P03-S-140

PREDICTION OF ENERGY EXPENDITURE FROM IMUs FOR BOTH OVERGROUND AND TREADMILL WALKING

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Introduction

- The modern urban lifestyle leads to sedentarism (e.g., obesity, physical inactivity…)
  => Results in many lifestyle-based diseases[1]
- Energy Expenditure(EE) is a key tool to measure physical (in)activity
  => The gold-standard -> indirect calorimetry, is Impractical to use in daily-life.
  => Smartwatches and activity monitors have poorer accuracy and are unreliable[2]
- Replicate and extend the Open Metabolics system (from Stanford U)[2] for a Japanese young population with low physical activity[3]
  => Extension to overground walking and different speeds

Conclusion

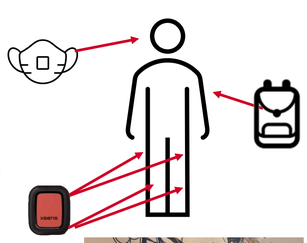
✓ Full replication remains a challenge, but smarter algorithms are key to EE prediction
- Anthropometric differences between the participants' pool
- Few participants in the original model (N=13[2])
- Walking surfaces (only treadmills[2])
- Usage of a simple linear regression model?

✓ Plan to build a new prediction model using our own data => real-life environments
- Use a neural network-based approach
- Test new predictions on daily-life gait data based on our trained model

Methods

- Participants
  - 10 Japanese males (age 23.3 ±1.4 years | height 1.73 ±0.05 m* | weight 63.2 ±9.1 kg*)
  - 10 Japanese females (age 21.0 ±1.9 years | height 1.58 ±0.04 m* | weight 49.6 ±5.4 kg*)

  *** significantly higher in males (p<0.001)**
- Setup
  - Face mask for breath measurement → Mouth
  - Mobile Aeromonitor (Minato Medical Science Co., Ltd.,) → Back
  - Put four 3-axes IMUs (Movella Inc.) → Thighs and shanks @60Hz
- Walking Conditions
  - Overground (OG) & Treadmill (TM)
  - 3 speeds : Slow 1.0m/s | Comfortable 1.3m/s | Fast 1.5m/s
  - Face mask (breath-by-breath measurement)
  - Shoe-type controlled
  - Randomized cross-over design



- Time line
  10 min TM familiarization → 5 min resting trial → Waling Trials : 6 min × 6 conditions
  (with 4-min rest between every walking trial and 10 mins rest between changing of OG and TM)
- Error comparison method

Reference EE: Mobile Aeromonitor (Ground truth)
- EE_Aero=(15962+5155 × RER) × VO_2 × 60 × body weight [4]
  - RER=Respiratory Exchange Ratio
  - VO_2=Oxygen consumption rate

Estimated EE: from IMUs (IMU predictions)
- EE_IMU=Open-source model (Stanford University)

Estimation Error (%)

$$EE\_Error\ (\%) = \frac{(EE\_Aero - EE\_IMU)}{EE\_Aero} \times 100$$

Results

The IMU-estimated EE showed substantial variation across participants and speeds* (p<0.001*) & TM showed smaller estimation errors than OG

- **Tendencies**

At comfortable speed → relatively the **best predicted** condition
At slow speed → EE **overestimated**
At fast speed → EE **underestimated**

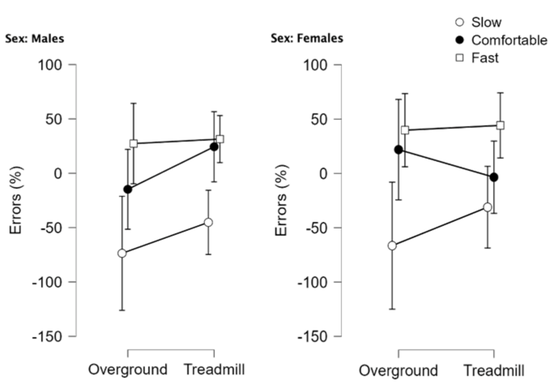


Fig 1. Descriptive plots of Estimation Errors

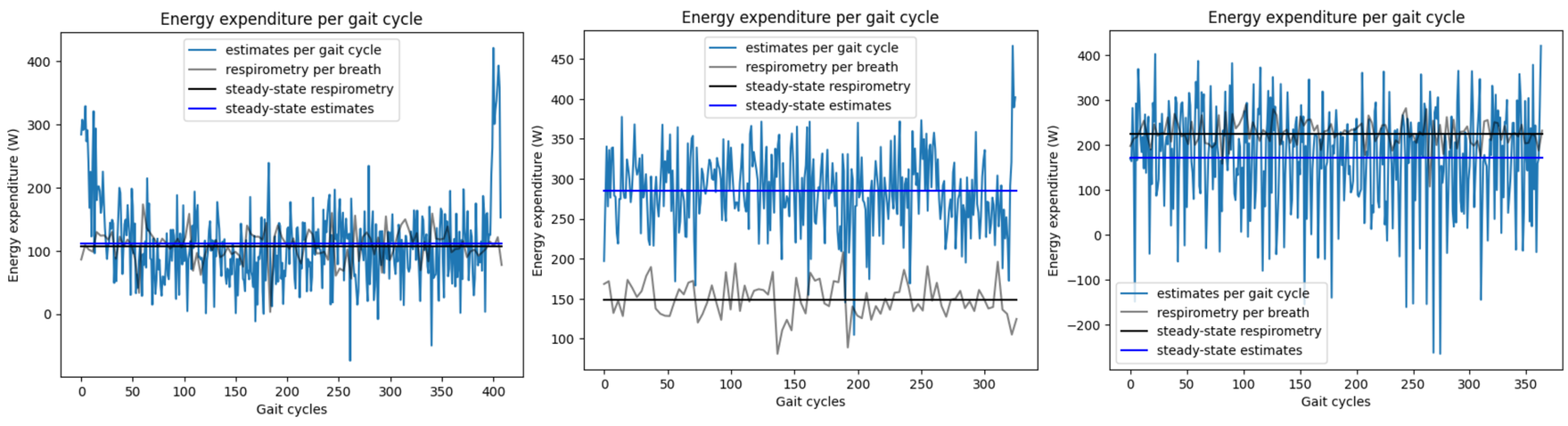


Fig 2. Three representative IMU based EE predictions compared to ground-truth EE. (BLUE=IMU predictions, BLACK=Ground truth)

Discussion

✓ IMU-based EE estimation is feasible, but currently inaccurate and only partially replicable
✓ We were unable to (completely) replicate the results of Slade et al., (2021) [2]

- **Possible Reasons**
  - Small training sample (N=13) in the original model?
  - Anthropometric differences between the participants' pool (USA v/s Japan)?
  - Differences in walking surface (only TM in the original model)?
  - Simplicity of the linear regression approach?
- **Future Work**
  - We plan to train a neural network-based model using our dataset and evaluate its generalizability to new participants

  => Extension from laboratory-overground to daily life gait data

References

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