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Short Communication

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Examination of the Estimated Resting Metabolic Equivalent (MET) in Overweight and Obesity

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ABSTRACT

Background: Energy expenditure is commonly expressed in multiples of the resting metabolic equivalent task (MET), with 1 MET estimated to be equivalent to 3.5 ml/kg/min or 0.250 L/min of oxygen consumption. This investigation examined whether the estimated resting oxygen consumption used to express a MET was significantly different than measured resting oxygen consumption in overweight, obese class I, and obese class II subjects.
Methods: Forty-five (age: 37.5±10.5, BMI: 32.4±3.5) overweight (N=11), Class I (N=21), or Class II (N=13) obese subjects participated in this study. Resting energy expenditure (REE) was assessed on two separate days. Following a 30-minute supine resting period in a semi-darkened room, REE was assessed using the dilution technique. Data were expressed as relative (ml/kg/min) and absolute (L/min) oxygen consumption.
Results: Relative oxygen consumption (3.0±0.6 ml/kg/min, $p<0.001$) was significantly lower than the reference value for 1 MET (3.5 ml/kg/min), with no difference across BMI categories, but a difference by gender ($p=0.002$). The reference-MET value over-estimated oxygen consumption for females and under-estimated oxygen consumption for males. There was no difference in the measured absolute resting oxygen consumption compared to the reference of 0.250 L/min; however, there were independent gender ($p<0.001$) and BMI ($p<0.001$) main effects.
Conclusions: These differences between the measured and estimated oxygen consumption representing 1 MET in overweight and obese adults may have implications with regards to energy expenditure and its assumed impact on body weight regulation. Continued efforts are needed to understand factors that influence metabolism and the variability observed between individuals in energy expenditure.

KEYWORDS: Metabolic equivalent task; Energy expenditure; Obesity; Overweight.

INTRODUCTION

The metabolic equivalent task (MET) is a measure of resting oxygen consumption that has the benefit of providing a common descriptor of workload or metabolic intensity.[1] The MET is considered to be a universal measure of expressing energy expenditure as a multiple of the resting or reference level in relation to body weight.[2] Based on work conducted in 1941 that involved heat exchange in a neutral environment under resting conditions, Gagge at el[3] are credited with coining the MET terminology, which most closely mirrors the current use of the MET with regard to energy expenditure.

The resting MET is commonly defined as 3.5 ml/kg/min or 0.250 L/min of oxygen consumption.[4,5] The origins of 3.5 ml/kg/min to represent a resting MET value of 3.5 ml/kg/min has been agreed to have resulted from the resting VO_2 data obtained from one 40 year old male subject weighing 70 kg.[6,7] Multiples of a resting MET are commonly used to estimate the energy expenditure and work performed during various activity tasks. Therefore, it is important that the estimate of the resting MET be accurate to minimize the likelihood of under- or over-estimation of energy expenditure. Moreover, given the importance of energy expenditure

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to the treatment of obesity, an understanding of whether the current estimates of a resting MET are accurate in individuals who are overweight or obese may be of clinical and scientific importance.

Therefore, the purpose of this investigation is to examine whether the measured resting oxygen consumption, which is used to define a resting MET, in individuals who are overweight or obese is consistent with the widely used estimation of a resting MET (3.5 ml/kg/min or 0.250 L/min of oxygen consumption). Moreover, this study examined whether this varied by gender (male or female) or by grade of overweight or obesity.

METHODS

Data were obtained from 45 overweight or obese, sedentary, but otherwise healthy adults (age: 37.2±10.5 years; body mass index [BMI]: 32.4± 3.5 kg/m^2). Subjects included 34 females and 11 males, with 11 overweight (25.0 to <30.0 kg/m^2), 21 with Class I obesity (30.0 to <35.0 kg/m^2), and 13 with Class II obesity (35.0 to <40.0 kg/m^2). Descriptive data are presented in Table 1.

Height was measured to the nearest 0.5 inch *via* a wall-mounted stadiometer and weight was measured to the nearest 0.5 pound on a calibrated scale with subjects wearing a cloth medical gown or light-weight clothing. BMI was calculated by dividing weight in kilograms (kg) by height in meters squared (m^2).

Resting oxygen consumption (VO_{2rest}) was measured with a metabolic cart using the dilution technique. Measurements were obtained between 7:30 AM and 10:30 AM. Pre-test instructions included: fasting for at least 12 hours the night before testing, avoiding consumption of any over-the-counter medications, abstaining from all vigorous physical activity the day before testing, and vehicle transportation to the research center the morning of testing. Study participants were questioned to confirm adherence to these pre-testing instructions upon arrival at the research center. Subjects were placed in a supine position in a semi-darkened room for a period of 30 minutes prior to data collection. Data collection occurred for at least 15 minutes with 5 consecutive minutes representing a steady state condition, defined as the range of energy expenditure across this 5 minutes differing by <150 kcal/d.[8] This is consistent with a technique that defined steady state of resting energy expenditure at a coefficient of variation of no more than 5% for both oxygen consumption and carbon dioxide production.[9] The initial 5 minutes were discarded to allow for the subject to acclimate to the dilution canopy, with the average of a subsequent five consecutive data points meeting the <150 kcal/d difference criteria used to represent VO_{2rest}.

Statistical analyses were conducted using IBM SPSS Statistics (release version 21.0.0.0). One-sample t-tests were used to compare relative and absolute measured VO_{2rest} to the reference-MET (relative=3.5ml/kg/min, absolute=0.250 L/min) value in all subjects. A multivariate analysis of variance was used to examine the difference measured *versus* estimated VO_{2rest} between genders (males *versus* females) and BMI categories (overweight, Class I obesity, Class II obesity). Main effects were further examined using post-hoc analysis with Bonferroni adjustment.

RESULTS

Measured relative VO_{2rest} was significantly less than the reference-MET value (3.0±0.6 ml/kg/min *versus* 3.5 ml/kg/min; $p<0.001$). There was no significant Gender X BMI interaction. There was also no significant main effect by BMI category for difference between measured and the reference-MET value for relative VO_{2rest} (Table 2). However, there was a significant difference ($p=0.002$) between males and females for the difference between measured and the reference-MET value for relative VO_{2rest} (Table 2). The reference-MET value over-estimated VO_{2rest} for females by 0.7±0.5 ml/kg/min and under-estimated VO_{2rest} for males by 0.2±0.4 ml/kg/min.

Overall, measured absolute VO_{2rest} (0.275±0.083 L/min) did not differ from reference-MET value (0.250 L/min) (Table 2). While there was no significant Gender X BMI interaction, there was a significant main effect for both Gender ($p<0.001$) and BMI category ($p<0.001$). The reference-MET over-estimated by 0.008±0.59 for females while it under-estimated VO_{2rest} by 0.125±0.066 L/min for males. The difference between the

Variable	Weight (kg)	BMI (kg/m^2)	Age (years)
All Subjects (n=45)	91.0±13.6	32.4±3.5	37.2±10.5
Females (n=34)	87.3±12.0	32.7±3.8	35.6±11.1
Males (n=11)	102.5±11.7	31.5±2.1	42.2±6.5
Overweight (N=11) (BMI=25.0-29.9 kg/m^2)	77.0±11.7	28.2±1.5	36.4±11.8
Obese Class I (N=21) (BMI=30.0-34.9 kg/m^2)	93.2±10.4	32.0±1.3	40.6±9.1
Obese Class 2 (N=13) (BMI=35.0-39.9 kg/m^2)	99.3±10.8	36.7±1.6	32.5±10.1

Table 1: Demographic characteristics of subjects.

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		Body Mass Index Category			*p*-value for difference between measured and reference-MET		
Gender	Variable	Overweight (25 to <30 kg/m²)	Obese I (30 to <35 kg/m²)	Obese II (35 to <40 kg/m²)	Gender	BMI Category	Gender X BMI Category
Relative VO_{2rest}							
Female	N	8	14	12	0.002	0.742	0.668
	Measured	2.73±0.59	2.73±0.56	2.86±0.54			
	Difference*	0.77±0.59	0.77±0.56	0.64±0.54			
Male	N	3	7	1			
	Measured	3.43±0.23	3.77±0.47	3.51±n/a			
	Difference*	0.07±0.23	-0.27±0.47	-0.01± n/a			
Absolute VO_{2rest}							
Female	N	8	14	12	<0.001	0.006	0.697
	Measured	0.197±0.053	0.239±0.049	0.277±0.053			
	Difference**	0.054±0.053	0.011±0.049	0.027±0.053			
Male	N	3	7	1			
	Measured	0.315±0.034	0.393±0.064	0.435±n/a			
	Difference**	0.065±0.034	0.143±0.064	0.185±n/a			

*relative reference-MET=3.5 ml/kg/min; positive value indicates reference-MET over-estimated, negative value indicated reference-MET under-estimates
**absolute reference-MET=0.250 L/min; positive value indicates reference-MET over-estimated, negative value indicated reference-MET under-estimates

Table 2: Comparison of relative and absolute VO_{2rest} to reference-MET values (mean±standard deviation).

measured and reference-MET value for absolute VO_{2rest} was significantly less in the overweight category compared to both the Class I (p=0.010) and Class II (p=0.026) obesity categories.

CONCLUSIONS

This study examined if measured VO_{2rest} differed from widely accepted reference-MET values (3.5ml/kg/min, 0.250 L/min) in adults who are overweight or obese. This study found that measured VO_{2rest} (3.0±0.6 ml/kg/min) in a sample of adults who are overweight or obese is less than the typically used reference-MET value of 3.5 ml/kg/min (Table 2). Results from this study are similar to results from others in which measured VO_{2rest} was less than the reference-MET value of 3.5 ml/kg/min. For example, in a sample of 36 males (age=40.0±3.3 years; BMI=25.9±3.8 kg/m²) measured relative VO_{2rest} (3.0±0.3 ml/kg/min) was significantly lower than the reference-MET value (3.5 ml/kg/min).[10] Gunn et al[11] have also reported a similar pattern in a sample of 50 males (age=60.6±3.2 years; BMI=26.7±3.2 kg/m²). In a mixed sample of males and females, Byrne et al[12] also reported that VO_{2rest} (2.6±0.4 ml/kg/min) was significantly lower than the reference-MET value (3.5 ml/kg/min). However, Byrne et al[12] did not examine whether there was a gender influence on the difference between the measured and reference-MET value. By comparison, the current study did report a gender difference between the measured and reference-MET value, with reference-MET value over-estimating VO_{2rest} for females and under-estimating VO_{2rest} for males.

Another unique contribution of the current study is the examination of whether the difference between measured and the reference-MET value was influence by BMI. Results showed no difference across BMI categories when examining relative VO_{2rest}; however, the difference between measured and the reference-MET value for absolute VO_{2rest} (L/min) was less in the overweight category compared to the Class I and Class II obesity categories. This may suggest that at higher levels of BMI the reference-MET for absolute VO_{2rest} (0.250 L/min) has less utility as an accurate measure. Others studies that have directly compared the measured and reference-MET value for VO_{2rest} have not examined the potential influence of BMI. This finding also has implications when using the reference-MET value of 0.250 L/min to estimate the energy costs of physical activity, as this may over-estimate the energy cost more as BMI increases.

Currently, VO_{2rest} is used to represent the resting MET, and multiples of this resting value are universally used to express energy expenditure of various forms of physical activity.[1,2] The origins of the MET to express energy expenditure during different forms of physical activity relative to resting energy expenditure appears to date back to approximately 1890,[13] which was followed by similar observations made decades later.[3,14] Thus, the findings of the current study, which are similar to the finding of others,[10,12] may suggest that the energy cost of a variety of physical activities may be over-estimated when using common reference-MET values. Moreover, the data from this study may suggest that this over-estimation may be of particular concern for women and for individuals at a higher BMI. However, given the relatively small sample and the limited inclusion criteria, these findings should be interpreted with caution and warrant further replication.

In summary, this study demonstrated that the conventional estimates of VO_{2rest}, represented as the MET, may differ

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from measured values in adults who are overweight or obese. These findings may have implications on estimates of resting and physical activity energy expenditure. Thus, while additional research to confirm these findings is warranted, this may suggest the need to establish new estimates of the resting MET that can be used broadly in clinical applications aimed at prevention or treatment of obesity.

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CONFLICTS OF INTEREST

The authors declared conflicts of interest.

AUTHOR CONTRIBUTIONS

RJR: Manuscript development; Statistical analyses.
JMJ: Data collection; Statistical analyses; Manuscript revision.

CONSENT STATEMENT

As per University of Pittsburgh Instructional Review Board Guidelines, all original signed consent forms have been retained by the principal investigator.

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