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Guidebook for safe manual lifting ergonomics in the removals industry to minimize demands on the lower back

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Guidebook for safe manual lifting ergonomics in the removals industry into minimize demands on the lower back

Degree programme in Physiotherapy

The aim of this thesis was to collect theoretical knowledge regarding safe manual lifting ergonomics as well as to provide an ergonomic lifting guide for employees in the removals industry. This thesis was done in collaboration with City Muutot OY with the agreement to distribute the guidebook to their current and future employees in order to promote safe ergonomic lifting practices and thereby minimize demands on the lower back.

Research has shown that common injuries in the workplace are musculoskeletal in nature. These injuries are due mainly to poor ergonomics and lower back injuries are a common health problem. Back pain can be caused by different work factors but is more common in occupational roles that involve repetitive tasks such as manual lifting of items.

Employee guidelines regarding correct lifting techniques, are necessary as they play an important role in the prevention of injuries by educating employees. In the removals industry, it is important for the employees to have access to a guidebook which provides advice regarding safe lifting ergonomics. For the employer it is also important, as it leads to better productivity and also promotes workplace safety.

Manual material handling environment can be stressful on the human body. The physical stress and strain often lead to muscle imbalances that eventually result in musculoskeletal disorders. In order to prevent or minimize these injuries, a proactive approach to ergonomics is required.

Keywords: lower back pain, musculoskeletal disorders, ergonomics, manual material handling, lifting postures, mechanical devices

CONTENTS

1 INTRODUCTION

Various studies have highlighted the impact of workplace lifting on the physical anatomy; in particular with regards to lower back pain (LBP). However, these studies vary both in focus area and in subsequent findings. General consensus, however, is that the lifting frequency, duration and load, as relates to weight and volume, creates a variable impact on the individual and the likelihood of suffering from LBP (Coenen et al 2014, 874).

Digital and automated operations, as well as innovation, are still relatively scarce as relates to the relocation and removal industry. Therefore, the importance and efficiency of manpower remains as crucial as ever. In these environments, human labour is a pivotal mechanism for operations, where carrying varying loads of materials in high frequency is still undertaken by manpower. A meta-analysis by Coenen et al (2014), concluded that the intensity and frequency of lifting were significantly impactful on the incidence rate of lower back pain (LBP).

The labour relating to the removals and relocation sector of logistics operations, usually takes place in environments and situations where load and access can vary greatly. The Workplace for Occupational Safety and Health Administration in Finland suggests that “procedures should be planned so as to minimize the distances by which heavy loads need to be carried” and that “lifting heavy loads above shoulder height must be avoided" (Työsuojelu, 2019). Herein lies a key challenge, since it is often difficult to minimize the distance over which heavy items must be carried by hand, as well as the technique by which carrying is possible, in confined spaces where this work takes place.

By minimizing improper lifting practices, which can lead to physical injury, staff can work more effectively and comfortably for longer periods of time. One study by Wynne-Jones et al (2014) found that 32% of employees who took leave of absence due to back pain, did not return to work within a one-month period. When coupled with

the findings which show a correlation between frequent lifting and resultant injury, there is a demonstrated need for improving lifting ergonomics.
In occupations, such as removals, where there is a lack of a controlled operating environment, there is a subsequent high variance in lifting situations. Therefore, the need for a more holistic knowledge of lifting ergonomics is increased.

Ultimately the objective of this thesis was to create a simple and implementable guide for correct lifting ergonomics, for employees in the removals sector. The aim of the guide was to lower the likelihood of improper lifting ergonomics, where possible, and to minimise and/or avoid employee injury.

2 AIM AND OBJECTIVE

The aim of this thesis was to improve ergonomics in the removal industry by gathering knowledge and evidence regarding back pain/injuries which are associated with repetitive manual lifting in an occupational setting.

The objective was to create a guidebook to educate on correct lifting ergonomics and to provide primary guidance for the prevention of back pain/injury, due to repetitive manual lifting, for warehouse workers and removal employees. The guidebook is intended for both future and current employees of the removal company; City Muutot Oy.

3 ERGONOMICS

3.1 What is ergonomics

The Cambridge dictionary describes the word, ergonomics, as “the scientific study of people and their working conditions, especially done in order to improve effectiveness” (Website of Cambridge Dictionary, 2020). The International Ergonomics Association (IEA), refers to ergonomics, as “the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data, and methods to design in order to optimize human well-being and overall system performance” (Website of International Ergonomics Association, 2020). They assert that there are three rather broad ergonomic domains of specialization. These three subset disciplines of ergonomics have been identified as physical, cognitive and organizational factors. (Website of International Ergonomics Association, 2020)

Physical ergonomics are predominantly focused on human anatomical, physiological, biomechanical and anthropometric characteristics relating to physical activity. Mental processes fall under the domain of cognitive ergonomics. The relative topics within this subset include memory, perception, reasoning, motor response and information processing as they affect interactions between humans and other elements of a system. Lastly, organizational ergonomics directs focus towards the optimization of sociotechnical systems, in conjunction with their policies, processes and organizational structures. Table 1. Below are listed the three subset disciplines of ergonomics and the relative topics each one encompasses. (Salvendy 2012, 4-5)

Table 1. Ergonomic domains of specialization and their relative topics. (Salvendy 2012, 4-5)

Physical	repetitive motion material handling workplace safety working postures work environment
Cognitive	mental workload decision making skilled performance human-computer interaction human reliability work stress training as these may relate to human-system design
Organizational	communication crew resource management work design design of working times teamwork new work paradigms community ergonomics computer-supported cooperative work virtual organizations telework quality management

3.2 Importance of ergonomics

The DG Employment and Social Affairs in Brussels commissioned an ad hoc analysis of the European Labour Force Survey in 2007. It revealed that within the European Union member states, 53% of all work-related diseases, were musculoskeletal disorders (MSDs). It is understandable then, that MSDs are the leading cause of work disability, absence from work and loss of productivity. The most common and most costly

MSD experienced in the workplace is low back disorders (LBDs). MSDs are not only responsible for the increase in economic cost, which is estimated to be in the region of €240 billion but social costs as well. (Bevan 2015, 356-360) It is not only in the EU that MSDs are the leading cause of disabling work-related injuries. In the US, MSDs alone, attribute to 29% of all work-related injuries. Recent focus and studies imply that MSDs are viewed as a growing problem in the developing world. (Van Eerd et al 2015, 62)

The Occupational Safety and Health Administration within the United States Department of Labor has submitted that an effective approach to preventing the development of work-related MSDs in high risk industries, is to implement an ergonomic process, by tailoring a job to the individual. This process systematically seeks out ergonomic hazards and puts in place administrative and engineering controls to quantifiably reduce risk factors. The potential benefits are a lowering of costs, higher productivity, better product quality, improvement in employee engagement and a better safety culture. (Website of United States Department of Labor. Website of ErgoPlus)

4 THE ANATOMY OF THE BACK

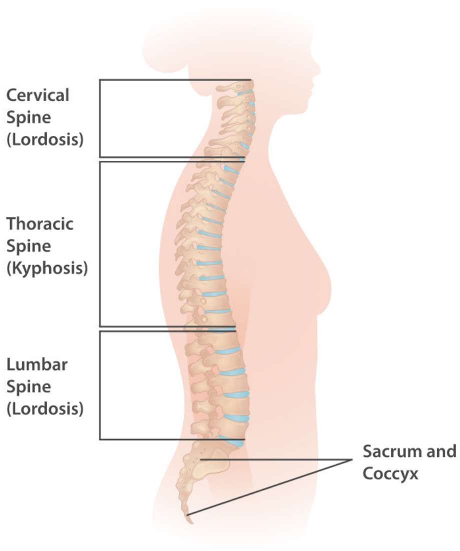
4.1 Overview

The human back is a complex structure of muscles, ligaments, tendons, disks and bones. It is located inferiorly to the neck and superiorly to the pelvis, on the posterior portion of the human body. The back serves as the primary structural support for the torso, housing and protecting the spinal cord. The back coordinates the movement of the lower and upper limbs, the spine and pelvis. (Website of Kenhub)

4.2 Spine

The spinal column or as it is also known, the vertebral column, is made up of 24 separate (presacral) vertebrae, 5 fused vertebrae in the sacrum and variably 4 fused or separate coccygeal vertebrae. The 24 separated vertebrae are divided into three main segments (Picture 1). Starting with 7 cervical vertebrae, followed by 12 thoracic vertebrae and then 5 lumber vertebrae. (Agur & Dalley II 2013, 290.) The movable vertebrae are the cervical, thoracic and lumbar and the immovable vertebrae are the sacrum and coccyx. The vertebral column is not only the home of and protector of the spinal cord, it also provides support for the head and provides the attachment points for the muscles of the back and upper limbs, the ribs and the pelvic girdle. (Tortora & Derrickson 2014, 213-214)

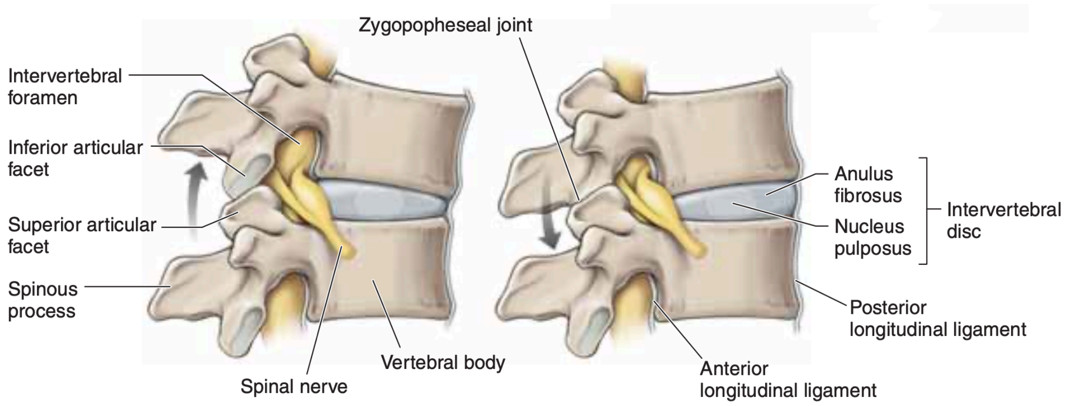
The vertebral column of a normal adult appears straight when it is viewed from the front or from the back. However, when viewing the spine from the side, a series of reciprocal curves are present, forming an “S”-like curve. (Tortora & Derrickson 2014, 214-215). These curves define the neutral position of the various regions of the spine when standing upright. The curve in the cervical and lumbar regions is called lordosis, which means to bend backwards. In the thoracic and sacrococcygeal regions, the natural curvature is called kyphosis (Picture 1). These curvatures of the vertebral column change shape and adjust posture. This is because they are dynamic. (Neumann 2010, 312) The natural curves increase the strength of the vertebral column, serve as shock absorbers during walking and, when in an upright position, help to maintain balance and also to provide protection for the vertebrae from possible fracture (Tortora & Derrickson 2014, 214-215).



Picture 1. Spine (Website of Injurymap)

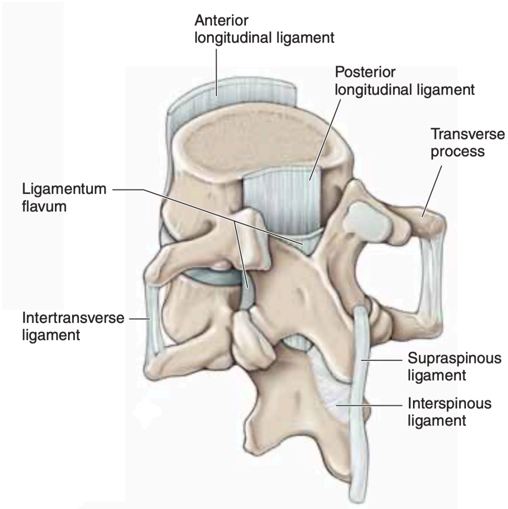
4.3 Joints and Ligaments

Between vertebrae there are two major types of joints. They are synovial joints and symphyses, which link vertebrae between their articular processes and vertebral bodies respectively. There is a total of six joints, four synovial (two superior and two inferior) and two symphyses (one superior and one inferior) in a typical vertebra with adjacent vertebrae. Movement between any two vertebrae is limited. However, when there is a large range of movement by the vertebral column, it is a result of all the vertebrae moving. Movements include extension, flexion, rotation, lateral flexion and circumduction. The shape and positioning of joint surfaces on the vertebral bodies and on the articular processes determine the movements by vertebrae in a specific region of the vertebral column. Joints between the superior and inferior articular processes on adjacent vertebrae are enclosed by a capsule of connective tissue and produce a fluid for nourishment and lubrication of the joint. Cartilage is coated on the joint surfaces allowing for a smooth gliding motion against each other. Due to the interlocking nature between vertebra there is more stability provided to the spine. The symphysis between vertebral bodies is formed by an intervertebral disc and a layer of hyaline cartilage on each of the vertebral bodies. Intervertebral discs make up about 25% of the vertebral column's height. These discs are found from the second cervical vertebra to the sacrum, between the bodies of adjoining vertebra. They prevent the vertebra from rubbing together. Each one of these discs has an outer ring of crisscrossing fibrous bands, called annulus and inside the disc is a soft, highly elastic substance-filled center called the nucleus. A thin layer of hyaline cartilage is present on both the superior and inferior surfaces. The discs function like coiled springs and form strong joints, absorb vertical shock and allow a variety of movements of the vertebral column (Picture 2). (Drake, Vogl & Mitchell 2018, 40. Tortora & Derrickson 2014, 215)



Picture 2. Lateral view of two vertebrae demonstrating intervertebral discs as shock absorbers. See how the facet joints facilitate flexion and extension of the vertebral column. (Morton, Foreman & Albertine 2011, 11)

A numerous set of strong fibrous bands, known as ligaments, reinforce and support the joints between vertebrae (Picture 3). The various ligaments of the vertebral column are the anterior and posterior longitudinal ligament, ligament flava, supraspinous ligament, ligamentum nuchae and interspinous ligaments. They limit the motion of the vertebral bones, aid in maintaining the natural curves of the spine, stabilizing the spine and by doing so, protect the spinal nerve roots and fragile spinal cord. (Neumann 2010, 315)



Picture 3. Two articulated vertebrae showing the ligaments (Morton, Foreman & Albertine 2011, 11)

4.4 Muscles

The muscles of the back are split up into three layers; superficial, intermediate and deep muscle layers. The superficial and intermediate muscles are classified as extrinsic muscles. The superficial muscles are located under the surface of the skin and superficial fascia. This group of muscles originate from the vertebral column and attach to the bones of the shoulder namely the clavicle, scapula and humerus. Each of these muscles are associated with the movements of the upper limbs. The trapezius, latissimus dorsi, levator scapula and rhomboid major and minor make up the superficial muscles of the back. The serratus posterior superior and serratus posterior inferior are the two muscles of the intermediate layer. These muscles originate from the vertebral column and attach at the ribcage and are associated with movements of the thoracic cage. (Website of Teach Me Anatomy)

The deep or intrinsic muscles are considered as the true muscles of the back. They are well-developed muscles, all of which, collectively run from the base of the skull to the sacrum. These deep muscles can be further subdivided into three layers: superficial, intermediate and deep. Splenius capitis and splenius cervicis make up the superficial intrinsic muscles and are associated with movements of the neck and head. The longissimus, iliocostalis and spinalis are the three intermediate intrinsic muscles and collectively form a column, known as the erector spinae. (Website of Teach Me Anatomy) They are situated on both sides of the vertebral column, running alongside the lumbar, thoracic and cervical regions of the spine. The function of this muscle group is to straighten the back and to produce side-to-side rotation. (Website of Spine-health) The deep intrinsic muscles are a group of short muscles, found underneath the erector spinae, known as the transversospinales. The semispinalis, multifidus and rotatores are the three major muscles. They help to stabilize the vertebral column, play a part in proprioception and balance, maintain posture and also help with movements of the vertebral column. (Website of Teach Me Anatomy)

5 MECHANICAL STABILITY OF THE LUMBAR SPINE

5.1 Biomechanics of Manual Handling

Intra-abdominal pressure (IAP) and trunk muscle co-contraction are important for the mechanical stability of the lumbar spine. During lifting activities, the lumbar spine performs an important mechanical function which is the support of the upper body by transmitting compressive and shearing forces to the lower body. The required forces, which transfer the loads to the spine, are greater when lifting an object more quickly as well as when the posture is more “off-balance” or asymmetric. The aforementioned two factors require high antagonistic contractions in the muscle groups around the trunk. The contraction and co-contraction as a result of the antagonistic contractions increase the compression and shear on the vertebral motion segments. When a heavy object is lifted, the spine is stabilised by means of the abdominal and thoracic muscles. A moment of flexion is placed on the spine when leaning forward to lift a heavy object. The flexion strain increases with an increase in the weight of the object. This flexion is resisted by the contraction of the back muscles which exert a moment of extension about the spine. The antagonistic contraction of the abdominal and thoracic muscles occurs simultaneously and pressurizes the contents of the abdomen and thorax and also opposes the flexion moment (Picture 4). Due to the increase in spinal compression during high load moments and high postural or asymmetric moments when lifting, the manual handling efficiency is affected by the lifting technique. As the gluteal muscles can generate an extension moment five to seven times greater than that generated by the lumbar erectors spinae, the hip extensors should play the greater role in powering the lift. (Cholewicki & McGill 1996, 1; Bridger 2017, 206-207)

Picture 4. During lifting: The abdominal mechanism (Bridger 2017, 207)

5.2 Intra-abdominal Pressure

Studies in biomechanics have supported evidence that intra-abdominal pressure is one mechanism that is an important component in spinal stability during tasks that load the spine, such as lifting. These studies have presented a consensus that IAP minimizes muscle and spinal joint loads needed for stability (Driscoll & Blyum 2019, 164). IAP as an unloading mechanism has been suggested to act like a pressurized balloon, trying to separate the pelvic floor and diaphragm. By doing so it minimizes the compression forces on the discs in the lumbar region by creating an extensor moment. The primary muscle responsible for generating IAP is the transverse abdominis. IAP has been shown to contribute to increased stiffness or mechanical stability of the spine. This occurs through a coactivation between the antagonistic trunk flexor and extensor muscles together with the diaphragm and pelvic floor muscles. (Nordin & Frankel 2012, 529-530) The analysis by Stokes, Gardner-Morse & Henry (2010) concluded that for all directions of generated external moments, there is a significant effect on the unloading of the spine as relates to IAP. This is as a result of IAP generating an extension moment which is greater than the flexion moment generated by the muscle activation forces in the abdominal wall.

5.3 Trunk Muscle Co-contraction

A study by Krajcarski et al. (1999) indicated that the higher the level of loading, the greater the increase in muscle co-contraction, spinal compression and trunk stiffness. However, if the weight of the object is unexpectedly heavy, the increase in muscle activity is 70% more than it would have been if the weight was anticipated. This may lead to injury. When lifting a heavy weight, there is a lack of increased coactivation of the trunk muscles, the spine would be insufficiently stiffened, and the flexion moment is not appropriately controlled. Repetitive loading can tire the trunk muscles which in turn can lead to loss of spinal stability. (Nordin & Frankel 2012, 531-532; Watanabe et al. 2013, 83)

6 LOWER BACK INJURIES IN THE WORKPLACE

6.1 Prevalence of Musculoskeletal Disorders in the Workplace

Work-related MSD's are any MSD directly tied to an exposure at work. The most common injury reported within the workplace is musculoskeletal in nature. These musculoskeletal disorders are due to poor ergonomics and span a wide range of injuries impacting tendons, muscles, ligaments, cartilage, nerves, bones and joints. Low back pain is the chief complaint reported and most costly amongst work-related MSDs. (Dennerlein 2017, 577) It was said that at some stage during their life, roughly 80% of adults in the USA will experience back pain and an episode of acute low back pain will be experienced every year by 4-5% of the population. (Plante, Rothwell & Tufo 1997) Most of the low back disorders are due to work-related factors and ultimately compensation costs increase greatly. (Spengler, Bigos & Martin 1986) As an example, 16-19% of all worker compensation claims were because of LBD’s, but the total cost of all worker compensation costs was 33-41% (Webster & Snook 1994, Spengler, Bigos & Martin 1986). All across the globe, government agencies have declared research related to work-related MSD’s a priority due to the overwhelming burden on public health. (Dennerlein 2017, 578)

6.2 Work-related Risk Factors

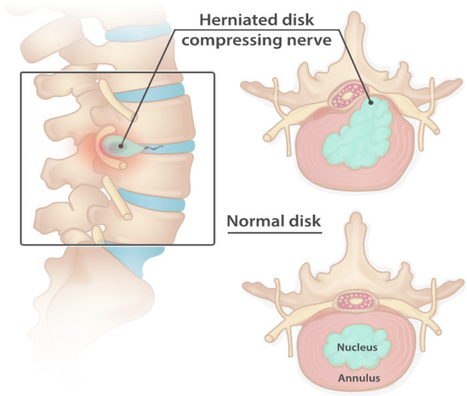
Occupations that require large amounts of manual materials handling are linked to a high incidence of low back pain. Physical demand and poor posture while carrying out tasks may result in MSD’s. Such tasks are ones that require lifting activity and pulling or pushing. (Basahel 2015, 4644) Work deemed as highly repetitive, work requiring forceful exertion and movement are all considered risk factors. (Bernard 1997) However, the level of risk varies depending on duration, magnitude and frequency of exposure to risk factors. (Lei et al 2005) Undesirable working conditions which require repetitive bending of the back and twisting when lifting objects and pushing or pulling of heavy objects are all examples which over a sustained period of time may lead to decrease in performance and an increase on postural stresses. (Trinkoff et al 2003) There is significant correlation between back pain, poor working postures and over exertion. (Krause et al 1997) A review, by the National Research Council and the Institute of Medicine (NCR/IOM) concluded that psychosocial factors are also connected to work-related MSDs (Table 2) (Dennerlein 2017, 579). There are several terms used to describe work-related MSD’s. Names such as Repetitive Stress Injuries (RSIs), repetitive motion disorders, cumulative trauma disorders (CTDs) and overexertion injuries come to mind. Examples of MSD’s affecting the back region are herniated discs, ligament sprain, muscle strain and mechanical back syndrome. (Kohn 1998, 9)

Table 2. Identifies the physical and psychosocial work-related risk factors for MSD's. (Dennerlein 2017, 579)

Body part	*Physical*	*Psychosocial*
Low back	• Lifting and or carrying of loads (manual materials handling) • Load moment • Whole body vibration • Frequent bending and twisting • Heavy physical work	• Rapid work pace • Monotonous work • Low job satisfaction • Low decision latitude • Job stress
Upper Extremity	• Repetitive tasks • Forceful tasks • Combination of repetition and force • Combination of repetition and cold • Vibration	• High job demands • High job stress

6.3 Common musculoskeletal disorders of the lower back

A herniated or slipped disc refers to a rupture of an intervertebral disc (Picture 5). Intervertebral discs are in constant states of compression and the pressure that develops in the nucleus pulposus (soft, jellylike center) may become great enough to cause a tear in the surrounding annulus fibrosus (tough, rubbery exterior) resulting in the nucleus protruding, usually posteriorly toward the spinal cord and spinal nerves. This results in possible nerve irritation, causing symptoms of pain and numbness in an arm or leg. This can occur in any region of the spine. However, most herniated discs occur in the lumbar region, as this region is responsible for carrying much of the body weight and is responsible for most of the flexing and bending movements. (Tortora & Derrickson 2014, 227) A study by Amin et al (2019) was aimed at measuring internal disc strains during repetitive lifting and their relation to disc injury. Herniation, large strains and annular protrusion in the posterolateral regions were found.



Picture 5. Herniated Disc (Website of Injurymap)

A strain and a sprain differ in that a strain is an injury to either a muscle or tendon and a sprain is the stretching and tearing of ligaments. With both muscle strains and ligament sprains a similar 3-point scale is utilized to indicate the severity of the injury (Table 3). The characteristics of ligament sprains and muscle strains, relating to degrees 1 and 2, are similar with regard to physical findings and tissue damage as well as having similar functional limitations for similar periods of time. However, a notable physical finding with regards to a 3rd degree muscle strain, is that the muscle cannot generate any force and when contraction is attempted, it appears to "ball up". (Cameron & Monroe 2007, 123)

A muscle strain is the stretching or tearing of fibers in a muscle or tendon attaching muscle to bone. The musculotendinous junction is where most muscle strains occur as it is the weakest area of a muscle. Muscle strains usually occur acutely, as a result of a single incident of improper lifting or over a period of time, by being exposed to repetitive load overuse when performing work tasks. Several factors contributing to potential muscle strain are inadequate strength or endurance of the muscle, synergistic muscle contraction, inadequate flexibility of the muscle, insufficient warm up and inadequate rehabilitation from a prior injury. (Cameron & Monroe 2007, 67-68. Tortora & Derrickson 2014, 396)

A ligament sprain is the result of a ligament being stressed past its normal capacity by a strong wrenching or twisting of a joint. This results in either a stretching or tearing of the ligaments. However, it does not lead to the dislocation of the bones. Bones are susceptible to possible fractures when ligament sprains occur. (Tortora & Derrickson 2014, 287)

Table 3. 3-point scale indicating degrees of ligament sprains (Cameron & Monroe 2007, 123)

1st degree
Minimal loss of structural integrity
No loss of motion
Little or no functional loss
Some localized tenderness and slight bruising
Return to activity immediately with some protection
Full unprotected activity 10-14 days
2nd degree
Weakening of ligament
Loss of motion
Bruising and swelling with pain at the limits of motion
Immobilization and/or protection required
Full activity 2-3 months
3rd degree
Ligament completely torn
Excessive motion and potential joint instability
Significant bruising and often bleeding in the joint

7 LIFTING ERGONOMICS

7.1 Manual Lifting Directives

According to the Finnish Government Decision on manual lifting and carrying at work (Valtioneuvoston päätös käsin tehtävistä nostoista ja siirroista työssä 1409/1993, section 2.), the employer must, when manual lifting or transfer cannot be avoided, take into account Annex 1 (Table 4) in order to reduce risk factors.

European and international directives have been developed which indicate that 25kg is an acceptable optimal lifting weight. When the lifting situation is not optimal, the acceptable limit of 25kg decreases. Factors affecting an optimal lifting situation include large load distances, asymmetry, excessive repetition and inappropriate coupling. (Coenen et al 2014, 871)

Table 4. Annex 1 (Valtioneuvoston päätös käsin tehtävistä nostoista ja siirroista työssä 1409/1993, section 2.)

1. Special features of the load - Manual lifting or moving may involve the risk of injury to the worker's back, if there is a load	**3. Special features of the work environment** - Specific features of the working environment may increase risk of injury to the worker's back in particular if:
-too heavy or too large	-there is not enough space to perform the task, especially vertically
-awkward or difficult to obtain a proper grip	-the floor is uneven and thus poses a risk of tripping, or is slippery on the workers footwear
-unstable or its contents may shift	-due to the working environment, lifting or moving cannot be done in a good position at the correct lifting height
-due to its location, it must be kept or handled away from the body or by bending or twisting the body	-the height of the floor level or work surface varies, requiring the load to be handled at different height levels

-by reason of its shape or composition, that could cause injury to the worker, particularly in the event of a collision	-the floor or footrest is unstable
	-temperature, humidity or ventilation are inappropriate
2. Necessary physical effort - Physical exertion may be associated with a particular risk of injury to the employee's back if the exertion	**4. Operational requirements** - The operation may present a risk of injury to the worker's back if it involves one or more of the following requirements
-is too strenuous	-too frequent or prolonged physical exertion, with particular strain on the back
-can only be done by rotating the body	-insufficient rest or recovery time
-could cause the load to move suddenly	-lifting or moving distance too long
-is made in an unstable position	-the pace of work determined by the process, which cannot be changed by the employee

7.2 Lifting Techniques

Stoop or squat are the most commonly researched techniques used to lift low lying objects off the floor. There is also a third technique, the semi-squat or freestyle lift, which combines elements of the stoop and squat lifts. Pictures 6, 7 and 8 demonstrate the squat, stoop and semi-squat lifting technique postures through three phases of each lift. The initiation position, when lifting from a floor level, of the squat technique, the most commonly recommended lifting technique, is a position of deep knee flexion of 45° and the torso close to straight with a flexion of less than 30°. The quadriceps and hip extensor muscles power the extension of the knees and hips during the lifts. During the stoop lift there is more flexion, around 90°, of the lower back, especially at the beginning of the lift. The knee flexion angle is more than 135° when lifting a low-lying object. More extension force is needed from the lower back and torso extension muscles. (Neumann 2010, 410-411; Straker 2003, 149-160)

Picture 6. Typical squat lifting technique posture. Picture by author (c. Cheyne Fowler)

Picture 7. Typical stoop lifting technique posture. Picture by author (c. Cheyne Fowler)

Picture 8. Typical semi-squat or “free-style” lifting technique posture. Picture by author (c. Cheyne Fowler)

During squat lifting the maximum oxygen consumption is 14,3% higher than during stoop lifting, maximum ventilation capacity is 18,7% higher and the heart rate is 6,5% higher. It can therefore be concluded, that higher aerobic capacity is required when using the squat technique for continuous lifting as it is more fatiguing. (Hagen, Hallen & Ringdahl 1993, 293-294)

Research data indicating that squat lifting imposes much lower shear forces of the spine than stoop lifting does, estimates that the shear forces for stoop lifting are a 180% greater than those for squat lifting. During a study of approximated stresses on discs and ligaments during the performance of squat and stoop lifting, it was found that there was 75% more stress on passive tissues. It has been indicated that during stoop lifting ligament recruitment in order to counter lumbar moment, is greater than during squat lifting. (Straker 2003, 152)

A third lifting technique, the semi-squat also known as freestyle lifting, combines elements of the two previously discussed techniques, namely stoop and squat lifting. The semi-squat posture taken at the beginning of extension is typically halfway between that of the squat and the stoop. It incorporates moderate knee flexion of approximately 90° and torso flexion around 45° when lifting from floor level. Results from studies comparing oxygen consumption and heart rates between semi-squat and squat lifting techniques, showed that both aforementioned rates were significantly lower than in semi-squat method. A further observation was that the maximum accepted weight limit (MAW) was less in the case of squat lifting. The conclusion found that more weight can be lifted using the semi-squat method for a similar oxygen consumption than if the squat method had been employed. It may be more desirable to educate and train regarding general lifting guidelines, as well as organized biomechanical movement patterns in order to assist the individual worker to find suitable postures and movement patterns, as there does not appear to be any lifting posture which is considered appropriate for all situations. (Straker 2003, 150; Vecchio 2017, 56-62) Table 5. Presents evidence as documented by Vecchio (2017) in support of each of the three techniques.

Table 5. Evidence in support of using squat, stoop or semi-squat lifting techniques. (Vecchio 2017, 56-62)

Squat Technique
Significantly lower lumbar shear forces
Lower lumber compressive forces
Increased tolerance of the joint to withstand compressive forces
Less lumbar passive tissue stress
Lower peak lumbar moment
Elimination of disc herniation risk
Elimination of interspinous ligament complex strain risk
Maximizing shear support by greater use of spinal musculature
Safeguards passive tissues, thus more likely to injure muscle than ligaments
Instinctive lifting method
Stoop Technique
Higher maximal accepted weights
Lower lumbar moments and compression forces
Lower inspiratory ventilation and energy expenditure
Lower quadriceps fatigue
More sustainable over longer periods of repetitive lifting
More sustainable for lifting tasks that require faster lifting speeds
Individuals are naturally inclined to stoop
Shown not be effective when attempting to change individual’s movement patterns
Semi-Squat Technique

Avoids knee and extreme lumbar ranges of motion
Higher maximum accepted weight than for squat and stoop
Less likely to injure lumbar ligaments, intervertebral discs or neural structures
Workers adopt this technique as they find it to be more of a "natural" movement pattern to lift with
Avoids high compressive forces on the knee, which may be detrimental for individuals with degenerative knee conditions
More practical to apply in most occupational environments
Less fatigue of the knee extensors; allowing workers to work over longer periods of time
Applies the best mechanics of squat and stoop and combines them into a more user-friendly approach

8 FACTORS CONTRIBUTING TO SAFE LIFTING

8.1 General considerations

In order to limit unnecessary injury, weights should be kept as constant as possible. If not possible, weight indicators should be clearly visible on the exterior of the container to be lifted. Results show that when a person is lifting an unknown weight, a certain weight is anticipated. The individual then exerts a commensurate effort based on this anticipation. When the anticipation is incorrect, and the weight is less than expected a secondary correction or a jerk occurs. This could result in an injury due to the spine being unnecessarily loaded. (Butler, Andersson, Trafimow, Schipplein & Andriacchi 1993, 1493)

In order to minimize the force demands on the back muscles, a lifted load should be as light as practical and held as close to the body as possible thereby minimizing the external torque of the load. In order to avoid excessive flexion and extension the lumbar spine should be kept as close as possible to its neutral position when lifting. The reason for this is that the intervertebral discs maybe damaged during extreme flexion combined with robust contraction of the back-extensor muscles. Conversely, apophyseal joints may be damaged during maximum extension combined with robust extensor muscle contraction. (Neumann 2010, 411)

Containers utilized during manual material handling, should preferably include handles as there have been indicators that this lessens many common risk factors connected to low back disorders. The presence of handles greatly reduces spinal loading as it minimizes the vertical distance the load must be lifted. This decreases the total exertion of the lift which in turn reduces fatigue. (Davis, Marras & Waters 1998, 1166; Neumann 2010, 411)

When there is more than one individual lifting an item simultaneously, it is important to coordinate via clear communication the synchronization of the lift. If a misunderstanding occurs, unnecessary risk is incurred (Marsh 2007, 44). In order to avoid twisting when lifting, it is advisable to move the feet or pivot if you need to alter direction. This reduces torsional forces being applied to vertebrae and helps decrease strain on the discs, muscles, tendons and ligaments of the back. (Marsh 2007, 46; Neumann 2010, 411)

Lifting should occur as slowly, and smoothly as prevailing conditions allow. Significant force and moment is caused by strong muscle contractions which are needed during very fast lifting. This in turn exposes musculoskeletal system to increased injury risk (Lin & Cheng 2017, 32-33). In order to reduce the risk of slipping and falling, the lift should occur with a reasonably wide support base provided by the legs. This also insures more comprehensive stability of the body. (Neumann 2010, 411)

Micro-breaks, short resting periods between work-related tasks, have been indicated by ergonomics research as an effective tool to alleviate musculoskeletal discomfort as well as strain associated with prolonged and/or repetitive tasks (Trougakos, Hideg, Cheng & Beal 2014, 406). Rest breaks have been shown to lead to increased levels of productivity, without a commensurate increase in time taken to complete the task.

When postural demands are high and prolonged periods of sustainable awkward positions are required, micro-breaks are especially important. To allow for recovery, minimize discomfort as well as to reduce work related musculoskeletal disorders, blood flow to the muscles can be increased by means of stretching exercises and postural changes during micro-breaks. (James 2006, 1-4)

8.2 Mechanical devices

To reduce the pressure on the back of the lifter, it is recommended, where possible, to make use of mechanical lifting aids. Pictures 9, 10 and 11 are examples of mechanical devices which are solely powered by human strength. Irrespective of the selected aid, it should always be inspected before usage and not be used if it is defective. As these mechanical devices all provide assistance, less force is required to accomplish the same task and easier handling and movement is facilitated. (Reese 2000, 25-26)

The hand truck is designed to move boxes, tall objects and heavy objects up to a limit of 250 kilograms in weight (Picture 9). It is a durable and strong steel construction with wheels that are cushioned rubber or pneumatic tires which provide resistance free movement. They are an ideal tool for movers as they are mobile and can be stored in a moving van. As multiple boxes can be moved at one time, it helps to alleviate the repetitive task of bending and lifting of boxes. (Website of The Workplace Depot)

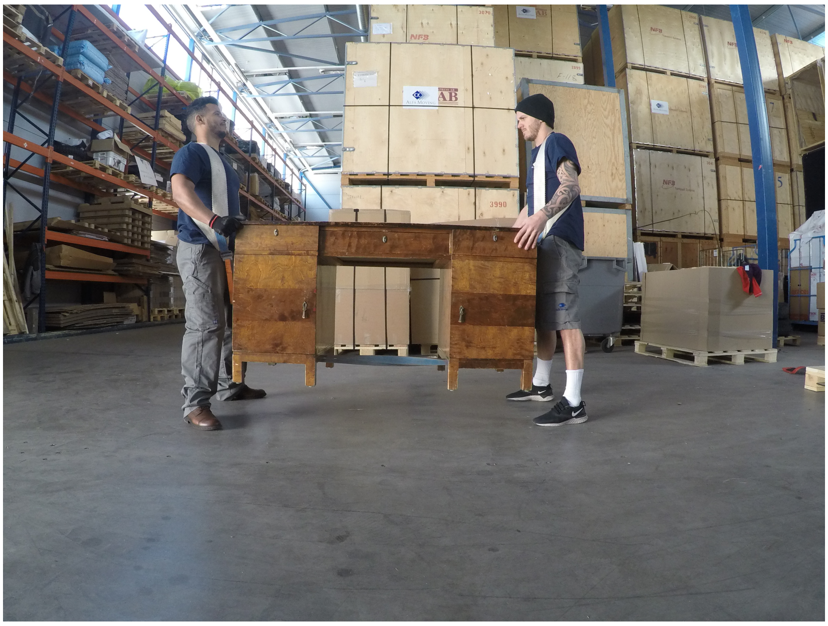
A moving or furniture dolly is the ideal product utilised in the moving of heavy items (Picture 10). This form of dolly allows for heavy items such as furniture or multiple boxes to be wheeled to its destination. This eliminates the strenuous demands normally placed on the back when carrying and all that is required is pushing and steering. It is able to bear weight ranging from 250-300 kilograms. It is constructed from a sturdy plywood platform with a non-slip coating which helps to prevent furniture or boxes from slipping when being moved. (Website of The Workplace Depot)

Lifting or shoulder dolly lifting straps have been designed to provide the users full control of their arms and hands to help stabilize the load during lifting and transit (Picture 11). This type of lifting strap system allows the weight of the object to be placed on the individual's shoulders and legs, thereby alleviating some demands placed on the back and minimizing the risk of injuries and strains in the process. It is completely adjustable, allowing for a broad variety of objects to be lifted and moved. Picture 12 illustrates two movers equipped with lifting straps, lifting an antique desk in unison. (Website of Safety Lifting Gear)

Picture 9. Hand truck. Picture by author (c. Cheyne Fowler)

Picture 10. Moving dolly. Picture by author (c. Cheyne Fowler)

Picture 11. Lifting straps. Picture by author (c. Cheyne Fowler)



Picture 12. Two movers lifting an antique desk with the aid of lifting straps. Picture by author (c. Cheyne Fowler)

9 CITY MUUTOT OY

City Muutot OY was established in 2012 and is located in Konala, Helsinki. Their Business identification number is 2466181-5 and their website is www.citymuutot.fi. The company currently has four permanent staff members and on average three part time workers. The two owners are Dennis Westerholm (Managing Director) and Peik Lekka (Director). The company provides full service moving assistance for home and office removals. This encompasses packing, transporting and unpacking services. In addition, City Muutot OY also offers secure storage facilities in Konala, Helsinki. (Website of City Muutot OY)

10 GUIDEBOOK FOR SAFE LIFTING ERGONOMICS

This thesis utilises research papers and journals as well as published books in order to assist in defining ergonomics in the workplace and the importance thereof. The research materials examined during the course of the preparation and writing of this thesis, discuss the anatomy of the back and provide details of the mechanical stability of the lumbar spine. The research on the anatomy of the back includes a brief discussion of the spine, joints and ligaments as well as the muscles of the back. The discussion of the mechanical stability of the lumbar spine concentrates on intra-abdominal pressure and trunk muscle co-contraction. Furthermore, this thesis discusses common musculoskeletal disorders of the lower back and work related risk factors which can place demands on the lower back. Also discussed in the thesis are lifting ergonomics and techniques which contribute to safe manual lifting, including a discussion of mechanical devices which can be utilised in the moving industry.

The above research and studies provide the basis for the guidebook which will be created and provided to City Muutot Oy, to be utilised by their current and future employees. The guidebook will be in the form of a pdf document which will be sent via email to City Muutot Oy who will in turn distribute it via email to their employees. The guidebook shows safe manual lifting techniques and optimal body positioning when lifting. It also indicates the function and correct usage of common mechanical devices which are in frequent use in the removals industry. Pictures with descriptive text are utilised to illustrate the above in the guidebook.

11 THESIS PROCESS AND METHOD

11.1 Thesis process

Table 6. presents the process of this thesis. This process started from the authors own experience in working part time in a manual material handling environment. After meeting and discussions with the owners of City Muutot Oy, there was a consensus between the author and the owners that there was a need for an employee guidebook that would educate their employees regarding safe lifting ergonomics. This thesis is a practical thesis which includes a guidebook pertaining to safe lifting ergonomics. A practical thesis includes a product which can be in the form of a guide, program or project (Airaksinen, 2009). Initially the author, after having worked part time for City Muutot Oy, researched and accumulated theory regarding ergonomics, physical demands due to the nature of the work as well as common injuries associate with this type of work. Study plan was produced and accepted and then approved by the supervising teacher. On completion of the theory content of the thesis, the author started compiling the guidebook for employees based on the conclusions and literature researched. During the authors part time employ at the subject company, the author observed and experienced first-hand the various lifting techniques as well as the various mechanical aids used. Pictures for the guidebook were taken by the author and the subject appearing in the picture is an employee of City Muutot Oy. The pictures were with the consent of the employee concerned.

Table 6. Timeline for thesis process

Decision made for topic	October 2019
Meeting with City Muutot Oy	November 2019
Study plan accepted and signed thesis agreement	February 2020
Research and of theoretical background writing	November 2019 - April 2020
Creating the ergonomic lifting guide	May 2020
Returning thesis to the supervising teacher and presenting the thesis	May 2020

11.2 Method

This thesis is a practice-based thesis. bThe subject researched, safe lifting ergonomics seeks to provide recommendations for workers in the removals industry, ie. City Muutot Oy employees, in order to improve their work efficiency as well as to minimize work related injuries. This thesis researches the reduction of demands on the musculoskeletal system utilizing ergonomics.

12 DISCUSSION

12.1 General

The author’s association with City Muutot Oy and their participation enabled the generation of this thesis. The aim of this thesis was to research and gather knowledge as well as evidence regarding lower back pain/injuries which are associated with repetitive manual lifting in an occupational setting. The objective was to produce a guideline and to educate warehouse and removals industry employees, ie. future and current employees of City Muutot Oy, regarding correct lifting ergonomics.

The author’s interest in the subject, as well as the decision to base the thesis on this specific topic, namely optimal ergonomic lifting, arose from his own experience of doing part-time summer work in the removals industry and experiencing first-hand the risks involved in doing hazardous manual tasks. These are tasks which require lifting, lowering, pushing, pulling or carrying objects and incorporate repetitive or sustained force, sudden or high force, repetitive movement as well as sustained or awkward posture. Being familiar with the topic enabled the author to sustain his interest. Both the researching of the scientific literature as well as the creation of the guide for optimal lifting ergonomics in the removals industry, expanded the author’s theoretical knowledge and provided meaningful information on the topic. The research commenced during the course of November 2019 and the bulk of the writing was completed during the spring of 2020.

The main challenge with regard to the researched literature on safe ergonomic lifting, was that virtually all the studies were conducted in mainly controlled environments. The author had difficulty finding studies which directly related to the removals industry, the tasks of which are very seldom conducted in a controlled environment. Over and above the aforementioned, there was also no general consensus in the researched studies conducted as to which lifting technique/posture was the most effective in relieving demands on the lower back. Having said that, the freestyle or semi squat lifting technique, appeared to be the one most commonly adopted, and it combines elements of the squat and the stoop lifting techniques/postures. In this thesis, the author included theory on the anatomy of the back, the various lifting techniques and a comparison of them as well as various mechanical devices that assist with safe lifting ergonomics.

12.2 Future Research

There appears to be more definitive research and studies done on the squat and stoop techniques as opposed to the semi-squat or freestyle technique. As this technique appears to be the one most commonly adopted in practice, more research and studies on the semi-squat technique would be beneficial and informative. Future research could also include research on the effectiveness of safe ergonomic manual lifting training and subsequent behavioural change of employees following training.

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APPENDIX 1