ONLINE SUPPLEMENT

The influence of exercise modality on dyspnoea perception during cardiopulmonary exercise testing in obese patients with COPD

Casey E. Ciavaglia, Jordan A. Guenette, Josuel Ora, Katherine A. Webb,
J. Alberto Neder, Denis E. O'Donnell

METHODS

Pulmonary function testing included routine spirometry, body plethysmography, single-breath diffusing capacity (D_LCO) and maximum voluntary ventilation (MVV) using automated testing equipment (Vs62j body plethysmograph with Vmax229d; SensorMedics, Yorba Linda, CA) and was performed according to recommended techniques [1-3]. Cardiopulmonary exercise tests were performed according to recommended guidelines [4] on an electronically-braked cycle ergometer (Ergometrics 800S; SensorMedics, Yorba Linda, CA) and a treadmill (Medtrack ST55; Quinton Instrument, Bothell, WA) using a SensorMedics Vmax229d Cardiopulmonary Exercise Testing System.

Linearized incremental treadmill protocol

The rate of work (watts) done against gravity while walking up an incline depends on the subject's absolute body weight, the walking speed and the grade [5]. Norman Jones [5] identified the following formula to quantify work done on the treadmill:

$$WR(t) = m * g * v(t) * AI/100$$

where *WR* is the time course of work (watts) performed, *m* is the absolute body mass in kilograms, *g* is the acceleration due to gravity (9.81 m/s^2), *v(t)* is the time course of velocity in meters/sec, and AI is the angle of inclination (or grade). Similarly, Cooper and Storer [6]

estimate work performed on a treadmill as follows: watts = 0.1634 * speed (m/min) * (% grade/100) * body mass (kg). This equation can then be rearranged to solve for % grade.

In this study, the external work performed during treadmill and cycle testing protocols was matched to allow accurate comparison of dyspnea and physiological measurements at standardized work rates (and times): a linearized protocol with 10 watt increments increasing every 2 minutes in a stepwise fashion was used. Treadmill belt speed was selected to meet the subject's functional abilities, limit biomechanical inefficiencies (with high treadmill belt speeds) [7] and create a linear rise over time. Similar to previous studies [8.9], treadmill belt speed was initiated at 0.8 miles per hour (mph) (0.36 m/s) during the first work rate (10 watts) and the subsequent linear rise in speed was kept constant for each subject (Figure 1). The belt speed increased progressively to 1.4 mph (0.63 m/s) at 40 watts and 2.2 mph (0.98 m/s) at 80 watts. Body weight varied between subjects; therefore, the inter-subject curvilinear rise in percent grade was different for each subject.

The following table is a sample calculation of a representative male subject weighing 102 kg.

Weight: 102 kg				
Time, minutes	**Work rate, watts**	**Speed*Grade** = Work rate/(weight*0.043827801), **mph*%**	**Speed, mph**	**Grade** = Speed*grade/Speed, **%**
1	10	2.236918397	0.8	2.8
2	10	2.236918397	0.8	2.8
3	20	4.473836793	1	4.5
4	20	4.473836793	1	4.5
5	30	6.71075519	1.2	5.6
6	30	6.71075519	1.2	5.6
7	40	8.947673587	1.4	6.4
8	40	8.947673587	1.4	6.4
9	50	11.18459198	1.6	7.0
10	50	11.18459198	1.6	7.0
11	60	13.42151038	1.8	7.5
12	60	13.42151038	1.8	7.5

13	70	15.65842878	2	7.8
14	70	15.65842878	2	7.8
15	80	17.89534717	2.2	8.1
16	80	17.89534717	2.2	8.1

Conversion factor: 0.1634 * 26.8224 (26.8224 m/min = 1 mph) = 0.043827801

RESULTS

Subjects

Subjects reported the following comorbidities: hypertension (n=5), diabetes mellitus (n=5), hypercholesterolemia (n=3), obstructive sleep apnea (n=3), arthritis (n=3), anxiety (n=4) and depression (n=2). Three subjects reported past myocardial infarction, although five had reported coronary intervention (coronary bypass graft: n=3; stents: n=2). The degree of obesity ranged from mild to severe (BMI 30-51 kg/m^2) [10]: there were eight class I (30-34.9 kg/m^2), seven class II (35-39.9 kg/m^2) and three class III (>40 kg/m^2) obese subjects.

Responses to cycle and treadmill exercise

Selected exercise responses are shown relative to oxygen consumption ($V'O_2$) during treadmill and cycle testing (Figure 2).

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FIGURE LEGENDS

Figure 1. **(a)** Schematic diagram of the stepwise incremental treadmill protocol. **(b)** A linear rise in treadmill speed (open diamonds) and a curvilinear rise in grade (open squares) was individualized for each subject to match the protocol used during cycle testing, i.e., 2-min increments of 10 watts. **(c)** Each subject achieved a matched rise in work rate during cycle (closed circles) and treadmill (open squares) exercise.

Figure 2. Selected exercise responses are shown relative to $V'O_2$ during treadmill (open squares) compared to cycle testing (closed circles). There was no difference between test modalities for: **(a)** heart rate, **(b)** arterial oxygen saturation measured by pulse oximetry (SpO_2), **(c)** ventilatory equivalent for carbon dioxide ($V'_E/V'CO_2$) **(d)** partial pressure of end-tidal CO_2 ($P_{ET}CO_2$), but significant differences (*$p<0.01$) in cycle versus treadmill at a standardized $V'O_2$ of 1 L/min for: **(e)** carbon dioxide output ($V'CO_2$) and **(f)** respiratory exchange ratio (RER). Data are shown as means ± SEM.