Using Wearable Sensors to Detect Changes in Physical Activity

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Introduction:

- Wearable sensor technology has become increasingly popular and had begun to be utilized in various healthcare disciplines.
- There are enormous applications for wearable technology in rehabilitation and physical intervention settings because of the difficulties inherent in assessing unsupervised physical activity through self-reporting
- Two different population groups are being tested in this study to asses if the Charge HR Fitbit (See Figure 1) is able to detect changes over time in both an inpatient and a free-living setting.

Figure 1: The Charge HR Fitbit

Methods:

Procedure

Group A: Saint Luke's Rehabilitation Institute (n=3, mean age=59.5 yrs)

- Participants were selected based on the following criteria: mobile-capable, aged 18+, English speaking, recently admitted, and appearing cognitively capable for the study.
- Two Charge HR Fitbits were set up for each patient, with one being attached and the other acting as a fully-charged alternate. Fitbits were worn at all times during inpatient treatment, unless pool therapy was employed.
- Daily check-ins were given. Skin integrity and Fitbit status were checked. Every four days, Fitbits were swapped.

Group B: Pullman, WA residents (n=8, mean age=25.5 yrs)

- Participants were selected based on the following criteria: ability to receive text messages, aged 18+, and willingness to wear Fitbits.
- One Charge HR Fitbit was set up for each participant. They were instructed to wear the Fitbit at all times for two weeks and to charge during sleep every fourth night.
- Daily text message reminders were sent to wear the Fitbit.

Data Analysis

- Collected minute by minute data for complete days of sensor was downloaded from fitbit.com wearing using a custom program.
- Steps walked per day were then calculated, and a pairwise student t-test with a Bonferroni p-value correction (See Table 1) was employed on both sliding data (where each full day was paired with the following day) and baseline data (where all days were paired with the step values of the first day).
- The critical p-value for significance after the Bonferroni correction was 0.025.

Results:

Average Weeks	Sliding T-Test	Baseline T-Test
Group A vs Group B	0.09147544	**0.000285483***
Group B vs Group A	0.346868227	0.051594546
Group A with Self	0.212382017	**0.001766552***
Group B with Self	0.272622783	**0.010142826***

Table 1: The averages of the first week of Group A and Group B compared using a sliding window approach with paired t-tests. Significant values are bolded and have an asterisk.

Results:

Participant (Group)	Sliding Pairwise P-Value	Baseline Pairwise P-Value
A (A)	0.367074061	0.042360491
B (A)	0.226255536	**0.001204391***
C (A)	0.208204856	**2.91723E-05***
1 (B)	0.429489038	**0.002313116***
2 (B)	0.473261316	**0.004955814***
3 (B)	0.332504467	**0.006931577***
4 (B)	0.36734231	**0.001547665***
5 (B)	0.414015744	0.172833841
6 (B)	0.392285976	**1.13493E-05***
7 (B)	0.495701926	0.127623405
8 (B)	0.471464286	0.207930333

Table 1: P-values obtained for all sliding window based pairwise student t-tests significant values are bolded and have an asterisk.

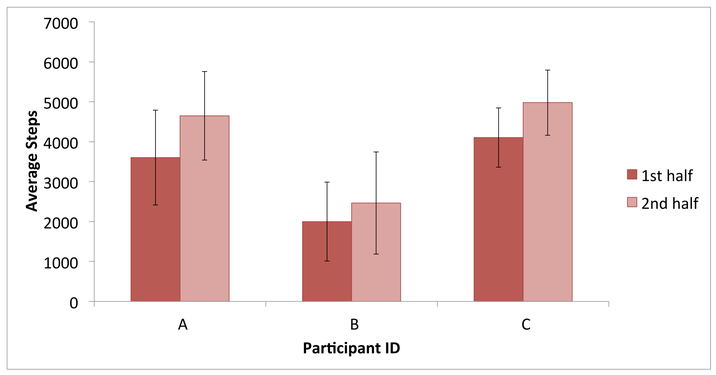

Figure 2: Average Steps Graph for Group A. The average steps during the participants 1st half of therapy compared to their 2nd half of therapy with error bars. A student t-test found the differences between participants insignificant with a p value of 0.2376.

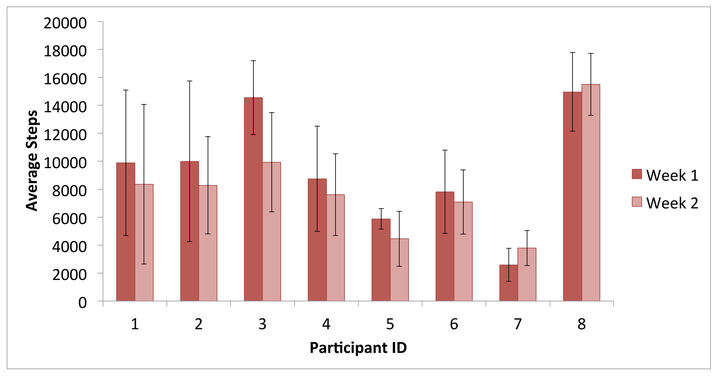

Figure 3: Average Steps Graph for Group B. The average steps during the participants 1st week compared to their 2nd week with error bars. A student t-test found the differences between participants insignificant with a p value of 0.2768.

Artificial Data:

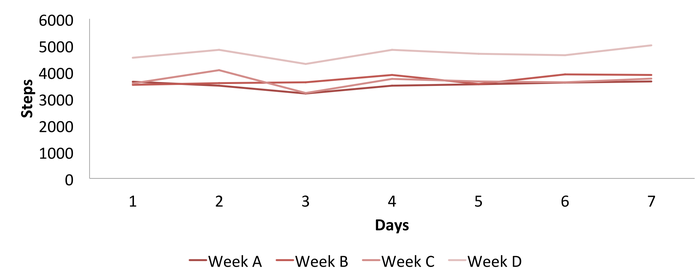

Figure 4: Total Steps Graph for Artificial Data. Four weeks of artificial normally distributed step data was generated using different means for steps taken in an hour. Means used to generate data were 150 (A), 151 (B), 151.1 (C), and 200 (D).

Weeks Compared	F-Test	T-test
Week A vs Week B	0.756258354	**0.025975666***
Week A vs Week C	0.249306227	0.11674847

Table 2: A F-Test was performed, and it was found that the variances did not differ significantly (critical value for both degrees of freedom being 6 is 8.47). A two-sample equal variance t-test was used to prove that the means were different for generated weeks.

Weeks Compared	Sliding T-Test	Baseline T-Test
Week A vs Week C	0.37226229	0.298049788
Week A vs Week D	0.165439096	**0.008552631***

Table 3: The artificial data was used to demonstrate that the sliding scale t-tests can effectively detect changes in steps taken, with a larger p-value corresponding with a smaller difference in mean steps taken, and a smaller p-value with a larger difference in steps.

Conclusions:

There is a significant difference between the size of the difference between the first and second half of the therapy treatment for Group A when compared to the first and second week of Group B (p=2.43628E-07). Based on this, the participants in Group A are improving their amount of physical activity and not just experiencing normal differences in walking present in group B. This experiment validates that our method can effectively capture significant changes in physical activity when they occur in the data.

Future Work:

- Since we had such a small sample size we are going to continue this study and recruit more participants to hopefully improve our statistical significance.
- Also, since there was such a large gap in age between Group A and Group B, it would be better to have our two groups be more similar in age to eliminate other variables that could affect the outcome.

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