

APPENDIX B-TABLE S1

Table S1: Abbreviation for pen-paper observation techniques with their expanded names.

| # | Abbreviation | Expanded name | Reference |
|----|-----------------------------|--|---|
| 1 | ACGIH-HAL | American conference of governmental industrial hygienists-Hand activity level | American Conference of Governmental Industrial Hygienists (ACGIH). TLVs and BEIs. Cincinnati: American Conference of Governmental Industrial Hygienists; 2000. |
| 2 | ART | Assessment of repetitive tasks of the upper limbs | Ferreira J, Grey M, Hunter L, Birtles M, Riley D. (2009). Development of an assessment tool for repetitive tasks of the upper limbs (ART). UK: Health & Safety Executive. |
| 3 | QEC | Quick exposure check | David G, Woods V, Li G, Buckle P. The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders. <i>Appl Ergon.</i> 2008;39 (1), 57-69. |
| 4 | OWAS | Ovake working posture analyzing system | Karhu O, Kansu P, Kuorinka I. Correcting working postures in industry: a practical method for analysis. <i>Appl Ergon.</i> 1977;8 (4), 199-201. |
| 5 | KIM-PP/KIM-LHC | Key indicator method for pulling and pushing/Key indicator method for lifting, holding and carrying | Steinberg U. New tools in Germany: development and appliance of the first two KIM (lifting, holding and carrying, pulling and pushing) and practical use of these methods. <i>Work.</i> 2012; 41(Supplement 1),3990-3996. |
| 6 | SNOOK | Liberty Mutual Manual Materials Handling Tables | Snook SH, Ciriello VM. The design of manual handling tasks: revised tables of maximum acceptable weights and forces. <i>Ergonomics.</i> 1991;34(9), 1197-1213. |
| 7 | MAC | Manual handling assessment charts | Tapley SE. Reliability of manual handling assessment charts (MAC) developed for health and safety inspectors in the UK: A field study. <i>HSE.</i> 2002;UK. |
| 8 | DINO | Direct nurse observation | Johnsson C, Kjellberg K, Kjellberg A, Lagerström M. A direct observation instrument for assessing patient transfer technique (DINO). <i>Appl Ergon.</i> 2004;35(6),591-601. |
| 9 | MAPO | Movement and assistance of hospital patient | Battevi N, Menoni O, Ricci MG, Cairoli S. MAPO index for risk assessment of patient manual handling in hospital wards: a validation study. <i>Ergonomics.</i> 2006;49(7),671-687. |
| 10 | Revised NIOSH Equation(CLI) | Revised national institute for occupational safety and health lifting equation (Composite Lifting Index) | Waters TR, Putz-Anderson V, Garg A, Fine LJ. Revised NIOSH equation for the design and evaluation of manual lifting tasks. <i>Ergonomics.</i> (1993);36(7):749-776. |
| 11 | Revised NIOSH Equation(VLI) | Revised national institute for occupational safety and health lifting equation (Variable Lifting Index) | Waters T, Occhipinti E, Colombini D, Alvarez-Casado E, Fox R. Variable Lifting Index (VLI) A New Method for Evaluating Variable Lifting Tasks. <i>Hum Factors.</i> 2016;58(5),695-711. |

| # | Abbreviation | Expanded name | Reference |
|----|-----------------------------|---|---|
| 12 | Revised NIOSH Equation(SLI) | Revised national institute for occupational safety and health lifting equation (Sequential Lifting Index) | Waters T, Lu ML, Occhipinti E. New procedure for assessing sequential manual lifting jobs using the revised NIOSH lifting equation. <i>Ergonomics</i> . 2007;50(11), 1761-1770. |
| 13 | CTD | Cumulative trauma disorder risk assessment model for the upper extremities | Seth V, Weston RL, Freivalds A. Development of a cumulative trauma disorder risk assessment model for the upper extremities. <i>Int J Ind Ergon</i> . 1999;23(4), 281-291. |
| 14 | OCRA | Occupational repetitive action index | Occhipinti E. OCRA: a concise index for the assessment of exposure to repetitive movements of the upper limbs. <i>Ergonomics</i> . 1998;41(9),1290-1311. |
| 15 | PTAI | Patient transfer assessment instrument | Karhula K, Rönholm T, Sjögren T. A method for evaluating the load of patient transfers. Occupational Safety and Health Administration. Occupational safety and health publications, 2009;83. |
| 16 | REBA | Rapid entire body assessment | Hignett S, McAtamney L. Rapid entire body assessment (REBA). <i>Appl Ergon</i> . 2000;31(2),201-205. |
| 17 | ROSA | Rapid office strain assessment | Sonne M, Villalta DL, Andrews DM. Development and evaluation of an office ergonomic risk checklist: ROSA-Rapid office strain assessment. <i>Appl Ergon</i> , 2012;43(1),98-108. |
| 18 | RULA | Rapid upper limb assessment | McAtamney L, Corlett EN. RULA: a survey method for the investigation of workrelated upper limb disorders. <i>Appl Ergon</i> . 1993;24(2),91-99. |
| 19 | WERA | Workplace ergonomic risk assessment | Rahman MNA, Rani MRA, Rohani JM. WERA: an observational tool develop to investigate the physical risk factor associated with WMSDs. <i>J Hum Ergol</i> . 2011;40(1_2),19-36. |
| 20 | Arbouw | The Arbouw guidelines | Karwowski W. International Encyclopedia of Ergonomics and Human Factors, 3 Volume Set, CRC, Press, 2006,1471-1484. |
| 21 | ALLA | Agricultural lower limb assessment | Kong YK, Lee SY, Lee KS, Kim DM. Comparisons of ergonomic evaluation tools (ALLA, RULA, REBA and OWAS) for farm work. <i>Int J Occup Saf Ergon</i> 2018;24(2), 218-223. |
| 22 | AWBA | Agricultural whole-body assessment | Kong YK, Lee SJ, Lee KS, Kim GR, Kim DM. Development of an ergonomics checklist for investigation of work-related whole-body disorders in farming-AWBA: Agricultural whole-body assessment. <i>J Agric Saf Health</i> . 2015;21(4),207-215. |
| 23 | ACGIH-Lifting TLV | American conference of governmental industrial hygienists lifting threshold limit values | American Conference of Governmental Industrial Hygienists (ACGIH) (2004), Threshold Limit Values for Chemical Substances and Physical Agents & Biological Exposure Indices, Cincinnati, OH. |
| 24 | EAWS | Ergonomic assessment worksheet | Schaub K, Caragnano G, Britzke B, Bruder R. The European assembly worksheet. <i>Theor Issues Ergon Sci</i> . 2013;14(6),616-639. |

| # | Abbreviation | Expanded name | Reference |
|----|--------------|--|---|
| 25 | EN 1005-2 | European Standard 1005-2 | Colombini D, Occhipinti E, Alvarez-Casado E, Waters TR. Manual lifting: A guide to the study of simple and complex lifting tasks, CRC Press, 2012. |
| 26 | ISO 11228-1 | International Organization for Standardization 11228-1 | ISO. 2003. ISO 11228-1. Ergonomics-Manual handling-Lifting and carrying. |
| 27 | ISO 11228-2 | International Organization for Standardization 11228-2 | ISO. 2007a. ISO 11228-2. Ergonomics-Manual handling-Pushing and pulling. |
| 28 | RSI | Revised Strain Index | Arun Garg J, Moore S, Kapellusch JM. The Revised Strain Index: an improved upper extremity exposure assessment model. <i>Ergonomics</i> . 2017;60 (7), 912-922. |

APPENDIX C-TABLE S2:

Table S2: The selection criteria and limitations of the pen-paper observational techniques.

| Technique | Selection criteria | | | Limitations of the technique |
|-----------|---|---|-------------------------------------|---|
| | Types of job/task | The purpose of the assessment | Body parts assessed | |
| ACGIH-HAL | Tasks that involve the same, or very similar repetitive hand, wrist, or forearm exertions | to determine unacceptable levels of hand activity and force | Wrist-forearm | Only consider repetition and force applied to monotonous handwork performed for four or more hours per day. |
| ART | Repetitive tasks | To assess tasks that require repetitive moving of the upper limbs | Neck, lower back, and upper limb | Does not consider the lower limb. it is not intended for display screen equipment (DSE) assessments. |
| QEC | A wide range of tasks | to quickly assess exposure to WMSD risks for a wide range of tasks | Wrist-elbow-shoulder-arm-neck-waist | Not suitable when tasks are highly varied. The method only allows for looking at the worst possible work positions for each body part involved in a task. Does not consider the lower limb. |
| OWAS | A wide range of tasks | To assess stressful work postures | The whole body and lower limb | Does not separate right and left upper extremities. posture coding crude for shoulders. does not consider repetition or duration of the sequential postures. assessments of neck and elbows/wrist are missing. |
| KIM-PP | Pushing or pulling load | Risk assessment of physical workload in pushing or pulling a load on the screening level | Trunk | Only suitable for screening pushing/pulling tasks. it provides a general risk level but cannot predict workers' injuries. |
| KIM-LHC | Lifting, holding or carrying a load | Risk assessment of physical workload in lifting, holding or carrying a load on the screening level | Trunk | Only suitable for screening lifting, holding, or carrying tasks and provides a general level of risk, but it cannot predict injuries to workers. |
| MAC | Lifting (and lowering), carrying, and team handling a load | To aid occupational health and safety inspectors assess the most common risk factors in lifting (and lowering), carrying, and team handling operations. | Back | Is not appropriate for tasks that involve pushing/pulling and is not designed to assess risks associated with workplace upper limb disorders. |
| DINO | Patient transfer tasks | To assess the work technique of nursing personnel during patient transfers | Back and shoulders | Only applicable for the risk assessment of patient manual handling in hospital yards. Non-applicability in some hospital wards e.g. resuscitation and psychiatry. It neglects all the other risk determinants (frequency, environment, work organization, etc.) |

Table S2 (Continued)

| Technique | Selection criteria | | | |
|-----------------------------|---|---|---|--|
| | Types of job/task | The purpose of the assessment | Body parts assessed | Limitations of the technique |
| MAPO | Patient manual handling | To assess the risk exposure level of patient manual handling in hospital wards | Low back | Only applicable for the risk assessment of patient manual handling in hospital yards. variables such as psychosocial factors and overtime hours are not included in the risk assessment of patient manual handling. |
| Revised NIOSH Equation(CLI) | Lifting/ lowering load(single-task) | To determine the recommended weight limit of a load base on lifting/ lowering characteristics and to estimate the relative magnitude of physical stress for a task or a job | Low back | This technique cannot be used for: one-handed lifting/lowering, lifting/ lowering tasks that are done for more than eight hours, lifting/lowering while seated or kneeling, lifting/lowering in restricted workspaces, lifting/lowering of unstable objects, people, or animals, carrying/pushing/pulling tasks (including use of a wheelbarrow or shovel), lifting/ lowering on slippery surfaces, lifting/ lowering in unfavorable environments and Lifting/lowering with high speed motion (faster than about 30 inches/ second). |
| Revised NIOSH Equation(VLI) | Lifting/ lowering load(variable-tasks) | | | |
| Revised NIOSH Equation(SLI) | Lifting/ lowering load(sequential-tasks) | | | |
| CTD | Industrial jobs based on task and hand motion parameters | To predict CTD incidence rates or a relative risk potential for the upper extremities. | Wrist- elbow- shoulder- arm-neck- waist | Is not applicable for jobs with cycle times under four seconds. |
| OCRA | Tasks that involve repetitive movements of the upper limbs | To identify a procedure for calculating a concise index of exposure to the risks of WMSDs associated with repetitive movements of the upper limbs. | Fingers, wrist- elbow- shoulder | The use is time-consuming. Well-trained observers needed. |
| PTAI | Patient transfers | To evaluate the load of patient transfers | Upper limb, trunk, lower back, and lower limb | Only applicable for evaluating the load of patient transfers in the healthcare sector. |
| REBA | Tasks that involve the types of unpredictable working postures found in health care and other service industries. | To quick postural analysis for whole-body activities, both static and dynamic. | The whole body | The right and left hands have to be assessed separately and there is no method to combine this data, duration, and frequency of items not included. This method is not recommended for assessing tasks that are primarily manual material handling tasks. The method is not suitable for assessing jobs that involve a number of different and varying tasks. |

Table S2 (Continued)

| Technique | Selection criteria | | | |
|-----------|--|---|----------------------------|--|
| | Types of job/task | The purpose of the assessment | Body parts assessed | Limitations of the technique |
| ROSA | Computer work | To quickly quantify risks associated with computer work and to establish an action level for change based on reports of worker discomfort. | The whole body | Only applicable for computer work in the office environment. |
| Arbouw | Lifting and carrying, pushing /pulling, static postures, and repetitive work | To develop guideline instrument for assessing physical workload | Lower back | Relative time-consuming but does not give very detailed information. |
| RULA | Tasks where the worker uses primarily the upper limbs to complete the task. | To provide a method of screening a working population quickly, for exposure to a likely risk of work-related upper limb disorders. | Upper limb /the whole body | The right and left hands have to be assessed separately and there is no method to combine this data. Does not consider the duration of exposure. It is appropriate for tasks that typically, the worker is seated or standing without much movement when performing the task. |
| WERA | The wide range of job/task | To assess the physical risk factors associated with work-related musculoskeletal disorders | The whole body | As with most techniques, do not consider psychosocial factors and the interaction of the risk factors. |
| SNOOK | Lifting, Lowering, Pushing, Pulling, Carrying tasks | To provide guidelines for predicting the maximum weights and workloads that are acceptable to different percentages of the male and female industrial population. | Low back | Does not consider any trunk rotation/ twisting that may take place while performing the task. This method is not suitable for use when the task involves one-handed lifting, lowering, carrying, pushing, or pulling. The method is also not useful for tasks that involve throwing or catching objects. |
| ALLA | Tasks that involve the types of postures for farm work | To assess lower limb postures for farm work | Lower limb | Only applicable for the risk assessment of the lower limb. As with most techniques do not consider psychosocial factors and the interaction of the risk factors. |
| AWBA | Agriculture | To assess various postures in agricultural work | The whole body | Only applicable for the risk assessment of agricultural work. Does not consider psychosocial factors and the interaction of the risk factors. |

Table S2 (*Continued*)

| Selection criteria | | | | |
|---------------------------|---|---|----------------------------|---|
| Technique | Types of job/task | The purpose of the assessment | Body parts assessed | Limitations of the technique |
| ACGIH-Lifting TLV | Tasks that involve Lifting /lowering a load | To provide guidance on acceptable weight limits for lifting tasks. | Low back | <p>This technique is not applicable for use with other material handling tasks such as carrying, pushing, and/or pulling and should not be used if any of the following is true:</p> <ul style="list-style-type: none"> - the trunk/twists rotate more than 30 degrees to either side; - more than 360 lifts per hour are required; - lifting is done for more than eight hours a day; - a constrained body posture is used when lifting (kneeling, restricted head room, seated, crouching); - one-handed lifting is required; - lifting is done in high heat and/or humidity; - the objects being lifted are unstable (containers with shifting center of mass, people, animals); - the object being lifted has poor hand holds or grasping points; - the workers' footing is unstable (slippery floor, unstable ground/or surface). |
| EAWS | Assembly tasks | To assess physical workload in cyclic work | The whole body | <p>Cannot be used for ergonomic job rotation planning as the sequence and the load characteristic of the tasks (e.g. aggravation of fatigue or recovery aspects) are not considered. The application is complex and requires intensive training.</p> |
| EN 1005-2 | Tasks that involve the manual handling of machinery, component parts of machinery, and objects processed by the machine (input/output) of 3 kg or more, for carrying less than 2 m. | To assess manual handling of machinery and component parts of machinery. | Lower back | Does not cover the holding of objects (without walking), pushing or pulling of objects, hand-held machines, or handling while seated. |
| ISO 11228-1 | Tasks that involve Lifting and Carrying a load | To set recommended limits for the mass of objects being manually handled. | Lower back | Does not include holding objects, pushing or pulling objects, lifting with one hand, or manual handling while seated. |

Table S2 (*Continued*)

| Selection criteria | | | | |
|---------------------------|---|---|----------------------------|--|
| Technique | Types of job/task | The purpose of the assessment | Body parts assessed | Limitations of the technique |
| ISO 11228-2 | Tasks that involve Pushing and Pulling a load | To determine whole-body pushing and pulling force limits, according to specific characteristics of the population and the task. | The whole body | Only applicable for tasks that involve Pushing and Pulling a load. |
| RSI | Repetitive “hand intensiv” tasks | To assess a distal upper extremity physical exposure | The wrist, forearm | Only applicable for simple, mono-task jobs where the constituent variables do not change substantially between different exertions during a task cycle and the worker does not rotate between different tasks during a work shift. |