

Comparison of the Patient Activity Monitor to a Pedometer During Ambulation Monitoring of Transtibial Amputees in a Community Simulated Environment

Nancy Dudek MD MEd
OAAC 2006

- Principle Investigator
 - Omar Khan MD
- Co-investigators
 - Edward Lemaire PhD
 - Nancy Dudek MD MEd
 - Meridith Marks MD MEd
 - Leyana Saville BSc
- Funding support
 - University of Ottawa Summer Studentship Program
 - Labatts Relay Research Fund

Introduction

- Walking is one of the most important components of daily activity
- Need for objective methods of assessing daily ambulation in lower extremity amputees
- Several devices proposed to do this

Holden J, Prosthet Orthot Int 1979

Shepherd EF, J Orthop Res 1999

Coleman KL, J Rehabil Res Dev 1999

Bussmann JB, Arch Phys Med Rehabil 2004

Patient Activity Monitor (PAM)

- Inertial sensor
- Measures and displays several data parameters related to activity level



Patient Activity Monitor (PAM)

- Valid for classifying everyday activities of persons with transtibial amputations

Busmann JB, IEEE Trans Neural Syst Rehabil Eng 2004



Yamax Digi-Walker SW-700 (DW)

- Among the most accurate and affordable commercially available models

Scheider PL, Med Sci Sports Exerc 2003 & 2004



Yamax Digi-Walker SW-700 (DW)

- Measures step count
- Calculates distance traveled



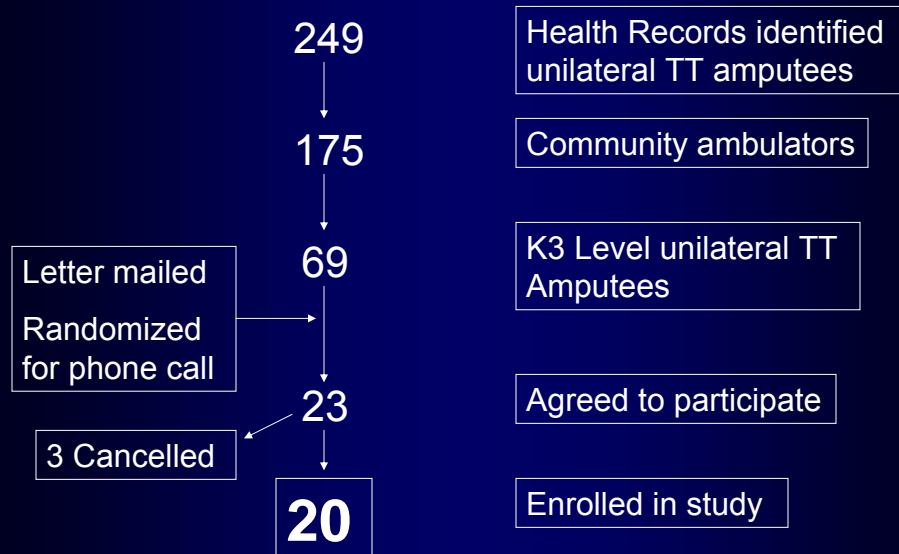
Objectives

- To **determine** the step count and ambulation distance accuracies of the DW and the PAM in K3 level transtibial amputees within a community-simulated environment
- To **compare** the step count and ambulation distance accuracies of the DW and the PAM in K3 level transtibial amputees within a community-simulated environment

Medicare Functional Classification Level (MFCL)

| K Level | Functional Level |
|---------|-----------------------------|
| 0 | Non-ambulator |
| 1 | Household ambulator |
| 2 | Limited community ambulator |
| 3 | Community ambulator |
| 4 | High-level user; Athletes |

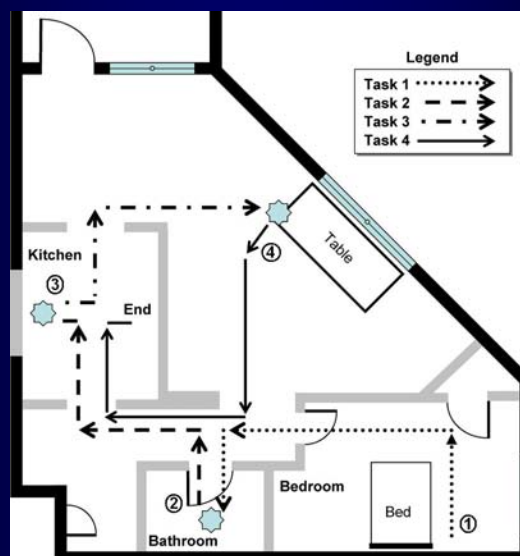
Subject Recruitment



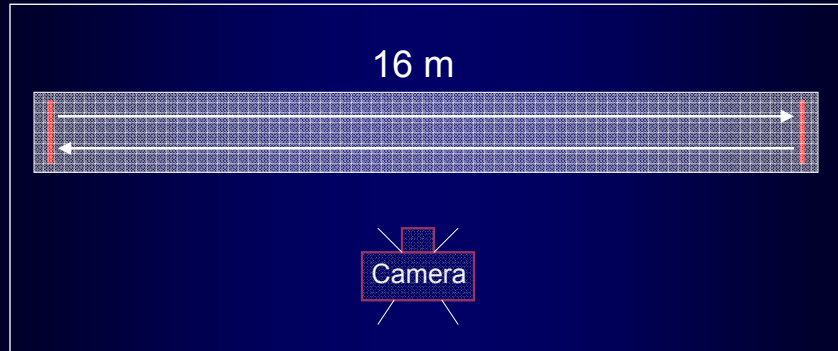
Procedures

- Two-part testing protocol
 - Household simulated environment tasks
 - Gymnasium walking and turning task
- Step count and distance measurements recorded
 - PAM
 - DW
 - Videotape data
 - Measurement wheel

Household Tasks (Apartment)



Gymnasium Walking Task



Completion of 10 gym lengths = 160m

Results

Demographics

| Variable | Value |
|-----------------------------|--------------------------|
| Age (yrs) | 58.6 ± 10.8 (43-82) |
| Height (cm) | 171.2 ± 8.9 (153-185) |
| Weight (kg) | 82.8 ± 16.3 (57.6-122.5) |
| Time Since Amputation (yrs) | 26.7 ± 20.0 (2-62) |
| BMI (kg/m ²) | 28.3 ± 5.3 (22-40) |
| Average Step Length (m) | 0.65 ± 0.07 (0.58-0.83) |
| ILU –Average Speed (m/s) | 0.93 ± 0.11 (0.79-1.20) |
| Gym –Average Speed (m/s) | 1.13 ± 0.14 (0.88-1.52) |

Values = mean ± SD (range)

% Accuracy of DW and PAM

| | DW | PAM | P-Value |
|------------|-------------|-------------|---------|
| Apartment | | | |
| Step Count | 75.3 ± 20.9 | 70.6 ± 10.1 | 0.305 |
| Distance* | 72.8 ± 18.2 | 0 | 0.000 |
| Gymnasium | | | |
| Step Count | 93.8 ± 6.7 | 94.0 ± 4.0 | 0.919 |
| Distance* | 92.5 ± 6.3 | 86.3 ± 7.7 | 0.007 |

Values are mean percentage ± standard deviation

* Statistically significant difference between device accuracies (p<0.05)

DW and PAM Validity Measures

| | Criterion | DW | P-Value | PAM | P-Value |
|---------------------|--------------|--------------|---------|--------------|---------|
| Apartment | | | | | |
| Step Count | 82.3 ± 8.1 | 64.5 ± 20.9 | 0.002 | 58.0 ± 9.5 | 0.000 |
| Distance (m) | 43.2 ± 2.1 | 40.5 ± 14.3 | 0.400* | 0 | - |
| Gymnasium | | | | | |
| Step Count | 248.1 ± 23.6 | 233.0 ± 29.0 | 0.001 | 236.3 ± 28.7 | 0.002 |
| Distance (m) | 160.0 | 156.0 ± 15.3 | 0.258* | 143.0 ± 18.9 | 0.001 |

*No statistically significant difference between criterion and device measurement

Effect of Obesity (DW)

| | Non-Obese (n=12) | Obese (n=8) | P-Value |
|-------------------|------------------|-------------|---------|
| Apartment | | | |
| Step Count | 83.2 ± 19.4 | 63.5 ± 18.1 | 0.035 |
| Gymnasium | | | |
| Step Count | 96.2 ± 4.6 | 90.2 ± 8.1 | 0.047 |

Obesity defined as BMI ≥ 30 kg/m²

Discussion

- Why were the devices inaccurate?
 - Introduced small steps, turns
 - PAM
 - Internal settings for activity classification
 - Short distances, interrupted by missed steps
 - DW
 - Internal switch mechanism
(acceleration $\geq 0.35\text{ g}$ to register a step)
 - Obesity for DW

Discussion

- How do our results compare?
 - DW: Track walking (able-bodied)
 - Distance 94%
 - Step Count 97%
 - Schneider PL, Med Sci Sports Exerc 2003*
 - PAM: Continuous ambulation over ground (12 unilateral transtibial amputees)
 - Distance 95.8%
 - Step count 98.4%
 - Bussmann JB, IEEE Trans Neural Syst Rehabil Eng 2004*

Conclusions

- DW offers
 - Low cost
 - Potential longer monitoring duration
 - Easy use
- PAM offers
 - Wider range of measurement parameters
 - Attaches directly to the prosthesis, potentially improving compliance

Conclusions

- Both devices are appropriate for assessing **relatively continuous** ambulation using **step counts**
- Neither device is currently appropriate for monitoring short distance, non-continuous ambulation (such as would be seen within the home or indoors in the community)

Questions