Continuous Assessment of Daytime Heart Rate Response During Inpatient Rehabilitation

Douglas L. Weeks[1,2]; Gina L. Sprint[3]; Alyssa La Fleur[4]; Jordana Dahmen[5]; Virgeen Stilwill[1]; Amy Lou Meisen-Vehrs[1]; and Diane J. Cook[6]

[1]St. Luke's Rehabilitation Institute, Spokane, WA, USA; [2]Elson S. Floyd College of Medicine, Washington State University, Spokane, WA, USA; [3]Department of Computer Science, Gonzaga University, Spokane, WA; [4]Department of Mathematics and Computer Science, Whitworth University, Spokane, WA; [5]School of Biological Sciences, Washington State University, Pullman, WA; [6]School of Electrical Engineering and Computer Science, Washington State University, Pullman, WA

Background

- To obtain cardiorespiratory benefit, the AHA/ASA recommends exercise at a level of intensity sufficient to maintain heart rate (HR) within a zone equal to 55%-80% of maximal estimated HR (target heart rate or THR) for at least 10 continuous minutes for a total of at least 20 minutes a day, 3-5 days per week.
- Physical activity in inpatient rehabilitation can used to achieve cardiorespiratory workload within the THR zone.
- It is unclear whether wearable HR sensors can be deployed long-term in inpatient rehabilitation to assess cardiorespiratory training response.
- If feasible, commercially-available sensors offer a low-cost, low-maintenance method for continuously assessing HR response in the inpatient rehabilitation setting.

Research Objectives

- Determine whether HR response to daytime therapy activities in inpatient rehabilitation was maintained within the THR zone for at least 10 continuous minutes for at least 20 minutes daily, 3-5 days per week.
- Determine incidence of excessive HR (EHR>80% of max HR).
- Determine incidence of device-acquired skin breakdown or protocol deviations from staff or patients removing sensors.

Methods

- 15 subjects 44-80 years of age with diagnoses of stroke, cardiac disorders, orthopedic disorders, medically complex conditions, or pulmonary disorder
- Subjects wore wrist-mounted HR sensors day and night throughout the inpatient stay.
- The proportion of subjects meeting THR thresholds for cardiorespiratory benefit and experiencing EHR episodes on a daily basis was quantified.
- Multiple regression techniques predicted THR and EHR outcomes from age, sex, length of stay, and motor function at admission and discharge.
- See Table 1 for patient characteristics.

Subject	Age	Sex	Rehabilitation Impairment Category	Length of Stay (days)	Admission FIM Motor Score	Discharge FIM Motor Score	Percent of Days Meeting All THR Recommendations (Goal = 42% of hospital days)*	Mean Duration of Longest THR Bout Each Day (min)
1	75	M	Orthopedic Disorder	10	56	83	100%	25
2	46	F	Stroke	13	54	85	30%	13
3	74	F	Pulmonary Disorder	19	35	79	88%	117
4	48	M	Cardiac Disorder	21	59	84	67%	31
5	55	M	Debility	11	50	69	100%	53
6	59	M	Medically Complex Condition	14	51	84	91%	11
7	68	M	Stroke	11	55	84	33%	9
8	50	F	Stroke	8	56	86	0%	9
9	80	F	Lower Extremity Fracture	10	44	59	100%	34
10	60	F	Stroke	11	37	63	0%	0
11	74	F	Stroke	19	49	70	100%	109
12	61	M	Stroke	11	60	83	100%	64
13	78	M	Cardiac Disorder	8	53	86	100%	2
14	48	F	Stroke	28	37	75	0%	0.4
15	44	M	Stroke	7	56	81	0%	0
Average	61			13	50	78	61%	32

Table 1: Subject characteristics and intensity, duration, and frequency of target heart rate (THR) events during the stay.

Figure 1: Percent of Subjects Meeting All THR Recommendations

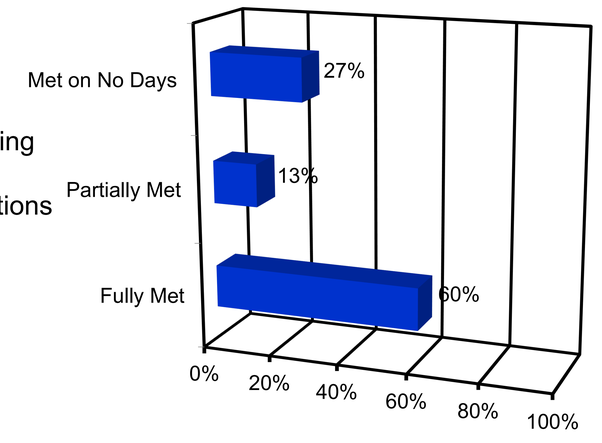
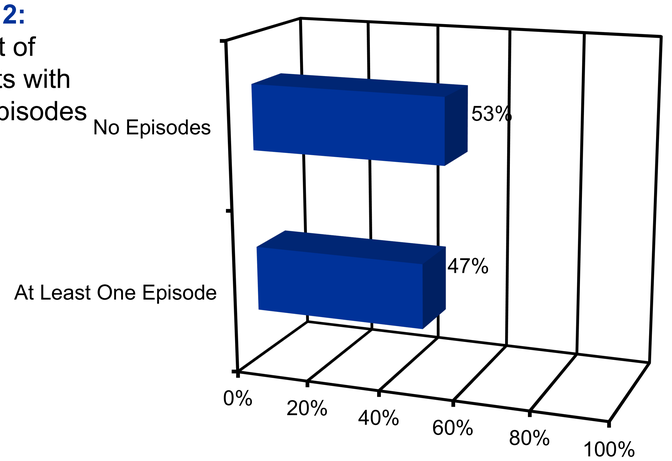


Table 2: Frequency and maximal duration of excessive heart rate (EHR) events during the stay.

Subject	Rehabilitation Impairment Category	Percent of Days with EHR Events	Longest Duration of an EHR Event (min)
1	Orthopedic Disorder	14%	1
2	Stroke	0%	0
3	Pulmonary Disorder	50%	6
4	Cardiac Disorder	11%	5
5	Debility	0%	0
6	Medically Complex Condition	45%	5
7	Stroke	11%	1
8	Stroke	0%	0
9	Lower Extremity Fracture	62%	16
10	Stroke	0%	0
11	Stroke	0%	0
12	Stroke	11%	2
13	Cardiac Disorder	0%	0
14	Stroke	0%	0
15	Stroke	0%	0
Average		14%	2.4

Figure 2: Percent of Subjects with EHR Episodes



Results

- 97,800 minutes of HR data were analyzed.
- 60% of subjects met the THR threshold for cardiorespiratory benefit (see Table 1 and Figure 1).
- Age was the single significant predictor of percent of days meeting THR threshold (R=0.58, p=.024).
- 47% of subjects experienced EHR episodes on at least one day (see Table 2 and Figure 2).
- No subjects experienced device-acquired skin breakdown or pressure ulcers, and no protocol deviations occurred from patients or staff removing the sensors.

Conclusions

- This is the initial study to illustrate that collection of HR continuously throughout an inpatient rehabilitation stay via wearable sensors is feasible, acceptable, and safe for assessing heart rate response to daytime therapy activities.
- There were no adverse events reported from long-term use, and no protocol deviations.
- Commercially-available activity monitors with HR-measurement capability have utility for providing long-term objective feedback about HR response in inpatient rehabilitation.