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The Acute and Chronic Responses to Exercise with the Core-Tex™

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ABSTRACT

Aim: The purpose of this study was two-fold: 1) quantify the *acute* physiological responses to exercise with the Core-Tex™ and 2) to determine the effectiveness of 6wk *chronic* exercise training with the Core-Tex™ at improving cardiorespiratory, flexibility, neuromotor, and muscular fitness.

Methods: Fifteen women and men (mean \pm SD: age, height, weight, and VO_{2max} = 26.1 \pm 6.8 years, 171.6 \pm 9.3 cm, 64.5 \pm 12.7 kg, and 41.3 \pm 6.5 mL/kg/min, respectively) participated in the study. A portable calorimetric measurement system and Polar F1 heart rate monitor were worn by each participant throughout two 30-minute Core-Tex™ training sessions (an upper body/core day and lower body/core day) to quantify the acute physiological response to exercise with the Core-Tex™. Cardiovascular and metabolic responses across these two sessions were averaged. Additionally, participants completed a 6wk Core-Tex™ exercise training program (30-minute sessions performed 4 times/wk). Cardiorespiratory, flexibility, neuromotor, and muscular fitness were measured at baseline and after 6wk training. **Results:** Overall heart rate for a 30-minute exercise session was 121.4 \pm 13.7 beats/min, which corresponded to 48.1 \pm 10.6% HRR. Exercise intensity in METs was 4.8 \pm 1.1, which equated to 35.2 \pm 5.9% VO_{2R} . Total energy expenditure for a Core-Tex™ exercise training session was 162.0 \pm 21.9 kcal/session. After 6wk of exercise training with a Core-Tex™ there were significant ($p < 0.05$) improvements all cardiorespiratory, flexibility, neuromotor, and muscular fitness measurements. **Conclusions:** Findings from the present study support the activity of Core-Tex™ as a feasible alternative to traditional exercise modalities for adults that elicits cardiovascular and metabolic responses within an accepted moderate intensity range. Moreover, regular exercise training with the Core-Tex™ improves various domains of fitness in a time efficient manner.

KEYWORDS: Cardiorespiratory Fitness, Energy Expenditure, Exercise Intensity, Muscular Fitness

Introduction

Cardiorespiratory, flexibility, neuromotor, and resistance training are each paramount for the overall health, physical fitness, and well-being of individuals. Health and fitness professionals can follow readily available

published guidelines, provided from major health organizations such as the American Council on Exercise (ACE) and the American College of Sports Medicine (ACSM), when designing training programs for positively modifying each of these fitness components

(Garber et al., 2011). To fulfill maximum frequency requirements of each form of activity (14 overall – 5 cardiorespiratory bouts, 3 flexibility bouts, 3 neuromotor bouts, and 3 resistance bouts) it is necessary for individuals to perform at least two (or more) activities the same day; and most likely within the same exercise session. It may be easier for individuals to achieve maximum frequency requirements for each form of activity if the exercise modality itself permits simultaneous training across various fitness components (i.e., neuromotor and cardiorespiratory).

The Core-Tex™ is a newcomer to the fitness industry and differs substantially in function from previous fitness modality products. Core-Tex™ training is underpinned by the premise of reactive variability. Reactive variability constantly provides variability to the muscles, nervous system and joints. Every exercise and repetition is different, thereby reducing stress on the joints, continually requiring the nervous system to adapt (plasticity) to coordinate new movements increasing muscle activation and efficiency. As such, the Core-Tex™ is a completely unique approach to 3 dimensional, functional movement. It is a reactive training tool that combines dynamic strength, reaction, cardiorespiratory endurance, flexibility and balance into a single modality design, creating the optimal training environment. Nevertheless, because of its novelty, there is a lack of research on the Core-Tex™. Understanding the physiological responses to exercise is

essential for designing safe and effective fitness and rehabilitation training programs. For example, it would be beneficial to understand the metabolic equivalent (MET) value associated with Core-Tex™. A MET value would allow the quantification of Core-Tex™ exercise intensity as low, moderate, or vigorous in nature, and hence, aid in establishing a safe and effective target workload. Furthermore, it would be valuable to have a better understanding of the neuromotor (i.e., balance and agility), strength, and flexibility gains associated with chronic Core-Tex™ training. The purpose of this study was two-fold: 1) quantify the **acute** physiological responses to exercise with the Core-Tex™ and 2) to determine the effectiveness of 6wk **chronic** exercise training with the Core-Tex™ at improving cardiorespiratory, flexibility, neuromotor, and muscular fitness. It was hypothesized that: 1) an **acute** bout of exercise training with the Core-Tex™ will be safe and effective and 2) **chronic** exercise training on the Core-Tex™ will lead to time-efficient improvements in cardiorespiratory, flexibility, neuromotor, and muscular fitness.

Methods

Participants

15 healthy men and women (mean ± SD: age = 26.1 ± 6.8 years, height = 171.6 ± 9.3 cm, weight = 64.5 ± 12.7 kg) were recruited from the student and faculty population of a local university, as well as the surrounding community. Participants were eligible for inclusion into the study if they were low risk-to-

moderate risk and physically inactive as defined by the ACSM (ACSM, 2018). This study was approved by the Human Research Committee at Western Colorado University. All participants provided informed consent in advance of participation.

Experimental design

Acute responses to exercise with Core-Tex™

To quantify acute cardiovascular and

metabolic responses to Core-Tex™ exercise an Oxycon Mobile portable calorimetric measurement system and Polar F1 heart rate monitor were worn by each participant throughout two 30-minute Core-Tex™ training sessions (Figure 1): upper body/core day and lower body/core day. Cardiovascular and metabolic responses across these two sessions were averaged.



Figure 1. The portable metabolic system attached to a participant during a Core-Tex™ training session.

Chronic responses to Core-Tex™

At baseline and post-program, participants performed a graded exercise test on a treadmill to determine cardiorespiratory

fitness via the gold standard measure of maximal oxygen uptake (VO_2max). Additionally, flexibility, neuromotor (i.e.,

agility and balance), and muscular fitness were also assessed at baseline and post-program. Specifically, the following measures were obtained to determine the effectiveness of a 6wk Core-Tex™ intervention at positively modifying fitness parameters:

- ✓ Maximal exercise test to determine cardiorespiratory fitness (i.e., VO₂max)
- ✓ Sit-and-reach test to assess flexibility
- ✓ Five-repetition maximum (5-RM) for

bench and leg press to quantify muscular fitness

- ✓ Plank test to assess core muscular fitness
- ✓ Agility was assessed using the Pro Agility shuttle run
- ✓ The impact of reactive variability training on balance was assessed with the Y-balance test

Table 1. The 6wk Core-Tex™ exercise training program.

Lower Body/Core (2 days/wk)	Upper Body/Core (2 days/wk)	Sets/Reps	Warm-Up (each day)	Reps
Squat with rotation	Push up with rotation	3 sets/15 reps 45 sec rest b/w sets	Downward-Upward Dog	10 each
Curtsy lunge (L & R)	Dumbbell Row (L & R)	3 sets/15 reps 45 sec rest b/w sets	Side to side lunges	10 per side
Hip Bridge (feet on)	Shoulder press	3 sets/15 reps 45 sec rest b/w sets	World's Greatest (L & R)	10 per side
Split squat rear foot elevated on Core-Tex	Side lateral raise with dumbbell	3 sets/15 reps 45 sec rest b/w sets	Thoracic rotations (L & R)	10 per side
Spider Man Plank	Windmills with med ball	3 sets/20 reps 1 min rest b/w sets		
Side plank with reach under (L & R)	Plank with locomotion	3 sets/20 reps 1 min rest b/w sets		
	Quadruped hip extensions (L & R)	3 sets/20 reps 1 min rest b/w sets		

Training program to determine chronic responses to Core-Tex™ exercise training

All participants completed a standard 6wk Core-Tex™ training program (Table 1). The

program consisted of 4 x 30minute Core-Tex™ exercise training sessions each week. Training sessions could be completed on all days of the week. However, participants

were encouraged to train no more than three consecutive days without a rest day. All Core-Tex™ exercise training sessions were performed within group classes of three to four participants supervised by one member of the research team. Only the data from those participants who completed $\geq 75\%$ of the training sessions (i.e., 18 out of 24 sessions) were included in the final analysis.

Exercise intensity and metabolic calculations

Individual heart rate reserve (HRR) was determined as the difference between resting and HRmax values. Percent HRR was calculated by subtracting resting HR from the Core-Tex™ HR response, dividing by HRR, and then multiplying the quotient by 100. Likewise, individual oxygen uptake reserve (VO₂R) was quantified by taking the difference between resting VO₂ (a constant of 3.5 mL/kg/min was used for all individuals) and maximum VO₂ values. Percent VO₂R was calculated by subtracting resting VO₂ from the Core-Tex™ VO₂ response, dividing by VO₂R, and then multiplying the quotient by 100. The metabolic equivalent (MET) for Core-Tex™ was determined by dividing the Core-Tex™ VO₂ by a standardized resting VO₂ value (i.e., 3.5 mL/kg/min). Energy expenditure (kcal/session) for the Core-Tex™ training session was calculated by multiplying the above-calculated MET equivalent of the Core-Tex™ training session by individual body mass, dividing by 1000, multiplying by the caloric equivalent for the measured respiratory exchange ratio or RER (e.g., an

RER of 0.83 equates to an energy cost of 4.838 kcal/L of oxygen), and last multiplying by 30-minute (duration of Core-Tex™ training session).

Statistical Analyses

All analyses were performed using SPSS Version 25.0 (IBM Corporation, New York, NY, USA) and GraphPad Prism 7.0. (San Diego, CA). Measures of centrality and spread are presented as mean \pm standard deviation (SD). Primary outcome measures for the acute cardiovascular and metabolic responses to the Core-Tex™ portion of the study were relative exercise intensity (% HRR and % VO₂R), metabolic equivalents (METs), and energy expenditure (kcal/min and kcal/session). Primary outcomes for the chronic responses to exercise training with the Core-Tex™ included various measures of cardiorespiratory, flexibility, neuromotor, and muscular fitness. Paired t-tests were used to compare mean primary outcome changes between baseline and 6wk. The probability of making a Type I error was set at $p < 0.05$ for all statistical analyses.

Results

Acute cardiovascular and metabolic responses to exercise with the Core-Tex™

The acute cardiovascular and metabolic responses (mean \pm SD) to a Core-Tex™ exercise training session for the 15 participants (women = 10, men = 5) who completed the study are presented in Table 2. Overall heart rate for a 30-minute exercise session was 121.4 ± 13.7 beats/min, which corresponded to $48.1 \pm 10.6\%$ HRR. Exercise

intensity in METs was 4.8 ± 1.1 , which equated to $35.2 \pm 5.9\%$ VO_2R . Total energy expenditure for a Core-Tex™ exercise training session was 162.0 ± 21.9

session. Figure 2 illustrates the exercise intensity in terms of HRR for a representative participant throughout the duration of a Core-Tex™ exercise training session.

Table 2. Acute cardiovascular and metabolic responses.

Parameter	mean \pm SD
HR (beats/min)	121.4 ± 13.7
%HRR	48.1 ± 10.6
% VO_2R	35.2 ± 5.9
METs	4.8 ± 1.1
kcal/min	5.4 ± 1.7
kcal/session	162.0 ± 21.9

HR, heart rate; %HRR, percentage heart rate reserve; kcal, kilocalories; METs, metabolic equivalents; % VO_2R , percentage oxygen uptake reserve.

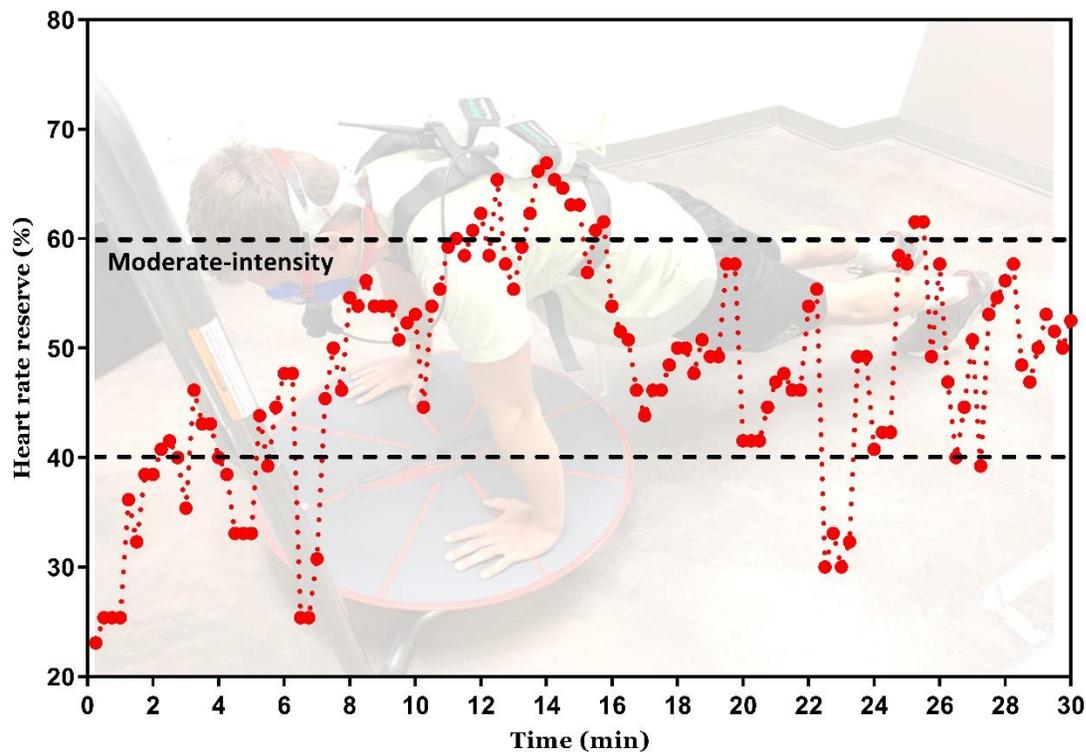


Figure 2. Exercise intensity in terms of heart rate reserve (HRR) for a representative participant throughout the duration of a Core-Tex™ exercise-training session. The dashed lines (-----) represent the moderate exercise intensity classification.

Chronic cardiovascular and metabolic responses to training with the Core-Tex™

The fitness-related responses to exercise training with the Core-Tex™ are presented in Table 3 for all individuals who completed

the intervention (N = 15). At 6wk, paired t-tests revealed favorable changes ($p < 0.05$) all fitness domains (cardiorespiratory, muscular, flexibility, and neuromotor).

Table 3. Baseline (mean \pm SD) and mean change (95% CI) at 6wk in all primary outcomes after Core-Tex™ exercise training.

Variable	Baseline mean \pm SD	Change at 6wk mean (95% CI)	p-value difference to baseline
VO ₂ max (mL/kg/min)	41.3 \pm 6.5	3.2 (2.6 to 3.7)	<0.001*
Sit-and-Reach (cm)	33.7 \pm 6.1	3.2 (2.5 to 4.0)	<0.001*
5-RM Bench Press (kg)	44.6 \pm 13.7	5.9 (3.6 to 8.2)	<0.001*
5-RM Leg Press (kg)	175.0 \pm 49.2	46.5 (8.4 to 84.7)	0.020*
Plank (sec)	91.9 \pm 30.6	18.7 (9.4 to 28.0)	0.001*
Pro Agility (sec)	5.66 \pm 0.45	-0.22 (-0.02 to -0.42)	0.031*
<i>Y Balance test</i>			
Right anterior (cm)	59.7 \pm 6.5	2.4 (0.7 to 4.1)	0.008*
Left anterior (cm)	59.1 \pm 7.2	4.1 (2.0 to 6.3)	0.001*
Right Posteromedial (cm)	97.9 \pm 8.6	6.1 (2.3 to 9.8)	0.004*
Left Posteromedial (cm)	98.3 \pm 9.3	6.4 (0.4 to 12.4)	0.037*
Right Posterolateral (cm)	99.5 \pm 7.6	4.4 (2.1 to 6.6)	0.001*
Left Posterolateral (cm)	98.9 \pm 8.2	5.3 (3.6 to 6.9)	<0.001*

Note: confidence interval (CI), five-repetition maximum (5-RM). *denotes $p < 0.05$.

Discussion

Physical inactivity is an important risk factor for the development and progression of CVD (Mozaffarian et al., 2015). Nevertheless, according to 2013 data in adults ≥ 18 years the age-adjusted proportion who reported engaging in moderate or vigorous physical activity that met current physical activity guidelines for Americans was 50.0% (Mozaffarian et al., 2015). This is perhaps due in part to a lack of enjoyment experienced from participation in traditional forms of physical activity (such as walking, running,

swimming, and cycling). Additionally, despite the long-existence of exercise-related health promotions, engagement in physical activities or exercise remains scarce, primarily reported to be due to 'lack of time' (Troost et al. 2002). One possible way in which to increase the number of individuals involved in regular physical activity is to emphasize that the health benefits of traditional exercise can often be found in alternative forms of exercise in a time-efficient manner. Results from the present study provide two preliminary lines of evidence

supporting the Core-Tex™ as an ideal alternative exercise modality:

1. The typical Core-Tex™ exercise session elicited cardiovascular and metabolic responses that fulfill exercise intensity guidelines for improving and maintaining cardiorespiratory fitness (ACSM, 2018; Bryant & Green, 2010). Mean exercise intensity was 48.1% of HRR and 4.8 METs, respectively. Overall energy expenditure for a Core-Tex™ exercise session was 162 kcal/session.
2. Participation in a 6wk exercise-training program with the Core-Tex™ positively modified various fitness domains. In fact, our findings demonstrated that the Core-Tex™ is an exercise modality that may simultaneously satisfy training guidelines for cardiorespiratory, flexibility, neuromotor, and muscular fitness.

Acute cardiovascular and metabolic responses to Core-Tex™

Exercise intensity is arguably the most critical component of the exercise prescription model. Failure to meet minimal threshold values may result in lack of a training effect, while too high of an intensity could lead to over-training and negatively impact adherence to an exercise program (Franklin, 2007). Results from the present study indicate exercise with a Core-Tex™ can be classified as “moderate” according to various

organizations definition of physical activity intensity (ACSM, 2018; Bryant & Green, 2010). For example, moderate exercise intensity in relative terms has been defined as 40-59% of HRR/VO₂R (ACSM, 2018). Participants in the present study exercised at workloads with the Core-Tex™ that elicited HRR (48.1%) values that fall within the moderate relative intensity category.

In the 2018 US physical activity guidelines report (Department of Health and Human Services, 2018) and elsewhere (Ainsworth et al., 2011), moderate-intensity physical activity in absolute metabolic terms has been classified as 3 to 6 METs. In the present study, the MET response to exercise with the Core-Tex™ averaged 4.8. Thus, participants in the present investigation exercised at workloads during a typical Core-Tex™ exercise session that elicited metabolic responses within the accepted moderate-intensity range. This is an important finding given the fact that moderate-intensity exercise has been widely recommended for health benefits (ACSM, 2018; Bryant & Green, 2010; Department of Health and Human Services, 2018). Additionally, MET values described in the present study compare favorably to more traditional land-based aerobic exercise values and non-traditional exercise values. For instance, treadmill and over ground brisk walking at 4.0 miles per hour is an equivalent moderate-intensity physical activity at 4.9 METs. Likewise, an 80-kg individual cycling

between 50 and 100 Watts will elicit a MET value ranging from 4.0 to 6.0 METs (ACSM, 2018). More recently, Smith and colleagues (2016) reported that participation in a TRX Suspension Training class also elicited an absolute moderate-intensity metabolic response at 5.8 METs.

Chronic cardiovascular and metabolic adaptations to Core-Tex™

In the past few decades both low cardiorespiratory and muscular fitness have garnered considerable attention as independent and powerful predictors of CVD risk and premature mortality. For instance, it has been reported that increased muscular fitness is associated with a reduced risk of all-cause mortality (Ruiz et al., 2008). Likewise, Williams (2001) showed in a meta-analysis that there was a marked decrease in relative risk for CVD when individuals moved out of the lowest quartile of cardiorespiratory fitness. More recently, Blair (2009) estimated that low cardiorespiratory fitness accounted for more overall deaths when compared to deaths which could be attributed to traditional CVD risk factors, such as obesity, smoking, hypertension, high cholesterol, and diabetes. Accordingly, the changes in cardiorespiratory (i.e., \uparrow VO_2max) and muscular fitness (i.e., \uparrow 5-RM bench press and leg press scores) in the current study have novel clinical and public health relevance, as a large number of adults fall into clinically-defined low cardiorespiratory and muscular fitness

categories and therefore demonstrate increased CVD risk (Lobelo et al., 2010). Overall, VO_2max was improved on average by ~ 1.0 METs following 6wk of exercise training. These improvements likely have important long-term prevention implications as a recent study reported a 1 MET increase in VO_2max was associated with an 18% reduction in deaths due to CVD (Barlow et al., 2012).

Methodological Considerations

Possible limitations to the present study merit discussion. The present study investigated the acute and chronic cardiovascular and metabolic responses to a representative sample of healthy, yet previously physically inactive, men and women participating in exercise training with a Core-Tex™ according to a standardized 30-minute routine (see Table 1). The cardiovascular and metabolic responses to Core-Tex™ exercise would undoubtedly vary across different routines. Additionally, the fitness-related adaptations to exercise training with a Core-Tex™ may be more pronounced with a longer training period beyond the 6wk duration of the present study. Future research might also examine other possible training adaptations including enhanced psychological health (e.g., reduced anxiety, lower stress levels).

Conclusions

Findings from the present study support the activity of Core-Tex™ as a feasible alternative to traditional exercise modalities

for adults that elicits metabolic responses within the accepted moderate intensity range. Moreover, regular exercise training with the Core-Tex™ improves various domains of fitness in a time efficient manner. Overall, these findings are important for exercise physiologists, personal trainers, and others who design exercise programs and promote physical activity in the adult population.

Competing interests

This investigation was supported financially by the American Council on Exercise (ACE). The American Council on Exercise (ACE) was not involved in development of the study design, data collection and analysis, or preparation of the manuscript. There are no other potential conflicts of interest related to this article

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