RE-ENGINEERING SEDENTARY WORK TO IMPROVE THE HEALTH OF WORKERS

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OVERVIEW

- Rationale for studying occupational sedentary work
- Recent studies in this area
- Ongoing and Future Research in this area

IN THE HEADLINES…

David Sturt and Todd Nordstrom
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Is Sitting The New Smoking?

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A study released by the American College of Occupational and Environmental Medicine suggests that, because you're human, you lose 11% to 14% of your productivity-potential every day. You check the news. You chitchat with a colleague in the next cubicle. You daydream about dinner, who is going to be on Jimmy Kimmel tonight, or your upcoming weekend road-trip. We're all human. We're not machines. And there's not much we do to change it.

Here's something you can change. Research also suggests that for every health risk you possess, you lose an additional percentage of your productivity-potential (small health risks obviously impact productivity less than serious health concerns). Some studies suggest

IN THE HEADLINES…

14 January 2015 Last updated at 21:41 ET

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Inactivity 'kills more than obesity'

COMMENTS (864)

By James Gallagher
Health editor, BBC News website

A lack of exercise could be killing twice as many people as obesity in Europe, a 12-year study of more than 300,000 people suggests.

University of Cambridge researchers said about 676,000 deaths each year were down to inactivity, compared with 337,000 from carrying too much weight.

They concluded that getting everyone to do at least 20 minutes of brisk walking a day would have substantial benefits.

Related Stories

- Labour pledges caps on fat and salt
- Why cycling is a winning exercise
- Obese lose up to eight years of life

IN THE HEADLINES…

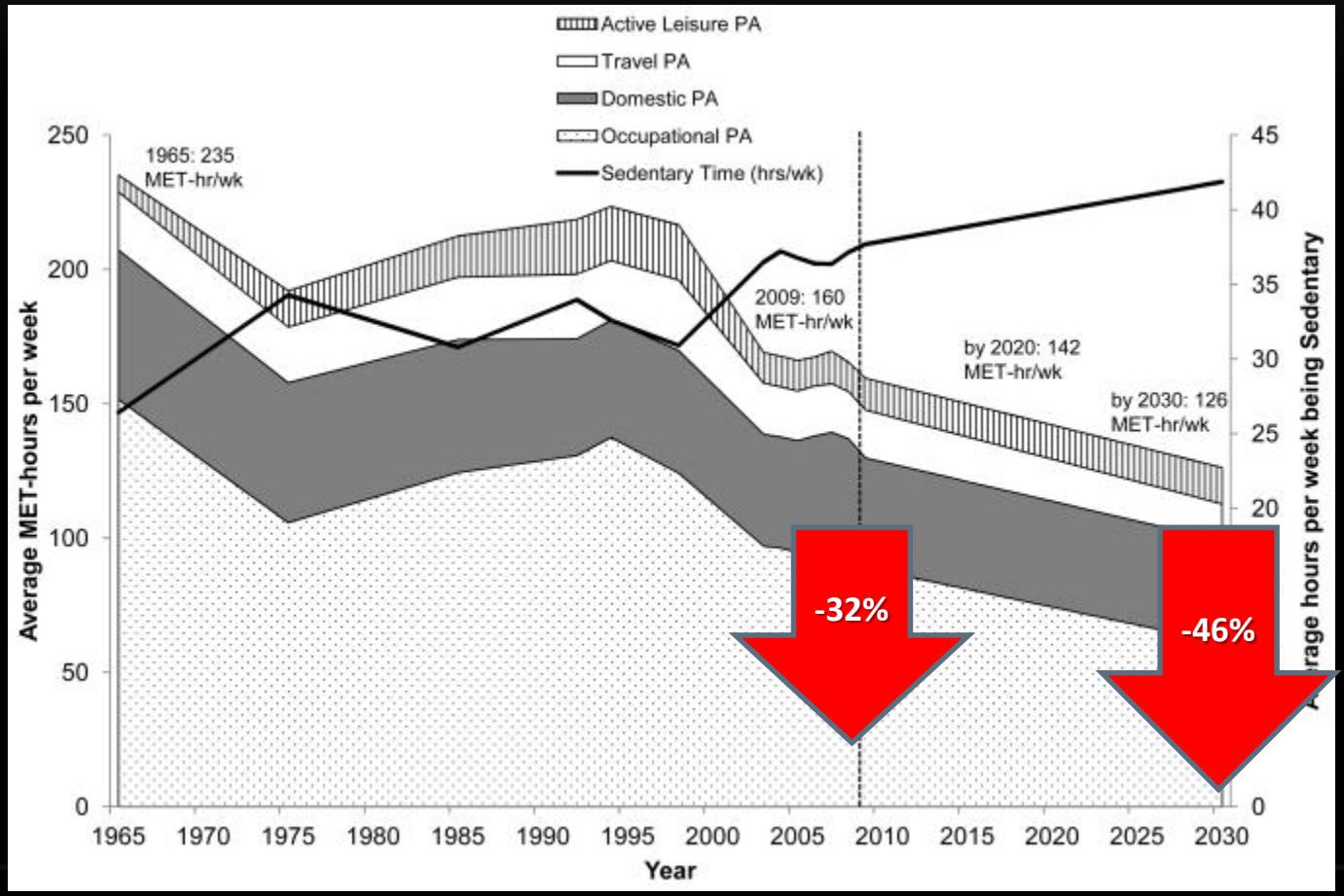
Even for the active, a long sit shortens life and erodes health

New research links sitting for long hours with elevated risk of cancer, cardiovascular disease, type 2 diabetes and early death. (Lawrence K. Ho / Los Angeles Times)

INACTIVITY EPIDEMIC

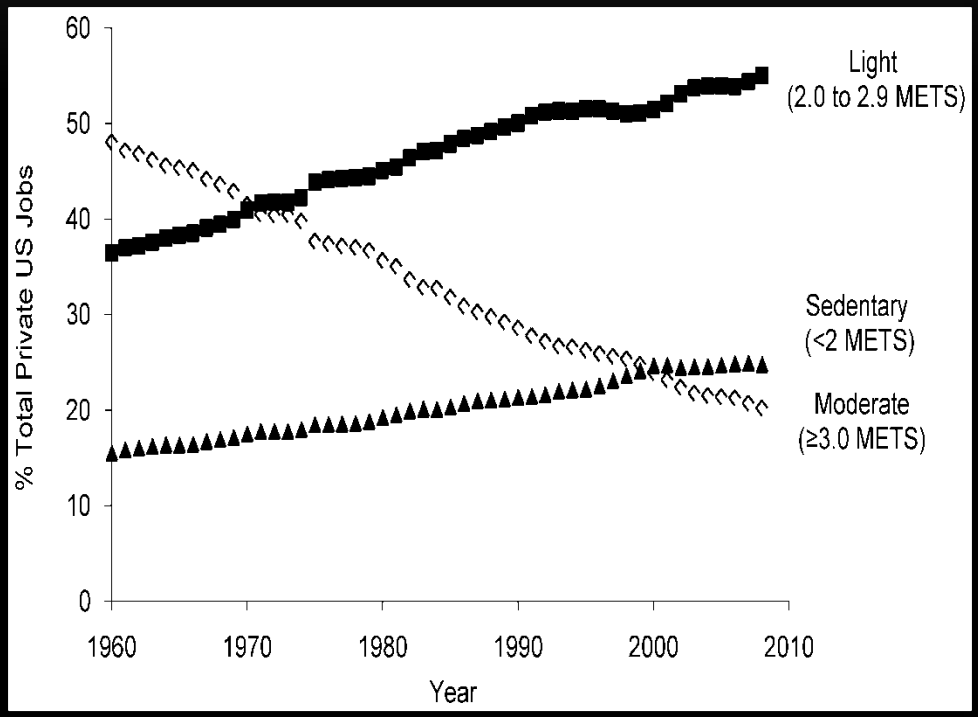
- Physical inactivity is the biggest public health problem in the 21st Century - Blair, *BJSM*, 2009
- Inactivity responsible for 9% of all premature deaths worldwide - Lee et al., *Lancet*, 2012
- Less than 5% of U.S. adults meeting recommendation to obtain 30 minutes MVPA/day – Troiano et al., *MSSE*, 2008
- U.S. adults spend > 50% wakeful time (6.5-8.3 hrs/day) sedentary - Hagstromer, 2007; Matthews et al., 2008

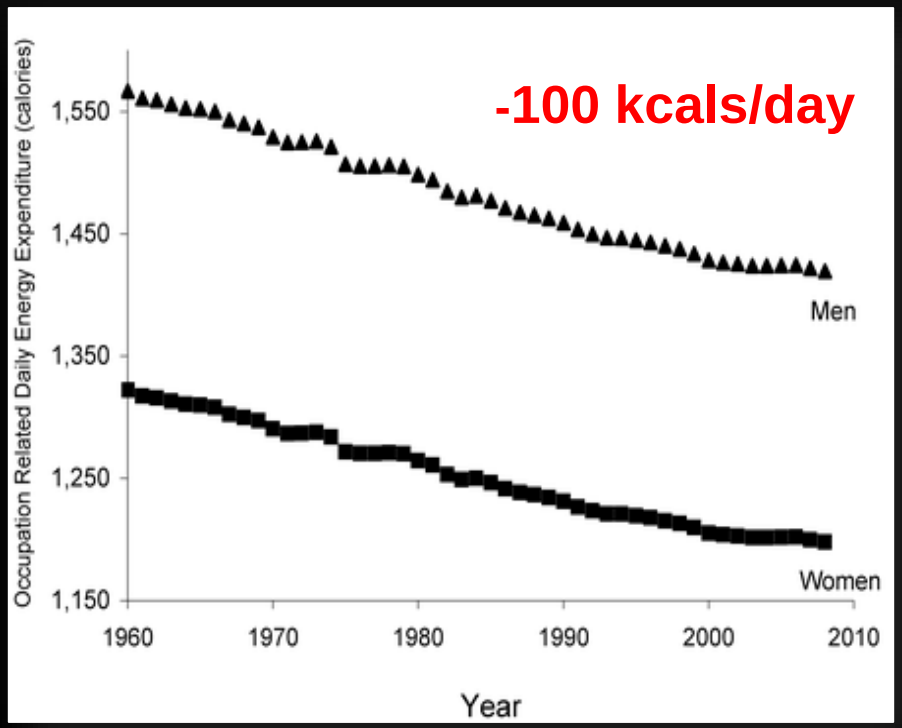
INACTIVITY EPIDEMIC



Ng and Popkin, *Obes Rev*, 2012

OCCUPATIONAL ENERGY EXPENDITURE IS DECLINING





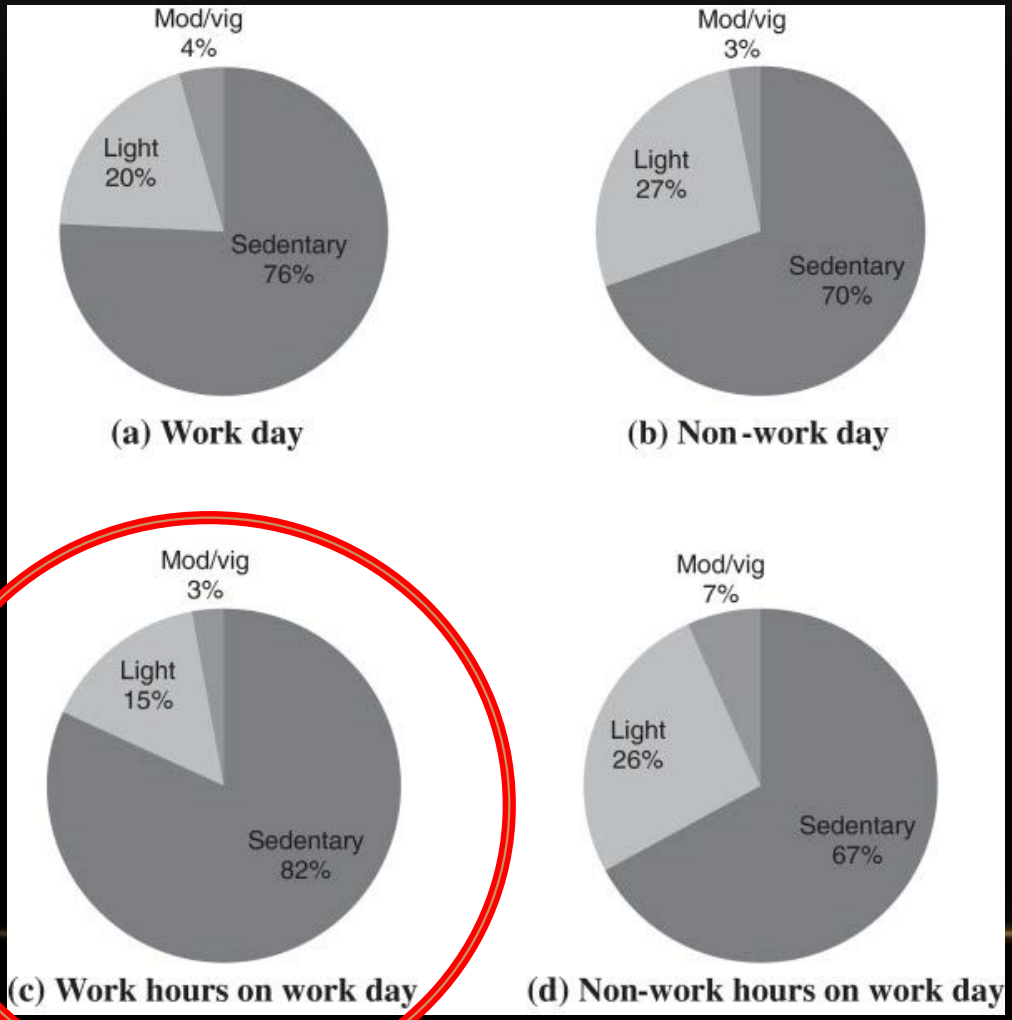
Church et al., PloS One, 2011

SEDENTARY/LOW ACTIVE JOBS MAKE UP LARGE PORTION OF WORKFORCE

	METs Median (min, max)	Activity Category
Farm Jobs	3.0 (2.5, 4.5)	Moderate
Goods-Producing		
Mining and logging	3.8 (3.0, 8.0)	Moderate
Construction	4.0 (1.5, 7.5)	Moderate
Manufacturing	3.0 (1.5, 4.0)	Moderate
Service-Providing		
Trade (wholesale & retail), transportation, and utilities	2.0 (1.5, 3.0)	Light
Information	1.5 (1.5, 1.5)	Sedentary
Financial activities	1.5 (1.5, 1.5)	Sedentary
Professional and business services	1.5 (1.5, 2.0)	Sedentary
Education and health services	2.5 (1.5, 4.0)	Light
Leisure and hospitality	2.5 (1.5, 3.5)	Light
Other services	2.5 (1.5, 3.0)	Light

Church et al., PloS One, 2011

OFFICE WORKERS SPEND >80% OF WORK TIME SEDENTARY

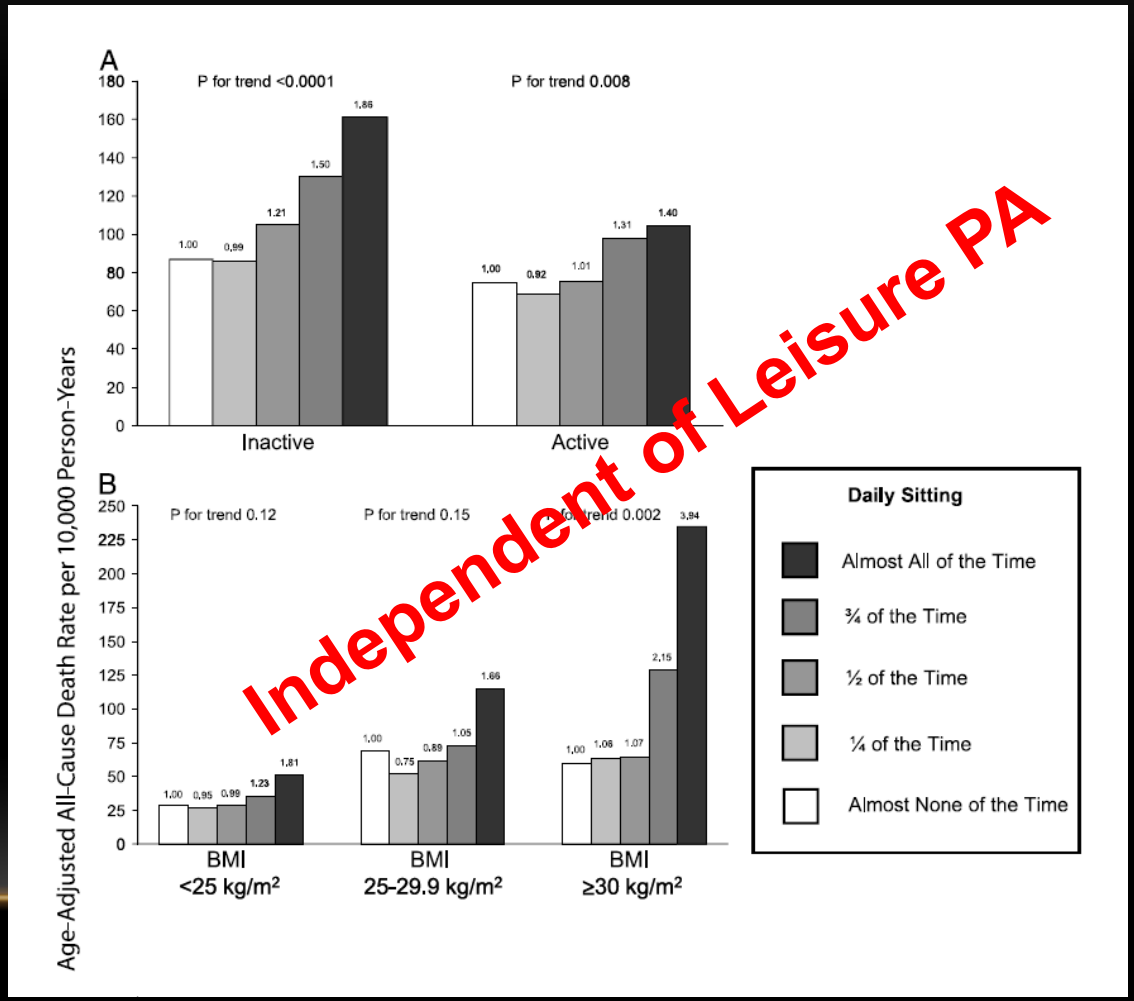


Parry and Straker, *BMC Public Health*, 2013

SEDENTARY BEHAVIOR INCREASES RISK FOR CHRONIC DISEASES AND MORTALITY

SEDENTARY AND MORTALITY

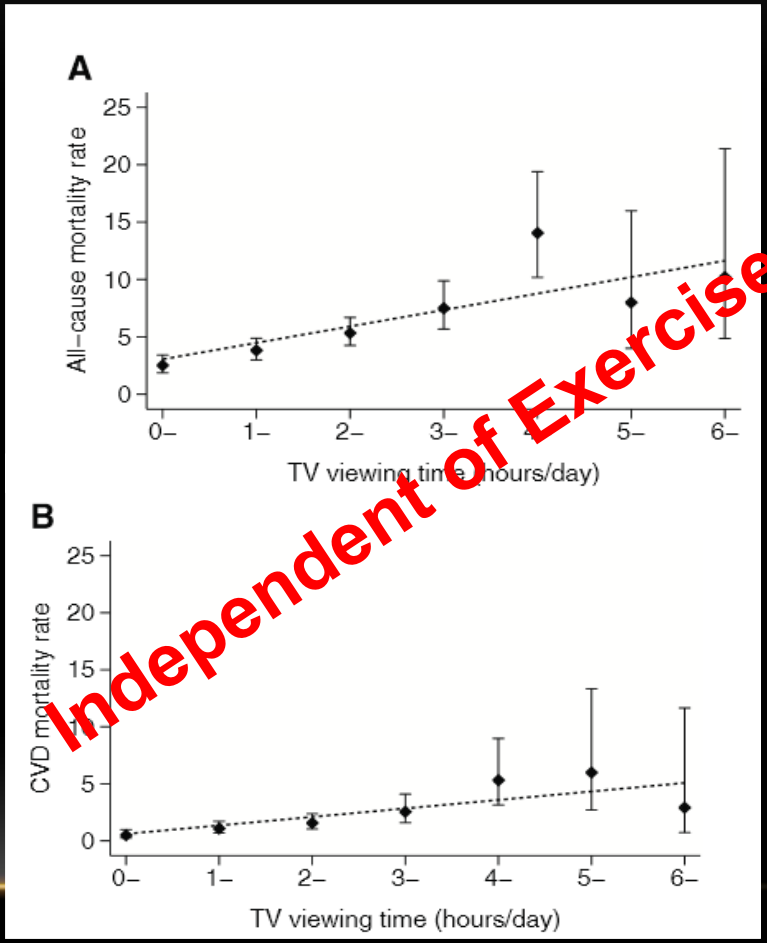
- 12 year follow up
- 17,000 adults
- 18-90 years age
- Dose-response for all cause and CVD mortality



Canadian Fitness Study- Katzmarzyk et al., *MSSE*, 2009

SEDENTARY AND MORTALITY

- 6.6 year follow up
- 8,800 adults
- 25+ years age
- Dose-response for all cause and CVD mortality

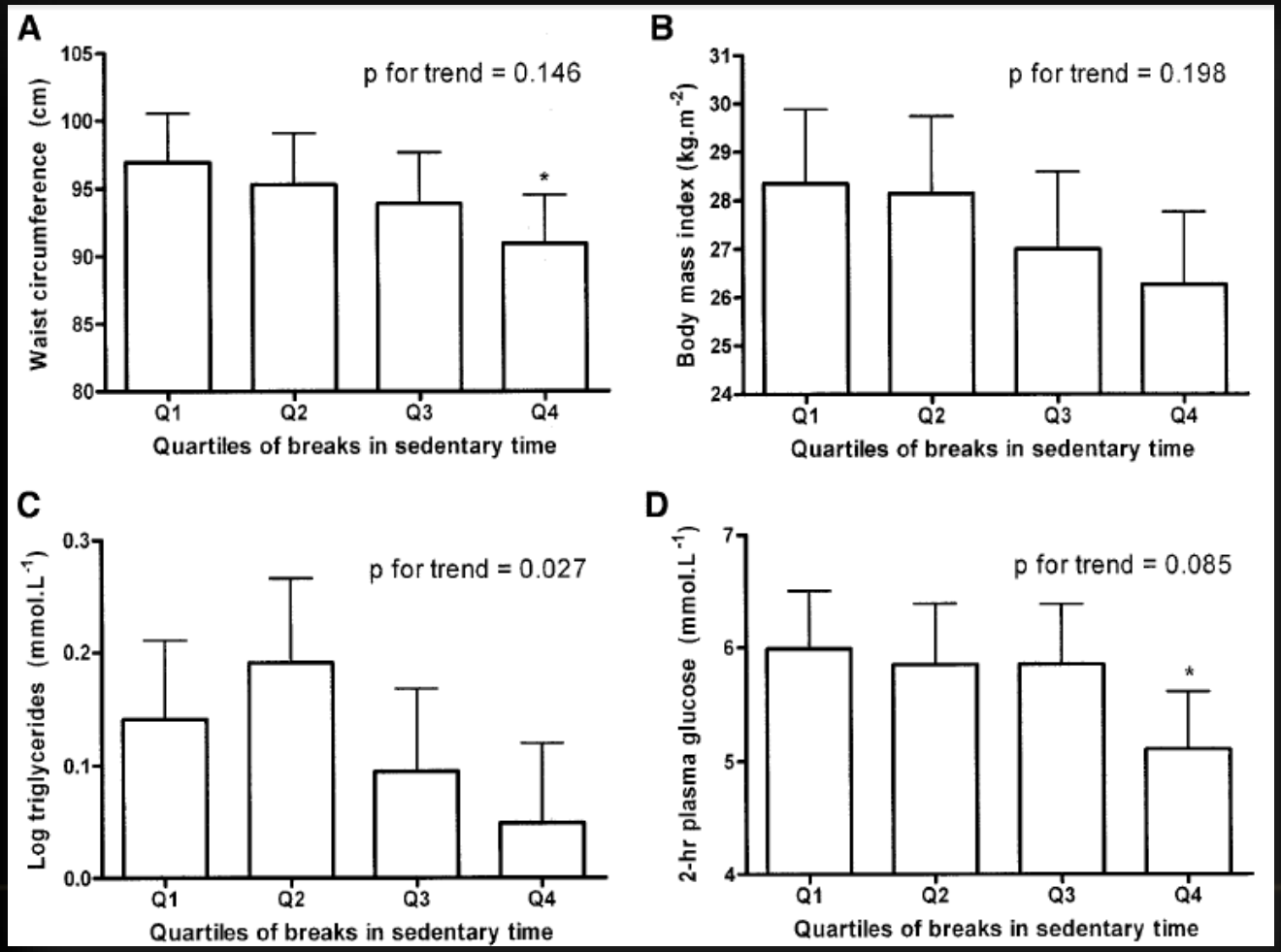


AusDiab Study - Dunstan et al., *Circulation*, 2010

INCREASED DISCOMFORT MAY DRIVE DECREASED WORKER PRODUCTIVITY

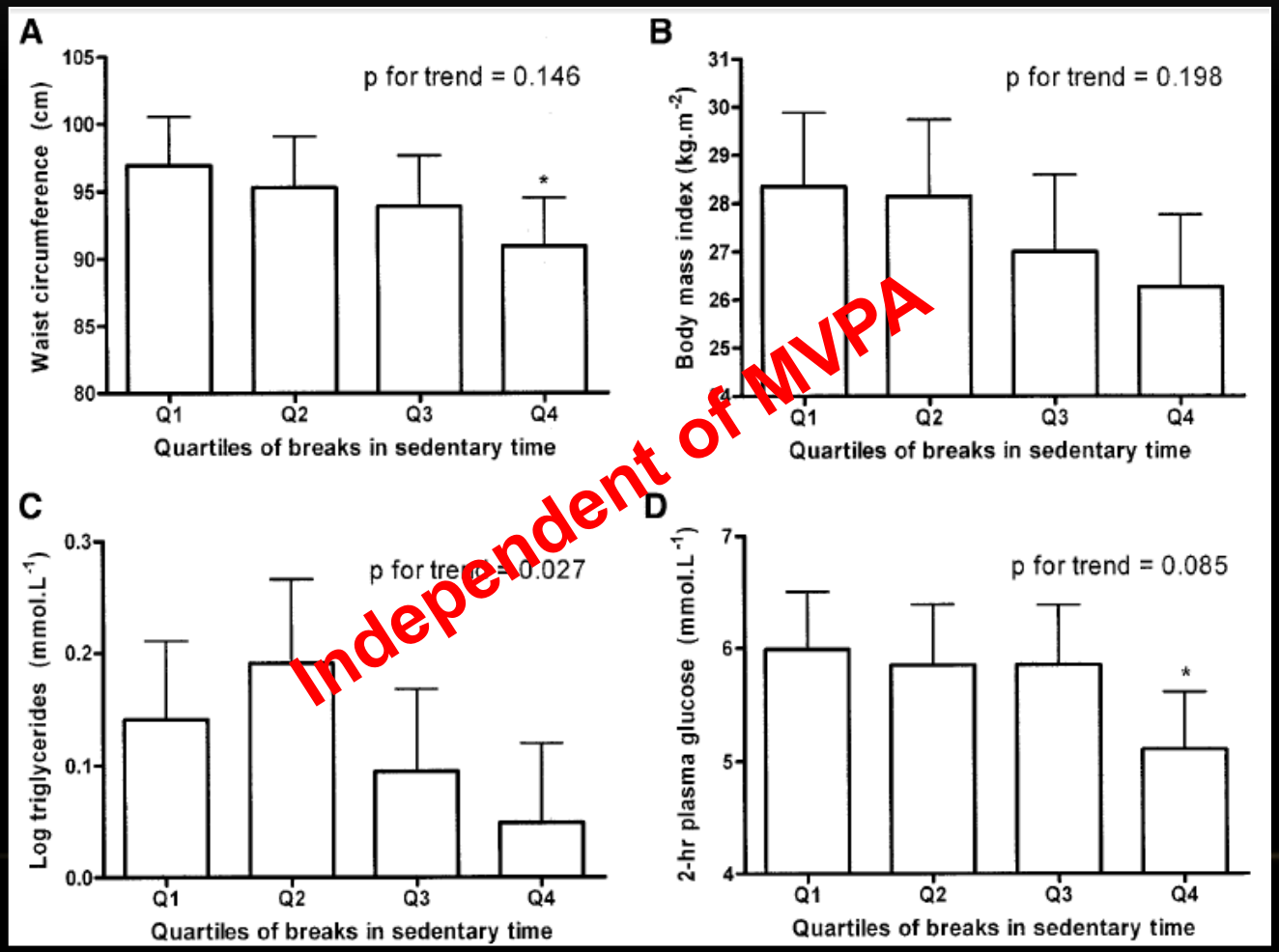
Liao and Drury, *Ergonomics*, 2000
Haynes and Williams, *Indust Ergo*, 2007

GOOD NEWS: INTERRUPTING SEDENTARY TIME MAY IMPROVE HEALTH INDEPENDENT OF MVPA



Healy et al., *Diabetes Care*, 2008

RELATION BETWEEN BREAKS IN SEDENTARY AND RISK FACTORS



Healy et al., *Diabetes Care*, 2008

UNIQUE SEDENTARY PHYSIOLOGY?

- Genetic evidence suggests physical activity and sedentary behavior may have two different phenotypes with unique underlying physiological mechanisms

de Vihena e Santos, Katzmarzyk et al., 2012

1. Physiological mechanisms linking sedentary behaviors to negative health outcomes are not well known
2. The dose and type of physical activity necessary to reverse negative health effects caused by sedentary behaviors are also poorly understood
3. Need for interventions that specifically target sedentary behaviors

Thyfault et al., *MSSE*, 2015

INTERVENTIONS FOR SEDENTARY BEHAVIORS

INTERVENTIONS TARGETING SEDENTARY BEHAVIOR AT WORK

- 6 Physical Activity RCT's have been conducted with reduced sitting as secondary outcome
- None focused on reducing sedentary behaviors
  - None demonstrated effectiveness
  - All used self report measures of sitting
- Only 4 interventions specifically targeting sedentary behaviors amongst adults
- Brief in duration

Chau et al., 2010

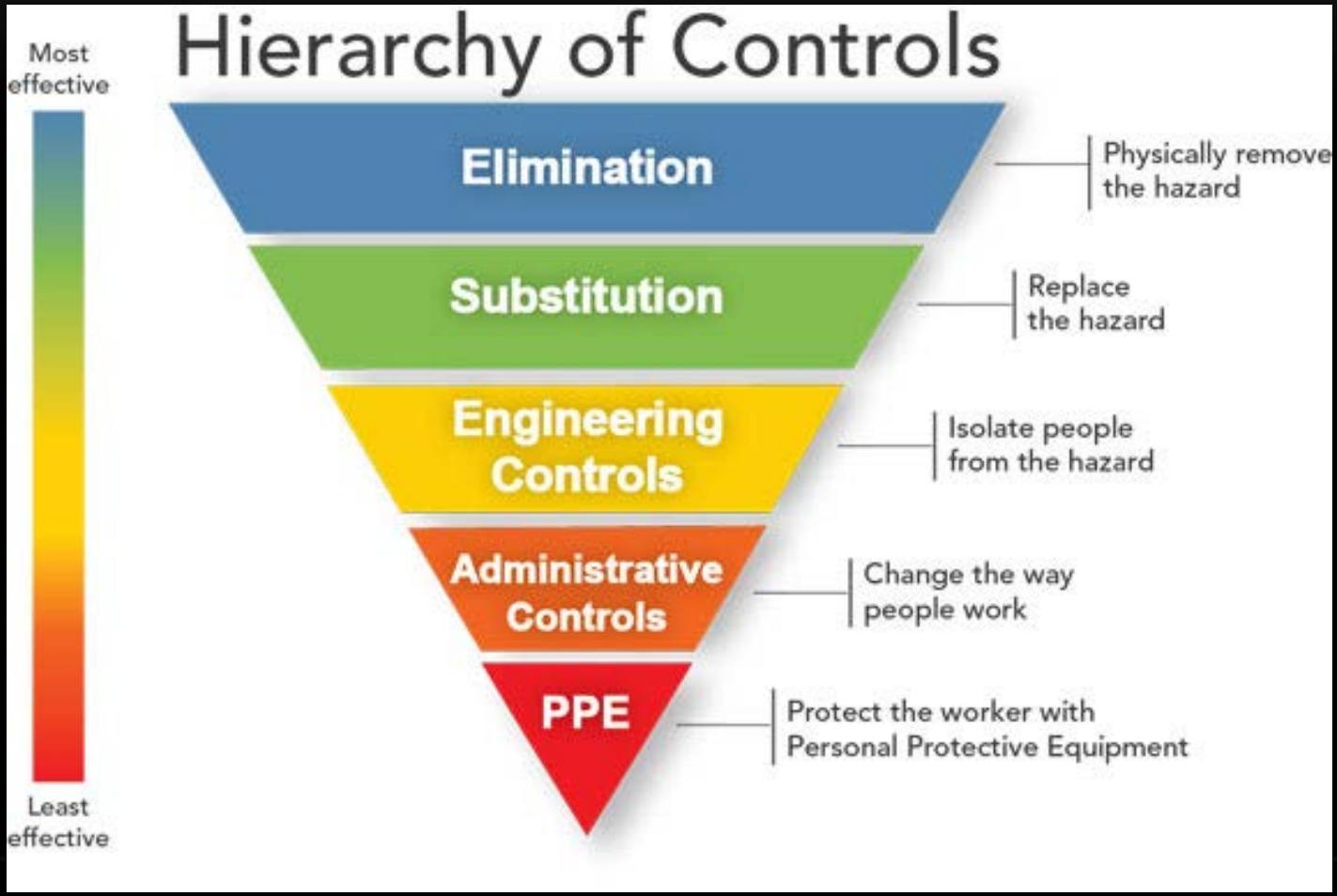
INTERVENTIONS TARGETING SEDENTARY BEHAVIOR AT WORK

- Cochrane review evaluated RCTs, cluster-RCTs, and quasi-randomized controlled trials of workplace interventions to reduce sitting at work
- 20 studies
- Sit-stand desks decreased work sitting 30-120 min/day
- Conflicting evidence for active workstations
- Walking breaks did not reduce sitting
- Limited evidence for counseling and computer prompting software programs

Conclusion: Quality of evidence low due to poorly designed studies, small sample sizes, short duration

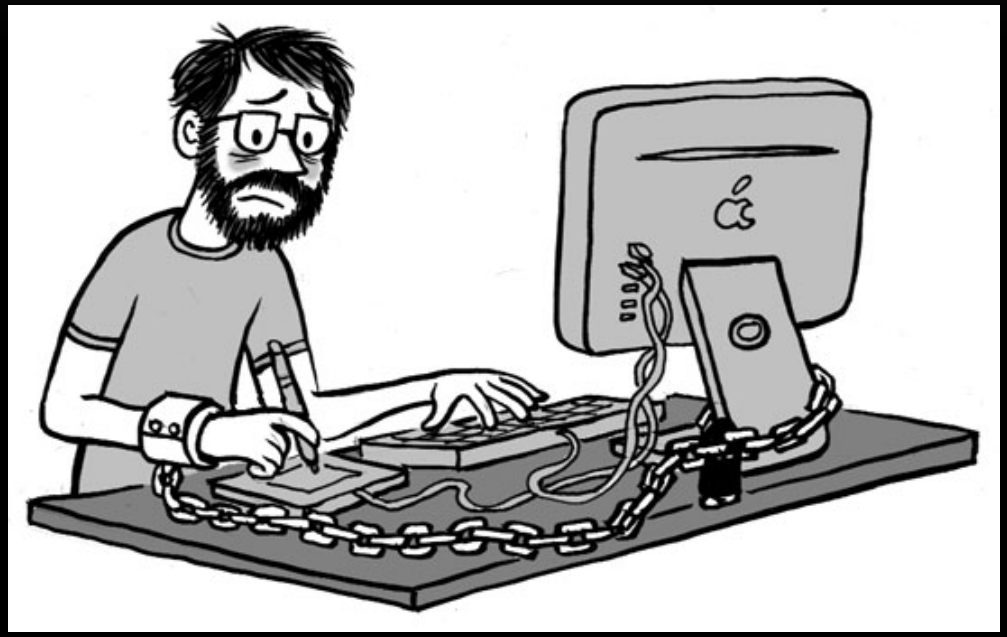
Shrestha et al., Cochrane Database Syst Rev. 2016

ENGINEERING APPROACHES COULD PROTECT EMPLOYEES FROM EXPOSURE TO HAZARDOUS SEDENTARY WORK



NIOSH, CDC, 2014

IDENTIFY THE SOURCE OF THE HAZARD

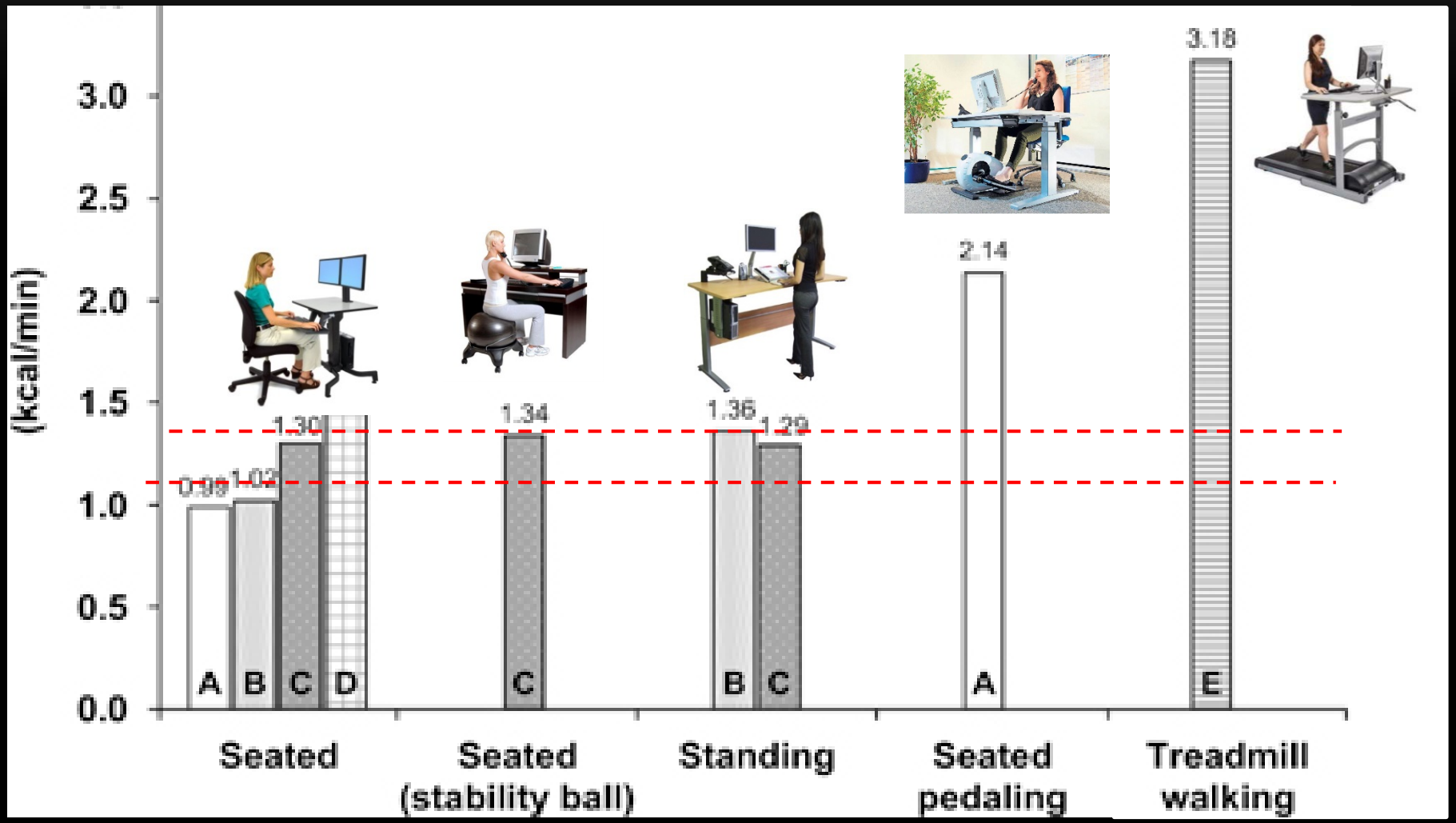


ACTIVE DESKS RE-ENGINEER THE SOURCE OF THE HAZARD

Sit-stand desk

Active seated desk

ACTIVITY PERMISSIVE WORKSTATIONS TO ENGINEER ACTIVITY INTO THE WORKDAY



Tudor-Lock et al., MSSE, 2014

STUDY 1: COMPARISON OF LONG-TERM SEATED VS SIT-STAND DESKS

RATIONALE FOR STUDY

- Although evidence suggests light-intensity physical activity may improve health, few data are available regarding the health benefits of increased standing.
- Sit–stand desks may reduce sitting time over a short duration (3 months).
- It is unknown, however, whether long-term access to sit–stand desks reduces sitting time or improves cardiometabolic risk factors.

LONG-TERM ACCESS TO STANDING DESKS ASSOCIATED WITH LESS SITTING

Desk Type	Proportion Time Seated (%)
Standing Desk (N=90)	78.5% [64.2-84.2]
Sitting Desk (N=41)	83.8% [76.7-86.8]

-5.3%
-25.4 minutes/day

- Limited to Swedish call center workers
- Only measured 1 day of work

Straker et al., *Applied Ergonomics,* 2013

Purpose

- Compare sedentary/physical activity behaviors and cardiometabolic risk factors among employees providedaccess to sit–stand desks or sitting desks for >6 months

Hypothesis

- Employees with access to sit–stand desks would sit less, stand more, and have healthier cardiometabolic profiles than employees with sitting desks.

DESIGN AND PARTICIPANTS

- Naturalistic study design
- 69 full-time (35 hrs/week) employees working in desk jobs who were assigned either sitting desks (N=39) OR sit-stand desks (N=31)
- Recruited those using desk for minimum of 6 months

MEASURES

1. Occupational and Daily Sedentary Time
   - activPAL inclinometer for 5 work days
   - Sitting, Standing, Walking, Steps, Sit-Stand Transitions
2. Cardiometabolic Risk Factors
   - Resting blood pressure and heart rate
   - Weight, body composition
   - Estimated peak $V0_2$

NO BETWEEN GROUP DIFFS FOR CARDIOMETABOLIC BIOMARKERS

Table 1. Combined and Between-Group Comparisons According to Desk Type (Mean±SD)

	All (N=69)	Sit desks (*n*=38)	Sit–stand desks (*n*=31)	*p*-value
Age (years)	44.1±10.7	43.6±10.6	43.4±13.5	0.56
% female	74	71	82	0.64
Average work time (hours/week)	39.5±7.9	39.1±9.9	39.9±4.3	0.78
Average duration with current desk type (years)	4.6±5.4	6.4±6.2	1.8±0.8	**<0.01**
Weight (lbs)	194.5±47.7	192.4±47.1	197.1±48.9	0.69
BMI (kg/m^2)	30.5±6.6	30.1±6.8	31.0±6.4	0.55
Lean mass (lbs)	119.0±25.1	119.7±25.4	118.0±25.1	0.78
Fat mass (lbs)	74.7±31.4	72.9±33.1	76.9±29.6	0.60
Percent body fat (%)	37.8±9.1	36.7±9.9	39.2±7.9	0.26
Waist circumference (cm)	99.0±16.4	97.8±14.9	100.6±18.1	0.49
Resting heart rate (bpm)	75±9	74±10	76±7	0.23
Systolic blood pressure (mmHg)	122±10	124±7	120±12	0.10
Diastolic blood pressure (mmHg)	75±9	77±8	73±10	0.08
Estimated peak V02 (ml/kg/min)	30.8±8.1	30.7±8.1	30.8±8.2	0.96

Note: Boldface indicates statistical significance ($p<0.05$).
bpm, beats per minute; cm, centimeter; kg, kilogram; lbs, pounds; m, meter; min, minute; ml, milliliter; mmHg, millimeters of mercury.

Carr et al., *AJPM*, 2016

SIT-STAND DESK EMPLOYEES STOOD MORE AND SAT LESS

Table 2. Between-Group Comparisons of Occupational Sedentary/Physical Activity Behaviors

	Sit desks (N=38)	Sit–stand desks (N=31)	*p*-value
Avg time sitting/lying (hours/day)	7.3 (6.4–8.1)[a]	6.2 (5.1–7.6)[a]	**0.02**
Avg time standing (hours/day)	1.9 (1.1–2.6)	2.9 (1.6–3.9)	**<0.01**
Avg time walking (hours/day)	0.7 (0.5–1.0)	0.9 (06–1.0)	0.22
Avg steps (steps/day)	4,407 (2,950–5,589)	4,589 (3,598–5,498)	0.32
Avg sit/stand transitions (/day)	33.7 (28.9–45.7)	29.4 (22.2–38.0)	0.09
Avg day EE (METs/day)	14.5 (13.9–15.0)	14.7 (14.5–15.6)	0.26

Note: Boldface indicates statistical significance ($p<0.05$).
[a]All measures presented as median (interquartile range).
Avg, average; EE, energy expenditure.

Carr et al., *AJPM*, 2016

CORRELATIONS BETWEEN SEDENTARY/PHYSICAL ACTIVITY AND CARDIOMETABOLIC RISK FACTORS

Table 3. Correlations Between Sedentary/Physical Activity Behaviors at Work and Cardiometabolic Biomarkers While Controlling for Sex (N=69)

	Sitting time	Standing time	Walking time	Steps taken	Sit–stand transitions
Weight (lbs)	0.03	−0.09	−0.11	**−0.23**	0.10
Lean mass (lbs)	0.20	−0.03	−0.19	**−0.28**	−0.01
Fat mass (lbs)	−0.05	0.13	−0.07	−0.18	0.14
BMI (kg/m^2)	−0.05	0.16	−0.10	−0.19	0.08
Body fat (%)	−0.16	0.18	0.01	−0.07	0.12
Waist circumference (cm)	−0.05	0.14	0.03	−0.07	0.12
SBP (mmHg)	0.11	−0.05	**−0.23**	−0.19	−0.06
DBP (mmHg)	−0.12	0.19	−0.11	−0.10	−0.07
Resting heart rate (bpm)	0.02	−0.03	−0.01	0.01	0.19
Estimated VO_2 (ml/kg/min)	0.03	−0.01	0.05	0.08	−0.05

Note: Boldface indicates statistical significance ($p < 0.05$; 1-tailed).
bpm, beats per minute; cm, centimeter; DBP, diastolic blood pressure; kg, kilogram; lbs, pounds; min, minute; ml, milliliter; mmHg, millimeters of mercury; SBP, systolic blood pressure.

Carr et al., *AJPM*, 2016

MOST EMPLOYEES REPORTED A PREFERENCE FOR AN ACTIVE DESK

Answer	%
Sit-Stand Desk	39%
Walking Treadmill Desk	30%
Active Sitting/Pedaling Desk	26%
Sit Only Desk	**4%**

Carr et al., *AJPM*, 2016

CONCLUSIONS FROM STUDY 1

- Sit-stand employees sat 66 minutes less and stood 66 min more than those with sitting desks
- Most (91%) of the 66-minute between-group difference in sitting time was accounted for by standing time
- Employees with sit–stand desks did not have healthier cardiometabolic profiles and no correlations were observed between sitting/standing time and any cardiometabolic risk factors.

Carr et al., *AJPM*, 2016

STUDY 2: EFFICACY OF INTRODUCING SEATED ACTIVE WORKSTATIONS INTO SEDENTARY WORK SETTING

RATIONALE FOR STUDY

- Total Worker Health™ encourages approaches that integrate health promotion and health safety to advance wellness of employees
- Seated active workstations effective at increasing occupational activity time (Carr et al., 2012; Carr et al., 2013) without impairing work ability or cognitive functioning (Carr et al., 2014)

Purpose

- To test the effect of an integrated health promotion/health protection worksite intervention (HP/HP) against a health protection–only intervention (HPO) on occupational physical activity, cardiometabolic biomarkers, musculoskeletal discomfort, and work productivity among a sample of adults working in full-time sedentary occupations.

Hypothesis

- HP/HP intervention would result in increased occupational physical activity and improved cardiometabolic biomarkers when compared with the HPO group.

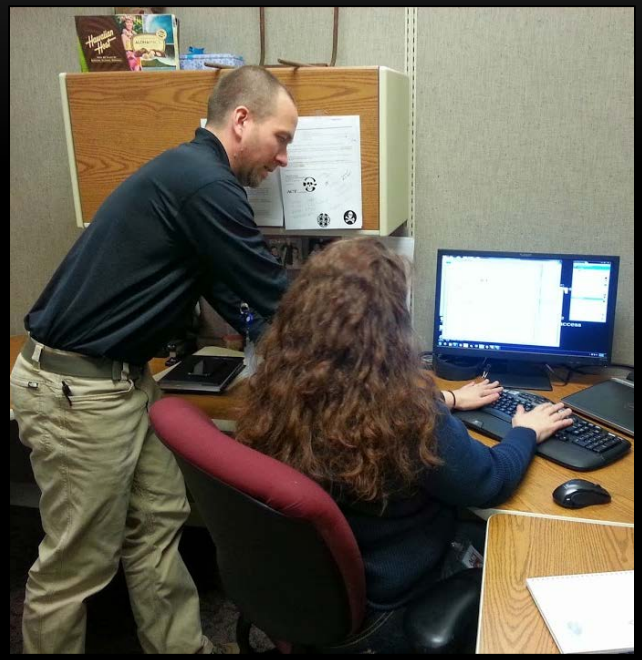
MEASURES

1. Occupational activity measured using GENEActiv monitor for 5 work days
2. Cardiometabolic outcomes - weight, body composition, RHR, BP, WC, estimated VO2
3. Work productivity – WHO Health and Work Performance Questionnaire (HPQ)

PARTICIPANTS

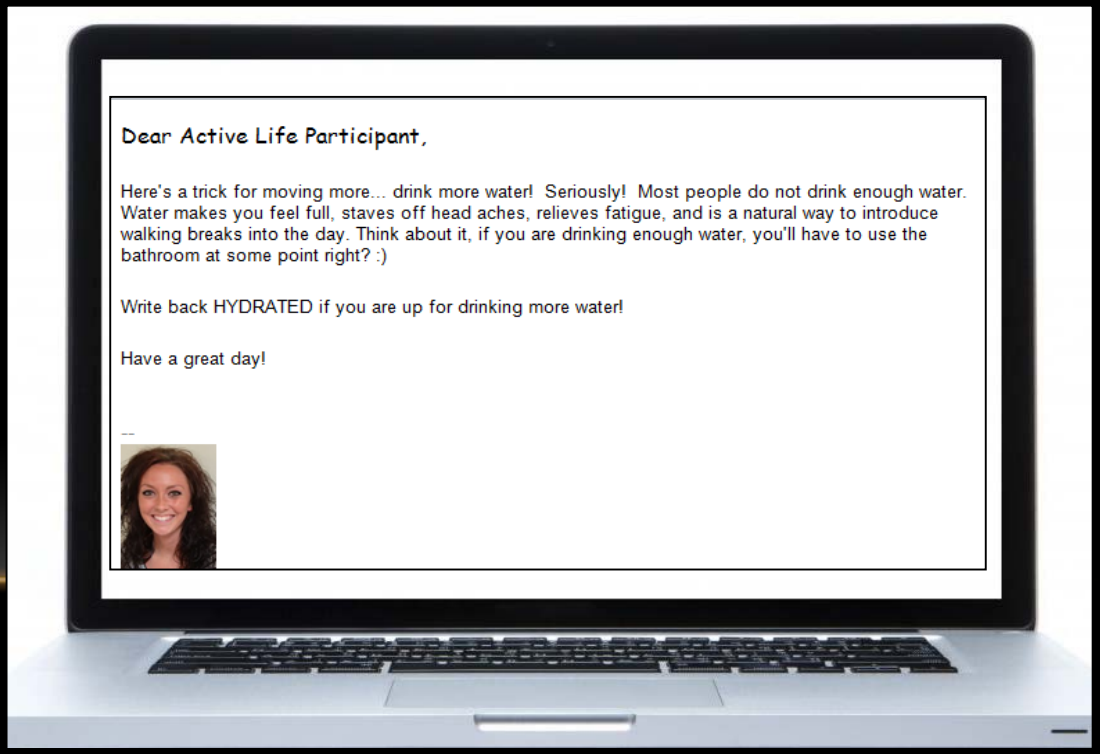
- 54 overweight (BMI>25.0 kg/m^2), full-time (35 hrs/week) employees working in sedentary (sit >75% day) jobs
- Allocated to either:
  - HP/HP Group (N=27)
  - HPO Group (N=27)

HPO GROUP

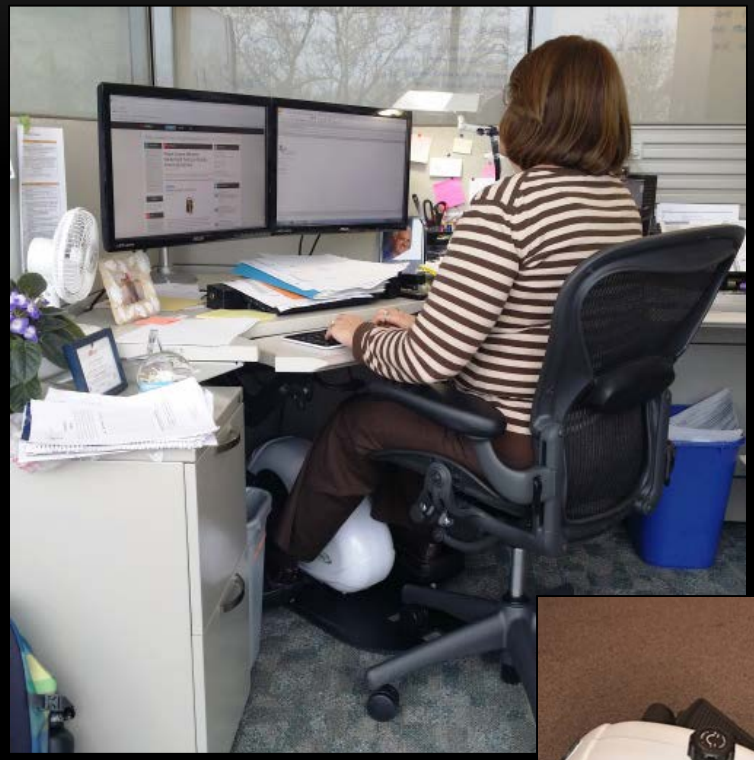


30 minute Ergonomic Workstation Optimization Intervention at baseline

3 Motivational emails/week (16 weeks) promoting activity and shifts in posture during day



HP/HP GROUP

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BASELINE CHARACTERISTICS BETWEEN GROUPS

Table 1. Baseline Characteristics Between Groups (M ± SD)

	Active control (N=27)	Integrated intervention (N=27)	*p*-value
Age (years)	45.0±10.7	45.2±10.9	0.95
Female (%)	70.0	70.0	1.00
Height (cm)	168.6±7.9	169.0±11.1	0.84
Weight (lbs)	206.4±29.6	215.9±42.7	0.18
BMI	33.0±5.6	34.5±6.8	0.23
Non-Hispanic (%)	100.0	100.0	1.00
White (%)	85.2	96.0	0.70
College graduate (%)	81.0	67.0	0.36
Income >$50,000 (%)	67.0	44.4	0.50
Years worked at current job	11.3±10.3	11.1±9.5	0.92
Average hours worked/week	38.1±6.7	40.8±5.4	0.13

Carr et al., *AJPM*, 2016

INCREASED % WORK TIME IN LIGHT INTENSITY PHYSICAL ACTIVITY

Table 2. Occupational Time Spent Sedentary and Physically Active at Baseline and Post-Intervention

	Baseline	Post-intervention	Mean difference[a] (95% CI)	Within group *p*-value	Group x time effect *p*-value
Total occupational physical activity (average counts/work day)					0.14
Control	91,266 (25,098)	91,124 (25,088)	−142 (−10,623, 10,339)	0.98	—
Intervention	84,665 (20,999)	94,417 (26,556)	9,752 (1,067, 18,436)	**0.03**	—
Percent work time sedentary (% workday)					0.08
Control	86.0 (4.4)	86.4 (4.6)	0.4 (−1.0, 1.8)	0.57	—
Intervention	86.8 (4.3)	84.8 (5.9)	−2.0 (−4.4, 0.3)	0.09	—
Percent work time in light intensity physical activity (% work day)					**0.04**
Control	4.7 (2.8)	4.3 (2.9)	−0.4 (−1.1, 0.2)	0.29	—
Intervention	4.2 (1.5)	4.9 (2.2)	0.7 (−0.2, 1.7)	0.08	—
Percent work time in moderate intensity physical activity (% work day)					0.38
Control	7.8 (2.0)	7.9 (2.2)	0.07 (−0.7, 0.8)	0.85	—
Intervention	8.0 (3.4)	9.1 (5.2)	1.1 (−1.1, 3.2)	0.32	—
Percent work time in vigorous intensity physical activity (% work day)					0.44
Control	1.5 (1.0)	1.5 (0.9)	0.0 (−0.3, 0.3)	0.84	—
Intervention	1.0 (0.7)	1.3 (0.7)	0.3 (0.0, 0.5)	0.10	—

Note: Boldface indicates statistical significance ($p < 0.05$). Data presented as Mean (SD).
[a]Mean change from baseline (95% CI), adjusted for baseline value (ANCOVA).

Carr et al., *AJPM*, 2016

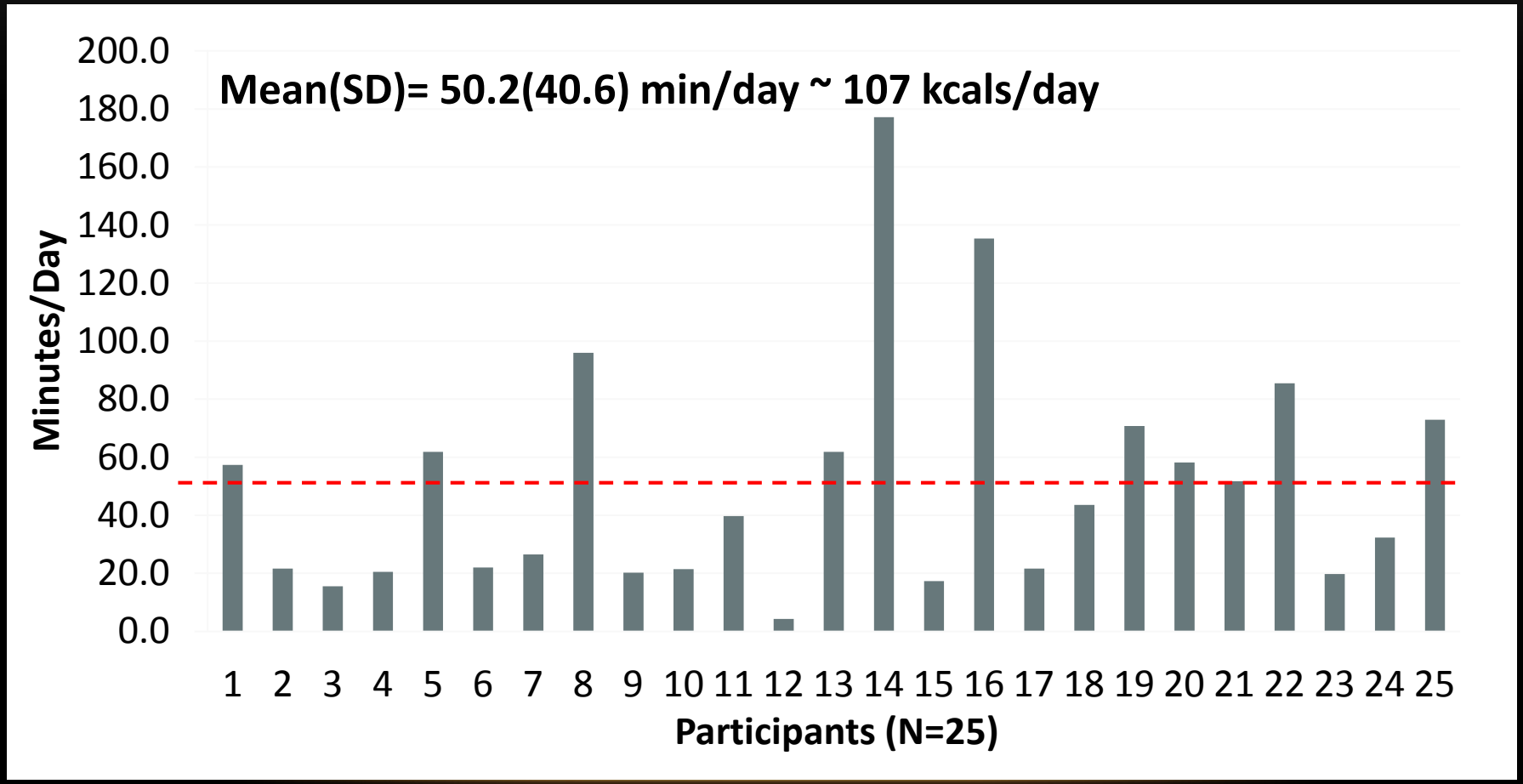
MORE PEDALING ASSOCIATED WITH BETTER CARDIOMETABOLIC RISK FACTORS AND WORK PRODUCTIVITY OUTCOMES

	Average pedal time/day (min)	Average # of pedal bouts/day	Average pedal speed (rpm)
Delta weight (lbs)	**R= −0.41; *p*=0.04**	—	—
Delta fat mass (lbs)	**R= −0.48; *p*=0.02**	—	—
Delta % body fat	**R= −0.45; *p*=0.02**	**R= −0.41; *p*=0.04**	—
Delta resting heart rate (bpm)	**R= −0.49; *p*=0.01**	**R= −0.45; *p*=0.02**	—
Delta waist circumference (cm)	—	—	**R= −0.48; *p*=0.02**
Concentration while at work	**R= 0.50; *p*=0.01**	—	—
Days missed because of physical/mental health over past 4 weeks	**R= −0.41; *p*=0.03**	—	—

Note: Boldface indicates statistical significance ($p < 0.05$).
bpm, beats per minute; cm, centimeter; lbs, pounds; min, minutes.

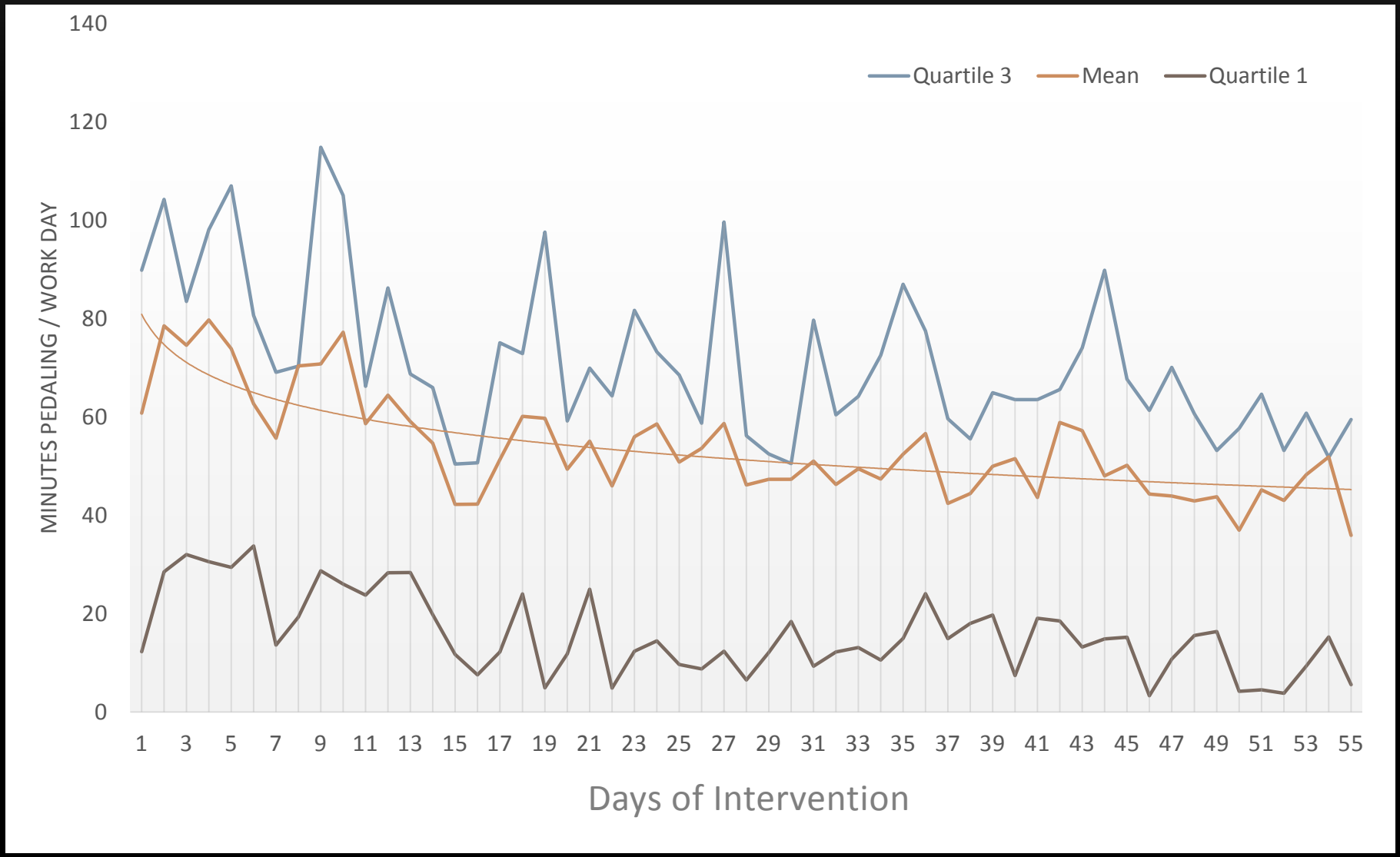
Carr et al., *AJPM*, 2016

WORKERS PEDALED AN AVERAGE OF 50 MIN/DAY



Carr et al., *AJPM*, 2016

DAILY PEDALING MAINTAINED FOR 16 WEEKS



CONCLUSIONS FROM STUDY 2

- Comprehensive TWH intervention significantly increased occupational light intensity PA (11.5% day)
- HP/HP group used seated active desks 50 minutes/work day (10.2% day)
- Estimated 107 additional kcals/day
- Pedaling appeared to reach steady state suggesting adherence
- 19 of 27 (70%) participants kept device post-study

Carr et al., AJPM, 2015

CONCLUSIONS FROM STUDY 2

- No intervention effects observed for any musculoskeletal discomfort outcomes or work productivity outcomes.
- No adverse events reported
- Dose-response relations between time spent pedaling and several cardiometabolic risk factors and work productivity outcomes

FUTURE WORK IN THIS AREA

- Long-term follow up to determine sustainability of active workstations
- Larger and longer trials that further explore impact on work productivity and cognitive function outcomes
- Test in small businesses who are less likely to have comprehensive workplace wellness programs yet employ >95% of workforce in states like Iowa

ACKNOWLEDGEMENTS

Our participants

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Research Staff

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Maggie Swift

Roberto Benzo

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Colleagues

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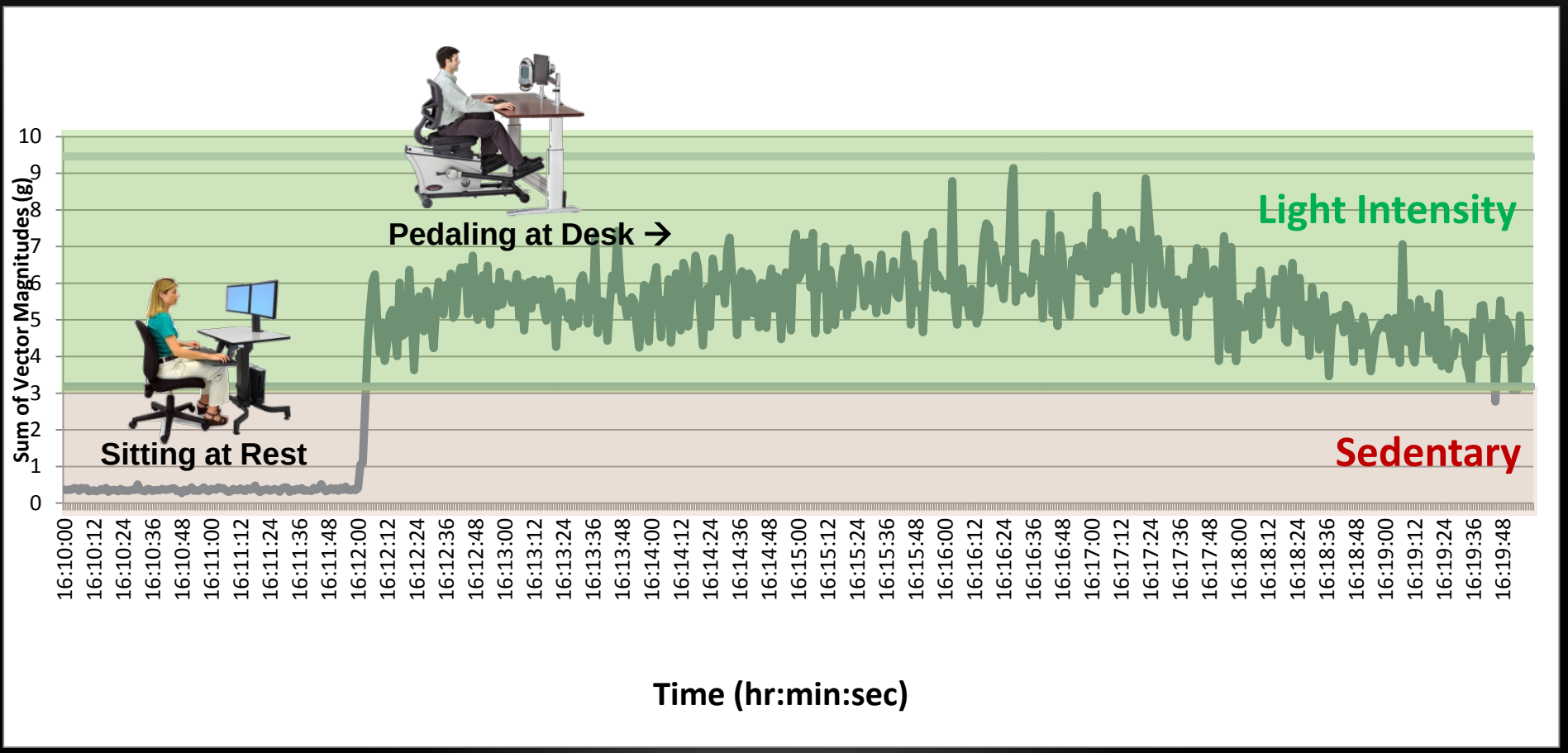
THANK YOU!

ANY QUESTIONS?

SEATED ACTIVE WORKSTATIONS INCREASE ENERGY EXPENDITURE – LIGHT INTENSITY



Carr et al., *BJSM*, 2012
Carr et al., *BMJ Open*, 2014