Evidence For Clinical and Research Walking Activity Measurement in Cerebral Palsy with the StepWatch (SW)

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I will not discuss off label use and/or investigational use in my presentation.

Objectives:
- Understand validity & accuracy of the SW strides taken in typically developing children/youth (TDCY) & with CP.
- Understand the walking activity levels and intensity of TDCY & with CP.
- Examine evidence for SW monitoring duration by Gross Motor Function Level (GMFCS) in children/youth with CP.
- Exemplars- clinical & research SW application in children with CP.
Physical Activity

Walking Activity

When we are not looking... how and how much are they walking?

Terminology:

- **Walking Activity (WA)** – step or stride taken for mobility, depending on device may be "step" or stride
  - **Step** - counts both left and right steps
  - **Stride** – step of one leg/side-3DG lab
Relationship of Stride Activity to Mobility-based Life Habits in Children with Cerebral Palsy (Bjornson, 2013)

- Average total strides/day was positively associated with the Personal Care, Housing, Mobility, and Recreation Life-H categories.

- Moderate/High walking stride rates (Ave > 30 stride/min/day) was associated with all categories

- Walking activity performance is significantly associated with levels of participation in mobility-based life habits for ambulatory children with CP.
Why the StepWatch?

ActiGraph: child with Spastic Diplegia

Stott, Mackey, 2011

StepWatch was the Most Accurate in Real World Walking

Pediatric StepWatch Accuracy/Precision & comparison to Pedometers:

- Mitre et al (2009) - treadmill trial
  - Lean and obese children
  - Omron and Digiwalker pedometers undercounting compared to manual counts (worse at slower speeds)
  - StepWatch had negligible error to manual counts of steps taken

StepWatch Accuracy to Observed Strides: TDY

- 20 normally developing children
- Age groups
  - 5-7 years & 9-11 years
- 3 - Two week intervals: 2 months apart
- Comparison manual counts
  - Walking 96-97%
  - Running 99%

Song K. J Peds Ortho, 26: 245-249;2006
StepWatch
- Two dimensional accelerometer
- Detects foot leaving the surface
- Completely sealed
- Worn with strap or ankle cuff
- Continuously records steps/time interval
- Up to two months duration
- AKA "SAM", "StepWatch3" and "GAM"
- www.modushealth.com

NEW UPDATE 2018
StepWatch 4 (SW4)-Activity Monitor
- $400 ea with iPad app
- App $1300 1x
- Additional $ monthly cloud-based
- rechargeable
- SW4 available 2018

support@modushealth.com

Seattle Clinical/Research SW Monitoring Guidelines
- Individually Set:
  - Sensitivity
  - Cadence
- Pre/Post intervention
- Wearing 7 to 14 days
- Analyze 5 to 14 days
- Depends on clinical question
StepWatch: How many days monitored

- TDY (n= 428, ages 2- 13 yrs) (Kang 2014)
  - Need to monitor ave 4.14 days
  - (range 3 to 6 by days 2 year age bands)

- Children with CP: (n=209) (Ishikawa, 2013)
  - GMFCS:
    - Level I 6 days
    - Level II 5 days
    - Level III 4 days

Kang et al Phys Meas. 2014
Ishikawa et al APRM. 2013

What do we know about walking with SW in TDY?

Measurement of Walking Activity throughout Childhood:
Influence of Leg Length
Bjornson et al, Ped Ex Sci 2010
Sample:

- 428 TDY children
- ages 2 to 15 years
- 30 boys / 30 girls per age group
- 7 groups of 2 year increments
- Calibration Accuracy: ave 100%
  - (range 90-112, sd 4.0)

<table>
<thead>
<tr>
<th>Age Group (yrs)</th>
<th>Gender (n)</th>
<th>Average Stride/Day</th>
<th>60-min peak</th>
<th>20-min peak</th>
<th>1-min peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-3</td>
<td>Boys (30)</td>
<td>8,159 (2,677)</td>
<td>28 (8)</td>
<td>40 (8)</td>
<td>70 (7)</td>
</tr>
<tr>
<td></td>
<td>Girls (30)</td>
<td>7,837 (1,771)</td>
<td>28 (5)</td>
<td>39 (7)</td>
<td>73 (10)</td>
</tr>
<tr>
<td></td>
<td>Total (60)</td>
<td>7,998 (2,257)</td>
<td>28 (7)</td>
<td>39 (8)</td>
<td>72 (7)</td>
</tr>
<tr>
<td>4-5</td>
<td>Boys (31)</td>
<td>9,411 (3,214)</td>
<td>30 (8)</td>
<td>44 (10)</td>
<td>71 (6)</td>
</tr>
<tr>
<td></td>
<td>Girls (31)</td>
<td>8,726 (1,992)</td>
<td>29 (6)</td>
<td>41 (8)</td>
<td>71 (7)</td>
</tr>
<tr>
<td></td>
<td>Total (62)</td>
<td>9,069 (2,674)</td>
<td>29 (7)</td>
<td>42 (9)</td>
<td>71 (7)</td>
</tr>
<tr>
<td>6-7</td>
<td>Boys (32)</td>
<td>9,880 (3,067)</td>
<td>31 (7)</td>
<td>43 (7)</td>
<td>70 (7)</td>
</tr>
<tr>
<td></td>
<td>Girls (30)</td>
<td>9,083 (2,492)</td>
<td>29 (5)</td>
<td>42 (6)</td>
<td>70 (6)</td>
</tr>
<tr>
<td></td>
<td>Total (62)</td>
<td>9,764 (2,510)</td>
<td>30 (6)</td>
<td>43 (6)</td>
<td>70 (7)</td>
</tr>
</tbody>
</table>
Basis for Pediatric Walking Intensity
Cut-points for StepWatch (SW)

- Intense walking adult US population documented peak step/min rate of 101 (Tudor-Locke, 2012)
- Intense walking bursts for children (< 18 years of age) are documented at 108 to 146 peak steps/min rates (10-12). (Barreira, 2012; Bjornson 2010; Tudorlocke, 2002)
- Moderate to vigorous physical activity (MVPA) = 120 step/min -10 to 14 y/o boys and girls with another pedometer (Graser, 2011)
- "High" intensity walking for StepWatch > 60 stride/min- as it counts only one leg.
Walking activity with StepWatch in children with CP?

**Neuromuscular Scoliosis (VEPTR) TDY**
### Ambulatory Physical Activity Performance in Youth with Cerebral Palsy & Youth Developing Typically

<table>
<thead>
<tr>
<th></th>
<th>CP  (n=81)</th>
<th>TDY  (n=30)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average step/day</td>
<td>4,222</td>
<td>6,739</td>
<td>.000</td>
</tr>
<tr>
<td>% All Time Active</td>
<td>40.2</td>
<td>49.6</td>
<td>.000</td>
</tr>
<tr>
<td>Ratio Medium to low Activity</td>
<td>.33</td>
<td>.47</td>
<td>.000</td>
</tr>
<tr>
<td>% Time High Activity</td>
<td>5.6</td>
<td>9.7</td>
<td>.000</td>
</tr>
</tbody>
</table>

#### Activity Capacity Functional Categories

- **TDY to levels I, II & III p <.001, TDY to level I p=.04, Level I to II p<.001, Levels I & II p=.001, Level II to III p<.001**

#### Walking activity patterns in youth with cerebral palsy and youth developing typically

- Compared walking with StepWatch
- 5 days of monitoring
- 209 youth with CP
- 368 TDY
- Ages 2-13 years

#### Intensity:

- Low: 1-30 stride/min
- Moderate: 31-60 stride/min
- High: >60 stride/min
Walking activity patterns in youth with cerebral palsy and developing typically

Low (1-30) Mod (31-60) High > 60

TDY GMFCS level I GMFCS level II GMFCS III

Low (1-30) Mod (31-60) High > 60

TDY GMFCS level I GMFCS level II GMFCS III

Low (1-30) Mod (31-60) High > 60

TDY GMFCS level I GMFCS level II GMFCS III
Clinical/Research Exemplars: StepWatch Measurement:
- Longitudinal monitoring-
  * Scoliosis
  * Diplegia (multiple interventions)
- Treadmill training
- Orthotics
- SW combined with GPS-community mobility

Neuromuscular Scoliosis (VEPTR): Average Steps/Day
Average steps/day:
CP Spastic diplegia 8 y/o -GMFCS II

Walking intensity: CP-GMFCS II

Short-burst interval treadmill training walking capacity & performance in cerebral palsy: a pilot study

Bjornson, et al Dev Neurorehab 2018
Funding:
R21HD077186- NICHD/NICMR
Average Strides/day at baseline, post SBLTT and 6 weeks post SBLTT (n=12).

<table>
<thead>
<tr>
<th>Walking Performance</th>
<th>BL Mean (SD)</th>
<th>Post 1 Mean change</th>
<th>p value</th>
<th>Post 2 Mean change</th>
<th>p value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Total Steps/day</td>
<td>2677 (1060)</td>
<td>+1712 &lt;.001</td>
<td></td>
<td>+948 &lt;.00</td>
<td></td>
</tr>
<tr>
<td>Percent Time walking</td>
<td>37.1 (9.5)</td>
<td>+7.68 .006</td>
<td></td>
<td>+4.89 .55</td>
<td></td>
</tr>
<tr>
<td>Percent Time &gt; 30 steps/min (Mod/High)</td>
<td>8.37 (4.0)</td>
<td>+4.4 .04</td>
<td></td>
<td>+3.8 .04</td>
<td></td>
</tr>
<tr>
<td># Step &gt; 30 steps/min</td>
<td>8245 (442)</td>
<td>+991 &lt;.001</td>
<td></td>
<td>+627 &lt;.00</td>
<td></td>
</tr>
<tr>
<td>Peak Activity Index (ave top 30 one min)</td>
<td>33.9 (5.4)</td>
<td>+9.4 &lt;.001</td>
<td></td>
<td>+6.1 &lt;.00</td>
<td></td>
</tr>
<tr>
<td>Max # steps 60 mins</td>
<td>13.2 (4.2)</td>
<td>+5.8 .006</td>
<td></td>
<td>+4.2 &lt;.00</td>
<td></td>
</tr>
<tr>
<td>Max # steps 20 mins</td>
<td>22.9 (4.3)</td>
<td>+7.3 &lt;.001</td>
<td></td>
<td>+7.1 &lt;.00</td>
<td></td>
</tr>
</tbody>
</table>
Orthotic Intervention: Walking Activity with StepWatch

SW Orthotics: n= 8 diplegia

Average # of Strides/day- low, mod & high

Fig. 4. Average strides/day current AFO versus AFO-FC.

4 y/o, spastic diplegia CP:
Average # of Strides/day- low, mod & high
4 y/o, spastic diplegia CP: Average # of Strides/day- low, mod & high

TDY (n=62, 4-5 y/o)

4 y/o, AFO- OFF

4 y/o, AFO- ON

What are they really doing?
Community Walking Activity in Cerebral Palsy: StepWatch & Global Positioning System (GPS)


Funding:
SCRI CHBD Stimulus Fund 2013
NIH R21 HD077186
Stride count intensity home/community (low, med, high), pre/post Interval Treadmill training (n=1)

Percent walking time-home/community, pre/post Interval Treadmill Training (n=12)
**StepWatch - Take Home**

- Highest accuracy to strides taken of current devices
- Published normative data for TDCY
- Emerging data for children with CP
- Evidence- Monitoring duration
  - GMFCS level
    - I = 6 days; II = 5 days; III = 4 days
- Pediatric cut points for intensity analysis

**Potential SW Clinical/Research Applications**

- **PRE/POST**
  - New assistive device/orthotics
  - Botox L/E/serial casting
  - Ortho surgery- SEML and Spinal
  - SDR
  - Oral medication movement disorders
  - Dose change of ITB pump
  - Burst of therapy (OT/PT)

**QUESTIONS ?**
References:


