ACGIH TLV for Hand Activity Level (HAL)

**General description and development of the method**

The ACGIH™ HAL TLV™ uses HAL (Hand activity level) and peak hand forces to evaluate the risk factors for developing disorders in hand, wrist, or forearm. It is aimed for monotask jobs with 4 or more hours of repetitive handwork. Observations are made during a worksite visit or from video recordings. HAL considers exertion frequency, recovery time, and the speed of motion and is rated on a single visuo-analogue scale (VAS) of 0 to 10. Peak force can be measured using a strain gauge or other instrumentation (and normalized on a scale of 0 to 10) or estimated by a trained observer using subjective exertion scales (i.e., Borg Modified CR-10 perceived effort scale). Peak force is related to the population characteristics of the evaluated worksite (e.g., age, gender, individual capacities). Combination of HAL and peak hand force are evaluated against the limits given for need of action and an absolute maximum allowed limit. (Armstrong 2006)

HAL was developed in the University of Michigan for the assessment of workload on the distal upper extremity in 1990s (Latko 1997). The method has been adopted by ACGIH that is a scientific organization that has established committees to review existing published, peer-reviewed literature. The committees recommend and the ACGIH Board of Directors approves the publication of guidelines known as Threshold Limit Values for use by industrial hygienists in making decisions regarding safe levels of exposure to various physical agents encountered in the workplace. (Armstrong 2006).

In addition to the hand activity and peak force, the evaluation on a similar visuoanalogue scale has been adopted for joint postures of the wrist, elbow and shoulder (Ebersole 2006, Werner 2005, Werner 2005)

**Exposure descriptors**

ACGIH TLV applies to monotask hand work performed for four or more hours per day. Other work factors, such as wrist posture, contact stresses, and hand-arm vibration should be considered particularly when the exposures are close to the TLV (Armstrong 2006)

<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></td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>movements</td>
<td>both dynamic and static exertions included in verbal anchoring descriptors of the scale</td>
<td>.</td>
<td>x</td>
<td>x</td>
</tr>
<tr>
<td>(external) force</td>
<td>peak finger force</td>
<td>x</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>vibration</td>
<td>no</td>
<td>.</td>
<td>.</td>
<td>.</td>
</tr>
<tr>
<td>contact forces</td>
<td>no</td>
<td>.</td>
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<td>.</td>
</tr>
</tbody>
</table>
Resource demands and usability

Equipment needed


Assessment can be done on video recordings. Hand dynamometers can be used to assess maximal forces. EMG may be useful for determining the peak effort required.

"Team members can be trained to rate repetition / hand activity in approximately 1 hour"
"As similar scales are included for the other physical stressors (force, contact stress, postural stress), it is predicted that training raters can be accomplished in approximately one day" (Latko 1997)

Process of coding and analysis

The first step is to identify the level of hand activity on a scale of 0 to 10, where zero is virtually no activity to a level of 10 (highest imaginable hand activity). The second step characterizes the effort level by noting the effort associated with a typically high force within the cycle of work. The normalized peak force (NPF) is the relative level of effort on a scale of 0 to 10 that a person of average strength would exert in the same posture required by the task. Three methods are suggested for assessing NPF: Noting the measured % of maximum voluntary contraction and a subjective report of perceived exertion (Subjective Scale) as well as an observational method borrowed from the Moore-Garg Strain Index. The third step is to locate the combination of HAL and NPF on the following TLV graph. [http://personal.health.usf.edu/tbernard/HollowHills/HALTLVM15.pdf](http://personal.health.usf.edu/tbernard/HollowHills/HALTLVM15.pdf)

Output type/level (risk assessment)

HAL and normalized peak hand force are combined on a graph showing Threshold Limit Value (TLV) and the Action Limit (AL).

Criteria to help the evaluator to make decision

HAL and normalized peak hand force are compared to the Threshold Limit Value (TLV) and the Action Limit (AL).

With values over the limits Action Limit it is advised to consider additional work related and personal factors that may increase the risk of musculoskeletal disorders.

Fields of the working life where the method has been used

Cashiers and office workers (Bonfiglioli 2007); workers in manufacturing sector (electronics, medical or exercise equipment, windows, kitchen cabinets, sawmill, and plywood mills) (Silverstein 2006); workers in a foundry (Armstrong 2002); industry workers (Ebersole 2006, Violante 2007); manufacturing and health care industry workers (Spielholz 2008); ironworkers (Albers 2007); industry and office workers (Franzblau 2005); workers in automotive plants (Drinkaus 2005)
Validity

Face validity / Contents validity

Does the method seem to be valid for the aimed purpose?

<table>
<thead>
<tr>
<th></th>
<th>yes</th>
<th>x</th>
</tr>
</thead>
<tbody>
<tr>
<td>Armstrong 2006</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1. The contents of the method is such that a relevant assessment can be expected</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Comments: Does not consider posture, vibration and contact trauma</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The correlation to more detailed data collection methods seems rather low.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. Items to be observed have a sound basis</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Comments: Main target on force, repetition and recovery time</td>
<td></td>
<td></td>
</tr>
<tr>
<td>The inter observer correlation for force are rather low. Another way of estimating force may make it higher.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3. Sound operationalization of the items to be observed</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Comments: Subjective evaluation, no clear anchors between the ends of scales</td>
<td></td>
<td></td>
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<tr>
<td>After comparison with SI it has been suggested that the limits should be lower. Also Armstrong 2006 suggests that the action limit should be lower</td>
<td></td>
<td></td>
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<tr>
<td>4. Sound process to collect data</td>
<td></td>
<td>x</td>
</tr>
<tr>
<td>Comments: Sampling not advised</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5. Sound process to get the output of the collected data</td>
<td></td>
<td>x</td>
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<tr>
<td>Comments: Assumes that there is a simple relationship between peak finger force and HAL-value.</td>
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<td></td>
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<tr>
<td>6. Output can help in decision making</td>
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</tbody>
</table>

Concurrent validity

How well does the method correspond with more valid method/s?

1) HAL vs. detailed information from video recordings (number of exertions/sec, recovery time per cycle, cycle time) (Latko 1997)
   - see results p. 281-2; figures 4, 6, 7
2) HAL vs. Strain Index (Spielholz 2008)
   Comparisons from video recordings
   - see results p. 254, Fig. 2
3) SI vs ACGIH HAL (Bao 2006)
   - Weighted kappa = 0.45; see Table 5
   - The SI method identified more hazard jobs than the HAL method.
"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**

1) (Gell 2005) p.50-1, Tab. 2-3
   OR 1.5 (95% CI 0.9 - 2.9)

2) (Werner 2005), p. 396-7, Tab. 1(B)
   - TLV-values showed no statistically discernible associations

3) (Werner 2005), p. 1046-7, Tab 1
   - TLV-values showed no statistically discernible associations

4) (Werner 2005), p. 134-5, Fig. 1
   - For visits to health station Hazard Ratio 2.7 (95% CI 0.95 - 7.9) (TLV 3 vs. 1)

5) (Werner 2005), p. 31-2, Tab 3

6) (Violante 2007), p. 1191-4, Tab 2-4
   - Comparison Below AL vs Above TLV: OR 2.8 - 3.0 (95% CI 1.9-2.0 - - 4.0 - 4.5)

Note that the populations in studies 1) to 5) are partly same and the different individual health outcomes have been reported in different studies

**Cross-sectional field studies**

1) (Latko 1999) p. 253, table 4: "linear trend", p< 0.001

2) (Drinkaus 2005) Original and Modified TLVs. p. 273: case-control OR 11

3) (Franzblau 2005), p. 62-3, Table 3: sensitivity weak (0.29 - 0.59); specificity moderate (0.67 - 0.73)

4) (Spielholz 2008) p. 254, tables 3-4. AL vs. safe OR 1.9 (95% CI 0.9 - 4.4)

**Intra-observer repeatability (within observers)**

1) Test-retest of 33 jobs by the same team (Latko 1997), p. 283, fig. 8
   Correlation r²=0.88

**Inter-observer repeatability (between observers)**

1) (Ebersole 2006)Inter-rater repeatability (12 observers in pairs, 848 jobs), p. 491
   - results see Table 2

2) (Spielholz 2008) Inter-rater repeatability (4 observers in pairs, 125 tasks)
   - results see Table 2

Comments: The peak force has a lower inter-rater reliability than the hand activity (HAL).
**Conclusions**

**Strengths of the method**

- Rapid and simple to use. In the assessment individual capacity is considered, although peak force is related to the population characteristics (e.g. age, gender, individual capacities)
- You do not need a lot of instruments, only a VAS-scale. Peak force can be estimated by an observer using a scale or measured using a strain gauge.
- Assessment can be done on video recordings.
- The analysis of a job takes less than one hour and the processing time is less than five minutes.

**Limitations in the use of the method**

- Subjective assessment, does not consider non-neutral postures, contact stress, low temperatures, and vibration; does not suitable to assess monotonous work < 4 hours repetitive work.
- There may be other factors beside those specified by the TLV that might lead to MSDs.
- If the peak force is estimated by an observing rater, it is likely to have a rather large variance especially at high forces.
- The threshold limit values (TLV) may be set to high, i.e. jobs that would be categorized as hazardous by other methods may be found below the TLV.

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

Occupational safety/health practitioners and research purposes

**References**


