Strain Index (SI)

**General description and development of the method**

Strain index is a semiquantitative job analysis methodology that results in a numerical score, which is believed to correlate with the risk of developing distal upper extremity disorders. Six task variables describing hand exertions are observed and scored with five levels: intensity of exertion, duration of exertion, exertions per minute, hand/wrist posture, speed of work (how fast), and duration per day. Each score is then weighted based on physiological (endurance, fatigue, recovery), biomechanical (internal forces, nonlinear relationship between strain and intensity of effort) and epidemiological principles. Multiplying the weighted scores gives a single figure of Strain Index. The approach is analogical to the NIOSH lifting index (Moore 1995, Moore 2005).

SI was developed, because previous exposure assessment methods were subjective, lacked standardization, and did not involve examination of risk factors’ interaction. Developed in US and described in literature in 1995. (Moore 1995).

Applications for multi-task jobs proposed by using either maximum task SI score or a cumulative frequency and duration to compute SI score. (Drinkaus 2005)

Effect of six different modifications on the magnitude of SI have been compared for multi-task jobs (Bao 2009)

Surface EMG recordings have been used to assess the effort level in case observational assessment is difficult. (Cabecas 2007)

**Exposure descriptors**

<table>
<thead>
<tr>
<th>Exposure</th>
<th>Description of exposure</th>
<th>magnitude/amplitude</th>
<th>duration</th>
<th>frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>posture</td>
<td>Hand and wrist: 5 descriptive classes (very good -- very bad)</td>
<td>X.</td>
<td>X.</td>
<td>X.</td>
</tr>
<tr>
<td>movements</td>
<td></td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>(external) force</td>
<td>Intensity of exertion, 5 descriptive classes (light -- near maximal)</td>
<td>X.</td>
<td>X.</td>
<td>X.</td>
</tr>
<tr>
<td>vibration</td>
<td>no</td>
<td>.</td>
<td>.</td>
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<tr>
<td>contact forces</td>
<td>no</td>
<td>.</td>
<td>.</td>
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</tbody>
</table>

Exposures assessed for each cycle with respect to duration (% of cycle), frequency (effort/minute) and speed of work (very slow -- very fast). Total duration of the task per day either measured or obtained from plant personnel.

**Resource demands and usability**

**Equipment needed**


A video camera is recommended. If the recording is to be digitized for analysis using software, an appropriate computer interface is also necessary. Manual analysis is best performed using a stopwatch to measure time intervals and a lap counter or fingers to count exertions. (Moore 2005).

A software available in [http://ergocenter.srph.tamhsc.edu/winsi/](http://ergocenter.srph.tamhsc.edu/winsi/).
Process of coding and analysis
1. Collect data on the six task variables.
2. Assign ordinal ratings using the ratings table
3. Determine multiplier values using the multiplier table
4. Calculate the SI score (the product of the six multiplier values).
5. Interpret the result. (Moore 2005)

Output type/level (risk assessment)
A single SI value

Criteria to help the evaluator to make decision
Job was considered safe when SI<3, with moderate risk when 3<SI<7, and hazardous when SI>7 (Moore 1995)
For multi-task jobs the risk limits shall be adopted according to the definition of effort and time aspects (Bao 2009, Drinkaus 2005)

Fields of the working life where the method has been used
Saw-filers (Jones 2007); automotive assembly plants (Drinkaus 2003); hose connector manufacturing plant (Moore 2001, Rucker 2002); furniture manufacturing plant and turkey processing plant (Moore 2001); surgical tasks (Lee 2005); manufacturing, meat/poultry processing, and manual material handling (Stephens 2006); turkey processing plant (Knox & Moore 2001); pork processing plant (Rucker 2002); manufacturing and health care sector (Bao 2006, Bao 2006); electronic industry (Pourmahabadian et al 2005).
Modified SI: automotive plants (Drinkaus 2005); cleaners (Cabecas 2007)

Validity
Face validity / Contents validity
Does the method seem to be valid for the aimed purpose?

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>1. The contents of the method is such that a relevant assessment can be expected</td>
<td>x</td>
</tr>
<tr>
<td>Comments: Does not consider vibration and contact forces</td>
<td></td>
</tr>
<tr>
<td>2. Items to be observed have a sound basis</td>
<td>x</td>
</tr>
<tr>
<td>3. Sound operationalization of the items to be observed</td>
<td>x</td>
</tr>
<tr>
<td>Comments: Three of the six observed items have to assess subjectively</td>
<td></td>
</tr>
<tr>
<td>4. Sound process to collect data</td>
<td>x</td>
</tr>
<tr>
<td>Comments: Selection of tasks not advised well</td>
<td></td>
</tr>
<tr>
<td>5. Sound process to get the output of the collected data</td>
<td>x</td>
</tr>
<tr>
<td>Comments: The choice of a multiplicative model, as well as the determination of the multipliers is somewhat arbitrary</td>
<td></td>
</tr>
<tr>
<td>6. Output can help in decision making</td>
<td>x</td>
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</tbody>
</table>
Concurrent validity
How well does the method correspond with more valid method/s?
1) SI vs RULA (Drinkaus 2003) (Industry)
2) SI vs RULA (Lee 2005) (Surgical operations)
   - These methods obviously measure different items
3) SI vs ACGIH HAL (Bao 2006)
5) SI vs ACGIH HAL (Spielholz 2008)
   - SI gave higher risk estimates than ACGIH HAL

"Predictive validity"
How well has the risk-estimation of the method been shown to be associated with or predicting musculoskeletal disorders (MSDs)?

Longitudinal field studies
(Knox 2001):
   - Sensitivity 0.91, specificity 0.83

Cross-sectional field studies
   - Sensitivity 0.92, specificity 1.00
3) (Rucker 2002)
   - Sensitivity 1.00, specificity 0.91
4) (Moore 2001)(pooling of (Knox 2001) and (Rucker 2002))
   - Sensitivity 0.93, specificity 0.89
5) (Drinkaus 2005): Modified Strain Index
   - Maximum task SI: Sensitivity 0.7, specificity 0.8
   - Cumulative assessment SI: Sensitivity 0.7 to .9, specificity 0.8 to 0.5
6) (Spielholz 2008):
   - Fig. 3; with SI level 7 sensitivity and specificity equal (about 0.55). With level 3 sensitivity about 0.75; with level >12 specificity >0.7

Intra-observer repeatability (within observers)
(Stephens 2006)
   - Intraclass correlation (ICC) coefficients for task variable ratings and accompanying data ranged from 0.66 to 0.95 for both individuals and teams. The Strain Index Score ICC(2,1) for individuals and teams were 0.56 and 0.82, respectively. Intrarater reliability for the hazard classification was 0.81 for individuals and 0.88 for teams

Inter-observer repeatability (between observers)
1) (Stevens 2004)
   - For task variables and estimated data,ICC(2,1) varied between 0.66–0.84 for individuals and 0.48–0.93 for teams. The Strain Index score had an ICC(2,1) of 0.43 and 0.64 for individuals and teams, respectively.
2) 4 observers in pairs, 125 tasks (Spielholz 2008)
   - Moderate inter-observer repeatability

**Conclusions**

**Strengths of the method**

- Takes into account the interaction of observed variables. One figure gives comparison of jobs.
- The methods assesses all main risk factors for distal upper limb disorders
- Validity and repeatability well documented in the literature

**Limitations in the use of the method**

- Multiplier values hypothetical; subjective assessment; does not consider vibration and contact stress; definitions of the criteria not very clear.
- Limited to distal upper limb exposure/risk assessment in “monotask” jobs.

**To whom can this method be recommended?**

To occupational safety and health practitioners and researchers. Preferably “monotask” repetitive jobs, which are possible to characterise by observing for a few cycles/minutes. Suggestions about how to extend SI for assessing “multi-task” jobs have been proposed (Drinkaus 2005; Bao 2009).

**References**


