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Abstract

ElliptiGO cycling is a new form of exercise; the metabolic demands, however, have not been investigated. In a cross-over design, 17 runners completed 5×3 min stages while either cycling on a stationary ElliptiGO or running on a treadmill during which HR, RPE, and expired gases were collected using a portable metabolic analyzer. Subjects increased one gear or 1 mph every 3 min during cycling or running respectively. A 10 min recovery between modes of exercise was given. For each testing intensity, metabolic demand (VO_2), HR, and V_E was significantly higher during running ($p < 0.05$), however the RPE for each intensity was similar ($p > 0.05$). There was a linear relationship between speed and VO_2 but the relationship for running had a steeper slope compared to the ElliptiGO. As a result, the ElliptiGO speed that was equivalent to the VO_2 of each running speed increased at a greater rate. When matched for VO_2, the HR, V_E, and RPE were actually higher for ElliptiGO compared to running.

Introduction

Runners often face injury due to the high impact nature of the sport and the strain it can put on lower limbs (Hreljac, 2004). When injury occurs, other forms of exercise are sought out to supplement the lack of running in their training. Biking and swimming are two common substitutes for running, and although they do promote cardiovascular fitness they do not mimic the biomechanics or muscle activation patterns of over ground running. For example studies using triathletes have found greater variation in muscle activation patterns compared to athletes who train for on specific discipline (A. Chapman, Vicenzino, Blanch, & Hodges, 2009; A. R. Chapman, Vicenzino, Blanch, & Hodges, 2007, 2008). Some athletes turn to elliptical training since the motion is most similar to running and they are avoiding the high impact of running over ground (Dalleck & Kravitz, 2007; Green, Crews, Pritchett, Mathfield, & Hall, 2004). However, being confined to their home or gym they are still lacking the enjoyment of being outdoors.

In an attempt to meet all these needs, an alternate form of cross-training known as the ElliptiGO bike (ElliptiGO Inc., Solana Beach, CA) (Figure 1) has recently become popular. This mode of exercise combines the low-impact of elliptical training with the mechanical patterns of running into a bike form that you can enjoy outdoors, over ground. However, currently there is no scientific research on the energetic demands of the ElliptiGO. Therefore the purpose of this study was to compare the metabolic demands of the ElliptiGO bike with running.

Methods

Design

A randomized crossover design was used in which the metabolic demands of running and ElliptiGO riding were measured at a range of speeds using a treadmill (TrackMaster 425Full Vision Inc., Newton, USA) and ElliptiGO bike (Figure 1). The speeds at which the metabolic demand were equivalent at running and riding were then matched using regression analysis.

Figure 1. A) Schematic of ElliptiGO bike, B) images of ElliptiGO bike and riders

Subjects

Seventeen elite distance runners (mean ± SD) (9 males; 8 females, age 21.4 ± 1.1 yr, body mass 60.8 ± 9.2 kg, height 1.70 ± 0.07 m, body fat 12.6 ± 5.9%) took part in the study. All subjects had prior experience on the ElliptiGO and refrained from any activities they were unaccustomed to in the three days prior to testing. Subjects were elite distance runners as indicated by their International Association of Athletics Federations (IAAF) score of 920 ± 52 on the IAAF Scoring Tables of Athletics, which equates to a (min:sec) 4:13 mile, 14:24 5k, 30:25 10k for men or 4:59 mile, 17:13 5k, 36:22 10k for women (Federations, 2011). The study was approved by the Grand Valley State University Human Subjects Review Board and all participants provided informed written consent.

Testing Procedures

Prior to testing we asked subjects to get an adequate amount of sleep and to refrain from having caffeine the day before their scheduled testing day. Upon arrival, we measured their height, weight and body fat using a bioelectrical impedance analysis scale (TBF-310GS Body Composition Analyzer, Tanita, Arlington Heights, IL). After a standardized warm-up, subjects were fitted with the portable metabolic analyzer (MedGraphics VO2000, Saint Paul, MN). Subsequently in a randomized crossover fashion, subjects completed 5× 3 min continuous stages on either the stationary ElliptiGO 8C bike or treadmill during which expired gases were measured continuously using a portable metabolic analyzer for determination of VO_2, VCO_2, V_E, RER, and caloric cost during each exercise bout. Heart rate was monitored continuously (Polar RS800sd, Polar Electro, Finlad). For both exercise modes, intensity increased every three minutes (Table 1) and rating of perceived exertion (RPE) was recorded at the end of each stage using a scale of 1-10 (Borg, 1970). During ElliptiGO riding, subjects rode in an upright touring position with the rider's hands on top of the brake hoods. Subjects started pedaling in gear four and shifted up one gear every three minutes until they reached gear eight. Pedaling cadence was fixed at approximately 70 rpm using a metronome. During running, subjects increased running speed one mph every three minutes. Men began running at 7 mph and women at 6 mph (Table 1). Subjects were given a 10 minute recovery between modes of exercise where they were able to remove their mask and were encouraged to hydrate.

Table 1. Testing velocities and cadences.

	ElliptiGO			**Running**	
	Speed		**Crank**	**Speed (mph)**	
Intensity	**(mph)**	**Gear**	**(rpm)**	**Men**	**Women**
1	11	4	69.0	7	6
2	13	5	69.4	8	7
3	15	6	69.9	9	8
4	17	7	69.6	10	9
5	19	8	69.6	11	10

Analysis
Data analysis was performed using customized spreadsheets (Hopkins, 2005, 2006; Hopkins & Hewson, 2001). Averages were calculated for physiological characteristics for each speed on ElliptiGO and running. Linear regression analyses were performed for each physiological variable and speed. Due to the linear relationship between metabolic demand (VO_2) and speed, the subsequent regression equations for ElliptiGO and running were used to extrapolate physiological data to slower and faster speeds. Metabolic demand data for running and ElliptiGO were matched to determine equivalent running and stationary ElliptiGO cycling speeds. The other physiological measures were then matched with the corresponding running and ElliptiGO cycling speeds.

Results

Group averages from raw data for running and ElliptiGO are presented in Table 2. For any given testing intensity VO_2, heart rate, energy expenditure, and ventilation were all significantly higher during running ($p < 0.05$), however, the RPE for each intensity was similar ($p > 0.05$). There was a clear linear relationship between speed and metabolic demand (VO_2) while running and ElliptiGO cycling (Figure 2), but the relationship between speed and metabolic demand for running had a steeper slope compared to the ElliptiGO. As a result, the ElliptiGO speed that was equivalent to the metabolic demand of each running speed increased at a greater rate (Table 3). When matched for metabolic demand, the HR, V_E, and RPE were actually higher for ElliptiGO compared to running (Table 3).

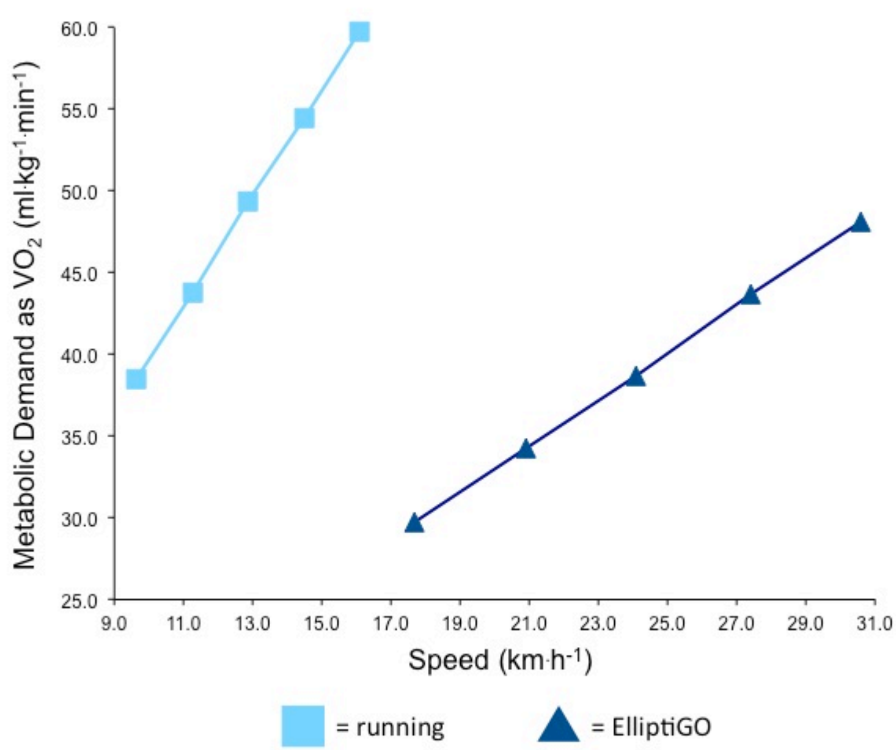

Figure 1. Linear regression analyses of VO_2 and speed for both running and ElliptiGO

Table 2. Group averages for each intensity for both modes of exercise

Variables	**Mode**										
	Running						**ElliptiGO**				
Intensity[a]	1 (6 mph)	2 (7 mph)	3 (8 mph)	4 (9 mph)	5 (10 mph)	6 (11 mph)	1 (Gear 4)	2 (Gear 5)	3 (Gear 6)	4 (Gear 7)	5 (Gear 8)
VO_2 (ml·min^{-1})	1706.3± 225	2255.7± 701	2591.7± 655	2859± 676	3141.7±604	3721.7± 752	1690.4±301	1798.8±313.4	2033.2±282	2292.9±268	2728.3±727
EE (Kcal)	11.7	13.3	14.9	16.6	18.2	19.8	8.5	9.0	10.2	11.5	13.6
Heart Rate (bpm)	139.9 ± 12.2	145.5 ± 17.7	154.5 ± 16.0	164.1± 14.9	175.5± 10.7	178.9± 7.5	133.1±19.8	138.1±20.2	146.9±21.0	158.2±17.6	171.7±14.3
METs	11.0	12.5	14.0	15.6	17.1	18.6	7.9	8.5	9.6	10.8	12.8
RPE (1-10)	2± 0.0	2.3± 0.9	3.2± 1.2	4.8± 1.0	6.5± 1.3	7.4± 1.1	1.8±0.6	2.7±0.6	4.2±1.2	5.5±1.4	7.2±1.6
RER	0.81± 0.04	0.82± 0.06	0.86± 0.06	0.89± 0.06	0.93± 0.07	0.93± 0.06	0.88±0.05	0.88±0.05	0.89±0.06	0.91±0.07	0.95±0.08
V_E (L·min^{-1})	43.4± 5.6	54.7± 14.6	66.4± 27.6	77.4± 22.8	88.3± 21.7	97± 21.6	43.0±5.4	45.5±5.4	52.2±6.5	61.5±10.7	77.7±19.7

[a]For running intensity, both men and women completed 5 stages. Women started at 6 mph and men at 7 mph
VO_2 = metabolic demand, EE = energy expenditure, METs = metabolic equivalents, RPE = rating of perceived exertion, RER = respiratory exchange ratio, V_E = minutes ventilation

Table 3. Equivalent energy expenditures between running and ElliptiGO

Running				ElliptiGO			
Speed (mph)	Heart Rate (bpm)	V_E ($L{\cdot}min^{-1}$)	RPE (1-10)	Speed (mph)	Heart Rate (bpm)	V_E ($L{\cdot}min^{-1}$)	RPE (1-10)
4	121.9	22.3	1.0*	**10.2**	126.3	35.5	1.1
4.5	126.1	27.8	1.0*	**11.4**	131.9	40.4	2.0
5	130.3	33.2	1.0*	**12.5**	137.5	45.4	2.9
5.5	134.5	38.6	1.0*	**13.7**	143.2	50.3	3.8
6	138.7	44.1	1.4	**14.8**	148.8	55.3	4.7
6.5	142.9	49.5	2.0	**16.0**	154.4	60.2	5.6
7	147.1	54.9	2.6	**17.1**	160.0	65.2	6.5
7.4	150.5	59.2	3.1	**18.3**	165.7	70.1	7.4
8	155.5	65.8	3.8	**19.5**	171.3	75.1	8.3
8.5	159.7	71.2	4.4	**20.6**	176.9	80.0	9.2
9	163.9	76.6	5.0	**21.8**	182.6	85.0	10.0*
9.5	168.1	82.0	5.6	**22.9**	188.2	89.9	10.0*
10	172.3	87.5	6.2	**24.1**	193.8	94.9	10.0*
10.5	176.5	92.9	6.8	**25.2**	199.5	99.8	10.0*
11	180.8	98.3	7.4	**26.4**	205.1	104.8	10.0*

V_E = minutes ventilation, RPE = rating of perceived exertion.
*based on linear regression, values fell outside the 1-10 Borg scale range and are adjusted to fit minimum and maximum values.

Discussion

The aim of this study was to compare the metabolic demand of ElliptiGO cycling with treadmill running. In general, when matched for metabolic demand the equivalent ElliptiGO cycling speeds increased at a greater rate compared to running. We found the metabolic demand of cycling to increase at a slower rate (Figure 1) therefore the speeds must increase faster to compensate for the slower increase of metabolic demand. Furthermore, HR, V_E, and RPE were higher for the ElliptiGO compared to running. This is in contrast to Wing (2011) who found the heart rate responses and RPE were similar to running. However, they measured energy cost while cycling and running over ground and we conducted our study stationary.

Most of the subjects in this study came to a general agreement that the ElliptiGO portion was much more difficult compared to the running portion. This is not surprising given the HR, V_E, and even the RPE were all higher compared to running values when matched for metabolic demand. However, our subjects were all trained, distance runners with minimal training on the ElliptiGO so they would be less economical compared to people who train solely on an ElliptiGO bike. Previous research has shown that less experienced runners are less economical compared to highly trained runners (K.R. Barnes & A.E. Kilding, 2015; K. R. Barnes & A. E. Kilding, 2015). Perhaps with further ElliptiGO training, our subjects would become more economical and decrease the discrepancy between the two modes of exercise.

Injured runners looking for other forms of training could greatly benefit from ElliptiGO cycling because of the similar biomechanics to running and the low-impact nature of the bike. Based on our results, Table 3 can be used as a reference to determine how fast an athlete must ElliptiGO to get the same physiological workout as running. The athlete would simply look at the table and find the speed at which they typically run, then find the corresponding ElliptiGO speed located in the same row. For example, if a person usually runs at seven mph, they must cycle at 17 mph to get the same physiological benefit (Table 3). In our study, 17 mph is equivalent to cycling in gear seven at approximately 70 rpms (Table 1). Similarly, if a person runs at eight mph, they must cycle at 19.5 mph (Table 3) at gear 8 (Table 1).

Table 2 presents the group averages of the physiological variables when running and ElliptiGO cycling were matched for intensity. We found running to produce higher physiological values rather than the ElliptiGO, because the intensities for each mode of exercise were not equivalent (Wing, 2011).

Some care should be used when applying the results of this study to real world application due to several limitations. First, this study was conducted in a laboratory on a stationary bike trainer and treadmill and therefore our findings are not applicable to over ground running and ElliptiGO cycling. Had the study been conducted over ground, new variables would be introduced to both modes of exercise such as wind resistance and drag. These factors would contribute to a higher metabolic demand, particularly with ElliptiGO cycling and therefore the conversion from running to ElliptiGO would be different than presented here (Table 3). A second limitation that must be addressed are the speeds someone must ElliptiGO to achieve a physiologically equivalent workout as running 8.5 mph or higher. According to Table 3, a person must cycle at 20.6 mph to match the metabolic demand of running 8.5 mph; speeds above 20 mph are difficult to obtain and sustain for long periods of time for even trained ElliptiGO riders. However, future research should use a similar methodology as we used here to examine the metabolic demands of over ground ElliptiGO cycling.

Conclusions

- The ElliptiGO bike is a very practical training device that will elicit a similar metabolic demand to running.

- When matched for metabolic demand, HR, V_E, and RPE were all higher for the ElliptiGo compared to running.

- At slower running velocities (5-7 mph), an athlete must cycle on the ElliptiGO about 8-10 mph faster to have a similar energetic cost. As the velocities get faster (9-11 mph), an athlete must ElliptiGO about 13-15 mph to achieve the same physiological benefit as running.

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