

**TITLE PAGE**

**Title:** The Efficacy of an 8-Week Concurrent Strength and Endurance Training Programme on Hand Cycling Performance

**Running Head:** Hand cycling performance

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**ABSTRACT**

The aim of the present study was to investigate the effects of an 8-week concurrent strength and endurance training programme in comparison to endurance training only on several key determinants of hand cycling performance. Five H4 and five H3 classified hand cyclists with at least one year's hand cycling training history consented to participate in the study. Subjects underwent a battery of tests to establish body mass, body composition,  $VO_{2peak}$ , maximum aerobic power, gross mechanical efficiency, maximal upper body strength, and 30 km time trial performance. Subjects were matched into pairs based upon 30 km time trial performance and randomly allocated to either a concurrent strength and endurance or endurance training only, intervention group. Following an 8-week training programme based upon a conjugated block periodisation model, subjects completed a second battery of tests. A mixed model, 2-way analysis of variance (ANOVA) revealed no significant changes between groups. However, the calculation of effect sizes (ES) revealed that both groups demonstrated a positive improvement in most physiological and performance measures with subjects in the concurrent group demonstrating a greater magnitude of improvement in body composition (ES -0.80 vs. -0.22) maximal aerobic power (ES 0.97 vs. 0.28), gross mechanical efficiency (ES 0.87 vs. 0.63), bench press 1 repetition maximum (ES 0.53 vs. 0.33), seated row 1 repetition maximum (ES 1.42 vs. 0.43), and 30 km time trial performance (ES -0.66 vs. -0.30). In comparison to endurance training only, an 8-week concurrent training intervention based upon a conjugated block periodisation model appears to be a more effective training regime for improving the performance capabilities of hand cyclists.

**Keywords:** Disability sport, arm ergometry, resistance training, conjugated block periodisation

## INTRODUCTION

Hand cycling is a form of Paracycling used by individuals who are unable to ride a conventional road bike or tricycle due to either a spinal cord injury and/or physical impairment of the lower extremities. Over the past two decades, the popularity of hand cycling as a sport, has increased considerably (3, 20). Indeed, in 1999 hand cycling was formally recognised as a sport by the International Paralympic Committee (IPC) and has been included in the Paralympic Games since Athens in 2004. Hand cycle races vary in length from 50 – 80 km for a criterium road race and 20 – 30 km for an individual time trial (32). Hand cycling race tactics are comparable to those of able-bodied cycling and include the use of variable pacing strategies, such as frequent short accelerations to push opponents, taking the lead, or drafting other riders to reduce the overall energy cost by 25 – 40% (3, 11). A typical hand cycling race has been shown to place a considerable demand upon the aerobic energy system (1). However, it can be speculated that the anaerobic energy system will be repeatedly taxed due to the requirement to generate a relatively high-power output for brief periods of time during surges in pace, climbing, or sprinting to the finish (1, 10, 11).

**## INSERT FIGURE 1 HERE ##**

Despite the increased interest in hand cycling as a sport there is currently a paucity of research in regard to the typical physiological characteristics of competitive hand cyclists. As with able-bodied cycling, peak oxygen uptake ( $VO_{2peak}$ ) (1, 21, 22, 25, 26, 30), maximal aerobic power (MAP) (18, 22, 23, 24, 30, 38), and gross mechanical efficiency (GME) (1, 18, 21, 30) have all been proposed to be significant physiological determinants of hand cycling performance. Furthermore, it can be inferred that other variables such as anaerobic threshold, maximal upper body strength and power-to-weight ratio may also impact upon hand cycling performance (3, 10, 11).

Relatively few studies have investigated the effects of a structured training intervention upon hand cycling performance (2, 22, 38, 39) with all but one (30) utilising endurance training only. In comparison to endurance training only, the concurrent integration of both strength (*e.g.*, resistance training) and endurance training (*e.g.*, cycling or running) into a single unified training programme has been demonstrated to significantly enhance body composition,  $VO_{2peak}$ , MAP, GME, anaerobic capacity and subsequent performance potential of individuals in endurance sports such as cycling (5, 37, 43), running (5, 37), and kayaking (15). However, it must be noted that despite enhancing endurance performance, relative to strength training alone, concurrent training has been shown to attenuate gains in muscle hypertrophy, maximal strength, rate of force development, and peak power output via a phenomenon commonly known as the interference effect (4, 13, 17, 42).

Several physiological adaptations have been proposed which may explain the observed improvements in endurance performance as result of concurrent training. These include: (i) greater force production capability; (ii) enhanced peak power output; (iii) improved musculotendinous stiffness, and (iv) superior GME due to a reduced relative energy expenditure at a given velocity or power output (17, 37). It can be argued that improved GME is of particular importance to endurance athletes as improved efficiency will effectively translate to a reduced work load. This will allow an individual to produce a higher power output for an equivalent amount of energy (*i.e.*, improved performance capacity) or alternatively result in a longer time to exhaustion at a given rate of work (*i.e.*, improved endurance capacity).

Given that concurrent training has been demonstrated to enhance body composition,  $VO_{2peak}$ , MAP, GME, and maximal strength of able-bodied cyclists (5, 37, 43), it can be speculated that it may also enhance hand cycling performance. Indeed, Garcia-Pallares (15, 16) recently demonstrated that a 12-week concurrent training programme based upon a block periodisation model, significantly improved several neuromuscular, cardiovascular, and performance markers in

eleven world-class kayakers. As kayaking demonstrates a similar upper body push/pull movement pattern to that of hand cycling it can be postulated that a comparable training intervention may also improve hand cycling performance. Based upon the theoretical potential of concurrent training to enhance hand cycling performance, the present study investigated the effects of an 8-week concurrent training programme compared to endurance training only upon several key determinants of hand cycling performance. It was hypothesised that an 8-week concurrent training programme would result in a greater improvement in hand cycling performance than purely endurance training alone.

## **METHODS**

### **Experimental Approach to the Problem**

A repeated-measures, pretest - posttest design, was used to test the hypothesis that concurrent training would result in a greater improvement in hand cycling performance when compared to endurance training alone. Body mass, body composition,  $VO_{2peak}$ , MAP, GME, maximal upper body strength and 30 km individual time trial (TT) performance was evaluated in ten experienced hand cyclists. Based upon 30 km TT performance subjects, were matched into pairs before being randomly assigned to either a concurrent (CT) or endurance training only (E) group. Subjects in the CT group were asked to complete an 8-week concurrent training intervention designed to develop aerobic capacity and upper body strength. Whereas, subjects in the E group were asked to complete an 8-week endurance training only intervention designed to develop aerobic capacity. Following, an 8-week training intervention all of the aforementioned variables were re-examined in order to determine which was the more effective training intervention.

## Subjects

Ten experienced hand cyclists with at least one year's recreational hand cycling experience provided written informed consent to take part in this study. All subjects were classified as either an H3 or H4 AP hand cyclist in accordance with current UCI Paracycling regulations (32). Three participants were bi-lateral, above knee amputees (H4); one was a triple amputee (H3); one a single, below knee amputee (H4); four were paraplegics (H3) and one had a chronic degenerative condition of the lower limbs (H4). Mean ( $\pm$  SD) characteristics of subjects were as follows: age  $32 \pm 9$  years; body mass  $79.8 \pm 16.3$  kg; 4-site skinfold summation  $21.8 \pm 3.5$  mm; chest circumference  $107.2 \pm 8.7$  cm; right upper arm girth  $33.5 \pm 8.7$  cm and relative  $\text{VO}_{2\text{peak}}$   $31.2 \pm 13.5$  mL·kg<sup>-1</sup>·min<sup>-1</sup>. No upper body musculoskeletal injuries that could affect a subject's participation were reported prior to the study. Finally, the study was conducted in accordance with the declaration of Helsinki with approval granted by the Research Ethics Committee of St. Mary's University (Twickenham, United Kingdom).

## Procedures

All subjects undertook a series of laboratory and field based testing protocols prior to (T1) and immediately upon completion (T2) of the 8-week experimental training intervention. Testing was completed over three consecutive days: anthropometry and an incremental, exhaustive hand cycling test (day 1); 1 repetition maximum (1RM) strength testing (day 2); and a 30 km individual TT (day 3). Before testing, all subjects were asked not to engage in any form of strenuous exercise and refrain from the consumption of alcohol for at least 48 hours. All laboratory testing was performed at the same time of day and in stable environmental conditions (18°C, 50 – 60 % relative humidity). Following T1, subjects were matched into pairs based upon TT performance. This was achieved by pairing the fastest TT time with the slowest; this process was then repeated until all subjects had been paired. Subjects from each pair were then randomly assigned into either the CT group or E group.

**Anthropometry**

Anthropometric measurements including body mass, four-site skinfold thickness summation (chest, triceps, subscapular, and Iliac crest), and muscle girths (chest and right upper arm), were performed by the same experienced investigator in accordance with International Society for the Advancement of Kineanthropometry guidelines (27). Body mass was measured to the nearest 0.1 kg using a calibrated scale (Seca 714, Hamburg, Germany); whilst skinfold thickness and muscle girths were measured to the nearest mm using a pair of skinfold callipers (accurate to 0.2 mm) and a flexible measurement tape (1.0 mm), both from the Harpenden range of anthropometric instruments (Holtain, Ltd, UK).

**Incremental Hand Cycling Test**

Subjects were asked to complete an incremental, exhaustive hand cycling test using their own hand bike fitted to a standard indoor cycling turbo trainer (Fluid 2, CycleOps, USA). Based upon their disability subjects had been previously custom fitted to their hand bike and were requested not to alter their crank width, crank height, or seat position for the duration of the study. Power output was measured using an instrumented front wheel hub (Powertap, G3, CycleOps. USA, 1.5% accuracy between 0 and 1999 W, sample frequency 0.2 Hz). The Powertap has been shown to be a reliable instrument (CV 0.9 – 2.9%) for the measurement of power whilst cycling (6) and was calibrated prior to testing in accordance with the manufacturer's instructions.

Throughout the test protocol heart rate (HR), oxygen uptake ( $\text{VO}_2$ ), carbon dioxide production ( $\text{VCO}_2$ ), and respiratory exchange ratio (RER) were continuously monitored using a HR receiver (Garmin 810, Garmin Ltd, USA) and a portable spiroergometry system (Metamax 3B, Cortez Biophysik, Germany), respectively. Gas calibrations were checked before and at the end of each trial to ensure no drift in calibration had occurred. As per the manufacturer's instructions oxygen and carbon dioxide sensors were firstly calibrated using a reference calibration gas of

known concentration (14.7% oxygen, 4.97% carbon dioxide), the calibration was then verified against ambient air. Secondly, an air volume calibration was performed using a standardised 3 L syringe. All respiratory parameters were calculated for each breath and averaged over 1-min durations at rest and over the last 15 s of each exercise stage. Gross mechanical efficiency was calculated as the ratio of external work produced to the amount of energy expended when a fixed blood lactate concentration of 2 mmol·L<sup>-1</sup> was reached. This metabolic threshold was selected as it represents a consistent, submaximal exercise intensity during which energy production is predominantly via aerobic metabolic pathways. Metabolic energy expenditure was calculated from VO<sub>2</sub> and RER data according to Garby and Astrup (14). Gross mechanical efficiency was then defined as;  $GME = ((\text{external work done}/\text{energy expenditure}) \times 100) (\%)$ .

Following a 10-min warm up at a self-selected power output, subjects were requested to start the test protocol at a work rate of 50 W with subsequent 15 W increments every 3-mins until the required power output could no longer be maintained. Maximal aerobic power (MAP) and VO<sub>2peak</sub> were identified as the average power output and peak oxygen consumption rate achieved during the last fully completed 3-min stage. Subjects were free to adjust their gear ratio and/or crank rate as needed in order to achieve and maintain the required power output. Every 3-mins and upon immediate completion of the test subjects were asked to indicate their rating of perceived exertion (RPE) using a 6- to 20- Borg scale (7).

At the end of each stage a small sample of capillary blood was collected from each subject's earlobe in order to identify fixed blood lactate concentrations of 2 mmol·L<sup>-1</sup>, 4 mmol·L<sup>-1</sup> and the blood lactate concentration at the point of volitional exhaustion. Each whole blood sample was analysed immediately to determine the concentration of blood lactate using a fully automated analyser (Biosen C-line, EKF Diagnostics, Barleben, Germany). All capillary blood samples were collected by an experienced phlebotomist and following analysis were disposed of immediately.

### **Maximal Upper Body Strength Testing**

Upper body strength was determined via the establishment of each subject's bench press and seated row 1RM. These exercises were chosen as they closely mimic the synchronistic, push/pull movement pattern observed during hand cycling. Bench press 1RM testing (CV 23 – 25.5%) was conducted on a specifically designed, IPC para-powerlifting bench (Eleiko, Sweden), using a 20 kg Olympic barbell, 450 mm diameter barbell plates (25 kg, 20 kg, 15 kg, and 10 kg), 200 mm diameter barbell plates (5.0 kg, 2.5 kg, 2.0 kg, 1.5 kg, 1.0 kg, and 0.5 kg) and two safety locks (Eleiko, Sweden). Seated row 1RM testing (CV 16 - 19.7%) was carried out on a seated row/rear deltoid resistance machine with 1.0 kg weight increments (Cybex Total Access, USA).

Both bench press and seated row 1RM testing was conducted in line with the protocols proposed by Haff and Triplett (19). Subjects were instructed to perform a light warm up with the bar only for 5 – 10 repetitions. Following a 1-min recovery period a second set of 3 – 5 repetitions was performed with an estimated 60% 1RM load. After a 3-min recovery period another set of 2 – 3 repetitions, was performed with an estimated 80% 1RM load. Thereafter, an estimated 1RM load was selected and the subject asked to perform a single repetition. If successful, the subject was given a 3-min recovery period prior to performing a further 1RM attempt with an increased load. Subjects were allowed, to perform 3 – 5 more 1RM attempts with 3-min recovery between sets until their 1RM had been established within a precision of 1.0 kg.

### **30 km Individual Time Trial**

In order to assess real world hand cycling performance, a 30 km individual TT (CV 17.1 - 18.1%) was conducted at a closed motor racing circuit (Thruxton, England). This location provided a flat 3.75 km circuit. Following two familiarisation laps, participants were required to complete eight laps of the 3.75 km circuit. Overall time and lap split times were manually recorded to the nearest second (Seiko S149, Seiko Watch Corporation, Japan).

## Training Intervention

Based upon a conjugated block periodisation model (15, 16, 17, 28, 29), the 8-week training intervention for both groups was divided into two consecutive phases. Phase one (P1) focused upon the development of upper body strength and/or aerobic capacity; whilst phase two (P2) focused upon the development of maximal upper body strength and/or anaerobic threshold. Each phase was 4 weeks in length, split into 3 weeks of accumulated training load, followed by a recovery week in the fourth where the total training volume was reduced by 50%. Subjects in the CT group were asked to perform two strength training and three endurance training sessions per week, whilst subjects in the E group were asked to perform five endurance training sessions per week.

**## INSERT TABLE 1 HERE ##**

Strength training loads in the CT group were determined via the use of repetition zones matched with appropriate volume and recovery parameters (33, 34, 35) in order to elicit the required adaptive response (*e.g.*, maximal strength). A detailed description of the strength training variables is given in Table 1. Three hand cycling training zones were identified based upon individual MAP established during the incremental ramp test: zone 1 (Z1) light intensity, between 50 – 70% MAP; zone 2 (Z2) moderate intensity, between 70 – 90% MAP; and zone 3 (Z3) high intensity, between 90 – 110% MAP. A detailed description of hand cycling training variables is given in Table 2. Subjects were asked to complete a weekly online training diary. The adherence rate for hand cycling training sessions was approximately 100% in both groups, whilst subjects in the CT group completed approximately 80% of the allocated strength training sessions

**## INSERT TABLE 2 HERE ##**

## Statistical Analyses

All data are reported as mean ( $\pm$  SD) with an *a-priori* level of significance for all statistical analyses set at  $p < 0.05$ . Statistical analyses were performed using SPSS Version 22.00 (SPSS Inc, Chicago). A mixed model, 2-way analysis of variance (ANOVA) test was used to evaluate changes in the selected variables, between groups (CT vs. E: independent measures) over the 8-week intervention period (T1 – T2: repeated measures). Where statistical significance was noted a *post-hoc* Bonferroni pairwise comparison was conducted to determine specifically where differences exist. In order to evaluate the magnitude of change for all parameters pre/post effect sizes (ES), were calculated using the following formula:  $[(\text{post-test mean} - \text{pre-test mean}) / \text{pre-test SD}]$  (8, 24). Based upon the recommendations of Rhea (36) subjects were classed as recreationally trained as such ES were classed as either trivial  $<0.35$ ; small  $0.35 - 0.80$ ; moderate  $0.80 - 1.5$ ; or large  $>1.50$ .

## RESULTS

Ten subjects started the study however; two withdrew due to personal reasons leaving four subjects in the CT group and four in the E group. Physiological and performance changes in both intervention groups are displayed in Table 3. ANOVA tests revealed no significant changes between the two groups in all measures. However, when the data was examined using ES, the CT group was found to have a greater magnitude of change in several measures when compared to the E group.

After the 8-week training intervention no significant changes were observed in body mass in either the CT group (ES = 0.04) or E group (ES = - 0.11,  $p = 0.163$ ). A moderate change in 4-site skin fold summation was observed in the CT group (ES = -0.80) however, only a trivial change was noted in the E group (ES = -0.22,  $p = 0.224$ ). A trivial increase in chest girth was detected in both the CT group (ES = 0.18) and E group (ES = 0.13,  $p = 0.639$ ), respectively. Furthermore, a small increase in upper arm girth was observed in the CT group (ES = 0.52) whereas, only a trivial increase was noted in the E group (ES = 0.23,  $p = 0.675$ ).

A trivial improvement in relative  $\text{VO}_{2\text{peak}}$  was noted in the CT group (ES = 0.14) whilst a moderate improvement was seen within the E group (ES = 0.70,  $p = 0.228$ ). Power output at a fixed blood lactate concentration of  $2 \text{ mmol}\cdot\text{L}^{-1}$  showed a moderate increase in both the CT group (ES = 0.94) and E group (ES = 1.30,  $p = 0.37$ ). A moderate improvement in GME was noted in the CT group (ES = 0.87) however, only a small increase was detected in the E group (ES = 0.63,  $p = 0.87$ ). In addition, a moderate increase in MAP (Figure 2) was observed in the CT group (ES = 0.97) whilst, only a trivial change was noted in the E group (ES = 0.28,  $p = 0.271$ ).

**## INSERT FIGURE 2 HERE ##**

A small increase in bench press 1RM was detected in the CT group (ES = 0.53) whereas, only a trivial increase was observed in the E group (ES = 0.33,  $p = 0.29$ ). Furthermore, a large increase in seated row 1RM was detected in the CT group (ES = 1.42) whilst, only a small increase noted in the E group (ES = 0.43,  $p = 0.32$ ). Finally, a small improvement in 30 km TT performance (Figure 3) was detected in the CT group (ES = -0.66) however, only a trivial change was observed in the E group (ES = -0.30,  $p = 0.548$ ).

**## INSERT FIGURE 3 HERE ##**

**## INSERT TABLE 3 HERE##**

## DISCUSSION

The aim of the present study was to investigate whether concurrent strength and endurance training would result in a greater improvement in hand cycling performance when compared to endurance training alone. Whilst not approaching significance using traditional statistical tests (*e.g.*, ANOVA), the use of contemporary statistical testing in the form of ES (8, 24, 36), revealed that both training interventions demonstrated a positive improvement in most physiological and performance measures with the CT group demonstrating a greater magnitude of improvement in body composition, relative  $\text{VO}_{2\text{peak}}$ , MAP, GME, upper body maximal strength, and 30 km TT performance.

Individuals with spinal cord injury (SCI) or lower limb amputation have a reduced physiological capacity compared with able-bodied persons (3, 30). Persons with an SCI may also display an even greater reduction due to reduced trunk muscle function as a result of the direct loss of motor control below the level of the lesion, as well as a lack of sympathetic innervation (21). Despite a reduced physiological capacity, individuals with a physical disability have been demonstrated to have a similar adaptive training potential to that of their able-bodied counterparts (3). Fundamentally, physiological adaptations which occur as a result of training are primarily dependent upon the frequency, intensity, time, and type of training performed (33, 34, 35). Therefore, it would be expected that an appropriate strength and/or endurance training regime would result in similar physiological adaptations to those observed in able-bodied persons.

The majority of studies investigating the effects of a structured training intervention upon hand cycling performance have focused upon endurance training only (2, 22, 38, 39). To the best of the authors' knowledge only one other study to date has investigated the influence of a concurrent training intervention upon hand cycling performance. Jacobs (30) examined the effects of a 12-week concurrent training programme in comparison to endurance training only using a group of

untrained paraplegic subjects. Similarly, to the present study the author demonstrated that in comparison to endurance training only, concurrent training resulted in a greater improvement in  $VO_{2peak}$  (15.1% vs. 11.8%), anaerobic capacity (8% vs. 5%), peak power (15.6% vs. 2.6%), and upper body strength (45% vs. - 4.2%). These findings demonstrated that individuals with SCI were able to improve their upper body work capacity, strength, and power. Furthermore, they suggest that in comparison to endurance training only, concurrent training may have the potential to significantly enhance hand cycling performance.

Whilst both training interventions in the present study were effective it must be noted that subjects in the CT group performed 40% less endurance training than those in the E group; with the reduced volume of endurance training replaced with two strength sessions per week. An excessive volume of endurance training has been linked with an increased likelihood of upper limb musculoskeletal overuse injury in wheelchair athletes (3). Therefore, a reduction in the total volume of hand cycling training combined with a greater improvement in performance suggests that a concurrent training regime based upon a conjugated block periodisation model may be a more effective, time efficient and safer approach for improving hand cycling performance, than engaging in purely endurance training alone.

It must be noted that there are several major limitations to the present study. Probability values (e.g.,  $p$  values) are affected by variance and sample sizes (36). As with many studies of this type it is extremely difficult to recruit a homogenous group of disabled subjects. As such, the subject group used in the present study was relatively heterogeneous in terms of age, performance level, and disability which resulted in considerable variance within the group. Furthermore, the overall number of subjects was low. Therefore, the use of ANOVA tests in this study may not have identified any significant difference between groups due to the level of between-subject variance and the small sample size. Another limitation of the present study was the lack of a control group by

which to compare the true effectiveness of either concurrent or endurance only training. Additionally, the 30 km TT was a self-paced time trial, which was conducted in variable climactic conditions. Such an approach represents a less controlled and less repeatable environment compared to laboratory conditions. However, it does add a degree of ecological validity as it relates more closely to a real-world hand cycling race. Finally, the authors also recognise that 8-weeks represents a relatively short period and that greater gains may have been observed had a longer training intervention been employed.

## **PRACTICAL APPLICATIONS**

In conclusion, the findings of this study demonstrate that both concurrent and endurance training only can result in meaningfully, greater improvements in several key determinants of hand cycling performance. Despite several major limitations the findings of the present study suggest that over an 8-week training intervention period concurrent training appears to result in a greater magnitude of improvement in body composition, relative  $VO_{2peak}$ , MAP, GME, upper body maximal strength, and 30 km TT performance when compared to endurance training alone. Based upon these findings it is recommended that hand cyclists utilise a concurrent training programme based upon a conjugated block periodisation model to optimise hand cycling performance and reduce the likelihood of developing some form of upper limb overuse musculoskeletal injury. It is recommended that future research in this area should aim to use a larger, more homogenous group of hand cyclists, over a longer training intervention period to better understand the long-term effects of concurrent training upon hand cycling performance.

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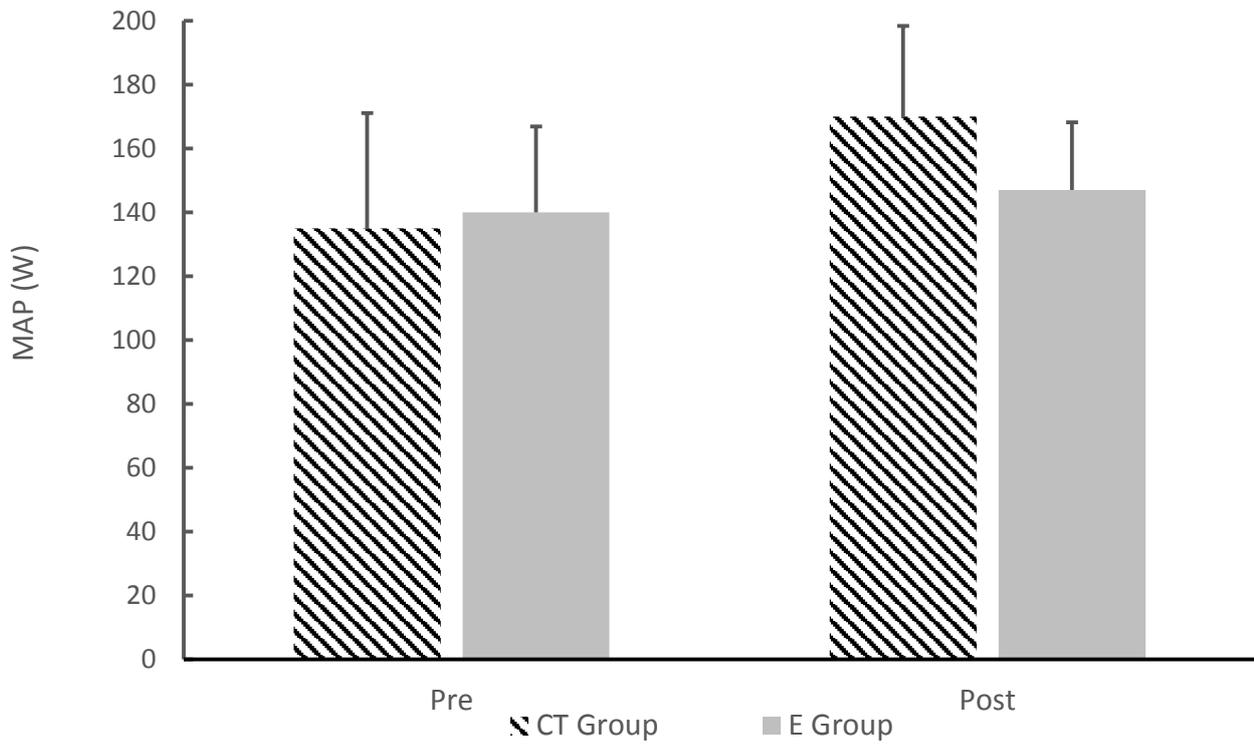
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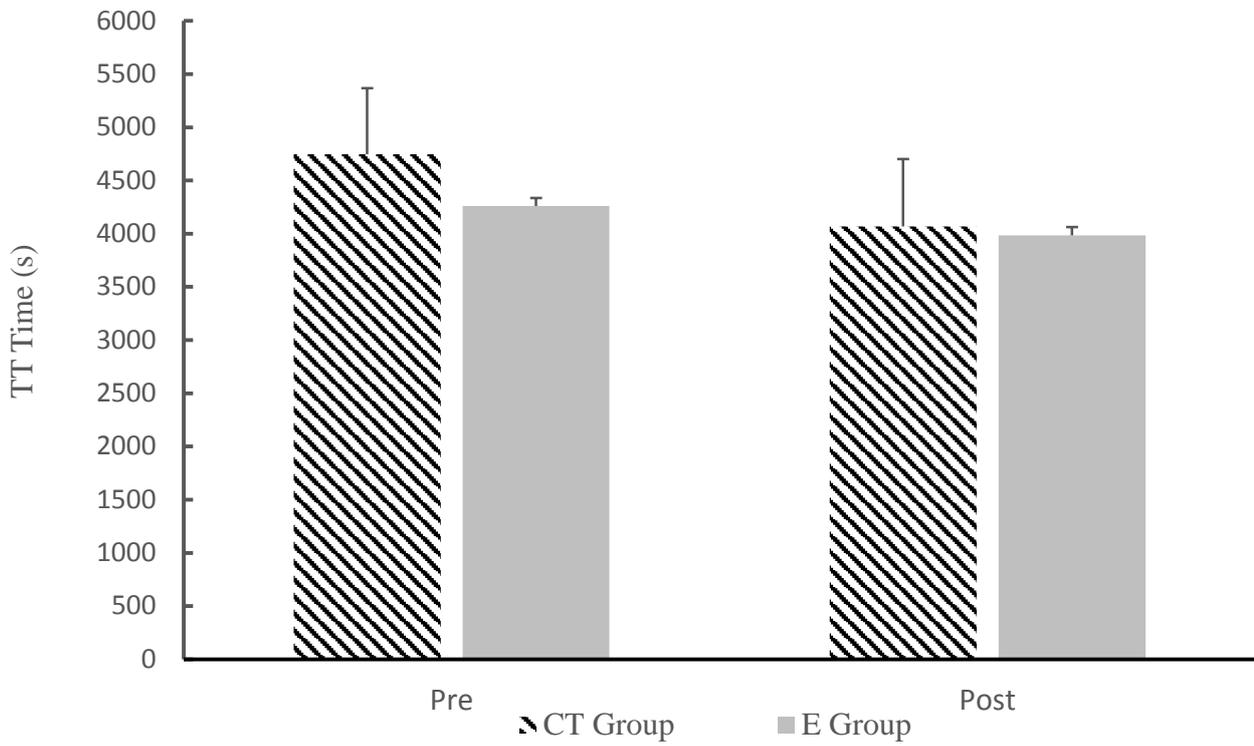
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**Figure 1.** Typical competitive H4 AP hand bike set-up



**Figure 2.** Mean ( $\pm$  SD) values of maximal aerobic power (MAP) achieved before and after 8-weeks of either concurrent or endurance only training.



**Figure 3.** Mean ( $\pm$  SD) 30 km time trial (TT) times achieved before and after 8-weeks of either concurrent or endurance only training.

**Table 1.** Strength training variables

Phase	Exercises	Repetition Loading Range	Sets	Recovery Between Sets
1	Chest Press, Seated Row, Overhead Press,	5 – 7	5	02:00
2	Lat Pull Down	2 – 4	6	03:00

**Table 2.** Endurance Training Variables

Intensity Zone	Sessions Per Week		Time (Mins: Secs)	Work to Recovery Ratio	Recovery Time (Mins:Secs)	Repetitions
	P1	P2				
Z1	2* / 2**	0* / 1**	60 – 110	1:1	n/a	n/a
Z2	1* / 2**	2* / 2**	05:00 – 10:00	2:1	02:30 – 05:00	x 4
Z3	0* / 1**	1* / 2**	00:30 – 01:20	1:2	01:30 – 03:00	x 8

\* CT group

\*\*E group

**Table 3.** Physiological and performance results in CT and E groups

Variables	CT Group ( <i>n</i> = 4)			E Group ( <i>n</i> =4)		
	Pre-Training	Post-Training	Effect Size	Pre-Training	Post-Training	Effect Size
Body Mass (kg)	68.8 ± 16.2	69.4 ± 15.4	0.04	80.7 ± 19	78.6 ± 19.3	-0.11
4- Site Skinfold Summation (mm)	22.7 ± 2.8	20.4 ± 6.9	-0.80	35.0 ± 8.8	33.1 ± 9.3	-0.22
Chest Girth (cm)	107.3 ± 6.5	108.5 ± 9.0	0.18	107 ± 11.2	108.5 ± 8.9	0.13
Arm Girth (cm)	33.3 ± 6.5	36.7 ± 3.2	0.52	33.5 ± 11.2	36.1 ± 1.7	0.23
Relative VO <sub>2</sub> peak (mL·kg <sup>-1</sup> ·min <sup>-1</sup> )	32.5 ± 15.7	41.0 ± 16.4	0.54	28.5 ± 8.0	34.1 ± 8.2	0.70
2 mmol·L <sup>-1</sup> (W)	65 ± 40.1	102.5 ± 21.4	0.94	55.0 ± 9.6	67.5 ± 14.4	1.30
GME (%)	9.7 ± 3.8	13.0 ± 4.2	0.87	11.5 ± 3.2	13.5 ± 1.4	0.63
MAP (W)	135.0 ± 36.1	170.0 ± 28.4	0.97	140.0 ± 26.9	147.5 ± 21.2	0.28
Bench Press 1RM (kg)	83.0 ± 17.8	92.5 ± 17.1	0.53	71.5 ± 25.9	80.0 ± 20.1	0.33
Seated Row 1RM (kg)	80.0 ± 3.8	85.4 ± 5.9	1.42	75.0 ± 23.2	85.0 ± 19.8	0.43
30 km TT (Secs)	4481 ± 621.2	4070.5 ± 633	-0.66	4260 ± 77	3986 ± 77	-0.30