

Celebrate Freedom with Wearable Technology;
Individualized Data; and Remote Monitoring

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Trinity Rehabilitation Services



- **KardiaMobile and KardiaBand**
 - Track Atrial Fib with EKG
- **Hexoskin**
 - HR, Resp, Activity, Position
- **TempTraQ**
 - 48 hour stick on patch, worn on the underarm
 - Real time temp and alerts if exceeds normal range
- **iTBra**
 - Early detection of breast CA with bra insert-thermodynamic assessment
- **Abilify MyCite**
 - Send signal from pill’s sensor to wearable patch
- **Air Louisville**
 - Asthma Improvement with GPS enabled air quality sensor
- **Embrace smartwatch**
 - Monitor seizures and send alerts
- **Dexcom G6**
 - Continuous Glucose Monitors
- **Google Glass and Wound Care**



Quest: Improve Human Function

- **Balance Technology and Hands on Care**
- **Allow for living independently**
- **Increase or Maintain Function**
 - One of top reasons a person ‘moves’ to institutional setting (NH)
 1. Incontinence
 2. Function
 3. Safety/Memory
 4. Fall/Severe Injury



Quest: Improve Human Function

- **Wearable Tech and Remote Patient Monitoring (RPM)**
- **Leading Age Presentation in 2017**
 - J Patrick Bewley, Big Cloud Analytics
 - Function is one of primary reasons for rehospitalization
- **Function:**
 - Gait Speed
 - Activity
 - HR at night >150 bpm
 - Sleep pattern

➤ **When to intervene to improve**



Three Topics: One Focus—Improve Human Function

1. **Technology**
 - Exponential advances
 - Sensors
2. **Data**
 - When is a step...a step
 - Benchmarks and Trendlines
 - Data Security
3. **Remote Monitoring**
 - Individualized Care
 - Case Studies



Exponential Rate of Change in Technology

Moore's Law 1965 - Exponential



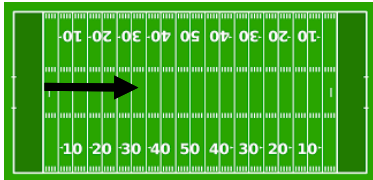
- The number of transistors on an affordable CPU doubles every two years

➤ More transistors=more calculating power

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Rate of Change in Technology

Linear
– 30 linear steps...
✓ ~30 meters



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Rate of Change in Technology

Exponential
– 30 exponential steps...
✓ More than 13 times around the earth!
✓ 536,870,912 meters



Step 1	1
Step 2	2
Step 3	4
Step 4	8
Step 5	16
Step 6	32
Step 7	64
Step 8	128
Step 9	256
Step 10	512
Step 11	1,024
Step 12	2,048
Step 13	4,096
Step 14	8,192
Step 15	16,384
Step 16	32,768
Step 17	65,536
Step 18	131,072
Step 19	262,144
Step 20	524,288
Step 21	1,048,576
Step 22	2,097,152
Step 23	4,194,304
Step 24	8,388,608
Step 25	16,777,216
Step 26	33,554,432
Step 27	67,108,864
Step 28	134,217,728
Step 29	268,435,456
Step 30	536,870,912

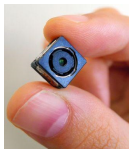
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Exponential Changes



1976 – First Digital Camera
0.01MP/ 8 lbs/ \$10,000

→

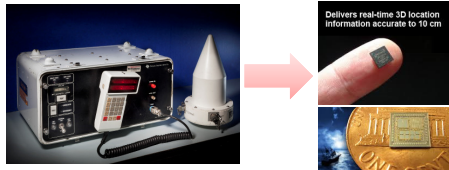


2014 – Digital Camera
>10MP/ 0.03 lbs/ \$10

~ 1 Billion Times Better
1,000x Resolution & 1,000x lighter & 1,000x cheaper

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Exponential Changes



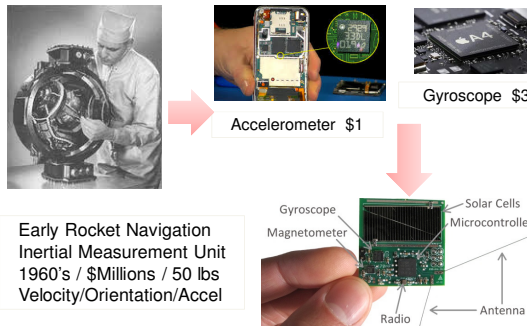
1981: 1st Commercial GPS Receiver
53 lbs / \$119,900

Single Chip GPS Receiver \$5

Delivers real-time 3D location information accurate to 10 cm

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Exponential Changes



Early Rocket Navigation Inertial Measurement Unit
1960's / \$Millions / 50 lbs
Velocity/Orientation/Accel

Accelerometer \$1

Gyroscope \$3

Gyroscope
Magnetometer
Solar Cells
Microcontroller
Radio
Antenna

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Change in Technology is Exponential

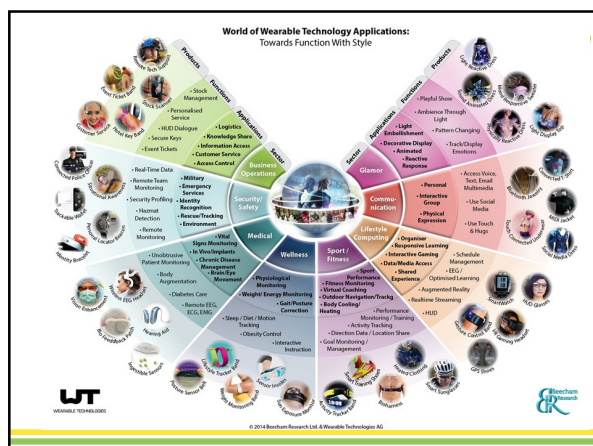


➤ 20 years later and these all fit in your pocket, on one device

- Smaller
- More Powerful
- Lower Cost

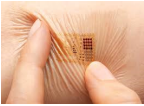


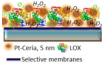
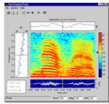
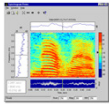




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Exponential Changes Technology: Sensors

- **Smaller, More accurate, Lower costs**


- **New types of sensors**
 - Chemical, Protein

- **Signal Processing and Pattern Recognition**
 - New algorithms for analysis and feedback

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Hardware: Sensors

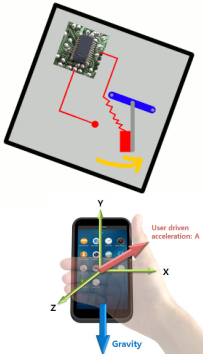
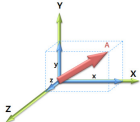
Good sensor:

1. Sensitive to the measured property,
2. Insensitive to any other property likely to be encountered in its application, and
3. Does not influence the measured property

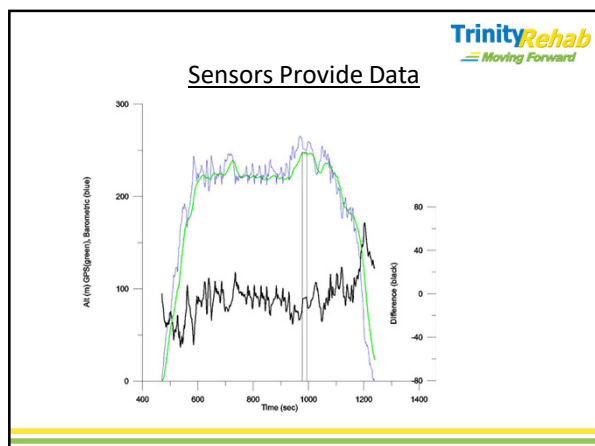
➤ **More than one type of sensor into a device**

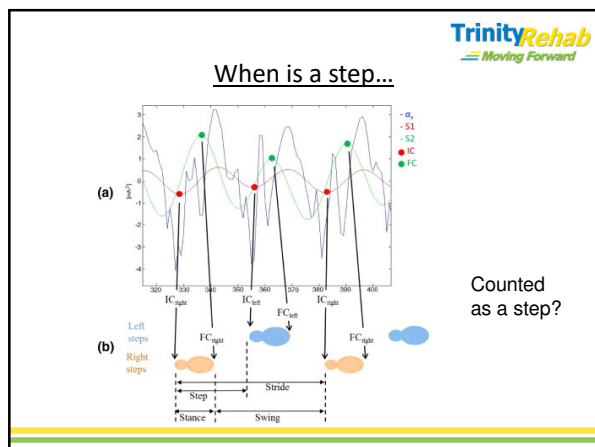
- 3d Accelerometer, Gyroscope, Altimeter, Bioimpedance
- Optical Sensor, Force, Pressure, Stretch, Temperature thermistor
- Piezoelectric (HR Monitoring),
- Photoplethysmography (Detection of blood volume)

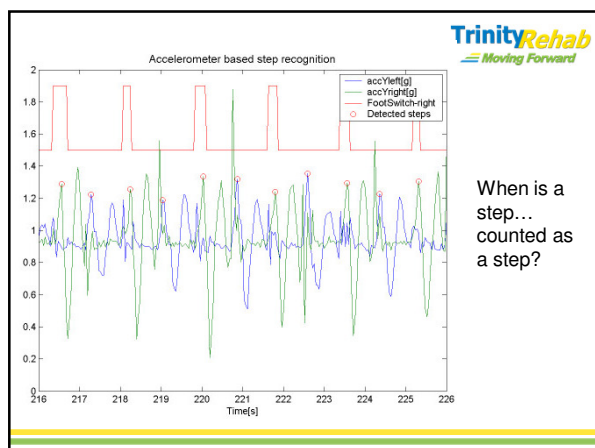
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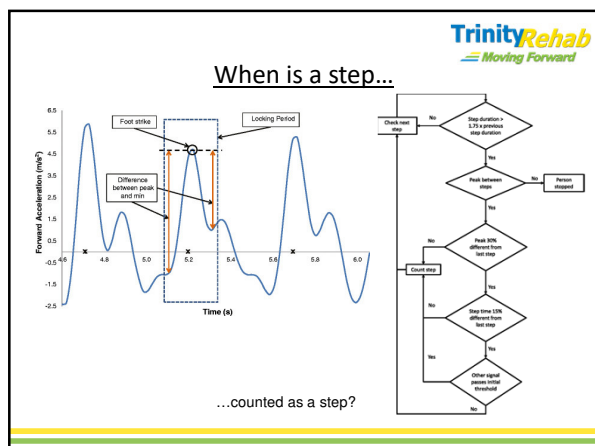



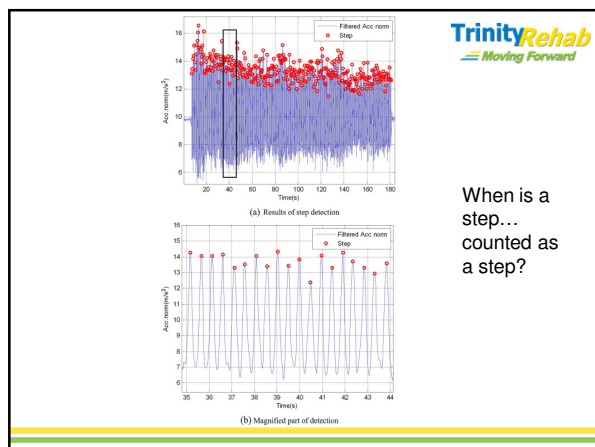
STEP RECORDED!

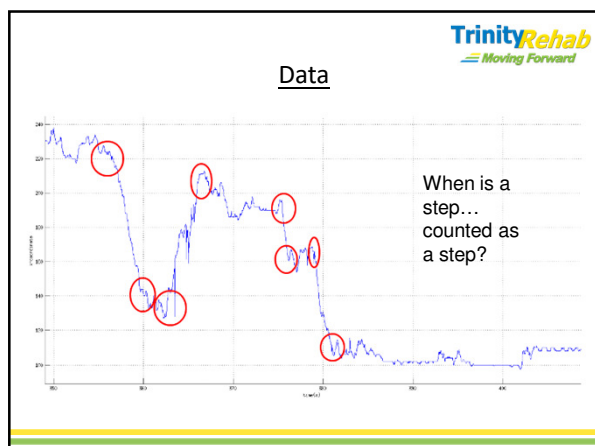












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When is a step... counted

Stepping up
In CNBC's unscientific test, we saw significant variance in our two days of testing.

	Test 1 = 2 hours	Test 2 = 500 steps
Apple Watch (1)	1,199	511
Apple Watch (2)	2,387	513
Fitbit Charge HR	1,949	505
Fitbit Flex	1,962	486
Garmin vivosmart HR	2,818	513
Jawbone UP3	2,099	479
Misfit Flash	1,872	446
Polar A360	2,127	513
Withings Pulse O ₂	1,592	507

Source: Big Crunch research. Note: Not a scientific study.

CNBC

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Which wearable?

- **Phone collects number of steps**
 - Wear in hip pocket vs carry in hand vs in 'arm pocket'
- **Watch more consistent than phone**
 - Dominant vs Non-Dominant
 - Change settings in device/app
- **StepWatch Activity Monitor**
 - 99% accurate at slow and irregular speeds
 - 99% accurate in people with COPD
 - 98% (unaffected) and 92% (affected) accurate in people with stroke
 - Harder to use
- **Consistent data, Battery life, Easy**



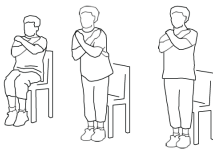
Bassett et al. Phys Ther Reviews. 2010
Bergman et al J Phys Act Health 2008
Cindy Ng et al. Disabil Rehabil. 2012
Coleman et al J Rehabil Res Dev 1999
Fulk et al Phys Ther 2014
Madko et al Med Sci Sports Exerc 2002

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Benchmarks and Trendlines

Instructions to the patient:

1. Sit in the middle of the chair.
2. Place your hands on the opposite shoulder crossed at the wrists.
3. Keep your feet flat on the floor.
4. Keep your back straight and keep your arms against your chest.
5. On "Go," rise to a full standing position and then sit back down again.
6. Repeat this for 30 seconds.

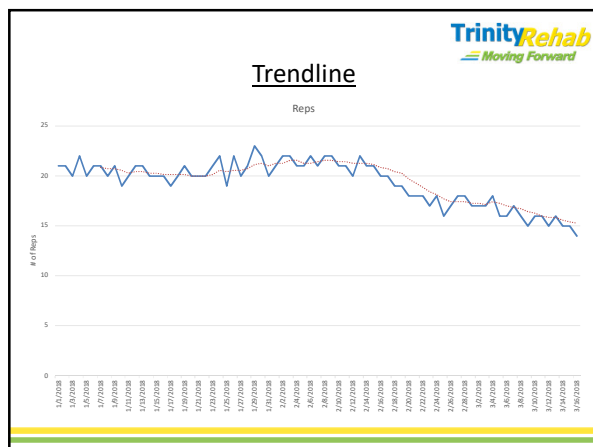


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Benchmark

Chair Stand—Below Average Scores

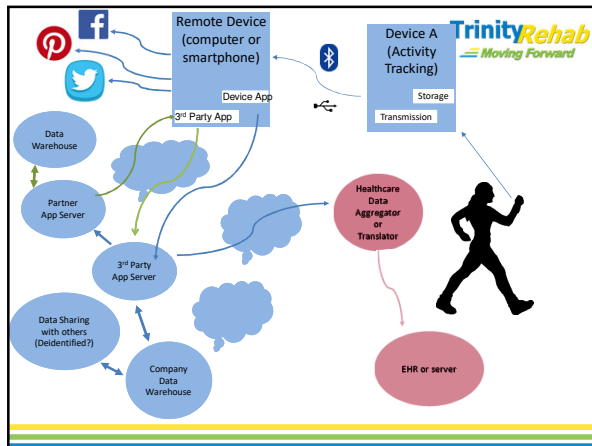
Age	Men	Women
60-64	< 14	< 12
65-69	< 12	< 11
70-74	< 12	< 10
75-79	< 11	< 10
80-84	< 10	< 9
85-89	< 8	< 8
90-94	< 7	< 4



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How do we get the data?

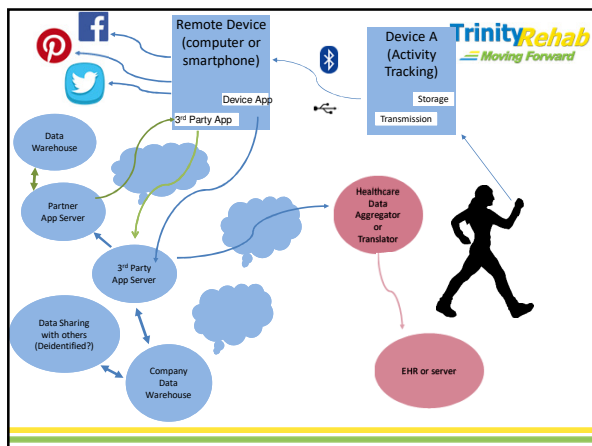
- **Data stored on device**
 - Show
 - Synch process (Push)
- **Data immediately sent to phone and then to database**
 - Continuous data transfer (Bluetooth or Wi-Fi) (Pull)
- **Auto-Share/Push or Push/Pull**
 - Multiple
 - EHR



Issue: Data privacy is everyone's responsibility

- **US FTC testing¹**
 - 12 mHealth and fitness apps
 - 76 different 3rd party companies
 - Phone unique device identifier; owners running route, dietary habits, and sleep patterns
- **Similar analysis of 43 fitness apps²**
 - 40% collecting 'high risk data' (address, financial info, full name, health info, location, DOB, zip code)
 - 55% sharing data with 3rd party analytical services

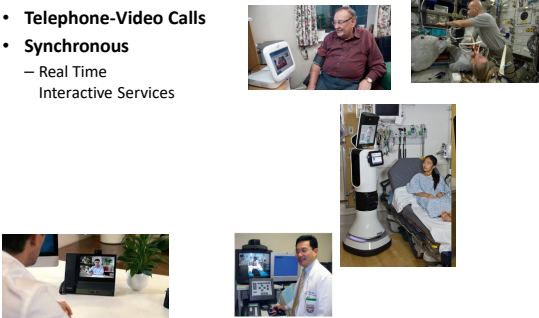
1. Steinhubl, SR, Muse, ED, Topol, EJ. The emerging field of mobile health. SearchHealthIT. April 15, 2015. Retrieved 4/3/2016 from <http://www.stslweb.org/wp-content/uploads/2015/04/Sci-Trans-Med-2015-Steinhubl.pdf>
2. Posted July 2013 and Revised December 2014. Retrieved 4/3/2016 from <https://www.privacyrights.org/mobile-health-and-fitness-apps-what-are-privacy-risks>



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TeleHealth, TeleMedicine, Tele...

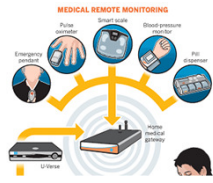
- **Telephone-Video Calls**
- **Synchronous**
 - Real Time Interactive Services



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TeleHealth... Not

- **Asynchronous**
 - Store and Forward
- **Remote Monitoring**
 - Interpretation of Data
 - Similar to Interpreting ECG or X-ray




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CMS and RPM Payment

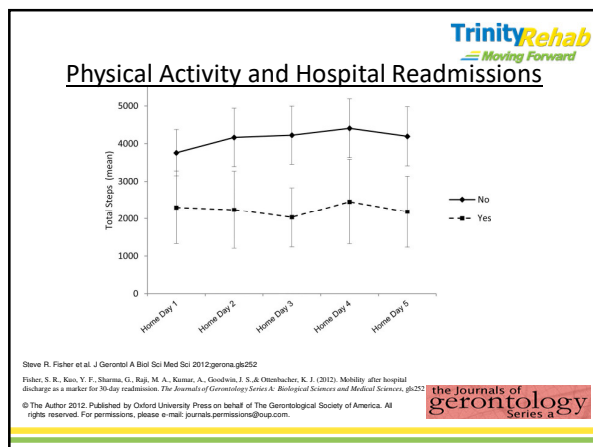
- **RPM is separate from Telehealth**
 - Can be from home
- **Jan 1, 2018: Remote Patient Monitoring**
 - CPT 99091 Collection and interpretation of physiologic data...requiring a minimum of 30 minutes of time...per 30 day period
- **Jan 1, 2019: Chronic Care Remote Physiologic Monitoring**
 - CPT 99453 Set-up and patient education on use of equipment
 - CPT 99454 Device(s) supply with daily recording(s) or programmed alert(s) transmission, each 30 days
 - CPT 99457 20 minutes or more of **clinical staff**/physician/other qualified healthcare professional time a calendar month requiring interactive communication with the patient/caregiver during the month
- **Jan 1, 2019 Home Health**
 - Allow costs on HH Cost Reports

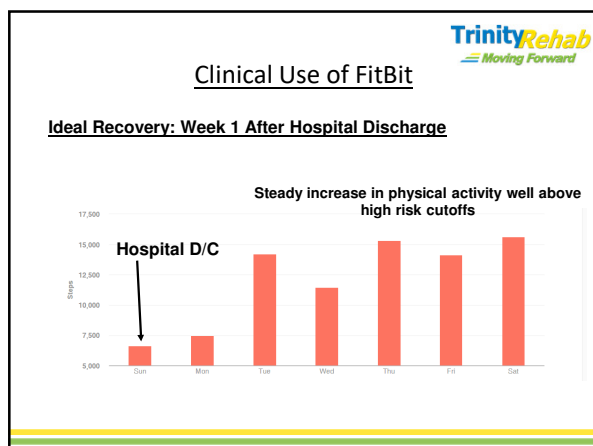
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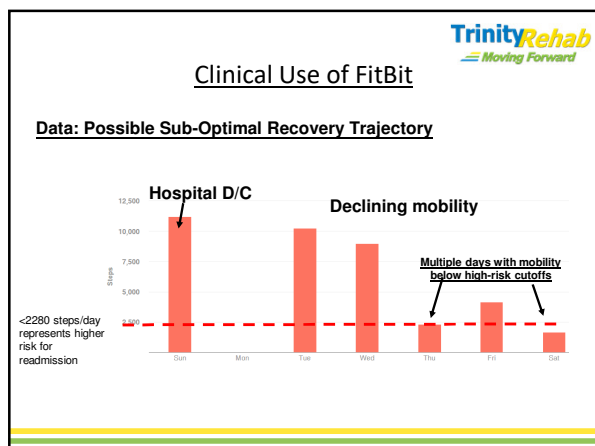
Avoidable Hospital Readmissions & Wearable Tech

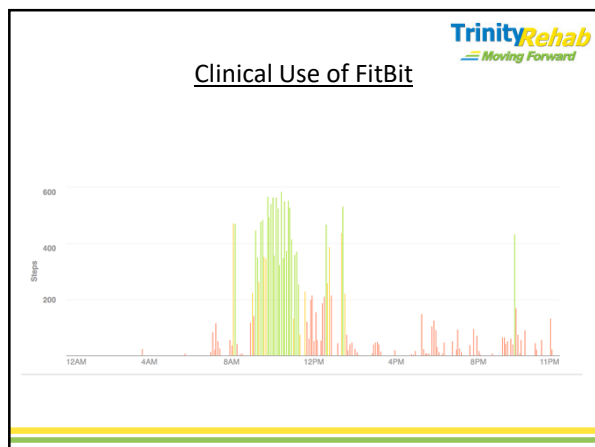
- **Function = major emerging quality indicator**
- **Impaired physical function and hospital-associated deconditioning are risk factors for hospital readmissions^{1,2}**

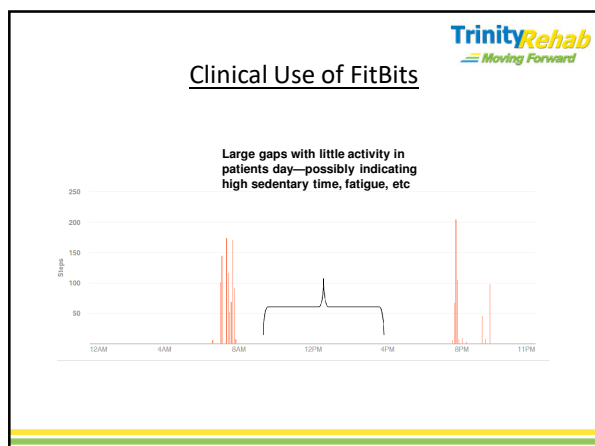
1. Falvey, J. R., Mangione, K. K., & Stevens-Lapsley, J. E. (2015). Rethinking hospital-associated deconditioning: proposed paradigm shift. *Physical Therapy*, 95(9), 1307-1315.
 2. Nguyen, H. Q., Chu, L., Amy Liu, I. L., Lee, J. S., Suh, D., Korotzer, B., ... & Gould, M. K. (2014). Associations between physical activity and 30-day readmission risk in chronic obstructive pulmonary disease. *Annals of the American Thoracic Society*, 11(5), 695-705.













Case Study 1

- 71 yo female, hosp admit d/t Resp infection
- Fitbit provided prior to DC and instruction to pt and family
- Pt seen by a PT 1 days post DC and 7 days post DC. Fitbit data synch to tablet. Progressing with rehab. Reported no other concerns
- Manager reviewed the activity data. Noticed downward trend in amount and intensity of activity.
 - Called pt to ask her if she had been wearing her device



Case Study 1

- Pt reports
 - Feeling a little unsteady when walking
 - Some mild abdominal pain, so she hadn't been as active. She attributed decreased activity to being tired from the PT sessions.
- Manager requested the PT schedule next visit early and re-evaluate these complaints
- PT notes decline in function and cognition
 - Calls MD who ordered lab testing
 - Dx of UTI



Case Study 1

- Unrecognized UTI may have led to a fall, ER visit, or unnecessary Hosp Adm
- Tracking physical activity level provided valuable clinical information

• Falvey, J. R., Mangione, K. K., & Stevens-Lapsley, J. E. (2015). Rethinking hospital-associated deconditioning: proposed paradigm shift. *Physical therapy*, 95(9), 1307-1315.
 • Fisher, S. R., Kuo, Y. F., Sharma, G., Raji, M. A., Kumar, A., Goodwin, J. S., & Ottenbacher, K. J. (2012). Mobility after hospital discharge as a marker for 30-day readmission. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences*, glz252.
 • Nguyen, H. Q., Chu, L., Amy Liu, L. L., Lee, J. S., Suh, D., Korotzer, B., ... & Gould, M. K. (2014). Associations between physical activity and 30-day readmission risk in chronic obstructive pulmonary disease. *Annals of the American Thoracic Society*, 11(5), 695-705.



Case Study 2

- 68 yo male, retired teacher
- Elevated lipids, HTN, obesity, CVD
- Sedentary lifestyle
- Type 2 Diabetic
- 5'7" and 268#
- Recommendation: Increase activity, monitor calorie intake, monitor sleep, work with RD, and diabetes educator
- Agreed to wear Fitbit and work with RD

Miller TW. Effectiveness of a Wearable Fitness Tracker: Practice Implications in Allied Health -- a Single Case Study. The Internet Journal of Allied Health Sciences and Practice. 2017 Jan 11;15(1), Article 3.



Case Study 2

- 2 week
 - Reports tracking steps as a motivator
 - Walking less than 1 mile/day (<1,000); Activity = 14 min/day; Calories = NA
- 12 weeks
 - Walking 1.39 miles/day (2991 steps); Activity = 23 min/day; Calories = 1,571
 - Sleep avg 6 hr 5 min
- 36 week
 - Walking 4.15 miles/day (8931 steps); Activity = 64 min/day; Calories = 2,758
 - Sleep avg 8 hr 8 min
 - 22# wt loss

➤ Most underestimate caloric intake and overestimate physical activity



Technology

- Alexa, Echo, Siri, etc
- Devices to measure BP (24x7) and movement too
- Device that measures HR and respiration of everyone in the room --from across the room
- Sensor pads under mattress to measure sleep, HR, Location
- SensFloor. Install below all kinds of flooring--Capacitive sensor floor
 - Measure number of people, direction, gait speed, detect falls, & control: music+









Quest: Improve Human Function

- **Balance Technology and Hands on Care**
- **Wearables and Remote Monitoring**
 - Function
 - Gait Speed
 - Activity level
 - High HR at night
 - Sleep pattern

➤ **When to intervene to improve function**



This is why...







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