Assessment of Free-living Physical Activity

Validation of a Newly Developed Device

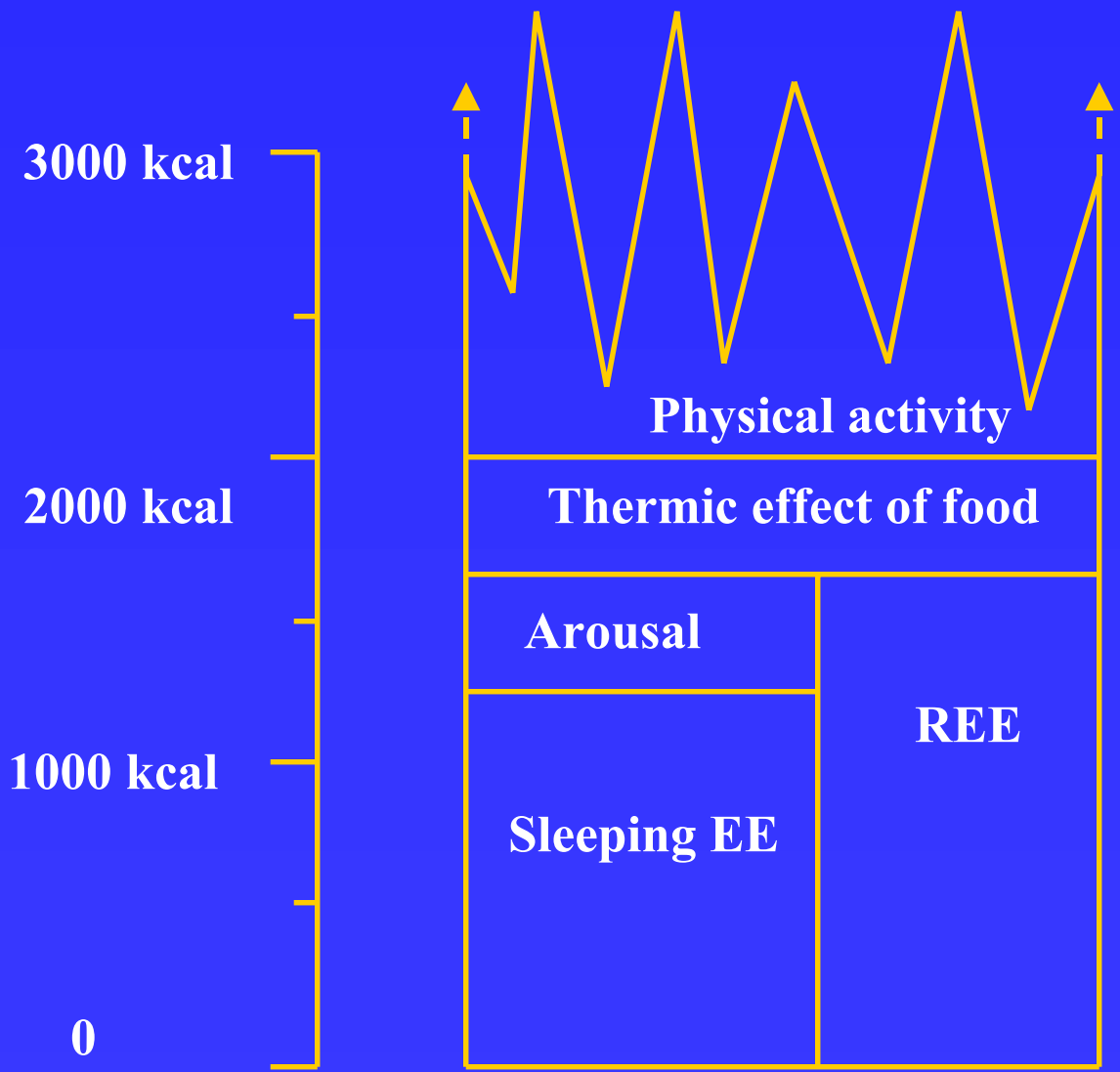
K Zhang[1], P Werner[1], M Sun[2], FX Pi-Sunyer[1], CN Boozer[1].

[1]NY Obesity Research Center, St. Luke's-Roosevelt Hospital, Columbia University; [2]MiniSun, LLC.

Background

- Health Impact of Physical Activity
  - Improves body composition
  - Weight control
  - Psychological well-being
- Low physical activity may contribute to obesity
- No. 1 of leading health indicators for People's Health 2000 & 2010

The most variable component of energy expenditure



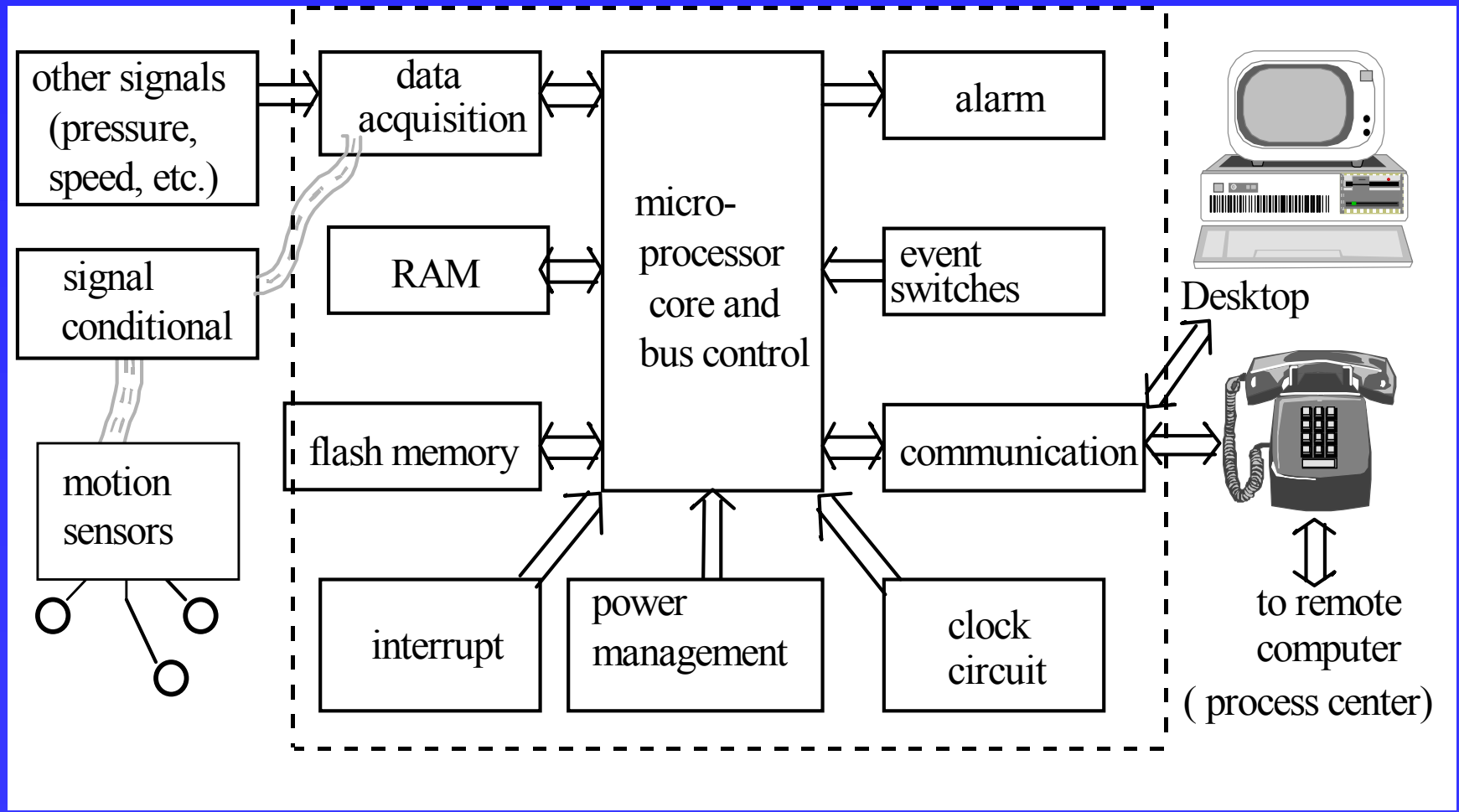
(Ravussin, AJCN, 1989)

Limitations of current methodologies

More than 30 methods have been reported for assessing PA, but have limitations on:

- **Type of PA**
- **Duration of PA**
- **Intensity of PA**
- **Energy Expenditure**

Intelligent Device for Energy Expenditure and Activity (IDEEA) System



Classification of Physical Activity

Gait (dynamic) & **Posture (**static)

Daily Physical Activities

Gait

- Walking
- Running
-
- Down stairs

Posture

Primary

- Sitting
- Reclining
- Standing
- Leaning
- Lying down

Secondary

1. Upright (normal)
2. Left leg over right leg
3. Right leg over left leg
4. Left foot moving
5. Right foot moving
6. Both feet moving
7. Elbows on knees
8. Left heel up
9. Right heel up
10. Both heels up
11. Both feet elevated

12. Both feet on the ground
13. Left leg over right leg
14. Right leg over left leg

15. Upright (normal)
16. Left leg moving
17. Right leg moving
18. Left foot on a step
19. Right foot on a step

20. Left shoulder against wall
21. Right shoulder against wall
22. Two elbows on a counter

23. Facing up
24. On right shoulder
25. Facing down
26. On Left shoulder

Subject Characteristics

No. of subjects	**76 (33 males and 43 females)**
Age (years)	**36.3 ± 14.9 (13 ~ 72)**
Body weight (kg)	**72.4 ± 14.8 (44.6 ~ 118.0)**
Height (cm)	**170.9 ± 9.4 (152.4 ~ 188.0)**
BMI (kg/m^2)	**24.7 ± 4.4 (18.4 ~ 41.0)**

Posture Identification

- **Protocol**: Subjects performed 26 postures in different order for 10 seconds each.
- **Results:**
  - Primary Postures:

    100%
  - Secondary Postures:

    98.96% ± 1.83% (89.89% - 100%)

Gait Detection and Speed Prediction

- **Protocol**
  - Walking and running on an indoor track

    Slow, normal, and fast speeds.
  - Up Stairs & down stairs

    Normal, fast and normal speeds.
- **Speed measurement**

  A series of light sensors along the track ceiling.

Number of Gaits

Type of gait	Actual Number	Detected Number	Rate	Rate SD
Walking	16179	16131	99.70%	0.0122
Running	10421	10341	98.99%	0.0180
Up stairs	3168	3119	98.45%	0.0504
Down stairs	3168	3120	98.48%	0.0377
Total	32936	32711	99.32%	0.0065

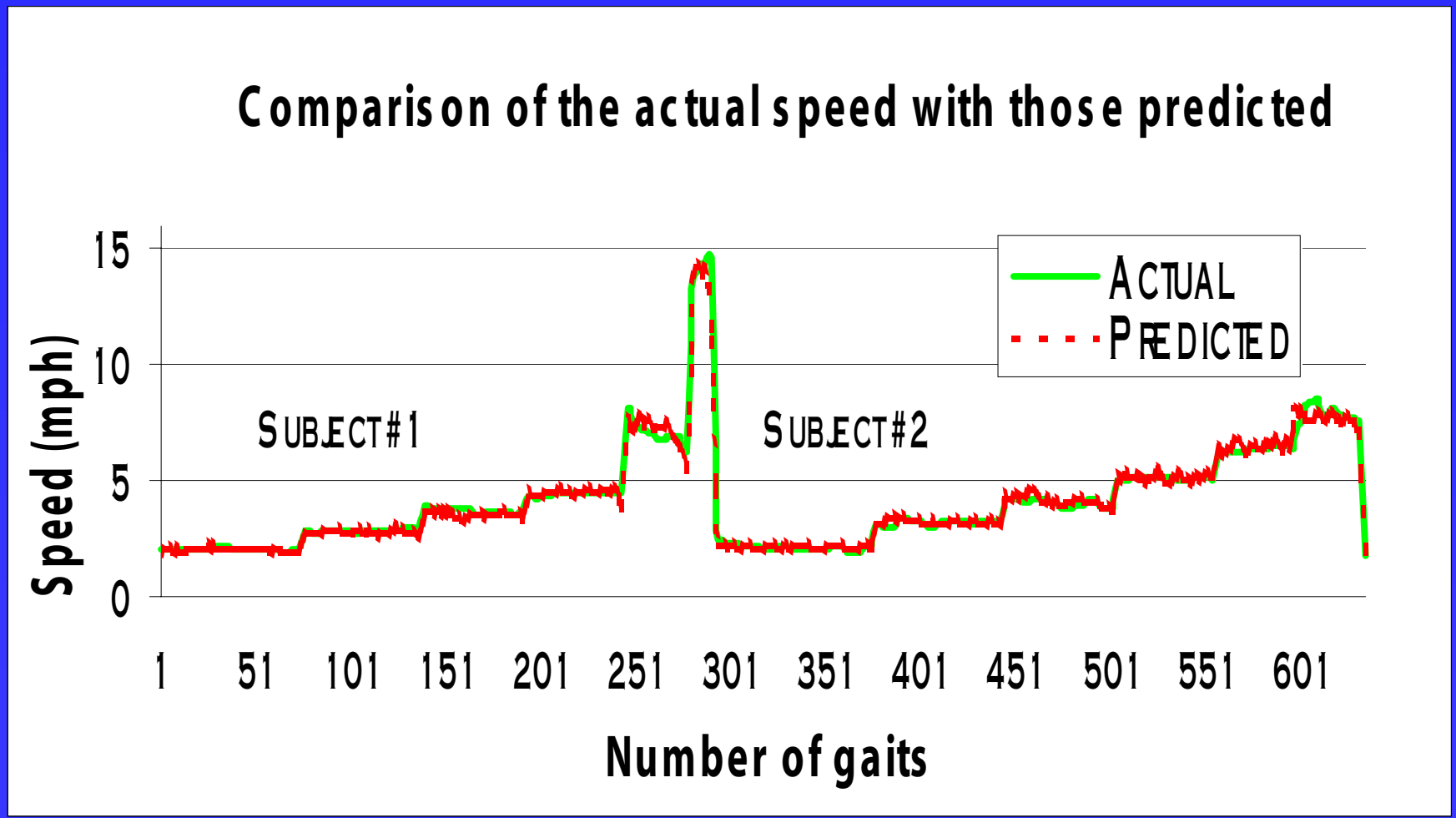
Type of Gaits

Type of gait	Actual gaits	Identified gaits	Rate	Rate SD
Walking	16179	16124	99.66%	0.0125
Running	10421	10316	98.99%	0.0180
Up stairs	3168	3116	98.36%	0.0508
Down stairs	3168	3109	98.14%	0.0385
Total	32936	32665	99.18%	0.0098

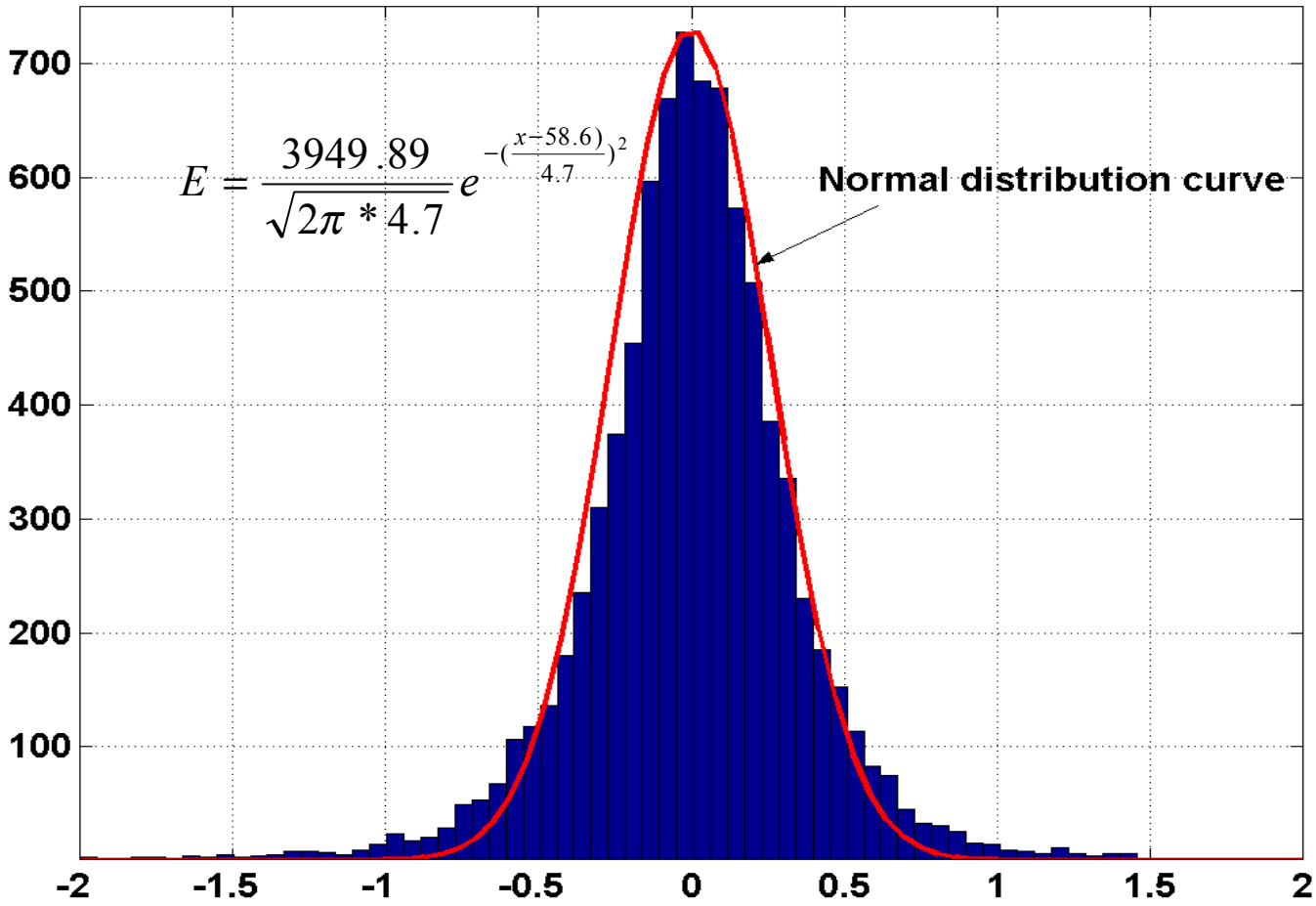
Speed Prediction

- **No. Steps:** 15,676
- **Actual:** 4.0893 ± 2.0125 mph (1.4300 ~ 18.4600)
- **Predicted :** 4.0930 ± 1.9755 mph (1.4300 ~ 18.0557)
- **Correlation:** 0.9869 ($p < 0.0001$)
- **Error:**
  - **Mean:** 0.0036 ± 0.3708 mph
  - **Absolute:** 0.2438 ± 0.2794 mph
  - **Distribution:** Normal

Speed Prediction



Speed Prediction Error Histogram



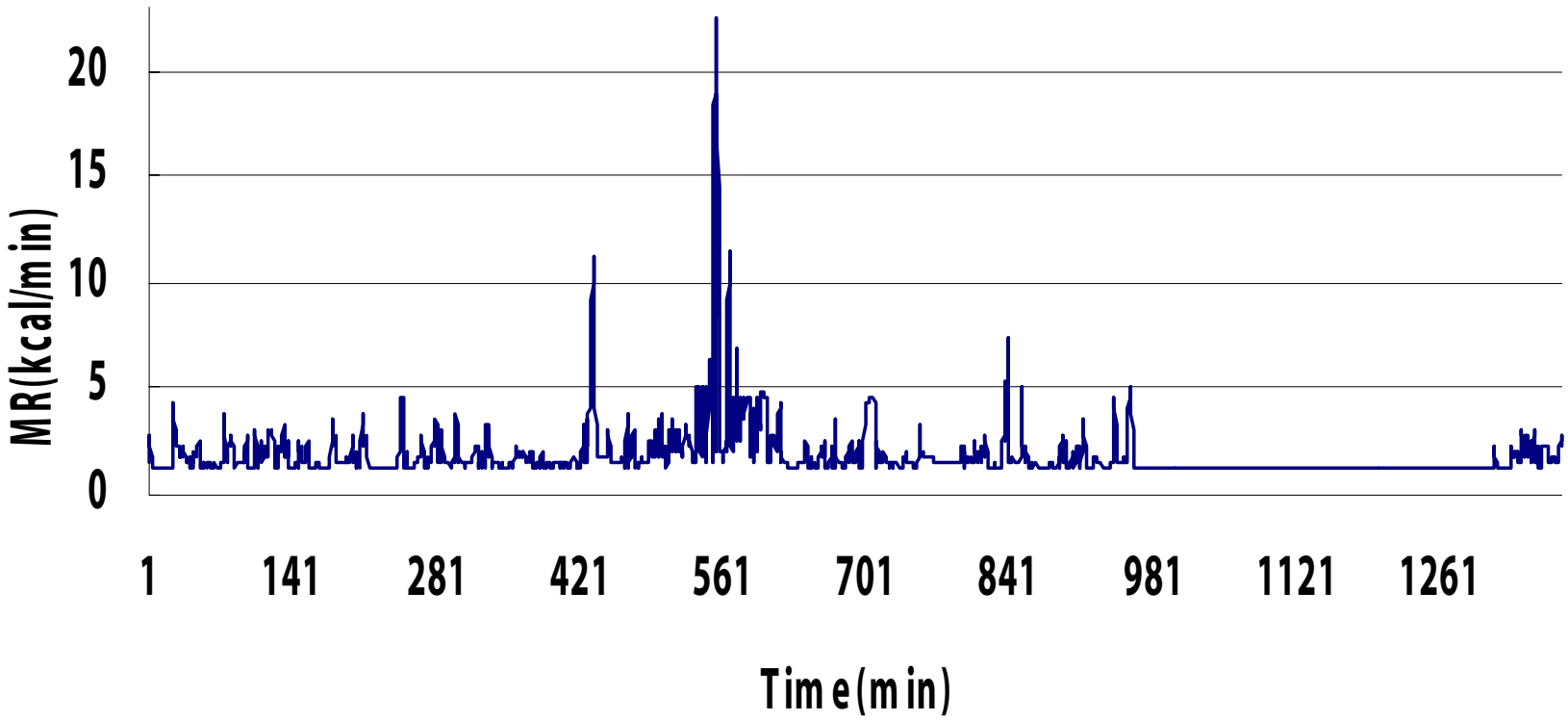
23-Hour Test by IDEEA

Subject: Male, 43 years old, 5’8”, 159 lb.

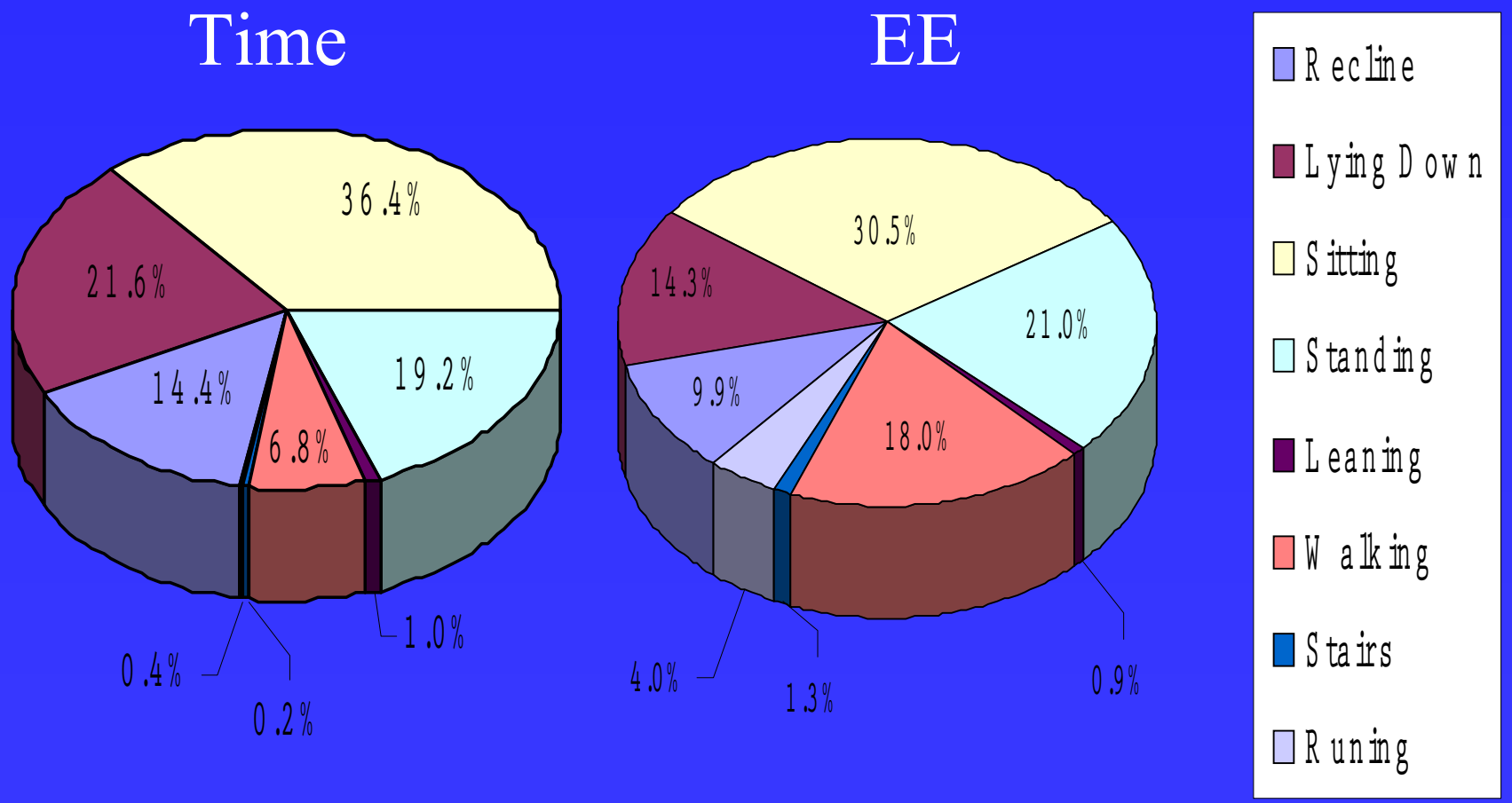
Estimated TEE: 2505 kcal

	Walking	Running	Stairs
No. of Gaits	**9410**	**920**	**356**
Power (W)	**63**	**278**	**168**
Distance (miles)	**4.37**	**0.81**	

23-Hour Energy Expenditure



Time and Energy Expenditure for Activities



Conclusions

- IDEEA is able to accurately record type, duration, frequency, intensity of daily PA with a precision approaching 100%.
- Great Potential for estimating energy expenditure due to PA.

To our knowledge, these events have never been accurately recorded by using such a small, portable device in free-living.

Future Goals

- **To conduct the PA study by accurately describing type, duration, frequency, intensity of daily PA in free-living individuals.**

- **After further validation we also expect to be able to assess energy expenditure associated with PA.**