Ventilatory Responses during Submaximal Exercise in Children with Prader-Willi Syndrome

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ABSTRACT

Introduction: Prader-Willi Syndrome (PWS) is a genetic neurobehavioral disorder that can result in morbid obesity. Hypoventilation under hypercapnic and hypoxic conditions at rest and during sleep has been well documented in children with PWS but not during exercise. This study examined ventilatory responses in children with PWS during submaximal exercise. Methods: Participants included eight children with PWS (age = 11.1 y ± 0.8; height [H] = 147.8 cm ± 8.2; body mass [BM] = 44.7 kg ± 11.7; total body fat % [BF%] = 37.2 ± 11.4). Seven participants with PWS were on growth hormone replacement therapy. The controls were ten obese (OB) children (Age= 10.6 y ± 1.1; H= 151.1 cm ± 9.6; BM= 62.1 kg ± 14.6; BF%= 44.5 ± 3.7) and nine lean (L) children (Age= 9.8 y ± 2.0; H= 142.9 cm ± 20.5; BM= 35.4 kg ± 11.3; BF%= 22.2 ± 8.6). Participants completed three 5 min bouts on a treadmill at 2.0, 2.5 and 3.0 mph in a randomized order with a 6 min seated rest period in between. Expiratory gases for the last 2 min at each speed were analyzed for VE, VCO_2, VO_2, and respiratory rate (RR); heart rate (HR) was measured via telemetry. Statistical differences at p<0.05. Results: PWS had a greater HR and RR compared to OB and L in all trials. PWS had greater METs than OB at 2.0 and 3.0 mph but similar to lean. PWS had greater VE than L at 2.5 and 3.0 mph and same as OB for all trials. PWS had greater VCO_2 than L at 3.0 mph only; no significant differences were found for ventilation per carbon dioxide ratio (VE/ VCO_2). Conclusion: the exercise placed a greater metabolic cost in PWS and L than OB. The greater HR and ventilatory responses in PWS suggest a greater excitatory stimulus to the control centers. The increase in VE with increased workload and VCO_2 suggest normal responses during submaximal exercise. GHRT might have played a role in these responses but our study was not powered to test this.

INTRODUCTION

- Prader-Willi Syndrome (PWS) is a genetic neurobehavioral disorder that can result in morbid obesity[1,2]
- Hypoventilation under hypercapnic and hypoxic conditions at rest and during sleep has been well documented in children with PWS but not during exercise[3,4,5]
- The normal response to hypercapnic or hypoxic conditions is to hyperventilate

PURPOSE

- To measure ventilatory responses of children with Prader-Willi Syndrome during submaximal exercise

METHODS

- Participants were eight children with PWS, seven on GHRT
- The controls were ten obese (OB) children and nine lean (L) children
- DEXA was used to measure percentage of total body fat (TBF) and lean body mass (LBM)
- Participants completed three 5 min bouts on a treadmill at 2.0, 2.5, and 3.0 mph in a randomized order with a 6 min seated rest period in between
- Expiratory gases for the last 2 min at each speed were analyzed for minute ventilation (VE), volume of expired carbon dioxide (VCO_2), oxygen uptake (VO_2), and respiratory rate (RR); heart rate (HR) was measured via telemetry
- Statistical differences at p<0.05.

Table 1: Participant characteristics presented as mean ± SD

	PWS (n=8)	Obese (n=10)	Lean (n=9)
Male/Female	3/5	5/5	3/6
Age (y)	11.1±0.8	10.6±1.1	9.8±2.0
Height (cm)	147.8±3.2	151.1±3.8	142.9±8.1
Body Mass (kg)	**†44.7±11.7**	**Ŧ 62.1±14.6**	35.4±1.3
Body Mass Index (kg/m^2)	**†21.1±6.2**	**Ŧ 26.8±3.6**	17.2±1.1
BMI (%tile)	***†56.5±43.3***	**Ŧ 96.9±1.5**	51.1±15.4
TBF (%)	**Ŧ37.5±11.4**	**Ŧ 44.5±3.7**	22.2±8.6
LBM (kg)	26.4±4.3	33.3±5.1	25.5±11.6

† Different than OB; Ŧ different than L; Italics = trend towards statistical significance

RESULTS

Table 2: Heart rate and oxygen uptake responses to walking at three different speeds (mean ± SD)

	Speed 2 mph			Speed 2.5 mph			Speed 3 mph		
	PWS	OB	L	PWS	OB	L	PWS	OB	L
HR (beats/min)	**‡ 126 ±13**	***111 ±8**	112 ±11	**‡ 129 ±15**	***114 ±9**	115 ±12	**‡144 ±16**	***120 ±6**	120 ±16
VO_2 (ml/kg/min)	**15.2 ±3.8**	***11.4 ±2.6**	**†15.4 ±1.3**	16.2 ±3.1	13.2 ±2.6	**†16.7 ±2.8**	19.3 ±4.0	***14.7 ±3.2**	**†19.0 ±3.6**
METS	**4.4 ±1.1**	***3.3 ±0.7**	**†4.4 ±0.4**	4.6 ±0.9	3.8 ±0.7	**†4.8 ±0.8**	**5.5 ±1.1**	***4.2 ±0.9**	**†5.4 ±1.0**

* Different than PWS; † different than OB; ‡ different than L; Italics = trend towards statistical significance

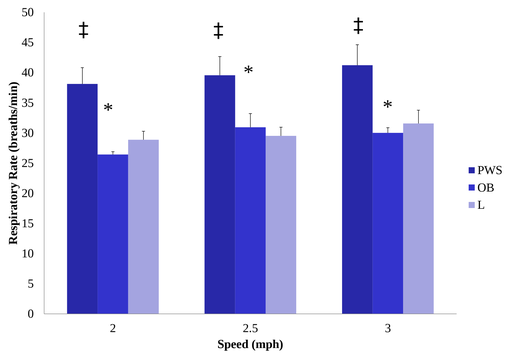

Fig. 1: Respiratory rate responses during walking in PWS, OB, and L (mean ± SE)

* Different than PWS; ‡ different than L

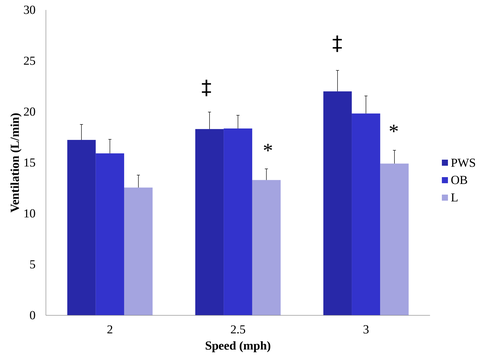

Fig. 2: Ventilatory responses during walking in PWS, OB, and L (mean ± SE)

* Different than PWS; ‡ different than L

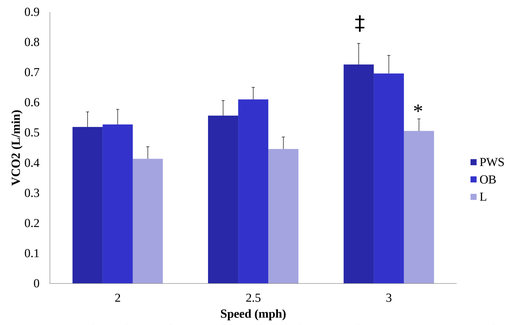

Fig. 3. Expired carbon dioxide (VCO_2) responses during walking in PWS, OB, and L (mean ± SE)

* Different than PWS; ‡ different than L

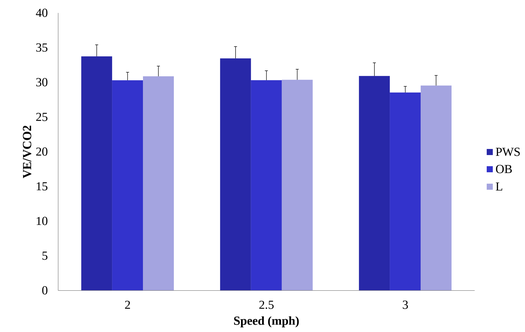

Fig. 4. Ventilation per carbon dioxide ratio (VE/VCO_2) responses during walking in PWS, OB, and L (mean ± SE)

No significant differences were found for VE/ VCO_2

CONCLUSIONS

- The exercise placed a greater metabolic cost in PWS and L than OB
- The increase in RR could be due to overcompensation for weak respiratory muscles and possibly inefficient gross motor control
- The greater HR and RR responses in PWS suggest a greater excitatory stimulus to the control centers in the medulla oblongata
- The increase in VE with increased workload and VCO_2 suggest no impairment in ventilatory control during submaximal exercise which contrasts with the sleep and rest studies done on children with PWS[3,4,5]
- The comparable VE/VCO_2 in PWS to controls suggests good ventilatory efficiency despite the high RR.
- GHRT might have played a role in these responses but our study was not designed to test this

References

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