A PHYSIOLOGICAL COMPARISON BETWEEN STANDING CYCLING AND RUNNING DURING AN INTERMEDIATE TERM ANAEROBIC CAPACITY SESSION.

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"We couldn't maintain our normal training schedule on the running track, therefore we had to shift our attention to the gym, doing lots of weights to maintain her body strength and anaerobic work on the stationary bike".

Referring to Cathy Freeman, Olympic Silver Medallist 400m, 1996 Atlanta Games.
(The Australian Way, Sept 1998)

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ABSTRACT

This study wished to compare the same physiological responses of elite athletes to a typical intermediate term anaerobic capacity track running session with those of standing cycling of similar intensity and duration. Twelve well trained/elite male distance runners completed maximal running, standing cycling and strength testing sessions; and Intermediate Term Anaerobic Capacity Sessions (ITACS) in running and standing cycling; each comprising eight efforts of approximately 30 seconds duration at 90% maximal effort in each mode of activity, separated by 2 minutes rest.

The experimental sessions took place from the end of November 1996 to the beginning of March 1997. The subjects were required to attend three maximal experimental sessions, which were performed on separate days and used for baseline data collection. On completing these they participated in both running and standing cycling ITACS, performed on separate days with at least 48 hours between each test protocol. There was complete randomisation of all test protocols.

Descriptive statistics were determined for all the variables. Independent t-testing was used to determine if similar temperature and humidity readings were obtained during the maximal testing for each mode of activity. Paired t-testing was used to compare the differences in warmup heart rates between the maximal and ITACS, the differences in peak lactates obtained after each type of ITACS, draw comparisons between heart rate (HR) changes over time during the ITACS and determine if a difference existed between workloads for the two modes of activity. It was also used to draw a comparison between the peak BLa values and ascertain if pre-test creatine kinase (CK) levels were the same for each mode of activity. A repeated measures one way ANOVA was used to determine if workload reduced over time for each type of ITACS. A three way ANOVA with repeated measures on one factor (repetition) was performed on HR response. It was used to determine if there was a difference between the workload/recovery HR response; if workload/recovery HR values increased over the duration of each ITACS; and if the workload/recovery HR response over time was mode specific. A two way ANOVA with repeated measures on one factor (repetition) was performed on blood lactate (BLa) response. It was used to determine if there was a significant interaction between the mode of activity and time, if BLa increased over the duration of each ITACS and if there was an effect of mode on its own on the BLa response. A two way repeated measures ANOVA was used to ascertain whether there was a difference in CK levels between the two modes of activity, with Tukey's multiple comparison tests used in post hoc analyses to show the amount of difference. A linear regression analysis was performed to determine if BLa response was similar across the duration of each type of ITACS.

The effects of temperature (22.3 ± 1.2 vs 21.1 ± 0.3 °C, run vs cycle, $t = -0.94$, $n = 12$, $p = 0.36$)) and humidity (57 ± 4.2 vs 52 ± 1.7%, run versus cycle, $t = -1.04$, $n = 12$, $p = 0.31$) did not influence any of the results obtained during the ITACS. Nor did differing warmup intensities (as indicated by heart rate - HR) during the maximal (160 ± 5.7 vs 158 ± 3.1 beats per minute (bpm), run vs cycle, $t = -0.45$, $n = 9$, $p = 0.66$) and ITACS (160 ± 3.6 vs 152 ± 3.1 bpm, run vs cycle, $t = -2.81$, $n = 9$, $p = 0.02$). An equal test preparation was confirmed by the warmup blood lactate (BLa) levels, which were not significantly different between the exercise modes for both the maximal (11.0 ±0.6 vs 11.8 ± 1.0 $mmol \cdot l^{-1}$, run vs cycle, $t = 2.26$,

n = 10, p =0.23) and ITACS (4.2 ± 0.7 vs 4.2 ± 0.6 mmol·l $^{-1}$, run vs cycle, t = 0.27, n = 10, p = 0.796).

A significantly higher workload was achieved during the running ITACS as compared to the standing cycling ITACS (105 ± 1.1 vs 89 ± 2.9 %, run vs cycle, t = 10.45, n = 12, p<0.0005). The increase in workload/recovery HR response and their changes as each type of ITACS progressed was not mode specific [F(1,40) = 0.94, p > 0.05]. Those subjects who possessed high BLa concentrations performed less work on the cycle ergometer. There was a strong negative relationship for average workloads and BLa accumulation for the standing cycling exercise (Spearmans rho = -0.799, n = 11, p<0.005) suggesting that BLa accumulation was a limiting factor in work production. The increase in BLa levels was not mode specific F(1,20) = 1.36, p > 0.05]. The BLa response was comparatively similar because the rate of increase in BLa accumulation and peak BLa values (19.7 vs 16.9 mmol·l $^{-1}$, cycle vs run, t = 2.1, n = 11, p = 0.06) were not significantly different between the modes of activity. Mode in conjunction with time affected standing cycling BLa response to a greater extent than running BLa levels [F(4.80) =3.929, p <. 0.05]. Standing cycling BLa concentrations were significantly negatively correlated with knee extension peak torque (Spearmans rho = - 0.771, n = 11, p < 0.01) and total work (Spearmans rho = - 0.802, n = 11, p < 0.01) measurements. In running they were negatively correlated with knee flexion total work measurements (Spearman rho = - 0.685, n = 11, p < 0.05) These findings suggest that BLa accumulation occurs from different muscle fibre recruitment patterns. Less work was performed in isokinetic knee extension following standing cycling as compared to running (2234 ± 68.4 vs 2462 ± 78.9 Nm, t = 2.23, n = 11, p < 0.05) suggesting that standing cycling is more fatiguing on the quadriceps than running. There was no difference in the knee flexion testing (1799 ± 89.6 vs 1785 ± 69.2, cycle vs run, t = 2.23, n = 11, p = 0.96). There was a significant difference in mean creatine kinase (CK) activity between the two modes 24 hours after completing the ITACS (450 ± 73.2 vs 320 ± 46.5 I/U, running vs cycle, F = 6.44, df = 1,17, p < 0.01). There was a significantly greater increase in CK activity and therefore muscle damage, following the running (mean increase of 190 I/U) as compared to the standing cycling session (mean increase of 44.0 I/U).

In terms of reducing the risk of injury, achieving a similar cardiovascular response and achieving comparable BLa accumulation (even though mechanism/s of accumulation may be different) standing cycling appears to be is a satisfactory substitute for running during an ITACS. The results of this research strengthen the concept of utilising a *simulated* mode of activity as a substitute for the primary activity in order to maximise transfer effects, providing there is a *careful balance* between the specific training and the near specific training. The differing physiological responses between the exercise modes (ie- different muscle fibre recruitment patterns, different workload capacity, different CK measures) suggest that standing cycling cannot act as a total/comprehensive replacement for running. A training study is warranted to further investigate the findings of this research.

TABLE OF CONTENTS

7.0 APPENDICES 106

LIST OF TABLES

LIST OF FIGURES

GLOSSARY

Selected terms used in text

Anaerobic Threshold: represents a particular workload, during a test to measure exercise tolerance, where blood lactate levels first begin to rise above their resting levels.

Anaerobic: conditions or processes not requiring oxygen.

Blood Lactate ($mmol \cdot l^{-1}$): concentration of lactate, the dissociation product of lactic acid in the blood. A product of anaerobic metabolism.

Cardiac Output ($L \cdot min^{-1}$): the amount of blood pumped in one minute by either the left or right ventricle of the heart ; the product of the heart rate and stroke volume.

Central Circulatory Adaptations: refers to adaptations which increase blood volume, erythrocyte production, stroke volume and maximal cardiac output. These factors increase the maximal capacity of the central circulatory system to transport oxygen.

Creatine Kinase: an enzyme used as an indicator of skeletal muscle damage.

Cross Training: refers to the participation of an individual in a mode of training alternative to the one normally used. That is, the activity is not task or training specific. It can also involve the combining of an additional training mode with task specific training.

Cycle Ergometer: a stationary bicycle apparatus used for measuring the physiological effects of exercise. Work is commonly measured in watts and kilojoules.

Dissimilar Activities: refers to exercise modes which when compared utilise different muscle groups and/or markedly different patterns of movement (ie- running vs swimming; leg vs arm exercise; strength training vs endurance exercise).

Duathlete: an athlete who trains in both running and cycling for competitions which combine both activities.

Heart Rate (bpm): the number of times the heart beats per minute, or single cardiac cycles of systole and diastole per minute.

Intermediate Term Anaerobic Capacity: total work output during maximal exercise lasting about 30 seconds. Performance under these conditions is primarily anaerobic with a major lactic component (about 70%), and significant alactic (about 15%) and aerobic (about 15%) components.

Metabolic Cost: the sum total of energy consumed over the duration of an activity.

Oxygen Uptake ($L \cdot min^{-1}$ or $ml \cdot kg^{-1} \cdot min^{-1}$): the consumption and utilisation of oxygen by the body.

Peripheral Adaptations: refers to adaptations in the exercising muscles which enhance oxygen utilisation. These adaptations include increased capillary density, mitochondrial number and volume, oxidative enzyme activity and arterial–venous oxygen difference. Peripheral adaptations are more strongly associated with specificity of training.

Similar Activities: refers to exercise modes which when compared utilise similar muscle groups and patterns of movement which do not differ markedly from the primary mode of activity (ie – running vs cycling; pool running vs land running; stair climbing vs running; standing cycling vs running).

Specificity: refers to adaptations in the metabolic and physiologic systems in response to the type of overload imposed. That is, specific exercise elicits specific adaptations creating specific training effects.

Stroke Volume (ml): the amount of blood pumped by the left or right ventricle of the heart per beat.

Submaximal Exercise: exercise demanding less than the maximal oxygen consumption of the performer.

Ventilatory Threshold: represents a particular workload, whereby an increase in blood lactate concentration creates an additionally powerful ventilatory response.

VO2max: equates to the maximum amount of oxygen that an organism can be stimulated to extract from the atmosphere and then transport it to the tissue. It is quantitatively equivalent to the maximum amount of oxygen that can be consumed per unit of time by an individual during large muscle mass exercise of progressively increasing intensity that is continued until exhaustion. It is usually expressed as absolute volume per minute ($L \cdot min^{-1}$) for sports such as rowing, in which total work output is important, and as volume per minute relative to body weight ($ml \cdot kg^{-1} \cdot min^{-1}$), such as running, in which body mass is supported during the performance.

Work (J): the product of force times the distance through which that force moves a load.

Workload: the amount of work set for each subject to complete; or the amount of work achieved by each subject on completion of a test.

ABBREVIATIONS

Selected abbreviations used throughout the text

BLa: blood lactate

bpm: beats per minute

CK: creatine kinase

cm: centimetre

°C: temperature in degrees centigrade

HR: heart rate/heart rates

U/L: units per litre

ITACS: intermediate term anaerobic capacity session/s

kJ: kilojoules

kms: kilometres

$L \cdot min^{-1}$: litres per minute

$ml \cdot kg^{-1} \cdot min^{-1}$: millilitres per kilogram per minute

$mmol \cdot l^{-1}$: millimoles per litre

NA: not applicable

Nm: newton metres

Tvent: ventilatory threshold

$\dot{V}O_2$: oxygen uptake / consumption

$\dot{V}O_{2max}$: maximal oxygen uptake

vs: versus

W: watts