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Original article

Effect of yelling on maximal aerobic power during an incremental test of cycling performance

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Abstract

Background: People experiencing strong feelings of fatigue during exercise sometimes subconsciously yell to refocus their efforts and, thus, maintain exercise performance. The present study examined the influence of yelling during high-intensity exercise by analysing cardiorespiratory reactions and integrated electromyography (iEMG) changes in the vastus lateralis during a cycle ergometer test.

Methods: A total of 23 moderately trained people were recruited. The cycling test began with a resistance of 25 W/min, which was gradually increased. During the experimental trial, the participants were required to yell at least 3 times when they felt exhausted; during the controlled trial, they were not allowed to produce any yelling sounds. The testing order was randomly assigned and the 2 trials were completed within an interval between 3–10 days. Two-way repeated measures ANOVA was applied to analyse the differences within and between the trials, and interaction of trial and time.

Results: The peak power and time to exhaustion ($p < 0.01$) in the yelling trial were higher than those in the control trial. However, the vastus lateralis iEMG values of both trials at peak power were not significantly different. During the yelling period at 90%–100% of the maximal effort, a significant time-by-trial interaction ($p < 0.05$) was observed in oxygen consumption (VO_2), CO_2 production, O_2 pulse, ventilation, and respiratory rate. All the above measures showed a significant between-trial difference ($p < 0.02$). However, heart rate, respiratory exchange ratio, end-tidal oxygen pressure, and ventilatory equivalent for oxygen showed only significant between-trial difference ($p < 0.05$), but without interaction of trial and time.

Conclusion: Yelling enhances the peak O_2 pulse and VO_2 and maintains CO_2-exclusion efficiency during high-intensity exercise. It may enable maintaining muscle activation without stronger EMG signals being required during high-intensity exercise.

Keywords: Aerobic exercise; Cardiopulmonary exercise test; Intense exercise; Performance-enhancing effect; Respiratory–cardiac activities; Shouting

1. Introduction

When experiencing substantial exercise fatigue, some athletes attempt to maintain a strong athletic performance by yelling. For example, a track-and-field runner might yell during a final sprint. However, the physiologic mechanism of the effect of yelling on sports performance remains unclear. The early study of Ikai and Steinhaus[1] demonstrated that simple shouts during exertion can increase the parameter that was previously believed to be maximal strength. However, that study focused primarily on investigating the effect of yelling on the performance of anaerobic exercises (e.g., weight lifting); hence, whether similar effects occur during extreme aerobic exercise remains unclear. Bunn and Mead[2] suggested that phonation can be regarded as a subsidiary of respiration. During vocalisation, the tidal volume (V_T) and expiratory time are increased, whereas inspiratory time is reduced. During high-effort whispers, the end-expiratory thoracic volume is substantially reduced because the volume of all compartments decreases, impinging on the maximal expiratory flow–volume curve.[3] Aliverti et al.[4] showed that, during exercise, the expired volume is entirely attributable to the abdomen, whereas during phonation, all 3 chest-wall compartments contribute to the expired

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volume. Therefore, we speculated that, during high-intensity exercise involving vigorous ventilation, forceful yelling may exert a considerable effect on thoracic and abdominal pressure as well as cause capacity changes that affect ventilation effectiveness during extreme exercise. Dempsey et al.[5] proposed that the control of the respiratory system contributes to exercise limitation, and that its primary effect originates from complex respiratory–cardiac interactive effects. Their study showed that respiratory muscle work and fatigue, cyclical fluctuations in intrathoracic pressure, and cardiac output are crucial determinants of performance. Effective respiratory control facilitates the promotion of the cardiac output required to meet the demands of limb activities during exercise, affects the progress of peripheral muscular fatigue, and affects the sense of central fatigue through the perception of effort. However, previous studies have investigated only the interaction between respiration and vocalisation at rest and respiratory muscle actions during exercise. The immediate effect of yelling (a loud vocalisation) during exercise has not been reported.

The purpose of the present study was to quantify participants' exercise performance by using an incremental maximal cycling test. We investigated the effects of yelling on lower-extremity muscle power and electromyography (EMG) signals when the participants experienced extreme feelings of exhaustion. In addition, we extensively investigated the effects of abdominal yelling on cardiorespiratory system changes and attempted to clarify how the physiologic mechanisms of yelling affect the performance of extreme aerobic exercises.

2. Methods

2.1. Participants

A total of 23 moderately trained people (19 men and 4 women) participated in this study. Their mean age, height, weight, and body mass index (BMI) were 20.3 ± 1.5 years, 170.3 ± 7.1 cm, 64.4 ± 7.4 kg, and 22.2 ± 2.0 kg/m^2, respectively. All participants were routinely involved (5.8 ± 2.2 h/week) in various intermittent activities (e.g., volleyball, tennis, basketball, and soccer), were familiar with maximal training, and had no history or clinical signs of cardiopulmonary diseases or orthopaedic from each participant injury in the lower extremities. Written consent was obtained and the Ethics Committee of I-Shou University granted ethical approval.

2.2. Design

The participants were not allowed to eat or drink coffee for 4 h before the exercise tests, and vigorous exercise and alcohol were forbidden for 24 h before the day of testing. Each participant visited our laboratory twice to participate in the incremental cycling test. The control and experimental trials (with yelling) were performed in random order. Each exercise test was conducted in an air-conditioned laboratory with an atmospheric temperature of 20°C–24°C and a relative humidity of 50%–60%. Each participant completed the experimental protocol within a period of 10 days, with at least 3 days between each exercise test, to ensure that the participants' level of physical fitness had not changed.

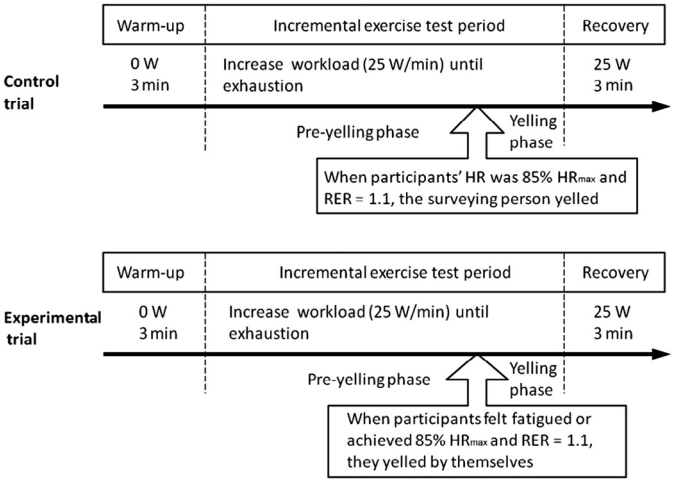

Fig. 1. Diagram of the experimental design and the point during the exercise test at which the yelling occurred. HR = heart rate; RER = respiratory exchange ratio; W = watt.

The participants produced a yell by forcefully contracting the abdominal muscles and emitting a short and loud tone (participants were asked to yell "Er") while exerting maximal effort in the final stage of the exercise test. The following criteria were used to determine the time point during each test at which the yelling occurred, with at least one of the criteria required to initiate the yelling: (1) the participant started to feel fatigued; (2) the participant reached a respiratory exchange ratio (RER) of 1.1 and achieved 85% of the age-predicted maximal heart rate (HR) (220 − age) (Fig. 1). Three to 5 yells at intervals of 1–3 s were required, and the participant was asked to sustain each yell 1–2 s. EMG was applied to the rectus abdominals to ensure that the yells were not only vocalised from the throat. By contrast, the participants in the control trial were encouraged by simulated yelling sounds (about 100 decibels emitted by the surveying person) in the final stage, but not allowed to produce any yelling sounds by themselves (Fig. 1). All participants were asked to practice the yelling maneuver before the first exercise test to ensure they can properly use abdominal muscles to issue the yelling volume up to 100 decibels. The yelling volume was measured by using a decibel meter (DSL-333; TECPEL, Taipei, Taiwan, China). However, we could not measure the actual decibel value of each yell emitted by the participants during the exercise test, because the detector of the decibel meter could not be inserted into the inside of the face mask.

2.3. Methodology

The participants performed incremental maximal exercise tests on a bicycle ergometer (ANGIO with a reclining chair, Lode, Groningen, The Netherlands). The exercise began after a 3 min warm-up period at 0 W, after which the workload was increased by 25 W/min (ramp protocol) until the participant felt exhausted.[6] The workload of the ergometer was subsequently returned to 25 W, and the participant continued to cycle for a 3 min recovery period. The pedalling rate was maintained at approximately 60 rpm for each participant to prevent the participants from varying the rate and, thus, potentially influencing