Advances in Physical Activity and Cardiometabolic Risk in American Indian and Alaskan Native Health

2016

RALPH LAFORGE, MSC, FNLA, CLS
DUKE UNIVERSITY MEDICAL CENTER
ENDOCRINE, METABOLISM, & NUTRITION DIVISION
DURHAM NC
Agenda

• 2016 ACSM Exercise Screening Guidelines
• Fitness activity trackers: Fitbit vs the rest
• The value of light-intensity exercise
• Fitness vs physical activity
• Energy cost of activities: estimating caloric expenditure
• Assessment of CV fitness vs PA
• Select research topic
Point Summary

• New guideline for assessing PA program participation eliminates CVD risk factors

• PA trackers record steps the best, EE the least

• Light intensity exercise generates CMR benefits

• Fitness best predicts risk, PA best predicts behavior

• Exercise energy cost must to consider NET cost, compensation, conservation

• Statins can affect exercise performance – Rx to prevent
Updating ACSM’s Recommendations for Exercise Preparticipation Health Screening

DEBORAH RIEBE¹, BARRY A. FRANKLIN², PAUL D. THOMPSON³, CAROL EWING GARBER⁴, GEOFFREY P. WHITFIELD⁵, MEIR MAGAL⁶, and LINDA S. PESCATELLO⁷

¹Department of Kinesiology, University of Rhode Island, Kingston, RI; ²Department of Preventive Cardiology, Beaumont Health Center, Royal Oak, MI; ³Department of Cardiology, Hartford Hospital, Hartford, CT; ⁴Teachers College, Columbia University, New York, NY; ⁵No affiliation; ⁶Division of Mathematics and Sciences, North Carolina Wesleyan College, Rocky Mount, NC; and ⁷Department of Kinesiology, University of Connecticut, Storrs, CT
Physical Activity

Recommendations for Physical Activity

- Document patients' level of physical activity at diabetes visits and encourage individuals to set behavioral goals to begin or increase physical activity.

- Assess patients for medical conditions that might affect the type, frequency, and intensity of physical activity in which they engage:
  
  * Some patients may require screening and additional testing before starting a physical activity program. See the American College of Sports Medicine (ACSM) Guidelines for Exercise Testing and Prescription: [Decision Tree Figure](#) [PDF - 43KB]

- When available, referral to a fitness specialist for supervision and coaching is highly recommended. There are fitness specialists and programs available in many AI/AN communities.
Decision Tree Figure: Screening for Exercise

Risk Stratification

Low Risk
Asymptomatic
≤ one (1) total risk factor

Moderate Risk
Asymptomatic
≥ two (2) total risk factors

High Risk
Symptomatic, or known diabetes, cardiac, pulmonary, or metabolic disease

Medical exam and ECG before exercise?

Moderate exercise: Not necessary
Vigorous exercise: Not necessary

Moderate exercise: Not necessary
Vigorous exercise: Recommended

Moderate exercise: Recommended
Vigorous exercise: Recommended

Moderate Exercise: Indicates 40-60% of aerobic capacity; three to six (3-6) metabolic equivalents (METs).

Vigorous Exercise: Indicates > 60% of aerobic capacity; > six (6) metabolic equivalents (METs).

Not Necessary: A medical examination, exercise test, and physician supervision of exercise testing would not be essential in the pre-participation screening; however, they should not be viewed as inappropriate.

Recommended: When physician supervision of exercise testing is “Recommended,” the physician should be in close proximity and readily available should there be an emergent need.
New Logic Model for PA Program Screening
New ACSM Guideline Logic Model
ACSM 2016

No CV, Metabolic or Renal Disease

**AND**
No Signs or Symptoms Suggestive of CV, Metabolic, or Renal Disease

Known CV, Metabolic or Renal Disease

**AND**
Asymptomatic

Any Signs or Symptoms Suggestive of CV, Metabolic, or Renal Disease

(Regardless of disease status)

Medical Clearance Not Necessary

Medical Clearance Recommended

Medical Clearance Recommended

Light to Moderate Intensity Exercise Recommended

May Gradually Progress to Vigorous Intensity Exercise Following ACSM Guidelines

Following Medical Clearance, Light to Moderate Intensity Exercise Recommended

May Gradually Progress as Tolerated Following ACSM Guidelines

Following Medical Clearance, Light to Moderate Intensity Exercise Recommended

May Gradually Progress as Tolerated Following ACSM Guidelines

Participants in Research
ACSM 2016

- No CV†, Metabolic‡‡, or Renal Disease AND No Signs or Symptoms§§§ Suggestive of CV†, Metabolic‡‡, or Renal Disease
  - Medical Clearance**** Not Necessary
  - Continue Moderate** or Vigorous*** Intensity Exercise
    - May Gradually Progress Following ACSM Guidelines

- Known CV†, Metabolic‡‡, or Renal Disease AND Asymptomatic
  - Medical Clearance**** for Moderate Intensity Exercise Not Necessary
  - Medical Clearance (within the last 12 months if no change in signs/symptoms) Recommended Before Engaging in Vigorous*** Intensity Exercise
  - Continue with Moderate** Intensity Exercise
    - Following Medical Clearance, May Gradually Progress as Tolerated Following ACSM Guidelines

- Any Signs or Symptoms§§§ Suggestive of CV†, Metabolic‡‡, or Renal Disease
  - (Regardless of disease status)
  - Discontinue Exercise and Seek Medical Clearance
  - May Return to Exercise Following Medical Clearance
    - Gradually Progress as Tolerated Following ACSM Guidelines
Q: What changed in the recommendations for exercise preparticipation health screening?
A: An expert panel proposed a new evidence-informed model for exercise preparticipation health screening based on three factors:
- The individual’s current level of physical activity
- Presence of signs, symptoms and/or known cardiovascular, metabolic or renal disease
- Desired exercise intensity.

The new recommendations no longer include the cardiovascular disease (CVD) risk factor profile as part of the decision-making for referral to a health care provider prior to the initiation of a moderate-to-vigorous intensity exercise program.

Additionally, the recommendations no longer utilize a low/moderate/high risk classification scheme. It makes general recommendations for medical clearance versus specific recommendations for medical exams or exercise tests. The manner of clearance is left to the discretion of the health care provider and does not automatically refer individuals with pulmonary disease for medical clearance prior to the initiation of an exercise program.
The **Big Three** when screening someone for and exercise program:

- Current level of activity
- Presence of symptoms
- Desired/planned exercise intensity

*These best predict exercise-generated CV complications, etc.*
CVD risk factor assessment is out! Why?

Two important considerations led to removing CVD risk factor assessment from the new ACSM exercise *preparticipation health screening process*.

1. The high prevalence of CVD risk factors among adults, combined with the extreme rarity of exercise-related SCD and AMI, suggests that the ability to predict these rare events by assessing CVD risk factors is low (42).

For example, the Centers for Disease Control and Prevention estimate that 65 million US adults have hypertension and 71 million adults have high LDL cholesterol. In contrast, 600,000 people die from heart disease each year and only a small fraction of those are due to exercise-associated SCD and AMI. Therefore, using CVD risk factors to identify those susceptible to exercise-associated SCD or AMI as ACSM has done in the past is unlikely to be effective in achieving its intended purpose.
2. Recent evidence suggests that conventional CVD risk factor-based exercise preparticipation health screening may be overly conservative because of the high prevalence of CVD risk factors.

A recent study found that 95% of men and women over 40 yr of age would be advised to consult a physician before exercise based upon the previous risk factor-based exercise preparticipation health screening process (48).
Current level of physical activity
Importance of frequent PA

Mittleman et al. NEJM 1993
Physical Activity & Risk of CVD Events

✓ The risk of acute heart attack for habitually inactive individuals was 50 times higher than that for the most physically active individuals (Figure).

Regular exercise reduces the 24-h risk of CVD events by approximately 50%, meaning that the regular exercisers relative risk is significantly lower during both vigorous-intensity exercise and over the remainder of the day, highlighting the clear net benefit of regular physical activity.

Medical Clearance

The term “medical clearance” has replaced specific recommendations for a medical examination or exercise test because it should be *the health care provider* who decides what evaluation, if any, is appropriate before the initiation of a moderate- to vigorous-intensity exercise program.
Presence of Symptoms

Resting or exertional symptoms:

- Cardiovascular
- Metabolic
- Renal disease
- or experience a change in health status.
Presence of Symptoms

<table>
<thead>
<tr>
<th>Sign or Symptom</th>
<th>Clarification/Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pain, discomfort (or other anginal equivalent)</td>
<td>One of the cardinal manifestations of cardiac disease, in particular coronary artery disease. Key features favoring an ischemic origin include:</td>
</tr>
<tr>
<td></td>
<td>- <strong>Character:</strong> Constricting, squeezing, burning, &quot;heaviness&quot; or &quot;heavy feeling&quot;</td>
</tr>
<tr>
<td></td>
<td>- <strong>Location:</strong> Substernal, across midthorax, anteriorly; in one or both arms, shoulders; in neck, cheeks, teeth; in forearms, fingers in interscapular region</td>
</tr>
<tr>
<td></td>
<td>- <strong>Provoking factors:</strong> Exercise or exertion, excitement, other forms of stress, cold weather, occurrence after meals</td>
</tr>
<tr>
<td></td>
<td>Key features against an ischemic origin include:</td>
</tr>
<tr>
<td></td>
<td>- <strong>Character:</strong> Dull ache; &quot;knife-like,&quot; sharp, stabbing; &quot;jabs&quot; aggravated by respiration</td>
</tr>
<tr>
<td></td>
<td>- <strong>Location:</strong> In left submammary area; in left hemithorax</td>
</tr>
<tr>
<td></td>
<td>- <strong>Provoking factors:</strong> After completion of exercise, provoked by a specific body motion</td>
</tr>
<tr>
<td>Shortness of breath at rest or with mild exertion</td>
<td>Dyspnea (defined as an abnormally uncomfortable awareness of breathing) is one of the principal symptoms of cardiac and pulmonary disease. It commonly occurs during strenuous exertion in healthy, well-trained persons and during moderate exertion in healthy, untrained persons. However, it should be regarded as abnormal when it occurs at a level of exertion that is not expected to evoke this symptom in a given individual. Abnormal exertional dyspnea suggests the presence of cardiopulmonary disorders, in particular left ventricular dysfunction or chronic obstructive pulmonary disease.</td>
</tr>
<tr>
<td>Dizziness or syncope</td>
<td>Syncope (defined as a loss of consciousness) is most commonly caused by a reduced perfusion of the brain. Dizziness and, in particular, syncope during exercise may result from cardiac disorders that prevent the normal rise (or an actual fall) in cardiac output. Such cardiac disorders are potentially life-threatening and include severe coronary artery disease, hypertrophic cardiomyopathy, aortic stenosis, and malignant ventricular dysrhythmias. Although dizziness or syncope shortly after cessation of exercise should not be ignored, these symptoms may occur even in healthy persons as a result of a reduction in venous return to the heart.</td>
</tr>
<tr>
<td>Orthopnea or paroxysmal nocturnal dyspnea</td>
<td>Orthopnea refers to dyspnea occurring at rest in the recumbent position that is relieved promptly by sitting upright or standing. Paroxysmal nocturnal dyspnea refers to dyspnea, beginning usually 2–5 h after the onset of sleep, which may be relieved by sitting on the side of the bed or getting out of bed. Both are symptoms of left ventricular dysfunction. Although nocturnal dyspnea may occur in persons with chronic obstructive pulmonary disease.</td>
</tr>
</tbody>
</table>
## Presence of Symptoms

<table>
<thead>
<tr>
<th>Sign or Symptom</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Presence of Symptoms</td>
<td>Clarification/Significance disease, it differs in that it is usually relieved after the person relieves himself or herself of secretions rather than specifically by sitting up.</td>
</tr>
<tr>
<td>Ankle edema</td>
<td>Bilateral ankle edema that is most evident at night is a characteristic sign of heart failure or bilateral chronic venous insufficiency. Unilateral edema of a limb often results from venous thrombosis or lymphatic blockage in the limb. Generalized edema (known as anasarca) occurs in persons with the nephrotic syndrome, severe heart failure, or hepatic cirrhosis.</td>
</tr>
<tr>
<td>Palpitations or tachycardia</td>
<td>Palpitations (defined as an unpleasant awareness of the forceful or rapid beating of the heart) may be induced by various disorders of cardiac rhythm. These include tachycardia, bradycardia of sudden onset, ectopic beats, compensatory pauses, and accentuated stroke volume resulting from valvular regurgitation. Palpitations also often result from anxiety states and high cardiac output (or hyperkinetic) states, such as anemia, fever, thyrotoxicosis, arteriovenous fistula, and the so-called idiopathic hyperkinetic heart syndrome.</td>
</tr>
<tr>
<td>Intermittent claudication</td>
<td>Intermittent claudication refers to the pain that occurs in a muscle with an inadequate blood supply (usually as a result of atherosclerosis) that is stressed by exercise. The pain does not occur with standing or sitting, is reproducible from day to day, is more severe when walking upstairs or up a hill, and is often described as a cramp, which disappears within 1–2 min after stopping exercise. Coronary artery disease is more prevalent in persons with intermittent claudication. Patients with diabetes are at increased risk for this condition.</td>
</tr>
<tr>
<td>Known heart murmur</td>
<td>Although some may be innocent, heart murmurs may indicate valvular or other cardiovascular disease. From an exercise safety standpoint, it is especially important to exclude hypertrophic cardiomyopathy and aortic stenosis as underlying causes because these are among the more common causes of exertion-related sudden cardiac death.</td>
</tr>
<tr>
<td>Unusual fatigue or shortness of breath with usual activities</td>
<td>Although there may be benign origins for these symptoms, they also may signal the onset of, or change in the status of cardiovascular, pulmonary, or metabolic disease.</td>
</tr>
</tbody>
</table>
Desired or planned exercise intensity

✓ Sudden cardiac death and acute myocardial infarction events have largely been in response to moderate to vigorous exercise

*Moderate* 40-60% of aerobic capacity

*Vigorous* ≥ 60%

- *Prolonged exercise* (>3 hr)
- *Sustained heavy resistance exercise*
The new ACSM exercise preparticipation health screening guidelines focus on assessing

1. Individual’s current level of physical activity,
2. Presence of signs or symptoms and/or known cardiovascular, metabolic, or renal disease, and
3. Desired (planned) exercise intensity.
Physical Activity Tracker

Tracking the trackers
Activity Tracking Technologies
New Evidence Fitness Trackers Don’t Actually Track Fitness
March 21, 2016 MedPage

–Little agreement found when 12 wearable devices were compared to gold standards

Fitness trackers have not been found to help people improve the way they exercise, an article in the Sunday New York Times noted in a summary of the case against wearable fitness trackers, pointing up technical and even philosophical limitations of the devices. Now a new paper published in JAMA Internal Medicine shows that these devices are not even correctly performing their most basic function, which is accurately measuring physical activity and estimating energy expenditure.
Accuracy of Wearable Devices for Estimating Total Energy Expenditure: Comparison With Metabolic Chamber and Doubly Labeled Water Method


<table>
<thead>
<tr>
<th>Device Name (Wearing Position)</th>
<th>Difference in TEE Between Each Device and Metabolic Chamber (kcal/day), Mean (SD)</th>
<th>Estimated TEE by Each Device, Mean (SD)</th>
<th>Spearman Rank Correlation Coefficient&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Difference in TEE Between Each Device and DLW (kcal/day), Mean (SD)</th>
<th>Estimated TEE by Each Device, Mean (SD)</th>
<th>Spearman Rank Correlation Coefficient&lt;sup&gt;a&lt;/sup&gt;</th>
</tr>
</thead>
<tbody>
<tr>
<td>Withings Pulse O2 (wrist)</td>
<td>1814.6 (230.3)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1815.8 (206.8)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>0.88</td>
<td>1913.6 (343.0)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2051.8 (277.7)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>0.93</td>
</tr>
<tr>
<td>Jawbone UP24 (wrist)</td>
<td>1844.1 (268.3)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>1846.7 (265.2)&lt;sup&gt;d&lt;/sup&gt;</td>
<td>0.90</td>
<td>1903.6 (334.3)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2081.5 (329.5)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>0.92</td>
</tr>
<tr>
<td>Garmin VivoFit (wrist)</td>
<td>1913.6 (343.0)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2128.5 (206.2)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.91</td>
<td>1913.6 (343.0)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2128.5 (206.2)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.91</td>
</tr>
<tr>
<td>ActiGraph GT3X (wrist)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>1913.6 (343.0)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2128.5 (206.2)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.91</td>
<td>1913.6 (343.0)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2128.5 (206.2)&lt;sup&gt;f&lt;/sup&gt;</td>
<td>0.91</td>
</tr>
<tr>
<td>Suunto Liferecor DX (wrist)</td>
<td>2051.8 (277.7)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2138.0 (243.5)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.92</td>
<td>2051.8 (277.7)&lt;sup&gt;c&lt;/sup&gt;</td>
<td>2138.0 (243.5)&lt;sup&gt;g&lt;/sup&gt;</td>
<td>0.92</td>
</tr>
<tr>
<td>Panasonic Actimeter (waist)</td>
<td>2081.5 (329.5)&lt;sup&gt;e&lt;/sup&gt;</td>
<td>2219.3 (327.5)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>0.90</td>
<td>2219.3 (327.5)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>2219.3 (327.5)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>0.90</td>
</tr>
<tr>
<td>Epson Pulsense (wrist)</td>
<td>2219.3 (327.5)&lt;sup&gt;h&lt;/sup&gt;</td>
<td>2221.5 (312.4)&lt;sup&gt;i&lt;/sup&gt;</td>
<td>0.84</td>
<td>2221.5 (312.4)&lt;sup&gt;i&lt;/sup&gt;</td>
<td>2221.5 (312.4)&lt;sup&gt;i&lt;/sup&gt;</td>
<td>0.84</td>
</tr>
<tr>
<td>Tanita AM-160 (pocket)</td>
<td>2221.5 (312.4)&lt;sup&gt;i&lt;/sup&gt;</td>
<td>2227.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>0.93</td>
<td>2227.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>2227.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>0.93</td>
</tr>
<tr>
<td>Fitbit Flex (wrist)</td>
<td>2227.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>2228.3 (367.2)&lt;sup&gt;k&lt;/sup&gt;</td>
<td>0.92</td>
<td>2228.3 (367.2)&lt;sup&gt;k&lt;/sup&gt;</td>
<td>2228.3 (367.2)&lt;sup&gt;k&lt;/sup&gt;</td>
<td>0.92</td>
</tr>
<tr>
<td>Misfit Shine (wrist)</td>
<td>2228.3 (367.2)&lt;sup&gt;k&lt;/sup&gt;</td>
<td>2229.3 (376.7)&lt;sup&gt;l&lt;/sup&gt;</td>
<td>0.92</td>
<td>2229.3 (376.7)&lt;sup&gt;l&lt;/sup&gt;</td>
<td>2229.3 (376.7)&lt;sup&gt;l&lt;/sup&gt;</td>
<td>0.92</td>
</tr>
<tr>
<td>Omron Active Style Pro (waist)</td>
<td>2229.3 (376.7)&lt;sup&gt;l&lt;/sup&gt;</td>
<td>2237.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>0.93</td>
<td>2237.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>2237.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>0.93</td>
</tr>
<tr>
<td>Omron CaloriScan (pocket)</td>
<td>2237.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>2237.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>0.93</td>
<td>2237.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>2237.5 (345.5)&lt;sup&gt;j&lt;/sup&gt;</td>
<td>0.93</td>
</tr>
</tbody>
</table>

Differences in Total Energy Expenditure in 19 Patients

Murikami 2016
Fitbit Flex, JAWBONE UP24, Misfit Shine, EPSON PULSENCE PS-100, Garmin Vivofit (wrist), TANITA AM-160, OMRON CaloriScan HJA-403C (hand-held), and Withings Pulse O2, OMRON Active style Pro HJA-350IT, Panasonic Actimarker EW4800, SUZUKEN Lifecorder EX, and ActiGraph GT3X (waist).

Murikamo 2016
Wearable Devices

✓ The wearable devices that we tested were able to rank daily total energy expenditure between individuals, but absolute values differed widely among devices and varied significantly from the gold standard measures. Furthermore, all wearable devices underestimated total energy expenditure under free-living conditions.

Our study was limited by the small sample size and including only nonobese, healthy participants. Although further studies are required, the findings presented herein suggest that most wearable devices do not produce a valid measure of total energy expenditure.

Murikami 2016
Fitbits One, Zip, and Flex and Jawbone UP24 for estimating EE and steps for specific activities. 30 subjects completed a structured protocol consisting of three sedentary, four household, and four ambulatory/exercise activities. The Omron HJ-720IT pedometer was used as a comparison of step count accuracy.

**Results:** All PA monitors predicted EE within 8% of COSMED for sedentary activity but overestimated EE by 16%–40% during ambulatory activity.

All monitors severely underestimated EE and steps during cycling.

**Conclusion:**

✓ Consumer based PA monitors should be used cautiously for estimating EE, although they provide accurate measures of steps for structured ambulatory activity, similar to validated pedometers.
Fitbit Flex

Fitbit One

Fitbit Zip
Physical Activity Tracker
COSMED K4B2
Measuring Energy Expenditure

In regard to the ambulatory activity category (excluding cycling), all consumer-based PA monitors significantly overestimated EE.

The findings of this study indicate that consumer-based PA monitor’s accuracy for tracking EE and steps is dependent on the type of activity being performed.

Consumer-based PA monitors do not provide accurate estimates of EE and should not be used for estimating EE.

Consumer-based PA monitors provided reasonably accurate measures of steps during structured ambulatory activity, were not accurate for measuring household steps.

Nelson 2016
Comparison of 5 activity trackers
L Ross, 2014.

- Nike Fuel,
- Jawbone Up,
- Fitbit Flex,
- Fitbit Zip
- StrivePlay
Comparison of 5 activity trackers (cont.)

<table>
<thead>
<tr>
<th></th>
<th>Nike Fuel</th>
<th>Jawbone Up</th>
<th>Fitbit 1</th>
<th>iFit</th>
<th>StriivPlay (on my waist)</th>
<th>Fitbit2</th>
<th>Fitbit Zip (on my waist)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEPS</td>
<td>8973</td>
<td>10,663</td>
<td>12,387</td>
<td>10,647</td>
<td>11,233</td>
<td>12,158</td>
<td>10,474</td>
</tr>
</tbody>
</table>

more action with my arms this day
Comparison of 5 activity trackers

I then walked on the treadmill for 10 minutes at a consistent pace (3.5 speed).

<table>
<thead>
<tr>
<th></th>
<th>Nike Fuel</th>
<th>Jawbone Up</th>
<th>Fitbit1</th>
<th>iFit</th>
<th>Strivr/Play (on my waist)</th>
<th>Fitbit2</th>
<th>Fitbit Zip (on my waist)</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEPS</td>
<td>1073</td>
<td>1228</td>
<td>1207</td>
<td>1217</td>
<td>1239</td>
<td>1203</td>
<td>1238</td>
</tr>
</tbody>
</table>
1 mile walk

Ped.  2165
Jbone  2166
FBflx  2140
Nike FB  2076
Jawboned Up
Fitbit
Validation of Fitbit-Flex as a measure of free-living physical activity in a community-based phase III cardiac rehabilitation population.


METHODS: 48 Cardiac patients and family members wore Fitbit-Flex and Actigraph simultaneously over four days to monitor daily step counts and minutes of moderate to vigorous physical activity (MVPA).

Fitbit-Flex and Actigraph were significantly correlated in males, females, total participants and cardiac patients for step counts (r = .96; r = .95; r = .95; r = .95), though less so for MVPA. As step counts increased the differences between Fitbit-Flex and Actigraph also increased.

✔ Fitbit-Flex over-estimated daily step counts in females (556 steps/day), males (1462 steps/day) and total participants (1038 steps/day) as well as for minutes of MVPA in females (4 min/day), males (15 min/day) and total participants (10 min/day).

CONCLUSION: Fitbit-Flex is accurate in assessing attainment of physical activity guideline recommendations and is useful for monitoring physical activity in cardiac patients. The device does, however, slightly over-estimate step counts and MVPA.
Systematic review of the validity and reliability of consumer-wearable activity trackers.

22 studies were included in the review (20 on adults, 2 on youth).

For laboratory-based studies using step counting or accelerometer steps, the correlation with tracker-assessed steps was high for both Fitbit and Jawbone (Pearson or intraclass correlation coefficients (CC) > =0.80).

Walking- and running-based Fitbit trials indicated consistently high interdevice reliability for steps (Pearson and intraclass CC 0.76-1.00), distance (intraclass CC 0.90-0.99), and energy expenditure (Pearson and intraclass CC 0.71-0.97). When wearing two Fitbits while sleeping, consistency between the devices was high.

CONCLUSION:

✔ This systematic review indicated higher validity of steps, few studies on distance and physical activity, and lower validity for energy expenditure and sleep.
Steps

(most reliable)

DISTANCE
(less reliable)

ENERGY EXPENDITURE
(least reliable)
Each Step

Liver
- Increases Fatty Acid Oxidation (Ketogenesis)
- Decreases Cholesterol Synthesis
- Decreases Lipogenesis

Pancreatic Islets
- Modulates Insulin Secretion

Skeletal Muscle
- Increases Fatty Acid Oxidation
- Increases Glucose Uptake

Adipocytes
- Decreases Lipogenesis
- Decreases Lipolysis
Next Generation of PA Tracking

Cost/Utility?
Predicting metabolic rate during level and uphill outdoor walking using a low-cost GPS receiver

Pierre-Yves de Müllenheim JAP 2016;121:577 Rennes, France;

30 young healthy adults performed randomized outdoor walking for 6-min periods at 2.0, 3.5, and 5.0 km/h and on three different grades: 1) level walking, 2) uphill walking on a 3.7% mean grade, and 3) uphill walking on a 10.8% mean grade. Cosmed V02 reference.

The prediction accuracy was very close when either actual $\text{SPEED/GRADE}$ values or GPS $\text{CORRECTED}$ values (for level and uphill combined) or GPS speed values (for level walking only) were used.

This is the first study to characterize the direct relationship between global positioning system (GPS) speed and grade and the metabolic rate while walking outdoors under different controlled speed and grade conditions.

Using GPS speed and grade yields accurate metabolic rate predictions during level and uphill outdoor walking, particularly when GPS grade is corrected. Moreover, when using GPS parameters with published speed/grade-based equations, the metabolic rate predictions were close to those obtained using actual speed and grade values.
The value of “light” intensity physical activity
# Physical Activity Levels Defined by Intensity

<table>
<thead>
<tr>
<th>Measure</th>
<th>Light</th>
<th>Moderate</th>
<th>Vigorous</th>
</tr>
</thead>
<tbody>
<tr>
<td>How you feel...</td>
<td>Feels easy</td>
<td>Feels somewhat hard</td>
<td>Feels very hard</td>
</tr>
<tr>
<td>How you breath...</td>
<td>No noticeable changes</td>
<td>Breathing quickens, but you’re NOT out of breath</td>
<td>Breathing is deep and rapid</td>
</tr>
<tr>
<td>How much you sweat...</td>
<td>You don’t sweat</td>
<td>You start to sweat after about 10 minutes</td>
<td>You sweat after just a few minutes</td>
</tr>
<tr>
<td>How much you can talk, or sing...</td>
<td>You can easily carry out a conversation and sing</td>
<td>You can still carry out a conversation, but you CANNOT sing</td>
<td>You can’t say more than a few words at a time</td>
</tr>
<tr>
<td>Example:</td>
<td>Walking slowly at a paces less than 3 mph</td>
<td>Walking briskly at 3 to 4.5 mph on a level surface</td>
<td>Walking fast at 5mph or faster</td>
</tr>
</tbody>
</table>
Relative Energy Cost of Physical Activity

- x-country skiing (25 METS)
- Competitive LD running
- longshoring
- mountain biking
- Cycling/spinning
- aerobic step or dance
- terrain hiking
- jogging
- Ashtanga yoga
- iyengar yoga
- swimming
- karate
- Resistance training
- golf
- household chores
- qigong ex
- restorative yoga

Light PA
- walking, slow-moderate pace
- meditation
- quiet contemplation

Modified from Ainsworth B, 2000
Cardiorespiratory Fitness and Light-Intensity Physical Activity Are Independently Associated with Reduced Cardiovascular Disease Risk in Urban Black South African Women: A Cross-Sectional Study
Kasha Dickie et.al. MET SYN RELATED DISORDERS Volume 14, Number 1, 2016 Cape Town

To examine the independent associations of physical activity, cardiorespiratory fitness, and sedentary time on body composition and cardiometabolic risk factors in 18–45 years SA women were recruited.

Results:

Light- but not moderate- to vigorous intensity physical activity was inversely associated with trunk fat mass ($P = 0.03$). Sedentary time was associated with triglyceride (TG) ($P = 0.01$) and TG/ HDL-C ($P = 0.04$), and these relationships were independent of body fat.

CRF was inversely associated with sedentary time ($P = 0.03$), but not with any of the physical activity variables ($P > 0.05$).

Conclusion: Both physical activity and cardiorespiratory fitness were associated with reduced total and central fat mass, VAT, and reduced cardiometabolic risk for CVD and T2D.
Physical Activity - Intensity

✓ These researchers have shown that time spent in light-intensity physical activity, as well as steps/day, but not moderate- to vigorous intensity physical activity, was associated with lower body fat measures.

✓ Independent of fat mass, steps/day was associated with improved insulin sensitivity.

Dickie 2016
Although, the majority of women met the WHO Global physical activity recommendations, it was light-intensity physical activity and cardiorespiratory fitness, rather than moderate- to vigorous intensity physical activity, which were more closely associated with reduced total and central fat mass and improved insulin sensitivity.

The majority of physical activity time was spent in light intensity (*5.3 hr/day).

• **Light Activity**: less than 3.0 METS* (less than 3.5 calories per minute)
• **Moderate Activity**: less 3.0-6.0 METS* (3.5 – 7 calories per minute)
• **Vigorous Activity**: greater than 6.0 METS* (more than 7 calories per minute)

Dickie 2016
Moderate - vigorous physical activity:

6+ METs for 50 minutes per day or approximately **400-500+ kcal**

_Light PA_

1-3 METs for 5.5 hours per day @ 3.5 kcal/min or ~**700-1100 kcal**
What Counts as Light-Intensity Aerobic Activity?

During light-intensity activities there is not noticeable change in your breathing; you can talk and sing normally. You also don’t break out in a sweat. Doing the activity feels easy.

Examples of activities that require only a small amount of energy above baseline—inactivity—for most people include:

- general housework,
- light gardening,
- playing an instrument,
- shopping,
- walking less than 3 mph,
- working at a computer
Light-Intensity Aerobic Activity
Fitness vs Physical Activity

Trait vs Behavior
How do you use fitness and physical activity measures when reporting outcomes and educating your patients
Fitness vs Physical Activity

Cardiorespiratory Fitness

- Aerobic capacity (i.e., maxVo2)
  - Genetics
  - Ex intensity
  - Gender
  - Age

Physical Activity

- Activity counts
- Energy expenditure (kcal)
- Self-report
- DLW
Max Aerobic Capacity

Max Vo2

= Cardiac Output \( (HR \times SV) \)
\( \times A-V\ O2\ difference \)

Genetics & Training
We know that the heritability of the response variance adjusted for age, sex, and baseline $V_{O_2}^{max}$ is in the range of 45–50%
Coronary Artery Risk Development in Young Adults (CARDIA) study

Twenty year fitness trends in young adults and incidence of prediabetes and diabetes: the CARDIA study

N= 4,373 (25 year span)

Examining participants who had fitness measured from young adulthood to middle age-

✓ we found that cardiorespiratory fitness was associated with lower risk for developing prediabetes/diabetes, even when adjusting for BMI over 25 year time period.
Diabetes and Vigorous Exercise Frequency

Fig. 3. Age-adjusted rates of diabetes by physical activity levels in US male physicians. Used with permission from Manson et al. (61). JAMA 268: 63–67, 1992. Copyright © 1992, American Medical Association. All rights reserved.
All-cause Mortality

Myers & Froelicher 2004

N=6213 men
### The Risk of Dying Prematurely Declines as People Become Physically Active—Data Points

<table>
<thead>
<tr>
<th>Minutes per Week of Moderate- or Vigorous-Intensity Physical Activity</th>
<th>Relative Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>1</td>
</tr>
<tr>
<td>90</td>
<td>0.8</td>
</tr>
<tr>
<td>180</td>
<td>0.73</td>
</tr>
<tr>
<td>✓</td>
<td></td>
</tr>
<tr>
<td>330</td>
<td>0.64</td>
</tr>
<tr>
<td>420</td>
<td>0.615</td>
</tr>
</tbody>
</table>

**Moderate 40-60% Vigorous >60%**

[https://health.gov/paguidelines/](https://health.gov/paguidelines/)
Bottom Line

Reducing cardiometabolic risk (diabetes, CVD)

**PA** - priority

(just move, and move often)

**Intensity** - secondary

incorporate 60-85% effort max
Intensity and Duration as Physiological CMR Response Stimulus

**Intensity-driven**

20-40 minutes of relatively high intensity activity – at or above lactate threshold, 60-80% VO2 max

"fitness"

**Duration-driven**

60+ minutes, low-moderate intensity, 25-55% VO2 max

- Increased central physiologic capacities & anatomic dimensions: VO2 max, SV and Q max, EDV, muscle glycogen utilization, max exercise performance
- Increased peripheral metabolic adaptations, insulin sensitivity, fat mobilization/utilization - oxidation, fibrinolysis
Native Lands
Assessment of PA and/or CRF in the IHS
Physical Activity Education Best Practice for Diabetes

Indian Health Service
The Federal Health Program for American Indians and Alaska Natives

Required Key Measure
Must be reported by grantees that select this Best Practice.

1. Number and percent of individuals in your Target Group who receive physical activity education.

Notes:
- Improvement: Increasing the number and percent of individuals in your Target Group who achieve this measure shows improvement.
- Timeframe: The timeframe for collecting data on the Required Key Measure will be January 1st to December 31st.
- Data Collection: For more information on data collection and reporting, see Evaluation Tools.

2016 Just Move It Campaign

JUST MOVE IT
It's up to you!
Section 4: Required Key Measures

In order to report SDPI outcomes to IHS headquarters, Congress, and others, all grantees must provide data for Required Key Measures for each Best Practice selected in FY 2015.

For an example of how to report the following information in this section, please reference Appendix B, Table 1 in ANY of the 2011 IHS Diabetes Best Practice documents.

<table>
<thead>
<tr>
<th>A. Measures</th>
<th>B. Objective #</th>
<th>C. Baseline or beginning value and date</th>
<th>D. Final value for FY 2015 and date</th>
<th>E. Data Source (where did these values come from)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Percent of individuals in the target population who have had their level of physical activity assessed and documented within grantee specified time period.</td>
<td>Select</td>
<td></td>
<td>as of</td>
<td>as of</td>
</tr>
<tr>
<td>2. Percent of individuals in the target population who showed improvement in their fitness levels in the relevant time period within grantee specified time period.</td>
<td>Select</td>
<td></td>
<td>as of</td>
<td>as of</td>
</tr>
<tr>
<td>3. Percent of individuals in the target population who met one or more of their physical activity behavioral goals within grantee specified time period.</td>
<td>Select</td>
<td></td>
<td>as of</td>
<td>as of</td>
</tr>
</tbody>
</table>
FY 2015 Annual/Final Progress Report Template: Part 2 Physical Activity for Diabetes Prevention and Care
Last Updated: March 2016 (cont.)

Section 5: Additional Measures
Report up to 5 additional measures based on the following criteria:

- Utilized the most grant funding
- Devoted the most program time
- Resulted in the most significant improvement from previous reporting

<table>
<thead>
<tr>
<th>A. Measures</th>
<th>B. Objective #</th>
<th>C. Baseline or beginning value and date</th>
<th>D. Final value for FY 2015 and date</th>
<th>E. Data Source (where did these values come from)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Select</td>
<td>[ ] as of [ ]</td>
<td>[ ] as of [ ]</td>
<td></td>
</tr>
<tr>
<td>2.</td>
<td>Select</td>
<td>[ ] as of [ ]</td>
<td>[ ] as of [ ]</td>
<td></td>
</tr>
</tbody>
</table>
The Doubly Labeled Water Method

**CRF Tests**
- Max Vo2 (treadmill/cycle)
- Astrand-Rhyming cycle ergometer test
- YMCA cycle ergometer test
- 15 min run test
- 1 mile Rockport walk test
- PWC170 cycle test
- Bench step-test

**PA Assessment**
- Self-report (generic)
- Diaries/logs
- Paffenbarger PA Questionnaire
- Kaiser, Yale, Minnesota, ACLS PA Questionnaires
- PA Vital Sign (EIM)
- RAPA
- 7-day recall
- Pedometer
- Accelerometer
- Doubly-labeled H2o
AHA Scientific Statement

Guide to the Assessment of Physical Activity: Clinical and Research Applications
A Scientific Statement From the American Heart Association

Scott J. Strath, PhD, Chair; Leonard A. Kaminsky, PhD, Co-Chair; Barbara E. Ainsworth, PhD, MPH, FAHA; Ulf Ekelund, PhD; Patty S. Freedson, PhD; Rebecca A. Gary, RN, PhD; Caroline R. Richardson, MD; Derek T. Smith, PhD; Ann M. Swartz, PhD; on behalf of the American Heart Association Physical Activity Committee of the Council on Lifestyle and Cardiometabolic Health and Cardiovascular, Exercise, Cardiac Rehabilitation and Prevention Committee of the Council on Clinical Cardiology, and Council on Cardiovascular and Stroke Nursing
Assessment of Physical Activity

### Table B. Strengths and Limitations to Objective and Subjective Methodologies

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Questionnaire</th>
<th>Diaries/Logs</th>
<th>Observation</th>
<th>Indirect Calorimetry</th>
<th>DLW</th>
<th>HR</th>
<th>Accelerometer</th>
<th>Pedometer</th>
<th>Multisensing Units</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Strengths</strong></td>
<td>Low cost</td>
<td>Low cost</td>
<td>No recall necessary</td>
<td>Highly accurate and reliable measure of physical activity and energy expenditure</td>
<td>Low burden for short periods</td>
<td>Concurrent measure of movement</td>
<td>Low cost</td>
<td>Low burden</td>
<td>Accuracy improved compared with single sensing assessments</td>
</tr>
<tr>
<td></td>
<td>Low burden</td>
<td>Detailed information on dimensions and domains</td>
<td>Provides excellent contextual information</td>
<td>Provides detailed information on dimensions and domains</td>
<td>&quot;Gold standard&quot; measure for total daily energy expenditure in free-living individuals</td>
<td>Relatively inexpensive</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Conventional easy</td>
<td>Applicable to large numbers of individuals</td>
<td>Not subjected to memory or recall as much as other subjective methods</td>
<td>Suitable criterion measure of physical activity and energy expenditure</td>
<td>Low burden to patients or participants</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Applicable to structured physical activity</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
</tr>
<tr>
<td></td>
<td>Can</td>
<td>successfully rank into high/low categories</td>
<td>Can assess different dimensions and domains</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
<td>Can</td>
</tr>
<tr>
<td><strong>Weaknesses</strong></td>
<td>Recall and social desirability bias can occur</td>
<td>Needs to be population and culture specific</td>
<td>Needs to be inquired of individuals</td>
<td>Affects by nonactivity stimulants</td>
<td>Cannot account for all activities, such as cycling, stair use, or activities that require lifting or a load</td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Simple pedometers cannot measure intensity/duration</td>
<td>Higher cost increased burden of wear for some devices</td>
</tr>
<tr>
<td></td>
<td>Very high burden on patients and participants</td>
<td>Complex and time-consuming data reduction and analysis</td>
<td>Similar to questionnaires, they should be population and culture specific</td>
<td>Expensive</td>
<td>Cannot account for all activities, such as cycling, stair use, or activities that require lifting or a load</td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Simple pedometers cannot measure intensity/duration</td>
<td>Higher cost increased burden of wear for some devices</td>
</tr>
<tr>
<td></td>
<td>High burden on the investigator</td>
<td>Training essential to successfully administer this technique</td>
<td>Can alter individual behavior of the one who is being assessed</td>
<td>Expensive</td>
<td>Cannot account for all activities, such as cycling, stair use, or activities that require lifting or a load</td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Simple pedometers cannot measure intensity/duration</td>
<td>Higher cost increased burden of wear for some devices</td>
</tr>
<tr>
<td></td>
<td>High degree of technical expertise required</td>
<td>Short time assessment only permissible</td>
<td>Unable to discern dimensions or domains</td>
<td>Expensive</td>
<td>Cannot account for all activities, such as cycling, stair use, or activities that require lifting or a load</td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Simple pedometers cannot measure intensity/duration</td>
<td>Higher cost increased burden of wear for some devices</td>
</tr>
<tr>
<td></td>
<td>Technical equipment and trained personnel required</td>
<td>Measure of resting metabolic rate and thermic effect of food required to derive PEE</td>
<td>Unable to discern dimensions or domains</td>
<td>Expensive</td>
<td>Cannot account for all activities, such as cycling, stair use, or activities that require lifting or a load</td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Simple pedometers cannot measure intensity/duration</td>
<td>Higher cost increased burden of wear for some devices</td>
</tr>
<tr>
<td></td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Unable to discern dimensions or domains</td>
<td>Expensive</td>
<td>Cannot account for all activities, such as cycling, stair use, or activities that require lifting or a load</td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Simple pedometers cannot measure intensity/duration</td>
<td>Higher cost increased burden of wear for some devices</td>
</tr>
<tr>
<td></td>
<td>Subject to interference with signal</td>
<td>Unable to discern dimensions or domains</td>
<td>Expensive</td>
<td>Cannot account for all activities, such as cycling, stair use, or activities that require lifting or a load</td>
<td>Weak relationship at low end of intensity scale</td>
<td>Subject to interference with signal</td>
<td>Simple pedometers cannot measure intensity/duration</td>
<td>Higher cost increased burden of wear for some devices</td>
<td></td>
</tr>
</tbody>
</table>

AHA 2013
# Assessment of Physical Activity

## Table 9. Practical Considerations for Use

<table>
<thead>
<tr>
<th>Questionnaire</th>
<th>Diaries/Logs</th>
<th>Observation</th>
<th>Indirect Calorimetry</th>
<th>DLW</th>
<th>HR</th>
<th>Accelerometer</th>
<th>Pedometer</th>
<th>Multisensing Units</th>
</tr>
</thead>
<tbody>
<tr>
<td>- What are the primary outcomes of the questionnaire?</td>
<td>- Clear instructions are essential</td>
<td>- Systems require extensive calibration to ensure data integrity</td>
<td>- Patients/ participants may have sensitive skin</td>
<td>- Similar to accelerometers, may need 7 d to assess</td>
<td>- Need to wear for a number of days to obtain a physical activity profile</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Do these match the desired information needed?</td>
<td>- Mechanisms to promote compliance need to be considered, such as prompts</td>
<td>- Portable systems are available and can measure for a few hours, but they are burdensome and can impact activities undertaken by patients or participants</td>
<td>- Reliant on technical experts</td>
<td>- Careful consideration to validity needed; cheaper brands prone to error</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How will the questionnaire be administered (face to face, telephone, by mail)?</td>
<td>- Considerable time and effort are needed to reduce, clean, and analyze data</td>
<td>- Portable systems are available and can measure for a few hours, but they are burdensome and can impact activities undertaken by patients or participants</td>
<td>- Reliant on technical expertise</td>
<td>- Careful consideration to validity needed; cheaper brands prone to error</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>What is the time frame of the questionnaire (24 hours, past week, month, year)?</td>
<td></td>
<td>- If more than one observer is used, need to train and establish interrater and intrarater reliability</td>
<td>- If individual calibration is used, may need prior physician consent</td>
<td>- Careful consideration to validity needed; cheaper brands prone to error</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is the questionnaire specific to the population under study?</td>
<td></td>
<td></td>
<td></td>
<td>- Careful consideration to validity needed; cheaper brands prone to error</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Is there any validity and reliability evidence to support use?</td>
<td></td>
<td></td>
<td></td>
<td>- Careful consideration to validity needed; cheaper brands prone to error</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>How will data be reduced, cleaned, and analyzed?</td>
<td></td>
<td></td>
<td></td>
<td>- Careful consideration to validity needed; cheaper brands prone to error</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

DLW indicates doubly labeled water; HR, heart rate; RMR, resting metabolic rate; and TEF, thermic effect of food.
The Energy Cost of Physical Activity
Key Concept

Since the vast majority of physical activities and chronic disease prevention studies have clearly demonstrated the relationship with increased daily physical activity energy expenditure (in kcal) - it then is imperative that health care professionals understand the rudiments of estimating the gross and net energy expenditure of recommended physical activity for their patients.
Kcal
Energy Cost of PA

- Time
- Intensity: Roughly 30 min at 40-60% of AC = ~300 gross kcal EE*
- Mode
- Body weight
Energy Cost of PA

Energy Expenditure of Walking and Running: Comparison with Prediction Equations

CAMERON HALL, ARTURO FIGUEROA, BO FERNHALL, and JILL A. KANALEY

Department of Exercise Science, Syracuse University, Syracuse, NY

ABSTRACT

HALL, C., A. FIGUEROA, B. FERNHALL, and J. A. KANALEY. Energy Expenditure of Walking and Running: Comparison with Prediction Equations. Med. Sci. Sports Exerc., Vol. 36, No. 12, pp. 2128–2134, 2004. Purpose: This study established the published prediction equations for the energy expenditure of walking and running compared with the measured values. To make this comparison we first determined whether differences exist in energy expenditure for 1600 m of walking versus running, and whether energy expenditure differences occur due to being on the track or treadmill. Methods: Energy was measured via indirect calorimetry in 24 subjects while walking (1.41 m·s⁻¹) and running (2.82 m·s⁻¹) 1600 m on the treadmill. A subgroup also performed the 1600-m run/walk on the track. The measured energy expenditures were compared with published prediction equations. Results: Running required more energy (P < 0.01) for 1600 m than walking (treadmill: running 481 ± 20.0 kJ, walking 340 ± 14 kJ; track: running 480 ± 23 kJ, walking 334 ± 14 kJ) on both the track and treadmill. Predictions using the ACSM or Léger equations for running, and the Pandolf equation for walking, were similar to the actual energy expenditures for running and walking (total error: ACSM: −20 and 14.4 kJ, respectively; Léger walking: −10.1 kJ; Pandolf walking: −10.0 kJ). An overestimation (P < 0.01) for 1600 m was found with the McArdle’s table for walking and running energy expenditure and with van der Walt’s prediction for walking energy expenditure, whereas the Epstein equation underestimated running energy expenditure (P < 0.01). Conclusion: Running has a greater energy cost than walking on both the track and treadmill. For running, the Léger equation and ACSM prediction model appear to be the most suitable for the prediction of running energy expenditure. The ACSM and Pandolf prediction equation also closely predict walking energy expenditure, whereas the McArdle’s table or the equations by Epstein and van der Walt were not as strong predictors of energy expenditure. Key Words: CALORIC COST, PREDICTED ENERGY COST, MODE OF EXERCISE, PREDICTION TABLES
Energy Cost of PA

METs and Accelerometry of Walking in Older Adults: Standard versus Measured Energy Cost

KATHERINE S. HALL\textsuperscript{1,4}, CHERYL A. HOWE\textsuperscript{2}, SHARON R. RANA\textsuperscript{2}, CLARA L. MARTIN\textsuperscript{3}, and MIRIAM C. MOREY\textsuperscript{1,4,5}

\textsuperscript{1}Geriatric Research, Education, and Clinical Center, Durham VA Medical Center, Durham, NC; \textsuperscript{2}School of Applied Health Sciences and Wellness, Ohio University, Athens, OH; \textsuperscript{3}Department of Exercise Science, Elon University, Elon, NC; \textsuperscript{4}Claude D. Pepper Center Older Americans Independence Center/Center for the Study of Aging and Human Development, Duke University Medical Center, Durham, NC; and \textsuperscript{5}Department of Medicine, Duke University Medical Center, Durham, NC

\textbf{ABSTRACT}

HALL, K. S., C. A. HOWE, S. R. RANA, C. L. MARTIN, and M. C. MOREY. METs and Accelerometry of Walking in Older Adults: Standard versus Measured Energy Cost. Med. Sci. Sports Exerc., Vol. 45, No. 3, pp. 574–582, 2013. Purpose: This study aimed to measure the metabolic cost (METs) of walking activities in older adults, to examine the relationship between accelerometer output and METs across walking activities, and to compare measured MET values in older adults with the MET values in the compendium. Methods: Twenty older adults (mean age = 75, range = 60–90 yr) completed eight walking activities (five treadmill based, three free living) for 6 min each. Oxygen consumption (\(\text{VO}_2\)) and resting metabolic rate (RMR) were measured using a portable metabolic system, and motion was recorded using a waist-mounted ActiGraph accelerometer (GT3X; ActiGraph, Pensacola, FL). Energy expenditure across activities was defined as kilocalories per minute and measured as METs (\(\text{VO}_2\) / RMR) and standard METs (\(\text{VO}_2\) / 3.5 mL kg\(^{-1}\) min\(^{-1}\)). Mixed modeling was used to assess differences in counts per minute and kilocalories per minute by weight status, sex, comorbidity status, and functional status. Linear regression analysis was applied to develop a prediction equation for kilocalories per minute. Energy costs of walking were subsequently compared with METs in the compendium of physical activities. Results: Average measured RMR was 2.6 mL kg\(^{-1}\) min\(^{-1}\), 31.6% less than the standard RMR of 3.5 mL kg\(^{-1}\) min\(^{-1}\). On average, standard METs were 71% lower than the measured METs across all walking activities. Measured MET levels differed from previously reported values in the literature and values listed in the compendium, resulting in misclassification of activity intensities for 60% of the walking conditions. Average counts for the walking activities ranged from 809 (treadmill = 1.5 mph) to 4593 counts per minute (treadmill = 3.5 mph). Previous regression equations consistently overestimate all activities compared with the measured energy cost in this sample of older adults. Conclusion: This study identifies the need for equations and cut points specific to older adults. Key Words: VALIDATION, ENERGY EXPENDITURE, ACTIVITY MONITORS, CALIBRATION, COMPENDIUM OF PHYSICAL ACTIVITIES, METABOLIC

81
Variability of EE for given walking step count in older individuals

Hall K 2013
What about older adults (>65y)

The results of our study also have public health implications.

When considered alongside public health guidelines, which stipulate that an activity intensity of ≥4 METs is necessary for decreasing risk of morbidity/mortality, it would appear that even slow walking (2.0 mph) is sufficient to meet this guideline for older adults.

Hall K 2013
300 kcal net energy expenditure

- Similar reduction in chronic disease risk

- Aerobic Endurance
- Circuit-Resistance
- LSD Walking
- Yoga or Tai Chi
- Household/Utilitarian
Net vs. Gross Caloric Cost of Exercise

“I’m going out for a 1-mile walk”

20-minutes of ADL ~ 25-30 kcal

20-minute 3 mph walk (1 mile) ~ 80-90 kcal

Net difference = ~ 50-60 kcal/mile

At moderate walking speeds, the net energy cost for walking on a mile is ~60% of the gross cost.
Generalizations on GROSS Energy Costs of Walking 1 Mile

**Walking** (2 - 4.5 mph)

- BMI < 30 ~ 100 kcal/mile
- BMI > 30 ~ 100 - 140 kcal/mile
What about the NET COST of Walking 1 Mile

Walking (2 - 4.5 mph)

BMI < 30 ~ 55 kcal/mile
BMI > 30 ~ 60-90 kcal/mile
Net Energy Cost

### Energy Compensation
- Increased food intake (CHO, beverages) as a result of appetite stimulation

### Energy Conservation
- Decreased Spontaneous physical activity as a result of “decreased energy”
How much weekly physical activity is required for weight loss in most obese patients?

1500 – 2800 kcal/week

Or, ~12-22 miles/week

Depending on body weight

Jeffrey, JCCP 1998
Schoeller, AJCN 1997
NWCR 2004

Foreyt 2004
Comparison of Energy Expenditure During Single-Set vs. Multiple-Set Resistance Exercise.

12 men and 12 women (age = 21.4 years) performed a **single-set** and **multiple-set** resistance exercise protocol in random order. The subjects performed two protocols at 70% of their 1-repetition maximum. The protocols consisted of 5 upper-body exercises of either 1 or 3 sets per exercise performed in random order.

**RESULTS:**

- Gross (167.9 kcal) and net (88.3 kcal) EE for the MS protocol
- Gross (71.3 kcal) and net (36.3 kcal) EE of the SS protocol (p<0.001 diff)

Significant gender differences (p < 0.001) in absolute and relative EE were observed for both protocols where values in men were higher than women.

The results of this study indicated that MS protocols yield greater metabolic and cardiovascular demands than SS protocols when the number of exercises performed is the same.
Energy Expenditure during Multiple Sets of Leg Press and Bench Press
Rodrigo Ferro Magosso et.al. J Ex Physio October 2013;16(5)57-62. Brazil

- Each successive set costs 10-12% more EE
- Total EE for each 4 set series: 45:50 kcal

For Comparison:
1 mile walk = ~100kcal
~20 minutes
A Systematic Review of the Energy Cost and Metabolic Intensity of Yoga

D. ENETTE LARSON-MEYER
Department of Family and Consumer Sciences, University of Wyoming, Laramie, WY

ABSTRACT

LARSON-MEYER, D. E. A Systematic Review of the Energy Cost and Metabolic Intensity of Yoga. Med. Sci. Sports Exerc., Vol. 48, No. 8, pp. 1558–1569, 2016. Purpose: With the increasing popularity of Hatha yoga, it is important to understand the energy cost and METs of yoga practice within the context of the American College of Sports Medicine (ACSM) and the American Heart Association (AHA) physical activity guidelines. Methods: This systematic review evaluated the energy cost and metabolic intensity of yoga practice including yoga asanas (poses/postures) and pranayamas (breath exercises) measured by indirect calorimetry. The English-speaking literature was surveyed via PubMed using the general terms “yoga” and “energy expenditure” with no date limitations. Results: Thirteen manuscripts were initially identified with an additional four located from review of manuscript references. Of the 17 studies, 10 evaluated the energy cost and METs of full yoga sessions or flow through Surya Namaskar (sun salutations), eight of individual asanas, and five of pranayamas. METs for yoga practice averaged $3.3 \pm 1.6$ (range $= 1.83–7.4$ METs) and $2.9 \pm 0.8$ METs when one outlier (i.e., 7.4 METs for Surya Namaskar) was omitted. METs for individual asanas averaged $2.2 \pm 0.7$ (range $= 1.4–4.0$ METs), whereas that of pranayamas was $1.3 \pm 0.3$. On the basis of ACSM/AHA classification, the intensity of most asanas and full yoga sessions ranged from light (less than 3 METs) to moderate aerobic intensity (3–6 METs), with the majority classified as light intensity. Conclusion: This review suggests that yoga is typically classified as a light-intensity physical activity. However, a few sequences/poses, including Surya Namaskar, meet the criteria for moderate- to vigorous-intensity activity. In accordance with the ACSM/AHA guidelines, the practice of asana sequences with MET intensities higher than three (i.e., $> 10$ min) can be accumulated throughout the day and count toward daily recommendations for moderate- or vigorous-intensity physical activity. Key Words: ENERGY EXPENDITURE, YOGA ASANAS, PRANAYAMA, METABOLIC EQUIVALENTS, OXYGEN UPTAKE, EXERCISE INTENSITY
FIGURE 1—Average METs from all participants for full yoga sessions, including exclusive devotion to flow through Surya Namaskar (Sun Salutations) with error bars representing the standard deviation of the mean. Bars are without error if only mean values were reported in the original study or if METs were calculated by the current study author from published VO₂ and body weight data. The average MET values for yoga practice were 3.3 ± 1.6 METs for all 10 studies and 2.9 ± 0.8 METs when the study of Mody (23) was omitted.
Surya Namaskar
Sun Salutation

1. Begin in mountain
2. Raise hands overhead, press pubic bone forward, tighten buttocks, open chest, **inhale**
3. Forward fold, tail bone up, hands next to feet, **exhale**
4. Right foot back to lunge - press heel of back foot, lengthen spine, **inhale**
5. Bring left foot back to plank position - long spine, **hold breath in**
6. Drag knees, chin and chest to floor, **exhale**
7. Sweep forward to cobra, **inhale**
8. Lift tailbone to downward dog, **exhale**
9. Left foot forward to forward fold, **exhale**
10. Lengthen spine, reaching out and up, press pelvis forward, opening chest, **inhale**
11. Exhale and release back to mountain

7-8 MET’s
This review suggests that yoga is typically classified as a light-intensity physical activity. However, a few sequences/poses, including Surya Namaskar (SS), meet the criteria for moderate- to vigorous-intensity activity.

In accordance with the ACSM/AHA guidelines, the practice of asana sequences with MET intensities higher than three (i.e., 910 min) can be accumulated throughout the day and count toward daily recommendations for moderate- or vigorous-intensity physical activity.
Select 2015-16 Research
This review explores mechanisms that may increase the risk of statin/exercise training (ET) interactions, examines the risks and benefits of combining physical activity and statin use, and offers strategies to minimize the hazards of this combination therapy.

- *e.g., crestor, lipitor, livalo, pravacol, zocor*
“We hypothesize that instability of the sarcolemmal membrane may be an effect of statin treatment, and when the integrity of the membrane is challenged is response to a bout of eccentric exercise, proteolytic cascades are activated in muscle.

Urso ML, Thompson PD, Clarkson P. et. al. ATVB 2005;25:2560 Umass
An assessment by the Statin Muscle Safety Task Force: 2014 update

Robert S. Rosenson, MD, FNLA*, Steven K. Baker, MSc, MD, FRCP(C), Terry A. Jacobson, MD, FNLA, Stephen L. Kopecky, MD, Beth A. Parker, PhD

Mount Sinai Heart, Icahn School of Medicine at Mount Sinai, 1425 Madison Avenue, New York, NY 10029, USA (Dr Rosenson); McMaster University, Hamilton, ON, Canada (Dr Baker); Emory University, Atlanta, GA, USA (Dr Jacobson); Mayo Clinic, Rochester, MN, USA (Dr Kopecky); and Department of Cardiology, Henry Low Heart Center, Hartford Hospital, Hartford, CT, USA (Dr Parker)
Are statin-associated muscle complaints altered by acute and chronic physical activity?

ANSWER: Yes

- For example, in the **STOMP study**, subjects who reported myalgia while taking atorvastatin therapy reported predominantly leg symptoms: **hip flexor, quadriceps, hamstring, and/or calf aches (n=10), quadriceps or calf cramps (n=5), and/or quadriceps, hamstring, and/or calf fatigue (n=6)**, whereas myalgic participants on placebo reported more diverse symptoms such as whole-body fatigue (n=3), worsening of pain in previous injuries (n=3), groin pain (n=3) and foot cramping (n=1).

- In the **PRIMO study**, incidence of muscle pain with statin therapy increased with the level of physical activity from 10.8% in those engaging in leisure-type physical activity to 14.7% in those regularly engaging in vigorous activity, suggesting that statin-associated muscle side effects are provoked by physical activity.

NLA Muscle Task Force 2014
Bruckert 2005
Strategies to Decrease the Risk of Adverse Interaction Between Statin and Exercise Training (ET) Therapy:

- Reassess the need for statin (*high CVD risk pts should prioritize statin*).
- Decrease the dose of statin. Change to a hydrophilic statin (*rosuva or prava*).
- Prescribe a statin holiday followed by a rechallenge.
- Decrease the intensity of ET. Decrease the duration of ET.
- Prescribe vitamin D replacement.
- Avoid drug interactions that increase statin toxicity (e.g., antifungals, antibiotics, danazol, ...)
- Prescribe coenzyme Q10 supplementation. ??

Deichman & Thompson 2015