RYERSON UNIVERSITY

Inventory of Human Factors Tools and Methods

A Work-System Design Perspective

Editor: W.P. Neumann, PhD, Eur. Eng

October 2007
Beta v2.0.0 – Available at http://www.ryerson.ca/hfe/-

Foreword

This is NOT a scientific report. This is an attempt to make the tools and methods developed by scientists and others available to you the reader. It is an effort to expand the USE of tools by today's practitioners. It aims to provide a 'catalogue' for you to browse and some starting points for where you might get more information on how to.

The 1st edition of this inventory was supported by the Swedish National Institute for Working Life's SMARTA theme (Christmansson et al., 2005). The NIWL was a research and development institute of world class stature that has recently been shut down by the new Swedish government. The continued work on this inventory has been supported by a grant from the Ontario Workplace Safety and Insurance Board.

This 2nd edition of the tool inventory is considerably expanded from the first edition that focused more on 'classical' ergonomics tools. Now we have expanded the focus of this inventory to include, for example, product design and usability tools, as well as the beginnings of tools for senior managers making strategic decisions for their company. This inventory is also moving into more traditional 'engineering' design tools. This is done with a deliberate intent to blur the lines between 'ergonomic' tools and 'regular' tools, so as to support integration of human factors as a natural part of the design process. This inventory also includes listings of commercially available software for ergonomics analysis. We have not examined any of this software ourselves and present it as possible leads for YOU, dear reader, to investigate as you work to improve ergonomics in your own design processes.

We hope you find this list beneficial and, as always, welcome your submission of tools or methods that could be added to this inventory.

W.P. Neumann, PhD, Eur. Eng
Editor

Contributors:
Jorgen Eklund
Bo Hannson
Aileen Lim
Lars Lindbeck
Tizneem Nagdee
David Scrivens

Please note that this document is a Beta release and is still a work in progress. We welcome your comments. Please direct them to WP Neumann at pneumann@ryerson.ca.

Acknowledgements

This work has been funded by the Ontario Workplace Safety and Insurance Board and the first edition of this inventory was also funded by the SMARTA theme of the Swedish National Institute for Working Life. Thanks go to the SMARTA 'Evaluation' Group including Jörgen Eklund, Lars Lindbeck, Lena Karlqvist, and Bo Hansson.

Table of Contents

Chapter

1

Introduction

This is an inventory of tools for design, description and evaluation of working environment / ergonomics.

This 'Tool Inventory' is intended to assist practitioners in identifying potentially useful methods for evaluating working environment in their professional work (or perhaps evaluating their own working environment!). The emphasis here is on tools that can be used to evaluate a workplace or a potential design for a workplace, often in some kind of quantitative way. Evaluation methods and change tools such as focus groups, photo-safari, or dialogue conferences are not included here. A number of such improvement tools are described in a related SMARTA project (Åteg et al., 2005). There are many evaluation tools 'out there' and this list includes only some of these.

The aim of this report is to provide those seeking evaluation approaches with a broad overview of available tools and connections to information that can help choose the tool best suited to their needs.

Why bother with ergonomics? Since ergonomics (and its synonym human factors), by definition , includes the objectives of improved system performance and operator well being, everyone has something to gain in the application of human factors knowledge. Globally the problem of work related ill health costs about 4% of the World's GDP (WHO, 1999). For companies the costs of poor ergonomics are usually reckoned in terms of sickness-absenteeism costs – although the 'hidden' or indirect costs, in terms of increased quality deficits, poorer organisational performance, hiring and replacement costs, reduced productivity and so on can cost many times the direct costs of any injury. Good ergonomics, as they say, is good economics (See for example: David C. Alexander, 1998; D.C. Alexander & Albin, 1999; J. Eklund et al., 2006; J. A. E. Eklund, 1995; Hendrick, 1996; Oxenburgh et al., 2004).

A variety of approaches were used to identify tools. This report includes:

- Tools and methods known to the author either directly or through reports and literature

- Tools identified in connection with the associated SMARTA evaluation review project tools that had been used in the scientific studies of ergonomics interventions were included
- Tools identified by web searches and from measurement text-books
- Tools and tips provided by colleagues who viewed early versions of this list

A classification scheme was developed as tool were collected based on characteristics of the tool and how the tool might be used. Whenever possible internet links and references are provided giving the reader access to more information and sometimes even copies or software of the method itself. This scheme is sequenced roughly in order of stages of development. Thus simulation tools, that can be used before a workplace is built, are listed before checklists that usually require existing workplaces.

So, what kinds of tools are there? This has actually been the most challenging aspect of compiling this list – creating a usable structure out of the many tools and methods that have been developed for work-place design and ergonomics analysis. We have adopted a model of the design process that we have been using in our research (Figure 1) (Neumann, 2004; Neumann et al., 2002).

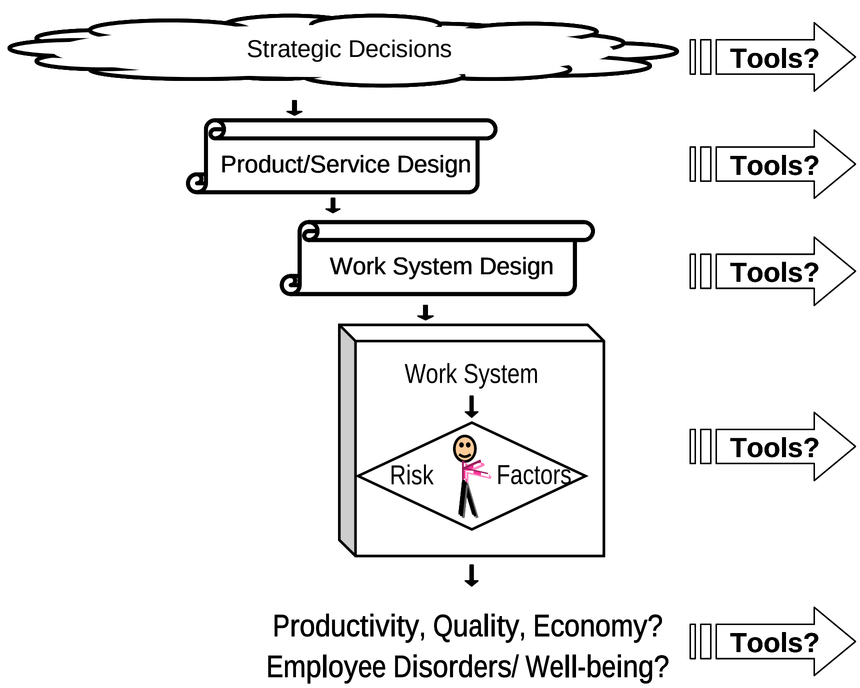

Figure 1. A simplified model describing general stages in the development of a 'work system' (including manufacturing and service type systems). Each set of decisions made in this process can influence the physical and psychosocial risks to operators in the resulting system. This inventory groups based on the stages of design illustrated here.

The stages of design include strategic decisions that define the company's position in the market and specify subsequent design objectives, product or service design decisions, The design of the work system in which the product or service will be produced and delivered to the customer, and finally the work system itself in which operators are responsible for quality and production of the product and are placed at risk for poor performance and poor health outcomes if the design is inadequate. These stages, are not static and often design processes move backwards and forwards through this process

Risk factors' have their roots in strategic decisions. While ergonomics risks for poor health and poor performance outcomes are found in the operating system, these risks actually start right from corporate strategic choices. How is the company organised? What competitive advantage is being pursued? How? These decisions exist mostly at the top of the model (see figure below) and define subsequent design tasks. The relation between strategic choices and ergonomics is not well studied or understood and the tools available here are few and not well developed. The range of 'strategic' decisions and company contexts is huge and highly dynamic making this a challenging area for application of human factors. We have argue that human factors can support the implementation of strategy and that humans have a vital strategic role to play in the success of the firm (Dul & Neumann, 2005, 2006; Neumann & Dul, 2005b).

Product (or service) design defines what must be accomplished. The design of the product or service defines the tasks that system operators must perform and hence plays a crucial role in ergonomics. Examples of issues in this phase include: Can the operator reach/see a connection? How much strength is required to fasten a component? How difficult is the 'fit' or parts? What postures must be adopted to attach a given component? Or, in that case of service operations, what possible risks exist in the relation between the employee and the customer (night bus drivers vs. tax advisors)? Tools and methods here include Design for Assembly (DfA) approaches, Kansei engineering, and usability evaluation approaches. Human Simulation can also play a role in evaluating the 'assembleability' of products.

System design determines how and when tasks will be performed – in which the work-system (be it production or service) is created poses the next stage in the creation (or elimination) of human factors risks. The flow of the system – such as conventional line flow or long cycle cellular flows – poses one example of design choices that define both repetition rates and working conditions for operators. Layout is another design area that has crucial impact on eventual risk factors – if parts are stored on boxe on the floor someone is going to have to bend over and pick up the last parts from the box creating risk for low back pain. Tools for evaluating risk in the design phase include many 'virtual' tools such as digital human models, biomechanical models, and even discrete event (flow) simulations. Some traditional ergonomics tools such as the NIOSH equation or Snook tables may be applicable at this stage as reach distances, weights, and repetitions become known to the design team.

Production system - 'the real world' is the first time that most of the conventional ergonomics tools such as checklists become applicable. Unfortunately it is also the case that changes made at this stage are the most expensive as it implies retrofitting and possible undoing design work completed previously. Other tools that become available at this stage include video analysis and questionnaires of operator perception.

It's not this simple! While we use this design structure (Figure 1) to help us organise the tool lists we also know that design is not so simple! It is a complex process involving many people with different skills, personalities, responsibilities and objectives. The extent to which feedback about problems or great solutions in current systems is provided to and applied by designers of new systems will vary greatly. In our experience however many companies are good at providing designers with information on simple performance related factors – but not so good on providing knowledge about human factors in the systems they have designed in the past (those currently operating). Many of the tools listed here could provide such feedback to designers – provided there is communications.

The Main Categories are based on the design process, and based on the tools we found in each category have been grouped as follows:

1. Tools for Strategic Decision Making
2. Tools for Product Design
    - Usability
    - Other Design Tools
3. Tools for Work System Design
    - Discrete Event Simulation
    - Digital Human Models
    - Other Design Tools
4. Tools for Work System Evaluation
    - Operator Physical Risk
    - Operator Psychosocial/Stress Risk
    - Operator Mental Workload
    - Other System Characteristics
5. System Outputs
    - Health Status and Wellbeing
    - Economic Assessments
6. Other Tools

These tools are described in the next chapters.

Advice for Tool Choosers and Users

There is only ONE system! There is not a 'production' part and a 'human part' that can be considered separately. So if you want to ensure you have a well designed system that lets your people perform their best – then you'll have to consider human factors throughout the design process. It is a common mistake to consider human factors only at the end of the design process once all critical technical decisions have been made. This usually not very effective and the system inevitably underperforms. *Make sure your design process includes some tools at every level of development or HF will fall off the table!*

Information alone won't win the day – In the end it is actions that count. IF the knowledge gained from a tool is not applied, then the value of the knowledge can be questioned. It is important therefore to pay attention to the communication channel between those with knowledge of human factors and those making key design decisions. This moves into the area of ODAM – Organisational Design and Management. Sometimes the design process itself and surrounding organisational structures might need adjustment to allow the HF knowledge to be really applied in the design process. This can pose a challenge to the ergonomists seen as a kind of 'medical' service provider to the company.

Use the right tool for the job. There is no 'best' tool. After all a hammer is not a 'better' tool than a saw. The choice of tool depends therefore on what needs to be done. Early in a design phase it may be more suitable to use simulation approaches that can be based on early design specifications. If a workplace is running, and a specific concern is to be addressed, then a simple paper and pencil tool may be more cost effective. When choosing a tool consider: What is the purpose of the evaluation? Who will gather the information? Who will use or act on the information? Just because you have a hammer in your hand doesn't mean your problem is a nail.

These tools aim to evaluate risk and consequences. Most of the tools listed here attempt to quantify the physical load or psychosocial conditions for the employee. Several tools are oriented to quantifying outcomes such as pain or disability. A few tools consist of economic models that try to evaluate a potential change in terms of productivity, costs, and financial benefits.

Every tool has a 'blind spot'. No tool is perfect. Carpenters have dozens of tools for different tasks. Remember that there are often 'intangible' effects from change projects. It is helpful to try and capture these with more qualitative approaches – by interviewing the people involved. This can provide insight into the effects (and process) of change that might not be clear from a particular tool. Operator and supervisor descriptions of how the system is working and where improvements might be made can support and shed light on the results of your analysis.

It's the skill of the carpenter not just the sharpness of the saw that counts. Of course a good tool makes a big difference, but how the tool is used is also critical. The way you use a tool and the process by which the information is used by you and by others can always be improved. Think of the tool as supporting your organisations continuing development efforts.

Think outside of the box. Many tools can be used in a variety of ways. Simulation tools, for example can include many different factors for study – even if these are normally used mostly for just technical design issues. Other methods, such as focus groups – can be used to explore a wide range of issues – including the performance of technical features of the workplace.

Don't let a tool 'box' limit you - Just because a tool or method is listed under 'usability' doesn't mean it can ONLY be used for product usability assessment. Perhaps it would be great for your assessment of a particular workstation – where the workstation or production system is the 'product'. In this inventory, tools and methods may be cross-listed (posted in different categories)

More tools options exist in later stages of design – There is a tendency for tools to 'become available' once sufficient information from the design has been determined. Thus these tools tend 'come on-line' during the process allowing more complete assessment as the design matures. That said, don't let this delay your consideration of human factors; the earlier in the process you consider HF, the cheaper your development and production costs will be in the long run.

Don't wait for the 'best' tool to become applicable - The problem with waiting until the 'best' information is that it may be too late to act! Sometimes a combination of thoughtful measurement and considered action now will give a better result than delaying until an 'optimal' tool can be developed and implemented. (But don't give up on developing new approaches that will help in the future.)

What do you need the information for? There are different approaches to using evaluation tools. One approach is to ask: 'Is this REALLY a problem?' This kind of pass/fail analysis sometimes implies a desire to do nothing unless it is mandated by some kind of law. It also demands clear reference values against which a particular result could be compared. An alternative approach is to ask – which design alternative, A or B, might be better? Such design questions might require tools with predictive capability since it is natural to ask this before either alternative is built. Finally tools might be used in more of a continuous improvement mode: How or where in the current design might we make improvements. Here, rather than asking the pass-fail question the emphasis is on improvement. This makes sense since current risk models suggest risk increases continuously with exposure. An analogy here is smoking – risk increases with the number of cigarettes smoked and there is no 'safe' number of cigarettes that does not increase your risk of lung cancer.

Develop both Leading and Trailing indicators – Leading indicators are those that give information before a problem emerges, trailing indicators usually provide knowledge after the problem has been identified. Injury rate, for example,

Is a trailing indicator, while biomechanical loading based on simulation ofwork might pose a leading indicator. We recommend using indicators all along the 'causal pathway' to understand where in the design process risks emerge and to support corrective measures at the earliest possible stage where the costs of change is lowest. See: *'A stitch in time saves nine'.*

A stitch in time saves nine – This grandmotherly saying points out that a single needle and thread stitch in a shirt can stop a small tear becoming bigger and requiring more work (stitching) to repair. In work system design processes (like that illustrated in Figure 1) the cost of change is least in the earliest stages when concepts are still being chosen. It is said to cost over 10 times more to retrofit or change an existing system then to adopt the change in the early design stages (David C. Alexander, 1998).

This list is incomplete. New tools are being developed continuously and old tools may become obsolete, unavailable, or simply missing from this list! (please submit tool information for inclusion in future inventory versions) Look around before choosing a tool. It may seem like extra effort but it can both save time and give better results in the long run making the early investment worthwhile. Use this list, and the links contained here, as a jumping off point to your own search for tools that suit your needs and the needs of your workplace.

Other Resources

If you are looking for tools to help you in your ergonomics work consider checking on the web (university, national and state research institutes, Workers' compensation boards, unions, etc.) for further tips. Here, we list a number of sites that can provide extra information both on evaluation tools and on work environment issues more generally.

General Information

- ErgoWeb's Ergonomic Concepts: http://www.ergoweb.com/resources/reference/concepts.cfm
- FAA Workbench Tools: http://www2.hf.faa.gov/workbenchtools/
- Humanics Ergonomics Resources: http://www.humanics-es.com/recc-ergonomics.htm#tools
- NASA Human Factors 101: http://human-factors.arc.nasa.gov/web/hf101/index.html

Standards

Consider available ergonomics standards - many of these include both guidelines for process as well as methods to support the given process. For an overview of standards see (Dul et al., 2004).

Check out available standards at:

- Canadian Standards Association: http://www.csa.ca
- European Committee for Standardisation: http://www.cen.eu/cenorm/homepage.htm

- Federal Aviation Association: http://www2.hf.faa.gov/workbenchtools/default.aspx?rPage=ToolList&subCatID=39

- International Standards Organisation: http://www.iso.org/iso/home.htm

- NASA Man-Systems Integration Standards: http://msis.jsc.nasa.gov/Volume1.htm

- Swedish Standards Institute: http://www.sis.se/DefaultMain.aspx

Books

A number of excellent books exist that include description of evaluation tools. These include:

Charlton, S. G. and O'brien, T. G. (Eds.) (2002) Handbook of human factors testing and evaluation. Lawrence Erlbaum Assoc., London. This book provides an overview of evaluation approaches – including discussions of how and when to evaluate - for a wide range of industries and needs.

Jordan, P. W. (1998). An Introduction to Usability. London: Taylor and Francis.

Stanton, N. A., Hedge, A., Brookhuis, K., Salas, E. and Hendrick, H. (2004) Handbook of human factors and ergonomics methods. CRC Press, London. 0-415-28700-6.

Wilson, J. R. and Corlett, E. N. (Eds.) (2005) Evaluation of Human Work. Taylor & Francis, London.

Online Resources

- Databases of Scientific Journals: The Elsevier database covering hundreds of journals. http://www.sciencedirect.com/

- Medical Database: The world's foremost 'medical' database includes journals from multiple publishers while focusing on human and public health issues. http://www.ncbi.nlm.nih.gov/sites/entrez/

- Web of Science Databases: http://portal01.isiknowledge.com/portal.cgi

- Ergonomics Abstracts Database: Managed by Taylor and Francis. (also a large science publisher (see also www.tandf.co.uk/journals) www.tandf.co.uk/ergo-abs

- Emerald Database: Another large scientific database specializing in engineering, business and management. http://www.emerald-library.com/Insight/

- Google Scholar: Searches multiple academic databases simultaneously. http://scholar.google.ca/

Government Websites & Institutes

(Note: these website links point to in English pages, where possible.)

- Canada's Institut de recherche Robert-Sauvé en santé et en sécurité du travail (IRSST): http://www.irsst.qc.ca/en/home.html

- Canada's Institute for Work and Health: http://www.iwh.on.ca/

- Canada's Worksafe BC: http://www2.worksafebc.com/Safety/Home.asp

- Denmark's National Institute for Working Life: http://www.arbejdsmiljoforskning.dk/?lang=en

- Dutch TNO Institute /Work and Health: http://www.tno.nl/home.cfm?context=kennis&content=onderzoek

- European Trade Union Institute/Health and Safety at Work: http://hesa.etui-rehs.org/uk/default.asp

- Finnish Institute of Occupational Health: http://www.ttl.fi/internet/english

- Swedish Environmental Research Institute Ltd: http://www.ivl.se/en/

- Swedish Industrial Research and Development Corporation: http://www.ivf.se/default____883.aspx

- Swedish internet portal for 'work environment' listings: http://www.arbetsmiljoupplysningen.se/AFATemplates/InfoBoxList____7282.aspx

- Sweden's National Institute for Working Life: Funder of the 1st edition of this inventory has information in both Swedish and English. Check the online library. http://www.arbetslivsinstitutet.se/en/

- Swedish Work Environment Authority: http://www.av.se/inenglish/

- UK Health and Safety Executive: Information and links to a number of tools (e.g. OWAS, QEC, RULA etc.). http://www.hse.gov.uk/

- US Department of Labour's Occupational Safety and Health Administration: http://www.osha.gov/

- US National Institute for Health and Safety (NIOSH): Reports & information. www.cdc.gov/niosh/homepage.html

Comments or suggestions? Please send them to pneumann@ryerson.ca.

Conclusions

There are many tools available for evaluating ergonomics at different stages in the development process. Checklists (often implemented on computers) for evaluating current working situation appear to be the most common tool type. Research is needed to examine the extent to which tools are being used by practitioners, the process by which tools are used, and their experience of the benefits and drawbacks of various tools.

Chapter
2

Tools for Strategic Decision Making

'If you can't measure it, you can't model it.'

Strategic choices form the first and sometimes most influential decisions in the creation of a work system (as illustrated in figure 1). While not studied frequently from an ergonomics perspective these decisions can have considerable impact on ergonomic conditions in the resulting system (Neumann, 2004). The reverse is also true – ergonomics can support the successful realisation of strategies chose by senior managers (Dul and Neumann, 2005; Neumann and Dul, 2005). There appear however to be few tools that explicitly recognise this relationship. Since the 1st edition of this inventory however we have begun to identify some 'strategic' level tools that could be adapted to include human factors concerns along with other critical factors. Other 'tools' also exist in this area such as workshops, focus groups and the like that are intended to provide a forum in which alternatives can be developed and examined by a broad range of stakeholders with different perspectives on the issues involved (Jensen, 2002). While the field of Operations Research has many approaches to 'multi-objective decision making' these do not appear to have been adapted to include Human Factors Issues.

NEW

Balanced Scorecard: The BSC is a widely used approach to permit the examination of company performance indicators that don't have the same units. It recognises that companies cannot be effectively managed for the long term using only financial indicators. It provides a means by which goals and measures can be examined from the perspective of finance, customers, innovation and learning, and from that of the internal business. These aspects can then related to larger company strategic objectives and plans (Kaplan and Norton 1992), (Kaplan and Norton 1996), (Braam and Nijssen 2004). There is considerable literature on the BSC including a 'for Dummies' guide so check your bookstore or library

NEW

MicroWorld Simulations: This simulation technology allows the examination of how executives assumptions about the firm interact within a given strategic profile. Computer simulations permit executive teams to quickly test these assumptions over many years and have potential to support decisions surrounding human factors, although this is rarely done.

Chapter

3

Tools for Product Design

Product (or service) design sets the stage for the eventual work-system design and, as such, may already determine ergonomics issues for employees, right from the outset.

While many tools exist to evaluate usability – where the focus is on the customer – fewer exist to consider the wellbeing or effectiveness of those who *build* the products or *deliver* the services. In this chapter, we present some (of the many) usability tools aimed at end-users as well as a few of these other methods related to human factors for the employee, including 'concepts' such as 'Design for Assembly' that provide principles for simplifying assembly, but are not as well developed, for example, as are checklists for work-system evaluation.

An 'internal-customer' perspective can help here – the employee is the 'user' and the work-system is the 'product' of the design exercise. With this perspective a number of these tools may help designers optimise their work-system designs to help the 'customers', the system operators, produce the service or product for their customers – the end user.

NEW

Usability

These tools and methods deal largely with customer perspectives with respect to Human-Computer Interaction (HCI), applying techniques that vary from cognitive walkthroughs to rapid prototyping. For general information and usability documentation, see these.

- Dated, but useful introduction: http://www.ucc.ie/hfrg/emmus/hftoc.htm
- Excellent portal site from the University of Aberdeen: http://www.csd.abdn.ac.uk/~jmasthof/teaching/CS2506/information/
- Comprehensive tool listing: http://www.usabilitynet.org/tools.htm
- Various HCI standards: http://www.usabilitynet.org/tools/r_international.htm
- IBM's Ease of Use gateway: http://www-03.ibm.com/easy/page/558

- Finally, the 'daily sucker' from Web Pages that Suck: http://www.webpagesthatsuck.com/dailysucker/

A-Prompt (accessibility prompt) – 'A tool developed to assist Web authors in improving the accessibility and usability of HTML documents. It is made available through a joint collaboration between the Adaptive Technology Resource Centre at the University of Toronto and the TRACE Center at the University of Wisconsin' (Web Design References: http://www.d.umn.edu/itss/support/Training/Online/webdesign/tools.html).

- A-prompt: http://aprompt.snow.utoronto.ca/

Alpha and beta tests: Early release of a product to a few users. These early releases can provide valuable feedback on problems, likes, and dislikes of customers. Such strategies can also be applied to workplace design using mock-ups and trials of equipment or even using early stage simulations to get input from operators on possible design improvements.

Castasia Screen Recorder and Video Editor: Castasia provides basic video capture functions during usability testing.

- http://www.techsmith.com/camtasia.asp

Cognitive Walkthrough: Cognitive walkthroughs are performed by a human factors analyst, rather than a user. As such, the sequence of action is studied, so that the effectiveness of an interface can be assessed, but not its user satisfaction. This task-based method can be performed at any stage of the design lifecycle. (Helander, 2006).

- Georgia Tech's summary: http://www.cc.gatech.edu/computing/classes/cs3302/documents/cog.walk.html

Computer System Usability Questionnaire (CSUQ): This questionnaire, developed at IBM and available in the public domain, presents 19 statements to which users respond on a 7-point scale. The evaluation is scenario-based and intended to measure both usability and satisfaction. (Lewis 1995)

- CSUQ and other questionnaires: http://www.usabilitynet.org/tools/subjective.htm

Critical Incident Study (CIS): Used to "look for the cause of human-product problems in order to minimize loss to person or property" (p.145). "CIS identifies possible sources of serious user-product difficulties" p.148) through individual interviews and past report reviews. Analysis and categorization of frequently occurring events help to determine recommendations for improvements. CIS is similar to Fault Tree Analysis (Nemeth 2004).

- More information: http://www.usabilitynet.org/tools/criticalincidents.htm

Denim Rapid Prototyping: Denim 2.1, developed at the University of Washington, enables fast website mock-ups that provide excellent functionality but little in terms of 'look-and-feel'. Good for early design work and testing

- Denim: http://dub.washington.edu/projects/denim/

Heuristic Evaluation. This evaluation assesses software interfaces with respect to accepted usability principles.

- Nielson's Ten Heuristics: http://www.useit.com/papers/heuristic/heuristic_list.html
- Shniederman's Eight Golden Rules: http://faculty.washington.edu/jtenenbg/courses/360/f04/sessions/schneidermanGoldenRules.html
- Tognazzini's First Principles: http://www.asktog.com/basics/firstPrinciples.html

IDEAL: IDEAL is a 'data gathering tool' developed at Virginia Tech to support usability testing of software applications. It manages both quantitative data, such as time-on-task and error rates, as well as qualitative data, such as audio and video clips associated with critical incidents. The ability to mark and annotate specific clips illustrating user frustration with the software enables designers to zero in on those aspects of the application that cause difficulty.

- More information: http://research.cs.vt.edu/usability/projects/ideal/ideal.htm

Web Analytics Tools: These tools measure various metrics related to website visitors and user behaviour.

- Free tools: http://www.readwriteweb.com/archives/10_web_analytics_tools_free_innovative.php
- Webtrends: http://www.webtrends.com/

Other Design Tools

These tools deal with non-usability aspects of design and some have good potential to help ensure good human factors for employees. Some may however require some adjustment in the way they are used to fully realise benefits in the HF area. First, a few general resources:

- U of Maryland Reliability and Maintainability Standards and Handbooks: http://www.enre.umd.edu/publications.htm

Design for Assembly (DfA): DfA encourages designers to consider the ease of assembly of a product, applying the principle that fewer parts likely translate into lower assembly times and costs (e.g. Sony Walkman, Swatch watch – see wikipedia.org). Two good references on this topic include:

Boothroyd, G., Dewhurst, P. And Knight, W., 2002, Product Design for Manufacture and Assembly (New York: Marcel Dekker).

Helander, M. and Nagamachi, M. (1992) Design for Manufacturability: A systems approach to concurrent engineering and ergonomics, Taylor & Francis.

- General description from Assembly Magazine: http://www.assemblymag.com/CDA/Articles/Feature_Article/BNP_GUID_9-5-2006_A_10000000000000059386

Design for Maintainability (DfM): DfM functions similarly to DfA, but emphasizing ease of manufacturability to reduce time-to-market and decrease costs (See Helander & Nagamachi, 1992).

- NASA: http://msis.jsc.nasa.gov/sections/section12.htm

NEW

FaroArm: The FaroArm is a fully articulated, six-axis device that can sense with high resolution the location of the tip of the wand in three dimensional space, once a zero-point has been determined. When used in conjunction with the company's proprietary software, AnthroCAM, the FaroArm can store the location of a large number of discrete points on any surface. The locations of measured points can then be compared to corresponding points in a CAD model or on a prototype of the actual product. (Charlton and O'Brian 2002).

- Faro: http://www.faro.com/default.aspx?ct=us

Kansei Engineering: More an approach than a tool this method focuses on designing products according to the users´ feelings and impressions. This approach has potential to be adapted to different 'users' of the work system. (see www.ikp.liu.se/kansei or (Nagamachi, 2002).

- General description from Linköping University: http://www.ikp.liu.se/kansei/wike.html

NEW

'Mean Time to Repair' Prediction (MTTR): MTTR is a widely used measure that calculates the time required to perform a given corrective maintenance action. This prediction tool can estimate the duration of a maintenance activity in the event of a system failure. It is also related to other maintenance and reliability prediction tools used to calculate system-wide availability and downtime. (Dhillon, 33).

- Extensive listing from U of Maryland : http://www.enre.umd.edu/tools/maint.htm

Participatory Design: This approach actively involves end-users in the design process. While participatory design has more often been applied to human-computer interaction, it has been successfully incorporated into ergonomic interventions and other design areas as well.

- General description from 'Computer Professionals for Social Responsibility': http://www.cpsr.org/issues/pd/introInfo

Haimes, M. C. & Carayon, P. (1998) Theory and practice for the implementation of 'in-house' continuous improvement participatory ergonomic programs. Applied Ergonomics, 29, 461-472

Imada, A. S. (1991) The Rationale and Tools of Participatory Ergonomics. Participatory Ergonomics, Edited by K. Noro and A.S. Imada. Taylor & Francis, London, 30 - 49 Number of Reference(s) 65

Noro, K. and A. S. Imada (1991). Participatory Ergonomics. London, Taylor & Francis

Vink, P., Urlings, I. J. M. & Van der Molen, H. F. (1997) A participatory ergonomics approach to redesign work of scaffolders. Safety Science, 26, 75-85

NEW

Photoproto: Photoproto, from Altia Inc, enables graphics and interface designers to transform Adobe Photoshop files into fully interactive interfaces. This enables high-fidelity user testing, facilitates team feedback sessions and aids requirements capture. Programming is not required.

- Altia: http://www.altia.com/

Quality Function Deployment (QFD): QFD is a comprehensive planning technique that translates 'the voice of the customer' into precise technical language via a QFD matrix and team-based decision-making activities. The technique integrates human factors considerations early into the design process. Based on the 'house of quality' methodology, QFD supports a balanced approach that prioritizes attributes and weighs trade-offs. Applicable in a wide variety of contexts from product design to software development. (Marsot, 2005)

- QFD Institute: http://www.qfdi.org/

NEW

Reliability-Centered Maintenance (RCM): Well maintained equipment can reduce loads on operators and, in turn, lower risks of musculoskeletal disorders. Reliability-centered maintenance (RCM) systematically identifies the preventative maintenance tasks required to sustain, in the most cost-effective manner possible, the maximum level of reliability and safety that can be expected from a product when it receives effective maintenance. (Dhillon, 161)

- Detailed RCM info from the 'Whole Building Design Guide': http://www.wbdg.org/design/rcm.php

Spiral Lifecycle Model: Used largely for interactive devices, the spiral model incorporates risk analysis and prototyping into an iterative framework that allows ideas and progress to be repeatedly checked and evaluated. The spiral model encourages alternatives to be considered, and steps in which problems or potential problems are encountered to be re-addressed. (Barry Boehm 1988)

Chapter

4

Tools for Work System Design

The design stages are where most decisions influencing HF in the workplace are made. This ranges from large scale decisions about pay systems and facility layout to minor decisions about the work-station layout and the type of power tool to provide. One problem conducting HF assessments at this stage is that some information regarding loads, frequencies or timings does not necessarily become apparent until later choices are made. Nevertheless, it is possible to make some determinations of the effects of two different options, for example, using modeling tools such as discrete event simulation (DES) or digital human modeling (DHM).

These are texts that discuss this stage of design:

> Boothroyd, G., Dewhurst, P. And Knight, W., 2002, Product Design for Manufacture and Assembly (New York: Marcel Dekker).
>
> Helander, M. and Nagamachi, M. (1992) Design for Manufacturability: A systems approach to concurrent engineering and ergonomics, Taylor & Francis.

Discrete Event Simulation

A number of different discrete event (flow) simulation tools exist on the market. These can be used to assess human factors in terms of time utilised for different activities in the system and can also be used to test how the system performs under different work organisation strategies (Neumann & Medbo, 2005). Flow simulation can also be used in combination with human-biomechanical simulation (or other tools) to predict loading with different configurations (Neumann & Kazmierczak, 2005). Many of these packages are made by the same companies that make human modeling software and/or other types of manufacturing information systems (MIS).

Arena

- Rockwell Automation: http://www.arenasimulation.com/

Delmia

- http://www.delmia.com/

microSAINT

- http://www.maad.com/index.pl/micro_saint

Simul8: A simple graphically oriented package.

- http://www.simul8.com/

Tecnomatrix

- http://www.ugs.com/en_us/products/tecnomatix/index.shtml

Others? Submit to: pneumann@ryerson.ca

For a more complete list, and evaluation review, of available simulation packages see:

- The excellent simulation software survey from the OR/MS journal: http://www.lionhrtpub.com/orms/surveys/Simulation/Simulation.html

- Institute for Operations Research and Management Science (INFORMS).: http://www.informs.org/

Digital Human Models

Digital Human Models, or computer mannequins, are computer programs that can allow the determination of postures, loads, and in more advanced models calculate reach, fit and field of vision of a simulated 'human' on the computer. These tools are very useful as you can simulate the task demands long before a workstation is built. We have split this category into 'simple' and 'complex' models based on price and features.

Simple Models

These models are generally less expensive and simpler to use. They may be 2 or 3 dimensional and may even consider repeated or cumulative loading as part of the assessment. These are good tools both in design stages and also to quantify loading of existing systems to help identify areas for improvement and quantify the extent of load reduction in a particular situation. These tools are a kind of 'Swiss army knife' of tools allowing relatively sophisticated loading analysis very quickly and at low cost.

3D SSPP: The University of Michigan's famous 3D Static Strength Prediction Program allows fast determination of 3D loads for specific work actions .

- http://www.engin.umich.edu/dept/ioe/3DSSPP/

4D WATBAK: A simple model from the University of Waterloo that allows modelling of single work activites as well as calculating cumulative load over a full shift (hence the 'fourth', time, dimension). Both indicators have been risk calibrated in epidemiological research (Neumann et al., 1999; Norman et al., 1998).

- www.ahs.uwaterloo.ca/~escs

BakPak: University of Windsor model - predicts spinal loads based on reach location inputs.

- Contact: jpotvin@uwindsor.ca

Complex Models

'Complex' computer models include higher-end products designed to allow 3D modeling of humans in a 3D environment such as CAD. For a complete discussion of the capabilities and utility of these tools check out works by Sundin for practitioners and researchers (A. Sundin, 2001; A. Sundin et al., 2004; A Sundin & Cyrén, 1998; A. Sundin & Sjöberg, 2004). These tools are a must if field of view is of interest and are great if you have already created a CAD layout that you want to test for HF suitability.

Boeing Human Modeling System (BHMS):. (Delleman, Haslegrave et al. 2004)

- http://www.boeing.com/assocproducts/hms/

eMHuman

- http://www.ugs.com/en_us/products/tecnomatix/

ENVISION/ERGO

- http://www.delmia.com/

ERGOMan

- http://www.delmia.com/

NEW

InterPOSTURE: (InterAction of Bath Ltd.)

- http://www.interactionofbath.com/products/InterPOSTURE.shtml

Jack

- http://www.ugs.com/en_us/products/tecnomatix/

- http://www.motionanalysis.com/applications/industrial/virtualdesign/jack.html

ManneQuinPRO and HumanCAD

- http://www.nexgenergo.com/ergonomics/mqpro.html

Ramsis

- http://www.human-solutions.com/automotive_industry/ramsis_en.php

SAFEWORK

- http://www.safework.com/

Other Design Tools

These tools span a range of design problems, from workload balancing in assembly to cognitive or activity based assessments aiming to prevent cognitive overload and ensure good system performance. This includes some hybridized production tools integrating HF into 'MTM' style standard motion time systems and 'Lean' style value-stream mapping; tools that aim to slip human factors aspects into widely used engineering methods.

NEW

Action-Information Analysis: Elaborates each function or action in functional flow or decision-action diagram by identifying the information that is needed for each action or decision to occur. This analysis is often supplemented with sources of data, potential problems, and error- or accident-inducing features associated with each function or action (Chapanis 1996)

NEW

Activity Analysis: Used in the early phases of development to determine the activities that occur, and how often the activities are performed through observation. The frequency and duration of tasks are observed and recorded on a pre-constructed table, then translated to bar graph form. This method determines time allocation to each activity, "time and sequence workers perform the parts of his or her job" (p.141), and unplanned activities that occur (Nemeth 2004).

Decision-Action Analysis: A method of identifying and depicting the sequence of functions or actions that must be performed by a system containing decisions that can be phrased as questions with binary (yes/no) choice alternatives (Chapanis 1996).

NEW

Distributed Cognition Analysis: Distributed cognition describes what happens in a cognitive system in terms of how information is represented and re-represented as it moves across individuals and through the array of artifacts that are used (e.g., maps, instrument readings, scribbles, spoken word) during activities. The distributed cognition analysis helps identify the problems, breakdowns, and concomitant problem-solving processes that emerge to deal with them.

ERGONOVA: Ergonomics addition to the classic lean production 'value stream mapping' tool for production system improvement (Jarebrant et al., 2004).

ErgoSAM: An ergonomic add-on for the Swedish SAM method for standard time allocations (which is a common job planning tool, an MTM system). Provides red-yellow-green determination based on the engineer's determination of task requirements (Laring et al., 2005; Laring et al., 2002). Ergonomics addition to the classic 'value stream mapping' tool for production system improvement (Jarebrant et al., 2004).

Failure Modes and Effects Analysis (FMEA): Failure Mode Effect Analysis; a common risk analysis tool that has been adapted to include ergonomics aspects in product and production process development (Munck-Ulfsfält, 2004). "Used to examine the potential for the concept under development to fail" (p.229) in a table format, accounting for both hardware / software failure and human erroneous acts. A "top-down" FMEA reviews all major components of a product and breaks them into parts to speculate what might go wrong with each; a "bottom-up" FMEA reviews all individual parts to speculate what might go wrong with each component" (p.229). "Specifications for the product design can be adjusted to eliminate options that might cause dysfunction, and records are "evidence that the producer was not negligent in development efforts for possible future use in legal investigations" (p.233) (Nemeth 2004).

- American Society for Quality: http://www.asq.org/learn-about-quality/process-analysis-tools/overview/fmea.html

NEW

Flow Analysis: Used "to analyze the nature and sequence of events in a product or process" through a "detailed examination of the progressive travel of either personnel or material from place to place and/or from operation to operation" (p.164). "The final version of the information flow diagram depicts the flow of action and information throughout a current or proposed product" or process (p.171) through visual representation (Nemeth 2004).

Chapter 5

Tools for Work System Evaluation

At this stage the work system exists and can be observed directly (as opposed to via CAD drawings or mock-ups). Most classical 'ergonomics tools', such as checklists, have been designed to apply to this level. Indeed almost all tools can be used in real working systems. There are many, many checklists 'out there' and this list has certainly missed some. Some extra time on a computer search engine may help you find one that is tailored to your circumstance (then tell us about it!). Here, we list some of the best known tools.

Operator Physical Risk

Physical risk factors are often seen as the dominant focus for ergonomics. Indeed in Swedish the word 'Ergonomi' is synonymous with 'physical loading ergonomics' and is not seen to include other aspects of the work environment like cognitive load and psychosocial conditions. As the reader can see there are many, many tools for assessing physical load in the workplace. This is good and important, but the reader should remember that, when it comes to sources of musculoskeletal risk, psychosocial factors account for almost as much risk as do the physical factors. Despite our efforts to collect the bounty of physical load tools we are aware of many tools, particularly commercial software, that has not made it to this list – please let us know if you favorite tool is missing. These are some of the best known and widely used tools for assessing physical hazards in the workplace.

Checklists

NEW

ACCGIH TLVs: The information in this user-friendly, pocket-sized publication is used worldwide as a guide for evaluation and control of workplace exposures to chemical substances and physical agents. Threshold Limit Value (TLV®) occupational exposure guidelines are recommended for more than 700 chemical substances and physical agents. (David, Woods et al. 2008)(David 2005 ; pg 193)

- ACGIH: http://www.acgih.org/store/ProductDetail.cfm?id=1910

'Arbetplatsprovaren': A Swedish language, internet-based survey of physical and psychosocial aspects of the workplace.

- http://www.tcodevelopment.com/

'Arbetsmiljön i skolan': A Swedish language checklist tool for improving school work environments.

- http://www.arbetslivsinstitutet.se/en/

NEW

Cumulative Trauma Disorder – Risk Assessment (CTD-RAM): Upper limb assessment tool for predicting injury incidence rates. This assessment model predicts injury incidence rates and assesses job risk. It further quantifies risk factors by strength, fatigue, and posture. The CTD-RAM specifies acceptable limits on work design for a given individual.(Seth, Weston et al. 1999)

NEW

ErgoIntelligence & Ergomaster: Software tools implementing a number of different checklist tools.

- http://www.nexgenergo.com/

NEW

ErgoEquations (Online Ergonomic Tools - Office Solutions): See Online ergonomic assessment tool for the office. Contains an ergonomic analysis for musculoskeletal complaints, including the Discomfort survey, which assesses discomfort levels before and after implementing ergonomic solutions to document effectiveness; employee training; and ergonomic program documentation and planning.

- ErgoEquations: http://ergoequations.com/info/office_solutions.html

Ergonomiska Checklista Datorarbete: A simple checklist for evaluation of computer workplaces.

- www.amm.se/fhvmetodik

Ergonomitermometer: A Swedish language tool using a 'thermometer' metaphor to help assess risk levels.

- This site contains a number of other 'work environment' checklists adapted to various sectors: http://www.prevent.se/in_english/default.asp

NEW

ISO/TS 20646-1: A procedure for reducing work-related musculoskeletal disorders including a risk assessment checklist. The checklist considers lifting, carrying, and work requiring high physical force.(20646-1:1004(E). 2004)

- International Organization for Standardization: http://www.iso.org/iso/iso_catalogue/catalogue_tc/catalogue_detail.htm?csnumber=35501

NEW

Job Hazard Pro (Production Technology Engineering and Management Services): Evaluates potentially harmful situations in the plant or office using REBA, the Strain Index, the NIOSH equation, RULA (please see the index for references to these), and a VDT Workstation Checklist.

- Job Hazard Pro: http://www.protech-ie.com/jhazpro.htm

Keyserling Checklist: A classic, simple, risk factor checklist easily adapted to users' needs (Keyserling et al., 1991).

- Scientific Commons: http://en.scientificcommons.org/855919

Manual Handling Assessment Chart (MAC): Like the NIOSH equation this allows easy assessment of MMH tasks.

- U.K. Health and Safety Executive: http://www.hse.gov.uk/msd/mac/

NEW

Manual Handling Guidance: Checklists for task, equipment, environment and individual risk factors. The Manual Handling Guidance checklists can be used to identify risk factors for manual handling. (David 2005;pg193)

Manual Tasks Risk Assessment Tool (ManTRA): A checklist from the University of Queensland.

- Cornell University Ergonomics Web: http://ergo.human.cornell.edu/cumantra2.htm

NIOSH Survey: A musculoskeletal checklist by the US NIOSH (Stanton et al., 2004). (see

- U.S. Dept of Health and Human Services (CDC): http://www.cdc.gov/niosh/

OCRA: A short checklist-based index for assessing risk due to repetitive movements (Grieco 1998; Occhipinti 1998; Stanton, Hedge et al. 2004).

Ovako Working Posture Analysis System (OWAS): For rapid assessment of postural loads at work. (free software available) (Karhu, Kansi et al. 1977; Karhu, Harrktinen et al. 1981)

- Tampere University of Technology: http://turva1.me.tut.fi/owas/

PLIBEL: A 1-page checklist, mostly of physical risk factors, available in several different languages. This is a method for the identification of musculoskeletal stress factors and risks.(Kemmlert 1994; Kemmlert 1995; Stanton, Hedge et al. 2004)

Quick Exposure Checklist (QEC): For assessing risk factors for work-related musculoskeletal disorders (Stanton, Hedge et al. 2004; David, Woods et al. 2008)

- QEC: http://www.sunderland.ac.uk/~ts0gli/QEC.html

Rapid Entire Body Assessment Tool (REBA): Similar to RULA but with a whole body focus(Hignett and McAtamney 2000; Stanton, Hedge et al. 2004) .

- Cornell University Ergonomics Web: http://ergo.human.cornell.edu/cutools.html
- U.K. Health and Safety Executive: http://www.hse.gov.uk/msd/

Rapid Upper Limb Assessment Tool (RULA): Provides a 'score' for upper limb demands by McAtamney and Corlett (McTamney & Corlett, 1994) see also (Stanton et al., 2004).

- Cornell University Ergonomics Web: http://ergo.human.cornell.edu/cutools.html
- U.K. Health and Safety Executive: http://www.hse.gov.uk/msd/

Risk Filter: Also from the UK Health & Safety Executive, this two stage tool focuses on upper limb MSD risk.

- www.hse.gov.uk/msd/risk.htm

Strain Index: Combines time, repetition, load, and posture into a single index focused on hand/wrist load (Szabo and King 2000; Stanton, Hedge et al. 2004)

Work Environment Survey Tool (WEST): Provides both traditional ergonomic and occupational hygiene analysis possibilities. From the Swedish Industrial Research and Development Corp.

- IVF Industrial R&D: http://www.ivf.se/upload/pdf-filer/Produkter_tjanster/WEST-Eng.pdf

Questionnaires

Dutch Musculoskeletal Questionnaire (DMQ) (Hildebrandt, Bongers et al. 2001; Stanton, Hedge et al. 2004)

- Hildebrandt thesis for TNO: http://www.tno.nl/downloads%5CProefschrift_Hildebrandt.pdf

Nordic Safety Questionnaire: A questionnaire tool from Scandinavian researchers with a safety-culture focus. (Kines, Lappalainen et al. 2005) (Contact: marianne.torner@amm.gu.se)

Risk Factor Questionnaire (RFQ): A 25-item questionnaire with a focus on risk factors for low back pain (Halpern, Hiebert et al. 2001)

Hardware Tools and Instruments

Many retailers sell ergonomic instrumentation; here's just one:

- Nexgen Ergonomics: http://www.nexgenergo.com/

Counter: A handheld counting tool that is helpful when counting repetition rates or parts for estimating total loading (available at your hardware store).

Data Loggers: Advanced data collection system for measuring EMG or posture while working. (Hansson, Asterland et al. 2003)

Force Gauge: Another classic tool; fish-hook type scales are cheapest but a push-pull gauge can be more versatile for measuring forces other than lifting. Multiple manufacturers exist.

Goniometer: A device that is helpful for measuring angles on a person.

Light Meters: Here again there are many manufacturers of these easy to use devices. Lack of light may lead to errors and quality deficits. It may also cause people to adopt awkward neck postures as they try to improve their vision.

Lumbar Motion Monitor: A device for tracking back postures in 3dimensions at work, development headed by Marras at Ohio State. (Marras, Lavender et al. 1995; Stanton, Hedge et al. 2004)

MEGA Electronics: A commercial system for measuring EMG or posture while working.

- Mega Electronics: http://www.meltd.fi/

Stopwatch: Time remains an important aspect of biomechanical exposures.

Synchronised Exposure and Image Presentation (SEIP): A tool allowing the presentation of video recordings and synchronised load/force/EMG measurements on a computer screen (Forsman, Sandsjö et al. 1999). (Contact: mikael.forsman@niwl.se)

Tape Measure: A classic but useful tool for reach & fit measures.

Vibration & Sound Meters: There are many on the market, make sure your tool complies to the latest standards that you wish to conform to. This inventory will not go into further details of available equipment.

Software Tools

ALBA: A tool for evaluation of anthropometric design, biomechanical loads and lifting. In Swedish.

- Linköpings University: http://www.ikp.liu.se/iav/Education/TMIA21/index.asp

BUMS (Belastningsergonomisk UtvärderingsMall Saab): An ergonomic evaluation tool developed by Saab, originally as a checklist, then integrated into IGRIP geometric simulation software (for info contact Ingrid Svensson or Karin Bergenfeldt Phone +46 520- 78457 ingrid.svensson@se.saab.com)

ERGOMIX: A method for integrating images of real operators with CAD-drawings to evaluate workstation layout (de Looze, van Rhin et al. 2003)

ERGOWATCH: A computerised ergonomics 'toolbox' including the Watbak biomechanical model, NIOSH equation and a job demands / worker capabilities analysis tool. From the University of Waterloo .

- University of Waterloo: http://ergonomics.uwaterloo.ca/rwtools.html

Flexible Interface Technology (FIT): A PDA-based tool for the observation of work tasks. (Held, Bruesch et al. 1999; Held 2000)

HARBO: A simple computer aided observation method for recording work postures. (Wiktorin, Mortimer et al. 1995)

Job Evaluator Toolbox (JET): A commercial package from ErgoWeb collecting a number tools in one repository. Used for identification and control of ergonomic concerns in industrial environments. Includes 2D static strength biomechanical methods, revised lifting equation (1991 and 198), Liberty Mutual, metabolic energy expenditure method, performance-oriented checklist method. Also includes educational and background material such as principles of ergonomics, basic anthropometry, survey forms, and hazard identification, evaluation and control methods.

- ErgoWeb: http://www.ergoweb.com/ergobuyer/index.cfm?fuseaction=product.display&Product_ID=84

Multimedia Video Task Analysis (MVTA): Multimedia Video Task Analysis tool for analysing video sequences in terms of postures and task performance. Developed at the University of Wisconson-Madison and available commercially.

- University of Wisconsin: http://mvta.engr.wisc.edu/
- Nexgen Ergonomics: http://www.nexgenergo.com/

Observer XT: An advanced video analysis tool suitable for task analysis and usability evaluation, allows PDA based assessment or integration of biophysical signals (force, EMG etc.).

- Noldus: http://www.noldus.com/site/nav10000

Portable Ergonomics Observation (PEO): Method for computer supported field observation, developed in Sweden. (Fransson-Hall, Hägg et al. 1993; Fransson-Hall, Gloria et al. 1995)

- http://www.arbetslivsinstitutet.se/

Posture Program: A relatively simple video-based approach, allowing quantification of trunk and arm postures and velocities during work. (Neumann, Wells et al. 2001)(Research prototype, now easily reproduced)

VIDAR/PSIDAR: A video-based system allowing employees to rate both physical (VIDAR) and psychosocial (PSIDAR) working environment at chosen points in time from the video. (Kadefors and Forsman 2000; Johansson Hanse and Forsman 2001) (Contact mikael.forsman@ki.sem)

WISER Risk: Cadmus Solutions Ltd. A software tool that supports the assessment and management of risks associated with workplace activities. Helps to prepare assessments of workplace activities, hazards and controls; communicate the risk assessment for personnel doing the job; and readily revise and update assessments to capture changes and improvements.

- Wiser Risk: http://www.wiser-risk.com/wiserprod.asp

Operator Psychosocial / Stress Risk

Psychosocial factors refer to the employee's perception (the psycho part) of the social conditions in the workplace (the social part). This refers to workplace aspects such as workload, autonomy, decision attitude, control over work, and supervisor or coworker support. Poor psychosocial conditions have long been associated with 'stress' type responses such as heart disease, gastrointestinal problems as well as musculoskeletal disorders such as shoulder/neck or back pain. Indeed in studies looking at both factors psychosocial factors account for almost as much injury variance as the physical risk factors (Kerr, Frank et al. 2001). It is most common to use questionnaires to quantify worker perceptions, but some checklists relating workplace features to psychosocial factors do appear to be emerging

Checklists

'Arbetplatsprovaren': A Swedish language, internet-based survey of physical and psychosocial aspects of the workplace.

- TCP Development: http://www.tcodevelopment.com/

Questionnaires

Copenhagen Psychosocial Questionnaire (CopSoq): Developed by the Danish 'Arbetsmiljöinstitutet', this instrument includes 3 levels of detail for researchers, consultants, and companies. (Second version to be released soon.)

- Danish National Research Centre for the Working Environment: http://www.arbejdsmiljoforskning.dk/?lang=en
- Danish National Institute of Occupational Health: http://hesa.etui-rehs.org/uk/newsletter/files/2002-19p45-47.pdf

Job Content Instrument: Perhaps the best-known psychosocial questionnaire. Based on the 'Demand-Control' model by Karasek and later extended to include a 'Support' dimension (Karasek 1979; Karasek and Theorell 1990; Karasek, Brisson et al. 1998)

- University of Massachusetts: http://www.jcqcenter.org/

PAK ('psykologisk arbetsmiljökartläggning'): a Swedish instrument for psychsocial work surveys (Rubenowitz 1987; Rubenowitz 1991).

'Psykisk Arbejdsmiljø': A Danish tool for psychological work environment evaluation, also from AMI , with long and short forms available on the web.

- Danish National Research Centre for the Working Environment: http://www.arbejdsmiljoforskning.dk/?lang=en

QPS Nordic & QPS34+: A 123 question (34 question short form) instrument on stressors in the working environment..

- User's guide: http://www.norden.org/pub/velfaerd/arbetsmiljo/sk/TN2000603.pdf

Stress-Energi: A Swedish psychosocial questionnaire focussing on 'stress' and 'energy' related consequences of work. (Kjellberg and Iwanowski 1989)

NEW

University of Wisconsin Office Worker Survey (OWS): A questionnaire developed to measure psychosocial work factors in office/computer work.

Operator Mental Workload

Psychophysical Ratings: A rating made by someone of her own experience ('psycho') of loading ('physical'). A versatile approach pioneered by Borg and broadly applied in various contexts. (Borg 1990)

Psychophysical Tables: An outgrowth of psychophysical ratings, these tables usually provide load or rate limits for material handling based on operators' perception of how much load they believe they can handle under varying conditions of load, frequency, position etc.. Sometimes called 'Snook' Tables after the innovator of this approach. A number of studies have been conducted by different researchers to provide load limits under different circumstances (Snook and Cirello 1991; Dahalan and Fernandez 1993; Potvin, Chiang et al. 2000). These tables are sometimes implemented in software versions (e.g. Ergowatch).

NEW

Mital et. al Tables: Derived using data from Snook and Ciriello, the Mital Tables provide a set of maximum acceptable weight limits adjusted for various biomechanical, physiological, and epidemiological criteria. The Mital tables also take into account several other factors impacting maximum acceptable weight of industrial workers including: working duration, limited headroom, asymmetrical lifting, load asymmetry, couplings, load placement clearance, and heat stress.

Mital A, Nicholson AS and Ayoub, M.M. 1997 A Guide to Manual Materials Handling (2nd Edition): Taylor & Francis

Other System Characteristics

NEW

AIRSWEB: (Safety Software Ltd.) AIRSWEB is an entirely Internet-based, with an Intranet-based option software application that can manage the entire Health, Safety & Environment management programme. Includes the following modules: Accident and Incident Recording and Reporting, Action Tracking, Cost Tracking, Monthly Statistics, and Site Visits/Audits. Features a module, which facilitates the recording and analysis of the causation factors behind accidents, incidents and near misses.

- Safety Software Ltd.: http://www.safety-software.co.uk/airsweb/index.htm

NEW

ErgoCoach™: A subdivision of ErgoEnterprise™, an anti-Injury ergonomic software for preventing repetitive stress injuries (RSI's) in the small business, "small office home office" SOHO, and home markets.

- Magnitude: http://www.magnitude.com/ergocoachmoredescription.asp

NEW

Management Oversight and Risk Tree Analysis (MORT): Incorporates a logic tree approach, similar to the fault tree analysis diagram, to investigate accidents and evaluate safety programs. Focusing on one system at a time, each logic tree portrays "lines of responsibility, barriers to unwanted energy, events, priority gates and assumed risks as well as controls, such as codes, standards, regulations and plans" (p.149). The logic tree can be used "to demonstrate a safety program that makes the best use of hardware/software, personnel and facilities" (p.151) (Nemeth 2004).

- FAA's Workbench Tools website: http://www2.hf.faa.gov/workbenchtools/default.aspx?rPage=Tooldetails&toolID=151

NEW

Hazard Analysis Method: This powerful tool determines the safety requirements for people, procedures, and equipment used in testing, operations, maintenance, and logistic support. This method also determines the compliance of system and equipment with specified safety requirements and criteria. (Dhillon, 127).

- FAA System Safety Handbook: http://www.faa.gov/library/manuals/aviation/risk_management/ss_handbook/

NEW

MSD Hazard Identification Tool Patrick, this section ok?

Option 1: Used to identify jobs or tasks that have MSD hazards. The tool graphically displays risk-associated actions divided into categories of MSD hazards (i.e. awkward postures, manual material handling, gripping and other), which are checked off if they exist. The tool also helps to identify if the hazard involves force, repetition, awkward postures and/or long durations.

Option 2 shares the same purpose of identifying jobs or tasks that have MSD hazards as Option 1. However, Option 2 is in the form of a checklist of MSD Hazards, in categories of gripping, force, repetition, posture and other. Each category lists specific actions to be identified.

Computer Workstation: Used to identify MSD hazards within the computer workstation. This tool is formed as a graphic and description checklist of hazardous tasks categorized by area of computer workstation, and provides information for corrective options.

NEW

Office Health and Safety: Training and assessment software designed to identify office workers who are exposed to any health and safety risks. Includes a computerized risk assessment questionnaire incorporating a health symptom checklist, general office health and safety checklist, fire and first aid checklist, display screen equipment checklist, manual handling checklist, electricity checklist, COSHH checklists.

- Performance Support International: http://www.psi2000.com/products/office/off_lt0401.pdf

NEW

Sample Prioritization Method and Worksheet: This tool helps workplaces prioritize their hazard identification findings in order to determine which hazards require the most attention. Using the Sample Prioritization Method and Worksheet can allow an organization to properly manage each hazard effectively and efficiently.

- Canadian Industrial Accident Prevention Association (draft version): http://www.iapa.ca/documents/MSD_2006%20_Prevention_Toolbox.pdf

NEW

Washington State Caution Zone Checklist: Used to determine if a typical work activity exposes workers to MSD hazards of sufficient magnitude and duration. The checklist guides users to place the work activity into a 'caution zone' – "jobs that have a 'sufficient degree of risk' so that workers performing these jobs should be provided with training related to MSD hazards, that further risk assessment should be done, and/or controls implemented" (p.103).

- Canadian Industrial Accident Prevention Association (draft version): http://www.iapa.ca/documents/MSD_2006%20_Prevention_Toolbox.pdf
- Dept of Labor and Industries: http://www.lni.wa.gov/Safety/Topics/Ergonomics/ServicesResources/Tools/default.asp

NEW

Washington State Hazard Zone Checklist: Used to perform further risk assessment on jobs that have been identified as 'caution zone' jobs. The checklist criteria are designed at levels such that the majority of workers would be at a high risk of developing a work-related MSD, if exposed on a regular basis.

- Dept of Labor and Industries: http://www.lni.wa.gov/Safety/Topics/Ergonomics/ServicesResources/Tools/default.asp

Chapter

6

System Outputs

This is the level of consequences – the results emerging from the running work system. Indicators here pose 'lagging' indicators of performance that has occurred, rather than predictive 'Leading' indicators available earlier in the process. While there may be some 'blurr' between psychosocial factors (seen in this inventory as a risk factor 'inside' the system, we nevertheless focus here on tools that can help assess the performance of the system in human terms including especially health outcomes such a disability, and economic outcomes that can be calculated based on known performance. Note that the cost calculation tools include models that might also be useful to understand the cost consequences of a design change under consideration

Health Status and Wellbeing

Fatigue, Motivation, Satisfaction, etc.

Health and Work Performance Questionnaire (HPQ): HPQ is a self-report instrument designed to estimate the workplace costs of health problems in terms of reduced job performance, sickness absence, and work-related accidents/injuries. (Kessler, Barber et al. 2003)

World Health Organization: http://www.hcp.med.harvard.edu/hpq/

Job Characteristics Model (JCM): JCM deals with "internal work motivation", whereby the presence of certain job attributes motivates workers. The more effort expended by workers on their jobs, the more motivated they will become creating a self-perpetuating cycle of motivation. The JCM proposes relationships between three classes of variables: job dimensions (CJDs), psychological states (CPSs); and outcomes (AOs).

Job Diagnostic Survey (JDS): An instrument designed to measure the following three classes of variables: (1) The objective characteristics of jobs, particularly the degree to which jobs are designed so that they enhance the internal work motivation and the job satisfaction of people who do them; (2) The personal affective reactions of individuals to their jobs and to the broader work setting; and (3) the readiness of individuals to respond positively to 'enriched' jobs-i.e., jobs which have measured potential for generating internal work motivation. (Hackman and Oldham 1974)

Job Satisfaction Tool: (Spector, 1997) One example found is a three question item in (Pousette & Johansson Hanse, 2002).

Minnesota Satisfaction Questionnaire (MSQ): The Minnesota Satisfaction Questionnaire (MSQ) is designed to measure an employee's satisfaction with his or her job. Three forms are available: two long forms (1977 version and 1967 version) and a short form. The MSQ provides more specific information on the aspects of a job that an individual finds rewarding than do more general measures of job satisfaction.(Weiss, Dawis et al. 1978)

NASA-TLX: Task Load Index: This is an assessment of subjectively experienced work load (Hart and Staveland, 1988). NASA TLX assesses the workload of each task on a 21-gradation scale of high, medium and low estimates, through questions regarding mental demand, physical demand, temporal demand, performance, effort and frustration. "Because of the length of evaluations, TLX is often used following task performance while participants watch a video recording of the event" (p.240). (Nemeth 2004)

Swedish Occupational Fatigue Inventory (SOFI): Provides a detailed reporting of employees perceived tiredness at the end of a working day (Elisabeth Åhsberg, 1998; E. Åhsberg et al., 2000; Åsberg, 2000). (report available from

www.arbetstlivsinstitutet.se

Pain, Disability & Symptom Surveys

Comfort Survey™: This is a self-paced questionnaire module used to gather information about factors that affect comfort at the workstation.

Disabilities of the Arms Shoulder and Hands (DASH): A diagnostic questionnaire from the Institute for Work & Health. (see www.iwh.on.ca)

- Institute for Work & Health: http://www.iwh.on.ca/

Discomfort Notes™: This includes optional Symptom Surveys to provide a musculoskeletal pictorial of the human body, to perform a necessary intervention assessment, corrective action and future monitoring.

NEW

Employee Discomfort Survey: This survey is used to identify and quantify musculoskeletal discomfort and pain felt by workers. The survey breaks the body into different regions and the worker is to rate the level of discomfort experienced within each region of the body on a scale from 0-10.

- Canadian Industrial Accident Prevention Association (draft version): http://www.iapa.ca/documents/MSD_2006%20_Prevention_Toolbox.pdf

NIOSH Survey: A musculoskeletal survey by the US NIOSH.

- US Dept of Health and Human Services: http://www.cdc.gov/niosh/

'Nordic' Symptom Questionnaire: A 'standardized' questionnaire that allows description of pain and disability for various body parts (Kuorinka et al., 1987). The tool has since been broadly adapted and applied in research. (for example: www.arbetslivsinstitutet.se)

NEW

Perceived Exertion Survey: This survey is used to estimate a worker's perception of job difficulty. This can be used before or after MSD concerns have been raised as a way to identify potential areas for improvement for any jobs within an organization. It breaks down the body into major segments and identifies which parts are most affected by a job task.

- Canadian Industrial Accident Prevention Association (draft version): http://www.iapa.ca/documents/MSD_2006%20_Prevention_Toolbox.pdf

SF-36, SF-12: Questionnaires (36 items & a less detailed 12 item version) on general health including physical and mental health (Roland & Morris, 1983; Ware et al., 1993).

Economic Assessments

Workability Model: A tool to help ergonomists and engineers evaluate the costs of disability and the financial benefits of an intervention. A basic version of the software is included in the book by Oxenburgh et al. (Oxenburgh et al., 2004).

PREVIA Model: A comprehensive model produced by a Swedish Company Health and Safety consulting company. (for information on this model please contact Bo Hansson [bo.hansson@ipf.se])

Chapter
7

Other Tools

This section is the ‘grab bag’ of tools that, although useful, didn’t fit directly in the framework as it is currently configured. Return to work, a new category of tools is a sufficiently important aspect of human factors that it seemed

Return-to-Work Tools

Tools for Modified Work: A process and checklist set supporting efforts of returning injured workers to the workplace with a focus on communications between the workplace and the care-giver. From the Quebec department of Public Health. (see www.santepub-mtl.qc.ca/omrt/tools.html)

Physical Demands Analysis: First published by the Ontario Ministry of Labour this general checklist covering a range of physical and mental workplace demands was intended to match injured or disabled employees to jobs using a functional capacities assessment of the employee. This tool is currently embedded in the ErgoWatch system (see Ch5 Work System Evaluation/Software Tools).

Miscellaneous Tools

Passports: Passports are a strategic employee involvement tool. The passport is a small booklet, the size of an actual passport, which lists a series of safety activities in which an employee may participate. Each passport has a specific focus or theme that promotes continuous improvement.

Index

Internet icon from http://htd.seesaa.net/category/2876167-1.html

References

Borg, G. (1990). "Psychophysical scaling with applications in physical work and the perception of exertion." Scand J Work Environ Health 16(Suppl 1): 55-8.

Braam, G. J. M. and E. J. Nijssen (2004). "Performance effects of using the Balanced Scorecard: a note on the Dutch experience." Long Range Planning 37(4): 335-349.

Chapanis, A. (1996). Human Factors in Systems Engineering. Toronto, John-Wiley & Sons.

Dahalan, J. B. and J. E. Fernandez (1993). "Psychophysical frequency for a gripping task." International Journal of Industrial Ergonomics 12(3): 219-230.

David, G., V. Woods, et al. (2008). "The development of the Quick Exposure Check (QEC) for assessing exposure to risk factors for work-related musculoskeletal disorders." Applied Ergonomics 39(1): 57-69.

de Looze, M. P., J. W. van Rhin, et al. (2003). "A participatory and integrative approach to improve productivity and ergonomics in assembly." Production Planning & Control 14(2): 174-181.

Delleman, N. J., C. M. Haslegrave, et al. (2004). Working Postures and Movements: Tools for Evaluation and Engineering. Boca Raton, CRC Press LLC.

Forsman, M., L. Sandsjö, et al. (1999). "Synchronized exposure and image presentation: Analysis of digital EMG and video recordings of work sequences." International Journal of Industrial Ergonomics 24(3): 261-272.

Fransson-Hall, C., R. Gloria, et al. (1995). "A portable ergonomic observation method (PEO) for computerised recording of postures and manual handling." Applied Ergonomics 26: 93-100.

Fransson-Hall, C., G. Hägg, et al. (1993). "Ryggont kan inte avföras som arbetsskada." Läkartidningen 90: 785-786.

Grieco, A. (1998). "Application of the concise exposure index (OCRA) to tasks involving repetitive movements of the upper limbs in a variety of manufacturing industries: preliminary validations." Ergonomics 41(9): 1347-1356.

Halpern, M., R. Hiebert, et al. (2001). "The test-retest reliability of a new occupational risk factor questionnaire for outcome studies of low back pain." Applied Ergonomics 32(1): 39-46.

Hansson, G. A., P. Asterland, et al. (2003). "Modular data logger system for physical workload measurements." Ergonomics 46(4): 407-15.

Held, J. (2000). Fitting the mental model: A new technique for computerised event recording. Engineering psychology and cognitive ergonomics. D. Harris. London, Asgate.

Held, J., M. Bruesch, et al. (1999). "The FIT-system: A new hand-held computer tool for ergonomic assessment." Medical & Biological Engineering & Computing 37(supl.2): 862-863.

Hignett, S. and L. McAtamney (2000). "Rapid Entire Body Assessment." Applied Ergonomics 31: 201-205.

Hildebrandt, V. H., P. M. Bongers, et al. (2001). "Dutch Musculoskeletal Questionnaire: description and basic qualities." Ergonomics 44(12): 1038-55.

Johansson Hanse, J. and M. Forsman (2001). "Identification and analysis of unsatisfactory pcychosocial work situations: a participatory approach employing video-computer interaction." Applied Ergonomics 32(1): 23-29.

Kadefors, R. and M. Forsman (2000). "Ergonomic evaluation of complex work: a participative approach employing video-computer interaction, exemplified in a study of order picking." International Journal of Industrial Ergonomics 25(4): 435-445.

Kaplan, R. S. and D. P. Norton (1992). "The Balanced Scorecard - measures that drive performance." Harvard Business Review 70(7/8): 172-180.

Kaplan, R. S. and D. P. Norton (1996). The Balanced Scorecard: translating strategy into action, McGraw Hill.

Karasek, R., C. Brisson, et al. (1998). "The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics." J Occup Health Psychol 3(4): 322-55.

Karasek, R. and T. Theorell (1990). Healthy Work. Stress Productivity, and Reconstruction of Working Life. New York, Basic Books Inc.

Karasek, R. A. (1979). "Job demands, job decisions latitude and mental strain: Implications for job redisign." Adm Science Quarterly 24: 285-307.

Karhu, O., R. Harrktinen, et al. (1981). "Observing working postures in industry: Examples of OWAS application." Applied Ergonomics 12(1): 13-17.

Karhu, O., P. Kansi, et al. (1977). "Correcting working postures in industry: A practical method for analysis." Applied Ergonomics 8(4): 199-201.

Kemmlert, K. (1994). PLIBEL hjälper dig att tala ur skägget. Sjukgymnasten: 21-23.

Kemmlert, K. (1995). "A method for identification of ergonomics hazards - PLIBEL." Applied Ergonomics 26(3): 199-211.

Kerr, M. S., J. W. Frank, et al. (2001). "Biomechanical and psychosocial risk factors for low back pain at work." Am J Public Health 91(7): 1069-75.

Kines, P., J. Lappalainen, et al. (2005). Safety climate dimensions for workplace interventions: the development of a Nordic questionnaire on occupational safety climate. 16th Nordic Conference on Safety, Gilleleje, Denmark.

Kjellberg, A. and S. Iwanowski (1989). Stress/Energi-formuläret: utveckling av en metod för skattning av sinnesstämning i arbetet. Stockholm, Arbetslivsinsititutet.

Marras, W. S., S. A. Lavender, et al. (1995). "Trunk motion and occupationally-realted low back disorder risk." Ergonomics 38(2): 377-410.

Nemeth, C. P. (2004). Human Factors Methods for Design. London, Taylor and Francis.

Neumann, W. P., R. P. Wells, et al. (2001). "Trunk posture: reliability, accuracy, and risk estimates for low back pain from a video based assessment method." International Journal of Industrial Ergonomics 28: 355-365.

Occhipinti, E. (1998). "OCRA: a concise index for the assessment of exposure to repetitive movements of the upper limbs." Ergonomics 41(9): 1290-1311.

Potvin, J. R., J. Chiang, et al. (2000). "A psychophysical study to determine acceptable limits for repetitive hand impact severity during automotive trim installation." International Journal of Industrial Ergonomics 26(6): 625-637.

Rubenowitz, S. (1987). Organisation, motivation och produktivitet. Människan i arbete. N. Lundgren, G. Luthman and K. Elgstrand. Stockholöm, Almqvist & Wiksell.

Rubenowitz, S. (1991). Arbetsorganisation och ledarskap. Människan i arbetslivet. Beteendevetenskaplig arbetsmiljöforskning. L. Lennerlöf. Stockholm, Allmämma förlaget: 140-157.

Snook, S. H. and V. M. Cirello (1991). "The design of manual handling tasks: revised tables of maximum acceptable weights and forces." Ergonomics 34(9): 1197-1213.

Stanton, N. A., A. Hedge, et al. (2004). Handbook of human factors and ergonomics methods. London, CRC Press.

Szabo, R. M. and K. J. King (2000). "Repetitive Stress Injury: Diagnosis or Self-Fulfilling Prohecy." The Journal of Bone and Joint Surgery 82(9): 1314-1322.

Wiktorin, C., M. Mortimer, et al. (1995). "HARBO, A simple computer aided observation method for recording work postures." Scand J Work Environ Health 21: 440-9.