Effects of a task-specific warm-up on anaerobic power

J.A. Hawley, MA, M.M. Williams, MSc, G.C. Hamling, MNZSP and R.M. Walsh, MNZSP

School of Physiotherapy, Faculty of Health Studies, Auckland Technical Institute, New Zealand

Twenty-four untrained (UT) males (age 21 ± 2.5 yr, height 1.77 ± 0.05 m, weight 75.3 ± 10.1 kg, values mean $\pm$ SD) performed the Wingate Anaerobic Test (WT) under two conditions, cold (C) and following a warm-up (WU). Trials were separated by a minimum of 48 h. A modified Monark 818 cycle ergometer was interfaced with an Apple IIE microcomputer and peak power (PEAK), mean power (MEAN) and fatigue index (FI) determined. The WU trial consisted of an 8 min incremental continuous cycling bout (cadence $90 \text{ rev} \cdot \text{min}^{-1}$) with 5 min rest before the WT. During the C trial subjects completed only the WT. A repeated measures design was employed with order of trials counterbalanced.

ANOVA revealed no significant differences for PEAK or MEAN between WU or C conditions. However FI was significantly greater ($p < 0.05$) following the WU. A significant correlation ($r = 0.45$, $p = 0.03$) was obtained between WU intensity and FI.

These findings suggest that our UT subjects were fatiguing themselves during the WU. Future studies are needed to assess whether a task-specific WU in which FI is not impaired would lead to improvements in PEAK and MEAN. Investigators should be aware that a self-spaced WU may increase FI in the WT in UT subjects.

Keywords: Anaerobic power, warm-up, Wingate test

Introduction

Warm-up (WU) exercise prior to strenuous physical activity is a generally accepted practice among athletes. Indeed, most athletes incorporate some form of preliminary activity or WU procedure into their training routines, especially if they anticipate a strenuous workout¹. Although WU is a simple ergogenic aid, its efficacy is essentially unsubstantiated.

Improved performance resulting from WU exercise has been reported in a number of studies²⁻⁶. Other investigations however demonstrate no such effects⁷⁻⁹. To date, few experiments have dealt with the effects of WU on high intensity supramaximal exercise which leads to exhaustion in less than one minute.

In recent years, the Wingate Anaerobic Test (WT) has been employed by a growing number of laboratories for evaluating the capacity for short-term exhaustive work^{4,10-12}. To date, only one study has assessed the effects of WU on performance in the WT¹.

In that investigation, a 15 min intermittent (30 s on, 30 s off) treadmill WU improved mean power by seven per cent ($p < 0.005$) in a group of young untrained (UT) males ignorant of the concept of WU. The nature of the WU however was not task specific.

Other studies have examined the effects of WU on maximal performance tasks other than the WT^{3,13}. Genovely and Stamford compared the effects of no WU with prolonged WU (60 min) at 40 per cent and 68 per cent of VO_2max on bouts of maximal work on a cycle ergometer. Their lower intensity WU did not alter performance, while the higher intensity WU impaired performance relative to no WU. It is unclear however whether these findings can be generalized to WU of shorter duration. The purpose of this investigation was to assess the effect of a short duration task-specific incremental WU in UT subjects in the WT.

Methods

Subjects and experimental protocol

Twenty-four UT male students volunteered to participate in this investigation. Prior to their first visit to the laboratory, subjects were advised as to the nature of the experimental protocol but were not informed of the specific purpose of the study. The subjects were led to believe that the study concerned gathering normative data on the WT using two differing protocols. Subjects signed an informed consent form in accordance with the guidelines outlined by the American College of Sports Medicine¹⁴. The experimental protocol was approved by the department's ethics committee.

A mechanically-braked Monark 818 cycle ergometer (Watson Victor, Auckland, NZ) was calibrated as previously described¹⁵. It was modified with toe clips, straps, adjustable racing handlebars and racing saddle, and interfaced with an Apple IIE microcomputer. An Optron OPB 125A (TRW, Optron, Auckland, NZ) reflective object sensor was mounted parallel to the ergometer flywheel, and a series of 36 (10 degree intervals) reflective to non-reflective transitions marked on the flywheel. Sample periods of 0.5 s enabled calculation of average flywheel frequency which was subsequently scaled to pedal frequency.

The WT consists of a 30 s exhaustive cycling exercise bout against a resistance determined by the body-weight and training status of the individual. The validity and reliability of this test have been documented

Address for correspondence: John A. Hawley, School of Physiotherapy, Faculty of Health Studies, Auckland Technical Institute, Auckland, New Zealand

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Table 1. Power output during the warm-up

Time period (min)	Power (W)
0–5	79.9 (±46.3)
5–7	190.9 (±69.5)
7–8	296.3 (±82.7)

Values are mean±SD

previously^{16,17}. Three parameters are determined from the WT: the peak power (PEAK) elicited during the test, taken as the highest average power for any 5 s period; the mean power (MEAN) that is sustained throughout the 30 s, and the fatigue index (FI) or power drop-off during the test. Subjects reported to the laboratory a minimum of 3 h post-absorptive and received standardized written instructions as to the testing procedure.

All subjects performed under the two separate test conditions; cold (C) and following a WU. Saddle height and handlebar position were the same for both tests. Order of trials was counterbalanced. Testing was carried out between 1200–1600 h with a minimum of 48 h separating trials.

During the WU trial, subjects performed a continuous 8 min incremental exercise bout on a cycle ergometer (cadence 90 rev.min⁻¹). For the first 5 min subjects were asked to cycle at a workload they perceived as 'very, very light'. For the next 2 min they were asked to cycle at a workload they perceived to be 'moderate', and for the final minute at a workload they perceived as 'moderately heavy'.

Subjects were shown how to adjust the resistance settings on the ergometer and were free to alter the workload at will throughout the WU. Upon completion of the WU, subjects dismounted the ergometer and were seated for 4 min.

After this rest period, subjects remounted the ergometer and the feet were firmly strapped. Five minutes after the completion of the WU, subjects began pedalling at minimal resistance and gradually increased the cadence to 115–120 rev.min⁻¹.

When this cadence was attained, the full load (0.075 kp.kg⁻¹ bodyweight) was manually applied by an investigator and the computer activated. Subjects were instructed to remain seated and verbally encouraged to maintain maximal pedal rates throughout the test. The time taken to load the subjects was in the order of 1.0–1.5 s.

Although recent reports^{10,18} have shown the optimal force to be higher than originally recommended by the Wingate group, the issue of optimal force settings in the WT has not been fully resolved¹⁷. The choice of load setting in this investigation was based on a pilot study of UT subjects. Further, a similar load has been used in other laboratories^{19–21} and permits comparisons with available literature.

During the C trial subjects were given no WU but were required to perform the WT as previously described.

Upon completion of their second trial, all subjects completed a post-study questionnaire to ascertain their perception of the purpose of the study.

Statistical analysis

Data was analysed by a repeated measures analysis of variance (ANOVA) and Pearson Product moment correlations, using the statistical software programme SYSTAT (SYSTAT Inc., Evanston, IL). Results were considered significant where $p < 0.05$.

Results

The mean (±SD) age (yr), height (m) and weight (kg) of our subjects was 21.0 (±2.5), 1.77 (±0.05), 75.3 (±10.1). Table 1 displays the mean power outputs attained during the WU prior to the WT. The mean power output during the entire eight minutes was 134.7 W (±59.6) and 226.0 W over the last three minutes.

Table 2 displays the performance data for the WT under the two trial conditions. No significant differences were found for PEAK or MEAN between the WU and C trials. However, FI was significantly greater ($p < 0.05$) following the WU trial.

Results from the post-study questionnaire revealed that no subject perceived the purpose of the study to be concerned with assessing the effects of a WU on performance.

Discussion

PEAK and MEAN power outputs obtained during the WT in this study are in the order of those previously reported for UT individuals^{17,21}. There were no significant differences in either of these variables under the two trial conditions as shown in Table 2. The FI however, was significantly greater ($p < 0.05$) following the WU.

Table 2. Performance data for the Wingate Anaerobic Test

Trial	Peak power		Mean power		Fatigue index (%)
	(W)	(W.kg ⁻¹)	(W)	(W.kg ⁻¹)	
Cold	855.4 (±81.2)	11.5 (±1.2)	655.5 (±66.4)	8.8 (±0.9)	41.9 (±6.8)
Warm	867.1 (±112.2)	11.6 (±1.4)	654.5 (±90.8)	8.7 (±1.2)	44.1* (±7.8)

Values are mean±SD

*Indicates significantly greater than C trial ($p < 0.05$)

Fatigue Index = ((PEAK – $\bar{X}$ FINAL 5 s)/PEAK)×100

These results demonstrate that our task-specific incremental WU did not improve performance in the WT in our UT individuals. This finding contrasts with a previous investigation⁴ which reported a highly significant ($p < 0.005$) improvement in MEAN in the WT in young males who undertook a 15 minute intermittent treadmill WU at approximately 60 per cent of $\dot{V}O_{2\max}$.

The disparity between the results of the current investigation and that of Inbar and Bar-Or⁴ can probably be explained by the different nature of the two WU protocols. The WU used in this present study was a continuous incremental task which, in our UT subjects, probably had a fatiguing effect which subsequently impaired performance in the WT. This is supported by the finding that the FI was significantly higher ($p < 0.05$) in subjects following a WU.

Post-hoc analyses revealed two other findings in this regard. First, the intensity with which subjects undertook their WU was not significantly related to their performance in the WT. Pearson correlation coefficients between mean power during the WU and PEAK and MEAN during the WT were -0.01 and -0.27 respectively. This indicates that the intensity with which subjects were undertaking the WU was unrelated to their individual physical capacity and subsequent performance in the WT. Second, there was a significant correlation ($r = 0.45$, $p = 0.028$) between the mean WU intensity and the subsequent FI during the WT. This suggests that MEAN was impaired for some subjects due to an excessively vigorous WU.

Although oxygen uptake was not directly assessed during our WU, if we assume the normal active 25 year old male has a $\dot{V}O_{2\max}$ of around $40 \text{ ml} \cdot \text{kg}^{-1} \cdot \text{min}^{-1}$ ²² estimations of $\dot{V}O_2$ from a predictive equation²³ would indicate that our UT subjects were performing at approximately 88 per cent of $\dot{V}O_{2\max}$ during the penultimate two minutes of the WU, and in excess of their aerobic power during the final minute of the WU.

Results of a recent investigation²⁴ suggest that lack of glycogen may be an important factor in the development of fatigue during exercise at intensities higher than ~ 90 per cent of $\dot{V}O_{2\max}$. Further, while glycogen is broken down mostly in type I fibres during exercise of low intensity (43 per cent of $\dot{V}O_{2\max}$), high intensity exercise (91 per cent $\dot{V}O_{2\max}$) results in glycogen breakdown in all fibre types²⁴. It has also been established that type I, IIA and IIB fibres are activated during the first four to seven minutes of exercise at intensities greater than 84 per cent of $\dot{V}O_{2\max}$ ^{25,26}. These findings suggest that in our UT subjects, glycogen depletion would have occurred during the WU, which may have resulted in the subsequent performance reduction in the WT.

While our study was unable to demonstrate any difference in performance indices of the WT following a WU, further investigations are needed in this area. Our UT subjects were unable to pace themselves effectively on our continuous incremental WU protocol. Future studies are needed to identify more appropriate self-pacing instructions such that subjects will not excessively fatigue themselves during a WU.

Alternatively, if a self-pacing protocol is not employed, the intensity and duration of the WU must be individualized to the particular fitness level of the subject and the anticipated physical task. Invest-

igators should be aware that UT subjects may impair performance in the WT if a WU is too intense.

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