Tools for Population Level Assessment of Physical Activity

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Overview

- Key Definitions
- Conceptual Framework
  - Dimensions/Features of Physical Activity
- Self Report Methods
- Objective Measures
  - Wearable sensors
- Global Efforts to Collect Physical Activity Data
- Future Directions – Research Priorities
Physical Activity as a Latent Construct

- Biomechanical
- Physiological
- Behavioural

Physical Activity
Physical Activity

Biomechanical
Physiological/EE
- O₂ and CO₂
- HR
- Ventilation
- Lactate
- Sweat/GSR
- Heat/Body Temp

Behavioural

- Absolute Intensity (METy)
- Relative Intensity
Physical Activity

- Biomechanical
- Physiological
- Behavioural
  - Flailing / Kicking
  - Tummy Time
  - Crawling
  - Energetic Play
  - Walk
  - Run
  - FMS’s
  - Sport
  - Recreation
  - Self-Care
  - Household Chores

- Type or Mode
- Context
- Domain
Physical Activity

Biomechanical
• Velocity
• Acceleration
• Force
• Loading
• Rotation
• Posture / Tilt
• Δ Location
• Δ Elevation
• Δ Proximity

Physiological

Behavioural
Biomechanical and Behavioural Indicators of PA are also linked or calibrated to EE units.
### Indicators of PA

#### Biomechanical
- Velocity
- Acceleration
- Force
- Rotation
- Posture / Tilt
- $\Delta$ Location
- $\Delta$ Elevation

#### Physiological
- $O_2$ and $CO_2$
- HR
- Ventilation
- Lactate
- Sweat/GSR
- Heat/Body Temp
- Energy Intake

#### Behavioural
- Flailing / Kicking
- Tummy Time, Crawling
- Energetic Play
- Walk, Run, FMS’s
- Sport Recreation
- Self-Care, Chores

#### Measures
- Accelerometer
- Gyroscope
- Magnetometer
- GPS
- Barometer
- IR Light Sensor
- Force Plate
- Room Calorimeter
- Portable Calorimeter
- Lactate analyser
- HR monitors
- GSR Sensor
- Contact Thermometry
- DLW
- Direct Observation
- Image recognition
- EMA
- Diaries & Logs
- Recalls
Hitchhiker's guides:
Recall Surveys

- Self-completed or interview administered
- Recall periods range from 1 day to lifetime
- Low cost, low subject burden, non-reactive
- Most popular tool for population surveys and epidemiological studies
- Subject to recall problems and reporting bias
- Poor validity in children < 10 yrs
- Parent-reported PA subject to limitations
- **Reliability:**
  - Same day ICC = 0.88, 1 month ICC = 0.53

- **Validity:**
  - Self Report = 4.8 ± 2.0 days
  - Accelerometer MVPA = 85 ± 30 mins
  - $r = 0.40$
  - Guideline: SR vs. Acc: 53% vs. 79%
  - Acc = 63%, Se = 71%, FP = 40%
15-year-old girls who report at least 60 minutes of MVPA daily

Legend:
- 25% or more
- 20–25%
- 15–20%
- 10–15%
- Less than 10%
- No data
Validation of a 24-h physical activity recall in indigenous and non-indigenous Australian adolescents


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Keywords: Exercise; Assessment; Physical Activity; Pedestrian; Children; Youth

Put a “✓” to rate the intensity of each activity

Write activity numbers in this column

<table>
<thead>
<tr>
<th>Activity Numbers</th>
<th>Light</th>
<th>Moderate</th>
<th>Hard</th>
<th>Very Hard</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before School</td>
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<td></td>
<td></td>
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<tr>
<td>7:00 – 7:30</td>
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<tr>
<td>During School</td>
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<tr>
<td>7:30 – 8:00</td>
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<tr>
<td>8:00 – 8:30</td>
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<td>8:30 – 9:00</td>
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<td>10:30 – 11:00</td>
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<tr>
<td>11:00 – 11:30</td>
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</tr>
</tbody>
</table>

12:00-13:00

12

During School

12:00-13:00

Very Hard

PDPAR/3DPAR: http://www.asph.sc.edu/USC_CPARG/instruments.html
YOUTH COMPRENDIUM of PHYSICAL ACTIVITIES

<table>
<thead>
<tr>
<th>METy Code</th>
<th>Activity Category</th>
<th>Specific Activity</th>
<th>Ages 6-9</th>
<th>Ages 10-12</th>
<th>Ages 13-15</th>
<th>Ages 16-18</th>
</tr>
</thead>
<tbody>
<tr>
<td>10100X</td>
<td>Active Play</td>
<td>Ball Games - Bouncing, Kicking, Dribbling Ball, Reaction Ball (Moderate Intensity)</td>
<td>6.0</td>
<td>6.2</td>
<td>6.3</td>
<td>6.5</td>
</tr>
<tr>
<td>10120X</td>
<td>Active Play</td>
<td>Ball Games - Bouncing, Kicking, Dribbling Ball, Reaction Ball (Vigorous Intensity)</td>
<td>6.1</td>
<td>6.3</td>
<td>6.4</td>
<td>6.6</td>
</tr>
<tr>
<td>10140X</td>
<td>Active Play</td>
<td>Dodgeball Type Games (E.G., Castles, Hot Feet)</td>
<td>5.8</td>
<td>6.0</td>
<td>6.1</td>
<td>6.3</td>
</tr>
<tr>
<td>10160X</td>
<td>Active Play</td>
<td>Free Play (Basketball, Rope, Hoop, Climb, Ladder, Frisbee)</td>
<td>5.7</td>
<td>5.9</td>
<td>6.0</td>
<td>6.1</td>
</tr>
</tbody>
</table>

https://www.nccor.org/tools-youthcompendium/
Global Matrix 3.0 Physical Activity Report Card Grades for Children and Youth: Results and Analysis From 49 Countries


Released in Adelaide, Australia on November 27, 2018, the Global Matrix 3.0 is the most comprehensive assessment of global variation in child and youth physical activity.

https://www.activehealthykids.org/

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Objective Measures of PA

- Direct Observation
- DLW
- HR monitoring
- Accelerometers
- Pedometers

- Avoid problems with recall limitations & bias
- Capture incidental PA
- Better estimates of EE
- Limited data on Mode and Context
- Lack of consensus on methods
- Difficult to use in large studies
Accelerometers

- Measure movement associated with performing physical activity
- Detected in one, two, or three planes
  - Vertical
  - Antero-posterior
  - Medio-lateral

Conversion of acceleration signal to “counts”
Deriving Intensity-Related Cut-Points

![Graph showing activity counts and METS relationship](image)

- Sensitivity: 85.7
- Specificity: 88.3
- Criterion: >418

![Receiver Operating Characteristic (ROC) curve with ActiGraph](image)
Proportion of children meeting recommendations for 24-hour movement guidelines and associations with adiposity in a 12-country study

Roman-Vinas et al. IJBNPA 2016;13:123

Objectively measured physical activity and sedentary time in youth: the International children’s accelerometry database (ICAD)

Cooper et al. IJBNPA 2015;12:113
Meeting Daily MVPA Guideline

Roman-Vinas et al. IJBNPA 2016;13:123
Fig. 4 Achievement of physical activity guidelines across selected countries. 

a Average percentage of participants achieving ≥60 min of MVPA each measurement day.

b Average percentage of days on which ≥60 min of MVPA were recorded.
Evenson: 67% Agreement Kappa = 0.67 (0.66 – 0.70)

Activity Recognition: Hip vs. Wrist 30 Hz

Overall Accuracy Hip = 91.0 ± 0.3 %
Overall Accuracy Wrist = 88.4 ± 0.3%

Relative Advantage: EE Prediction

Two-Step Algorithm for Estimating EE from Wrist Accelerometer Data in Youth
Future Directions & Priorities

- Development of a standardized global surveillance system of physical activity and related indicators among children and youth.

- Harmonization of signal processing methods and modeling of wearable sensor data for prediction of physical activity outcomes.
THANK YOU!
<table>
<thead>
<tr>
<th>Physical Activity</th>
<th>Exercise</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Bodily movement via skeletal muscles</td>
<td>• Bodily movement via skeletal muscles</td>
</tr>
<tr>
<td>• Results in energy expenditure</td>
<td>• Results in energy expenditure</td>
</tr>
<tr>
<td>• Energy expenditure varies continuously from low to high</td>
<td>• Energy expenditure varies continuously from low to high</td>
</tr>
<tr>
<td>• Positively correlated with physical fitness</td>
<td>• Very positively correlated with physical fitness</td>
</tr>
<tr>
<td></td>
<td>• Planned, structured and repetitive bodily movement</td>
</tr>
<tr>
<td></td>
<td>• An objective is to improve or maintain physical fitness component(s)</td>
</tr>
</tbody>
</table>

Caspersen CJ, Powell KE, Christenson GM Public Health Reports 1985;100:126-131
Pattern Recognition Requires:

- A sensor that gathers data to be classified or described.
- A feature extraction mechanism that computes numeric information from the observations (window).
- An algorithm (model) that is trained to perform the task of classification or prediction (e.g. Regression, SVM, ANN, Decision Tree, Logistic Regression).
Average MVPA – Accelerometer

Roman-Vinas et al. IJBNPA 2016;13:123