The need for rapid, rigorous, assessment of manual handling tasks has resulted in the creation of researched based, validated, approaches/techniques. This introduction provides, for six ergonomic based techniques/"filters", a brief overview and sources from which extensive detail may be obtained. A good overview of various Musculoskeletal Disorders (MSDs) can be found at: http://www.hse.gov.uk/msd/index.htm while the european overview can be found at: https://osha.europa.eu/en. The TUC links material [http://www.tuc.org.uk/workplace/index.cfm?mins=124&minors=4&majorsubjectID=2] and the monthly “Risks” magazine (among other excellent materials) can be assessed (as a pdf) from here.

<table>
<thead>
<tr>
<th>Approach</th>
<th>Observations and key reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>MAC [Manual Handling Assessment Charts]</td>
<td>HSE (2003). Downloadable from <a href="http://www.hse.gov.uk">www.hse.gov.uk</a> where you will also find training materials as well as the 16 page .pdf file. The MAC introduction may be found at: <a href="http://www.hse.gov.uk/msd/mac/introduction.htm">http://www.hse.gov.uk/msd/mac/introduction.htm</a>. The main pdf download is fairly clear if printed in black &amp; white but ease of use does benefit from colour. Appendix 5 of MHOR (HSE2004a) is an introduction to MAC. This document is used by Factory Inspectors to arrive a quick and reliable decision as to the safety of most (but not all) manual handling tasks. Tapley (2002) outlines the reliability [<a href="http://www.hse.gov.uk/msd/mac/guidance01a">http://www.hse.gov.uk/msd/mac/guidance01a</a>] and Tapley and Buckle (2003) and Pinder (2003) contain an introductory academic justification of the technique and refers to additional sources.</td>
</tr>
<tr>
<td>MHOR [Manual Handling Operations Regulations]</td>
<td>The Health and Safety Executive’s “Manual Handling Operations Regulations” were established in 1992 and are now in their 3rd revision. They are the definitive legal tool, established as a Statutory Instruments and published with guidance [HSE 2004a]. Central to their operation is an image showing “guideline loads” linked to anthropometric landmarks. Each edition continues significant revisions so that the earlier editions should not be used for contemporary assessments. The Library contains paper copies. . A downloadable introductory guide is available at – <a href="http://www.hse.gov.uk/pubns/indg143.pdf">http://www.hse.gov.uk/pubns/indg143.pdf</a>. (HSE2004b) and a more general review can be found in Haslegrave and Corlett (2005).</td>
</tr>
<tr>
<td>NIOSH [National Institute for Occupational Safety and Health]</td>
<td>The Lifting equation (1991 revision) created by NIOSH is, broadly, the USA’s equivalent of the HSE but is based on numerical calculation and thus is more easily computerised. Further details can be found on the Centre for Disease Control homepage. [<a href="http://www.cdc.gov/niosh/docs/2007/pdfs/20007-13i">www.cdc.gov/niosh/docs/2007/pdfs/20007-13i</a>] A general review can be found in Haslegrave and Corlett (2005) while fuller and better details of this approach may also be found in Waters et al (1994). I can, on request, email the Excel spreadsheet I use, other versions can be found on the web. Eg <a href="http://www.ccohs.ca/oshanswers/ergonomics/niosh/calculating_rwl.html">http://www.ccohs.ca/oshanswers/ergonomics/niosh/calculating_rwl.html</a></td>
</tr>
<tr>
<td>OWAS [Ovako Working position Analysing System]</td>
<td>This posture recording scheme is popular, has been available for over 30 years, and has recently been converted to a computer package. For example, <a href="http://ergo.human.cornell.edu/gradprojects/cheese/cheese.html">http://ergo.human.cornell.edu/gradprojects/cheese/cheese.html</a> gives details of a research project using OWAS and NIOSH. Details can be found in Karhu et al (1977), Karhu et al (1981) and Corlett (2005).</td>
</tr>
<tr>
<td>RULA [Rapid Upper Limb Assessment]</td>
<td>This approach is a development of RULA which focused on the upper body only. [McAtamney &amp; Corlett (1993) &amp; Corlett (2005)] [The article is held by the library as a paper copy but the scoring chart (and brief notes) is also available as a .pdf download [<a href="http://www.ergonomics.co.uk/rula.html">http://www.ergonomics.co.uk/rula.html</a>]. This site provides a simple calculator for checking results, but not a page for manual calculation. The data collection, and postural definition forms are reproduced from page 9 in this document.]</td>
</tr>
<tr>
<td>REBA [Rapid Entire Body Assessment]</td>
<td>Hignett and McAtamney (2000) [The paper copy is held in the library but it is also available as a .pdf download from <a href="http://ergo.human.cornell.edu/ahREBA.html">http://ergo.human.cornell.edu/ahREBA.html</a>.] This site also has a link to a “30 day trial version &quot;of software that states it runs on “MS XP&quot;. See also Corlett (2005) and the adaptations/application proposed by Janowitz et al 2006.</td>
</tr>
</tbody>
</table>

In all cases, further references and worked examples/case studies have been published. Wilson and Corlett (2004) provide a comprehensive introduction to evaluation, from an ergonomic perspective. I shall now introduce/describe four (MAC, MHOR, NIOSH, RULA) of these approaches.
Summary of the numerical “guidelines” for manual handling (HSE 2004a)

“The filter is based partly on data in published scientific literature and partly on accumulated practical experience of assessing risks from manual handling. Its guideline figures are pragmatic, tried and tested; they are not based on precise formula. The intention is to set out an approximate boundary within the load is unlikely to create a risk of injury to warrant a detailed assessment.”

[Appendix 3, Para.5, p54 HSE 2004a]

There is no doubt that there is not a identifiable “safe” or “optimal” load for any specified task although it is clear some loads that will be more unsafe for some individuals than may be the case for other people. These guidelines are reasonable for ordinary people undertaking well considered tasks but if should be applied after consideration of all circumstances of the tasks and the people undertaking it.

The loads lifted, in competition, by highly trained individuals are not, in any way, applicable to the real world; the loads are, for example, rarely lowered down to the floor, dropping and standing back is preferable!

The title page of HSE(2004a) states:

“This guidance is issued by the Health and Safety Executive. Following the guidance is not compulsory and you are free to take other action. However, if you do follow the guidance you will normally be doing enough to comply with the law. Health and safety inspectors seek to secure compliance with the law and may refer to this guidance as illustrating good practice.”

The basic guidance is given as a diagram (Figure 1) and this forms the basis of data presented in Table 1 & 2.

Figure 1
A Reprint of Figure 22 in HSE (1998), (Figure 23 in HSE (2004a) contains identical data.)

At the end of Appendix 3 (para.30(HSE 2004a) the following is stated:

“Remember: The use of these guidelines does not affect the employer’s duty to avoid or reduce risk of injury where this is reasonably practicable. The guideline figures, therefore, should not be regarded as weight limits or approved figure for safe lifting. They are an aid to highlight where detailed risk assessments are most needed. Where doubt remains, a more detailed risk assessment should always be made.” (Original emphasis.)

The Manual Handling Operations Regulations(MHOR) 1992 (HSE 1992) were the first, legally established, adopted set of regulations to comprehensively control manual handling/lifting in UK workplaces. However, HSE 2003 contained many limitations of which the most important was the lack of guidance for women. The diagram in Appendix 1 (HSE 1992) gave guideline data that gave a ”reasonable level of protection for “around 95% of” employed males or females. The recommendation was made to reduce the guideline data by one third to give a similar level of protection (ie for 95% of the population) for “nearly all working women”.

The 3rd Edition of the HSE Guideline Loads (HSE 2004a) covers this, and other, weaknesses and suggests guideline loads for females, pushing, pulling etc. In all but one cases these levels are

1 Wikipedia gives world records (♂) for the “snatch” lift as 214kg (151 kg ♀) and “Clean and jerk” 263kg (181kg ♀) when the HSE would advise maxima of 10kg (7kg ♀) to head height, nothing above. [Details at: http://en.wikipedia.org/wiki/List_of_world_records_in_Olympic_weightlifting]
simple numerical rounding of the numbers that may be calculated from the guidance in the first edition. However, one important exception is the maximum female load that calculates to 16.8Kg but this has been, prudently, reduced to 16Kg. Below are further extracts from the current, 3rd edition.

“The Regulations set not specific requirements such as weight limits. The ergonomic view approach shoes clearly that such requirements are based on too simple a view of the problem and may lead to incorrect conclusions. Instead, an ergonomics assessment base on a range of relevant factor is used to determine the risk of injury and point the way to remedial action.”

[Para.17, p5 HSE 2004a – original emphasis.]

“Application of the guidelines will provide a reasonable level of protection to around 95% of working men and women. However, the guidelines should not be regarded as safe weight limits for lifting. There is no threshold below which manual handling operations may be regarded as ‘safe’. Even operations lying within the boundary mapped out by the guidelines should be avoided or made less demanding wherever it is reasonably practicable to do so.”

[Appendix 3, Para.6, p54 HSE 2004a]

“Identify if each activity being performed comes within the guideline and if there are other considerations to be taken into account …. Then make a final judgement of whether the task needs a full risk assessment. Remember you should be able to do this quickly – if not then a full risk assessment is required (see Appendix 4.)”

(Appendix 4 contains a checklist and guidance for its completion and HSE2004b is an introductory guide.)

[Appendix 3, Para.29, p59 HSE 2004a]

“basic guideline figures for lifting and lowering … are for relatively infrequent operations - up to approximately 30 operations per hour or one lift every 2 minutes …. As a rough guide”, the figures should be reduced by 30% where the operation is repeated once or twice per minute, by 50% where the operation is repeated around five to eight times per minute and by 80% where the operation is repeated more than about 12 times per minute.

[Appendix 3, Para.15, p56 HSE 2004a]

“As a rough guide”; the guideline figures should be reduced by 10% where the handler twists through 45° or more and by 20% where the handler twists through 90° or more, “viewed from the front”.

[Appendix 3, Paras.17/18, p56/7 HSE 2004a]

“The guideline figures for lifting and lowering apply to carrying operations where the load is: a) held against the body; b) carried no further than about 10M without resting....Where the load can be carried securely on the shoulder without first having to be lifted... the guideline figures can be applied to carrying distances in excess of 10M.”

[Appendix 3, Paras.20/21, p57 HSE 2004a]

“For pushing and pulling operations (whether the load is slid, rolled or supported on wheels) the guideline figures assume the force is applied with the hands, between knuckle and shoulder height. It is also assumed that the distance involved is not more that about 20M”. The guideline figure for starting or stopping a load is a force of about 20Kg (ie ~200N) for men and about 15Kg (ie ~150N) for women. The guideline figure for keeping the load in motion is a force of about 10Kg (ie ~100N) for men and about 7Kg (ie ~70N) for women.

[Appendix 3, Paras.23, p57 HSE 2004a]

MHOR is focused on individuals undertaking the task but often people work together. Approximate, the capability of a two person team is two thirds of the sum of their individual capabilities; and for three the capability is only half the sum of their individual capabilities. MAC (HSE 2003) contains more details but note that the limits for teams is not well researched or agreed. Grieco et al (1997), for example, proposes 0.85 of the combined capacity for a team of two or more working together; always in the same workplace. It is vital that there are sufficient handholds, space to manoeuvre and that the various team members to do not impede each other’s movement or vision. Steps, slopes, and any difference is strength and size will also severely reduce the lifting capacity available.

Conclusions

All approaches were created to deal with lifting by well trained and fit employees under generally good task and environmental conditions. There is assumed to be a high co-efficient of friction between shoe and floor. The shoe should also be “flat” and to be closely fitted to the foot – no, for example, flip flops!. The load is assumed to be inanimate and without any attribute that would necessitate special handling (unstable centre-of-gravity, toxic, spillable etc.

The HSE “filter” is best used as an initial screening and the conclusions from two (or more) techniques compared. If changes are proposed then the “after” analysis should suggest a lower risk than the “initial” situation. However, in most cases a more comprehensive investigation and evaluation will be beneficial. Overleaf, Guideline data (HSE 2004a) for two rates of working,
Table 1

Guideline loads for strength by height of lift for standing individuals.
Anthropometric data added to the Manual Handling Operations Regulations (MHOR) and Guidelines (HSE 2004a).


Guideline loads, “not limits”, for infrequent lifting (“up to approximately 30 operations per hour”) giving “reasonable protection for:"

<table>
<thead>
<tr>
<th>(Anthropometry in mm and shod nude(^2) (Pheasant 1984))</th>
<th>95% of males “Near”</th>
<th>95% of males “Far”</th>
<th>95% of females “Near” twisting thru’ 90º</th>
<th>95% of females “Far” twisting thru’ 90º</th>
</tr>
</thead>
<tbody>
<tr>
<td>≤ Forearm (grip) length</td>
<td>330</td>
<td>370</td>
<td>410</td>
<td>290</td>
</tr>
<tr>
<td>5%ile</td>
<td>50%ile</td>
<td>95%ile</td>
<td>5%ile</td>
<td>50%ile</td>
</tr>
<tr>
<td>≤ Arm (grip) length</td>
<td>1650</td>
<td>1765</td>
<td>1880</td>
<td>1530</td>
</tr>
<tr>
<td>≤ Full height (stature)</td>
<td>1335</td>
<td>1440</td>
<td>1550</td>
<td>1245</td>
</tr>
<tr>
<td>≤ Shoulder height</td>
<td>1020</td>
<td>1105</td>
<td>1190</td>
<td>930</td>
</tr>
<tr>
<td>≤ Elbow height</td>
<td>720</td>
<td>790</td>
<td>860</td>
<td>665</td>
</tr>
<tr>
<td>≤ Knuckle height</td>
<td>225</td>
<td>245</td>
<td>265</td>
<td>215</td>
</tr>
</tbody>
</table>

- The table gives anthropometric dimensions in millimetres (mm) and loads in kilograms (Kg). These load values may, perhaps, be multiplied by up to 2 for “a minority of fit, well trained individuals working under favourable conditions”. This is an exceptional, not a common, modification.
- The anthropometric data is based on unclothed British adults but has been corrected for the “sensible” shoes worn by adding 25mm to stature.
- The “Guideline loads” are taken from the Guidance to the MHOR published by the Health and Safety Executive (1988) and then reduced by a further 20% to accommodate turning through more than 90º. (Turns of between 45º and 90º only require a reduction of 10%.)
- **Warning** - These data should not be interpreted further without reference to MP and the MHOR Guidelines (HSE 2004a)

\(^2\) Remember, **indoor** clothing will add little to the anthropometric dimensions of the individual but may greatly restrict movement and thus mobility or lifting ability.
Table 2

**Guideline loads for strength by height of lift for standing individuals.**

Anthropometric data added to the Manual Handling Operations Regulations (MHOR) and Guidelines (HSE 2004a).

Adding Anthropometric data to the “Guideline loads” given in the Guidance to the MHOR HSE (1988). (After Pheasant & Stubbs 1991.)

Guideline loads, “not limits”, for lifting “more than about 12 times per minute” (80% reduction) giving “reasonable protection for:"

(Anthropometry in mm and shod nude\(^3\) (Pheasant 1984))

<table>
<thead>
<tr>
<th></th>
<th>Male</th>
<th>Female</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>5%ile</td>
<td>50%ile</td>
</tr>
<tr>
<td>≤ Forearm (grip) length</td>
<td>330</td>
<td>370</td>
</tr>
<tr>
<td>≤ Arm (grip) length</td>
<td>580</td>
<td>640</td>
</tr>
<tr>
<td>≤ Full height (stature)</td>
<td>1650</td>
<td>1765</td>
</tr>
<tr>
<td>≤ Shoulder height</td>
<td>1335</td>
<td>1440</td>
</tr>
<tr>
<td>≤ Elbow height</td>
<td>1020</td>
<td>1105</td>
</tr>
<tr>
<td>≤ Knuckle height</td>
<td>720</td>
<td>790</td>
</tr>
<tr>
<td>≤ Mid lower leg</td>
<td>225</td>
<td>245</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>95% of males</th>
<th>95% of males twisting thru’ 90º</th>
<th>95% of women</th>
<th>95% of women twisting thru’ 90º</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Near”</td>
<td>Far”</td>
<td>Near”</td>
<td>Far”</td>
</tr>
<tr>
<td>≤ Forearm (grip) length</td>
<td>2.0Kg</td>
<td>1.0Kg</td>
<td>1.6Kg</td>
<td>0.8Kg</td>
</tr>
<tr>
<td>≤ Arm (grip) length</td>
<td>4.0Kg</td>
<td>2.0Kg</td>
<td>3.2Kg</td>
<td>1.6Kg</td>
</tr>
<tr>
<td>≤ Full height (stature)</td>
<td>5.0Kg</td>
<td>3.0Kg</td>
<td>4.0Kg</td>
<td>2.4Kg</td>
</tr>
<tr>
<td>≤ Shoulder height</td>
<td>4.0Kg</td>
<td>2.0Kg</td>
<td>3.2Kg</td>
<td>1.6Kg</td>
</tr>
<tr>
<td>≤ Elbow height</td>
<td>2.0Kg</td>
<td>1.0Kg</td>
<td>1.6Kg</td>
<td>0.8Kg</td>
</tr>
<tr>
<td>≤ Knuckle height</td>
<td>2.0Kg</td>
<td>1.0Kg</td>
<td>1.6Kg</td>
<td>0.8Kg</td>
</tr>
<tr>
<td>≤ Mid lower leg</td>
<td>1.4Kg</td>
<td>0.6Kg</td>
<td>1.1Kg</td>
<td>0.5Kg</td>
</tr>
</tbody>
</table>

- The table gives anthropometric dimensions in millimetres (mm) and loads in kilograms (Kg). These load values may, perhaps, be multiplied by up to 2 for “a minority of fit, well trained individuals working under favourable conditions”. **This is an exceptional, not a common, modification.**

- The anthropometric data is based on unclothed British adults but has been corrected for the “sensible” shoes worn by adding 25mm to stature.

- The “Guideline loads” are taken from the Guidance to the MHOR published by the Health and Safety Executive (1988) and then reduced by a further 20% to accommodate turning through more than 90º. (Turns of between 45º and 90º only require a reduction of 10%.)

- **Warning** - These data should not be interpreted further without reference to MLP and the MHOR Guidelines (HSE 2004a)

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\(^3\) Remember, *indoor* clothing will add little to the anthropometric dimensions of the individual but may greatly restrict movement and thus mobility or lifting ability.
Standards


The NIOSH Lifting equation (1991 revision)
Introduction

The original 1981 version of the NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks (NIOSH 1981) was used and critically evaluated by many academics and industrial/commercial safety officers throughout the 1980s. It was found to be generally effective but the evaluation also found that the formula underestimated the risk associated with some common lifts. The formula assumed two-handed lifting with good coupling in the sagittal plane yet most industrial and commercial lifts are asymmetrical. The original formula was revised and published in 1991. (Waters et al 1993). Further details concerning the revision procedure can be found in Waters et al (1993 & 1998) or Jacobs and Bettencourt (1995); Bridger (2003) also contains a worked example.

The NIOSH Lifting equation (1991 revision)
The original 1981 version of the NIOSH Equation for the Design and Evaluation of Manual Lifting Tasks (NIOSH 1981) was revised in 1991. The outcome is expected to be “safe” for 75% (females) or 99% (males). For a greater “safety” margin, especially for females, replace the initial value of 23kg by, say, 15kg. The supporting text, suggests, if the workforce is 50/50 M/F then the NIOSH Lifting Equation, with 23kg as the initial value, will cover 90% of the “working population” safely.

The 1991 Equation (Metric units):

\[
\text{RWL (in kg)} = 23 \times (25/H) \times [1 - (0.003|V - 75|)] \times [0.82 + (4.5/D)] \times (1-0.0032A) \times FM \times CM
\]

Where:

- **RWL** Recommended weight limit (kg)
- **H** The Horizontal distance of the hands from the mid point between the ankles to the mid point at which the load is grasped. (Cm). The greatest distance between the start of the lift and its finish gives the limiting value.
- **V** The vertical distance of the hands (axis of grip) from the floor. (Cm).
- **D** Vertical distance moved by the hands during the lift. It is the absolute value of the height of the destination minus the original starting height. (Cm).
- **A** Angle of asymmetry through which the load is transported. (degrees) For any given weight, the risk of injury with asymmetrical lifting is greater than with symmetrical. Thus, it should be avoided.
- **FM** Frequency multipliers. The average frequency of lifts per minute with allowance for the duration of work undertaken (short, moderate, long), vertical distance of the lift together with the required recovery time (RRT) all influence the figure to be adopted. The value is obtained from Table 3 (overleaf).
- **CM** Coupling multiplies. This is a measure of the maximum force a worker can exert on an object. This may vary throughout the lift, the most stressful classification should be selected from Table 4 (overleaf).

**Note** \(| V - 75 |\) refers to modulus “V –75”; a value that is always positive, ie \(| -6 |\) and \(| 6 |\) both have the value of 6
Table 3. NIOSH Frequency Multiplier Table to be used to find the value for FM

<table>
<thead>
<tr>
<th>Frequency (lifts/minute)</th>
<th>V&lt;75</th>
<th>V≥75</th>
<th>V&lt;75</th>
<th>V≥75</th>
<th>V&lt;75</th>
<th>V≥75</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.2</td>
<td>0.85</td>
<td>0.85</td>
<td>0.95</td>
<td>0.95</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td>0.5</td>
<td>0.81</td>
<td>0.81</td>
<td>0.92</td>
<td>0.92</td>
<td>0.97</td>
<td>0.97</td>
</tr>
<tr>
<td>1</td>
<td>0.75</td>
<td>0.75</td>
<td>0.88</td>
<td>0.88</td>
<td>0.94</td>
<td>0.94</td>
</tr>
<tr>
<td>2</td>
<td>0.65</td>
<td>0.65</td>
<td>0.84</td>
<td>0.84</td>
<td>0.91</td>
<td>0.91</td>
</tr>
<tr>
<td>3</td>
<td>0.55</td>
<td>0.55</td>
<td>0.79</td>
<td>0.79</td>
<td>0.88</td>
<td>0.88</td>
</tr>
<tr>
<td>4</td>
<td>0.45</td>
<td>0.45</td>
<td>0.72</td>
<td>0.72</td>
<td>0.84</td>
<td>0.84</td>
</tr>
<tr>
<td>5</td>
<td>0.35</td>
<td>0.35</td>
<td>0.62</td>
<td>0.60</td>
<td>0.80</td>
<td>0.80</td>
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<tr>
<td>6</td>
<td>0.27</td>
<td>0.27</td>
<td>0.50</td>
<td>0.50</td>
<td>0.75</td>
<td>0.75</td>
</tr>
<tr>
<td>7</td>
<td>0.22</td>
<td>0.22</td>
<td>0.42</td>
<td>0.42</td>
<td>0.70</td>
<td>0.70</td>
</tr>
<tr>
<td>8</td>
<td>0.18</td>
<td>0.18</td>
<td>0.35</td>
<td>0.35</td>
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<td>0.60</td>
</tr>
<tr>
<td>9</td>
<td>0.00</td>
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<td>0.30</td>
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<td>0.28</td>
</tr>
<tr>
<td>&gt;15</td>
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<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 4. NIOSH Coupling Multiplier Table to be used to find the value for CM.
(Note that by implication this table provide hints at what might make an effective box/handle design and what does not!)

<table>
<thead>
<tr>
<th>Coupling Quality</th>
<th>Coupling criteria to be met</th>
<th>V&lt;75</th>
<th>V≥75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Good</td>
<td>handles (cylindrical, with a non slip surface, 2 - 4 cm in diameter, more than 11 cm long with 5 cm of clearance)</td>
<td>1.00</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>handhold cut-outs, smooth, semi oval non slip, 8 cm high, 11 cm long with 5 cm of clearance. (The container must be 1 cm or more thick)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>If boxed the container must be 41 cm or longer (front) 30 cm or less high with a smooth, non-slip surface.</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>If unboxed the worker must be able to comfortably wrap a hand around to grip the object without wrist deviation, awkward postures or excessive grip force.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fair</td>
<td>handles or handhold cut-outs at less the optimal design</td>
<td>0.95</td>
<td>1.00</td>
</tr>
<tr>
<td></td>
<td>the worker must be able to “clamp” fingers at nearly 90° under the container if no handholds or cut-outs exist.</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Poor</td>
<td>container is 41 cm or longer in front, 30 cm or more high, has a rough/slippery surface, sharp edges, an asymmetric centre of mass, unstable or un pleasant contents or requires the use of gloves.</td>
<td>0.90</td>
<td>0.90</td>
</tr>
<tr>
<td></td>
<td>container has no cut-outs or handles.</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
In addition, the following criteria must be met for the NIOSH equation to be applicable.

1. The working environment must be favourable; temperature between 18°C and 27°C within the range of 35% to 50% relative humidity.
2. The worker does not undertake other work (or leisure activity) which requires a high level of energy expenditure.
3. The lifting task is two handed and not performed in a jerky, high speed (< 2 - 4 seconds) or rushed manner.
4. The force applicable is not limited by the worker/shoe/floor coupling. The friction is similar to that between a smooth dry floor and the sole of a clean, dry leather shoe sole. (μ = 0.4 - 0.5).
5. It is assumed that both the lifting and lowering of the object have equal levels of risk. This assumption may not be true if, for example, the box is dropped to the floor at the end of the lifting task.
6. The formula, like the HSE tables, assumes passive loads; it is used to guide/inform but has never been validated on live loads.
7. The task must be undertaken in “free space” – neither clothing or build environment must restrict/limit the postures to be adopted.

In order to quantify a particular task the **lifting index** is often quoted. This is simply calculated by dividing the actual load lifted by the NIOSH(1991) predicted “safe” value. Viz. \( LI = \frac{L}{RWL} \)

Where:
- \( LI \) Lifting index
- \( L \) Weight of object lifted (Kg)
- \( RWL \) Recommended weight limit (kg)

**Clearly if LI > 1.0 overexertion injury is likely as the load handled exceeds the prescribed “safe” weight limit. If the Value of LI < 1.0 then the task should be “safer” than predicted!**

**Conclusions regarding the NIOSH formula**

There can be no such thing as a **safe** load for manual handling. However, the 1991 NIOSH equation has been found to provide useful guidelines and is robust enough to be used by non-ergonomists (Waters et al 1998). However, remember that experience (backed by academic researchers) suggests that the indications of the NIOSH Equation are only “good” for 95% of fit working males and 85% of females. (See, for example, Hidalgo et al (1995) or Waters et al (1993))

The NIOSH equation are, not, at present accepted by the UK Courts who prefer to use the simpler HSE recommendations found in the Manual Handling Regulations. (HSE 1992, 2003 and 2004a). Remember, the NIOSH formula, like the HSE tables, is based on passive loads; it may be used to guide/inform but has never been validated on live loads!

Warning this formula was, like the HSE tables, based on passive loads. It is frequently used to guide/inform but has **never** been validated on live loads, people, pigs, etc.

**Self reporting via Body maps**

Over thirty years ago Corlett and Bishop (1974) (See also Corlett 2005) reported using a body map on which the subject market areas of “discomfort”, “pain”, etc. This was a novel idea when introduced but has, subsequently prove to be most effective. These can prove to be useful but with refinement even more effective. See, for example the recent review and proposed refinements by Messing et al (2008)

Note that it is easier to get people to report discomfort (an absence of comfort) rather than the reverse. ‘This notion also, of course, applies to industrial, commercial situations as much as it does to chair or workstation comfort’
RAPID UPPER LIMB ASSESSMENT – Checklist

Client: ____________________________ Date/time: ____________________________ Assessor: ____________________________

**Right Side:**

**Right Upper Arm**
- Shoulder is raised
- Upper arm is abducted
- Lower arm is supporting the weight of the arm

**Right Lower Arm**
- Working across the midline of the body or out to the side

**Right Wrist**
- Wrist is bent away from midline

**Right Wrist Twist**
SELECT ONLY ONE OF THESE:
- No resistance • less than 2kg intermittent load or force
- 2–10kg intermittent load or force
- 2–10kg static load • 2–10kg repeated loads or forces • 10kg or more intermittent load or force
- 10kg static load • 10kg repeated loads or forces • Shock or forces with rapid build-up

**Muscle Use**
- Posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per

**Left Side:**

**Left Upper Arm**
- Shoulder is raised
- Upper arm is abducted
- Lower arm is supporting the weight of the arm

**Left Lower Arm**
- Working across the midline of the body or out to the side

**Left Wrist**
- Wrist is bent away from midline

**Left Wrist Twist**
SELECT ONLY ONE OF THESE:
- No resistance • less than 2kg intermittent load or force
- 2–10kg intermittent load or force
- 2–10kg static load • 2–10kg repeated loads or forces • 10kg or more intermittent load or force
- 10kg static load • 10kg repeated loads or forces • Shock or forces with rapid build-up

**Muscle Use**
- Posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per
<table>
<thead>
<tr>
<th>Neck Twist</th>
<th>Neck Side-bend</th>
<th>Trunk Twist</th>
<th>Trunk Side-bend</th>
<th>Legs</th>
</tr>
</thead>
<tbody>
<tr>
<td><img src="image1" alt="Neck Twist Image" /></td>
<td><img src="image2" alt="Neck Side-bend Image" /></td>
<td><img src="image3" alt="Trunk Twist Image" /></td>
<td><img src="image4" alt="Trunk Side-bend Image" /></td>
<td><img src="image5" alt="Legs Image" /></td>
</tr>
</tbody>
</table>

**Legs**
- Legs and feet are well supported and in an evenly balanced posture.
- Legs and feet are NOT evenly balanced and supported.

**Force & Load for the neck, trunk and legs**
- SELECT ONLY ONE OF THESE:
  - No resistance • less than 2kg intermittent load or force
  - 2–10kg intermittent load or force
  - 2–10kg static load • 2-10kg repeated loads or forces • 10kg or more intermittent load or force
  - 10kg static load • 10kg repeated loads or forces • Shock or forces with rapid build up

**Muscle Use**
- Posture is mainly static, e.g. held for longer than 1 minute or repeated more than 4 times per
Comments/observation of Task

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Whilst COPE Occupational Health and Ergonomic Services Ltd (COPE) and Osmond Group Limited (Osmond) have taken every care in preparing this resource, it must be used according to the guidelines based on the original article* by Prof E.N. Corlett and Dr L. McAtamney.

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For further information on methodology, please refer to our on-line guidance at www.ergonomics.co.uk or:
McAtamney, L and Corlett, E.N. Reducing the risks of work related upper limb disorders - A guide and methods. Published by: Institute for Occupational Ergonomics, University of Nottingham, Nottingham NG7 2RD, UK. (1992). Tel: +44 (0)115 9514005 for details.

Conclusion

All six of these ergonomic, musculoskeletal assessment schemes are widely used and you can easily find many more references to them than are listed here. [Indeed, this might make a good opportunity to test Ergonomics Abstracts or the library’s database searching software.] If you do download from the web, you should satisfy yourself as the authority, rigour, accuracy and reliability of the materials.

The risk of injury either from a single incident or cumulatively over a period of time is not trivial. It is also an area where the details and the nuances can be complex and may be given to courts to decided. A database of cases specifically relating to WRULS can be found at: http://www.humanetechnology.co.uk/wruldii/intro.php. (Free registration is required).

The Institute of Ergonomics and Human Factors has active discussion boards at http://www.ergonomics.org.uk where you can ask questions and contribute. You can also use this site to make contact with other ergonomists. You will find other groups on Linkedin etc.

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WILSON, JR and CORLETT EN (2005)
Appendix 1. Consider these, not uncommon situations from an ergonomic perspective and focus upon the manual handling operation.

1. A box of A4 photocopying paper (5 reams at 80gsm) is to be lifted from the floor up to a table (1050mm high) by the copier. A turn of $90^\circ$ is required but the box will not require any carrying. The action is only performed infrequently when the copier requires filling. Does this appear to be an acceptable task from the perspective of the HSE guidelines or the NIOSH formula? If one box is always left on the floor and only the box stacked on top is handled; is the task much safer? Why?

2. Two paramedics/ambulance crew work together, one male and one female. Consider the following four cases:
   a. A 75kg flaccid but stable patient is to be picked up from the floor on a “stretcher” which weighs 10kg and then carried 25m before being loaded into the back of the ambulance.
   b. An old lady (55kg including “transport chair”) is to be moved down two flights of stairs and then loaded into the ambulance.
   c. Following a road accident, an unconscious biker must be transported from the roadside to the ambulance while the airway is monitored. The weight of the biker is unknown but the ambulance crew “guess” is 110kg. (And note some people are twice as heavy!]
   d. A 85kg (estimate) “fighting drunk” local celebrity has fallen, banged his head and, with police help, the paramedics are wish to transport him to hospital. Surround the operation are many members of the public with their camera phones at the ready.

3. A family is going to move and the grandparents decide to organise a party. They visit the local supermarket and buy three packs, each containing 24 700ml tins of beer and several cases of wine (in 70cl bottles). What might be issues associated with loading these items (and the crisp, nuts etc) into the car boot and then, once home, removing them and carrying them 20m to the kitchen. How are the risk changed if two of the grandchildren (a girl of 16 and a boy of 13) offer to undertake the loading, unloading and carrying?

4. Do you have a water cooler in your office? Is it plumbed in or does it require bottled water? If it uses bottled water, consider the refilling task – undertake an ergonomic assessment of this task using a range of the techniques introduced in this document. MHOR, MAC, NIOSH, OWAS, REBU and RULA are all applicable to this situation. You might find it helpful to talk to a range of people undertaking (or with experience of undertaking) the task. Typically, the water bottles are 25L (25.5kg) without an integral handle or 20kg (20.5kg).

5. A mother lifts her child into a rear, correctly specified, car seat. They then reach over to adjust and lock the restraining straps. Which technique would you use to assess this task? How much worse (from an ergonomic perspective) is the task if the seat is on the far side of the car but the doors on that side are un-useable due to the proximity of obstructions/other cars. At 12-15 months, the child might weight 10/12 kg while by 11 they can still require the seat but weight 35/40 Kg. How does the assessment of the task change if the person doing the restraining is a carer (and not the mother) and if the child is unable to control/co-ordinate their body?
Appendix 2. Outline answers to the first two questions but what comments/observations do you have about these task assessments?

1.
Each ream will weigh about 2.5kg (routine 80gsm paper) and the full box, including wrapping about 12.75Kg. You might like to reconsider this question if “top sheet” paper at 90gsm (14.3kg for five reams, boxed) or even “copy card” at 110gsm (17.4kg for five reams, boxed).

**HSE Guideline Loads**
- The best “near” guideline load for a lift from the floor is 10Kg but this reduces to 7.0 Kg for women and 5.0Kg when she is to turn through 90°. If the lift cannot be performed “near” to the body then the values should be halved and if a more frequent operation is required, perhaps if a pallet need to be unloaded and the boxes transferred to a cupboard, then lower values would apply.

- A box place upon another, especially if it is one of the better designs with side handholds, will move the load into the next categories where the guideline loads above become 20Kg, 13.0Kg and 10.4Kg respectively. This arrangement, of course, looks much better although still, ergonomically, sub-optimal!

- The tabletop is, for most percentiles, in the region of highest strength and thus is not the limiting value for the lift, even if a “far” placement of the carton is required. (Of course, for the small person a “far” placement would be the limiting factor for the lift for the top of two boxes.)

**NIOSH Equation**
- Assuming a good handhold and lifting from the floor then the NIOSH equation resolves to 6.08kg and 6.84kg from one box high if the “unfactored load constant” is taken to be 15k gf for a female. Thus the lifting index is between 2.10 and 1.87 respectively. If the standard value of 23Kgf for the “unfactored load constant” is used then the equation resolves to 10.13Kg and 11.4Kg respectively. Still below the actual weight of the carton of five reams that is to be lifted! The advantages of using another box to raise the load off the ground is clear.

**General**
- Consideration should, routinely, be given to footwear, clothing gender and age and it might also be necessary to consider any constriction of posture that may be caused by limited space around the copier. It should always be remembered that paper (whether as files or raw supplies) is dense and is a common cause of musculoskeletal injury among office staff.

- In fact the loads that are routinely carried (or rather one is encouraged to carry) can often be well outside what might be regarded as “safe”. For example, my local DIY Supermarket does offer to help load you car but, sadly, not unload it! One of the biggest sellers is a smooth plastic bale of compressed potting compost 33cm x 45cm x 68cm and weighing between 42.5kg and 44.5kg depending how wet the contents are. (The bales are stored outside.)

- Try lifting that in and out of a car boot, avoiding the boot’s locking pin (which can easily rip the bale), especially if you do not wish to hold it close to the trunk as it is often wet and dirty! Obviously not within the “guideline loads” but a common load for the older gardener to attempt! Of course, compressed compost bales are not the only problem, large tins of paint, new doors, sheet materials and “flat-pack” furniture can also raise manual handling issues!
2.

- Two ambulance staff work together, one male and one female. Consider the following cases:

- Picking up from the ground, near to the body the male guideline is 10Kg and the female 7Kg. Assuming that they are both at peak fitness and everything else is favourable then these may be doubled (but without much confidence of long-term safety!) Using the multiplier (0.67) for two people in a team then the maximum capacity available only becomes 22.8Kg! (Of course, in the maximum strength - knuckle to elbow range - this figure is 54.9Kg.) Thus, a typical nine patient shift for an ambulance crew is never without the risk of musculoskeletal injury!

- Case (a) This demands a maximum strength lift of just over 3 times the guideline load and nearly 7.5 times for the lift from the floor! The walk (25M), in this case, does not appear critical given the extremes just lifting and lowering the patient. The “stretcher” should have wheels and if the surface is fairly flat they should, once locked down, take the load but the possibility of slips/trips/falls must be considered, as the forward view may be limited. (75Kg is about 11 stone 11lb)

- Case (b) Not so much of problem here as the wheels will take the weight but care must be taken when going down stairs to ensure that the load is split evenly. It is possible, for example, for the “head” to find themselves resisting the whole weight of the chair and patient while the “foot” just guides. Teamwork, confidence in each other and training are required. (55Kg is about 8 stone 9lb)

- Case (c) Hopefully others are around to help with the lift, especially as the “head” will be managing the airway/conscious level. A load of 110Kg represent c10 times the - lift from floor - guideline load for the team! Alternatively, perhaps the biker is just left by the roadside until heavy lifting tackle is brought along! (110Kg is about 17 stone 4lb)

- Case (d) Well does the fact that you are being watched and the patient is fighting back make any difference?! (85Kg is about 13 stone 5lb)

- In all of these cases, a more sophisticated assessment is clearly called for. Try using the Assessment checklist given as Appendix 2 in the MHOR (HSE 1998). You will find a worked example to help you get started. A preliminary discussion concerning spine loading and trunk kinematics can be found in Marras et al (1999). Kanlayanaphotorn et al (2003) also investigate this technique with specific reference to spinal loading and subjects with low back pain.

- It should also be noted that the dynamic measurement of the slipperiness of surfaces is not well established, techniques vary and, at the time of writing, standardised measures are not yet agreed. See, for example, the special issue of Ergonomics concerning this complex and, as yet, unresolved methodological issue (Volume 44 (13) October 2001).

The issue of handling patients within the health care sector is currently the subject of a draft ISO Standard; ISO/NP TR 12296 Ergonomics -- Manual handling of people in the healthcare sector. The date by which this will be agreed and finalised is not yet known.