The Cardiovascular Effects of Prolonged Sitting or Standing & The Effects of Sit-Stand Workstations

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[I have no financial interests]
Sit – Stand and Health

- Reduces back-neck pain.
- Reduces cardiovascular risk?

“You were right - I do feel more productive standing up”
Work hours and CVD
US Prospective PSID Population Survey 1986-2011, N=22,000; adjusted for age, sex, industry, occupation. [Conway et al. JOEM 2016; 58(3):221]
Predicted Weight Changes

![Graph showing predicted weight changes over time for men and women, based on change in occupation-related energy expenditure.](image)


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Do sit-stand workstations reduce CVD risk?

• Does occupational sitting increase CVD?
• Does occupational physical activity decrease CVD?
• Can sit-stand reduce BMI?
• Can sit-stand reduce blood pressure?
Daily Standing Time and All-Cause Mortality

[Katzmarzyk 2009]

“For those activities which you do most days of the week (such as work, school and housework), how much time do you spend standing?”

17,013 Canadians, ages 18-90, (41% of mortality = CVD), no adjustment for covariates
Daily Standing Time and All-Cause Mortality

[Katzmarzyk 2014]

Adjusted for age, smoking, alcohol, LTPA, physical activity readiness
**Total Sitting Time & CVD**

- **Borodulin 2014:** N= 4,516 x 8.6 yrs; 25-74 yo, HR **1.06** (1.01-1.11) (h/d)
- **Matthews 2015:** N=154,614 x 6.8 yrs; 59-82 yo
  - Male HR =1.10 (5-7h) =1.18 (7-9h) =1.29 (9-12h) **=1.42** (>12h)
  - Female: HR =1.07 (5-7h) =0.99 (7-9h) =1.36 (9-12h) **=1.47** (>12h)
- **Petersen 2014:** N= 71,363 x 5.4 yrs; 18-99 yo; HR= 0.97 (6-10h); **=1.27** (>10h)
- **Chau 2015:** N= 50,817 x 3.3 yrs; HR **2.15** (1.34- 3.44) (>10h vs < 4h)
- Occupational sitting time does not increase risk

**Occupational Sitting Time & CVD**

- **Stamatakis 2013:** N= 11,168x12.9 yrs; >40 yo; **HR=0.94** [sit v stand-walk]
- **Moller 2016:** N= 11,996x19.0 yrs; 21-69 yo; **HR=0.98** (0.88-1.09)
- **Kikuchi 2015 (all cause mortality)**
  - Office M N= 15,863x10.0 yrs; 57 yo; HR **0.87** (0.75-1.01) [>3h/d]
  - F N= 12,005x10.2 yrs; 57 yo; **HR=1.03** (0.77-1.39) [>3h/d]

Adjustment: gender, age, employment, education, smoking, LTPA, BMI, diet, alcohol, serum cholesterol, hypertension
London Bus Drivers Study

Drivers at increased risk for incident CHD compared to conductors: 2.7 v 1.9/1000.

“Differences due to differences in physical activity”
London Bus Drivers Study

Drivers at increased risk for incident CHD compared to conductors: 2.7/1000 vs 1.9.

“Differences due to differences in physical activity”

No control for stress, BP, smoking, or BMI

Urban bus drivers have elevated BP.
Leisure Time Physical Activity (LTPA) Reduces CVD

LTPA and CVD: Meta-analysis [Li et al., 2013]

- 23 prospective studies
- 790,000 adults
- 22,000 incidents
- Confounders controlled

- Moderate level LTPA reduced CVD risk 20-30%
- High level LTPH reduced CVD risk 30-40%
Occupational Physical Activity (OPA) Does Not

[Li et al. Current Opinion in Cardiology. 28(5):575-583, 2013]

- 7 prospective studies with adjustment for covariates
- Moderate OPA increased risk 5-15%
- High OPA increased risk 10-30%

<table>
<thead>
<tr>
<th>Study</th>
<th>RR (95% CI) (moderate PA vs. low PA)</th>
<th>RR (95% CI) (high PA vs. low PA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CHD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holtermann A, et al. [16]</td>
<td>1.26 (1.02, 1.56)</td>
<td>1.55 (1.19, 2.02)</td>
</tr>
<tr>
<td>Holtermann A, et al. [17]</td>
<td>1.30 (1.03, 1.64)</td>
<td>1.20 (0.93, 1.55)</td>
</tr>
<tr>
<td>Petersen CB, et al. [24]</td>
<td></td>
<td>1.52 (1.15, 2.02)</td>
</tr>
<tr>
<td>Huerta JM, et al. [25]</td>
<td>0.98 (0.60, 1.59)</td>
<td>0.99 (0.56, 1.72)</td>
</tr>
<tr>
<td>Clays E, et al. [32]</td>
<td></td>
<td>1.28 (0.68, 2.44)</td>
</tr>
<tr>
<td>Holtermann A, et al. [17]</td>
<td>0.76 (0.56, 1.02)</td>
<td>0.98 (0.67, 1.44)</td>
</tr>
<tr>
<td>Petersen CB, et al. [24]</td>
<td></td>
<td>0.81 (0.50, 1.56)</td>
</tr>
<tr>
<td>Huerta JM, et al. [25]</td>
<td>3.24 (0.97, 10.8)</td>
<td>4.78 (0.92, 24.8)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>1.13 (0.86, 1.47)</td>
<td>1.25 (1.04, 1.51)</td>
</tr>
<tr>
<td>Stroke</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Huerta JM, et al. [25]</td>
<td>0.91 (0.67, 1.23)</td>
<td>0.94 (0.66, 1.33)</td>
</tr>
<tr>
<td>Huerta JM, et al. [25]</td>
<td>2.07 (1.00, 4.28)</td>
<td>1.97 (0.58, 6.67)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>1.28 (0.58, 2.83)</td>
<td>1.07 (0.62, 1.86)</td>
</tr>
<tr>
<td>Unclassified CVD</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hu GC, et al. [33]</td>
<td>1.56 (0.62, 3.89)</td>
<td>2.81 (1.25, 4.70)</td>
</tr>
<tr>
<td>Hu GC, et al. [33]</td>
<td>1.19 (0.64, 2.23)</td>
<td>1.30 (0.74, 2.32)</td>
</tr>
<tr>
<td>Moe B, et al. [28]</td>
<td>0.84 (0.70, 1.43)</td>
<td>1.01 (0.85, 1.72)</td>
</tr>
<tr>
<td>Subtotal</td>
<td>0.97 (0.72, 1.32)</td>
<td>1.47 (0.83, 2.59)</td>
</tr>
<tr>
<td>Overall</td>
<td>1.10 (0.91, 1.33)</td>
<td>1.24 (1.05, 1.47)</td>
</tr>
</tbody>
</table>
Standing at Work Increases CVD
Standing Increases Carotid Atherosclerosis

4-year Change of Carotid Intima Media Thickness (IMT), adjusted for Age, Technical, Physical and Psychosocial Job Factors, Income, Biological and Behavioral Factors: Men with IHD

Adjusted Mean Change in IMT (mm)

Standing at Work

Standing compared to Smoking

Adjusted Mean Change in IMT (mm)

Standing at Work / Smoking


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**NEPA: Non-exercise physical activity**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Energy Expenditure (kcal/min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standing</td>
<td>0.99, 1.02</td>
</tr>
<tr>
<td>Seated (stability ball)</td>
<td>1.30</td>
</tr>
<tr>
<td>Standing</td>
<td>1.34</td>
</tr>
<tr>
<td>Seated pedaling</td>
<td>1.36, 1.29</td>
</tr>
<tr>
<td>Treadmill walking</td>
<td>3.18</td>
</tr>
</tbody>
</table>

**Standing v Sitting**
- 20 kcal/h (B: Reiff 2012)
- -1 kcal/h (C: Speck 2011)
- 4 kcal/h (Beers 2008)

**Treadmill Walk v Sitting**
- 120 kcal/h

**Seated Pedaling v Sitting**
- 56 kcal/h
Use of Sit-Stand Workstations

• Increases standing 50-70 minutes per day.
Does Work NEPA reduce Blood Pressure?

8 week RCT [Graves et al, 2015]

<table>
<thead>
<tr>
<th></th>
<th>Control (N=21)</th>
<th>Sit-Stand Desk (N=23)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sitting</td>
<td>402 min/d</td>
<td>Δ Sitting -87.6 min/d</td>
</tr>
<tr>
<td>Standing</td>
<td>44 min/d</td>
<td>Δ Standing 72.9 min/d</td>
</tr>
<tr>
<td>Walking</td>
<td>34 min/d</td>
<td>Δ Walking 7.1 min/d</td>
</tr>
<tr>
<td>Δ Glucose</td>
<td></td>
<td>-0.09 mmol/L</td>
</tr>
<tr>
<td>Δ Triglycerides</td>
<td></td>
<td>0.11 mmol/L</td>
</tr>
<tr>
<td>Δ Cholesterol</td>
<td></td>
<td>-0.40 mmol/L</td>
</tr>
<tr>
<td>Δ SBP</td>
<td></td>
<td>-1.6 mmHg</td>
</tr>
<tr>
<td>Δ DBP</td>
<td></td>
<td>-2.5 mmHg</td>
</tr>
</tbody>
</table>

[All differences NS]
Sitting and Lipid Profiles
[Saidj 2013]

• Danish working adults; N=2544; 18-69 yr
• Leisure time sitting (3.1h) assoc with increased TGs, cholesterol, body fat, BMI, waist circumference. (no assoc with Hgb A1c, Plasma glucose)

• Occupational time sitting (4.1h) no associations

• Adjusted: sex, age, ed, smoking, alcohol, diet, PA
Does Work NEPA reduce Blood Pressure?

4 month RCT [Mainsbridge, JOEM 2014]

- Every hour software prompt to stand up and move
- NEPA of 8 minutes/day reduced resting mean arterial pressure (MAP) by 10 mmHg after 4 months.

**Strength:** RCT

**Limitations:**
- small samples (N=11+18)
- randomization not successful (controls 5.5 years older)
- no blinding
- no age-adjustment
- no between group-effects analyzed, only pre-post
Predicted Weight Changes

- NHANES
- Predicted Based on Change in Occupation Related Energy Expenditure

### Men
- Baseline
- 1960-62
- 1971-74
- 1976-80
- 1988-94
- 1999-02
- 2003-06

### Women
- Baseline
- 1960-62
- 1971-74
- 1976-80
- 1988-94
- 1999-02
- 2003-06
US Caloric Consumption per Day

+900 daily kcals

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USDA, Credit Suisse
Conclusions

• No convincing epidemiologic evidence that sitting at work increases CVD.
• Standing at work increases CVD.
• Occupational physical activity does not decrease CVD.
• No epidemiologic evidence that sit-stand workstations decrease CVD.
• Sit-stand used standing only 50-70 minutes per day ..... inadequate to decrease BMI.
• Standing NEPA effects on BP uncertain.
References: Sit-Stand

- Korshøj et al., Does aerobic exercise improve or impair cardiorespiratory fitness and health among cleaners? A cluster randomized controlled trial. SJWEH 2015; 41(2):140-152.
References: Sit-Stand

• Mainsbridge CP et al. The effect of an e-Health intervention designed to reduce prolonged occupational sitting on mean arterial pressure. JOEM 2014; 56(11):1189-1194.
• Saidj M et al. Separate and joint associations of occupational and leisure-time sitting with cardio-metabolic risk factors. PLOS One 2013; 8(8):e70213.