Impact of physical activity on stress. Can we reduce stress through exercise?

Maroje Sorić, MD, PhD

Department of Sport and Exercise Medicine, Faculty of Kinesiology, Zagreb, Croatia
• Understanding physical activity and stress
• Are PA and stress associated?
• Do PA and exercise improve one’s ability to adapt to stress?
• Can exercise programs reduce stress?
• Can exercise programs reduce stress-induced medical problems?
• Employers corner
• Implementation at worksite – the optimal dose?
Understanding Physical activity - Definitions of key terms

**PHYSICAL ACTIVITY (PA)** - any bodily movement produced by skeletal muscles that results in energy expenditure above resting levels

**EXERCISE** – PA that is planned, structured, and repetitive and has as an objective the improvement or maintenance of physical fitness

**PHYSICAL FITNESS** - The ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy [leisure] pursuits and to meet unforeseen emergencies.

Includes cardiorespiratory fitness, muscular strength and endurance, body composition and flexibility, balance, agility, reaction time and power
The construct of PA

- Operationalized through FITT principle:
  - Frequency
  - Intensity
  - Time
  - Type
Aerobic (endurance, cardiorespiratory)
Increases cardiorespiratory endurance

Anaerobic
short-lasting, high-intensity activity, promotes speed, strength and power

Resistance
Increases muscle mass, muscle endurance, strength and power
Understanding PA - Epidemiology

- around 60% of the world does not engage in the recommended volume of PA*

- causes 3 200 000 deaths/year worldwide* (ranked 4.)
  - 1 000 000 deaths in Europe (10%; ranked 3.)

*WHO. Global Health Risks, 2009
Understanding stress

‘Stress is a word used to describe experiences that are challenging emotionally and physiologically’

Induces (patho)physiological changes:
- ↑ Stress hormones (adrenaline, cortisol)
- ↑ Heart rate
- ↑ Blood pressure

↓ Medical problems and illnesses

Are PA and stress associated?
**Associations of PA and stress**

- **>12000 participants**
  - 4-yr follow-up

- **Leisure time PA**
  - Up to **70%** lower risk for high stress

- **Change in PA**
  - **70%** lower risk for high stress in constantly active participants

<table>
<thead>
<tr>
<th>Physical activity level</th>
<th>High level of stress</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mult. adj.</td>
</tr>
<tr>
<td>Low</td>
<td>1</td>
</tr>
<tr>
<td>Moderate</td>
<td>0.46</td>
</tr>
<tr>
<td>High</td>
<td>0.42</td>
</tr>
<tr>
<td>Joggers</td>
<td>0.30</td>
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</thead>
<tbody>
<tr>
<td></td>
<td>Mult. adj.</td>
<td>OR (95% CI)</td>
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<tr>
<td>Sedentary</td>
<td>1</td>
<td></td>
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<tr>
<td>Active</td>
<td>0.48</td>
<td>(0.36–0.63)</td>
</tr>
<tr>
<td>Active</td>
<td>0.64</td>
<td>(0.49–0.83)</td>
</tr>
<tr>
<td>Active</td>
<td>0.29</td>
<td>(0.23–0.36)</td>
</tr>
</tbody>
</table>
3114 health care workers in Sweden
2-y follow-up
60% lower risk of high stress level in active participants
Causality?
Bidirectional relations?
Stress and PA

- 7500 participants, Denmark
- 16-y follow-up

Twofold risk of becoming inactive in the high stress group
Do PA and exercise improve one’s ability to adapt to stress?
The effect of PA level on physiological reactions to stress

- 50 young women
- Inactive vs. Moderately active vs. Highly active
- Reaction to acute stress
The effect of PA level on physiological reactions to stress

Stress hormone (cortisol)  Heart rate

Psychology of Sport and Exercise 14 (2013) 266–274

Psychoneuroendocrinology (2009) 34, 190–198
Exercise reduces both SBP and DBP

- Larger effects for larger doses
- Min dose: 30 min at 50% max

<table>
<thead>
<tr>
<th>Effect</th>
<th>No. of studies</th>
<th>Total no. of subjects</th>
<th>Combined ES</th>
<th>Combined z</th>
<th>Combined p</th>
<th>Fail-safe N</th>
<th>Critical no. for drawer</th>
<th>Absolute effect ± S.D. (mmHg)</th>
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</thead>
<tbody>
<tr>
<td>SBPR</td>
<td>15</td>
<td>496</td>
<td>0.38</td>
<td>4.03</td>
<td>&lt;0.01</td>
<td>1340</td>
<td>85</td>
<td>$-3.7 \pm 3.9$</td>
</tr>
<tr>
<td>DBPR</td>
<td>15</td>
<td>496</td>
<td>0.40</td>
<td>4.86</td>
<td>&lt;0.01</td>
<td>1949</td>
<td>85</td>
<td>$-3.0 \pm 2.7$</td>
</tr>
</tbody>
</table>

Note: Absolute effect is the calculated difference in change score from pre- to post-stressor between exercise and control conditions.
Exercise and resilience

- 144 employees
  Personal resources
  (resilience, optimism)

- The effect of exercise is positive only when sleep is prolonged
Can exercise programs reduce stress?
The effect of exercise training on stress

- 75 young adults; 4 week exercise programme
  - 30 min of aerobic exercise
  - +/- exercise on test day

positive mood ↑

anxiety ↓

perceived stress
The effect of exercise training on stress

- 75 participants; casino employees
- 20 min exercise; 3x/week; 6 months

<table>
<thead>
<tr>
<th>Outcome measure</th>
<th>Treatment</th>
<th>Controls</th>
<th>t test (week 0)</th>
<th>Adjusted baseline (week 24)</th>
<th>Adjusted covariates (week 24)</th>
<th>Effect size</th>
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</thead>
<tbody>
<tr>
<td>SF-36°</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>P</td>
<td>P</td>
<td>P</td>
<td></td>
</tr>
<tr>
<td>Depression</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Pre</td>
<td>7.4 (9.6)</td>
<td>6.0 (7.7)</td>
<td>0.58</td>
<td>0.085</td>
<td>0.048</td>
<td>-0.16</td>
</tr>
<tr>
<td>Post</td>
<td>3.0 (2.9)</td>
<td>4.1 (4.1)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Δ</td>
<td>-59</td>
<td>-31</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Anxiety</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>3.6 (4.8)</td>
<td>5.3 (6.5)</td>
<td>0.35</td>
<td>0.23</td>
<td>0.23</td>
<td>0.05</td>
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<tr>
<td>Post</td>
<td>1.7 (1.8)</td>
<td>3.2 (4.4)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Δ</td>
<td>-53</td>
<td>-40</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Stress</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pre</td>
<td>10.6 (8.8)</td>
<td>9.5 (8.0)</td>
<td>0.67</td>
<td>0.012</td>
<td>0.036</td>
<td>-0.56</td>
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<tr>
<td>Post</td>
<td>4.0 (3.4)</td>
<td>7.1 (7.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>%Δ</td>
<td>-62</td>
<td>-25</td>
<td></td>
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</table>
Can exercise programs reduce stress-induced medical problems?
2 banks in Taiwan
109 workers

30 min aerobic exercise
1x or 2x/week
12 weeks

Industrial health
2013; 51:336-346

Burnout symptoms

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Personal burnout

Work-related burnout

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control ---- low frequency — high frequency
Exercise in the treatment of burnout

12 men; 12 weeks; 17.5 kcal/kg/week

Figure 1 Participants’ Changes in Burnout Symptomatology After Twelve Weeks Aerobic Exercise Training Regarding Emotional Exhaustion (Figure 1a) and Depersonalization (Figure 1b).
Anxiolytic effects of exercise

- Exercise vs. no treatment (3500 participants)
  \[ ES = 0.48 \]
  3.5 points on a scale that measures anxiety (range = 60 p.)

- Exercise vs. other treatments (2000 participants)

\[ \text{NO CLEAR DOSE RESPONSE!} \]

Table 2: Effect Sizes of Types of Treatment Compared With Exercise

<table>
<thead>
<tr>
<th>Treatment</th>
<th>k</th>
<th>Effect size</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cognitive/behavioral therapy</td>
<td>2</td>
<td>0.00</td>
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<tr>
<td>Group therapy</td>
<td>3</td>
<td>-0.09</td>
</tr>
<tr>
<td>Light exercise (stretching, yoga)</td>
<td>6</td>
<td>-0.15</td>
</tr>
<tr>
<td>Relaxation/meditation</td>
<td>9</td>
<td>-0.23</td>
</tr>
<tr>
<td>Stress management education</td>
<td>5</td>
<td>-0.45</td>
</tr>
<tr>
<td>Pharmacotherapy</td>
<td>2</td>
<td>0.11</td>
</tr>
<tr>
<td>Music therapy</td>
<td>1</td>
<td>-0.05</td>
</tr>
<tr>
<td><strong>Total:</strong></td>
<td>28</td>
<td><strong>-0.19</strong>*</td>
</tr>
</tbody>
</table>

*One-sample t test, \( p < .05 \)
Exercise and anxiety sensitivity

- 54 participants
- 6x20 min of aerobic exercise
- 20% and 50% of participants experienced a large decrease in ASI in moderate and vigorous exercise group, respectively

![Graph showing changes in BSI scores over sessions](image)
Antidepressive effects of exercise

- 3000 participants
  ES = 1.07
  ↓
  4 points on a scale that measures depression (range 63p.)
  ? Same as antidepressant medications
  ? Possibly better than psychotherapy

- In non-clinical population largest effects for:
  - medium-term interventions
  - short duration (20-30min)
  - combined aerobic and resistance exercise
  - High intensity (>75%)

NO CLEAR DOSE-RESPONSE!
Disturbed sleep and stress

- 558 women
- 20-60 years old
- Sweden

Daytime sleepiness (odds ratio)

<table>
<thead>
<tr>
<th>Psychological distress</th>
<th>Odds Ratio (95% CI)</th>
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<tbody>
<tr>
<td>None</td>
<td>1.0</td>
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<tr>
<td>Anxiety</td>
<td>2.43 (1.98-2.99)</td>
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<tr>
<td>Depression</td>
<td>3.99 (2.59-5.87)</td>
</tr>
<tr>
<td>Anxiety and depression</td>
<td>4.51 (3.51-5.79)</td>
</tr>
</tbody>
</table>

EPIDEMIOLOGY

What are the Important Risk Factors for Daytime Sleepiness and Fatigue in Women?

Jenny Theorell-Haglöf, BSc; Eva Lindberg, PhD; Christer Janson, PhD

SLEEP; 29(6):751-757.
Disturbed sleep – effect of chronic stress on sleep duration

1300 middle aged men and women

Chronic emotional Stress

0.3-1h decrease in SD

Short sleep duration and obesity: the role of emotional stress and sleep disturbances

AN Vgontzas1, H-M Lin2, M Papallaga3, S Calhoun1, A Vela-Bueno3, GP Chrousos4 and EO Bixler1

Is PA associated to sleep

- 65 years
- Prospective cohort study

**Figure 2.** Prevalence of insomnia according to physical activity levels (categories = activity score quintile ranges; insomnia by physical activity $\chi^2 = 39.1; \text{d.f.} = 1; P < 0.001$).

**Figure 3.** Prevalence of insomnia according to daily walking levels (categories = above/below median minutes/day purposeful walking; insomnia by walking level $\chi^2 = 8.72; \text{d.f.} = 1; P < 0.01$).

*J. Sleep Res. (2003) 12, 231–238*
Is PA associated to sleep

- 156,000 participants of the Behavioural Risk Factors Surveillance System

Sleep complaints
Can aerobic exercise training improve sleep?

>55 years
17 women
Insomniacs
sedentary

Exercise programme:
16 weeks
4 times/week
30-40 min
75%HR_{\text{max}}

Subjective sleep quality

Daytime sleepiness
Aerobic exercise training

30-55 years
19 sedentary Insomniacs

PSG:

Exercise programme:
6 months
3 times/week
50 min

VT₁

<table>
<thead>
<tr>
<th>Variable</th>
<th>Group</th>
<th>Pre-intervention</th>
<th>Post-intervention</th>
<th>Effect size Cohen’s d</th>
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</thead>
<tbody>
<tr>
<td>TST (min)</td>
<td>Morning</td>
<td>352.5 (17.6)</td>
<td>355.3 (11.0)</td>
<td>0.16</td>
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<tr>
<td></td>
<td>Late afternoon</td>
<td>316.5 (18.6)</td>
<td>351.5 (11.6)</td>
<td>1.71</td>
</tr>
<tr>
<td></td>
<td>Combined</td>
<td>335.5 (13.1)</td>
<td>353.5 (7.7)</td>
<td>0.97</td>
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<tr>
<td>SOL (min)</td>
<td>Morning</td>
<td>16.8 (3.7)</td>
<td>10.5 (1.9)</td>
<td>-1.67</td>
</tr>
<tr>
<td></td>
<td>Late afternoon</td>
<td>17.4 (4.4)</td>
<td>6.7 (1.8)</td>
<td>2.46</td>
</tr>
<tr>
<td></td>
<td>Combined</td>
<td>17.1 (2.6)</td>
<td>8.7 (1.4)</td>
<td>-2.06</td>
</tr>
<tr>
<td>LREM (min)</td>
<td>Morning</td>
<td>100.0 (15.8)</td>
<td>68.7 (5.8)</td>
<td>-2.23</td>
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<tr>
<td></td>
<td>Late afternoon</td>
<td>122.4 (18.4)</td>
<td>72.8 (6.3)</td>
<td>-3.56</td>
</tr>
<tr>
<td></td>
<td>Combined</td>
<td>110.6 (11.4)</td>
<td>70.6 (3.7)</td>
<td>-2.89</td>
</tr>
<tr>
<td>SE (%)</td>
<td>Morning</td>
<td>83.8 (4.1)</td>
<td>89.6 (2.1)</td>
<td>1.68</td>
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<tr>
<td></td>
<td>Late afternoon</td>
<td>75.4 (4.9)</td>
<td>84.6 (2.7)</td>
<td>2.16</td>
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<tr>
<td></td>
<td>Combined</td>
<td>79.8 (3.0)</td>
<td>87.2 (1.6)</td>
<td>1.91</td>
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<tr>
<td>WASO (min)</td>
<td>Morning</td>
<td>52.5 (17.7)</td>
<td>30.7 (7.8)</td>
<td>-1.45</td>
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<td></td>
<td>Late afternoon</td>
<td>75.2 (20.6)</td>
<td>50.5 (10.5)</td>
<td>1.82</td>
</tr>
<tr>
<td></td>
<td>Combined</td>
<td>63.2 (12.8)</td>
<td>40.1 (6.0)</td>
<td>-1.66</td>
</tr>
</tbody>
</table>
Stress related illnesses - CVD

- 812 employees, metal industry, Finland
- 27-y follow-up

- job strain
- Effort-reward imbalance

2-fold risk for CVD death
# PA and cardiovascular disease


## Most active vs. least active

<table>
<thead>
<tr>
<th>Activity</th>
<th>RR</th>
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</thead>
<tbody>
<tr>
<td>Total PA</td>
<td>↓25%</td>
</tr>
<tr>
<td>Leisure time PA</td>
<td>↓26%</td>
</tr>
<tr>
<td>Work PA</td>
<td>↓16%</td>
</tr>
<tr>
<td>PA in transportation</td>
<td>↓13%</td>
</tr>
</tbody>
</table>

PA and CHD

Dose-Response Between Physical Activity and Risk of Coronary Heart Disease: A Meta-Analysis


Men

- Relative Risk: 9%
- Leisure-time Physical Activity (Kcal/wk): 0–600

Women

- Relative Risk: 20%
- Leisure-time Physical Activity (Kcal/wk): 0–1000

- Relative Risk: 28%
- Leisure-time Physical Activity (Kcal/wk): 1000–1500

- Relative Risk: 48%
- Leisure-time Physical Activity (Kcal/wk): 1500–2500
<table>
<thead>
<tr>
<th>Type of training</th>
<th>Aerobic endurance (RRsys)</th>
<th>Dynamic resistance (RRdy)</th>
<th>Isometric resistance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerobic endurance</td>
<td>3.5mmHg</td>
<td>2.5mmHg</td>
<td>10.9mmHg</td>
</tr>
<tr>
<td>Dynamic resistance</td>
<td>1.8mmHg</td>
<td>3.2mmHg</td>
<td>6.2mmHg</td>
</tr>
</tbody>
</table>
Employers corner - the effects on absenteeism and productivity
Stress and common cold

- 420 participants
- Infected with a respiratory virus
- The lowest vs. the highest stress
- 2 times increase in risk

Evidence for dose response

**PSYCHOLOGICAL STRESS AND SUSCEPTIBILITY TO THE COMMON COLD**

Sheldon Cohen, Ph.D., David A.J. Tyrrell, M.D., and Andrew P. Smith, Ph.D.

Common cold and production losses

- Sweden (+allergic rhinitis)
- 5 days/year
- 650€/worker/year
- 2,7 billions €

Allergy. 2010 Jun 1;65(6):776-83
The impact of an exercise programme on common cold:

- ↓27% risk
- ↓3.5 days
Exercise and work ability

- 371 employees in Finland
- 12 months
- 3-5 x/week
- Moderate aerobic exercise

Increases larger in those with worse baseline work ability!
Exercise and productivity

- 200 participants, dental health centres, Sweden
- 2.5 h/week aerobic exercise or free activities
- Same workload compared to reduced work hours and control:
  - Increase in self-rated quantity of work and work ability
  - Decrease in sickness frequency and duration
  - No decrease in objective measures of productivity
  - Reduced costs in the exercise group (22.2%) and RWH (4.9%) conditions but not among controls (10.2% increase).
Implementation at the workplace
Effect of the Work Environment on Using Time at Work to Exercise

188 faculty staff
- Participants who felt comfortable taking time off work to exercise were 2.8 times more likely to use time to exercise
- Participants who reported too much work were 3 times less likely to exercise
- Job satisfaction and the ability to take time off for personal matters were not significantly associated
Is exercise a drug?

- Effect of withdrawal
  - 40 participants
  - At least 30 min, 3x/week, 6 months

Increase in:
- Fatigue
- Negative mood
- Depressive symptoms
Implementation

- Min 20 min; 2-3x/week
- Aerobic or combined exercise
- No evidence for dose response for stress, but firm evidence regarding stress-related illness
- No loss of productivity; Dropouts mostly due to lack of time

Implement exercise during work hours!
## Conclusions

- Are PA and stress associated? **YES!**

- Do PA and exercise improve one’s ability to adapt to stress? **YES!**

- Can exercise programs reduce stress? **YES!**

- Can exercise programs reduce stress-induced medical problems? **YES!**
Good practice example

- CROZ (Zagreb, Croatia)
- Software industry
- 150 employers

Free bicycles for employers
To be used during work time