	13.9 ± 0.6	15.6 ± 0.5	12.4 ± 2.1	0.004
Energy Expenditure (kcals/min)	5.7 ± 0.4	6.4 ± 0.6	11.7 ± 2.8	0.03

Total Energy Expenditure (kcals)	356.5 ± 27.8	405.6 ± 37.9	13.5 ± 3.4	0.03
Ventilation (l/min)	28.8 ± 2.9	32.4 ± 4.1	11.5 ± 2.8	0.04
Heart Rate (bpm)	115.7 ± 5.6	135.8 ± 7.0	17.5 ± 2.5	0.01

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