THE IMPACT OF WEARABLE MOTION SENSING TECHNOLOGIES ON PHYSICAL ACTIVITY: A SYSTEMATIC REVIEW

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January 14, 2015

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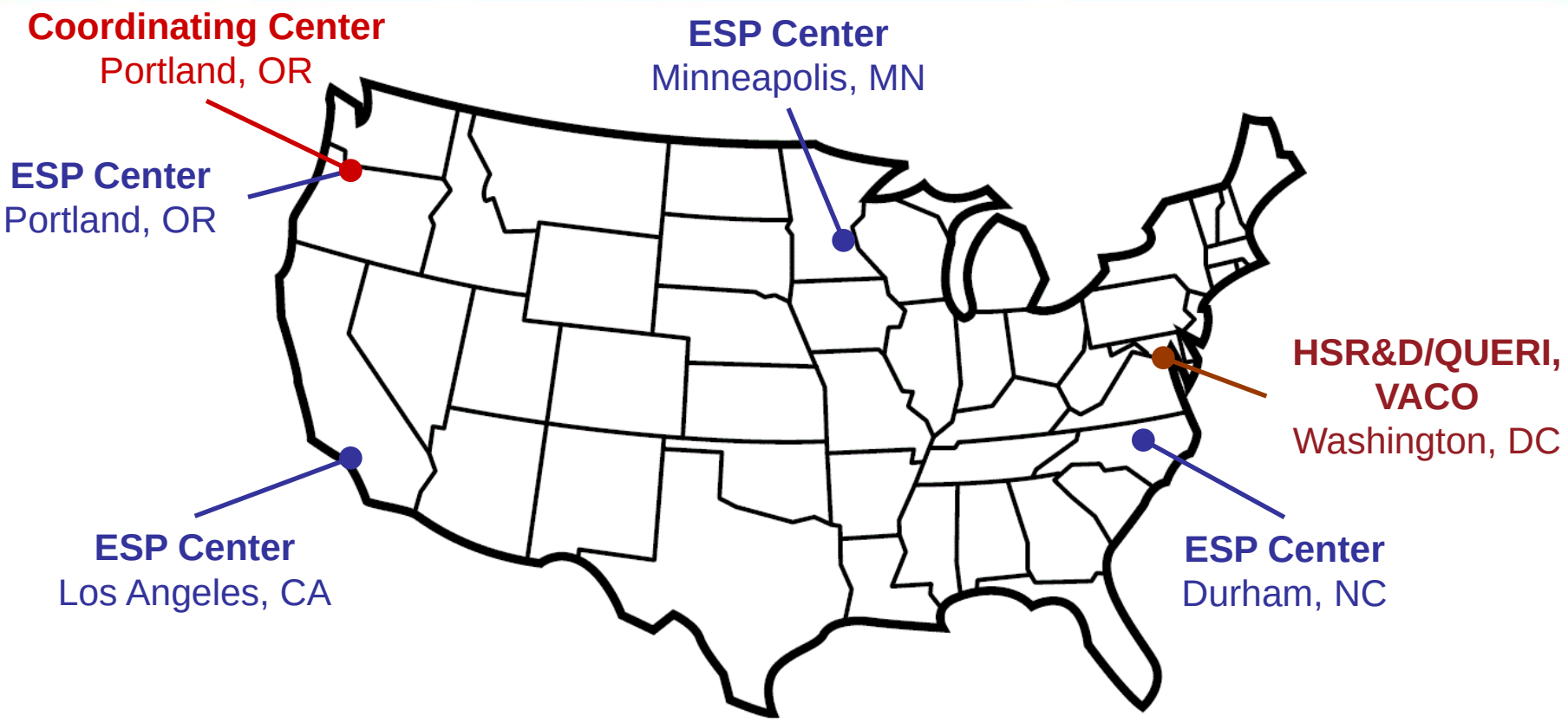
Disclosure

This report is based on research conducted by the Evidence-based Synthesis Program (ESP) Center located at the Durham VA Medical Center, Durham, NC, funded by the Department of Veterans Affairs, Veterans Health Administration, Office of Research and Development, Quality Enhancement Research Initiative. The findings and conclusions in this document are those of the author(s) who are responsible for its contents; the findings and conclusions do not necessarily represent the views of the Department of Veterans Affairs or the United States government. Therefore, no statement in this article should be construed as an official position of the Department of Veterans Affairs. No investigators have any affiliations or financial involvement (*eg*, employment, consultancies, honoraria, stock ownership or options, expert testimony, grants or patents received or pending, or royalties) that conflict with material presented in the report.

VA Evidence-based Synthesis Program (ESP) Overview

- Sponsored by VA Office of Research and Development and the Quality Enhancement Research Initiative (QUERI)
- Established to provide timely and accurate syntheses/reviews of healthcare topics identified by VA clinicians, managers, and policy-makers, as they work to improve the health and healthcare of Veterans.
- Reports conducted by internationally recognized VA clinician methodologists
- Builds on staff and expertise already in place at the Evidence-based Practice Centers (EPC) designated by AHRQ. Four of these EPCs are also ESP Centers, as shown on the following map.

ESP Center Locations



VA Evidence-based Synthesis Program (ESP) Overview

- Provides evidence syntheses on important clinical practice topics relevant to Veterans. These reports help:
  - develop clinical policies informed by evidence;
  - the implementation of effective services to improve patient outcomes and to support VA clinical practice guidelines and performance measures; and
  - guide the direction of future research to address gaps in clinical knowledge.
- Broad topic nomination process – *eg*, VACO, VISNs, field staff – facilitated by the ESP Coordinating Center (Portland) through an online process:

http://www.hsrd.research.va.gov/publications/esp/TopicNominationForm.pdf

VHA National Center for Health Promotion and Disease Prevention

- **NCP's Vision:** An all-encompassing culture of health promotion and disease prevention throughout the continuum of care that supports Veterans in achieving optimal health and well-being.
- Aligned with VHA's **Blueprint for Excellence** (BFE): address the Triple Aim to **promote both individual Veteran and population health**

Key Behavioral Determinants

3 Health Behaviors

↓

4 Major Chronic Diseases

↓

50% of Overall Mortality

Tobacco

Diet

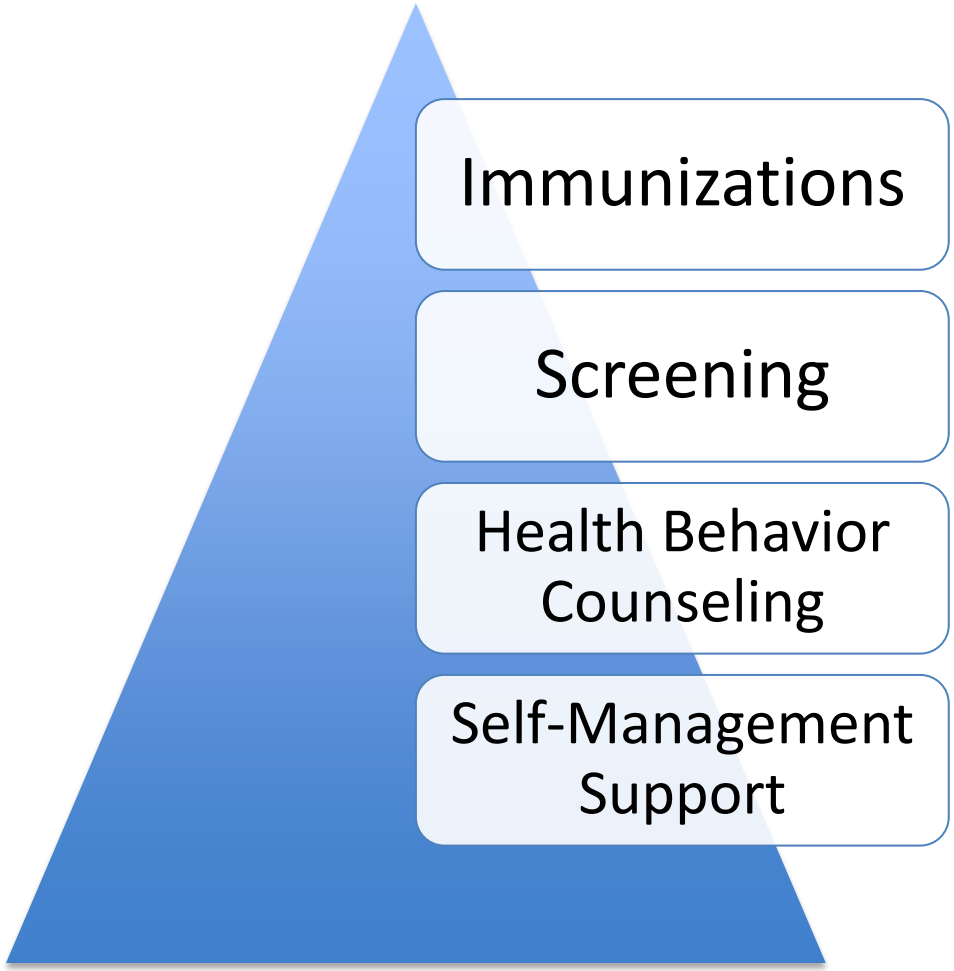
Inactivity

Burden of Overweight/Obesity in VHA

- In 2015, 42% of Veterans treated in the VHA were obese (BMI ≥ 30)
- Another 37% were overweight (25<BMI<30)
- 3.9 million Veterans treated in VHA in 2015 were overweight/obese

NCP Core Program Areas

- Clinical Preventive Services
- Health Promotion/Disease Prevention Program
- Veterans Health Education and Information
- MOVE!® Weight Management Program for Veterans



NCP's Broad Questions

1. Does the inclusion of physical activity monitors:
   - Enhance weight loss outcomes in comprehensive lifestyle weight management interventions (e.g., MOVE!)?
   - Enhance physical activity outcomes in interventions focused on increasing physical activity?
2. Does the inclusion of physical activity monitors in interventions increase patient engagement and participation in programming?
3. What impact do monitors have on Veteran experience and satisfaction?

Current report

THE IMPACT OF WEARABLE MOTION SENSING TECHNOLOGIES ON PHYSICAL ACTIVITY: A SYSTEMATIC REVIEW

(October 2016)

Full-length report available on ESP website:
http://www.hsrd.research.va.gov/publications/esp/reports.cfm

Background

- Participation in regular physical activity is important for improving health, but sedentary behavior is difficult to change
- One option is to provide feedback on physical activity with wearable motion sensing technologies (activity devices)
- Pedometers. . . first generation of activity monitors but. . .
  - reduced measurement properties in overweight/obese populations and individuals with slower ambulation speeds continues to be a limitation.
  - increasingly being replaced by accelerometers
- The effectiveness of NEXT GENERATION activity monitors has undergone limited investigation

Report goal: To synthesize the literature on newer wearable activity devices to determine effectiveness for physical activity outcomes and to describe factors that impact the effectiveness of wearable activity devices

Key Questions

KQ1: Among adults, what is the effectiveness of wearable motion sensing technologies (*eg*, activity devices such as accelerometer-based fitness trackers, global positioning systems [GPS]) on :

a. Physical activity levels?
b. Weight loss or maintenance?
c. Patient satisfaction with healthcare?

KQ 2: Among adults, does the impact of wearable motion sensing technologies (*eg*, activity devices such as accelerometer-based fitness trackers, GPS) vary by:

a. Characteristics of the population (overweight/obese/sedentary adults, older adults, healthy volunteers, and individuals with chronic medical illnesses)
b. Type of adjunctive interventions (does the activity device play a major or minor role)
c. Adherence to use of the device
d. Characteristics of the device (body location—waist, arm, wrist, or multisite)

METHODS

Study Eligibility

Study Characteristic	Inclusion Criteria
Population	Adults 18 years of age and older
Interventions	Wearable activity devices that provide objective feedback on physical activity to the wearer (*eg*, non-pedometer–based trackers such as accelerometer-based fitness trackers, smartphone applications, GPS-based trackers), alone or in combination with other interventions to enhance physical activity
Comparators	Usual care/standard of care, waitlist control Pedometer-based interventions Other active comparator focused on enhancing physical activity (*eg,* educational or behavioral interventions)
Setting	Outpatient general medical settings Specialty medical care clinics Community settings
Study design	RCTs, n>20

Data Synthesis

- **If quantitative synthesis possible:**
  - >=3 studies
  - Summary Standardized Mean Differences (SMDs) for physical activity outcomes
  - Summary Mean Differences (MD) for weight outcomes
  - Random-effects model with the Knapp and Hartung method to adjust the standard errors of the estimated coefficients
  - Evaluated statistical heterogeneity by visual inspection and Cochran's Q and I^2 statistics.
  - Results stratified by active and inactive comparator

- **Qualitative synthesis:**
  - < 3 studies
  - Gave more weight to higher quality studies
  - Synthesized reasons for inconsistency in effects across studies by evaluating differences in the study population, intervention, comparator, and outcome definitions

Data Synthesis: Potential Moderators

- **Population Characteristics** (overweight/obese/sedentary adults, older adults, healthy volunteers, and individuals with chronic medical illnesses)

- **Role device played in study**
  - Major - Central motivational enhancement intervention; other adjunctive interventions played a minor role in enhancing physical activity.
  - Minor - Integrated component of a suite of other motivation enhancement interventions
    - such as a structured exercise program, diet or chronic disease counseling/education/monitoring, self-management techniques, or monetary or nonmonetary incentives.

- **Adherence to the device**

- **Device Location (body location—waist, arm, wrist, or multisite)**

RESULTS

Literature Search & Study Characteristics

Literature search January 1, 2000, and January 6, 2015:

- Identified 4,787 titles; 176 full-text reviews
- 14 unique trials (n=12 studies on physical activity and n=11 studies on weight loss)

Study characteristics:

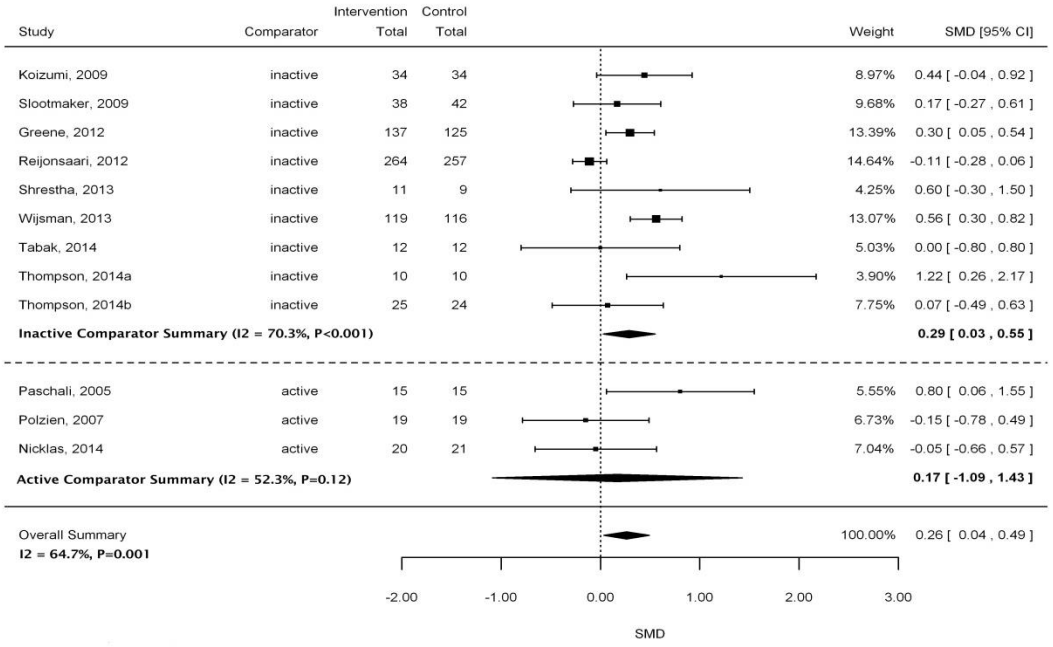
- 62.5% Women, Median age 49.7 (range 28.7 to 79.8 years)
- Study sizes ranged (20 to 544)
- Samples: n=4 older adults, n=5 overweight/obese,
  n=3 chronic illness, and n=2 healthy volunteers
- Interventions varied widely
  - duration range 12 to 52 weeks
  - planned contact with participants ranged from 0 to 52 weekly contacts.
- Wide variety of adjunctive interventions (e.g., diet, counseling, feedback, web-based modules)
- The majority (n=8) studies had high ROB

- **ALL STUDIES USED ACCELEROMETERS**

KQ 1a: Physical Activity

KQ 1a Results: Physical Activity

Physical Activity:



- Wide range of individual study estimates (-0.15 to 1.22)
- Slightly stronger effect (SMD=0.29) for inactive comparators compared to active (SMD=0.17)
- High heterogeneity found in the overall pooled estimate

Relationship between accelerometer use and physical activity

Pooled SMD : 0.26 (0.04 to 0.49)

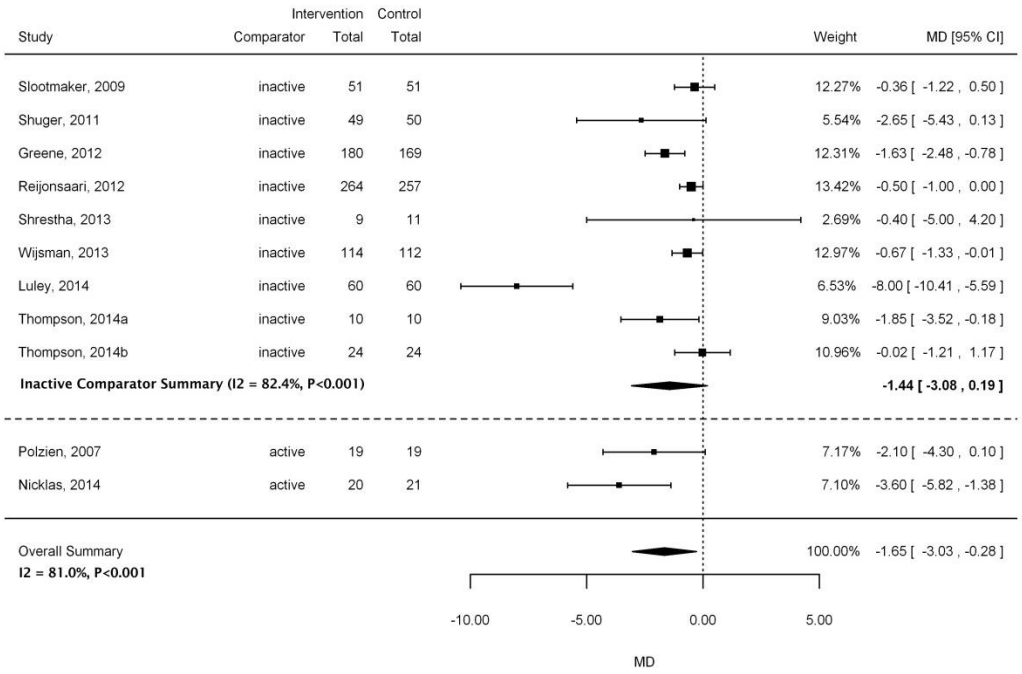
Take home message: Physical Activity

- We found 12 studies that met eligibility for physical activity outcomes. Most (n=9) compared the accelerometer against a weak inactive comparator.
- Substantial variability was found in individual study estimates and in outcome measures utilized.
- No studies were found in a specific VA population
- *Existing evidence suggests small statistically significant positive effect of accelerometer interventions on increasing physical activity levels.*

KQ 1b:
Weight Loss or Maintenance

KQ 1b Results: Weight Loss or Maintenance

Accelerometers & Weight Loss or Maintenance:



Relationship between accelerometer use and weight loss or maintenance

Pooled MD : -1.65 (-3.03 to -0.28)

- 11 studies met eligibility
- Variability in the strength of individual study estimate. Most estimates favored weight loss (-0.36kg to -2.65kg). One study had a -8.0kg weight loss.
- High heterogeneity found in the overall pooled estimate
- Two studies with active controls
  - Polzen, 2007 and Nicklas, 2014- Both studies showed a decrease in body weight. Only the Nicklas was statistically significant. This study used structured and supervised exercise, meal preparation and counseling for 5 months

Evidence-based Synthesis Program (ESP)

ESP Evidence-based Synthesis Program

Take home message: Weight Loss or Maintenance

- We found 11 studies that met eligibility for physical activity outcomes. Most (n=9) compared the accelerometer against a weak inactive comparator.

- Substantial variability was found in the strength of individual study estimates. However, most studies favored weight loss.

- Only 2 studies used active comparators; both demonstrated a positive trend of weight loss, but only one study was statistically significant. The device played a minor role in this study.

- *Existing evidence suggests small statistically significant positive effect of accelerometer interventions on weight loss or maintenance*

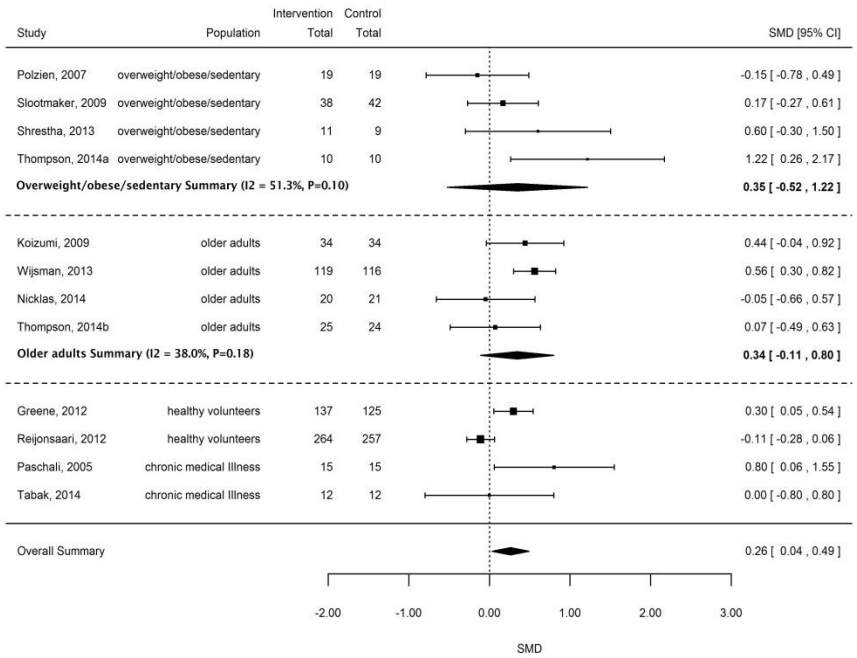
KQ 1c:
Patient satisfaction with healthcare

- No RCT's identified to address this outcome

KQ 2: Do the effects vary?

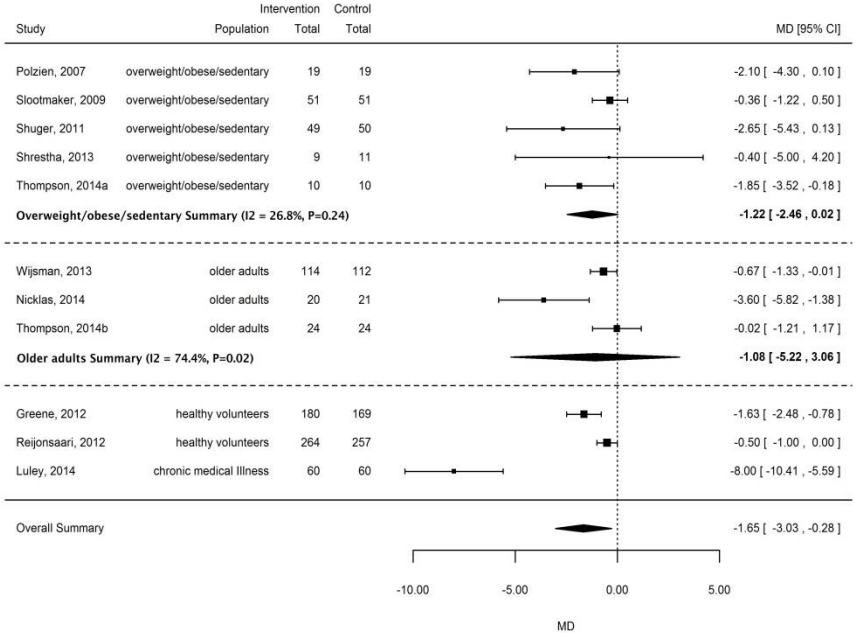
KQ 2a Results: Characteristics of the Population

Accelerometer Use and Physical Activity Across Population Characteristics



No significant differences by population characteristic

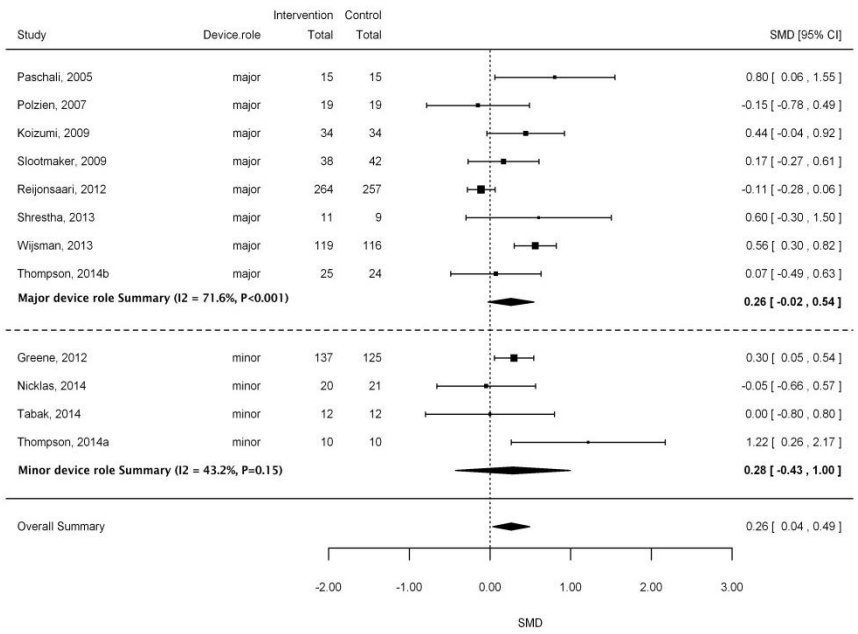
Accelerometer Use and Weight Loss Across Population Characteristics:



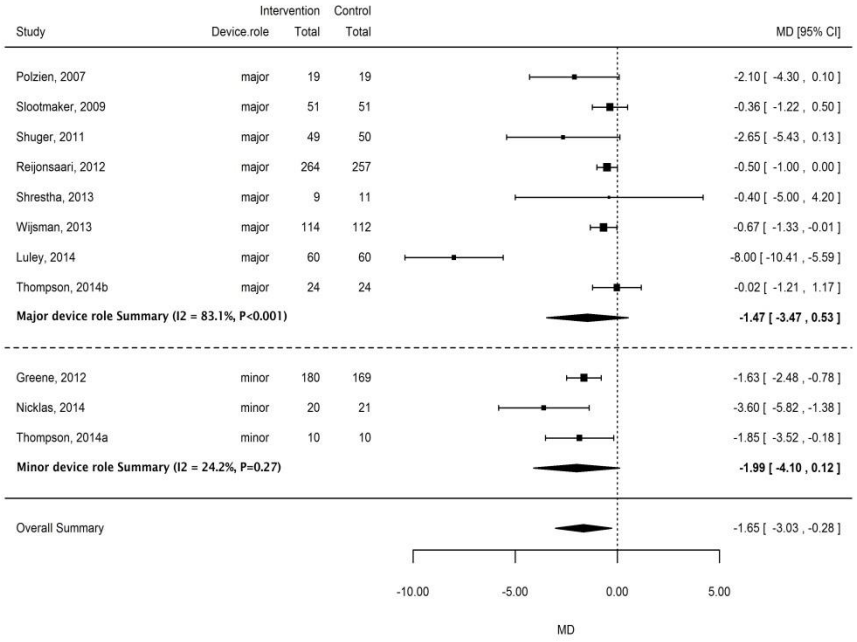
No significant differences by population characteristic

KQ 2b Results:
Device Role – Major vs. Minor

Accelerometer Use and Physical Activity Across Device Role



Accelerometer Use and Weight Loss Across Device Role



No significant differences by population characteristic

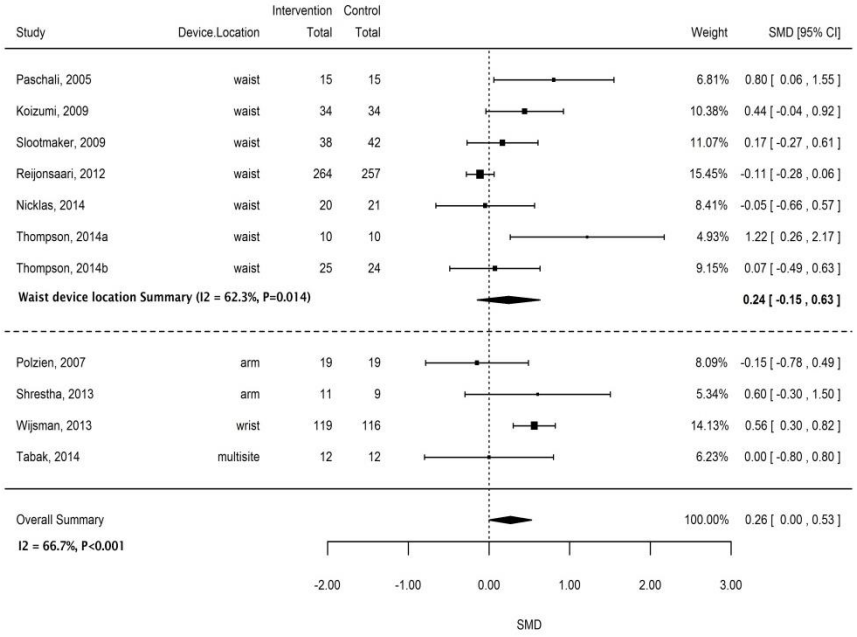
No significant differences by population characteristic

KQ 2c Results: Adherence

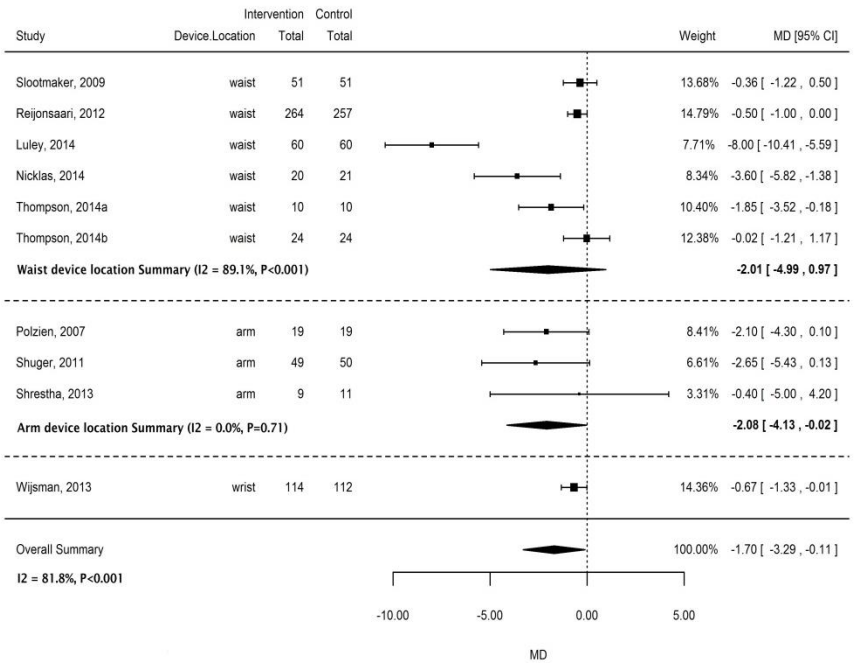
- 4 of 14 studies reported adherence
- Variability in the measure of adherence (e.g., time use, days worn, % of days)
- Drop outs from the studies ranged from 12% to 31%
- In 3 studies where the accelerometer played a major role in the intervention a consistent pattern of decline in participant use was evident over study duration
- We are unable to determine whether accelerometer adherence has an effect on the outcomes of interest when accelerometers are used as part of behavioral interventions

KQ 2b Results: Device Location

Accelerometer Use and Physical Activity Across Device Location



Accelerometer Use and Weight Loss Across Device Location



No significant differences by population characteristic

No significant differences by population characteristic

Take home message:
Do the effects vary?

- In general, interventions that capitalized on self-monitoring and tailored activity were associated with greater decreases in weight loss.

- Effects were even greater when these strategies were paired with behavioral counseling focused on device feedback.

- *We did not identify any individual factors that were robust explanatory variables of heterogeneity.*

Limitations

- Limitations of the literature
  (few studies, design limitations, diverse intervention packages)
- Small sample sizes of most included trials may have resulted in a type II error
- No studies specifically recruited Veterans
  - Population consisted of conditions and subjects highly applicable to VA
- High heterogeneity in pooled estimates unexplained by subgroup analyses

Research Gaps & Future Directions

- Population
  - Limited studies among those with chronic medical illness
- Interventions
  - Optimal adjunctive interventions
  - Intensity or dose of adjunctive interventions
  - Adherence influence outcomes
  - Effectiveness of accelerometer based feedback
- Comparators
  - Few studies with active or robust comparators
  - No head to head comparisons with pedometers
- Outcomes
  - How do participants interact with their feedback
  - Facilitators and barriers to adoption

Summary

- Accelerometers demonstrated small positive effects on physical activity and weight loss.
- The small sample sizes with moderate to high heterogeneity in the current studies limit the conclusions that may be drawn.
- Larger, well-designed randomized controlled trials are needed.
- Clinicians and policymakers should consider these findings and the existing gaps in the literature before widespread use of these technologies.

Questions?

ESP Questions?

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The full report and cyberseminar presentation is available on the ESP website: *http://www.hsrd.research.va.gov/publications/esp/*

NCP Questions?

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