Development of the SmartPad System for Energy Expenditure Detection

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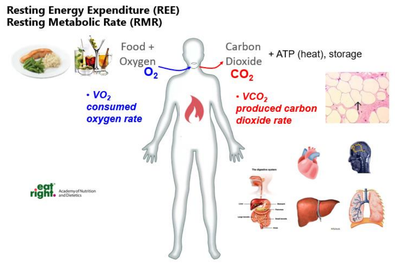
Background

Energy Expenditure (measured in kcal/day) is the energy organisms utilize to carry out their cognitive and physical actions. A mismatch between energy expenditure, energy storage, or energy intake can lead to a variety of diseases[1] such as obesity. Individuals gain weight when their dietary intake exceeds their energy expenditure, but a calorie reduction or an increased sustenance of physical activity does not always lead to weight loss since individuals often reach a weight plateau due to a change in their intrinsic energy expenditure[2,3]. Therefore, energy expenditure must be measured frequently to optimize weight management.



Resting Energy Expenditure:

Indirect Calorimetry Principle

Weir Equation:

REE (kCal/day) = [3.9 (VO_2) + 1.1 (VCO_2)] x 1.44

VO_2: consumed oxygen rate (mL/min)
VCO_2: produced carbon dioxide rate (mL/min)

REE (kCal/day) = [3.9 (VCO_2/ RQ) + 1.1 (VCO_2)] x 1.44

RQ: Respiratory Quotient
RQ = 0.85 (averaged value from population)

Weir, J. B. D. (1949). "New Methods For Calculating Metabolic Rate With Special Reference To Protein Metabolism." Journal Of Physiology-London 109(1-2): 1-9.

Weir, J. B. D. (1990). "Nutrition Metabolism Classic - New Methods For Calculating Metabolic-Rate With Special Reference To Protein-Metabolism." Nutrition 6(3): 213-221.

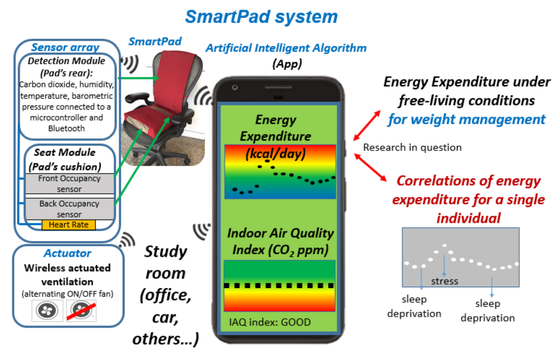
Table 1.

	Doubly labeled water method	Mobile/portable metabolic analyzers	Metabolic cart	Metabolic rooms	*SmartPad* system [this project]
Use	research	clinical, fitness, personal	clinical, fitness, research	research, less than 10 in US.	clinical, fitness, research
Test time	7-10 days	2-10 min, prior resting of 20 min	10 min, prior resting 20 min or under exercise	1-7 days	occupancy time, weeks, months or years
Sample	urine	breath	breath	breath	indoor air
Attachments/instruments	none	mask or nose clip and mouthpiece	mask or nose clip and mouthpiece	bulky instruments, air pumps, flowmeters, etc.	none/ passive sensors
Testing condition	free-living + twice appointment	one-point-in-time appointment	one-point-in-time appointment	one-point-in-time appointment	free-living
Interruptions to regular life	partial	partial	partial	full dedicated time	none
Cost/test (consumables)	$1,000/test	$6-$33/test	~$50/test	$600-1000/test	~$0.50/ day (100+ tests/ day)
Outcome	EE average	EE average	EE average	EE average and pattern	EE average and pattern

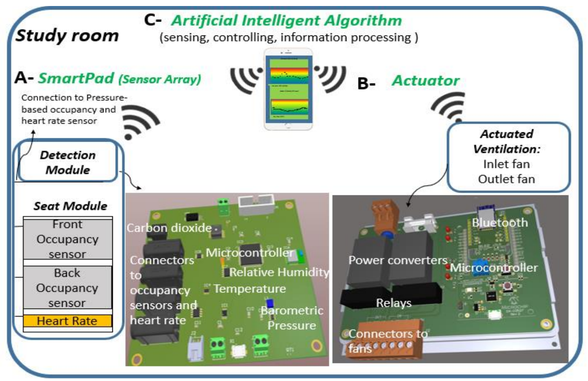
Engineering Hypothesis

It is feasible for the SmartPad system to be developed and validated for automatic, non-intrusive, continuous, and reliable assessment of body total EE under free-living conditions without the disruption of the subject's life

Our Solution

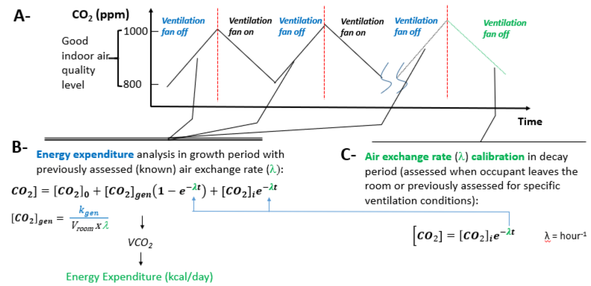


Study Room

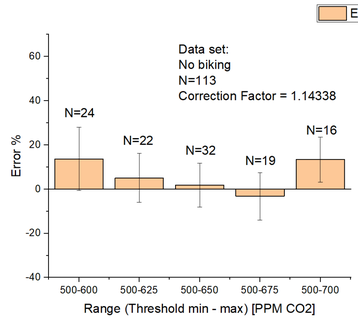


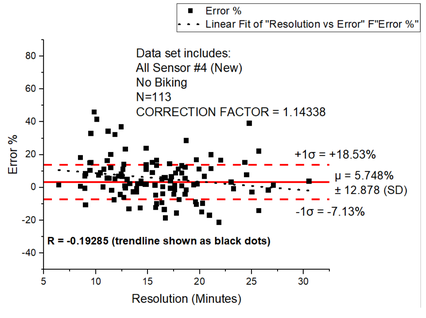
System Set-Up

Data Analysis Process



Findings





Conclusion

- Preliminary tests of the SmartPad are promising as results have shown that the SmartPad is 90% accurate when measurements are taken in a 20 minute time interval.
- Further testing needs to be done to optimize the design parameters of the system

References

1. Lightin, J., Limitations and requirements for measuring metabolic rates: a mini review. European Journal of Clinical Nutrition 2017, 71, 301–305.
2. Esparza, J.; Fox, C.; Harper, I. T.; Bennett, P. H.; Schulz, L. O.; Valencia, M. E.; Ravussin, E., Daily energy expenditure in Mexican and USA Pima Indians: low physical activity as a possible cause of obesity. International Journal Of Obesity 2000, 24 (1), 55-59
3. Manore, M. M.; Meyer, N. L.; Thompson, J., Sport Nutrition for Health and Performance. Human Kinetics (Ed.) 2009, Second Edition

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