A Study on the Application of the UK HSE Heavyweight Handling Guideline to Koreans

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Abstract
This study was conducted to analyze the appropriateness of Korean for the UK Health and Safety Executive (HSE) heavyweight handling guideline. According to the Korea Ministry of Labor’s statistics on industrial injuries, 46.1% of musculoskeletal patients in 2017 were found to have low back pain caused by manual material handling (MMH) task processes. In Korea, foreign heavyweight handling evaluation criteria have been employed without modification. A number of studies have been conducted on whether the Lifting Guideline, provided by the National Institute for Occupational Safety and Health (NIOSH), is suitable for Koreans. The UK HSE heavyweight handling guideline is widely used in Korea, but there are few researches on whether it is suitable for Koreans. This study deals with the anthropometry data in the 1st, 50th, and 99th percentiles of Korean men aged 20 to 45. Also, 3DSSPP software was utilized in order to check whether the guideline of the UK HSE is applicable to Koreans. Korean anthropometry data was based on the Korean Agency for Technology and Standards. According to the results of the study, the degree of load on the lumbar spine (L5/S1) was lower in the 1st percentile than in the 50th percentile and the 99th percentile. Also, a handling heavyweight in the outstretched arm posture had a higher degree of load on the lumbar spine (L5/S1) than a handling heavyweight in the bent arm posture. Through this study, it is believed that the research could be used as a basis for data for the development of the MMH guideline, considering the physical characteristics of Koreans.

Keywords: MMH, 3DSSPP, L5/S1, Heavyweight

1. Introduction
Many areas including work efficiency and the convenience of working methods are improving due to production technology development such as mechanization and automation in the modern industrial society. In reality, however, manual labor based on human’s strength is carried out in many industrial fields [1]. Also working methods are too much inappropriate and thus excessive physical load is given to workers. This is connected to occupational disease like low back pain, and a typical example can be work-related musculoskeletal disorders (WMSDs). WMSDs add physical and mental pain to workers, and cause economic losses such as productivity reduction, and therefore WMSDs become a significant problem throughout industries in Korea [2].

According to the industrial injury statistics of the Korea Occupational Safety Health Agency (KOSHA), 46.1% of the WMSDs that occurred in 2017 were investigated as occurring in the manual material handling (MMH) process [3]. MMH is a representative work causing low back pain and burden to human body [4].

US Occupational Safety and Health Administration (OSHA) points out low back pain is the most critical problem to be solved in the industrial safety and health field [5]. The main causes of low back pain in the industrial sites are physical stress taking place by lifting, pushing, pulling, and transporting heavyweight. According to a research of KOSHA on work-related low back pain, the number of injuries of low back pain by lifting heavyweight causing excessive strength to muscles took up the most in view of injury-causing work type in Korea.

To prevent WMSDs occurring due to manual material handling (MMH), an objective and reasonable evaluation method on the harmfulness and risk of the work concerned is needed. Also, various preventive measures including engineering improvement on risk factors are required.

The US and UK devised and has been applying proper evaluation criteria on MMH. However foreign MMH evaluation criteria are currently applied to Korea without the revision of them [6]. Many studies on the application of lifting guideline to Koreans presented by the US National Institute of Occupational Safety & Health (NIOSH) have been carried out. Although the Heavyweight Handling Guideline presented by the UK Health & Safety Executive (HSE) is widely used in Korea, studies on the application of the guideline to Koreans is insufficient.
This study aims to find out the application possibility of the UK Heavyweight Handling Guideline presented by the UK HSE to Koreans through a 3D static strength prediction program.

2. Methods

2.1 Subjects
As shown in Table 1, the anthropometric data of the 1st, 50th, and 99th percentiles of Korean males aged 20-45 were collected using the statistical data of the Korean Agency for Technology and Standards (KATS).

Table 1. Anthropometric Dimension Data

| Dimension             | 1st Percentile | 50th Percentile | 99th Percentile |
|-----------------------|----------------|-----------------|-----------------|
| Height (mm)           | 1607.0         | 1730.5          | 1866.5          |
| Weight (kg)           | 51.1           | 72.8            | 106.1           |
| Arm length (mm)       | 520.0          | 590.5           | 655.0           |
| Upper arm length (mm) | 294.5          | 339.5           | 379.0           |
| Lower arm length (mm) | 225.5          | 251.0           | 278.0           |
| Head height (mm)      | 1607.0         | 1730.5          | 1866.5          |
| Shoulder height (mm)  | 1285.0         | 1401.5          | 1533.5          |
| Elbow height (mm)     | 974.0          | 1060.5          | 1164.5          |
| Fist height (mm)      | 696.0          | 775.5           | 858.5           |
| Knee height (mm)      | 393.5          | 452.5           | 508.5           |

2.2 Experimental Design
This study analyzed load generated to lumbar spine (L5/S1), if Korean males conduct heavyweight handling work in line with the range presented by the UK HSE Guideline. However, the legs were kept in a vertically straight posture. Figure 1 shows the Males’ Heavyweight Handling Guideline presented by the UK HSE.

2.3 Data Analysis
To obtain the experimental data, this study utilized 3D static strength prediction 4.0 program developed by Michigan University. The main input variables in program analysis are human dimension and weight of heavy weight. The output variable is lumbar spine (L5/S1) compression force. Figure 2 shows 50th percentile males’ bent arm posture and outstretched arm posture at fist height.

3. Results

3.1 Classification on Risk Level
This study decided risk levels according to the risk level classification criteria based on the analysis results of lumbar spine (L5/S1) compression force through 3D static strength prediction program. The compression force given to the lumbar spine (L5/S1) shows 3,400N, which is the action limit (AL) presented by the USNOISH as risk standard. This study, however, analyzed by segmenting the lumbar spine load in more detail. The reason is because it was judged that more than 2,500N lumbar spine load in the NIOSH Lifting Guideline can give burden to the lumbar spine in the case of working for a long time, although it is allowable. Consequently this study classified the load generated to
the lumbar spine (L5/S1) is high risk level, if the lumbar spine (L5/S1) compression force is 3,400N or more, risk level if it is 2,500N or more and less than 3,400N, and safe level if it is less than 2,500N. Table 3 shows the risk level classification criteria.

Table 3. Criteria on Risk Level of Lumbar Spine (L5/S1) Compression Force

| L5/S1 Disc Compression (N) | 3,400N or more | High risk |
|---------------------------|----------------|-----------|
|                            | 2,500N or more – less than 3,400N | Risk |
|                            | Less than 2,500N | Safe |

3.2 Lumbar Spine (L5/S1) Load of the 1st Percentile Males

As a result of analyzing the load level generated to the lumbar spine (L5/S1) of the 1st percentile Koran males as shown in Table 4, it was analyzed that handling heavyweight weighing 25kg or more at elbow height and fist height is dangerous in the case of handling heavyweight in the outstretched arm posture.

Table 4. Results of the 1st Percentile Males’ lumbar spine (L5/S1) Compression Force

| 1st Percentile | 5kg | 10kg | 15kg | 20kg | 25kg |
|----------------|-----|------|------|------|------|
| Shoulder height (bent arm posture) | 403±21 | 713±36 | 927±51 | 1,136±65 | 1,340±79 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |
| Shoulder height (outstretched arm posture) | 932±57 | 1,366±91 | 1,760±122 | 2,133±152 | 2,485±182 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |
| Elbow height (bent arm posture) | 534±25 | 740±39 | 960±54 | 1,167±68 | 1,370±82 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |
| Elbow height (outstretched arm posture) | 1,005±64 | 1,415±95 | 1,803±126 | 2,170±156 | 2,517±185 |
| (Risk) | (Risk) | (Risk) | (Risk) | (Risk) | (Risk) |
| Fist height (bent arm posture) | 778±45 | 982±59 | 1,182±73 | 1,378±86 | 1,569±100 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |
| Fist height (outstretched arm posture) | 1,400±99 | 1,764±128 | 2,108±156 | 2,433±182 | 2,740±208 |
| (Risk) | (Risk) | (Risk) | (Risk) | (Risk) | (Risk) |

3.3 Lumbar Spine (L5/S1) Load of the 50th Percentile Males

As a result of analyzing the load generated to the lumbar spine (L5/S1) of the 50th percentile Korean males as shown in Table 5, it was analyzed that handling heavyweight weighing 20kg or more is dangerous at shoulder height and elbow height in the case of handling heavyweight in the outstretched arm posture.

Table 5. Results of the 50th Percentile Males’ Lumbar Spine (L5/S1) Compression Force

| 50th Percentile | 5kg | 10kg | 15kg | 20kg | 25kg |
|-----------------|-----|------|------|------|------|
| Shoulder height (bent arm posture) | 660±29 | 902±45 | 1,132±61 | 1,362±77 | 1,589±93 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |

3.4 Lumbar Spine (L5/S1) Load of the 99th Percentile Males

As a result of analyzing the load generated to the lumbar spine (L5/S1) of the 99th percentile Korean males as shown in Table 6, it was analyzed that handling heavyweight weighing 15kg or more at shoulder height and elbow height and 5kg or more at fist height is dangerous in the outstretched arm posture.

Table 6. Results of the 99th Percentile Males’ lumbar spine (L5/S1) Compression Force

| 99th Percentile | 5kg | 10kg | 15kg | 20kg | 25kg |
|-----------------|-----|------|------|------|------|
| Shoulder height (bent arm posture) | 897±38 | 1,153±56 | 1,396±73 | 1,632±90 | 1,861±107 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |
| Shoulder height (outstretched arm posture) | 1,793±116 | 2,242±151 | 2,665±187 | 3,038±221 | 3,384±253 |
| (Risk) | (Risk) | (Risk) | (Risk) | (Risk) | (Risk) |
| Elbow height (bent arm posture) | 945±42 | 1,192±59 | 1,431±76 | 1,682±93 | 1,887±109 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |
| Elbow height (outstretched arm posture) | 1,000±124 | 2,336±161 | 2,738±195 | 3,106±228 | 3,443±260 |
| (High risk) | (High risk) | (High risk) | (High risk) | (High risk) | (High risk) |
| Fist height (bent arm posture) | 1,302±72 | 1,532±89 | 1,758±105 | 1,973±121 | 2,183±136 |
| (Safe) | (Safe) | (Safe) | (Safe) | (Safe) | (Safe) |
| Fist height (outstretched arm posture) | 2,550±186 | 2,898±219 | 3,216±248 | 3,503±276 | 3,805±304 |
| (High risk) | (High risk) | (High risk) | (High risk) | (High risk) | (High risk) |

4. Conclusion

This study analyzed the application of the Heavyweight Handling Guideline presented by the UK HSE to Koreans. Based on the results of lumbar spine (L5/S1) compression force, the risk levels were determined with the classification criteria. The analysis results can be synthesized as follows:

First, the 1st percentile males’ load generated to the lumbar spine (L5/S1) was lower than that of the 50th and 99th percentiles males. This is judged that the 1st percentile meals have shorter heavyweight handling point and separation distance from the body, compared to the 50th and 99th percentile males, and thus load
generated to the lumbar spine (L5/S1) is lower.

Second, the load was higher in handling heavyweight in the outstretched arm posture than in the bent arm posture (L5/S1).

Third, it is judged that the 1st and 50th percentile males will not have big burden to the lumbar spine (L5/S1), although they handle heavyweight based on the criteria of the UK HSE Heavyweight Handling Guideline. Meanwhile, the 99th percentile males are judged to have big burden to the lumbar spine (L5/S1), if they handle heavyweight based on the criteria of the UK HSE Heavyweight Handling Guideline. Therefore, there is a need to revise the allowable standard in handling heavyweight presented in the guideline to reduce the load generated to the lumbar spine (L5/S1).

The results of this study are judged to be used as baseline data for the research of heavyweight handling guideline that considers Koreans’ physical characteristics.

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