

Abstract

PURPOSE: We report testing results of wearing a positive end-expiratory pressure (PEEP) valve mouthpiece during exercise on VO_{2max} and cycling time to exhaustion. **METHODS:** 4 women & 5 men (Age 31±2 yrs, Ht 172.2±3.8 cm, WT 72.1±3.7 kg) were assigned at random on two separate occasions (time of day controlled, at least 48 hr between each test) to wear our PEEP mouthpiece or a Battle Oxygen Mouthguard® during cycle ergometer (Corival®) testing to maximal voluntary exhaustion (3 min unloaded warmup, then 150W for 2 min x 30W/2 min stages thereafter until exhaustion); VO₂ was measured continuously (MGC Ultima®), and heart rate (HR, bpm) and blood pressure (BP, mmHg) were recorded at the end of each stage. There followed approximately one week later a timed endurance ride to exhaustion with the assigned mouthpiece at a power (W) equivalent to each subject's ventilatory threshold (VT) measured during the VO₂ test. **RESULTS:** Table (all p<0.05, paired t-test). Notably, time to exhaustion at VT was 13% greater with PEEP, but this did not reach statistical significance. Ratings of perceived exertion recorded during exercise did not differ between mouthpiece conditions. **CONCLUSION:** The wearable PEEP-valve mouthpiece significantly improves cycling maximal aerobic capacity, reduces peak exercise systolic blood pressure, and may improve cycling performance. The PEEP mouthpiece technology appears to confer a benefit to cyclists performing high intensity exercise.

Variable ▶	VO _{2max} (ml·kg ⁻¹ ·min ⁻¹)	Time to Fatigue (sec)	Max SBP (mmHg)
Condition ▼			
Control	42.44 ± 2.33	495.3 ± 72.8	193 ± 6
PEEP	45.18 ± 2.41	521.8 ± 73.4	186 ± 5
Change from Control	+6.7%	+5.8%	-3.6%

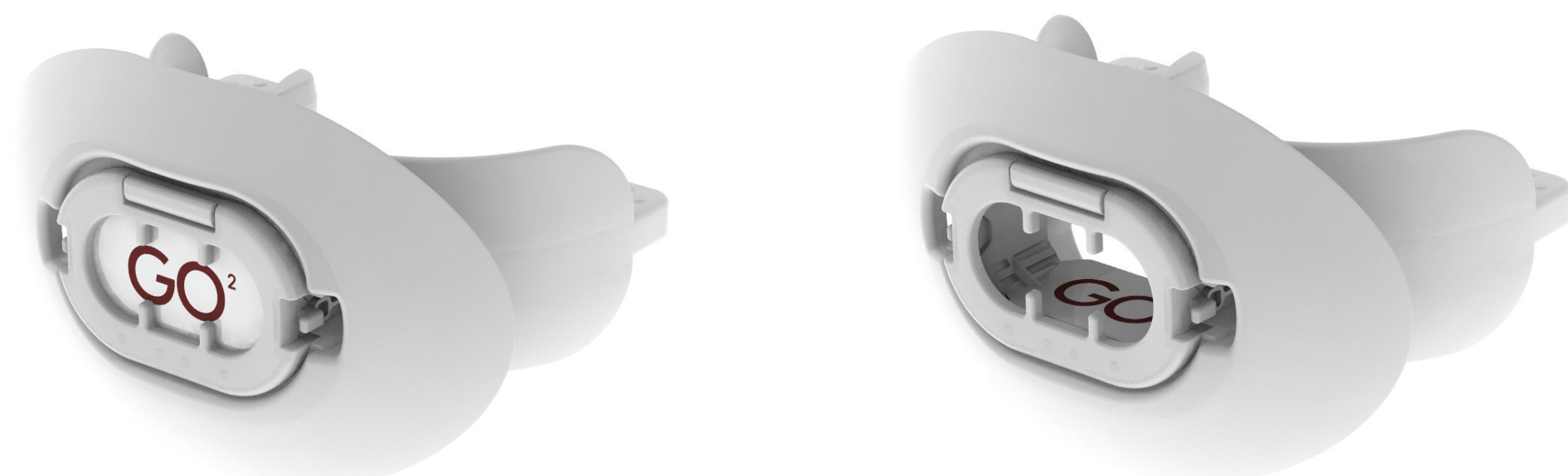
Background

- Positive-end expiratory pressure (PEEP) is a well-known pulmonary physiologic principle. There are on average 600 million alveoli in the lung. Each alveolus has surfactant to resist the natural propensity for these small air sacs to collapse during exhalation when the lungs are compressed. Despite this surfactant, some alveoli will collapse and not be available to exchange air. This is called atelectasis. This atelectasis results in a ventilation/perfusion mismatch where alveolar units are perfused but not adequately ventilated. This is often referred to as shunting, i.e., blood flowing through the pulmonary circuit, returning to the heart without gas exchange.
- PEEP decreases the propensity for the alveoli to collapse by increasing the air pressure in the lungs. This residual pressure in the lungs at the end of exhalation decreases shunting and allows for more complete gas exchange. In patients, PEEP is one of the safest ways to increase the PaO₂ and is used on almost all modern ventilator settings.
- We have designed a comfortable, lightweight, wearable valve mouthpiece, named a GO², that effectively delivers PEEP with every breath. (Fig 1)

Purpose

- To test the potential performance benefits during maximal exertion cycling exercise of wearing a PEEP valve mouthpiece (GO²) compared with a Battle® Oxygen Convertible Strap Football Mouthguard (Control) on VO_{2max} and cycling time to exhaustion.

Fig 1 – GO² (PEEP) Mouthpiece Prototype



1a – PEEP Mouthpiece valve closed during expiration.

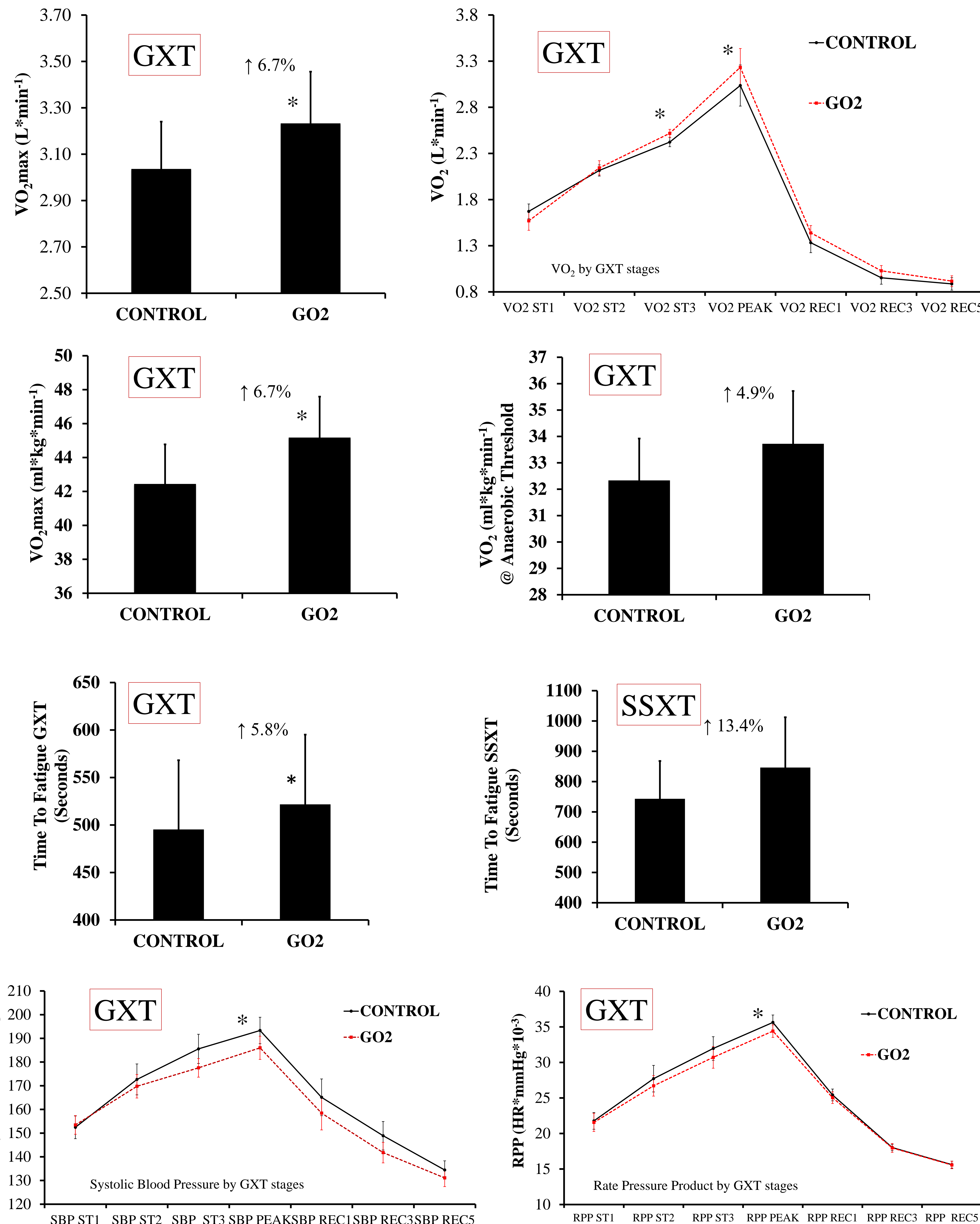
1b – PEEP Mouthpiece valve open during inhalation.

Wearable Positive End-Expiratory Pressure Valve Increases Aerobic Capacity and Performance

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Results



Data are presented as means ± SEM, * = p < 0.05

Methods

- This investigation was conducted by an independently contracted laboratory. (Orthopedic Biomechanics Research Laboratory, Department of Orthopedics & Sports Medicine, Houston Methodist Hospital, Houston TX). All Ss read and signed an IRB approved informed consent prior to participation.
- 5 ♂ & 4 ♀ (Age 31±2 yrs, Ht 172.2±3.8 cm, WT 72.1±3.7 kg), healthy, active (4 x wk exercise) recruited.
- Testing randomized to either GO² (PEEP) or Control (Battle Mouthguard®)
 - Two cycle ergometer (Lode®) VO_{2max} (MGC Ultima®) graded exercise tests (GXT) performed ≥ 1 wk apart (Fig 2).
 - Protocol: 3 min warmup @ 100 W, then 150 W with 30W ↑ every 2-min until voluntary exhaustion.
 - Blood pressure and ratings of perceived exertion (Borg scale) every 2 min.
 - HR monitored continuously, recorded every stage & max.
 - ≥ 72 hr after VO_{2max}, steady-state exercise tests (SSXT) to exhaustion at ventilatory threshold assessed from VO_{2max} test.
 - 5-min post-exercise recovery at 0-watts at self-selected cadence. Gas exchange and heartrates monitored and recorded 1, 3, & 5 min of recovery
- Statistics: simple statistics and two-tailed paired sample t-tests to compare gas exchange, heartrate, and hemodynamic variables of interest during exercise and recovery. α = 0.05



Fig 2 – GO² (PEEP) Cycle Ergometer Testing

Conclusions

- The GO² mouthpiece is an effective and safe means to improve exercise performance in high-intensity and maximal effort cycling exercise, while simultaneously reducing systolic blood pressure and the work of the heart (↓ RPP).
- It is highly likely that physical exercise and training of any kind having an aerobic component for performance or recovery would benefit from the use of the GO² mouthpiece.