Efficient methods for assessment of physical load at work

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According to the Swedish Work Environment Authority employers are obliged to arrange risk assessments as well as provide education and training for employees in proper working technique to prevent musculoskeletal disorders (MSDs). Ergonomists in occupational health (OHS) are well suited to perform both risk assessments and training in working technique. There are several methods developed for risk assessment of physical load at work but OHS ergonomists mostly perform risk assessments without any specific method. OHS ergonomists often claim that the method they use must be very quick and feasible. Cash register work is repetitive work where training in working technique has been proposed as a method to prevent MSDs. As part of the project “BAsIK- Better Workstyle in Cash Register work”, we developed a protocol for ergonomists to assess working technique in cash register work.

The overall aim of the thesis was to develop and evaluate methods for assessment of physical load at work.

In Paper I the aim was to evaluate intra- and inter-observer reliability and criterion validity of the developed BAsIK observation protocol for assessing working technique in cash register work.

In Paper II the aim was to investigate inter- and intra-observer reliability of risk assessments performed by ergonomists without the use of any specific observational method.

In Paper I, inter- and intra-observer reliability of the developed BAsIK working technique protocol was evaluated. Two OHS ergonomists, with experience of assessing and training working technique in cash-register work, independently used the protocol for assessing 17 15-min videos of cash register on two occasions each. The criterion validity of the protocol was evaluated by comparing these assessments with meticulous video-based analyses by researchers.

In Paper II, the inter-observer reliability was evaluated by letting 21 experienced OHS ergonomists independently perform risk assessments for MSDs. Overall risk assessment, as well as an assessment of the neck, shoulders, elbows, wrists and low back was performed from videos of 10 different work tasks (supermarket work, meat cutting and packing, engine assembly, cleaning, post sorting and hairdressing). A second assessment was performed by 9 OHS ergonomists to evaluate intra-observer reliability.

A proportional agreement larger than 0.7 and Kappa value larger than 0.4 was considered to indicate an acceptable performance.

The intra-observer reliability of the BAsIK protocol of working technique was considered acceptable but only 3 of 10 questions in the protocol showed acceptable inter-observer reliability and 3 of 10 showed acceptable criterion validity.

The intra-observer reliability of OHS ergonomist risk assessment without any specific method was only acceptable for assessment of risk for low back pain. The inter-observer reliability was not acceptable for risk assessment of any body regions.

Most aspects of working technique in cash register work cannot be assessed with acceptable accuracy from quick observations of cash register work. Systematic methods, repeated assessments or technical measurements need to be considered for risk assessment of repetitive load at work.
To Malte and Ellen
List of Papers

This thesis is based on the following papers, which are referred to in the text by their Roman numerals.


II Eliasson K, Palm P, Nyman T, Forsman M. Inter- and intra-observer reliability of risk assessment of repetitive work without any specific method.
Contents

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Abbreviations

BAsIK – Swedish abbreviation for Better Workstyle in Cash Register Work (Bättre Arbetssätt I Kassan)

HAL – Hand Activity Level

ICC – Intra Class Correlation

MSDs - Musculoskeletal disorders

OHS - Occupational Health Services

PABAK- Prevalence and Bias Adjusted Kappa

QEC – Quick Exposure Check
Introduction

Musculoskeletal pain is a large problem throughout the world. The point prevalence of low back pain has been estimated to be about 15-30% (Hoy et al., 2012). Neck pain is almost as common as low back pain and varies between different countries but also between occupations within the same country (Côté et al., 2008). Whereas the prevalence of pain in elbows/lower arms and hands are about half compared to low back pain and neck pain (Bergman et al., 2001). Sickness absence, hampered productivity and quality at work due to pain constitute large costs for the society, organisations (van Leeuwen, Blyth, March, Nicholas, & Cousins, 2006) and individuals. Low back pain was the most common musculoskeletal diagnosis that led to more than 14 days of sick leave among both female and males in Sweden in 2009. The second most common musculoskeletal diagnosis was carpal tunnel syndrome among females and shoulder disorder among males (Försäkringskassan (The Swedish Social Insurance Agency), 2011).

The etiology of development of pain and sickness absence is multifaceted but occupational factors are of relevance. For example, several occupational factors have been identified to contribute to the development of neck pain (Côté et al., 2008) and demanding physical work contribute to long term sick leave among persons with neck pain (Holtermann, Hansen, Burr, & Søgaard, 2010). In general, there is a gradient in pain in relation to socioeconomic groups. Pain is more common among manual worker than among non-manual employees and upper level executives (Bergman et al., 2001).

To prevent musculoskeletal disorders at work it is important to identify and eliminate the occupational risk factors. In Sweden, risk assessment of work is mandatory. Ergonomists in occupational health services (OHS ergonomists) are well suited to perform these risk assessments.

Several physical occupational risk factors have been identified in the literature to be associated with musculoskeletal pain and disorders (MSDs). The major physical occupational risk factors related to musculoskeletal pain and disorders that should be identified through risk assessment can be classified as: repetitive work; forceful work and manual handling; awkward postures and vibration.

Repetitive work

In Sweden about a third of all workers report that they repeat the same movements at least twice each minute at least a fourth of the working time.
(Arbetmiljöverket, 2014). Repetitive work is more common among female than males and most common among young women (16-29 years). The proportion of young Swedish women who report that they are exposed to repetitive work has increased from 42 % year in 2011 to 52 % in 2013 (Arbetmiljöverket, 2014). Repetitive work is identified as an occupational risk factor for developing chronic neck pain (Palmer & Smedley, 2007), as well as shoulder disorders (van Rijn, Huisstede, Koes, & Burdorf, 2010), disorders in the elbows (van Rijn, Huisstede, Koes, & Burdorf, 2009) and wrists (Palmer, Harris, & Coggon, 2007).

**Forceful work and manual handling**
In Sweden, frequent handling of heavy weights ( >15 kilo) is reported especially often among nursing assistants (34 %) and construction workers (31%). Heavy lifts and manual handling is associated with low back pain (SBU Statens beredning för medicinsk utvärdering, 2014). To lift more than 20 kg > 10 times/day or any work that exposes the employee to forces requirements have been related to shoulder disorders (van Rijn et al., 2010).

Forceful power grip and handling of load >20 kg > 10 time/day is also related to elbow disorders (van Rijn et al., 2009)

**Awkward postures**
About 27 % of the Swedish working population report that they bend forward while working or work with a twisted back at least a fourth of their working time. The highest exposed occupational groups are construction and healthcare workers (Arbetmiljöverket, 2014). Awkward back postures are related to low back pain (SBU Statens beredning för medicinsk utvärdering, 2014). Awkward arm postures such as working with elevated arms for more than a fourth of the working day are reported by about 18 % (Arbetmiljöverket, 2014) The highest exposed occupation group is construction workers. Working with elevated arms are related to shoulder disorders (van Rijn et al., 2010).

**Vibration**
Whole body vibration is related to low back pain (Bovenzi, 2006; SBU Statens beredning för medicinsk utvärdering, 2014) and hand arm vibration is related to incidence of carpal tunnel syndrome (Palmer et al., 2007) and hand arm vibration syndrome (Bovenzi, 2006).

**Combination of exposures**
In real situations many exposures co-exist and in many studies a combination of exposures has been identified to be associated with disorders. For example, repetitive work in combination with neck flexion has been identified as a risk factor for developing chronic neck pain (Palmer & Smedley,
The combination of repetitive work and forceful grip has been related to the incidence disorders in the wrist, e.g. carpal tunnel syndrome (Bonfiglioli et al., 2013; Kapellusch Jm et al., 2014; Palmer et al., 2007).

Table 1. Overview of the major physical occupational risk factors for low back, neck, and upper extremity pain and disorders that have been identified in systematic literature reviews

<table>
<thead>
<tr>
<th>Repetitive work</th>
<th>Heavy lifts, Manual handling,</th>
<th>Awkward postures</th>
<th>Vibration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Forceful work</td>
<td>(SBU Statens beredning för medicinsk utvärdering, 2014)</td>
<td>(SBU Statens beredning för medicinsk utvärdering, 2014)</td>
<td>(Bovenzi, 2006; SBU Statens beredning för medicinsk utvärdering, 2014)</td>
</tr>
<tr>
<td>Low back</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Neck</td>
<td>(Palmer &amp; Smedley, 2007)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Shoulder</td>
<td>(van Rijn et al., 2010)</td>
<td>(van Rijn et al., 2010)</td>
<td>(van Rijn et al., 2010)</td>
</tr>
<tr>
<td>Hand, wrist/ elbow</td>
<td>(van Rijn et al., 2009) *</td>
<td>(van Rijn et al., 2009)</td>
<td>(Bovenzi, 2006)</td>
</tr>
</tbody>
</table>

* Forceful power grip

**Risk assessment**

The risk assessment aims at identifying risk situations where one risk factor or combination of risk factors occur and when these risk factors have the magnitude (dose) to constitute a risk for MSDs. There are several tools developed that can be used for risk assessment of work (Takala et al., 2010). These tools are appropriate in different settings. An overview of what kind of exposure and outcome the tools are developed for is presented in table 2.

However, a websurvey distributed to Swedish ergonomists in 2012 indicated that OHS ergonomists often perform risk assessment only, based on his/her knowledge and experience, without the use of any specific method.
(Eliasson K., Unpublished results). OHS ergonomists often claim that the methods they use shall be efficient, quick and feasible in use (David, Woods, Li, & Buckle, 2008).

According to the Swedish work environment act, the risk shall be handled and eliminated. In some situations a worker is exposed to situations at risk and there are limited opportunities to change the work situation. The employer is then obliged to take other actions. One action is to arrange for training in proper working technique to prevent MSDs. This kind of training is often performed by OHS ergonomists.
Table 2. Overview of observational methods for risk assessment of physical load at work. More comprehensive presentations and links to the methods are available in a Swedish report (Palm, Eliasson, Lindberg, & Hägg, 2014)

<table>
<thead>
<tr>
<th>Screening tools</th>
<th>Mainly for repetitive work</th>
<th>Mainly for awkward postures</th>
<th>Mainly for manual handling</th>
</tr>
</thead>
<tbody>
<tr>
<td>QEC</td>
<td>Washington state ergonomic check-list (Palm et al., 2014)</td>
<td>HARM</td>
<td>KIM III</td>
</tr>
<tr>
<td>Push/pull</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Heavy lifts</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Force</td>
<td>Yes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Repetitivity</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Awkward postures</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Combination of exposures</td>
<td>Yes</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Neck/shoulders</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Elbow/wrist</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>Low back</td>
<td>Yes</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Legs</td>
<td>No</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Includes time dimension/dose</td>
<td>Yes</td>
<td></td>
<td>Yes</td>
</tr>
</tbody>
</table>
Cash register work
Cash register work is an example of an occupation where musculoskeletal disorders are common, especially in the upper extremities. Handling of goods in the check-out can be characterised as a hand intensive work task and repetitive work. In the statistics, cash register workers at supermarkets belongs to the occupation coded as vendor of groceries SSYK 5222. According to official statistics in Sweden, female vendors of groceries are the occupational group that reported the second highest prevalence of symptoms due to short repeated operations, 10.2 %, and the third highest prevalence of neck symptom, 8.2 %, in 2014. Several reports of a high prevalence of symptoms among cash register workers have been presented in the literature during the nineties (Baron & Habes, 1992; Hinnen, Läubli, Guggenbühl, & Krueger, 1992; Lundberg et al., 1999; Niedhammer et al., 1998; Osorio et al., 1994). In newer publications a high prevalence of symptoms are still being reported (Balogh, Ohlsson, Hansson, & Nordander, 2011; Bonfiglioli et al., 2007). One explanation of the high prevalence is likely due to the repetitive work while handling groceries. A comparison of the prevalence of carpal tunnel syndrome among supermarket employees that work full time at the cash register desk and those who work half time indicates that it is the work at the cash register desk that are particularly harmful (Bonfiglioli et al., 2007).

In Sweden, many stores have introduced systems where the customer register their groceries themselves. This means that the cashiers can avoid the physical repetitive elements of the work. Traditional manned check-out desks with conveyor belts still exists in most of the stores. According to the manufacturer of check-out systems the traditional check-out desks will remain for many years in the future, since there are many customers who prefer these check-outs. [personal communication].

To prevent musculoskeletal disorders among cash register workers it is important to intervene on an organisational level at the workplace. For example, by adjusting the schedules so the worker can rotate between different tasks in the store and avoid long periods at the check-out. It is also important to ensure that the physical workplace is optimally designed for the work task. Within the frame of the thesis an instrument to assess both the work organisation and physical design of the cash-register desk has been develop, BaSIK. BaSIK is a Swedish abbreviation of Better Workstyle in Cash Register Work. However, despite organisational interventions and optimal physical design of the check-out counter there is still a need to perform the cash register work in a gentle and optimal way. Training in working technique has therefore been proposed as a method to prevent musculoskeletal symptoms among cash register workers. There are no specific tools developed for this kind of training. Therefore we also developed a protocol to assess working technique to be included in the BAsIK instrument (appendix 1). The protocol consists of ten questions concerning different aspects of working technique that could be considered to have an impact on musculoskeletal symptoms.

Objectives
The overall aim of the thesis work was to develop and evaluate efficient methods for assessment of physical load at work.

In Paper I the aim was to evaluate intra- and inter- observer reliability and criterion validity of the developed BAsIK observation protocol for assessing the working technique in cash register work.

In Paper II the aim was to investigate the inter- and intra- observer reliability of risk assessments performed by ergonomists without the use of any specific observational method.
Methods

In this work, reliability was defined as the extent to which assessments of the same sequence of work agree. The intra-observer reliability is synonymously with test–retest reliability and refers to the extent the assessments from the same observer agree from time to another. Correspondingly, inter-observer reliability is the extent to which assessments performed by different observers agree (Mokkink et al., 2010).

In Paper I, inter- and intra-observer reliability of the developed BAsIK working technique protocol (appendix 1) was evaluated by letting two OHS ergonomists independently use the protocol for assessing 17 15-min videos of cash register workers on two occasions each. The criterion validity of the protocol was evaluated by comparing these assessments with meticulous video-based analyses by researchers.

In Paper II, inter-observer reliability was evaluated by letting 21 experienced OHS ergonomists independently perform risk assessments for MSDs. Overall risk assessment, as well as an assessment of the neck, shoulders, elbows, wrists and low back was performed from videos of 10 different work tasks (supermarket work, meat cutting and packing, engine assembly, cleaning, post sorting and hairdressing). Each of the videos were 2-6 minutes long. A second assessment was performed by 9 OHS ergonomists to evaluate intra-observer reliability.

Reliability
The reliability was calculated as the proportion of assessments that agree in percent. To take the agreement due to chance into account proportion agreement was combined with kappa statistics.

In both papers, a proportional agreement larger than 0.7 and a Kappa value larger than 0.4 was considered to show an acceptable performance.

Paper I
In paper I, assessments of two ergonomists were compared and the answer alternatives were mostly on two-point scales, positive/ negative. For this situation the Cohen kappa (Landis & Koch, 1977) was suitable and calculated. However, Cohen’s kappa is influenced by both the prevalence of positive assessments and the extent to which the observers disagree on positive or negative cases (Sim & Wright, 2005). A low or high prevalence of positive ratings will give a low kappa value even if observers agree. This was the case for some questions in the protocol. Therefore a prevalence and bias adjusted kappa PABAK was also calculated in Paper I.

Criterion validity
In Paper I, the criterion validity was assessed for eight of the ten questions in the protocol. Criterion validity was not assessed for “Working posture” because it was evident if the person was standing or sitting. Neither was the criterion assessed for “Tense shoulders” because no relevant criterion reference could be obtained. The criterion validity was examined by comparing all ratings by the ergonomists for each question against the outcome of a detailed video analysis, performed by 1-2 researchers in the project group. The assessment procedure for each question are presented in detail in Paper I under section 2.5.1 and table 3. The ratings were plotted against the outcome of the detailed video analysis (Figure 1 in Paper I). These two distributions were compared using a Wilcoxon signed rank test to determine the extent to which ratings were associated with the “true” results. Questions for which the two distributions differed significantly (p<0.05) in the expected direction were considered to have an acceptable criterion validity.

Paper II
Since Cohen’s kappa is only applicable when two raters or test-retest reliability shall be evaluated, a kappa that was pairwise averaged over all pairs was calculated for the inter-observer reliability in Paper II. This was done in the way suggested by Davies and Fleiss (Davies & Fleiss, 1982), where the expected agreement, Pe, in Cohen’s kappa formula for each pairwise comparison, k = Po − Pe / (1-Pe), is substi-
tuted by the average Pe of all pairs. Since the risk ratings represent ordinal data (low, moderate and high risk) and Cohen’s unweighted kappa does not distinguish minor from major discrepancies in ratings, the linearly weighted kappa (Cohen, 1968) was also computed and averaged (Davies & Fleiss, 1982). The intraclass correlation (ICC), two-way, absolute agreement method 2.1 was also computed to facilitate comparisons with other studies (Shrout & Fleiss, 1979).
Results

Paper I

The intra-observer reliability of the BAsI K protocol of working technique was considered acceptable (PABAK Kappa >0.4 and >70% agreement for all questions, but only 3 of 10 questions in the protocol showed acceptable inter-observer reliability. Those questions were:

- Working Posture (Which posture has the cashier during the observed time? standing/sitting/alternating)
- Micro breaks (Does the cashier take the chance to take short breaks and relieve or move their shoulders for more than 2 seconds? Yes, for the most part; No, rarely or never)
- Quality of movement (Does the cashier work with smooth, gentle movements? Yes, for the most part; No, he/she works mostly with quick or jerky movements).

In total 3 of 10 questions showed acceptable criterion validity:

- Quality of movement (Does the cashier work with smooth, gentle movements?)
- Rotating the head (Is the cashier’s face continually directed to the side 20 degrees or more when scanning many groceries that come in quick succession? Yes; No, rarely or never)
- Receipt handling (Does the cashier have his/her hand outstretched towards the receipt printer in anticipation of printing? No, rarely or never; Yes.)

Thus, the only item that showed both acceptable inter-observer reliability and criterion validity was “Quality of movements” and “Working posture”. Even though “Working posture” was not assessed for criterion validity it was evident that it is possible to assess if the person was standing or sitting.

Paper II

The intra-observer reliability of OHS ergonomist risk assessment without any specific method was only acceptable for the assessment of risk for low back pain (0.76% agreement and weighted Kappa 0.41). The inter-observer reliability was not acceptable for the risk assessment of any body regions.
Discussion

According to our chosen criteria with at least 0.7 agreement and a kappa value larger than 0.4, the intra-observer reliability was considered acceptable for all ten included questions in the BAsIK protocol in Paper I. In Paper II the intra-observer reliability was considered acceptable only for the assessment of risk for low back pain. According to Paper I, the inter-observer reliability was considered acceptable for assessment of whether the cashiers worked in a standing or sitting position, whether the cashier used micro-breaks when possible, and whether the cashier worked with smooth and gentle arm movements. When comparing the two ergonomists’ repeated ratings with more meticulous assessments the protocol showed to have acceptable criterion validity regarding whether or not the cashier worked with smooth arm movements, worked continuously with a rotated head, and kept the arm outstretched towards the receipt printer in anticipation of printing.

In Paper II, the inter-observer reliability was not acceptable for any of the assessed eight body regions. Inter- and intra-observer reliability is often not sufficiently assessed in papers presenting systematic observational methods. However, there are studies done and some of them appear to offer at least fair to moderate reliability when observing postures and movements of large body parts (Takala et al., 2010). David et al. evaluated inter- and intra-observer reliability of the observational risk assessment method Quick Exposure Check (QEC) which is a general screening risk assessment method that includes both assessment of large body parts such as back posture and movement but also shoulder and wrist posture and movements (David et al., 2008). In the first version of QEC the inter-observer reliability was fair to moderate (kappa values ranged from 0.17-0.47). This is comparable with the results of the inter-observer reliability of many questions in the BAsIK instrument in Paper I. In a Brazilian-Portuguese version of the QEC, moderate to substantial inter-observer reliability has been demonstrated (Comper, Costa, & Padula, 2012). Regarding risk methods that has been specifically designed to assess hand intensive and repetitive work, as in the present case, Strain index have demonstrated moderate to excellent inter observer reliability and OCRA excellent reliability (Paulsen et al., 2015; Stevens, Vos, Stephens, & Moore, 2004). Similar results for Strain index and HAL were presented by Spielholz et al. (Spielholz et al., 2008).

In both Paper I and II the results were interpreted with percent agreement together with kappa statistics. In Paper I, PABAK kappa was used due to the nominal scale and the skewed distribution of prevalence or positive and negative ratings. In Paper II, the linearily weighted kappa was used to interpret the results, but several other statistics were also presented to make comparison with other studies possible to perform. In many of the studies mentioned above, ICC 2.1 has been used. (Comper et al., 2012; Paulsen et al., 2015; Stevens et al., 2004, p. 2). ICC 2.1 has been demonstrated to be comparable with quadratically weighted kappa. However, the linearily weighted kappa has been recommended because the quadratically weighted kappa tend to produce high values even if the observed agreement is low (Warrens, 2013).

Tables for evaluating statistics for reliability in the form of words has been presented. Landis and Koch suggested that kappa values 0.21-0.40 are “fair”, 0.41-0.60 “moderate”, 0.61-0.80 “substantial”, and 0.81-1.00 “almost perfect”(Landis & Koch, 1977). A suggested corresponding table for ICC has been proposed whereas ICC < 0.4 are considered “poor” 0.4-0.75 “moderate to good” and >0.75 “excellent”(Stephens, Vos, Stevens Jr., & Steven Moore, 2006). However, these translations from figures to words are arbitrary and may be interpreted cautiously.

The choice of using the criteria 0.7 agreement and a kappa value larger than 0.4 to be acceptable, that was made in both Paper I and II can be questioned. If the outcome and consequences of the assessments had been more critical, higher criteria should have been used. However, we deemed these criteria to be a suitable trade off in a practical point of view when OHS ergonomists assess physical load at work. It is also possible to argue that stricter criteria should be applied to intra-observer reliability than to inter-observer
reliability because the between observer variance is not present in intra-observer reliability. However, for simplicity we chose the same criteria for both intra- and inter-observer reliability.

If we had applied the same interpretation of our results in Paper II according to the ICC as other authors have done before, we would have concluded that the intra-observer reliability for most of the body parts was moderate to good and that the inter-observer reliability was moderate for “left shoulder” and “overall risk”. Taking this into consideration, the difference in reliability between studies, were systematic methods were used and the results in Paper II, when no systematic method was used, the difference is not dramatically large.

There are several sources of variability that can affect the outcome of an assessment of a work task and some of these sources cannot be eliminated by using a systematic method.

1) One source of variability is due to the workers that performs the job. The movement and postures within the same job can differ between different workers. This can also be interpreted as the concept of working technique. In Paper I these differences between individuals within the same job was the target of the assessment. In both Paper I and Paper II, the reliability scores have not been affected by this source of variability because all ergonomists observed the same videos of the same workers.

2) Another source of variability is due to when in time the observation is performed. In both Paper I and Paper II these sources of error were somewhat minimized because all observers assessed the same 2-17 minute video sequence. However, the ergonomists may have viewed sequences of work within the videos that did indeed differ, since movements and postures may have varied within this time. One example supporting this notion is that in Paper I the two ergonomists did not perfectly agree on whether the cashiers were sitting or standing, which would appear evident.

3) Another source of variability is that it could be hard to visually assess movements and postures at work. This has especially been demonstrated for movement of small body parts (Takala et al., 2010).

4) The last source of variability is the observers’ perception of how to translate the movements and postures into risk estimates. The last source of variability can be handled when using systematic risk assessment methods. However, there can still be uncertainties about how to interpret the instructions given in a systematic method.

The studies mentioned above, demonstrates a higher inter-observer reliability than in Paper II. This indicates that using a systematic method is one way to increase the reliability when performing risk assessment at work. The other sources of variability as mentioned above is still present when one single observer is assessing one single sample of a work sequence. To take this variability into account another alternative could be to assess the same videos repeatedly or engage several observers, and in some way use the mean assessment, such as suggested by Mathiassen et al. (Mathiassen, Liv, & Wahlström, 2013). One example of how this approach can increase the informative value of observations was shown in Paper I. The questions “Rotating the head” and “Receipt handling” did not show acceptable inter-observer reliability. However, when comparing four repeated assessments (2 times X 2 observers) with the meticulous assessment, these questions showed acceptable criterion validity.

Development of cheap and feasible technique such as accelerometers enable practitioners to use technical measurements of movements and postures instead of observation. (Dahlqvist, Hansson, & Forsman, 2016) There is, however, still a lack of reference values and threshold limits to guide the practitioner in the interpretation of data from technical measurements into risk for developing MSDs. Therefore technical measurements are still best suited to be used when comparing the exposure between workplaces or assessing the effect on the exposure before and after an intervention.

Both technical measurements and repeated visual assessments with several observers have been demonstrated to be more cost effective compared to the most commonly used method by practitioners when one single observer observe one or several videos of work sequences. (Mathiassen et al., 2013; Trask, Mathiassen, Wahlström, & Forsman, 2014).
A weakness in Paper I is that observations were performed by two OHS ergonomist only. This could hamper the generalizability of the results. However, reliability tests by students, during the development of earlier versions of the protocol also indicated that inter-observer reliability was not acceptable. In Paper II the number of observers was a strength. It is common in reliability studies that fewer observers are participating (David et al., 2008; Paulsen et al., 2015; Stevens et al., 2004).

In Paper II risk assessments were only performed from videos. In real situations the ergonomists interview employees while on site at the work place. This limitation in the present study was addressed by supplying the observers with written information on the different work tasks.

It is important to keep in mind that when OHS ergonomists perform risk assessments of work, the observation is only one among other sources of information that are used for the overall judgment. Experiences from the employer, workers and the OHS service about sickness absence, musculoskeletal complaints and discomfort are also of importance. But the results from both paper I and II indicate that OHS ergonomists need to be cautious and humble when they communicate results of workplace assessments that are based on observations.

Even though the reliability and criterion validity of the working technique protocol assessed in paper II were generally not acceptable, we still believe that the protocol can be useful to point out important aspects of working technique that the cashier should be aware of. This is supported by the notion, that during the development process, both ergonomists and cashiers deemed the instrument to be relevant and feasible to use.

**Conclusion**

The results from both Paper I and II indicate that one single observation of a work sequence is in most cases not a reliable mean when assessing postures and movements during more or less repetitive work. In Paper II it was shown that the information from one single observation when performing risk assessments of work, without any specific method, is unreliable and dependent on the observer. Regarding cash register work, even with a systematic protocol, one single observation is unreliable for assessments of most aspects of working technique as shown in Paper I. Systematic methods, repeated assessments, or other solutions as technical measurements, needs to be considered for assessments of repetitive work.
References


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