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Krueger, Matthew C. ***An Evaluation of Ergonomic Workstation Design for Restaurant XYZ***

Abstract

Restaurant XYZ opened in the 1960s and utilizes much of the original kitchen equipment to prepare and cook food. The original equipment and workstation layout utilized at the grilled and fried preparation workstations are placing employees at risk of sustaining musculoskeletal disorders (MSDs). Consequently tasks, tools, and workstation characteristics were evaluated to quantify the amount of ergonomic stressors which are present at Restaurant XYZ. Risk factors at were assessed include repetition, forceful exertions, awkward posture, and contact stress. Evaluation was completed by utilizing qualitative and quantitative assessment tools in order to analyze tasks, tools, and workstation characteristics. Qualitative assessment tools included the Great American Insurance Company Ergonomic Task Analysis Worksheet, The California OSHA and NIOSH Checklist for Hand Tool Selection, the Revised NIOSH Lifting Equation, and the Snook Tables. Quantitative assessment tools included a tape measure to determine workstation characteristics and a goniometer to measure joint angles via video and pictures while performing tasks. The analysis revealed the presence of numerous risk factors and provided recommendations utilized the hierarchy of engineering-based controls in addition to necessary administrative practices.

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Chapter I: Introduction

A classical ergonomics definition states that scientific information regarding human beings is applied to the design of objects and the environment (Gainer, 2008). This definition appears to persist in the modern era as the interaction of humans and their environment has increasingly been applied to the workplace. The identification of repetitive motion injuries and the subsequent application of ergonomic corrective actions to prevent musculoskeletal disorders (MSDs) is likely to have increased in numerous workplace industries. According to the Bureau of Labor Statistics, the incident rate for MSDs in the Accommodation and Food Service industry is nineteen reported MSDs cases for every 10,000 employees (Bureau of Labor Statistics [BLS], 2016). Devices and specialized equipment change over the years; however, a fundamental element of workplace design dictates that each employee's workstation should be analyzed as a whole. The correction of one piece of equipment is typically not sufficient to protect against the occurrence of musculoskeletal disorders (MSDs) which are caused by the presence of identifiable ergonomic risk factors (Emanoil, 2000). Thus, the analysis of humans' interaction with their workstations may be considered a crucial activity in order to reduce the occurrence of MSDs in the workplace.

Restaurant XYZ was established in 1966 in the small tourist town of Nisswa, Minnesota, and employs between 10 and 15 employees throughout the year. Restaurant XYZ is quick service in nature, which implies that the food is prepared on an individual order basis in a rapid manner. In contrast, many fast food establishments may prepare several common items prior to a shift and keep the food warm until purchased and prepared. Restaurant XYZ may receive 650 orders daily throughout the summer tourist months, which typically consists of orders that range from one-to-five individual meals. Completion of food preparation requires using the fried and

the grilled food preparation workstations, which are operated by no more than two employees daily. The fried food preparation workstations utilizes three fryers, a dual steam table, a fry prep pan, a completed product staging table, a stand-up freezer, and numerous overhead and adjacent bins for packaging food. The grilled food preparation workstation utilizes a flat-top grill, a cold bar section, an overhead microwave, two refrigerators, a three-pan steam table, low shelves for bun storage, and a completed product staging table.

Restaurant XYZ utilizes much of the original equipment from 1966, including various tools which are used at the food preparation workstations. Consequently, both the fried and grilled food workstations are nonadjustable from a height stand point and require the employee to perform activities such as spine flexion, overhead and outward reaching, and repetitive upper body movements that potentially place him/her at risk of developing a MSD. Additional risk is placed on the respective employees as a result of the need to stand at these workstations for an average of five to eight hours. Two previous owners have described symptoms of MSDs while operating Restaurant XYZ, while one of the individuals received carpal tunnel surgery. While no employees have missed work due to MSD illness, both the current owner and manager have experienced symptoms of MSDs and equally operate the food preparation workstations. Currently no employees have missed work due to MSD illness. Thus, it is perceived that the grilled and fried food preparation workstations at Restaurant XYZ are placing employees at risk of experiencing musculoskeletal disorders.

Purpose of the Study

The purpose of this study is to analyze the grilled and fried food preparation workstations for potential exposures to ergonomic risk factors within Restaurant XYZ.

Goals of the Study

The goals of this study include:

- Identify the specific tasks that Restaurant XYZ employees perform at the grilled and fried food preparation workstations
- Measure the extent of physical stress that is being placed on the upper extremities, lower extremities, and spine of the employees who are performing grilled and fried food preparation-related tasks
- Identify the activities and specific risk factor that are placing the grilled and fried food preparation employees at risk of developing MSDs

Background and Significance

An ergonomic analysis of Restaurant XYZ's food preparation workstations is crucial to determine the risks of developing MSDs. Past owner and employee accounts of experiencing symptoms of MSDs represent a potential for the business to lose employees and the experience they incur, reduced productivity, and sustain loss of business due to poor reviews. The potential gap left by one employee with an MSD may result in multiple negative effects in a small business. For instance, various employees, the manager, or the owner will have to the fill the gap left by the employee who experienced an MSD and consequently place themselves at risk. A poor online review may also occur as the result of slow service due to the business operating with one less employee. In a world where customers expect everything instantly, slow service as the result of a missing employee can mean individuals seeking other restaurant options in the area. Additionally, recurring injury may cause the business to acquire an adverse reputation as being an employer who doesn't care about the employees' welfare and thus lead to difficulty in

hiring replacements, increased employee turnover, and potential Occupational Safety and Health Administration (OSHA) violations for not maintaining a safe work environment for employees.

Assumptions of the Study

The assumptions of the study are as follows:

- The observed shift lengths are representative of what the employees normally work.
- The activities that are analyzed by the author of this study are representative of what the employees normally perform.

Limitations of the Study

The limitations of the study are as follows:

- The study is limited to data collection of employees who are over the age of 18 years old.
- The study is limited to the time frame of 3/1/2019 to 5/1/2019

Chapter II: Literature Review

The purpose of this study is to analyze the grilled and fried food preparation workstations for potential exposures to ergonomic risk factors within Restaurant XYZ. This chapter discusses past research relating to ergonomics and the food service industry. Past research involving musculoskeletal disorders (MSDs) has included the types of injury, correlation between ergonomic related injuries sustained in the workplace and loss of productivity, and the extent of repetitive motion illness in the food service industry. Research has identified awkward posture, repetition, forceful exertions, contact stress, lighting, vibration, extended standing, and heat stress as ergonomic risk factors. Qualitative and quantitative analysis contribute to ergonomic assessment, and the hierarchy of controls, workstation layout and tool design are essential to preventing and mitigating ergonomic risk factors.

Soft Tissue Components and Musculoskeletal Disorders

Musculoskeletal skeletal disorders (MSDs) are injuries associated with components of the same-named system of the body. Tissues and structures in the musculoskeletal system include bones, ligaments, tendons, muscles, and joints. Additionally, MSDs also affect nerves and blood vessels that are a part of the nervous and cardiovascular system respectively. Musculoskeletal injuries with a chronic onset as the result of micro traumas are often referred to as Cumulative Trauma Disorders (CTDs) (Putz-Anderson, 1988). Cumulative Trauma Disorders can occur to both the upper body and lower body and involve body tissues such as tendons, nerves, muscles, blood vessels, joints, and bursas (Buckle & Devereux, 2002).

Tendons. Tendons are tissue that connect muscles to bones. Injuries result from over stretching of the tendon as collagen containing fibers tear apart (Kroemer, 1989). A tendon that is subject to forces past the point of failure is referred to as a strain and may be stretched acutely

or repetitively. The body generates scar tissue in place of collagen fiber, which creates chronic tension on the tendon and increases the risk of reinjury (Kroemer, 1989). Tendonitis is an inflammation of a tendon due to repetitive forces and commonly found in areas including the shoulder and arms (Putz-Anderson, 1988). Tissues called sheaths surround several tendons and contain synovial fluid, which is used as lubricant to assist tendon contraction (Kroemer, 1989). A reduction in synovial fluid may occur and the sheath become inflamed due to friction forces (Kroemer, 1989). Inflammation is a protective response of the body, and signs include warmth and swelling due to an increase in blood flow (Kroemer, 1989). The Achilles, which attaches the calf muscle to the heel, is an example of a tendon with a sheath. Inflammation of a sheath is referred to as Tenosynovitis. Repeated movement of the tendon will cause increased damage and inflammation, resulting in thickening of the tendon sheath (Kroemer, 1989).

Stenosing tenosynovitis is a condition involving a sheath thickening to the point of constricting a tendon (Kroemer, 1989). A common type of stenosing tenosynovitis is called De Quervain's disease and involves a sheath around the abductor and extensor tendons of the thumb (Kroemer, 1989). Swelling of a synovial fluid filled sheath may occur and cause a bump underneath the skin called a ganglionic cyst or cystic tumor (Kroemer, 1989). Irritation of tendons may occur at attachment points of bones resembling symptoms of epicondylitis. Forearm tendons which attach to the medial and lateral epicondyle of the elbow may become irritated by friction forces. Golfer's Elbow is a common term for medial epicondylitis and Tennis Elbow refers to lateral epicondylitis (Kroemer, 1989).

Nerves. Repeated or sustained pressure from other surrounding structures or equipment may affect the transmission of nerve signals throughout the body (Kroemer, 1989). Pressure placed on nerves may originate from bones, ligament, or tendons or may be caused by

interactions with tools, surfaces, or equipment (Kroemer, 1989). Symptoms of nerve impingement include numbness and tingling in the affected area. Carpal tunnel syndrome of the wrist is a common example of nerve compression injury. Symptoms of Carpal Tunnel Syndrome include discomfort, numbness, and tingling in the hands (Kroemer, 1989). Less common examples of nerve compression include Cubital Tunnel Syndrome, Pronator Teres Syndrome, Cervical Syndrome, and Digital neuritis (Putz-Anderson, 1988).

Muscles. Muscles are made of thousands of fibers that extend and contract by means of neurological stimulation and the body's metabolism. A minor strain or irritation may occur and result in temporary aching and inflammation (Kroemer, 1989). Performing a task that is not normally executed may subsequently result in an aching muscle and is an example of temporary irritation. Fibers may extend to the point of failure and be torn apart which results in a strain (Kroemer, 1989). Muscles strains may result in inflammation symptoms such as swelling and warmth. Finally, blood supply can be interrupted due to trauma and thus result in the muscle decreasing in size. Muscles in need of blood may shrink due to insufficient oxygen supply (Kroemer, 1989).

Circulatory system. Compression by other structures in the body can occur to blood vessels and negatively affect blood flow and oxygen supply (Putz-Anderson, 1988). The most common type of blood vessel compression is in the shoulder and is referred to as Thoracic Outlet Syndrome. Thoracic Outlet Syndrome occurs as a result of decreased blood flow to the brachial plexus in the shoulder due to excessive pressure placed on blood vessels (Putz-Anderson, 1988). Thoracic Outlet Syndrome symptoms may experience tingling of fingers and arm numbness (Putz-Anderson, 1988). Vibration syndrome is the closure of the digital arteries of the hand due to prolonged or forceful use of tools (Putz-Anderson, 1988). Repetitive forces can cut off blood

supply to the fingers and cause tissues in the hand to become inflamed. Fingers affected by Vibration Syndrome will appear pale and cold (Putz-Anderson, 1988).

Ligaments. Ligaments are tissues that connect joint-related bones and assist in maintaining motions within the normal range of motion (Putz-Anderson, 1988). A sprain can occur when ligaments, like tendons, become over extended to the point of failure. Ligaments are commonly ruptured completely as a result of high force impacts and motions and not as a result of cumulative trauma (Putz-Anderson, 1988). Repetitive overstretching of ligaments can contribute to permanent joint instability over time (Putz-Anderson, 1988). Individuals may be disposed to greater risks of injury as range of motion increases over time due to repetitive stretching forces to the ligament (Putz-Anderson, 1988).

Bursa. A bursa is a fluid-filled sac that provides lubrication between a joint and the closely-located bones (Kroemer, 1989). Similar to oil for a car, a bursa assists in the movement of high repetitive motions of the body. Commonly injured bursas are located in the shoulders, elbows, and knees. Bursas may be injured acutely by an impact to the structure or chronically by repetitive motion. An inflamed bursa is referred to as bursitis (Kroemer, 1989).

Workplace Musculoskeletal Injuries and Employee Loss Time

Research surrounding the correlation between MSDs sustained in the workplace and lost time due to employee injury differs on the amount of decreased productivity. Agreement exists that MSDs contribute to decreased productivity in the workplace. The average employed person loses almost two workdays every year due to musculoskeletal issues (Putz-Anderson, 1988). Lost productivity due to employee injury-related absence may have substantial effects on a business. Productivity expectations of a business are required regardless of whether the organization is fully staffed or if employees are absent due to injury. Consequently, uninjured

and present employees may be required to supplement the lost labor-related productivity as a result of the injured individual losing time away from work.

The Bureau of Labor Statistics (BLS) indicated that MSDs play a significant role in employee absence. The Bureau of Labor Statistics states there were 1,153,490 days away from work in 2015 due to injury in private industry, state, and local government sectors, while MSDs accounted for 31% of the total cases (Bureau of Labor Statistics [BLS], 2016). These statistics denote the number of workdays employees of private industry, state, and local government businesses experienced loss of productivity due to injuries. Private industry accounted for 80% of MSDs injuries with 286,350 incidents and a median of 12 days away from work (BLS, 2016). Local government received the second highest number of MSD incidents at 54,190 for a median of 10 days away from work, and state-based government recorded 16,380 MSD incidents for a median of 15 days away from work (BLS, 2015). Total MSDs accounted for 356,910 injuries that resulted in a median number of 12 days away from work (BLS, 2016). The Bureau of Labor Statistics (2016) indicates that MSDs contribute to a significant amount of lost productivity by means of employee absence in 2015.

Food Service Industry Musculoskeletal Disorders

Research involving musculoskeletal disorders in the food-service industry has been limited by irregular access of human resources due to the high level of seasonal and part time work within the field (Laperriere, Messing, & Bourbonnais, 2016). The food industry has a high employee turnover rate and employs a large percentage of young individuals (Laperriere et al., 2016). Long-term studies on employees with MSDs may need to end abruptly in the event the employees leave for other employment opportunities. Food industry jobs are generally low paying and the associated employees may not have access to vacation or paid time off benefits,

which potentially results in high turnover (Laperriere et al., 2016). The food industry employs the largest part-time fraction of part-time employees and the second largest provisional worker population (Laperriere et al., 2016). The presence of part-time employees may potentially limit the quality of studies due to time required for in-depth research endeavors. Food service jobs often require employees to work irregular hours (Laperriere et al., 2016). Irregularity of employee hours may limit necessary contact time with employees similar to part-time work. The above employee employment issues may be why there is a deficit of research involving MSDs in the food industry.

Musculoskeletal injuries may play a significant role in the occurrence of days away from work for food service employees. The relationship of 2015 BLS statistics may assist in quantifying the amount of loss which occurred to the private food service industry. Potential contributing factors of employee loss time due to injury may include musculoskeletal incidents, the percentage of injuries sustained in private industry, and the amount of non-fatal injuries which occurred in food service-related occupations within the private sector. Musculoskeletal disorders accounted for 31% of all incidents in 2015 for private, state, and local government sectors, while private industry incurred 80% of the total reported MSDs (Bureau of Labor Statistics, 2016).

Simultaneously, the majority of injuries in many food service-related occupations occurred in private industry, which indirectly reveals the loss to food service jobs in private industry due to musculoskeletal disorders. The majority of injuries for nonfatal occupational injuries and illnesses involving days away from work were found in private industry in 2015 when compared to state and local governments. Food preparation workers in private industry sustained 90.2% of non-fatal injuries for a median of six days away from work compared to

other sectors (BLS, 2016). Institution-based cooks and cafeteria workers sustained 54.5% of non-fatal injuries for a median of five days away from work compared to other sectors (BLS, 2016). Chefs and head cooks sustained 97.2% of non-fatal injuries for a median of five days away from work compared to other sectors. Thus, the Bureau of Labor Statistics information may indicate loss has occurred in the private industry driven occupation of food service as a result of musculoskeletal disorders.

Ergonomic Risk Factors

The identification of risk factors is essential to mitigating and preventing ergonomic illnesses. Ergonomic risk factors are well documented and address issues which include awkward posture, repetition, forceful exertions, contact stress, lighting, vibration, extended standing, and heat stress. Cohen et al. suggests the three greatest ergonomic risk factors include awkward posture, repetition, and forceful exertions. The potential of a MSD increases if two of the three factors exist in a situation (Cohen, Gjessing, Fine, Bernard, & McGlothin, 1997).

Awkward posture. Awkward postures include body positions that are stationary and not natural. Lifting loads unevenly may result in excessive strain to a joint (Putz-Anderson, 1988). The body is evenly balanced, and unequal weight on one side by means of carrying or reaching with a load may cause excessive force to be placed on joints, resulting in injury. Fixed positions may cause excessive pressure to be placed on structures of the body (Putz-Anderson, 1988). Extended standing in one position without movement or contracting a muscle for a lengthy period of time may cause damage to muscles and joints, resulting in MSD symptoms. Unbalanced, awkward, and stationary body postures may lead to musculoskeletal disorders (Putz-Anderson, 1988).

Repetition. Repetitive manipulations for extended periods of time may contribute to musculoskeletal failure (Luttmann, Jager, Griefahn, Caffier, Liebers, & Steinberg, 2003). Insufficient recovery time between repetitive motions or lack of variation in the movement may result in musculoskeletal failure (Luttmann et al., 2003). The human body adapts well to stresses placed on structures, however, time is required for soft tissue recovery. Tendonitis is an example of a MSD injury due to repetitive motion. The repetition risk factor depends on the body part (Cohen et al., 1997). Particular parts of the body are better at repetition recovery than other areas. The high-risk rate for the shoulder and the finger is more than two and a half times a minute and more than two hundred times a minute respectively (Cohen et al., 1997). The shoulder is at a high risk for an MSD if contractions occur continually for more than two and a half times a minute without sufficient recovery time. Similarly, fingers are at high risks for an MSD if motions occur continually for more than 200 times a minute without sufficient recovery time. The risk is increased if awkward posture or excessive force are present (Cohen et al., 1997). Repetitive motions without sufficient recovery time between muscle contractions may lead to musculoskeletal injury.

Forceful exertions. Forceful exertions of muscles are commonly referred to as dynamic loading and require more demand from the body's musculoskeletal system than routine movements. The expenditure of forceful exertions may overload the muscle and result in a musculoskeletal injury (Luttmann et al., 2003). Body structures are subject to great forces during high intensity movements which may place the body at risk for injuries such as sprains and strains. A sprain is a tear of a ligament while a strain is a tear of a muscle or tendon. Similarly, static loading of muscles may lead to musculoskeletal injury (Luttmann et al, 2003). Static loading occurs when a muscle is tensed over a period of time which consequently does not

provide adequate recover time (Luttmann et al, 2003). There is no change to muscle length during static loading, however, the muscle remains contracted over a period of time which may result in an increased risk of injury and fatigue. Repetitive forced exertions may cause fatigue of the body, which predisposes the individual to injury (Luttmann et al., 2003). A fatigued individual may be more likely to have poor posture as other structures in the body compensate for the exhausted muscles. Dynamic and static loading of muscles may contribute to increased risk of musculoskeletal injuries.

Contact stress. Contact stress occurs as a result of frequent interaction between the body and a hard or sharp surface (Cohen et al., 1997). The most common example is working at a computer station where the keyboard is situated on a surface with a square edge. In this scenario, an individual's forearms may contact the table or desk edge while typing on the keyboard. Blood vessels and nerves in the affected area may become irritated and function may become inhibited (Cohen et al., 1997). Symptoms of contact stress include tingling and numbness of the affected structures. Musculoskeletal disorder symptoms may occur as a result of contact stress risk factors.

Lighting. Lighting should be taken into consideration in workstations. Arguably the most common eye injury resulting from poor lighting are eyestrains. Eyestrain, also known as asthenopia, refers to a variety of symptoms, including irritation and dryness of the eye, blurred vision, and headaches (Rajnarayan, Saha, & Parikh, 2011). Poorly lit workstations require operators to focus more intensely on tasks and thus result in eyestrain symptoms. Several environmental factors should be taken into consideration at workstations including illumination, glare, brightness, and viewing angles (Rajnarayan et al., 2011). Personal factors that should be taken into consideration include stress, uncorrected vision, and posture (Rajnarayan et al., 2011).

Workstations should provide lighting that facilitates efficiency of performing tasks, safety, and employee comfort level (Kralikova & Wessely, 2016). Providing illumination that is appropriate for the task at hand and considering environmental and personal factors may prevent ergonomic risk factors involving appropriate lighting.

Vibration. Vibration as an ergonomic risk factor occurs when body parts directly contact vibrating tools or surfaces (Kroemer, 1989). The result is vascular compression caused by repeated irritation to blood vessels. A common example of vibration as an ergonomic risk factor is the use of power tools for an extended period of time. An individual who uses hand-held power tools on a regular basis may develop Raynaud's Syndrome, which is characterized by repetitive irritation to the blood vessels in the hands, resulting in inflammation and paleness due to lack of blood flow. Similarly, exposure to vibrating surfaces may increase the risk of MSD injury to the back. Whole body vibrations may increase the risk of injury or degenerative disorders of the thoracic and lumbar spine (Luttmann et al., 2003). A common example of whole-body vibration exposure involves sitting within heavy equipment while working on uneven surfaces. Repetitive exposure to vibrating tools and surfaces may increase the risk of MSDs injuries.

Heat stress. Heat stress occurs as a result of increased cardiac output needs due to high workplace temperatures (Cohen et al., 1997). The heart requires additional effort to keep the body cool as heat exposure occurs. Blood may not be able to carry enough oxygen to the body, and thus result in increased fatigue and decreased performance (Cohen et al., 1997). The capacity for physical activity may decrease, and fatigue will set in to predispose individuals to suffer injuries if work requirements are not adjusted accordingly for temperate exposure.

Qualitative and Quantitative Assessment Tools

Ergonomic assessments are necessary for the prevention and mitigation of musculoskeletal disorders. Ergonomic assessments evaluate workplace environments and human postures that influence bodily stress (Herzog & Buchmeister, 2015). Workplace environments are assessed by means of evaluating temperature, lighting, noise, and humidity (Herzog & Buchmeister, 2015). The workplace is assessed to evaluate risk factors such as awkward posture, repetition, and force (Herzog & Buchmeister, 2015). Qualitative and quantitative assessments are both utilized based on necessity of the analysis and capabilities of the tool. Qualitative assessments include the Great American Insurance Company Ergonomic Task Analysis Worksheet, Snook tables, and the NIOSH lifting equation.

Great American Insurance Company Ergonomic Task Analysis Worksheet. The Task Analysis Worksheet is a tool used to recognize, assess, and control ergonomic risk factors (Great American Insurance Company, 2004). Tasks are organized by risk factor and scored as either ideal (meaning hazards are within acceptable limits), warning level (meaning there is a potential concern), or take action (meaning that corrective action needs to be taken) (Great American Insurance Company, 2004). Several sections address repetition, posture vibration, reach, force, static loading, contact stress, manual materials handling, and environmental risk factors. The repetition section assesses repetitive tasks involving standing, sitting, the head and neck, hands, and wrists. The posture section addresses head and neck, hands, and wrist concerns (Great American Insurance Company, 2004).

A section of the Great American Insurance Company Ergonomic Task Analysis Worksheet asks if hand, arm, or whole-body vibrations are present during tasks. The Reach/ Height section analyzes location and angles of the arms and trunk during the tasks. The force

section assesses the weight and frequency of lifts, the presence of pinch and power grip, and the properties of tools and objects being moved (Great American Insurance Company, 2004). Static loading and fatigue addresses lack of movement concerns, contact stress examines whether tools and surfaces have impacted commonly affected body areas, and material handling discusses the amount of lifting, pushing, pulling, and high intensity forces used during tasks. Finally, the environmental section analyzes work pace, lighting, temperature, noise, and flooring surfaces (Great American Insurance Company, 2004).

Risk factors identified during the analysis are summarized at the end of the survey by severity of risk. Risks that are found to be at the take action level should be prioritized. An advantage of the Task Analysis Worksheet is the simplistic and arguably easy-to-follow layout which allows utilization to be feasible in a range of settings. The action plan section of the worksheet allows the evaluator to summarize concerns simplistically, which may be easy to present to an organization's leadership. The Great American Insurance Company Ergonomic Task Analysis Worksheet is found in Appendix A.

Snook Tables. The Liberty Mutual Manual Materials Handling Tables were originally published by Dr. Stover Snook in 1978 (Liberty Mutual Insurance, 2012). The Snook tables are utilized to calculate the percentage of a male or female population that can perform a task without overexertion (Liberty Mutual Insurance, 2012). Eleven sets of tables allow for analysis of lifting, lowering, pushing, pulling, and carrying tasks. An advantage of the Snook Tables is the in-depth analysis that can be performed due to the amount of information that must be known ahead of time. The evaluator must have knowledge of the frequency of the task, the weight of the object, the traveling distance, and either the hand distance, the hand distance of the body, or the pushing, pulling, and carrying distance. The result of the input data is the percentage of the male

or female population which can perform a task without over exertion (Liberty Mutual Insurance, 2012). As a general rule, tasks should be designed for at least 75% of the working population to accomplish (Liberty Mutual Insurance, 2012). The Liberty Mutual Manual Material Handling Tables are found in Appendix B.

Revised NIOSH Lifting Equation. A common qualitative methodology of ergonomic assessment is a lifting equation developed by the National Institute for Occupational Safety and Health (NIOSH). The Revised NIOSH Lifting Equating is designed to provide a recommended weight limit (RWL) that nearly every healthy worker could perform in an eight-hour period (Waters, Putz-Anderson, & Garg, 1994). The lifting equation considers the object's weight, the horizontal and vertical position, any spine twisting angles, the duration of the lift, the frequency, and coupling factor (Waters et al., 1994). An advantage of the NIOSH lifting equation is the in-depth analysis an assessor is able to achieve of a single lift, however, the equation is unable to include environmental factors which may affect the lift. The following equation and definitions describe how the Revised NIOSH Lifting may be used to assess a lift.

RWL=LC x HM x VM x DM x AM x FM x CM

RWL=51 x (10/H) x 1-(.0075[V-30]) x .82+(1.8/D) x 1-(.0032A) x FM x CM

LC= 51

HM= (10/H)

VM= 1-(.0075[V-30])

DM= .82+(1.8/D)

AM= 1-(.0032A)

FM= See Figure 1: Frequency Multiplier Table (FM)

CM= See Figure 2: Coupling Multiplier (CM)

- The Recommended Weight Limit (RWL) is the weight of the load nearly all healthy workers could lift for an eight-hour period (Waters et al., 1994).
- The Lifting Index (LI) is an estimation of physical stress accompanying a lift and is a product of the load weight (L) divided by the RWL (Waters et al., 1994).
- Horizontal Location (H) is the measure from the midpoint of the ankles to the center of the object being moved (Waters et al., 1994).
- The Vertical Location (V) is the distance the hands are from the floor (Waters et al., 1994).
- The Vertical Travel Distance (D) is the how far vertically the load was lifted or lowered (Waters et al., 1994).
- The Asymmetry Angle (A) is how much the body was rotated in degrees from the start of the lift to the end.
- The Frequency Multiplier (FM) table is found as Figure 1 and depends on the frequency and duration of the lifts and vertical location at the start of the lift (Waters et al., 1994).

Frequency Multiplier Table (FM)

Frequency Lifts/min (F) ‡	Work Duration					
	≤1 Hour		>1 but ≤2 Hours		>2 but ≤8 Hours	
	V < 30†	V ≥ 30	V < 30	V ≥ 30	V < 30	V ≥ 30
≤0.2	1.00	1.00	.95	.95	.85	.85
0.5	.97	.97	.92	.92	.81	.81
1	.94	.94	.88	.88	.75	.75
2	.91	.91	.84	.84	.65	.65
3	.88	.88	.79	.79	.55	.55
4	.84	.84	.72	.72	.45	.45
5	.80	.80	.60	.60	.35	.35
6	.75	.75	.50	.50	.27	.27
7	.70	.70	.42	.42	.22	.22
8	.60	.60	.35	.35	.18	.18
9	.52	.52	.30	.30	.00	.15
10	.45	.45	.26	.26	.00	.13
11	.41	.41	.00	.23	.00	.00
12	.37	.37	.00	.21	.00	.00
13	.00	.34	.00	.00	.00	.00
14	.00	.31	.00	.00	.00	.00
15	.00	.28	.00	.00	.00	.00
>15	.00	.00	.00	.00	.00	.00

Figure 1. Frequency multiplier (FM). (Waters et al, 1994)

Coupling Multiplier

Coupling Type	Coupling Multiplier	
	V< 30 inches (75 cm)	V ≥ 30 inches (75 cm)
Good	1.00	1.00
Fair	0.95	1.00
Poor	0.90	0.90

Figure 2. Coupling multiplier (CM). (Waters et al, 1994)

Quantitative assessment tools. There are numerous instruments available to assist in ergonomic assessment. Goniometers allow the assessor to collect information regarding joint angles in degrees. Quantitative measurement of range of motion is important in the diagnosis of injuries (Rezende, Alves, Marques, Silva, & Naves, 2018). Goniometers can be mechanical or electromechanical and are used to measure the articular motion of joints (Rezende et al., 2018). Mechanical goniometers may be more common due to cost effectiveness and accessibly of use. The goniometer is placed at the pivot point of the joint with both arms aligned with adjacent bones of the body. The angle of the articulation is read from the center pivot point of the goniometer. The results of a joint's motion during an assessed task can be compared to the required joint angle for an improved task.

An individual's joint-related range of motion can be assessed by video analysis (Rezende et al., 2018). Video-based analysis techniques allow the assessor to record information, such as range of motion, reaches, and angles in real-time and review tangible anecdotal information. A combination of video-based analysis and a goniometer use may be utilized for increased accuracy of assessment. Force gauges are used to quantify push and pull needed in tasks. Force gauges may be mechanical or electromechanical in nature in that tension causes an analogue display to rotate or a digital screen to display force respectively based on energy needed to move an object. Similar quantitative assessment tools are utilized for respective risk factors.

Thermometers, commonly mercury or electronic, are used to assess temperature of workstations. Mercury in a glass tube changes height with temperature. The height of the mercury denotes that temperature and is displayed on the thermometer. Electronic thermometers use a thermocouple sensor, and the temperature is displayed on a screen. Noise dosimeters have a variety of functions but commonly use a microphone to collect sound-based information for eventual analysis. A light meter collects quantities of illuminance in order to evaluate brightness of work areas. Many tools are available and may be used in conjunction with one another to assess the entire ergonomic risk of a situation.

Hierarchy of Ergonomic-Based Controls

A two-tiered hierarchy of control system is widely accepted as a means to prevent and mitigate hazards in the workplace, including ergonomic risks (Cohen et al., 1997). Generally speaking, engineering controls change the workstation to meet the individual's needs and administrative controls change the employees' behavior to meet the work needs (Kroemer, 1989). Administrative controls should be used as a means to minimize risk, as temporary correction or the issue, or if engineering controls are not available (Cohen et al, 1997).

Engineering controls are the preferred approach to minimize ergonomic risk and should be designed to moderate and remove hazards (Cohen et al., 1997). Engineering controls typically isolate the individual from the hazard or reduce the hazard to acceptable levels. Engineering controls should design the job to fit the employee (Cohen et al., 1997). Methods to control ergonomic risk factors by means of job design include workstation and tool layout as well as material selection (Cohen et al., 1997). Examples of engineering controls in the workplace include using lift assist devices, modifying containers for easier handling, engineering more ergonomic grips on tools and having workstations capable of adjustable heights. If

feasible, ergonomic risk factors should be controlled via engineering controls as a first line of defense (Cohen et al., 1997).

Administrative controls attempt to dictate behavior to reduce exposure to hazards (Cohen et al., 1997). Policies, procedures, and work practices are modified to decrease risk, however, administrative controls do not fully isolate the employee from exposure. Strategies for administrative controls should focus on job rules, shift rotations, and awareness of ergonomic risks (Cohen et al., 1997). Administrative control examples include employee rotation during strenuous tasks, decreased shift length or increased breaks, training, and awareness on hazards. Administrative controls only reduce ergonomic risk factors and should be used only after engineering control efforts have been exhausted (Cohen et al., 1997).

Ergonomic Workstation Design Guidelines

The overall goal of incorporating ergonomic principles to workstation design is to improve worker productivity by reducing efforts that are not essential, minimize the risk of overexertion and fatigue, and use employee skills to increase job satisfaction and fulfillment (Eastman Kodak Company, 2004). This is accomplished by fitting the workstation to the operator's needs and should be designed to fit as many people as possible (Eastman Kodak Company, 2004). Several demographic factors must be considered when designing workstations, including gender and age (Eastman Kodak Company, 2004).

Capabilities to complete tasks may vary between gender and age. An individual who is seventy years old may have a harder time flexing or extending at the waist than an eighteen-year-old employee. A female may have a difficult time performing a task requiring an isometric handgrip if it was designed to fit the maximum strength of the average male (Eastman Kodak Company, 2004). If the task previously mentioned is designed to fit 95% of the female

population, the majority of the work force would be able to perform the task (Eastman Kodak Company, 2004). Ergonomic considerations in workstation design is essential for employee productivity, health, and job satisfaction (Eastman Kodak Company, 2004).

Numerous templates exist for the assistance of determining appropriate workstation parameters. A common tool utilized in workstation analysis is Kodak's Ergonomic Design for People at Work (Eastman Kodak Company, 2004). Anthropometry is the study of people's physical dimensions by means of measuring human characteristics (Eastman Kodak Company, 2004). Anthropometric data found in Eastman Kodak's book allows the workstation evaluator to view commonly accepted parameters from numerous subjects of workplace design, including physiological needs such as height and reach considerations as well as guidelines to address ergonomic risk factors, including manual handling, carrying objects, tool grips, and exerting forces (Eastman Kodak Company, 2004).

Carrying bags and boxes could be considered as being critical to the food service industry. Delivery trucks transport a variety of shapes, sizes, and weights of bags and boxes of food and other items to sustain a food service-based organization. Anthropometric data may be used to assist in workstation and tool design including parameters on lifting objects. Table 25-1 in *Kodak's Design for People at Work* provides an example of anthropometric data that can be applicable to the food service industry (Eastman Kodak Company, 2004). Figure 3 below displays Table 25-1 and describes the maximum number of bags that should be lifted per shift by one individual based on vertical height above the floor and the weight of the bag (Eastman Kodak Company, 2004).

Additionally, the standard food bag weight in the United States is 50 pounds, and lifts should be kept between 20 and 40 vertical inches (Eastman Kodak Company, 2004).

Consequently, all incoming items should be in bags less than 50 pounds. If an ergonomic risk is found, an organization may find this anthropometric data useful to contact vendors to deliver products in smaller bags, rearrange a delivery staging area so employees do not have to flex the spine over to pick up items, or incorporate a worker rotation schedule so employees are not exposed to repeated lifting.

Vertical Height Above Floor** cm (in.)	Maximum Number of Bags to Be Lifted per Shift*			
	Weight of Bag, in kg (lbm)			
	16 (35)	25 (55)	34 (75)	45 (100)
25–102 (10–40)	500	250	50	<10
103–127 (41–50)	250	100	<10	N.R.
128–152 (51–60)	100	50	<10	N.R.

Figure 3. Maximum number of bags to be lifted per shift. (Eastman Kodak Company, 2004)

Ergonomic tool design guidelines. Tool design is an important aspect of ergonomic assessment. There are numerous ergonomic concerns to take into account when designing tools to address awkward postures, power grips, contact pressure points, pinch grips, single handle and double handled instruments (California Occupational Safety and Health Administration Consultation Service, California Department of Industrial Relations and the National Institute for Occupational Safety and Health, 2004). The appropriate tool for a job allows the individual to work comfortably and reduces forces associated with ergonomic risk factors (California Occupational Safety and Health Administration Consultation Service et al., 2004). The wrong

tool for the job may place individuals at risk for injuries. There are numerous guidelines available to assist in tool design, including several checklists.

A checklist developed by California's Occupational Safety and Health Administration and the National Institute of Occupational Safety and Health is an uncomplicated way to compare tools against design characteristics (California Occupational Safety and Health Administration Consultation Service et al., 2004). Eleven checklist items evaluate ergonomic concerns, such as grip diameter, length and span, textures of handles, and usage concerns, such as high force tasks. A checklist asks numerous questions, and the evaluator is required to check a box if the tool is within the described design characteristic. If the tool is not within acceptable parameters, no check is made and the evaluator is able to refer back to the item and correct the potential ergonomic risk. The Checklist for Hand Tool Selection is found in Appendix C.

Ergonomic tools have been developed for the food service industry. Ergonomic devices to assist food service employees are associated with food preparation, manual material handling in the kitchen, stocking supplies, transporting food, and dishwashing (University of California Ergonomics Project Team, 2012). For purposes of this study, ergonomic tools will only be mentioned that may potentially be associated with food preparation workstations. Figures 4-12 below from the University of California Ergonomics Project Team describes ergonomic-based tools used to reduce risk factors and assist employees in the food service industry in tasks including opening lids, cutting and mixing, and piping, lifting, and moving food containers (University of California Ergonomics Project Team, 2012).

	**Criteria:**	Reducing strain on the hand and wrist while opening food containers
	Application:	Opening food container pail lids

Figure 4. Lid opening assist. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Automated equipment to reduce repetitive motions and force during food preparation
	Application:	Automate cutting, slicing, opening cans, and other repetitive food preparation tasks

Figure 5. Automated food preparation. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Reducing hand and wrist strain from manual mixing
	Application:	Mixing viscous foods

Figure 6. Mixing assist. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Automates the piping process, replaces a pastry bag
	Application:	Automates piping such as batter, fruit fillings, frostings, creams and custards

Figure 7. Automated piping process. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Refrigerated salad bars (requiring no ice)
	Application:	Self-serve salad bars

Figure 8. Self-serve salad bar. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Gravity-assisted ice storage and transport system
	Application:	Loading and transporting ice from kitchen to areas of use

Figure 9. Gravity-assisted ice machine. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Moving dining equipment or product; providing height adjustability at work area for dining staff
	Application:	Hydraulic stainless steel height adjustable mobile carts provide clean work surfaces for food prep or equipment for staff of different heights. The carts can be moved out of the way when not needed.

Figure 10. Adjustable height equipment. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Automate lifting and tipping heavy mixing bowls
	Application:	Lifting and tilting large mixing bowls in bakery and pot washing area

Figure 11. Lifting assists. (University of California Ergonomics Project Team, 2012)

	**Criteria:**	Storage systems/racks for storage and retrieval of goods
	Application:	Storage of variety of food supplies and stock

Figure 12. Movable storage racks. (University of California Ergonomics Project Team, 2012)

Summary

The identification of musculoskeletal disorders and the subsequent development of ergonomic improvement-related activities may contribute to prevention and mitigation of lost employee time and company resources due to injury. This chapter discussed past research relating to ergonomics and the food service industry, including musculoskeletal disorders (MSDs), ergonomic risk factors, ergonomic assessments, and workstation controls. Both qualitative and quantitative analysis may be used to contribute to an ergonomic assessment in the food service industry. The Great American Insurance Company Ergonomic Assessment Worksheet, Snook tables, and the Revised NIOSH Lifting Equation are qualitative tools that may assist in ergonomic analysis. Goniometers, force gauges and video-based analysis are quantitative instruments used to identify risk factors. Workstation layout and tool design are essential to preventing and mitigating ergonomic risk factors in the food service industry. The

hierarchy of controls is utilized to reduce ergonomic risk. Administrative controls should be utilized if engineering is not feasible. Kodak's Design for People at Work contains anthropometric information which may assist in workstation layout and numerous checklists are available for tool design including the California OSHA/ NIOSH checklist. The above-mentioned ergonomic workstation analysis approaches will be used to assess Restaurant XYZ's food preparation area to determine the extent of ergonomic risk factors that may be present. Once identified, then the ergonomic risk factors will be analyzed for the purpose of making realistic recommendations to management in order to reduce the physical stressors that the applicable employees may be experiencing.

Chapter III: Methodology

The purpose of this study was to analyze the grilled and fried food preparation workstations for potential exposures to ergonomic risk factors within Restaurant XYZ. This study includes three ergonomic-based goals in order to accomplish the purpose of the study and include:

- Identify the specific tasks that Restaurant XYZ employees perform at the grilled and fried food preparation workstations
- Measure the extent of physical stress that is being placed on the upper extremities, lower extremities, and spine of the employees who are performing grilled and fried food preparation-related tasks
- Identify the activities and specific risk factors that are placing the grilled and fried food preparation employees at risk of developing MSDs

Subject Selection and Description

The evaluator did not use human subjects to complete this study. Data collected for food preparation tasks, lifts, and tool manipulations were completed by the researcher after Restaurant XYZ's operating hours were closed. Pictures and videos utilized for task analysis were taken solely at the researcher while he performed the analyzed tasks. No human interaction was necessary for quantitative measurement needed for workstation and tool analysis. For purposes of this study, workstation, tool, and task analysis were only completed for duties relating to food preparation or maintenance of the grilled and fried food workstations.

Instrumentation

Several qualitative and quantitative instruments were used during this study to analyze workstations at Restaurant XYZ. In order to utilize each instrument for analysis, food

preparation tasks were identified prior to the formal ergonomic assessment process. Identified tasks are found in the Data Collection Procedures section of this chapter. The following instruments were utilized to complete the study at Restaurant XYZ.

- The Great American Insurance Company Ergonomic Task Analysis Worksheet (Appendix A) was utilized to identify the presence of ergonomic risk factors during grill and fried food preparation workstation tasks.
- The Snook Tables (Appendix B) were utilized to identify task demands after the data was collected. Initial collection of data was necessary before the Snook Table could be referred to for further analysis.
- The Revised NIOSH Lifting Equation was utilized to determine acceptable weight limits to raise and lower identified tasks at the food preparation workstations. Lifting tasks were identified in order to utilize the Revised NIOSH Lifting Equation and are discussed in the Data Collection Procedures section of this chapter.
- The California OSHA and NIOSH Tool Checklist for Hand Tool Selection (Appendix C) was utilized to evaluate instruments operated at food preparation workstations. Tools applicable to the grilled and fried food workstations were identified in order to utilize this checklist and are discussed in the Data Collection Procedures section of this chapter.
- A video camera was utilized to record joint angles as well as repetition rates/cycles of the researcher's postures while performing tasks.
- A goniometer was utilized to measure angles of body structures from pictures and video taken of the researcher while he was performing various tasks.

- A tape measure was utilized to calculate current workstation parameters in order to compare against anthropometric data.

Data Collection Procedures

Fried and grilled food preparation workstation tasks were identified at Restaurant XYZ in order to complete this study. Video and/or still pictures were collected for all tasks identified after operating hours and thus no employee interaction occurred while conducting this study. The researcher referred to the videos and pictures after data was collected and utilized a goniometer to measure body angles. Current body angles and workstation characteristics were compared to anthropometric data for analysis. Additionally, the above-mentioned instruments were used to collect data and identify ergonomic risk factors for each task. The list below describes the tasks that were studied, steps taken to perform by the evaluator to perform the task, and which tools were used for data collect. Tasks were classified as either fried or grilled food preparation workstations.

The fried-food preparation workstation tasks include:

- Operating fryers. Many products are cooked in the fryers, however, this task analysis focused on preparing fries due to the high level of manipulation required when compared to other products. Fries are removed from plastic storage bags and placed into fryer baskets, which are placed into the hot cooking oil. Once cooking is complete, the fries are raised out of the oil and placed in a holding pan for final packaging. The Great American Insurance Company Ergonomic Task Analysis Form was used to evaluate risk factors of this task.
- Measuring fry quantities. Fries that are made on an individual order basis are required to be measured for the correct quantities. A scale is located toward the rear

of the workstation to complete this task. Fries are manipulated by hand from plastic storage bags to a bowl on the scale until the correct quantity is reached. Fries are poured from the bowl to the fry basket after the correct quantity has been reached. The Snook Tables were utilized to analyze the reach risk factor of this task.

- Fry scoop tool evaluation. A fry scoop is a one-handed tool which is utilized to scoop fries from the holding pan to the finished product pouches. The California OSHA and NIOSH Tool Checklist for Hand Tool Selection was utilized for this tool-related evaluation.
- Tongs tool evaluation. Tongs are one-handed instruments utilized to manipulate products from the fryer to the final product pouches. The California OSHA and NIOSH Tool Checklist for Hand Tool Selection was utilized for this tool-related evaluation.
- Chili and cheese sauce distribution. A chili and cheese sauce steamtable is located toward the rear of the workstation. A ladle is required to pour chili and cheese sauce on products or in a soufflé cup as a condiment. The steamtable cover is removed before sauce can be distributed and replaced at the completion of the task. The Great American Insurance Company Ergonomic Task Analysis Worksheet was used to evaluation ergonomic risk factors of this task.
- Ladle tool evaluation. A ladle is manipulated to pour chili and cheese sauce on products or in a soufflé cup as a condiment. The California OSHA and NIOSH Tool Checklist for Hand Tool Selection was utilized for this tool-related evaluation.
- Restocking food-prep freezer. Storage bags containing frozen foods are placed in a food-preparation freezer adjacent to the fried food workstation for easy access when

an order is placed. Storage boxes containing frozen food must be removed from shelving within a large freezer and placed on the floor next to the front-accessed food preparation freezer. The box is opened, storage bags are removed, products are placed on a shelf in the food preparation freezer. For purposes of this study, the manual handling of French fry containers will be evaluated do to the high level of manipulation. Two Revised NIOSH Lifting Equations were performed for analysis of this task. The first NIOSH Lifting Equation was completed for a fry box lift from a storage location in the large freezer to the evaluator's grasp at chest level. The second NIOSH Lifting Equation was completed for a placement of a fry box from the evaluator's grasp at chest level to the floor adjacent to the food-preparation freezer. The Snook Tables were utilized to evaluate reach needed to place a fry storage bag in the food-preparation freezer.

The grilled-food preparation workstation tasks include:

- Cold bar and sandwich building. A sandwich bun is dropped in a toaster located to the right of the workstation. A sandwich wrap is reached from a shelf above the sandwich building work area. The sandwich bun is reached from the toaster and is placed on the sandwich building surface located on a countertop directly in front of the operator. Cold-bar products, including vegetables and mayonnaise, are located towards the rear of the workstation and are required to be reached. Cold-bar products are placed on the bun. A spatula is positioned in a container and is required to be manipulated to retrieve mayonnaise for the bun. The Great America Insurance Company Ergonomic Task Analysis Worksheet was utilized to evaluate ergonomic risk factors of this process.

- Hamburger patty manipulation. Hamburger patties are located in a cold-bar refrigerator located below the sandwich building surface. The refrigerator is opened and a hamburger patty is reached from a box. The patty is placed on a grill located between the fryers and the cold-bar work surface. A spatula is manipulated to flip and remove hamburger patties. The Great America Insurance Company Ergonomic Task Analysis Worksheet was utilized to evaluate ergonomic risk factors of this process.
- Spatula tool evaluation. A spatula is used to flip and remove warm hamburger patties from the grill. The California OSHA and NIOSH Tool Checklist for Hand Tool Selection was utilized for evaluation.
- Chili dog building. A hot dog bun is removed from a sandwich bag located below the counter top located on the right side of the workstation and placed in a microwave. The bun is heated and is placed in a chili dog carton as final packaging. A steamtable containing hot dogs is located on the countertop. A cover is removed from a steamtable and a hot dog is manipulated with tongs and placed in the bun. The steamtable cover is placed back in the original position and the carton is closed for packaging. The Great American Insurance Company Ergonomic Task Analysis Worksheet was used to evaluate ergonomic risk factors of this process.
- Restocking the cold bar refrigerator. A refrigerator is located below the sandwich building work surface and is used for hamburger patty and cold-bar product storage. Cold bar products are placed in metal storage containers and placed in the refrigerator for future use. A hamburger patty box is removed from a large freezer and placed in the cold-bar refrigerator. The Snook Tables were used to analyze the reach required

for moving cold-bar products, and two Revised NIOSH Lifting Equation analysis were performed to evaluate acceptable lifting parameters for manipulating a hamburger patty box. The first NIOSH Lifting Equation measured the lift from the floor of the storage freezer to the evaluator's grasp at chest level. The second NIOSH Lifting Equation was utilized to measure the lowering of the hamburger patty box from the evaluator's grasp at chest level to the height of the shelf in the cold-bar refrigerator.

- Grill scraper tool evaluation. A scraper is manipulated to remove remnants of hamburger patties left on the grill. The two-handed tool is utilized by scraping a blade across the grill top and removing the charred food remnants from the grill into a grease trap. The California OSHA and NIOSH Tool Checklist for Hand Tool Selection was utilized for this tool-related evaluation.

Data Analysis

Risk factors were identified using the Great American Insurance Company Ergonomics Task Analysis Form, the Snook Tables, the California OSHA and NIOSH Tool Checklist for Hand Tool Selection, the Revised NIOSH Lifting Equation, videos, and pictures. A goniometer was used to measure body angles documented in videos and pictures and a tape measure was utilized to record current workstation characteristics. Risk factors were analyzed by comparing current task, tool, and workstation characteristics to anthropometric data such as the Snook Tables and information found in Kodak's Design for People at Work.

Limitations of the Study

The limitations of the study are as follows:

- The study is limited to the cooking facility at Restaurant XYZ.

- The study is limited to the time frame of April 1, 2019 to April 5, 2019.

Chapter IV: Results

The purpose of this study was to analyze the grilled and fried food preparation workstations for potential exposures to ergonomic risk factors within Restaurant XYZ. The goals of this study included:

- Identifying the specific tasks that Restaurant XYZ employees perform at the grilled and fried food preparation workstations
- Measuring the extent of physical stress that is being placed on the upper extremities, lower extremities, and spine of the employees who are performing grilled and fried food preparation-related tasks
- Identifying the activities and specific risk factors that are placing the grilled and fried food preparation employees at risk of developing MSDs

The goals of this study were met utilizing the previously-mentioned methodologies in Chapter III. Tasks and tools were identified at the grill and fried food preparation workstations at Restaurant XYZ and qualitative methodologies were applied to each activity for analysis. A summary of identified tasks and tools with the applied methodology is presented below in Table 1. The researcher collected quantitative data at Restaurant XYZ by means of videotaping himself performing the tasks, collecting pictures of tools and obtaining measurements of current workstation characteristics. The researcher utilized data collected from qualitative and quantitative methodologies to accomplish the goals of the study.

Table 1

Task or Tool with Applied Qualitative Methodology

Identified Task or Tool	Applied Methodology
1. Operating fryers	Great American Insurance Company Ergonomic Task Analysis Worksheet
2. Measuring fry quantities	The Snook Tables
3. Fry scoop tool evaluation	The California OSHA and NIOSH Tool Checklist for Hand Tool Selection
4. Tongs tool evaluation	The California OSHA and NIOSH Tool Checklist for Hand Tool Selection
5. Chili and cheese sauce distribution	The Great American Insurance Company Ergonomic Task Analysis Worksheet
6. Ladle tool evaluation	The California OSHA and NIOSH Tool Checklist for Hand Tool Selection
7. Restocking food-prep freezer	Revised NIOSH Lifting Equations
	The Snook Tables
8. Cold bar and sandwich building	The Great America Insurance Company Ergonomic Task Analysis Worksheet
9. Hamburger patty manipulation	The Great America Insurance Company Ergonomic Task Analysis Worksheet
10. Spatula tool evaluation	The California OSHA and NIOSH Tool Checklist for Hand Tool Selection
11. Chili dog building	The Great American Insurance Company Ergonomic Task Analysis Worksheet
12. Restocking the cold bar refrigerator	Revised NIOSH Lifting Equations
	The Snook Tables
13. Grill scraper tool evaluation	The California OSHA and NIOSH Tool Checklist for Hand Tool Selection

Presentation of Collected Data

Data collection was completed by utilizing qualitative and quantitative assessments tools and include the Great American Insurance Company Ergonomic Task Analysis Worksheet, the California OSHA and NIOSH Checklist for Hand Tool Selection, the Revised NIOSH Lifting Equation, the Snook Tables, photographs, a tape measure and a goniometer. The results of the data collection are presented below and completed assessments forms may be found in the appendices of this study.

The Great American Insurance Company Ergonomic Task Analysis Worksheet.

The Great American Insurance Company Ergonomic Task Analysis Worksheet was completed for five tasks which include the operating fryers, chili and cheese sauce distribution, cold bar and sandwich building, hamburger patty manipulation, and chili dog building. Tasks were analyzed by completing nine sections of The Great American Insurance Company Ergonomic Task Analysis Worksheet which assessed repetition, posture, vibration, reach/proper height, force, static loading/fatigue, pressure/contact stress/repeated impacts, lifting/material handling, and environmental stressors. Risk factors were scored as either ideal (meaning hazards are within acceptable limits), warning level (meaning there is a potential concern), or take action (meaning that corrective action needs to be taken). Table 2 below summarizes the total quantities of risk factors per category and per task that were identified at the take-action level. Consequently, take-action level risk factors represent ergonomic hazards that should be addressed with corrective actions.

The ergonomic analysis completed utilizing the Great American Insurance Company Ergonomic Task Analysis Worksheet identified 38 risk factors for five tasks. The results revealed that risk factors involving reach/proper height and posture were the most prevalent

while zero vibration hazards were identified. Four of the five tasks possessed between six and eight risk factors, and 11 hazards were identified at the cold bar and sandwich building workstation. The largest proportion of risk factors for posture (3) and reach (3) related categories were identified at the cold bar and sandwich building workstation. Consequently, the cold bar and sandwich-building task may present the greatest amount of ergonomic risk.

Categories of material handling and the environment received the third and fourth most commonly identified risks respectively. Accounting for the second and third most ergonomically hazardous tasks were the hamburger patty manipulation and the fryer operation activities with six and seven hazards being identified respectively. The results concluded risk factors were prevalent throughout all five tasks, and there was a need to mitigate workstation characteristics such as required employee reaches, workstation heights, and environmental risk factors. The completed Great American Insurance Company Ergonomic Task Analysis Worksheets are located in Appendix D.

Table 2

Total Number of Take Action Risk Factors

	Operating fryers	Chili/cheese sauce distribution	Cold bar/ sandwich building	Hamburger patty manipulation	Chili dog building	Total quantity of risk factors
Repetition	0	0	1	1	0	2
Posture	1	2	3	1	2	9
Vibration	0	0	0	0	0	0
Reach/Proper Height	2	1	3	3	2	11
Force	1	1	0	0	0	2
Static Loading/Fatigue	0	0	1	1	0	2
Contact Stress	1	1	1	0	0	3
Material Handling	1	0	1	1	1	4
Environment	1	1	1	1	1	5
Total quantity of risk factors per task	7	6	11	8	6	38

The California OSHA and NIOSH Checklist for Hand Tool Selection. The California OSHA and NIOSH checklist for Hand Tool Selection was utilized to evaluate five tools which are utilized within the grill and fried food preparation workstations at Restaurant XYZ. The California OSHA and NIOSH checklist for Hand Tool Selection was completed for activities that utilized the fry scoop, tongs, ladle, spatula, and grill scraper. The checklist asked eleven questions and required the researcher to answer yes or no. A yes answer denoted the tool is ergonomically sufficient in the examined category while a no answer signified there was a potential hazard. The eleven questions asked concerned handle characteristics, pinch and power

grip of the user, and the operator's postures while utilizing the equipment. Table 3 below summarizes the risk factors identified for the completed California OSHA and NIOSH checklist for Hand Tool Selection forms. Identified risks factors were denoted with an X in the columns for each represented tool in Table 3. The completed California OSHA and NIOSH checklist for Hand Tool Selection forms are located in Appendix E.

The ergonomic analysis which was completed for five tools utilizing the California OSHA and NIOSH checklist for Hand Tool Selection revealed the existence of eleven risk factors for the five evaluated tools. The results indicated that the same risk factor was present on multiple tools twice. All tools were lacking a non-slip textured handle, which may be essential for usage around equipment containing kitchen oil and grease. Two tools did not have a handle made of soft material to reduce exposure to repetitive contact stress. All identified risk factors related to the tool handles, including one hazard that was additionally associated with the researcher's posture while operating the equipment. The researcher was not able to maintain his wrist in a neutral position while operating the ladle and thus required 20 degrees of wrist flexion. The California OSHA and NIOSH checklist for Hand Tool Selection results revealed risk factors were present while operating all evaluated tools and displayed a potential need to correct tool materials and usage procedures at Restaurant XYZ.

Table 3

Existence of Tool Evaluation Risk Factors

	Fry scoop	Tongs	Ladle	Spatula	Grill scraper
For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 ½ inches when open?					X
Is the tool handle without sharp edges or finger grooves?			X		
Is the tool handle coated with soft material?		X			X
Can the tool be used while keeping your wrist straight?			X		
Can the tool be used with your dominant hand or with either hand?	X				
Does the tool handle have a non-slip surface?	X	X	X	X	X

Revised NIOSH Lifting Equation. Revised NIOSH lifting equations were calculated to examine four movements of boxes at Restaurant XYZ. The analyzed movements occurred while stocking the prep-freezer and cold bar fridge with fries and hamburger patties respectively. The Revised NIOSH lifting equation assisted with calculating a recommended weight limit (RWL) and aids in quantifying the extent of exposure by utilizing a Lifting Index (LI) as discussed in Chapter III. Variables included in the Revised NIOSH lifting equation included a load constant (51 pounds), horizontal multiple (HM), vertical multiplier (VM), distance multiplier (DM), asymmetric multiplier (AM), frequency multiplier (FM), and a coupling multiplier (CM). Details of the incorporated variables were discussed more in depth in Chapter III. Table 4 below

defined the Revised NIOSH Lifting Equation, summarized results for each variable used in the different movements, and identified the RWL and the LI suggested for safe transfer of the product boxes. Data collected for the revised NIOSH lifting equations were found in Appendix F.

The results of the four revised NIOSH lifting equation calculations revealed that all four movements exceeded the recommended weight limit. Given the inputted risk factors, the fry boxes should not exceed a weight of 9.38 pounds and 11.89 pounds for fry box lifts one and two respectively. The hamburger patty boxes should not exceed a weight of 9.73 pounds and 4.86 pounds for lifts one and two respectively. The fry and patty box exceeded at least twice the recommended limit in all movements, signifying a potential of a musculoskeletal injury to occur. The lifting index for patty box lift two was measured at 4.86, and thus indicates that the box weight was nearly five times greater than the recommended limit. The results of the revised NIOSH lifting equations revealed a need for ergonomic improvement for material handling.

Table 4

Revised NIOSH Lifting Equation Results

LC x HM x VM x DM x AM x FM x CM= RWL

51 x (10/H) x 1-(.0075 [V-30]) x .82+(1.8/D) x 1-(.0032A) x FM x CM= RWL

	LC	HM	VM	DM	AM	FM	CM	RWL (LI)
Fry box lift 1: Lowering box from shelf to researcher's grasp	51	.417	.835	1.07	.997	.55	.90	9.38 lbs (3.84)
Fry box lift 2: Lowering box from researcher's grasp to floor	51	.625	.874	.865	.997	.55	.95	11.89 lbs (3.02)
Patty box lift 1: Lifting box from floor to researcher's grasp	51	.625	.874	.865	.997	.45	.90	9.73 lbs (2.06)
Patty box lift 2: Lowering box from researcher's grasp to shelf height	51	.270	.874	.880	.997	.45	.90	4.86 (4.11)

The Snook Tables. The Liberty Mutual Snook Tables were utilized to examine three tasks at the grilled and fried food preparation workstations at Restaurant XYZ. The three tasks which were analyzed included measuring fries, restocking the prep-freezer, and restocking the cold-bar refrigerator. The Snook tables considered numerous variables to determine a percentage of a population that is capable of performing a task. Variables that were utilized included the weight of the object, the lift or lower distance, hand distance in front of the body, hand height, carry distance, frequency, force, and the height at which the task was completed. As discussed in Chapter III, at least 75% of a population should be able to complete any task to adequately accommodate a diverse workplace environment. The analysis was completed by collecting applicable workstation and product characteristics and examining the appropriate Snook Tables to determine the acceptable parameters for male and female populations. Results

of the analysis revealed that all movements were within acceptable parameters to accommodate greater than 90 percent of the male population. The results of the female population analysis varied based on the task which was assessed.

Measuring fries required the researcher to pour the contents of a six-pound bag into a bowl to measure individual servings. The workstation was 54 inches from the ground to the bowl which was sitting on a scale, and required a lifting distance of 20 inches to pour the contents. The distance from the bag to the researcher was seven inches. The frequency of this task was between one and five minutes per repetition. The applicable Snook Tables for this analysis were 2M for males and 3F for females. The results of the analysis concluded that measuring fries did not present any ergonomic risk factors. The object weights provided on table 2M do not decline below 28 pounds; consequently, the task may be assumed as achievable for greater than 90 percent of the male population. The six-pound object weight parameter was provided on Table 3F for females. Results of female population analysis revealed that greater than 90 percent of the population could complete the movement regardless of repetition and lifting distance parameters discussed in the Snook Tables.

The prep-freezer was a multi-level stand-up unit which stored product immediately before cooking. Restocking required product to be carried from a larger unit to the prep-freezer. Products stored in the prep-freezer weighed between six and 36 pounds. Products were required to be held seven inches away from the body and were lifted a distance of 30 inches. The analysis was completed utilizing the top rack of the freezer which is situated 52 inches above the floor. The Snook Table parameters were examined for the minimum and maximum weight of product stored in the freezer as a result of a non-standardized approach for product placement. Bags that were six pounds and/or boxes that are 36 pounds may be placed on the top shelf of the prep-

freezer, depending on the restocking employee's physical characteristics and comfort level. Tables 2M and 2F were utilized to complete the analysis for both male and female populations respectively.

The results of the examination revealed that the fry bag weight of six pounds was less than the minimum object weight parameters provided in table 2M and 2F of the Snook Tables. Consequently, the task may be assumed to be completed by greater than 90 percent of both male and female populations. The Snook Table analysis of identical parameters with a 36-pound box revealed a potential ergonomic hazard to the female population, although greater than 90 percent of the male population could perform the associated lift with minimal injury-based risk. According the Snook Tables, 35-pound lift, which was carried out once every eight hours, accommodated between 52 and 66 percent of the female population, depending on a 20 or 30-inch vertical lifting distance. Conversely, the 36-pound lift may be accomplished by greater than 90% of the male population in an eight hour shift regardless of lifting distance. The majority of movements analyzed were within acceptable limits; however, there was a potential for employee injury and a need for corrective action when lifting larger products to the top shelf of the prep-freezer.

A cold-bar refrigerator was located below the sandwich building workstation and required periodic restocking of products for quick access to food items. The largest item stored in the cold-bar refrigerator was a 42-pound case of cheese slices. Restocking the cheese case required the researcher to lower the box to the rack on the bottom of the refrigerator, which is ten inches off the ground. The box was held seven inches away from the body, the lowering distance was 20 inches, and the frequency of the task is one repetition in an eight-hour period. Tables 4M and 4F were utilized to complete the analysis of this lowering activity. Results of the

examination revealed that greater than 90 percent of the male population was capable of completing the task while 76 to 89 percent of the female population was capable of completing the task which depended on the lowering distance. The Snook Table results for the cold-bar restocking task concluded that a majority of the female and male populations were capable of lowering the cheese box into the cold bar refrigerator; consequently, the task did not pose a significant risk of injury for Restaurant XYZ employees.

Quantitative measures. Quantitative measurements of workstation parameters were collected utilizing a tape measure and goniometer. Table 5 below lists the fried and grilled food preparation workstation characteristics which were measured during data collection and summarized corresponding dimensions of the workstation with anthropometric data required to complete the task. Heights were measured from the floor to the lowest required grasp, and depths were measured from the front of the workstation to the longest necessary reach. Quantitative measurements were analyzed by comparing anthropometric data to qualitative evaluation results, such as the Great American Insurance Company Ergonomic Task Analysis Worksheet, and recommendations were made based on identified risk factors. Quantitative analysis revealed potential risk factors relating to shoulder and spinal flexion and presented a need to correct several workstation reach and height requirements. These results were similar to conclusions which were reached during the preceding qualitative analysis, and the associated recommendations are discussed in Chapter V.

Table 5

Quantitative Workstation Measurements

Workstation characteristic	Dimension	Anthropometric data
Chili and cheese steam pan	Height: 51 ½ inches	Shoulder extension: 70 degrees
	Depth: 20 inches	Spinal flexion: 0 degrees
		Wrist flexion: 90 degrees
		Radial Deviation: 10 degrees
Fry scale	Height: 54 inches	Shoulder extension: 20 degrees
	Depth: 26 ½ inches	Spinal flexion: 45 degrees
Fryer handle	Height: 45 inches	Wrist flexion: 90 degrees (moving fries to pan)
	Depth: 5 inches	
		Ulnar Deviation: 15 degrees
Fry pan	Weight: 2.4 pounds	Wrist extension: 90 degrees (holding fry pan)
	Height: 39 ½ inches	
	Depth: 7 inches	
Overhead shelf	Height: 65 ¼ inches	Shoulder extension: 115 degrees
	Depth: 15 inches	Spinal flexion: 0 degrees
Grill	Height: 36 inches	Shoulder extension: 70 degrees
	Depth: 29 inches	Spinal flexion: 28 degrees
Cold-bar workstation	Height: 39 ½ inches	Shoulder extension: 90 degrees
	Depth: 31 inches	Spinal flexion: 45 degrees
Cold-bar refrigerator	Height: 10 inches (to bottom)	Shoulder extension: 45 degrees
		Spinal flexion: 90 degrees
	Depth: 28 ¾ inches	
Microwave	Height: 69 inches	Shoulder extension: 110 degrees
	Depth: 0 inches	Spinal flexion: 0 degrees
Hot dog steam table	Height: 49 ¼ inches	Shoulder extension: 75 degrees
	Depth: 3 inches	Spinal flexion: 0 degrees

Discussion

The results of the ergonomic analysis at Restaurant XYZ relate directly to concepts which were discussed in Chapter II. Collected data suggested that certain food production activities Restaurant XYZ exhibited present ergonomic risk factors that may predispose employees to musculoskeletal disorders. Stress placed on the shoulders, the spine, and wrists may lead to injury of ligaments, tendons, muscles, and joints of associated structures. Furthermore, injury to these structures may result in pathologies such as sprains, strains, carpal tunnel, or thoracic outlet syndrome.

Assessment techniques discussed in Chapter II were successful at identifying ergonomic risks factors at Restaurant XYZ. Qualitative assessment tools were utilized to examine tasks and tools for potential risk factors. The Great American Insurance Company Ergonomic Task Analysis Worksheet identified postural ergonomic exposures to the shoulders, arms, spine, and wrists as well as the excessive noise hazards. Additionally, the Great American Insurance Company Ergonomic Task Analysis Worksheet was utilized to identify activities associated with excessive repetition, and was proficient at detecting contact stress risk factors due to workstation characteristics and awkward postures. The Snook Tables identified risks factors associated with certain lifting or lowering tasks while defending current parameters as acceptable for other movements. The Revised NIOSH Lifting Equation assessment tool discussed in Chapter II was utilized to identify four lifting or lowering tasks which exceeded the recommended lifting weight. The California OSHA and NIOSH Checklist for Hand Tool Selection was successful in identifying risk factors of instruments relating to the handle and unnatural body positions of the researcher. The researcher was able utilize the checklist to identify risk factors relating to the handle including lack of a non-slip surface, a narrow grip, presence of sharp edges, and the

inability to use either hand for operation. Quantitative assessment tools including a tape measure and goniometer were utilized to collect data on workstation dimensions and joint positions respectively. Anthropometric data and quantitative measurements were successfully analyzed and contributed in the identification in the above-mentioned risk factors at Restaurant XYZ to determine the amount of stress placed on the body.

Chapter V: Conclusions and Recommendations

The purpose of this study was to analyze the grilled and fried food preparation workstations for potential exposures to ergonomic risk factors within Restaurant XYZ. The goals of this study included:

- Identify the specific tasks that Restaurant XYZ employees perform at the grilled and fried food preparation workstations
- Measure the extent of physical stress that is being placed on the upper extremities, lower extremities, and spine of the employees who are performing grilled and fried food preparation-related tasks
- Identify the activities and specific risk factors that are placing the grilled and fried food preparation employees at risk of developing MSDs

The goals of this study were met by utilizing qualitative and quantitative assessment tools. Tasks were identified and qualitative methodologies were applied to each activity for analysis. Qualitative assessment tools that were utilized included the Great American Insurance Company Ergonomic Task Analysis Worksheet, the Snook Tables and the Revised NIOSH Lifting Equation. Tools utilized at the grilled and fried food preparation workstations were identified and the California OSHA and NIOSH Checklist for Hand Tool Selection form was completed for each instrument during the analysis process. The researcher videotaped and collected pictures of himself performing the tasks for eventual postural and repetition-based quantitative analysis. A goniometer was utilized to measure joint positions during various tasks and a tape measure was utilized to calculate workstations characteristics. The quantitative and qualitative assessment tools allowed the researcher to accomplish the goals of this study.

Conclusions

The following conclusions were made as a result of completing the ergonomic analysis for the grill and fried food preparation workstations at restaurant XYZ.

- Operating fryers. The Great American Insurance Company Ergonomic Task Analysis Worksheet completed for the fryer operation revealed the identification of ergonomic hazards associated with positions required for the wrists, shoulders, and arms as well as the weight of the fry pan, repetitive movements, noise exposures, and bodily contact stress. In order to move the fries from the fry basket to the pan, 90 degrees of wrist flexion is required. The researcher was required to reach with an outstretched arm to manipulate items located on the overhead shelf at a 45-degree angle. Both actions were identified at the take action level of the Great American Insurance Company Ergonomic Task Analysis Worksheet. Both tasks are repetitive in nature, which consequently increases the risk of the operator developing musculoskeletal disorders. Ergonomic analysis revealed the recommended weight of the fry pan should not exceed one pound for items requiring manipulation more than twenty times per hour. The current weight of the fry pan is 2.4 pounds and the manual manipulation of this tool exceeds twenty times per hour. Contact between the operator's body and the workstation occurred while reaching to dispense the cooked fries and consequently was identified at the take action level for the contact stress risk factor. The contact stress risk factor is present in part due to the 26-½" reach required to manipulate the scale. Ergonomic improvement should be incorporated into this task to reduce exposure to risk factors such as reaching, contact stress, and repetition.

- Measuring fry quantities. The ergonomic analysis which was completed with the Snook Tables for measuring the weight of the fries indicated the minimal presence of risk factors. Six-pound bags may be safety lifted to the scale by both male and female populations regardless of repetition of the task or vertical lifting distance.
- Fry scoop tool evaluation. The results of the completed California OSHA and NIOSH Checklist for Hand Tool Selection form for the fry scoop concluded that this tool possesses two risk factors. The fry scoop did not possess a non-slip handle and thus a textured slip-resistant handle may be beneficial due to the high amount of grease and oil that may spill as a result of preparing food. A slip-resistant handle would likely allow the associated food service employee to properly operate the fry scoop. The lack of a slip-resistant handle was identified as a risk factor for all five tool evaluations which resulted in identical conclusions and will therefore only be mentioned once. The fry scoop handle is in a fixed and non-adjustable position, which makes fry scoop operations exclusively feasible with the right hand and thus creates a repetitive motion hazard for employees who desire to utilize this tool with the left hand. Employees may feel comfortable and be more efficient as a result of operating equipment with a left hand, and operating the fry scoop in an unnatural position with only one hand may increase the risk of developing a MSD.
- Evaluation of the tongs tool. The results of the completed California and NIOSH Checklist for Hand Tool Selection form concluded that the tongs utilized by Restaurant XYZ possess two risk factors which are associated with the metal handle of the tongs. The tongs do not possess a soft material for the handle as well as a slip-resistant surface. A soft material may prevent contact stress exposure to the hand as a

result of frequent use of the tongs. Exposure to the above-mentioned risk factors may be effectively reduced by replacing the tongs with an alternative which incorporates posture and/or hand grip qualities.

- Chili and cheese sauce distribution evaluation. The results of an analysis on the chili and cheese sauce distribution task concluded there were six risk factors present at the take action level with regard to the Great American Insurance Company Ergonomic Task Analysis Worksheet. The researcher was observed performing the task while rotating his cervical spine 30 degrees to the right while incurring 45 degrees of spinal flexion to access the chili and cheese sauce steamtable. Ninety degrees of wrist flexion was required while operating the ladle. These positions are out of the ideal parameters according to the Great American Insurance Company Ergonomic Task Analysis Worksheet and thus place the individual at risk of a developing a musculoskeletal disorder. While the ladle handle is within the parameters set forth by the California OSHA and NIOSH Checklist for Hand Tool Selection form, the instrument did not fit the researcher's entire hand and thus was identified at the take action level with regard to the Great American Insurance Company Ergonomic Task Analysis Worksheet. Contact stress was identified as a risk factor at the take action level due to the reach of 20 inches required to access the chili and cheese steamtable. The research's legs were positioned against the front of the workstation in order to access the steamtable and may constitute a contact stress risk due to the repetitiveness of the task. Thus, the continuous use of unnatural positions coupled with task repetitions may place fried-food preparation workstation employees at risk of developing an injury.

- Ladle tool evaluation. The tool evaluation on the ladle identified three risk factors. The tool handle possessed sharp edges on either side of the grip, which could result in a contact stress exposure. The ladle required the researcher to experience 30 degrees of wrist flexion while gripping the handle. Ideally, the wrists should remain in a reasonably neutral position while operating tools/equipment. The above-mentioned non-slip surface of the handle was the third identified risk factor. Redesigning the ladle or replacing the instrument with an ergonomically supportive tool should be considered to reduce exposure to the above-mentioned risk factors.
- Evaluation of restocking food-prep freezer. Two Revised NIOSH Lifting Equations were completed for restocking the food-prep freezer indicated that the 36-pound fry box exceeded the recommended weight limit as a result of the inputted parameters which were presented in Chapter IV. The recommended weight limit to remove the fry box from the large storage freezer to the researcher's grasp is 9.38 pounds. The recommendation weight limit to lower the 36-pound fry box from the researcher's grasp to the floor was 11.89 pounds. The Snook Table analysis completed for restocking the prep-food freezer concluded that greater than 90 percent of both male and female populations are capable of lifting the 6-pound fry bags into the food-prep freezer as a result of the inputted parameters which are presented in Chapter IV. However, only 52 to 66 percent of the female population are capable of lifting the 36-pound fry box to the top shelf in the food-prep freezer while utilizing the inputted parameters discussed in Chapter IV. Consequently, this task does not accommodate the recommended 75 percent of the workforce, and an ergonomic hazard may exist if administrative practices dictate that the 36-pound box must be placed on the top shelf.

- Cold-bar and sandwich building. The Great American Insurance Company Ergonomic Task Analysis Worksheet completed for the cold-bar and sandwich-building workstation identified nine risk factors at the take action level which may place Restaurant XYZ employees at risk of developing musculoskeletal disorders. The cold-bar and sandwich building task contained ergonomic hazards relating to repetition and static loading of the muscles. A large proportion of the task involved reaching for food items to place on a sandwich bun, which utilized awkward positions including a 45-degree outstretched arm, 90 degrees wrist flexion, and a 45-degree flexed neck. All positions were identified at the take action level of the Great American Insurance Company Ergonomic Task Analysis Worksheet. The researcher's legs were in contact with the workstation while reaching for cold-bar products which presents a contact stress risk factor. Sandwich wrappers are located on a 65- ¼" overhead shelf which requires shoulder extension of 115 degrees to reach. Wrappers are reached for every sandwich and thus result in a repetitive manual handling hazard at the take action level. The researcher was required to rotate the cervical portion of his spine 35 degrees to the right in order to reach for sandwich buns from the toaster which was identified at the take action level. Engineering controls such as redesigning the workstation should be considered to reduce the awkward posture and repetition ergonomic risk factors associated with this task.
- Hamburger patty manipulation. Risk factors relating to hamburger patty manipulation were associated with operations at the grill and cold-bar refrigerator. Repetition, static loading, and recurring materials handling risks were identified for activities associated with manipulating patties at the grill and lifting hamburgers out

of the refrigerator. Patties are stored in the cold-bar refrigerator below the workstation and are required to be lifted to the grill following order placement. Repetitive lifting of hamburger patties requires squatting for greater than a total of three hours a day or bending with spinal flexion of 80 degrees to access the refrigerator. Operating the grill requires a reach of 70 degrees with an outstretched arm to manipulate the farthest patties and 90 degrees of wrist flexion to flip patties. Ergonomic improvements should be incorporated into this task to reduce the lifting and reaching risk factors.

- Spatula tool evaluation. Tool evaluation completed for the spatula identified the above-mentioned lack of a non-slip handle as the only risk factor. The spatula did appear to have a non-slip grip in the past but was worn to the point of no longer possessing textured and adhesive properties. The risk factor may be reduced by replacing this equipment with a tool which incorporates a non-slip ergonomically designed handle.
- Chili dog building evaluation. An analysis which was completed on the chili dog building task identified the presence of six risk factors relating to the operation of the microwave and manipulating the buns. Chili dog buns are located on a shelf below the workstation and require 20 degrees of cervical rotation and 25 degrees of thoracic/lumbar spine flexion to one side. Both items are identified at the take action level of the Great American Insurance Company Ergonomic Task Analysis Worksheet. The microwave is located on an overhead shelf with a height of 69 inches and requires 110 degrees of shoulder extension and neck extension of ten degrees to operate. Ergonomic improvements such as redesigning the overall layout

of the workstation should be considered to reduce the excessive reaching and awkward posture risk factors associated with this task.

- Evaluation of restocking the cold bar refrigerator. Two Revised NIOSH Lifting Equations completed for restocking the cold bar refrigerator indicated that the 20-pound hamburger patty box exceeded the recommended weight limits while utilizing the inputted parameters which were presented in Chapter IV. The recommended weight limit to lift the hamburger patty box from the floor to the researcher's waist level was 9.73 pounds. The recommended weight limit to lower the hamburger patty box from the researcher's waist level to the bottom shelf of the refrigerator was 4.86 pounds. The Snook Table analysis for restocking the cold bar refrigerator concluded that no risk factors were present while manipulating the 42-pound case of cheese while utilizing the inputted parameters discussed in Chapter IV. Greater than 90 percent of the male population and 76 to 89 percent of the female population were capable of restocking the cold-bar refrigerator with the 42-pound case of cheese while utilizing the inputted parameters discussed in Chapter IV. The Snook Table analysis concluded the task is able to accommodate greater than 75 percent of both male and female populations while utilizing the inputted parameters. Consequently restocking the cold bar refrigerator presents a potential ergonomic risk for employees and Restaurant XYZ should exercise caution when performing this task. This potential hazard may be reduced by utilizing a lift-assistant device manipulate materials.
- Grill scraper tool evaluation. The tool evaluation performed on the grill scraper identified three risk factors. The handle width did not meet the required two inches as discussed in the California OSHA and NIOSH Checklist for Hand Tool Selection.

The handle of the scraper was metal and was not a soft material which increased the risk of contact stress concerns. The Scraper handle did not possess a non-slip surface similar to all five tools evaluated at Restaurant XYZ. Exposure to ergonomic risk factors associated with the grill scraper appear to be significant and thus may be reduced by redesigning the tool or substituting the equipment with an instrument which incorporates an ergonomically supportive handle.

- Noise. Noise produced at the grilled and fried food preparation workstations was identified at the take action level for all five tasks evaluated due to the sound created by equipment. The take-action level parameter discussed in the Great American Insurance Company Ergonomic Task Analysis Worksheet was defined as an environment exceeding the capability to carry on a conversation. During business hours, employee and customer conversation may additionally contribute to noise and thus increase the risk to the development of hearing loss.

Recommendations

The above-mentioned conclusions result a need to control the identified ergonomic hazards that exist at Restaurant XYZ. Following are various engineering and administrative-based techniques which should be considered in order to mitigate and prevent future hazards and ergonomic risk factors:

- It is recommended that Restaurant XYZ purchase adjustable height workstations where feasible. Workstations which can be lowered and raised are capable of accommodating the heights of all employees, and thus reduce the contact stress risk factor as well as hazardous shoulder and spine positions required to reach for items at the cheese and chili sauce steamtable, fryers, grill, cold-bar, and chili dog steamtable

workstation surfaces. Workstations should be adjustable between the heights of 34 and 45 inches in order accommodate at least 95% of the female and male workforce. Training on proper use of adjustable workstations should be provided to employees.

- It is recommended that shelving units be utilized at several workstation surfaces to avoid overhead reaching required to manipulate food packaging items stored on the overhead shelf. Fry pouches, sandwich wrappers, chili dog containers, and soufflé cups are stored on the overhead shelf. These packaging items should be stored in a manner that does not require employees to reach overhead. Shelving units should not exceed a height of 53 inches in order to accommodate female and male populations as presented in the Liberty Mutual Snook Tables.
- It is recommended that a 4-step stool be utilized to reach overhead items when needed. The stool should be utilized in a manner which does not require employees to reach overhead and thus a 4-step stool will accommodate the variety of male and female employee heights in the workforce.
- It is recommended that the microwave be lowered to countertop height. Lowering the microwave to countertop height would allow all employees to operate the microwave without stresses being placed on the arms as a result of reaching overhead. The microwave should be utilized at the above-mentioned shoulder height or between 53 and 57 inches.
- It is recommended that Restaurant XYZ purchase fry scoops, tongs, ladles, spatulas, and grill scrapers which possess non-slip and soft material handles to minimize the risk of contact stress as well as promote a neutral posture of the associated employees' wrists, forearms, elbows and shoulders.

- It is recommended that Restaurant XYZ purchase fry scoops which can be utilized by either hand to accommodate both left and right-handed employees.
- It is recommended that Restaurant XYZ purchase a fry pan which weighs less than one pound to reduce ergonomic risk factors associated with repetition.
- It is recommended that Restaurant XYZ purchase an adjustable height materials handling cart to restock the prep-freezer and the cold-bar refrigerator. A materials handling cart would reduce the distance employees need to lift or lower containers such as fry, hamburger patty, and cheese boxes. The cart should be a capable of being lowered to 34 inches and being raised to 45 inches to accommodate the heights of female and male populations as mentioned above and discussed in the Liberty Mutual Snook Tables.
- It is recommended a shelving unit be purchased to store several packages of chili dog buns and be placed next to the chili dog steam table. This will reduce the amount of times employees are required to flex the spine to reach for buns and thus limit the associated spinal flexion which is required to complete the task. The shelving unit should be utilized between 53 and 57 inches to accommodate male and female populations as discussed in the Liberty Mutual Snook tables.
- It is recommended that restaurant XYZ standardize placement of frozen items in the food-prep freezer based on weight in order to accommodate the greatest proportion of the diverse male and female workforce. Heavy items should be placed between heights of 28 and 57 inches or the lowest female knuckle height and tallest male shoulder height respectively as presented in the Liberty Mutual Snook Tables. The heaviest items should be placed on a shelf which is waist level while the lightest

items placed on the top or bottom shelves. Furthermore, training should occur on correct food placement and shelves should be labeled to ensure proper organization of the freezer.

- It is recommended that a two-hour work rotation schedule be utilized at the cold-bar and sandwich building workstation when feasible to reduce risk factors associated with high repetitive tasks such as reaches which are required for sandwich building.
- It is recommended that employees operating the fried-food workstation be trained and provided the opportunity to move the chili and cheese sauce steamtable and the fry scale to an acceptable distance of between seven to fifteen inches away from the body. Both height and reach-based individual physical characteristics will dictate the distance. Employees should move the steamtable and scale to a distance not to exceed 15 inches that does not require spine flexion.

Areas of Further Research

This study focused on ergonomic analysis of the grilled and fried food preparation workstations. Consequently, there is a potential for research to occur in additional areas of Restaurant XYZ. The additional areas of research include the following:

- Quantifying the noise exposure which exists at Restaurant XYZ.
- The ergonomic stressors associated with the tasks of operating tills, making desserts, and cleaning.
- Material handling during deliveries and the existence of ergonomic exposure.
- The extent of musculoskeletal disorders which exist at Restaurant XYZ by means of examining a symptom survey.

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Appendix A: Great American Insurance Company Ergonomic Task Analysis Worksheet

Ergonomics Task Analysis Worksheet

Directions: **The Ergonomics Task Analysis Worksheet** provides a method for identifying, evaluating, and eliminating/controlling ergonomic risk factors. Observe several task cycles prior to making notes or drawing conclusions. Score each risk factor (ideal, warning level, or take action) that most resembles the task you are analyzing. Once you have completed the worksheet, create an Action Plan (how to control or eliminate the risk factor), focusing on tasks from the "Take Action" column first. It is often helpful to videotape the job to facilitate a more detailed review and action plan.

Repetition

NIOSH defines a repetitive task as one with a task cycle time of less than 30 seconds or performed for prolonged periods, such as an 8-hour shift.

Ideal	Warning Level - Monitor	Take Action
1. No repetitive hand or arm motions	1A. Repetitive hand or arm motions with cycle times of 30-60 seconds	1B. Repetitive hand or arm motions with cycle times of less than 30 seconds

Posture

Ideal	Warning Level - Monitor	Take Action
Standing 2. Knees are straight, but not locked. Back is upright and straight. No twisting, reaching or bending. (See reaching) 	**Standing** 2A. Knees partly bent. 	**Standing** 2B. Squatting > 3 hrs/day  2B. Kneeling > 3 hrs/day  2B. Using a foot pedal 
Sitting 3. Back and legs supported by comfortable chair. Feet are flat on floor or foot rest. 	**Sitting** 3A. Back is only partially supported or feet are not flat. 	**Sitting** 3B. Little support for legs and back. Feet do not touch floor. 
Head/Neck 4. Head and neck are upright and straight 	**Head/Neck** 4A. Bent forward less than 20° 	**Head/Neck** 4A. Bent forward more than 20° > 3 hrs/day 

Posture (continued)

Ideal	Warning Level - Monitor	Take Action
Head/Neck 4. Head and neck are upright and straight 	**Head/Neck** 4B. Bent back less than 10°  4C. Bent sideways less than 20°  4D. Twisting neck less than 20° 	**Head/Neck** 4B. Bent back more than 10°  4C. Bent sideways more than 20°  4D. Twisting neck more than 20° 
Ideal	**Warning Level - Monitor**	**Take Action**
Hands 5. Palms are vertical (handshake position) 	**Hands** 5A. Hands rotate less than 20° 	**Hands** 5A. Hands rotate more than 20° 
Wrists 6. Wrists are straight 	**Wrists** 6A. Wrists are bent between 5 and 30 times per minute and bent less than 20°  6B. Wrists move sideways between 5 and 30 times per minute and less than 20° 	**Wrists** 6A. Wrists are bent more than 30 times per minute or bent more than 20°  6B. Wrists move sideways more than 30 times per minute or more than 20° 

Vibration (Check with tool manufacturer for recommendations or warnings.)

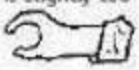
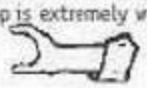
Ideal	Warning Level - Monitor	Take Action
7. No hand or arm vibration	7A. Occasional hand or arm vibration	7B. Constant hand or arm vibration
8. No whole body vibration	8A. Occasional whole body vibration	8B. Constant whole body vibration

Reach/Proper Height

Ideal	Warning Level - Monitor	Take Action
9. Work should be performed at 90° or slightly above or below elbow level 	9A. Arms forward up to 45° or frequently maintained outside of the ideal position > 4 hrs/day 	9A. Arms forward more than 45° or constantly maintained outside of the ideal position > 3 hrs/day 
	9B. Arms back up to 20° and no more than 2-4 times per minute > 4 hrs/day 	9B. Arms back more than 20° or more than 4 times per minute > 3 hrs/day 
	9C. Elbows bent up to 25% above or below the ideal position > 4 hrs/day 	9C. Elbows bent more than 25% above or below the ideal position > 3 hrs/day 
	9D. Elbows up to 45° away from body > 4 hrs/day 	9D. Elbows more than 45° away from body > 3 hrs/day 
10. No twisting, reaching or bending 	10A. Twisting up to 45° or frequent twisting (2-4 times per minute) 	10A. Twisting more than 45° or highly repetitive twisting (more than 4 times per minute) 
	10B. Bending/reaching forward up to 45°, frequent bending (2-4 times per minute) or > 30% more than 4 hours per day without support 	10B. Bending/reaching forward more than 45°, highly repetitive bending (more than 4 times per minute) or more than 2 hours per day without support 
	10C. Bending/reaching to the side up to 20° or frequent bending (2-4 times per minute) 	10C. Bending/reaching to the side more than 20° or highly repetitive bending to the side (more than 4 times per minute) 

Force

Force is the amount of physical effort required to do a task or maintain control of the tools or equipment. Effort depends on the weight of the object, type of grip, object dimensions, type of activity, slipperiness of the object and duration of the task.

Ideal	Warning Level - Monitor	Take Action
11. Objects lifted by hand weigh less than 1 pound	11A. Objects lifted by hand weigh less than 1 pound and frequent lifting (no more than 20 times an hour)	11B. Objects lifted by hand weigh more than 1 pound or highly repetitive lifting (more than 20 times an hour)
12. Objects lifted by the back weigh less than 5 pounds	12A. Objects lifted by the back weigh between 5 and 25 pounds or frequent lifting (no more than 20 times/hour)	12B. Objects lifted by the back weigh more than 25 pounds or highly repetitive lifting (more than 20 times/hour)
Duration 13. No pinch grip used. Fingers and thumb comfortably fit around tool or object 	**Duration** 13A. Moderate pinch grip or pinch grip with less than 2 pounds of force  13B. Grip is slightly too wide 	**Duration** 13A. Severe pinch grip or pinch grip used with greater than 2 pounds of force  13B. Grip is extremely wide 
14. Power grip used with little to no force.	14A. Power grip used with less than 10 pounds of force. Forearm rotation force is less than 5 pounds	14B. Power grip used with more than 10 pounds of force. Forearm rotation force is more than 5 pounds
15. Entire hand controls trigger 	15A. Thumb activated control 	15B. Finger(s) activated control 
16. Tools or objects have handles that are rounded	16A. Awkward handles 16A. Tools with awkward handles  Choose One 16A. Objects with awkward handles 	16B. Handles, tools or objects that concentrate force or have no handles 16B. Handles that concentrate force  16B. Objects with no handles 
Slipperiness 17. Gloves do not need to be worn at any time 	**Slipperiness** 17A. Gloves are needed but fit well 	**Slipperiness** 17B. Gloves are needed but fit poorly 

Static Loading and Fatigue

Static loading refers to staying in the same position for prolonged periods. Tasks that use the same muscles or motions for long durations (6 seconds or more at one time) and repetitively (more than 50% repetition) increase the likelihood of fatigue.

Ideal	Warning Level - Monitor	Take Action
Duration 18. Constant position, tool or object is held less than 6 seconds	**Duration** 18A. Constant position, tool or object is held 6 to 10 seconds	**Duration** 18B. Constant position, tool or object is held more than 10 seconds
Repetition 19. Less than 25% of the task is repetitive	**Repetition** 19A. 25% to 50% of the task is repetitive	**Repetition** 19B. More than 50% of the task is repetitive

Pressure/Contact Stress/Repeated Impacts

Refers to pressure or contact from tools or equipment handles with narrow width that create local pressure. It also applies to sharp corners of desks or counter tops. Impact refers to the use of hands, knees, foot, etc. as a hammer. *(Related to Force Conditions in item 16.)*

Ideal	Warning Level - Monitor	Take Action
20. No contact or impact stress: tools, objects, or workstation do not press against hands or body	20A. Occasional and minimal pressure or impact on hands or body. Hand, knee or other body part used as hammer less than 2 hours/day	20B. Constant pressure or impact on hands or body. Hand knee or other body part used as hammer more than 2 hours/day

Lifting and Materials Handling

Ideal	Warning Level - Monitor	Take Action
21. No lifting or lowering of materials (see also Force for weights of objects handled)	21A. Occasional lifting and/or lowering (no more than 20 times per hour)	21B. Constant lifting and/or lowering (more than 20 times per hour)
Push/Pull 22. No pushing or pulling of carts or materials	**Push/Pull** 22A. Pushing or pulling 10-50 carts per shift	**Push/Pull** 22B. Pushing or pulling more than 50 carts per shift
23. Slight force is required to push or pull carts or materials. Pushing is preferred over pulling objects.	23A. Moderate force is required to push or pull carts or materials.	23B. High force is required to push or pull materials.

Environment

Ideal	Warning Level - Monitor	Take Action
Work Pace 24. Worker has adequate control over work pace.	**Work Pace** 24A. Worker has some control over work pace.	**Work Pace** 24B. Worker has no control over work pace.
Lighting 25. The lighting is adequate for the task.	**Lighting** 25A. The lighting is slightly too bright or too dark for the task.	**Lighting** 25B. The lighting is significantly too bright or too dark for the task.
Temperature 26. The temperature is comfortable.	**Temperature** 26A. The temperature is slightly too cold or too hot.	**Temperature** 26B. The temperature is significantly too cold or too hot.
Noise 27. The work area is quiet.	**Noise** 27A. The work area is slightly noisy.	**Noise** 27B. The work area is significantly noisy (too noisy to carry on a conversation).
Floor Surface 28. The flooring provides good traction. 29. The flooring is sufficiently padded to relieve stress on back and legs. 30. Floor mats are provided to relieve stress on back and legs. Employee can alternate between sitting and standing.	**Floor Surface** 28A. The flooring is slightly slippery. 29A. The flooring contributes slight stress to the back and legs. 30A. Standing 0-50% of time without floor mats or other means to relieve stress on back and legs.	**Floor Surface** 28B. The flooring is moderately to extremely slippery. 29B. The flooring contributes moderate to extreme stress to the back and legs. 30B. Standing more than 50% of time without floor mats or other means to relieve stress on back and legs.

Comments: _____

_____

_____

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Note: The levels provided above are standard practices which have been accepted or established by NIOSH, OSHA, ANSII and other related organizations.

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Repetition			
1. No repetitive hand or arm motions. (*Monitor* if repetitive cycle every 30-60 seconds; *take action* if repetitive cycle of less than 30 seconds.)	1	1A	1B
Posture			
2. Standing, with knees straight but not locked. (*Monitor* if standing with knees partially bent; *take action* if using a foot pedal or squatting or kneeling more than 3 hours/day.)	2	2A	2B
3. Sitting, back and legs comfotably supported, feet flat on floor/foot rest. (*Monitor* if back partially supported or feet not flat on floor; *take action* if little support for back and legs, feet not touching floor.)	3	3A	3B
4. Head and neck are upright and straight. (*Monitor* if head and neck are bent forward < 20°; *take action* if >20° >1 hours/day.)	4	4A	4A
Head and neck are bent back. (*Monitor* if < 10°; *take action* if >10°.)	4	4B	4B
Head and neck are bent sideways. (*Monitor* if < 20°; *take action* if >20°.)	4	4C	4C
Head and neck are twisting. (*Monitor* if < 20°; *take action* if >20°.)	4	4D	4D
5. Hands (palms) are vertical. (*Monitor* if hands rotate < 20°; *take action* if hands rotate >20°.)	5	5A	5B
6. Wrists are straight. (*Monitor* if wrists are bent, extension/flexion, < 20° for 5-30 times/minute; *take action* if bent >20° or >30 times/minute.)	6	6A	6A
Wrists move sideways, ulnar/radial. (*Monitor* if < 20° and 5-30 times/minute; *take action* if bent >20° or >30 times/minute.)	6	6B	6B
Vibration			
7. No hand or arm vibration. (*Monitor* if occasional; *take action* if constant.)	7	7A	7B
8. No whole body vibration. (*Monitor* if occasional; *take action* if constant.)	8	8A	8B
Reach			
9. Arms positioned at elbow level. (*Monitor* if up to 45° or frequently out of ideal position for more than 4 hours/day; *take action* if arms are forward >45° or constantly out of ideal position >3 hours/day.)	9	9A	9A
Arms back. (*Monitor* if arms back up to 20° between 2-4 times/minute for more than 4 hours/day; *take action* if arms back >20° or >4 times/minute for more than 3 hours/day.)	9	9B	9B
Elbows bent upward. (*Monitor* if elbows bent up to 20% above or below ideal position >4 hours/day; *take action* if bent upward >25% above or below ideal position >3 hours/day.)	9	9C	9C
Elbows away from body. (*Monitor* if elbows are up to 45° away from body >4 hours/day; *take action* if elbows are >45° away from body >3 hours/day.)	9	9D	9D
10. No twisting, reaching or bending, twisting/repetitive. (*Monitor* if twisting up to 45° or 2-4 times/minute; *take action* if >45° or >4 times/minute.)	10	10A	10A
Reaching/bending forward. (*Monitor* if bending/reaching forward up to 45° or 2-4 times/minute or >10° for >4 hrs/day w/out support; *take action* if >45° or >4 times/minute or >2 hrs/day w/out support.)	10	10B	10B
Reaching/bending to the side. (*Monitor* if up to 20° or 2-4 times/minute; *take action* if >20° or >4 times/minute.)	10	10C	10C
Force			
11. Objects lifted by hand weigh less that one pound. (*Monitor* if objects weighing < 1 lb. are lifted up to 20 times/hour; *take action* if objects weigh >1 lb. or lifting occurs >20 times/hour.)	11	11A	11B
12. Objects lifted by the back weigh less than 5 pounds. (*Monitor* if objects weigh 5-25 lbs. or lifting occurs up to 20 times/hour; *take action* if objects weigh >25 lbs. or lifting occurs >20 times/hour.)	12	12A	12B
13. No pinch grip used. (*Monitor* use of pinch grip with < 2 lbs. of force; *take action* if pinch grip with >2 lbs. of force is used.)	13	13A	13A
Wide pinch grip used. (*Monitor* if slightly too wide; *take action* if extremely wide.)	13	13B	13B
14. Power grip used with no force. (*Monitor* if power grip with < 10 lbs. force is used and forearm rotation force is < 5 lbs.; *take action* if power grip with >10 lbs. force is used and forearm rotation force is >5 lbs.)	14	14A	14B
15. Entire hand controls trigger. (*Monitor* if thumb controls; *take action* if finger(s) control.)	15	15A	15B
16. Tools or objects have rounded, padded handles. (*Monitor* if handles are awkward; *take action* if there are no handles or handles concentrate force.)	16	16A	16B
17. Gloves do not need to be worn at any time. (*Monitor* if gloves are needed but fit well; *take action* if gloves fit poorly.)	17	17A	17B
Static Loading and Fatigue			
18. Constant position, tool or object is held less than 6 seconds. (*Monitor* if held between 6-10 seconds; *take action* if held >10 seconds.)	18	18A	18B
19. Less than 10% of the task is repetitive. (*Monitor* if 25-50% repetitive; *take action* if >50% repetitive.)	19	19A	19B
Pressure/Contact Stress/Repeated Impacts			
20. No contact/impact stress. (*Monitor* if occasional pressure or body part is used as hammer < 2 hours/day; *take action* if constant pressure or body part is used as hammer >2 hours/day.)	20	20A	20B

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Lifting and Materials Handling			
21. No lifting or lowering of materials. (*Monitor* if occasional and/or no more than 20 times/hour; *take action* if constant and/or greater than 20 times/hour.	21	21A	21B
22. No pushing or pulling of materials. (*Monitor* if pushing/pulling 10-50 carts/shift; *take action* if pushing/pulling more than 50 carts/shift.)	22	22A	22B
23. Slight force is required to push or pull materials. (*Monitor* if moderate force is required; *take action* if high force is required.)	23	23A	23B
Environment			
24. Worker has adequate control over workplace. (*Monitor* if worker has some control; *take action* if worker has no control.)	24	24A	24B
25. Lighting is adequate for the task. (*Monitor* if slightly too dark or bright; *take action* if significantly too dark or bright.)	25	25A	25B
26. Temperature is comfortable. (*Monitor* if slightly too cold or hot; *take action* if significantly too cold or hot.)	26	26A	26B
27. Work area is quiet. (*Monitor* if slightly too noisy; *take action* if significantly too noisy.)	27	27A	27B
28. Flooring provides good traction. (*Monitor* if flooring is slightly slippery; *take action* if moderately to extremely slippery.)	28	28A	28B
29. Flooring is sufficiently padded to relieve stress on back and legs. (*Monitor* if slight stress to back and legs; *take action* if moderately to extreme stress.)	29	29A	29B
30. Floor mats are provided. Employee can alternate between sitting and standing. (*Monitor* if employee is standing up to 50% of shift without floor mats or other stress relief for back and legs; *take action* if standing >50% of shift without floor mats or other relief for back and legs.	30	30A	30B

Action Plan

Today's date: _____ Date Solution to be Completed _____

Location/Department: _____

Job/Task Title: _____

Evaluator: _____

Describe MSD in previous 24 months: _____

_____

Task: _____

Summary of Problem: _____

_____

Alternative Solution and Costs: _____

_____

Recommended Solution: 1) Engineering _____

_____

2) Administrative: _____

_____

3) Use of personal protective equipment _____

_____

Date Solution Actuall/ Completed: _____ Actual Cost: _____

GREAT AMERICAN.
INSURANCE GROUP

Appendix B: Liberty Mutual Manual Material Handling Snook Tables

TABLE 1 F - FEMALE POPULATION PERCENTAGES FOR LIFTING TASKS ENDING BELOW KNUCKLE HEIGHT (<28")

OBJECT WEIGHT (POUNDS)	LIFTING DISTANCE (INCHES)	HAND DISTANCE	7 INCHES					10 INCHES					15 INCHES				
		FREQUENCY ONE LIFT EVERY	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	65	28	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-
		20	-	-	-	-	29	-	-	-	-	14	-	-	-	-	-
		10	-	-	-	-	34	-	-	-	-	20	-	-	-	-	-
	62	28	-	-	-	-	17	-	-	-	-	-	-	-	-	-	-
		20	-	-	-	-	35	-	-	-	-	19	-	-	-	-	-
		10	-	-	-	-	40	-	-	-	-	26	-	-	-	-	-
	59	28	-	-	-	-	22	-	-	-	-	-	-	-	-	-	-
		20	-	-	-	-	41	-	-	-	-	25	-	-	-	-	-
		10	-	-	-	-	46	-	-	-	-	32	-	-	-	-	-
	56	28	-	-	-	-	29	-	-	-	-	14	-	-	-	-	-
		20	-	-	-	-	48	-	-	-	-	31	-	-	-	-	-
		10	-	-	-	-	53	-	-	-	-	38	-	-	-	-	13
	53	28	-	-	-	-	35	-	-	-	-	20	-	-	-	-	-
		20	-	-	-	-	54	-	-	-	-	38	-	-	-	-	-
		10	-	-	-	12	59	-	-	-	-	45	-	-	-	-	18
	50	28	-	-	-	-	43	-	-	-	-	26	-	-	-	-	-
		20	-	-	-	13	61	-	-	-	-	45	-	-	-	-	14
		10	-	-	-	17	65	-	-	-	-	53	-	-	-	-	25
	47	28	-	-	-	-	51	-	-	-	-	34	-	-	-	-	-
		20	-	-	-	19	67	-	-	-	-	53	-	-	-	-	20
		10	-	-	14	24	71	-	-	-	11	60	-	-	-	-	32
	44	28	-	-	-	11	58	-	-	-	-	42	-	-	-	-	12
		20	-	-	16	27	73	-	-	-	13	60	-	-	-	-	28
		10	14	16	20	32	76	-	-	-	17	67	-	-	-	-	41
	41	28	-	-	-	18	66	-	-	-	-	51	-	-	-	-	18
		20	-	14	24	36	78	-	-	11	20	68	-	-	-	-	36
		10	21	23	29	41	81	-	-	14	24	73	-	-	-	-	50
	38	28	-	12	16	26	73	-	-	-	13	60	-	-	-	-	27
		20	16	22	33	46	83	-	-	18	29	74	-	-	-	-	46
		10	30	33	38	50	85	14	16	22	34	78	-	-	-	-	58
	35	28	17	19	25	37	79	-	-	11	21	68	-	-	-	-	37
		20	25	32	44	56	87	11	16	27	39	80	-	-	-	-	56
		10	40	43	49	60	88	22	25	32	44	83	-	-	-	13	67
	32	28	27	30	36	48	84	12	14	20	31	76	-	-	-	-	49
		20	36	43	55	65	+	19	25	38	50	85	-	-	-	18	66
		10	51	54	59	69	+	33	37	43	55	87	-	-	12	22	75
	29	28	39	43	49	60	88	21	25	32	44	82	-	-	-	13	60
		20	49	55	65	74	+	30	38	51	62	89	-	-	18	29	74
		10	63	65	69	77	+	46	49	55	66	+	11	14	22	34	81
	26	28	53	56	61	70	+	35	38	46	57	87	-	-	14	24	71
		20	61	67	75	81	+	44	51	63	72	+	-	16	31	43	82
		10	73	75	78	83	+	59	62	67	75	+	21	26	36	48	87
	23	28	66	69	73	80	+	50	54	60	70	+	14	18	27	39	80
		20	73	77	83	87	+	59	65	74	81	+	22	30	46	58	87
		10	81	83	85	89	+	71	73	77	83	+	36	42	51	62	+
	20	28	78	79	82	87	+	66	69	73	80	+	29	35	45	57	87
		20	82	85	89	+	+	72	77	83	88	+	39	48	63	72	+
		10	88	89	+	+	+	81	82	85	89	+	54	59	66	75	+
	17	28	87	88	89	+	+	79	81	84	88	+	50	55	64	73	+
		20	89	+	+	+	+	83	86	+	+	+	59	66	77	83	+
		10	+	+	+	+	+	88	89	+	+	+	71	74	79	85	+
	14	28	+	+	+	+	+	88	89	+	+	+	71	74	80	85	+
		20	+	+	+	+	+	+	+	+	+	+	77	81	87	+	+
		10	+	+	+	+	+	+	+	+	+	+	84	86	89	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 1 M - MALE POPULATION PERCENTAGES FOR LIFTING TASKS

ENDING BELOW KNUCKLE HEIGHT (<31")

OBJECT WEIGHT (POUNDS)	HAND DISTANCE	LIFTING DISTANCE (INCHES)	FREQUENCY ONE LIFT EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	96		30	-	-	-	30	49	-	-	-	16	35	-	-	-	-	-
			20	-	-	13	34	54	-	-	-	20	39	-	-	-	-	12
			10	-	11	25	48	65	-	-	13	33	53	-	-	-	-	23
	92		30	-	-	14	34	54	-	-	-	20	40	-	-	-	-	12
			20	-	-	17	39	58	-	-	-	24	44	-	-	-	-	16
			10	-	15	30	52	69	-	-	16	38	57	-	-	-	11	28
	88		30	-	-	17	39	58	-	-	-	25	45	-	-	-	-	16
			20	-	-	21	44	62	-	-	-	29	49	-	-	-	-	20
			10	11	19	34	57	72	-	-	20	43	61	-	-	-	15	33
	84		30	-	-	22	45	63	-	-	-	30	50	-	-	-	-	20
			20	-	11	26	49	66	-	-	14	34	54	-	-	-	-	25
			10	15	23	40	61	75	-	11	25	48	65	-	-	-	19	38
	80		30	-	-	27	50	67	-	-	14	35	55	-	-	-	-	25
			20	-	14	31	54	70	-	-	18	40	59	-	-	-	13	30
			10	20	28	45	65	78	-	15	30	53	69	-	-	-	24	43
	76		30	-	14	33	55	71	-	-	19	41	60	-	-	-	13	31
			20	11	19	37	59	73	-	-	23	46	63	-	-	-	17	36
			10	25	34	51	69	80	12	19	36	58	73	-	-	-	29	49
	72		30	-	19	39	60	74	-	-	24	47	64	-	-	-	18	37
			20	15	24	43	64	77	-	12	29	51	68	-	-	-	22	42
			10	31	40	56	73	83	16	25	42	63	76	-	-	14	35	55
	68		30	15	25	45	65	78	-	12	30	53	69	-	-	-	24	43
			20	20	31	50	69	80	-	16	35	57	72	-	-	-	28	48
			10	37	46	62	77	85	21	31	48	68	79	-	-	19	42	60
	64		30	20	31	52	70	81	-	17	37	59	73	-	-	11	30	50
			20	26	37	56	73	83	13	22	42	63	76	-	-	14	35	54
			10	44	53	67	80	87	29	38	55	72	82	-	-	25	48	66
	60		30	27	39	58	75	84	13	23	44	65	77	-	-	16	37	57
			20	34	45	62	77	85	18	29	49	68	80	-	-	20	42	60
			10	51	59	72	83	89	35	45	61	76	85	-	14	33	55	71
	56		30	35	46	64	79	86	19	31	52	70	81	-	-	22	45	63
			20	41	52	68	81	88	25	37	56	73	83	-	-	27	50	66
			10	58	65	76	86	+	42	52	67	80	87	12	21	40	62	75
	52		30	43	54	70	82	89	27	39	59	75	84	-	11	30	53	69
			20	49	59	73	84	+	33	45	63	78	86	-	14	35	57	72
			10	65	71	80	88	+	51	60	72	84	99	19	28	48	68	79
	48		30	52	62	76	85	+	36	48	66	80	87	-	17	39	61	75
			20	58	66	78	87	+	42	53	69	82	88	11	22	44	64	77
			10	71	76	84	+	+	59	66	77	87	+	26	37	57	74	83
	44		30	60	69	80	88	+	45	57	73	84	89	14	26	49	68	80
			20	65	73	82	89	+	52	62	75	85	+	19	31	53	71	82
			10	76	81	87	+	+	66	73	82	89	+	35	47	65	79	86
	40		30	68	76	85	+	+	56	66	78	87	+	23	37	59	75	84
			20	73	79	86	+	+	61	70	81	88	+	29	42	62	77	85
			10	81	85	+	+	+	73	79	86	+	+	46	57	72	83	89
	36		30	76	81	88	+	+	65	73	83	+	+	35	48	68	81	88
			20	79	84	89	+	+	70	77	85	+	+	40	53	71	83	89
			10	86	88	+	+	+	80	84	89	+	+	57	66	78	87	+
	32		30	82	86	+	+	+	74	80	88	+	+	48	60	76	86	+
			20	84	88	+	+	+	77	83	89	+	+	53	64	78	87	+
			10	89	+	+	+	+	85	88	+	+	+	67	75	84	+	+
	28		30	87	+	+	+	+	81	86	+	+	+	61	71	83	+	+
			20	89	+	+	+	+	84	87	+	+	+	66	74	84	+	+
			10	+	+	+	+	+	89	+	+	+	+	77	82	88	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 2F - FEMALE POPULATION PERCENTAGES FOR LIFTING TASKS

ENDING BETWEEN KNUCKLE AND SHOULDER HEIGHT (≥28" AND ≤ 53")

OBJECT WEIGHT (POUNDS)	HAND DISTANCE	LIFTING DISTANCE (INCHES)	FREQUENCY ONE LIFT EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	59		30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	56		30	-	-	-	-	-		-	-	-	-	-	-	-	-	-
			20	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			10	-	-	-	-	15	-	-	-	-	-	-	-	-	-	-
	53		30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-
			10	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-
	50		30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	17	-	-	-	-	-	-	-	-	-	-
			10	-	-	-	-	29	-	-	-	-	14	-	-	-	-	-
	47		30	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	24	-	-	-	-	11	-	-	-	-	-
			10	-	-	-	-	38	-	-	-	-	21	-	-	-	-	-
	44		30	-	-	-	-	19	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	34	-	-	-	-	17	-	-	-	-	-
			10	-	-	-	15	48	-	-	-	-	30	-	-	-	-	-
	41		30	-	-	-	-	29	-	-	-	-	14	-	-	-	-	-
			20		-	-	12	44	-	-	-	-	26	-	-	-	-	-
			10	-	-	14	23	58	-	-	-	-	41	-	-	-	-	-
	38		30	-	-	-	-	40	-	-	-	-	22	-	-	-	-	-
			20	-	-	12	21	56	-	-	-	-	38	-	-	-	-	-
			10	-	-	23	34	68	-	-	-	18	52	-	-	-	-	17
	35		30	-	-	-	18	52	-	-	-	-	34	-	-	-	-	-
			20	-	14	22	32	66	-	-	-	16	50	-	-	-	-	16
			10	11	18	35	47	76	-	-	18	29	63	-	-	-	-	28
	32		30	-	-	20	30	64	-	-	-	15	48	-	-	-	-	14
			20	20	25	34	46	76	-	11	18	28	62	-	-	-	-	28
			10	20	30	49	60	83	-	14	31	42	73	-	-	-	11	42
	29		30	12	18	33	45	75	-	-	17	27	61	-	-	-	-	27
			20	34	39	49	60	83	18	22	31	43	74	-	-	-	11	42
			10	34	45	62	71	89	18	27	45	56	82	-	-	13	22	56
	26		30	25	33	50	60	84	11	17	32	43	74	-	-	-	11	43
			20	50	55	64	73	89	32	38	47	58	83	-	-	14	23	58
			10	50	60	75	81	+	33	43	61	70	88	-	12	26	37	70
	23		30	43	52	66	74	+	25	34	50	61	84	-	-	16	26	60
			20	66	70	77	83	+	51	56	64	73	89	17	21	30	41	73
			10	67	74	84	88	+	51	61	75	81	+	18	26	44	55	81
	20		30	62	70	80	85	+	46	54	68	76	+	14	20	35	46	76
			20	80	83	87	+	+	69	73	79	84	+	37	41	51	61	84
			10	80	85	+	+	+	69	76	85	89	+	37	47	64	72	89
	17		30	79	84	+	+	+	68	74	83	88	+	35	44	59	68	87
			20	+	+	+	+	+	83	86	89	+	+	60	64	71	79	+
			10	+	+	+	+	+	84	88	+	+	+	61	69	80	85	+
	14		30	+	+	+	+	+	85	88	+	+	+	63	70	80	85	+
			20	+	+	+	+	+	+	+	+	+	+	80	83	87	+	+
			10	+	+	+	+	+	+	+	+	+	+	81	85	+	+	+
	11		30	+	+	+	+	+	+	+	+	+	+	85	88	+	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
	8		30	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 2M - MALE POPULATION PERCENTAGES FOR LIFTING TASKS

ENDING BETWEEN KNUCKLE AND SHOULDER HEIGHT (≥31" AND ≤57")

OBJECT WEIGHT (POUNDS)	LIFTING DISTANCE (INCHES)	HAND DISTANCE / FREQUENCY ONE LIFT EVERY	7 INCHES					10 INCHES					15 INCHES				
			15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	96	30	-	-	-	-	12	-	-	-	-	-	-	-	-	-	-
		20	-	-	-	-	25	-	-	-	-	12	-	-	-	-	-
		10	-	-	16	21	46	-	-	-	-	30	-	-	-	-	-
	92	30	-	-	-	-	16		-	-	-	-	-	-	-	-	-
		20	-	-	-	-	30	-	-	-	-	16	-	-	-	-	-
		10	-	-	20	26	52	-	-	-	13	36	-	-	-	-	-
	88	30	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-
		20	-	-	-	13	36	-	-	-	-	21	-	-	-	-	-
		10	-	11	25	32	57	-	-	12	17	42	-	-	-	-	13
	84	30	-	-	-	-	27	-	-	-	-	13	-	-	-	-	-
		20	-	-	12	17	42	-	-	-	-	26	-	-	-	-	-
		10	-	15	31	38	63	-	-	17	22	48	-	-	-	-	17
	80	30	-	-	-	11	33	-	-	-	-	18	-	-	-	-	-
		20	-	-	17	23	49	-	-	-	11	32	-	-	-	-	-
		10	12	20	38	44	68	-	-	22	28	54	-	-	-	-	23
	76	30	-	-	11	16	40	-	-	-	-	24	-	-	-	-	-
		20	-	-	23	29	55	-	-	11	15	39	-	-	-	-	11
		10	17	26	45	51	72	-	13	29	35	60	-	-	-	-	29
	72	30	-	-	16	21	47	-	-	-	-	31	-	-	-	-	-
		20	-	14	30	36	61	-	-	16	21	47	-	-	-	-	16
		10	23	33	52	58	77	11	19	36	42	66	-	-	-	13	36
	68	30	-	11	22	28	54	-	-	-	15	39	-	-	-	-	11
		20	12	20	37	44	67	-	-	22	28	54	-	-	-	-	23
		10	30	41	59	64	81	16	25	43	50	72	-	-	14	19	44
	64	30	12	17	30	36	61	-	-	16	21	47	-	-	-	-	16
		20	18	27	45	52	73	-	14	29	36	61	-	-	-	-	30
		10	38	49	65	70	84	23	33	51	57	77	-	-	20	26	52
	60	30	18	25	38	45	68	-	12	23	29	55	-	-	-	-	24
		20	25	35	54	60	78	13	20	38	44	68	-	-	-	15	39
		10	47	57	72	76	87	31	42	59	64	81	-	13	28	34	60
	56	30	26	33	48	54	74	13	19	32	38	63	-	-	-	-	32
		20	34	45	62	67	83	20	29	47	53	74	-	-	17	22	48
		10	56	65	77	81	+	41	51	67	71	85	13	20	37	44	67
	52	30	36	43	57	63	80	21	28	41	48	70	-	-	13	17	42
		20	44	54	69	74	86	28	39	56	62	80	-	11	25	31	57
		10	64	72	82	85	+	50	60	73	77	88	20	29	47	53	74
	48	30	46	54	66	71	85	31	38	52	58	77	-	11	21	27	53
		20	54	63	76	80	+	39	49	65	70	84	12	19	36	42	66
		10	72	78	86	88	+	60	68	80	83	+	30	40	57	63	80
	44	30	57	64	74	78	88	42	50	62	67	83	14	19	32	38	63
		20	64	72	82	85	+	51	60	74	77	88	20	29	47	53	74
		10	79	84	+	+	+	69	76	85	87	+	42	51	67	71	85
	40	30	68	73	81	84	+	55	61	72	76	87	24	31	44	51	72
		20	73	79	87	89	+	62	70	81	84	+	32	42	59	64	81
		10	85	88	+	+	+	77	82	89	+	+	54	63	75	79	89
	36	30	77	81	87	89	+	66	72	80	83	+	38	45	58	63	80
		20	81	85	+	+	+	72	78	86	88	+	46	56	70	74	87
		10	89	+	+	+	+	84	88	+	+	+	66	73	82	85	+
	32	30	84	87	+	+	+	77	81	86	88	+	53	60	70	74	87
		20	87	+	+	+	+	81	85	+	+	+	61	69	79	83	+
		10	+	+	+	+	+	89	+	+	+	+	76	82	88	+	+
	28	30	+	+	+	+	+	85	88	+	+	+	68	73	81	84	+
		20	+	+	+	+	+	88	+	+	+	+	74	79	87	89	+
		10	+	+	+	+	+	+	+	+	+	+	85	88	+	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 3F - FEMALE POPULATION PERCENTAGES FOR LIFTING TASKS

ENDING ABOVE SHOULDER HEIGHT (>53")

OBJECT WEIGHT (POUNDS)	LIFTING DISTANCE (INCHES)	HAND DISTANCE	FREQUENCY ONE LIFT EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
		40	30	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	26	-	-	-	-	12	-	-	-	-	-
			10	-	-	-	-	40	-	-	-	-	22	-	-	-	-	-
		38	30	-	-	-	-	19	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	33	-	-	-	-	17	-	-	-	-	-
			10	-	-	-	15	48	-	-	-	-	30	-	-	-	-	-
		36	30	-	-	-	-	26	-	-	-	-	12	-	-	-	-	-
			20	-	-	-	11	41	-	-	-	-	24	-	-	-	-	-
			10	-	-	12	21	55	-	-	-	-	38	-	-	-	-	-
		34	30	-	-	-	-	34	-	-	-	-	18	-	-	-	-	-
			20	-	-	-	18	50	-	-	-	-	32	-	-	-	-	-
			10	-	-	18	29	63	-	-	-	14	46	-	-	-	-	13
		32	30	-	-	-	12	43	-	-	-	-	26	-	-	-	-	-
			20	-	-	15	24	59	-	-	-	-	41	-	-	-	-	-
			10	-	11	26	38	70	-	-	12	21	55	-	-	-	-	20
		30	30	-	-	11	19	53	-	-	-	-	35	-	-	-	-	-
			20	11	14	22	33	67	-	-	-	17	51	-	-	-	-	17
			10	11	18	36	47	77	-	-	19	29	64	-	-	-	-	29
		28	30	-	-	18	28	62	-	-	-	13	45	-	-	-	-	13
			20	18	22	32	44	74	-	-	16	26	60	-	-	-	-	25
			10	18	27	46	57	82	-	13	28	40	72	-	-	-	-	39
		26	30	-	14	27	39	71	-	-	13	21	56	-	-	-	-	21
			20	28	33	43	54	81	13	17	25	37	69	-	-	-	-	36
			10	28	38	57	67	87	13	21	39	51	79	-	-	-	17	50
		24	30	16	23	39	51	79	-	-	22	33	66	-	-	-	-	32
			20	40	45	55	65	86	23	27	37	49	77	-	-	-	15	48
			10	40	50	67	75	+	23	33	51	62	84	-	-	17	27	61
		22	30	27	36	52	63	85	13	19	34	46	76	-	-	-	13	45
			20	53	58	66	74	+	35	40	50	61	84	-	-	16	26	60
			10	53	62	76	82	+	35	46	63	72	89	-	13	28	40	72
		20	30	41	50	65	73	+	24	32	49	59	83	-	-	15	24	59
			20	65	69	76	82	+	49	54	63	72	89	16	20	28	40	72
			10	66	73	84	88	+	50	59	74	81	+	16	25	43	54	80
		18	30	57	64	76	82	+	39	48	63	72	89	-	15	28	40	72
			20	76	79	84	88	+	64	68	75	81	+	30	35	44	55	81
			10	77	82	89	+	+	64	72	83	87	+	30	40	58	68	87
		16	30	71	77	85	89	+	57	64	76	82	+	22	30	46	57	82
			20	85	87	+	+	+	76	79	84	88	+	48	52	61	70	88
			10	85	89	+	+	+	77	82	89	+	+	48	57	72	79	+
		14	30	83	86	+	+	+	73	78	86	+	+	42	50	64	73	+
			20	+	+	+	+	+	86	88	+	+	+	66	70	76	82	+
			10	+	+	+	+	+	86	+	+	+	+	66	73	83	88	+
		12	30	+	+	+	+	+	85	88	+	+	+	64	70	80	85	+
			20	+	+	+	+	+	+	+	+	+	+	81	83	87	+	+
			10	+	+	+	+	+	+	+	+	+	+	81	85	+	+	+
		10	30	+	+	+	+	+	+	+	+	+	+	82	85	+	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		8	30	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		6	30	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 3M - MALE POPULATION PERCENTAGES FOR LIFTING TASKS

ENDING ABOVE SHOULDER HEIGHT (>57")

OBJECT WEIGHT (POUNDS)	LIFTING DISTANCE (INCHES)	FREQUENCY ONE LIFT EVERY	7 INCHES					10 INCHES					15 INCHES				
			15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	77	30	-	-	-	-	28	-	-	-	-	14	-	-	-	-	-
		20	-	-	14	18	44	-	-	-	-	28	-	-	-	-	-
		10	-	16	33	39	64	-	-	18	24	49	-	-	-	-	19
	74	30	-	-	-	11	33		-	-	-	18	-	-	-	-	-
		20	-	-	17	23	49	-	-	-	11	33	-	-	-	-	-
		10	12	20	38	45	68	-	-	22	29	54	-	-	-	-	23
	71	30	-	-	-	15	39	-	-	-	-	23	-	-	-	-	-
		20	-	-	22	28	54	-	-	-	14	38	-	-	-	-	11
		10	16	25	44	50	72	-	12	28	34	59	-	-	-	-	28
	68	30	-	-	14	19	45	-	-	-	-	29	-	-	-	-	-
		20	-	12	27	34	59	-	-	14	19	44	-	-	-	-	14
		10	21	31	49	55	75	-	17	33	40	64	-	-	-	11	34
	65	30	-	-	19	25	50	-	-	-	12	35	-	-	-	-	-
		20	-	16	33	40	64	-	-	18	24	50	-	-	-	-	19
		10	27	37	55	61	79	13	22	39	46	69	-	-	11	16	40
	62	30	-	13	24	31	56	-	-	12	16	41	-	-	-	-	12
		20	13	22	40	46	69	-	-	24	30	56	-	-	-	-	25
		10	33	43	60	66	82	18	27	46	52	73	-	-	16	21	46
	59	30	12	18	31	37	62	-	-	16	22	47	-	-	-	-	17
		20	18	28	46	52	73	-	14	30	37	62	-	-	-	-	31
		10	39	50	66	71	85	24	34	52	58	77	-	-	21	27	53
	56	30	17	24	38	44	68	-	11	22	28	54	-	-	-	-	23
		20	24	34	53	59	78	12	20	37	44	67	-	-	-	14	38
		10	46	56	71	75	87	30	41	58	64	81	-	12	27	33	59
	53	30	23	31	45	51	73	11	17	29	35	61	-	-	-	-	30
		20	31	42	59	65	81	17	26	44	51	72	-	-	15	20	45
		10	53	62	76	79	89	38	48	64	69	84	11	18	34	41	65
	50	30	31	38	52	58	77	17	23	37	43	67	-	-	-	14	37
		20	39	50	66	77	85	24	34	52	58	77	-	-	21	27	53
		10	60	68	80	83	+	46	55	70	74	87	16	25	42	49	71
	47	30	39	47	60	65	82	24	31	45	51	73	-	-	15	20	46
		20	47	57	72	76	87	32	42	59	65	81	-	13	28	35	60
		10	67	74	84	86	+	54	63	76	79	89	23	33	50	56	76
	44	30	48	55	67	72	85	32	40	53	59	78	-	12	22	28	54
		20	56	65	77	81	+	41	51	67	71	85	13	20	37	44	67
		10	73	79	87	89	+	61	69	80	83	+	31	41	58	64	81
	41	30	57	63	74	77	88	42	49	62	67	82	13	19	31	37	62
		20	64	72	82	85	+	50	59	73	77	88	20	29	46	53	74
		10	79	83	+	+	+	69	75	84	87	+	41	51	66	71	85
	38	30	65	71	79	82	+	51	58	70	74	86	21	28	41	48	70
		20	71	78	86	88	+	59	67	79	82	+	29	39	56	62	79
		10	83	87	+	+	+	75	81	88	+	+	51	60	73	77	88
	35	30	73	78	84	87	+	61	67	77	80	+	31	39	52	58	77
		20	78	83	89	+	+	68	75	84	86	+	40	50	65	70	84
		10	87	+	+	+	+	81	85	+	+	+	61	69	79	83	+
	32	30	80	83	88	+	+	70	75	83	85	+	43	50	62	68	83
		20	84	87	+	+	+	76	81	88	+	+	52	61	74	78	88
		10	+	+	+	+	+	86	89	+	+	+	70	76	85	87	+
	29	30	85	88	+	+	+	78	82	87	89	+	56	62	72	76	88
		20	88	+	+	+	+	83	86	+	+	+	63	71	81	84	+
		10	+	+	+	+	+	+	+	+	+	+	78	83	89	+	+
	26	30	+	+	+	+	+	85	88	+	+	+	68	73	81	83	+
		20	+	+	+	+	+	88	+	+	+	+	74	79	87	89	+
		10	+	+	+	+	+	+	+	+	+	+	85	88	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 4F - FEMALE POPULATION PERCENTAGES FOR LOWERING TASKS

BEGINNING BELOW KNUCKLE HEIGHT (<28")

OBJECT WEIGHT (POUNDS)	HAND DISTANCE	LOWERING DISTANCE (INCHES)	FREQUENCY ONE LOWER EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	51		30	-	-	-	-	47	-	-	-	-	26	-	-	-	-	-
			20	-	-	-	17	69	-	-	-	-	50	-	-	-	-	12
			10	-	-	-	22	73	-	-	-	-	56	-	-	-	-	16
	48		30	-	-	-	-	56		-	-	-	36	-	-	-	-	-
			20	-	-	-	25	75	-	-	-	-	59	-	-	-	-	18
			10	-	-	11	31	79	-	-	-	14	64	-	-	-	-	24
	45		30	-	-	-	14	65	-	-	-	-	46	-	-	-	-	-
			20	-	-	14	35	81	-	-	-	16	68	-	-	-	-	27
			10	-	12	18	41	84	-	-	-	21	72	-	-	-	-	33
	43		30	-	-	-	20	71	-	-	-	-	53	-	-	-	-	14
			20	-	-	19	42	84	-	-	-	22	73	-	-	-	-	34
			10	14	17	24	49	87	-	-	-	28	77	-	-	-	-	41
	41		30	-	-	-	26	76	-	-	-	-	60	-	-	-	-	19
			20	-	12	25	50	87	-	-	-	29	78	-	-	-	-	42
			10	20	24	31	56	89	-	-	14	35	81	-	-	-	-	48
	39		30	-	-	13	34	80	-	-	-	15	67	-	-	-	-	26
			20	12	18	33	58	+	-	-	15	37	82	-	-	-	-	50
			10	27	31	39	63	+	-	12	20	43	85	-	-	-	-	56
	37		30	-	12	19	42	84	-	-	-	22	73	-	-	-	-	34
			20	18	25	41	65	+	-	-	21	45	86	-	-	-	-	58
			10	35	39	48	70	+	15	18	27	52	88	-	-	-	13	63
	35		30	15	19	26	51	88	-	-	-	30	78	-	-	-	-	43
			20	25	34	50	72	+	-	14	29	54	89	-	-	-	14	66
			10	44	48	56	76	+	22	26	35	60	+	-	-	-	19	70
	33		30	23	27	36	60	+	-	-	17	40	83	-	-	-	-	52
			20	34	43	59	78	+	14	22	39	63	+	-	-	-	22	73
			10	53	57	64	81	+	30	35	45	68	+	-	-	-	27	77
	31		30	32	37	46	68	+	13	16	25	50	87	-	-	-	11	62
			20	44	53	67	83	+	22	31	49	70	+	-	-	11	31	79
			10	62	66	72	86	+	40	45	55	75	+	-	-	15	37	82
	29		30	43	47	56	76	+	21	25	35	60	+	-	-	-	19	70
			20	55	63	75	87	+	32	41	59	77	+	-	-	18	41	84
			10	71	74	79	89	+	51	55	64	81	+	-	13	23	48	87
	27		30	54	58	66	82	+	31	36	47	69	+	-	-	-	29	78
			20	65	72	81	+	+	43	53	68	83	+	-	11	28	53	88
			10	78	80	84	+	+	61	65	73	86	+	16	22	34	59	+
	25		30	65	69	75	87	+	43	49	58	77	+	-	-	18	41	84
			20	74	79	87	+	+	55	64	77	88	+	11	20	40	64	+
			10	84	86	89	+	+	71	74	80	+	+	26	33	46	69	+
	23		30	75	78	82	+	+	56	61	69	84	+	12	17	29	54	89
			20	81	85	+	+	+	67	74	84	+	+	21	32	53	74	+
			10	89	+	+	+	+	79	82	86	+	+	39	46	59	78	+
	21		30	83	85	88	+	+	69	72	79	89	+	23	30	44	67	+
			20	88	+	+	+	+	77	82	89	+	+	34	46	66	82	+
			10	+	+	+	+	+	86	88	+	+	+	53	60	71	85	+
	18		30	+	+	+	+	+	83	86	89	+	+	47	54	66	82	+
			20	+	+	+	+	+	88	+	+	+	+	59	68	82	+	+
			10	+	+	+	+	+	+	+	+	+	+	74	78	85	+	+
	15		30	+	+	+	+	+	+	+	+	+	+	72	77	84	+	+
			20	+	+	+	+	+	+	+	+	+	+	80	85	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	88	+	+	+	+
	12		30	+	+	+	+	+	+	+	+	+	+	89	+	+	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 4M - MALE POPULATION PERCENTAGES FOR LOWERING TASKS

BEGINNING BELOW KNUCKLE HEIGHT (<31")

OBJECT WEIGHT (POUNDS)	HAND DISTANCE	LOWERING DISTANCE (INCHES)	FREQUENCY ONE LOWER EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	87		30	-	-	23	47	73	-	-	11	31	62	-	-	-	-	33
			20	-	14	28	51	76	-	-	14	36	66	-	-	-	-	38
			10	21	28	42	64	83	-	14	26	50	75	-	-	-	20	52
	84		30	-	13	27	51	75	-	-	14	35	65	-	-	-	-	37
			20	-	17	32	55	78	-	-	17	40	69	-	-	-	12	42
			10	24	32	46	67	84	11	17	30	54	77	-	-	-	24	55
	81		30	-	16	31	55	78	-	-	17	40	69	-	-	-	12	41
			20	13	20	36	59	80	-	-	21	44	72	-	-	-	15	46
			10	29	36	50	70	86	14	20	35	58	80	-	-	-	28	59
	78		30	13	20	35	58	80	-	-	21	44	71	-	-	-	15	46
			20	16	24	40	62	82	-	11	25	49	74	-	-	-	19	50
			10	33	40	54	72	87	17	24	39	61	81	-	-	11	32	63
	75		30	16	24	40	62	82	-	11	25	49	74	-	-	-	19	50
			20	20	28	45	66	84	-	14	29	53	77	-	-	-	23	54
			10	37	45	58	75	88	21	29	44	65	83	-	-	15	36	66
	72		30	20	28	45	66	84	-	14	29	53	77	-	-	-	23	54
			20	24	33	49	69	85	11	18	34	57	79	-	-	-	27	59
			10	42	50	62	78	89	25	33	48	68	85	-	-	18	41	70
	69		30	24	33	50	69	85	11	18	34	57	79	-	-	-	27	59
			20	29	38	54	72	87	14	22	39	61	81	-	-	11	32	63
			10	47	54	66	80	+	30	38	53	72	87	-	-	23	46	73
	66		30	29	38	54	73	87	15	23	39	62	82	-	-	12	32	63
			20	34	43	59	76	88	18	27	44	66	84	-	-	15	37	67
			10	52	59	69	82	+	35	44	58	75	88	-	13	27	51	76
	63		30	35	44	59	76	89	19	28	45	66	84	-	-	15	38	67
			20	40	49	63	78	+	23	32	49	69	85	-	-	19	43	70
			10	57	63	73	84	+	41	49	62	78	89	-	17	33	56	79
	60		30	40	49	64	79	+	24	33	50	70	86	-	-	20	43	71
			20	45	54	67	81	+	28	38	55	73	87	-	-	24	48	74
			10	62	67	76	86	+	46	54	66	80	+	14	21	38	61	81
	57		30	46	55	68	82	+	29	39	56	74	88	-	-	26	49	75
			20	51	59	71	83	+	34	44	60	76	89	-	13	30	54	77
			10	66	72	79	88	+	52	59	71	83	+	18	27	44	66	84
	54		30	52	60	72	84	+	36	45	61	77	89	-	14	32	55	78
			20	57	64	75	86	+	40	50	65	80	+	-	18	36	59	80
			10	71	75	82	+	+	58	64	74	85	+	24	33	50	70	86
	51		30	58	66	76	86	+	42	52	66	80	+	11	19	38	61	81
			20	62	69	79	88	+	47	56	70	82	+	14	23	43	65	83
			10	75	79	85	+	+	63	69	78	87	+	30	40	56	74	88
	48		30	64	71	80	88	+	49	58	71	83	+	16	26	45	66	84
			20	68	74	82	89	+	54	62	74	85	+	20	30	50	70	86
			10	78	82	87	+	+	68	74	81	89	+	37	47	62	78	+
	45		30	70	75	83	+	+	56	64	76	86	+	22	33	52	71	86
			20	73	78	85	+	+	60	68	78	87	+	26	38	57	74	88
			10	82	85	89	+	+	73	78	84	+	+	44	54	68	81	+
	42		30	75	79	86	+	+	63	70	80	88	+	30	41	60	76	89
			20	77	81	87	+	+	67	73	82	89	+	34	46	63	79	+
			10	85	87	+	+	+	78	82	87	+	+	52	61	73	85	+
	39		30	79	83	88	+	+	69	75	83	+	+	38	49	66	80	+
			20	81	85	89	+	+	72	78	85	+	+	43	54	70	82	+
			10	88	+	+	+	+	82	85	89	+	+	60	67	78	87	+
	36		30	83	+	+	+	+	75	80	87	+	+	47	58	73	84	+
			20	85	+	+	+	+	78	82	88	+	+	52	62	75	86	+
			10	+	+	+	+	+	85	88	+	+	+	67	74	82	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 5F - FEMALE POPULATION PERCENTAGES FOR LOWERING TASKS

BEGINNING BETWEEN KNUCKLE AND SHOULDER HEIGHTS (≥28" AND ≤53")

OBJECT WEIGHT (POUNDS)	LOWERING DISTANCE (INCHES)	HAND DISTANCE	FREQUENCY ONE LOWER EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
		51	30	-	-	-	-	25	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	43	-	-	-	-	23	-	-	-	-	-
			10	-	-	-	21	58	-	-	-	-	38	-	-	-	-	-
		48	30	-	-	-	-	35		-	-	-	17	-	-	-	-	-
			20	-	-	-	17	53	-	-	-	-	33	-	-	-	-	-
			10	-	-	-	30	67	-	-	-	14	49	-	-	-	-	12
		45	30	-	-	-	12	46	-	-	-	-	26	-	-	-	-	-
			20	-	-	-	26	63	-	-	-	-	44	-	-	-	-	-
			10	-	-	11	41	75	-	-	-	22	59	-	-	-	-	20
		43	30	-	-	-	17	54	-	-	-	-	33	-	-	-	-	-
			20	-	-	-	33	69	-	-	-	15	51	-	-	-	-	14
			10	-	-	15	49	79	-	-	-	29	65	-	-	-	-	27
		41	30	-	-	-	24	61	-	-	-	-	41	-	-	-	-	-
			20	-	-	-	41	75	-	-	-	22	59	-	-	-	-	20
			10	-	-	22	57	83	-	-	-	37	72	-	-	-	-	35
		39	30	-	-	-	32	68	-	-	-	14	50	-	-	-	-	13
			20	-	11	16	49	80	-	-	-	29	66	-	-	-	-	27
			10	-	14	29	64	87	-	-	13	45	77	-	-	-	-	43
		37	30	-	-	-	40	74	-	-	-	21	58	-	-	-	-	20
			20	14	16	23	58	84	-	-	-	38	72	-	-	-	-	36
			10	14	21	38	71	+	-	-	19	54	82	-	-	-	16	52
		35	30	-	-	16	50	80	-	-	-	30	66	-	-	-	-	28
			20	21	24	31	66	88	-	-	14	47	78	-	-	-	11	45
			10	21	30	47	77	+	-	13	27	62	86	-	-	-	23	61
		33	30	-	13	24	59	85	-	-	-	39	74	-	-	-	-	37
			20	29	33	41	73	+	13	16	22	57	83	-	-	-	18	55
			10	30	39	57	82	+	13	21	37	70	89	-	-	-	33	69
		31	30	14	20	34	68	89	-	-	16	50	80	-	-	-	13	48
			20	40	44	52	80	+	21	24	31	66	88	-	-	-	27	64
			10	40	50	66	87	+	21	30	47	77	+	-	-	12	43	76
		29	30	23	30	45	76	+	-	14	25	60	85	-	-	-	22	59
			20	51	55	62	85	+	31	35	43	74	+	-	-	-	38	73
			10	51	60	74	+	+	32	41	58	83	+	-	-	20	54	82
		27	30	34	42	57	82	+	16	23	37	70	89	-	-	-	33	69
			20	62	65	71	89	+	43	47	54	81	+	-	12	16	50	80
			10	62	70	81	+	+	44	53	68	88	+	-	16	30	65	87
		25	30	47	55	68	88	+	27	35	50	79	+	-	-	13	46	77
			20	72	75	80	+	+	56	59	66	87	+	18	21	27	62	86
			10	72	79	87	+	+	56	65	77	+	+	19	27	43	74	+
		23	30	60	67	77	+	+	41	49	63	85	+	-	13	24	59	85
			20	81	83	86	+	+	68	71	76	+	+	31	34	41	73	+
			10	81	85	+	+	+	68	75	84	+	+	31	40	57	82	+
		21	30	72	78	85	+	+	56	63	74	+	+	19	25	39	71	+
			20	87	89	+	+	+	78	80	84	+	+	46	50	56	82	+
			10	88	+	+	+	+	78	83	+	+	+	46	55	70	89	+
		18	30	86	89	+	+	+	76	81	87	+	+	43	50	63	86	+
			20	+	+	+	+	+	89	+	+	+	+	69	72	76	+	+
			10	+	+	+	+	+	89	+	+	+	+	70	76	85	+	+
		15	30	+	+	+	+	+	+	+	+	+	+	70	76	83	+	+
			20	+	+	+	+	+	+	+	+	+	+	86	88	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	87	+	+	+	+
		12	30	+	+	+	+	+	+	+	+	+	+	89	+	+	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 5M - MALE POPULATION PERCENTAGES FOR LOWERING TASKS

BEGINNING BETWEEN KNUCKLE AND SHOULDER HEIGHT (≥31" AND ≤57")

OBJECT WEIGHT (POUNDS)	LOWERING DISTANCE (INCHES)	HAND DISTANCE	FREQUENCY ONE LOWER EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
		75	30	15	17	20	36	62	-	-	-	22	49	-	-	-	-	20
			20	21	25	33	51	73	-	13	19	36	62	-	-	-	-	34
			10	41	46	54	68	83	27	31	39	56	76	-	-	12	27	54
		72	30	19	21	24	41	66	-	-	12	26	54	-	-	-	-	25
			20	26	30	38	55	76	14	17	24	41	66	-	-	-	14	39
			10	46	50	58	71	85	32	36	44	60	79	-	11	16	31	58
		69	30	24	25	29	47	70	12	13	16	32	59	-	-	-	-	30
			20	31	35	44	60	79	18	21	29	46	70	-	-	-	18	44
			10	51	55	63	75	87	37	41	49	64	81	12	14	20	37	63
		66	30	29	31	35	52	74	16	17	21	37	63	-	-	-	11	35
			20	36	41	49	64	81	22	26	34	51	73	-	-	-	22	50
			10	56	60	67	78	89	42	47	54	69	84	15	18	25	42	67
		63	30	34	36	41	57	77	21	22	26	43	68	-	-	-	15	41
			20	42	47	55	69	84	28	32	40	57	77	-	-	13	28	55
			10	61	65	71	81	+	48	52	59	72	86	20	23	31	48	71
		60	30	40	43	47	62	80	26	28	32	49	72	-	-	-	20	47
			20	48	52	60	73	86	34	38	46	62	80	-	12	18	34	60
			10	68	69	75	83	+	54	58	64	76	88	25	29	37	54	75
		57	30	47	49	53	67	83	32	34	38	55	76	-	-	12	26	53
			20	54	58	65	76	88	40	44	52	67	83	14	17	23	40	65
			10	71	73	78	86	+	59	63	69	79	89	32	35	43	59	78
		54	30	53	55	59	72	85	39	41	45	61	79	13	14	16	32	59
			20	60	64	70	80	+	47	51	58	71	85	19	22	29	47	70
			10	75	77	81	88	+	65	68	74	82	+	38	42	50	65	82
		51	30	60	61	65	76	88	46	48	52	66	82	18	20	22	39	65
			20	66	69	74	83	+	53	57	64	76	88	25	29	36	53	75
			10	79	81	84	+	+	70	73	78	85	+	45	49	56	70	84
		48	30	66	67	70	80	+	53	55	58	72	85	25	26	29	47	70
			20	71	74	79	86	+	60	64	70	80	+	32	36	44	60	79
			10	82	84	87	+	+	75	77	81	88	+	53	56	63	75	87
		45	30	71	73	75	83	+	60	62	65	76	88	32	34	37	54	75
			20	76	78	82	88	+	67	70	75	83	+	40	44	52	66	82
			10	85	87	89	+	+	79	81	84	+	+	60	63	69	79	89
		42	30	76	78	80	87	+	67	68	71	81	+	41	43	46	62	80
			20	80	82	86	+	+	72	75	79	86	+	49	53	59	72	86
			10	88	89	+	+	+	83	85	87	+	+	67	69	74	83	+
		39	30	81	82	84	89	+	73	74	77	85	+	50	52	55	69	84
			20	84	86	88	+	+	78	80	83	89	+	57	61	67	78	88
			10	+	+	+	+	+	86	88	+	+	+	73	75	79	86	+
		36	30	85	86	87	+	+	79	80	82	88	+	59	61	63	75	87
			20	88	89	+	+	+	82	84	87	+	+	65	68	73	82	+
			10	+	+	+	+	+	89	+	+	+	+	78	80	84	89	+
		33	30	88	89	+	+	+	84	84	86	+	+	68	69	71	81	+
			20	+	+	+	+	+	86	88	+	+	+	73	75	79	86	+
			10	+	+	+	+	+	+	+	+	+	+	83	85	87	+	+
		30	30	+	+	+	+	+	88	88	89	+	+	75	76	78	85	+
			20	+	+	+	+	+	+	+	+	+	+	80	81	84	+	+
			10	+	+	+	+	+	+	+	+	+	+	87	89	+	+	+
		27	30	+	+	+	+	+	+	+	+	+	+	82	83	84	89	+
			20	+	+	+	+	+	+	+	+	+	+	85	86	89	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		24	30	+	+	+	+	+	+	+	+	+	+	87	88	89	+	+
			20	+	+	+	+	+	+	+	+	+	+	89	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%+

TABLE 6F - FEMALE POPULATION PERCENTAGES FOR LOWERING TASKS

BEGINNING ABOVE SHOULDER HEIGHT (>53")

OBJECT WEIGHT (POUNDS)	LOWERING DISTANCE (INCHES)	HAND DISTANCE FROM BODY	FREQUENCY ONE LOWER EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
		51	30	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-
			10	-	-	-	-	33	-	-	-	-	14	-	-	-	-	-
		48	30	-	-	-	-	13		-	-	-	-	-	-	-	-	-
			20	-	-	-	-	27	-	-	-	-	11	-	-	-	-	-
			10	-	-	-	-	43	-	-	-	-	21	-	-	-	-	-
		45	30	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-
			20	-	-	-	-	38	-	-	-	-	19	-	-	-	-	-
			10	-	-	-	17	53	-	-	-	-	31	-	-	-	-	-
		43	30	-	-	-	-	28	-	-	-	-	12	-	-	-	-	-
			20	-	-	-	12	45	-	-	-	-	26	-	-	-	-	-
			10	-	-	-	23	61	-	-	-	-	39	-	-	-	-	-
		41	30	-	-	-	-	36	-	-	-	-	17	-	-	-	-	-
			20	-	-	-	17	53	-	-	-	-	33	-	-	-	-	-
			10	-	-	-	31	67	-	-	-	12	47	-	-	-	-	-
		39	30	-	-	-	11	44	-	-	-	-	24	-	-	-	-	-
			20	-	-	-	24	61	-	-	-	-	42	-	-	-	-	-
			10	-	-	-	39	73	-	-	-	18	55	-	-	-	-	13
		37	30	-	-	-	17	53	-	-	-	-	33	-	-	-	-	-
			20	-	-	-	32	68	-	-	-	15	50	-	-	-	-	14
			10	-	-	15	48	79	-	-	-	26	63	-	-	-	-	19
		35	30	-	-	-	24	61	-	-	-	-	42	-	-	-	-	-
			20	-	-	11	41	75	-	-	-	22	59	-	-	-	-	21
			10	-	-	22	57	84	-	-	-	35	70	-	-	-	-	27
		33	30	-	-	-	34	69	-	-	-	16	52	-	-	-	-	15
			20	-	12	17	51	81	-	-	-	31	67	-	-	-	-	29
			10	-	16	31	66	88	-	-	13	45	77	-	-	-	-	37
		31	30	-	-	12	44	77	-	-	-	24	62	-	-	-	-	23
			20	16	19	26	61	86	-	-	11	42	75	-	-	-	-	40
			10	17	24	42	73	+	-	-	20	55	83	-	-	-	13	47
		29	30	-	-	20	55	83	-	-	-	35	71	-	-	-	-	33
			20	25	29	37	70	89	11	13	18	53	81	-	-	-	15	51
			10	26	35	53	80	+	11	16	30	65	87	-	-	-	21	58
		27	30	12	18	31	66	88	-	-	14	47	78	-	-	-	11	45
			20	37	41	49	78	+	19	22	29	64	87	-	-	-	25	62
			10	37	47	64	86	+	19	27	42	74	+	-	-	-	32	68
		25	30	22	29	44	75	+	-	13	24	59	85	-	-	-	21	58
			20	50	54	61	85	+	30	34	42	73	+	-	-	-	37	72
			10	50	59	73	+	+	31	39	55	81	+	-	-	13	45	77
		23	30	35	43	58	83	+	17	24	38	71	+	-	-	-	34	69
			20	63	66	72	+	+	44	48	55	82	+	-	12	17	51	81
			10	63	71	82	+	+	44	53	67	87	+	11	14	24	59	84
		21	30	50	58	70	89	+	31	38	53	80	+	-	-	15	49	79
			20	74	77	81	+	+	59	62	68	88	+	21	24	31	65	87
			10	75	80	88	+	+	59	66	78	+	+	21	27	38	71	+
		18	30	72	78	85	+	+	56	63	74	+	+	19	25	39	71	+
			20	87	89	+	+	+	78	80	84	+	+	46	50	56	82	+
			10	87	+	+	+	+	78	83	89	+	+	46	52	63	85	+
		15	30	88	+	+	+	+	79	83	89	+	+	48	55	67	87	+
			20	+	+	+	+	+	+	+	+	+	+	73	75	79	+	+
			10	+	+	+	+	+	+	+	+	+	+	73	77	83	+	+
		12	30	+	+	+	+	+	+	+	+	+	+	78	82	88	+	+
			20	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 6M - MALE POPULATION PERCENTAGES FOR LOWERING TASKS

BEGINNING ABOVE SHOULDER HEIGHT (>57")

OBJECT WEIGHT (POUNDS)	LOWERING DISTANCE (INCHES)	HAND DISTANCE	FREQUENCY ONE LOWER EVERY	7 INCHES					10 INCHES					15 INCHES				
				15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
		73	30	-	-	-	16	42	-	-	-	-	27	-	-	-	-	-
			20	-	-	14	28	56	-	-	-	15	41	-	-	-	-	14
			10	20	23	31	49	72	-	12	18	34	60	-	-	-	-	32
		70	30	-	-	-	20	47	-	-	-	-	32	-	-	-	-	-
			20	-	11	17	33	60	-	-	-	19	46	-	-	-	-	18
			10	24	28	37	54	75	12	15	22	39	65	-	-	-	12	37
		67	30	-	-	11	25	52	-	-	-	13	37	-	-	-	-	11
			20	12	15	22	39	65	-	-	11	24	52	-	-	-	-	22
			10	29	34	42	58	78	16	20	27	44	69	-	-	-	16	42
		64	30	11	12	15	30	57	-	-	-	17	43	-	-	-	-	15
			20	16	20	27	45	69	-	-	15	30	57	-	-	-	-	28
			10	35	39	48	63	81	21	25	33	50	72	-	-	-	21	48
		61	30	15	16	20	36	62	-	-	-	22	49	-	-	-	-	20
			20	21	25	33	50	73	-	13	19	36	62	-	-	-	-	34
			10	41	45	53	68	83	26	31	39	56	76	-	-	12	26	54
		58	30	20	22	25	42	67	-	-	13	27	55	-	-	-	-	26
			20	27	31	39	56	76	14	18	25	42	67	-	-	-	14	40
			10	47	51	59	72	86	33	37	45	61	79	-	11	17	32	59
		55	30	26	28	32	49	72	13	15	18	34	61	-	-	-	-	32
			20	33	38	46	62	80	20	23	31	48	71	-	-	-	19	46
			10	53	57	64	76	88	39	43	51	66	82	13	16	22	39	65
		52	30	32	34	38	55	76	19	20	24	41	66	-	-	-	14	39
			20	40	45	53	67	83	26	30	38	55	76	-	-	12	26	53
			10	60	63	69	80	89	46	50	58	71	85	18	22	29	46	70
		49	30	40	42	46	62	80	25	27	31	48	71	-	-	-	19	46
			20	48	52	59	72	86	33	37	45	61	80	-	12	17	33	60
			10	66	69	74	83	+	53	57	64	76	87	25	29	36	53	75
		46	30	48	50	53	68	83	33	35	39	56	76	-	-	12	26	54
			20	55	59	66	77	88	41	45	53	67	83	14	17	24	41	66
			10	71	74	79	86	+	60	64	70	80	+	32	36	44	60	79
		43	30	55	57	61	73	86	41	43	47	63	80	15	16	18	35	61
			20	62	66	72	81	+	49	53	60	73	86	21	24	32	49	72
			10	76	79	82	88	+	67	70	75	83	+	41	45	52	67	83
		40	30	63	65	68	78	89	50	52	56	69	84	22	23	26	44	68
			20	69	72	77	85	+	57	61	67	78	89	29	33	41	57	77
			10	81	83	86	+	+	73	75	80	87	+	49	53	60	73	86
		37	30	70	72	74	83	+	59	61	64	76	87	31	33	36	53	74
			20	75	78	82	88	+	65	68	74	83	+	39	43	50	65	82
			10	85	86	89	+	+	78	80	84	89	+	58	62	68	78	89
		34	30	77	78	80	87	+	67	69	71	81	+	41	43	46	62	80
			20	81	83	86	+	+	73	75	80	86	+	49	53	60	73	86
			10	88	89	+	+	+	83	85	87	+	+	67	70	75	83	+
		31	30	82	83	85	+	+	75	76	78	85	+	53	54	57	71	85
			20	85	87	89	+	+	79	81	84	+	+	60	63	69	79	89
			10	+	+	+	+	+	87	88	+	+	+	74	77	81	87	+
		28	30	87	87	89	+	+	81	82	84	89	+	64	65	67	78	89
			20	89	+	+	+	+	85	86	88	+	+	69	72	77	84	+
			10	+	+	+	+	+	+	+	+	+	+	81	83	86	+	+
		25	30	+	+	+	+	+	87	87	88	+	+	73	74	76	84	+
			20	+	+	+	+	+	89	+	+	+	+	78	80	83	89	+
			10	+	+	+	+	+	+	+	+	+	+	86	88	+	+	+
		22	30	+	+	+	+	+	+	+	+	+	+	82	82	84	89	+
			20	+	+	+	+	+	+	+	+	+	+	85	86	88	+	+
			10	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 7 - POPULATION PERCENTAGES FOR PUSHING TASKS
INITIAL FORCES

INITIAL PUSHING FORCE (POUNDS)	HAND HEIGHT (INCHES) - MALES		MALE						HAND HEIGHT (INCHES) - FEMALES		FEMALE				
	FREQUENCY ONE PUSH EVERY			30s	1m	5m	30m	8h			30s	1m	5m	30m	8h
	130		57	-	-	-	-	25		53	-	-	-	-	-
			37	-	-	13	14	36		35	-	-	-	-	-
			25	-	-	-	-	22		22	-	-	-	-	-
	127		57	-	-	-	-	28		53	-	-	-	-	-
			37	-	-	15	16	39		35	-	-	-	-	-
			25	-	-	-	-	25		22	-	-	-	-	-
	124		57	-	-	-	11	31		53	-	-	-	-	-
			37	-	12	18	19	42		35	-	-	-	-	-
			25	-	-	-	-	29		22	-	-	-	-	-
	121		57	-	-	12	13	35		53	-	-	-	-	-
			37	-	14	20	21	46		35	-	-	-	-	-
			25	-	-	-	11	32		22	-	-	-	-	-
	118		57	-	-	15	16	38		53	-	-	-	-	-
			37	-	17	23	25	49		35	-	-	-	-	-
			25	-	-	13	13	35		25	-	-	-	-	-
	115		57	-	12	17	18	42		53	-	-	-	-	-
			37	11	19	27	28	52		35	-	-	-	-	-
			25	-	-	15	16	39		22	-	-	-	-	-
	112		57	-	14	20	21	46		53	-	-	-	-	-
			37	13	23	30	31	56		35	-	-	-	-	-
			25	-	12	18	19	43		22	-	-	-	-	-
	109		57	-	17	24	25	49		53	-	-	-	-	-
			37	16	26	34	35	59		35	-	-	-	-	-
			25	-	15	21	22	46		22	-	-	-	-	-
	106		57	12	20	27	28	53		53	-	-	-	-	-
			37	19	30	38	39	63		35	-	-	-	-	-
			25	-	18	24	26	50		22	-	-	-	-	-
	103		57	14	23	31	32	57		53	-	-	-	-	-
			37	23	34	42	43	66		35	-	-	-	-	-
			25	12	21	28	29	54		22	-	-	-	-	-
	100		57	17	27	35	36	60		53	-	-	-	-	-
			37	26	38	46	47	69		35	-	-	-	-	-
			25	14	24	32	33	58		22	-	-	-	-	-
	97		57	21	31	39	41	64		53	-	-	-	-	-
			37	30	42	50	51	72		35	-	-	-	-	-
			25	17	28	36	38	61		22	-	-	-	-	-
	94		57	25	36	44	45	67		53	-	-	-	-	-
			37	35	46	54	55	75		35	-	-	-	-	-
			25	21	33	41	42	65		22	-	-	-	-	-
	91		57	29	40	48	49	71		53	-	-	-	-	-
			37	39	51	58	59	77		35	-	-	-	-	-
			25	25	37	45	46	68		22	-	-	-	-	-
	88		57	33	45	53	54	74		53	-	-	-	-	13
			37	44	55	62	63	80		35	-	-	-	-	13
			25	29	42	50	51	72		22	-	-	-	-	-
	85		57	38	50	57	58	77		53	-	-	-	11	17
			37	49	59	66	67	82		35	-	-	-	11	17
			25	34	47	54	56	75		22	-	-	-	-	-
	82		57	43	54	62	63	79		53	-	-	-	14	22
			37	53	64	70	71	84		35	-	-	-	15	22
			25	39	51	59	60	78		22	-	-	-	-	-
	79		57	48	59	66	67	82		53	-	-	14	19	27
			37	58	68	73	74	86		35	-	-	14	20	28
			25	44	56	63	64	80		22	-	-	-	-	-

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 7 (CONTINUED) - POPULATION PERCENTAGES FOR PUSHING TASKS
INITIAL FORCES

INITIAL PUSHING FORCE (POUNDS)	HAND HEIGHT (INCHES) - MALES		MALE					HAND HEIGHT (INCHES) - FEMALES		FEMALE				
	FREQUENCY ONE PUSH EVERY		30s	1m	5m	30m	8h			30s	1m	5m	30m	8h
	76	57	53	64	70	71	84		53	-	-	19	25	34
		37	63	72	77	77	88		35	-	-	19	25	34
		25	50	61	68	68	83		22	-	-	-	-	-
	73	57	59	68	74	74	86		53	-	-	24	31	40
		37	67	75	80	80	+		35	-	-	25	31	41
		25	55	66	72	72	85		22	-	-	-	-	11
	70	57	63	72	77	78	88		53	-	12	31	38	47
		37	71	78	82	83	+		35	-	12	31	38	48
		25	60	70	75	76	87		22	-	-	-	-	15
	67	57	68	76	80	81	+		53	-	17	38	45	54
		37	75	82	85	85	+		35	-	17	39	46	55
		25	65	74	79	79	89		22	-	-	-	14	21
	64	57	73	79	83	84	+		53	14	23	46	53	61
		37	79	84	87	88	+		35	13	24	46	53	62
		25	70	78	82	82	+		25	-	-	14	19	27
	61	57	77	83	86	86	+		53	20	30	54	60	68
		37	82	87	89	+	+		35	19	31	54	61	68
		25	74	81	85	85	+		22	-	-	20	26	35
	58	57	80	85	88	89	+		53	27	39	61	67	74
		37	85	89	+	+	+		35	26	39	62	68	74
		25	78	84	87	88	+		22	-	-	27	34	44
	55	57	84	88	+	+	+		53	36	48	69	74	80
		37	88	+	+	+	+		35	34	48	69	74	80
		25	82	87	89	+	+		22	-	15	36	43	52
	52	57	87	+	+	+	+		53	45	57	75	79	84
		37	+	+	+	+	+		35	44	57	76	80	84
		25	85	89	+	+	+		22	12	23	45	52	61
	49	57	89	+	+	+	+		53	55	65	81	84	88
		37	+	+	+	+	+		35	54	66	81	85	88
		25	88	+	+	+	+		22	19	32	55	61	69
	46	57	+	+	+	+	+		53	64	73	86	88	+
		37	+	+	+	+	+		35	63	74	86	89	+
		25	+	+	+	+	+		22	28	42	64	70	76
	43	57	+	+	+	+	+		53	73	80	+	+	+
		37	+	+	+	+	+		35	72	80	+	+	+
		25	+	+	+	+	+		22	39	54	73	78	83
	40	57	+	+	+	+	+		53	80	86	+	+	+
		37	+	+	+	+	+		35	79	86	+	+	+
		25	+	+	+	+	+		22	51	64	80	84	88
	37	57	+	+	+	+	+		53	86	+	+	+	+
		37	+	+	+	+	+		35	86	+	+	+	+
		25	+	+	+	+	+		22	63	74	86	89	+
	34	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	74	82	+	+	+
	31	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	83	88	+	+	+
	28	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	89	+	+	+	+
	25	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 8F - FEMALE POPULATION PERCENTAGES FOR PUSHING TASKS
SUSTAINED FORCE

SUSTAINED PUSHING FORCE (POUNDS)	HAND HEIGHT (INCHES)	PUSHING DISTANCE	7 FEET					25 FEET					50 FEET				
		FREQUENCY ONE PUSH EVERY	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h
	80	53	-		-	-	23	-	-	-	-	-	-	-	-	-	-
		35	-	-	-	-	16	-	-	-	-	-	-	-	-	-	-
		22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	76	53	-	-	-	-	28		-	-	-	-	-	-	-	-	-
		35	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-
		22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	53	-	-	-	14	34	-	-	-	-	-	-	-	-	-	-
		35	-	-	-	-	26	-	-	-	-	12	-	-	-	-	-
		22	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-
	68	53	-	-	13	19	40	-	-	-	-	12	-	-	-	-	-
		35	-	-	-	12	32	-	-	-	-	16	-	-	-	-	-
		22	-	-	-	-	18	-	-	-	-	11	-	-	-	-	-
	64	53	-	-	18	25	47	-	-	-	-	17	-	-	-	-	-
		35	-	-	12	17	39	-	-	-	-	22	-	-	-	-	-
		25	-	-	-	-	24	-	-	-		15	-	-	-	-	-
	60	53	-	13	24	31	54	-	-	-	-	23	-	-	-	-	-
		35	-	-	17	23	46	-	-	-	-	29	-	-	-	-	12
		22	-	-	-	11	30	-	-	-	-	21	-	-	-	-	-
	56	53	-	19	31	39	60	-	-	-	11	30	-	-	-	-	14
		35	-	13	23	30	53	-	-	-	15	36	-	-	-	-	18
		22	-	-	11	17	38	-	-	-	-	28	-	-	-	-	12
	52	53	16	26	40	47	66	-	-	12	17	39	-	-	-	-	20
		35	-	19	31	39	60	-	-	16	22	44	-	-	-	-	25
		22	-	-	17	24	46	-	-	-	15	36	-	-	-	-	18
	48	53	23	35	48	55	72	-	-	18	25	47	-	-	-	-	28
		35	16	27	40	47	67	-	12	23	30	53	-	-	-	14	34
		22	-	14	25	32	54	-	-	16	23	45	-	-	-	-	26
	44	53	32	44	57	63	77	13	15	27	34	56	-	-	11	17	38
		35	24	36	49	56	73	12	20	32	40	61	-	-	15	21	43
		22	12	21	34	42	62	-	13	25	32	54	-	-	-	15	35
	40	53	43	54	65	70	82	21	24	37	44	65	-	-	19	26	48
		35	34	46	59	65	78	20	29	43	50	69	-	13	24	31	53
		22	20	31	45	52	70	18	22	35	42	63	-	-	17	23	46
	36	53	54	64	73	77	86	32	35	48	55	72	-	17	30	37	58
		35	46	57	67	72	83	31	41	54	60	75	-	22	35	43	63
		22	30	43	55	62	77	28	33	46	53	71	-	16	27	35	57
	32	53	64	73	80	83	89	45	48	60	66	79	16	29	42	50	68
		35	57	67	75	79	87	44	53	64	70	82	14	35	48	55	72
		22	43	55	66	71	82	41	46	58	64	78	13	27	40	47	67
	28	53	74	80	85	87	+	58	61	71	75	85	29	44	56	62	77
		35	69	76	82	85	+	57	65	74	78	86	26	49	61	67	80
		22	57	67	75	79	87	55	59	69	74	84	25	41	54	60	76
	24	53	82	86	89	+	+	71	73	80	83	89	46	59	69	74	84
		35	78	83	87	89	+	70	76	82	85	+	43	64	73	77	86
		22	70	77	83	85	+	68	71	79	82	89	42	57	68	72	83
	20	53	88	+	+	+	+	81	82	87	89	+	64	73	80	83	89
		35	86	89	+	+	+	81	84	88	+	+	61	76	82	85	+
		22	80	85	89	+	+	79	81	86	88	+	60	72	79	82	89
	16	53	+	+	+	+	+	89	89	+	+	+	79	84	88	+	+
		35	+	+	+	+	+	88	+	+	+	+	77	86	89	+	+
		22	88	+	+	+	+	88	89	+	+	+	76	83	88	89	+
	12	53	+	+	+	+	+	+	+	+	+	+	89	+	+	+	+
		35	+	+	+	+	+	+	+	+	+	+	88	+	+	+	+
		22	+	+	+	+	+	+	+	+	+	+	88	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 8M - MALE POPULATION PERCENTAGES FOR PUSHING TASKS
SUSTAINED FORCE

SUSTAINED PUSHING FORCE (POUNDS)		HAND HEIGHT (INCHES)	PUSHING DISTANCE	7 FEET					25 FEET					50 FEET				
			FREQUENCY ONE PUSH EVERY	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h
	105		57	-		-	-	23	-	-	-	-	-	-	-	-	-	-
			37	-	-	-	11	28	-	-	-	-	-	-	-	-	-	-
			25	-	-	-	-	27	-	-	-	-	-	-	-	-	-	-
	100		57	-	-	-	12	29		-	-	-	11	-	-	-	-	-
			37	-	-	12	15	34	-	-	-	-	-	-	-	-	-	-
			25	-	-	11	14	32	-	-	-	-	-	-	-	-	-	-
	95		57	-	-	13	16	35	-	-	-	-	16	-	-	-	-	-
			37	-	-	17	20	40	-	-	-	-	14	-	-	-	-	-
			25	-	-	16	19	39	-	-	-	-	11	-	-	-	-	-
	90		57	-	-	18	22	42	-	-	-	-	21	-	-	-	-	-
			37	-	-	22	26	47	-	-	-	-	20	-	-	-	-	-
			25	-	-	21	25	45	-	-	-	-	16	-	-	-	-	-
	85		57	-	-	24	28	49	-	-	-	11	27	-	-	-	-	-
			37	-	13	29	33	53	-	-	-	-	26	-	-	-	-	-
			25	-	12	28	32	52	-	-	-		22	-	-	-	-	-
	80		57	-	14	31	36	56	-	-	13	16	35	-	-	-	-	13
			37	-	18	36	41	60	-	-	12	15	33	-	-	-	-	12
			25	-	17	35	39	59	-	-	-	12	29	-	-	-	-	-
	75		57	-	21	39	44	63	-	-	19	23	43	-	-	-	-	19
			37	13	25	44	49	67	-	-	18	21	41	-	-	-	-	18
			25	12	24	43	47	66	-	-	14	17	37	-	-	-	-	14
	70		57	16	29	48	52	69	-	11	27	31	51	-	-	12	15	26
			37	20	33	53	57	72	-	-	25	29	50	-	-	12	14	24
			25	19	32	52	55	72	-	-	21	25	45	-	-	-	11	20
	65		57	23	38	57	60	75	-	18	36	40	60	-	-	19	23	34
			37	28	43	61	64	78	-	16	34	38	58	-	-	18	22	33
			25	27	42	60	63	77	-	13	29	34	54	-	-	14	18	28
	60		57	33	48	65	68	80	-	26	46	50	67	-	12	28	33	43
			37	38	52	69	71	82	-	25	44	48	66	-	11	27	31	42
			25	37	51	68	71	82	-	21	39	44	63	-	-	23	26	37
	55		57	44	58	72	75	85	11	37	56	60	75	-	20	39	43	53
			37	49	62	76	78	86	14	36	55	58	74	-	19	38	42	52
			25	47	61	75	77	86	13	31	50	54	71	-	15	33	37	47
	50		57	55	67	79	81	88	20	49	66	69	81	-	32	51	55	62
			37	59	71	82	83	+	23	47	65	68	80	-	30	50	53	61
			25	58	70	81	83	89	23	43	61	64	78	-	25	45	49	57
	45		57	66	76	85	86	+	32	61	75	77	86	15	45	62	66	71
			37	70	78	86	88	+	36	59	74	76	85	19	43	61	65	70
			25	69	78	86	87	+	35	55	71	73	84	20	38	57	61	67
	40		57	76	83	89	+	+	47	72	82	84	+	28	58	73	76	79
			37	78	85	+	+	+	50	71	81	83	+	33	57	72	75	78
			25	78	84	+	+	+	50	67	79	81	88	34	53	69	72	75
	35		57	84	88	+	+	+	62	81	88	89	+	44	71	82	83	85
			37	85	+	+	+	+	65	80	87	89	+	49	70	81	83	85
			25	85	89	+	+	+	65	78	86	87	+	50	67	79	81	83
	30		57	+	+	+	+	+	75	88	+	+	+	62	82	88	89	+
			37	+	+	+	+	+	77	87	+	+	+	66	81	88	89	+
			25	+	+	+	+	+	77	86	+	+	+	67	79	87	88	88
	25		57	+	+	+	+	+	86	+	+	+	+	77	89	+	+	+
			37	+	+	+	+	+	87	+	+	+	+	80	89	+	+	+
			25	+	+	+	+	+	87	+	+	+	+	80	88	+	+	+
	20		57	+	+	+	+	+	+	+	+	+	+	88	+	+	+	+
			37	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
			25	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 9 - POPULATION PERCENTAGES FOR PULLING TASKS
INITIAL FORCES

INITIAL PULLING FORCE (POUNDS)	HAND HEIGHT (INCHES) - MALES		MALE FREQUENCY ONE PULL EVERY 30s	1m	5m	30m	8h	HAND HEIGHT (INCHES) - FEMALES		FEMALE FREQUENCY ONE PULL EVERY 30s	1m	5m	30m	8h
130	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	-	-	13	35		-	-	-	-	-
	25		-	-	-	-	29	22		-	-	-	-	-
127	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	-	-	16	35		-	-	-	-	-
	25		-	-	-	-	33	22		-	-	-	-	-
124	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	-	-	19	35		-	-	-	-	-
	25		-	-	-	11	37	22		-	-	-	-	-
121	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	-	-	22	35		-	-	-	-	-
	25		-	-	13	14	41	22		-	-	-	-	-
118	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	-	-	26	35		-	-	-	-	-
	25		-	-	16	17	45	25		-	-	-	-	-
115	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	-	-	30	35		-	-	-	-	-
	25		-	12	19	20	49	22		-	-	-	-	-
112	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	-	-	34	35		-	-	-	-	-
	25		-	15	23	24	53	22		-	-	-	-	-
109	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	12	13	39	35		-	-	-	-	-
	25		-	18	27	28	58	22		-	-	-	-	-
106	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	-	15	16	43	35		-	-	-	-	-
	25		11	22	31	33	62	22		-	-	-	-	-
103	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	11	18	19	48	35		-	-	-	-	-
	25		14	27	36	38	66	22		-	-	-	-	-
100	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	15	22	24	53	35		-	-	-	-	-
	25		17	31	41	43	70	22		-	-	-	-	-
97	57		-	-	-	-	-	53		-	-	-	-	-
	37		-	18	27	28	58	35		-	-	-	-	-
	25		21	36	46	48	73	22		-	-	-	-	-
94	57		-	-	-	-	12	53		-	-	-	-	-
	37		11	23	32	33	62	35		-	-	-	-	-
	25		26	42	51	53	77	22		-	-	-	-	-
91	57		-	-	-	-	16	53		-	-	-	-	-
	37		14	28	37	39	67	35		-	-	-	-	-
	25		31	47	56	58	80	22		-	-	-	-	13
88	57		-	-	-	-	20	53		-	-	-	-	-
	37		19	33	43	44	71	35		-	-	-	-	11
	25		37	53	61	63	83	22		-	-	-	-	17
85	57		-	-	-	-	25	53		-	-	-	-	-
	37		23	39	49	50	75	35		-	-	-	-	15
	25		42	58	66	68	85	22		-	-	-	14	22
82	57		-	-	-	-	30	53		-	-	-	-	14
	37		29	45	54	56	79	35		-	-	-	12	20
	25		48	63	71	72	88	22		-	-	13	19	28
79	57		-	-	-	11	37	53		-	-	-	12	19
	37		35	51	60	62	82	35		-	-	12	17	26
	25		54	68	75	76	+	22		-	-	18	24	34

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 9 (CONTINUED) - POPULATION PERCENTAGES FOR PULLING TASKS
INITIAL FORCES

INITIAL PULLING FORCE (POUNDS)	HAND HEIGHT (INCHES) - MALES		MALE					HAND HEIGHT (INCHES) - FEMALES		FEMALE				
	FREQUENCY ONE PULL EVERY		30s	1m	5m	30m	8h			30s	1m	5m	30m	8h
	76	57	-	-	15	16	43		53	-	-	12	17	25
		37	42	57	66	67	85		35	-	-	17	23	32
		25	60	73	79	80	+		22	-	-	24	31	41
	73	57	-	13	20	21	50		53	-	-	17	23	32
		37	48	63	71	72	88		35	-	-	22	30	40
		25	66	77	83	83	+		22	-	11	31	38	49
	70	57	-	17	26	27	56		53	-	-	23	30	40
		37	55	69	76	77	+		35	-	-	29	37	47
		25	71	81	86	86	+		22	-	15	38	46	56
	67	57	12	24	33	34	63		53	-	-	30	38	48
		37	62	74	80	81	+		35	-	15	37	45	55
		25	76	85	88	89	+		22	13	22	46	54	63
	64	57	17	31	40	42	69		53	-	15	38	46	56
		37	68	79	84	84	+		35	13	21	46	53	63
		25	81	88	+	+	+		25	19	29	54	62	70
	61	57	23	39	48	50	75		53	14	22	47	55	64
		37	74	83	87	88	+		35	19	29	54	62	70
		25	84	+	+	+	+		22	27	38	63	69	76
	58	57	31	47	56	58	80		53	21	31	56	63	71
		37	79	86	+	+	+		35	27	38	63	69	76
		25	88	+	+	+	+		22	36	47	70	76	82
	55	57	40	56	64	66	84		53	29	40	65	71	78
		37	83	89	+	+	+		35	37	48	71	76	82
		25	+	+	+	+	+		22	46	57	77	81	86
	52	57	49	64	72	73	88		53	40	51	73	78	83
		37	87	+	+	+	+		35	47	58	78	82	87
		25	+	+	+	+	+		22	56	66	82	86	+
	49	57	59	72	78	79	+		53	50	61	80	84	88
		37	+	+	+	+	+		35	58	67	83	87	+
		25	+	+	+	+	+		22	65	74	87	+	+
	46	57	68	78	83	84	+		53	61	70	85	88	+
		37	+	+	+	+	+		35	68	76	88	+	+
		25	+	+	+	+	+		22	74	81	+	+	+
	43	57	76	84	88	88	+		53	71	79	+	+	+
		37	+	+	+	+	+		35	76	83	+	+	+
		25	+	+	+	+	+		22	82	87	+	+	+
	40	57	82	89	+	+	+		53	80	85	+	+	+
		37	+	+	+	+	+		35	84	88	+	+	+
		25	+	+	+	+	+		22	87	+	+	+	+
	37	57	88	+	+	+	+		53	87	+	+	+	+
		37	+	+	+	+	+		35	89	+	+	+	+
		25	+	+	+	+	+		22	+	+	+	+	+
	34	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	+	+	+	+	+
	31	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	+	+	+	+	+
	28	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	+	+	+	+	+
	25	57	+	+	+	+	+		53	+	+	+	+	+
		37	+	+	+	+	+		35	+	+	+	+	+
		25	+	+	+	+	+		22	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 10F - FEMALE POPULATION PERCENTAGES FOR PULLING TASKS
SUSTAINED FORCE

SUSTAINED PULLING FORCE (POUNDS)	HAND HEIGHT (INCHES)	PULLING DISTANCE	7 FEET					25 FEET					50 FEET				
		FREQUENCY ONE PULL EVERY	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h
	76	53	-		-	-	13	-	-	-	-	-	-	-	-	-	-
		35	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-
		22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	72	53	-	-	-	-	19		-	-	-	-	-	-	-	-	-
		35	-	-	-	-	16	-	-	-	-	-	-	-	-	-	-
		22	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	68	53	-	-	-	-	25	-	-	-	-	13	-	-	-	-	-
		35	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-
		22	-	-	-	-	13	-	-	-	-	-	-	-	-	-	-
	64	53	-	-	-	-	32	-	-	-	-	19	-	-	-	-	-
		35	-	-	-	-	29	-	-	-	-	16	-	-	-	-	-
		22	-	-	-	-	19	-	-	-	-	-	-	-	-	-	-
	60	53	-	-	-	16	41	-	-	-	-	26	-	-	-	-	-
		35	-	-	-	13	37	-	-	-	-	22	-	-	-	-	-
		25	-	-	-	-	26	-	-	-		14	-	-	-	-	-
	56	53	-	-	16	23	49	-	-	-	12	34	-	-	-	-	15
		35	-	-	13	20	46	-	-	-	-	31	-	-	-	-	12
		22	-	-	-	12	35	-	-	-	-	21	-	-	-	-	-
	52	53	-	12	24	32	58	-	-	12	19	44	-	-	-	-	22
		35	-	-	21	29	55	-	-	-	16	40	-	-	-	-	19
		22	-	-	12	19	44	-	-	-	-	30	-	-	-	-	11
	48	53	14	19	34	42	66	-	-	20	28	54	-	-	-	-	32
		35	12	16	30	39	63	-	-	17	24	50	-	-	-	-	28
		22	-	-	20	28	54	-	-	-	15	40	-	-	-	-	19
	44	53	23	29	45	53	74	-	16	30	39	63	-	-	12	18	43
		35	20	26	41	50	72	-	13	26	35	60	-	-	-	15	39
		22	12	17	30	39	64	-	-	17	25	51	-	-	-	-	29
	40	53	35	41	56	64	80	17	27	42	51	72	-	-	21	29	55
		35	31	38	53	61	79	14	23	38	47	70	-	-	18	25	51
		22	21	27	43	51	73	-	15	28	36	62	-	-	-	16	41
	36	53	48	54	67	73	86	28	40	55	63	80	-	19	33	42	66
		35	45	51	65	71	85	25	36	52	59	78	-	16	30	38	63
		22	34	40	55	63	80	16	26	41	50	72	-	-	20	28	54
	32	53	62	67	77	81	+	43	55	67	73	86	-	33	48	56	74
		35	59	64	75	80	89	40	51	65	71	85	-	29	45	53	74
		22	49	55	68	74	86	29	41	56	63	80	-	19	34	43	66
	28	53	74	78	85	88	+	59	69	78	82	+	23	50	64	70	84
		35	72	76	83	86	+	56	66	76	81	+	20	46	60	67	83
		22	64	69	78	82	+	46	57	69	75	87	12	35	51	59	77
	24	53	84	86	+	+	+	74	80	96	89	+	43	67	77	81	+
		35	82	85	+	+	+	71	78	85	88	+	39	64	75	79	89
		22	77	80	87	89	+	64	72	81	84	+	28	55	68	73	86
	20	53	+	+	+	+	+	85	89	+	+	+	64	81	87	89	+
		35	+	+	+	+	+	84	88	+	+	+	61	79	85	88	+
		22	87	89	+	+	+	79	84	89	+	+	51	73	81	85	+
	16	53	+	+	+	+	+	+	+	+	+	+	81	+	+	+	+
		35	+	+	+	+	+	+	+	+	+	+	80	89	+	+	+
		22	+	+	+	+	+	89	+	+	+	+	74	96	+	+	+
	12	53	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		22	+	+	+	+	+	+	+	+	+	+	89	+	+	+	+
	8	53	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		35	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		22	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% **- = LESS THAN 10%**

TABLE 10M - MALE POPULATION PERCENTAGES FOR PULLING TASKS
SUSTAINED FORCE

SUSTAINED PULLING FORCE (POUNDS)	HAND HEIGHT (INCHES)	PULLING DISTANCE	7 FEET					25 FEET					50 FEET				
		FREQUENCY ONE PULL EVERY	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h	30s	1m	5m	30m	8h
		57	-														
105		37	-	-	-	-	18	-	-	-	-	-	-	-	-	-	-
		25	-	-	-	-	25	-	-	-	-	-	-	-	-	-	-
		57	-	-	-	-	-		-	-	-	-	-	-	-	-	-
100		37	-	-	-	-	24	-	-	-	-	-	-	-	-	-	-
		25	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-
		57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
95		37	-	-	-	-	31	-	-	-	-	-	-	-	-	-	-
		25	-	-	-	13	38	-	-	-	-	13	-	-	-	-	-
		57	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
90		37	-	-	-	13	38	-	-	-	-	13	-	-	-	-	-
		25	-	-	-	19	46	-	-	-	-	19	-	-	-	-	-
		57	-	-	-	-	11	-	-	-	-	-	-	-	-	-	-
85		37	-	-	-	19	46	-	-	-	-	19	-	-	-	-	-
		25	-	-	-	26	54	-	-	-	-	26	-	-	-	-	11
		57	-	-	-	-	17	-	-	-	-	-	-	-	-	-	-
80		37	-	-	-	27	54	-	-	-	-	27	-	-	-	-	11
		25	-	-	15	34	61	-	-	-	11	35	-	-	-	-	17
		57	-	-	-	-	25	-	-	-	-	-	-	-	-	-	-
75		37	-	-	16	35	62	-	-	-	12	36	-	-	-	-	18
		25	-	-	22	43	69	-	-	-	17	44	-	-	-	-	24
		57	-	-	-	11	34	-	-	-	-	11	-	-	-	-	-
70		37	-	11	24	45	70	-	-	-	19	46	-	-	-	-	26
		25	-	16	31	53	75	-	-	-	25	53	-	-	-	-	34
		57	-	-	-	18	45	-	-	-	-	18	-	-	-	-	-
65		37	-	18	34	55	77	-	-	-	28	56	-	-	-	12	36
		25	16	25	41	62	81	-	-	16	36	63	-	-	-	18	44
		57	-	-	11	28	56	-	-	-	-	28	-	-	-	-	12
60		37	18	28	45	65	83	-	-	18	39	65	-	-	-	20	48
		25	25	36	53	71	86	-	-	25	47	71	-	-	14	27	55
		57	-	-	19	40	66	-	-	-	15	41	-	-	-	-	22
55		37	29	40	57	74	87	-	-	29	51	74	-	13	17	32	59
		25	37	48	63	78	+	-	12	37	58	79	-	19	23	40	66
		57	-	17	32	53	76	-	-	-	26	54	-	-	-	11	34
50		37	43	53	68	81	+	-	16	42	63	81	-	23	29	45	70
		25	50	61	73	85	+	-	23	50	69	85	-	31	36	53	75
		57	20	30	46	66	83	-	-	20	41	67	-	-	-	22	49
45		37	57	66	78	87	+	-	29	56	74	87	12	38	43	59	79
		25	64	72	82	+	+	14	37	64	79	+	18	46	51	66	83
		57	35	46	62	77	89	-	11	35	57	78	-	17	22	37	64
40		37	70	77	85	+	+	21	46	70	83	+	26	54	59	72	86
		25	76	81	88	+	+	29	53	76	86	+	33	61	66	77	89
		57	54	63	75	86	+	-	26	54	72	86	-	34	40	56	77
35		37	81	86	+	+	+	39	63	81	89	+	44	70	74	83	+
		25	85	89	+	+	+	47	69	85	+	+	52	75	78	86	+
		57	71	78	86	+	+	23	47	71	84	+	27	56	61	73	87
30		37	89	+	+	+	+	60	78	89	+	+	64	82	85	+	+
		25	+	+	+	+	+	67	82	+	+	+	70	86	88	+	+
		57	85	89	+	+	+	48	70	85	+	+	53	75	79	86	+
25		37	+	+	+	+	+	78	89	+	+	+	81	+	+	+	+
		25	+	+	+	+	+	82	+	+	+	+	84	+	+	+	+
		57	+	+	+	+	+	74	86	+	+	+	77	89	+	+	+
20		37	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
		25	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

TABLE 11F - FEMALE POPULATION PERCENTAGES FOR CARRYING TASKS

OBJECT WEIGHT (POUNDS)	HAND HEIGHT (INCHES)	CARRYING DISTANCE	7 FEET					14 FEET					28 FEET				
		FREQUENCY ONE CARRY EVERY	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h	15s	30 s	1m	5m	8h
	73	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		31	-	-	-	-	21	-	-	-	-	-	-	-	-	-	-
	70	40	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
		31	-	-	-	-	28	-	-	-	-	70	-	-	-	-	12
	67	40	-	-	-	-	15	-	-	-	-	13	-	-	-	-	-
		31	-	-	-	-	36	-	-	-	-	21	-	-	-	-	18
	64	40	-	-	-	-	22	-	-	-	-	19	-	-	-	-	-
		31	-	-	-	-	45	-	-	-	-	29	-	-	-	-	25
	61	40	-	-	-	-	30	-	-	-	-	27	-	-	-	-	13
		31	-	-	-	-	54	-	-	-	-	38	-	-	-	-	34
	58	40	-	-	-	-	40	-	-	-	-	36	-	-	-	-	20
		31	-	-	-	11	63	-	-	-	-	47	-	-	-	-	43
	55	40	-	-	-	-	50	-	-	-	-	46	-	-	-	-	29
		31	-	-	14	18	71	-	-	-	-	57	-	-	-	-	54
	52	40	-	-	-	-	60	-	-	-	-	57	-	-	-	-	39
		31	-	14	22	27	79	-	-	11	14	67	-	-	-	12	63
	49	40	-	-	13	17	70	-	-	11	14	67	-	-	-	-	51
		31	18	22	33	39	85	-	-	18	23	75	-	15	15	20	73
	46	40	-	13	22	27	78	-	-	19	24	76	-	-	-	11	62
		31	28	34	45	51	89	-	-	29	34	82	12	25	25	30	80
	43	40	17	23	34	40	85	-	-	31	36	83	-	15	15	20	73
		31	41	47	58	63	+	-	13	42	47	88	22	37	37	43	86
	40	40	29	36	48	54	+	-	15	44	50	89	18	27	27	32	81
		31	55	60	70	74	+	-	23	55	61	+	35	51	51	57	+
	37	40	44	51	62	67	+	11	27	59	64	+	31	41	41	47	88
		31	68	72	80	83	+	19	38	69	73	+	50	65	65	70	+
	34	40	60	66	75	79	+	23	43	72	76	+	47	57	57	63	+
		31	79	82	87	89	+	34	54	80	83	+	65	77	77	81	+
	31	40	74	79	85	87	+	40	60	83	86	+	64	72	72	76	+
		31	88	+	+	+	+	51	70	88	+	+	78	86	86	88	+
	28	40	85	88	+	+	+	59	76	+	+	+	78	84	84	86	+
		31	+	+	+	+	+	69	82	+	+	+	87	+	+	+	+
	25	40	+	+	+	+	+	77	87	+	+	+	88	+	+	+	+
		31	+	+	+	+	+	83	+	+	+	+	+	+	+	+	+

+ = GREATER THAN 90% - = LESS THAN 10%

Appendix C: California OSHA and NIOSH Checklist for Hand Tool Selection

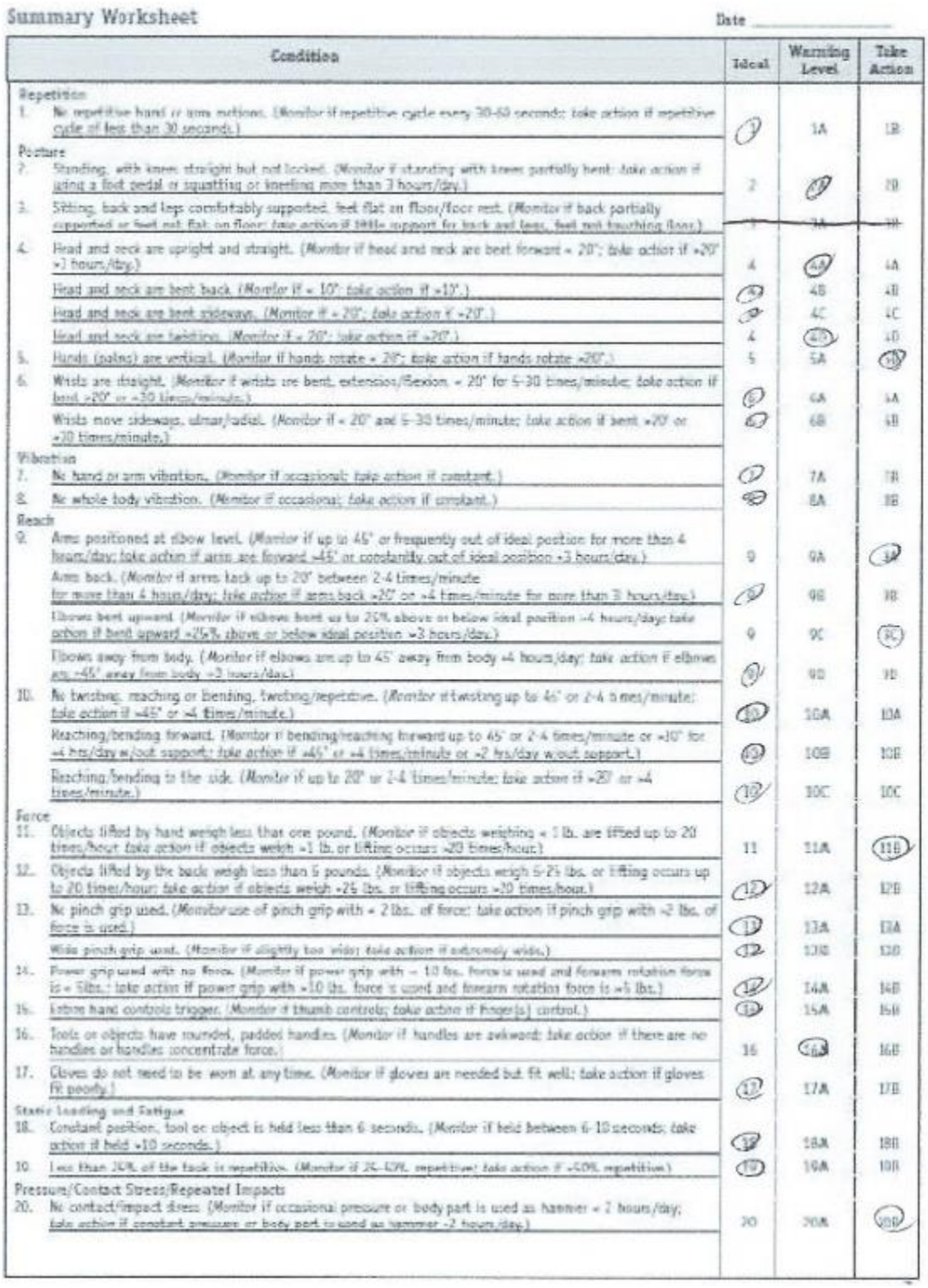
Use **BOTH** sides of the **checklist** to compare similar tools. For example, if you have two pliers and want to select the best of the two, compare each tool against the features on the checklist. The more "Yes" answers the tool has, the better the tool.

Refer to Section D, **Tips for Selecting Hand Tools**, for more details.

	Checklist for Hand Tool Selection Select the tool that has the most "YES" answers.	**Examples**	Check if "YES"			
			Single-handle tools		Double-handle tools	
			Tool 1	Tool 2	Tool 1	Tool 2
1	For single-handle tools used for power tasks: Does the tool feel comfortable and have a handle diameter between 1 1/4 inches and 2 inches? (pg. 8)					
2	For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/2 inch? (pg. 8)					
3	For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg. 8)					
4	For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg. 9)					
5	For double-handle tools: Is the handle spring-loaded? (pg. 9)					

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers		**Examples**	Check if "YES" for all tools	
			Tool 1	Tool 2
6	Is the tool handle without sharp edges or finger grooves? (pg. 9)			
7	Is the tool handle coated with soft material? (pg. 9)			
8	Can the tool be used while keeping your wrist straight? (pg. 10)			
9	Can the tool be used with your dominant hand or with either hand? (pg. 10)			
10	For high-force tasks: Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg. 11)			
11	Does the tool handle have a non-slip surface? (pg. 11)			

Appendix D: Completed Great American Insurance Company Ergonomic Task Analysis Worksheets



Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Repetition			
1. No repetitive hand or arm motions. (*Monitor if repetitive cycle every 30-60 seconds; take action if repetitive cycle of less than 30 seconds.*)	1	1A	1B
Posture			
2. Standing, with knees straight but not locked. (*Monitor if standing with knees partially bent; take action if using a foot pedal or squatting or kneeling more than 3 hours/day.*)	2	2A	2B
3. Sitting, back and legs comfortably supported, feet flat on floor/foot rest. (*Monitor if back partially supported or feet not flat on floor; take action if little support for back and legs, feet not touching floor.*)	3	3A	3B
4. Head and neck are upright and straight. (*Monitor if head and neck are bent forward < 20°; take action if >20° >1 hours/day.*)	4	4A	4A
Head and neck are bent back. (*Monitor if < 10°; take action if >10°.*)	4	4B	4B
Head and neck are bent sideways. (*Monitor if < 20°; take action if >20°.*)	4	4C	4C
Head and neck are twisted. (*Monitor if < 20°; take action if >20°.*)	4	4D	4D
5. Hands (palms) are vertical. (*Monitor if hands rotate < 20°; take action if hands rotate >20°.*)	5	5A	5B
6. Wrists are straight. (*Monitor if wrists are bent, extension/flexion < 20° for 5-30 times/minute; take action if bend >20° or >30 times/minute.*)	6	6A	6A
Wrists move sideways, ulnar/radial. (*Monitor if < 20° and 5-30 times/minute; take action if bent >20° or >30 times/minute.*)	6	6B	6B
Vibration			
7. No hand or arm vibration. (*Monitor if occasional; take action if constant.*)	7	7A	7B
8. No whole body vibration. (*Monitor if occasional; take action if constant.*)	8	8A	8B
Reach			
9. Arms positioned at elbow level. (*Monitor if up to 45° or frequently out of ideal position for more than 4 hours/day; take action if arms are forward >45° or constantly out of ideal position >3 hours/day.*)	9	9A	9B
Arms back. (*Monitor if arms back up to 20° between 2-4 times/minute for more than 4 hours/day; take action if arms back >20° or >4 times/minute for more than 3 hours/day.*)	9	9B	9B
Elbows bent upward. (*Monitor if elbows bent up to 20% above or below ideal position >4 hours/day; take action if bent upward >25% above or below ideal position >3 hours/day.*)	9	9C	9C
Elbows away from body. (*Monitor if elbows are up to 45° away from body >4 hours/day; take action if elbows are >45° away from body >2 hours/day.*)	9	9D	9D
10. No twisting, reaching or bending, twisting/repetitive. (*Monitor if twisting up to 45° or 2-4 times/minute; take action if >45° or >4 times/minute.*)	10	10A	10A
Reaching/bending forward. (*Monitor if bending/reaching forward up to 45° or 2-4 times/minute or >10° for >4 hrs/day w/out support; take action if >45° or >4 times/minute or >2 hrs/day w/out support.*)	10	10B	10B
Reaching/bending to the side. (*Monitor if up to 20° or 2-4 times/minute; take action if >20° or >4 times/minute.*)	10	10C	10C
Force			
11. Objects lifted by hand weigh less that one pound. (*Monitor if objects weighing < 1 lb. are lifted up to 20 times/hour; take action if objects weigh >1 lb. or lifting occurs >20 times/hour.*)	11	11A	11B
12. Objects lifted by the back weigh less than 5 pounds. (*Monitor if objects weigh 5-25 lbs. or lifting occurs up to 20 times/hour; take action if objects weigh >25 lbs. or lifting occurs >20 times/hour.*)	12	12A	12B
13. No pinch grip used. (*Monitor use of pinch grip with < 2 lbs. of force; take action if pinch grip with >2 lbs. of force is used.*)	13	13A	13A
Wide pinch grip used. (*Monitor if slightly too wide; take action if extremely wide.*)	13	13B	13B
14. Power grip used with no force. (*Monitor if power grip with < 10 lbs. force is used and forearm rotation force is < 5lbs.; take action if power grip with >10 lbs. force is used and forearm rotation force is >5 lbs.*)	14	14A	14B
15. Entire hand controls trigger. (*Monitor if thumb controls; take action if finger(s) control.*)	15	15A	15B
16. Tools or objects have rounded, padded handles. (*Monitor if handles are awkward; take action if there are no handles or handles concentrate force.*)	16	16A	16B
17. Gloves do not need to be worn at any time. (*Monitor if gloves are needed but fit well; take action if gloves fit poorly.*)	17	17A	17B
Static Loading and Fatigue			
18. Constant position, tool or object is held less than 6 seconds. (*Monitor if held between 6-10 seconds; take action if held >10 seconds.*)	18	18A	18B
19. Less than 20% of the task is repetitive. (*Monitor if 20-40% repetitive; take action if >40% repetitive.*)	19	19A	19B
Pressure/Contact Stress/Repeated Impacts			
20. No contact/impact stress. (*Monitor if occasional pressure or body part is used as hammer < 2 hours/day; take action if constant pressure or body part is used as hammer >2 hours/day.*)	20	20A	20B

Summary Worksheet Date _____

Condition	Ideal	Warning Level	Take Action
Lifting and Materials Handling			
21. No lifting or lowering of materials. (Monitor if occasional and/or no more than 20 times/hour; take action if constant and/or greater than 20 times/hour	21	21A	21B
22. No pushing or pulling of materials. (Monitor if pushing/pulling 10-50 carts/shift; take action if pushing/pulling more than 50 carts/shift.)	22	22A	22B
23. Slight force is required to push or pull materials. (Monitor if moderate force is required; take action if high force is required.)	23	23A	23B
Environment			
24. Worker has adequate control over workplace. (Monitor if worker has some control; take action if worker has no control.)	24	24A	24B
25. Lighting is adequate for the task. (Monitor if slightly too dark or bright; take action if significantly too dark or bright.)	25	25A	25B
26. Temperature is comfortable. (Monitor if slightly too cold or hot; take action if significantly too cold or hot.)	26	26A	26B
27. Work area is quiet. (Monitor if slightly too noisy; take action if significantly too noisy.)	27	27A	27B
28. Flooring provides good traction. (Monitor if flooring is slightly slippery; take action if moderately to extremely slippery.)	28	28A	28B
29. Flooring is sufficiently padded to relieve stress on back and legs. (Monitor if slight stress to back and legs; take action if moderately to extreme stress.)	29	29A	29B
30. Floor mats are provided. Employee can alternate between sitting and standing. (Monitor if employee is standing up to 50% of shift without floor mats or other stress relief for back and legs; take action if standing >50% of shift without floor mats or other relief for back and legs.	30	30A	30B

Action Plan

Today's date: 4/2/2019 Date Solution to be Completed _____

Location/Department: _____

Job/Task Title: Operating Fryers

Evaluator: Matt Krueger

Describe MSD in previous 24 months: _____

Task: _____

Summary of Problem: _____

Alternative Solution and Costs: _____

Recommended Solution: 1) Engineering _____

2) Administrative: _____

3) Use of personal protective equipment _____

Date Solution Actually Completed: _____ Actual Cost: _____

GREAT AMERICAN INSURANCE GROUP

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Repetition			
1. No repetitive hand or arm motions. (*Monitor if repetitive cycle every 30-60 seconds; take action if repetitive cycle of less than 30 seconds.*)	1	1A	1B
Posture			
2. Standing, with knees straight but not locked. (*Monitor if standing with knees partially bent; take action if using a foot pedal or squatting or kneeling more than 3 hours/day.*)	2	2A	2B
3. Sitting, back and legs comfortably supported, feet flat on floor/floor rest. (*Monitor if back partially supported or feet not flat on floor; take action if little support for back and legs, feet not touching floor.*)	~~3~~	~~3A~~	~~3B~~
4. Head and neck are upright and straight. (*Monitor if head and neck are bent forward = 20°; take action if =20° >1 hours/day.*)	4	4A	4A
Head and neck are bent back. (*Monitor if = 10°; take action if =10°.*)	4	4B	4B
Head and neck are bent sideways. (*Monitor if = 20°; take action if =20°.*)	4	4C	4C
Head and neck are twisting. (*Monitor if = 20°; take action if =20°.*)	4	4D	4D
5. Hands (palms) are vertical. (*Monitor if hands rotate = 20°; take action if hands rotate =20°.*)	5	5A	5B
6. Wrists are straight. (*Monitor if wrists are bent, extension/flexion, = 20° for 5-30 times/minute; take action if bent =20° or =30 times/minute.*)	6	6A	6A
Wrists move sideways, ulnar/radial. (*Monitor if = 20° and 5-30 times/minute; take action if bent =20° or =30 times/minute.*)	6	6B	6B
Vibration			
7. No hand or arm vibration. (*Monitor if occasional; take action if constant.*)	7	7A	7B
8. No whole body vibration. (*Monitor if occasional; take action if constant.*)	8	8A	8B
Reach			
9. Arms positioned at elbow level. (*Monitor if up to 45° or frequently out of ideal position for more than 4 hours/day; take action if arms are forward =45° or constantly out of ideal position =3 hours/day.*)	9	9A	9A
Arms back. (*Monitor if arms back up to 20° between 2-4 times/minute for more than 4 hours/day; take action if arms back =20° or =4 times/minute for more than 3 hours/day.*)	9	9B	9B
Elbows bent upward. (*Monitor if elbows bent up to 20% above or below ideal position =4 hours/day; take action if bent upward =20% above or below ideal position =3 hours/day.*)	9	9C	~~9C~~
Elbows away from body. (*Monitor if elbows are up to 45° away from body =4 hours/day; take action if elbows are =45° away from body =2 hours/day.*)	9	9D	9D
10. No twisting, reaching or bending, twisting/repetitive. (*Monitor if twisting up to 45° or 2-4 times/minute; take action if =45° or =4 times/minute.*)	10	10A	10A
Reaching/bending forward. (*Monitor if bending/reaching forward up to 45° or 2-4 times/minute or =10° for =4 hrs/day w/out support; take action if =45° or =4 times/minute or =2 hrs/day w/out support.*)	10	10B	10B
Reaching/bending to the side. (*Monitor if up to 20° or 2-4 times/minute; take action if =20° or =4 times/minute.*)	10	10C	10C
Force			
11. Objects lifted by hand weigh less than one pound. (*Monitor if objects weighing = 1 lb. are lifted up to 20 times/hour; take action if objects weigh =1 lb. or lifting occurs =20 times/hour.*)	11	11A	11B
12. Objects lifted by the back weigh less than 5 pounds. (*Monitor if objects weigh 5-25 lbs. or lifting occurs up to 20 times/hour; take action if objects weigh =25 lbs. or lifting occurs =10 times/hour.*)	12	12A	12B
13. No pinch grip used. (*Monitor use of pinch grip with = 2 lbs. of force; take action if pinch grip with =2 lbs. of force is used.*)	13	13A	13A
Wide pinch grip used. (*Monitor if slightly too wide; take action if extremely wide.*)	13	13B	13B
14. Power grip used with no flaws. (*Monitor if power grip with = 10 lbs. force is used and forearm rotation force is = 5lbs.; take action if power grip with =10 lbs. force is used and forearm rotation force is =5 lbs.*)	14	14A	14B
15. Entire hand controls trigger. (*Monitor if thumb controls; take action if finger(s) control.*)	15	15A	15B
16. Tools or objects have rounded, padded handles. (*Monitor if handles are awkward; take action if there are no handles or handles concentrate force.*)	16	16A	16B
17. Gloves do not need to be worn at any time. (*Monitor if gloves are needed but fit well; take action if gloves fit poorly.*)	17	17A	17B
Static Loading and Fatigue			
18. Constant position, tool or object is held less than 6 seconds. (*Monitor if held between 6-10 seconds; take action if held =10 seconds.*)	18	18A	18B
19. Less than 20% of the task is repetitive. (*Monitor if 20-50%, repetitive; take action if =50% repetitive.*)	19	19A	19B
Pressure/Contact Stress/Repeated Impacts			
20. No contact/impact stress. (*Monitor if occasional pressure or body part is used as hammer = 2 hours/day; take action if constant pressure or body part is used as hammer =2 hours/day.*)	20	20A	20B

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Lifting and Materials Handling			
21. No lifting or lowering of materials. (Monitor if occasional and/or no more than 20 times/hour; take action if constant and/or greater than 20 times/hour.)	21	(21B)	21B
22. No pushing or pulling of materials. (Monitor if pushing/pulling 10-50 carts/shift; take action if pushing/pulling more than 50 carts/shift.)	(22)	22A	22B
23. Slight force is required to push or pull materials. (Monitor if moderate force is required; take action if high force is required.)	(23)	23A	23B
Environment			
24. Worker has adequate control over workplace. (Monitor if worker has some control; take action if worker has no control.)	(24)	24A	24B
25. Lighting is adequate for the task. (Monitor if slightly too dark or bright; take action if significantly too dark or bright.)	(25)	25A	25B
26. Temperature is comfortable. (Monitor if slightly too cold or hot; take action if significantly too cold or hot.)	(26)	26A	26B
27. Work area is quiet. (Monitor if slightly too noisy; take action if significantly too noisy.)	27	27A	(27B)
28. Flooring provides good traction. (Monitor if flooring is slightly slippery; take action if moderately to extremely slippery.)	28	28A	28B
29. Flooring is sufficiently padded to relieve stress on back and legs. (Monitor if slight stress to back and legs; take action if moderately to extreme stress.)	29	29A	29B
30. Floor mats are provided. Employee can alternate between sitting and standing. (Monitor if employee is standing up to 50% of shift without floor mats or other stress relief for back and legs; take action if standing >50% of shift without floor mats or other relief for back and legs.	30	30A	30B

Action Plan

Today's date: 4/2/2019 Date Solution to be Completed _____

Location/Department: _____

Job/Task Title: Chilgood Cheese Since Distribution

Evaluator: Matt Krueger

Describe MSD in previous 24 months: _____

Task: _____

Summary of Problem: _____

Alternative Solution and Costs: _____

Recommended Solution: 1) Engineering _____

2) Administrative: _____

3) Use of personal protective equipment _____

Date Solution Actually Completed: _____ Actual Cost: _____

GREAT AMERICAN INSURANCE GROUP

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Repetition			
1. No repetitive hand or arm motions. (Monitor if repetitive cycle every 30-60 seconds; take action if repetitive cycle of less than 30 seconds.)	1	1A	(1B)
Posture			
2. Standing, with knees straight but not locked. (Monitor if standing with knees partially bent; take action if using a foot pedal or squatting or kneeling more than 1 hour/day.)	2	(2A)	2B
3. Sitting, back and legs comfortably supported, feet flat on floor/foot rest. (Monitor if back partially supported or feet not flat on floor; take action if little support for back and legs, feet not touching floor.)	3	3A	3B
4. Head and neck are upright and straight. (Monitor if head and neck are bent forward < 20°; take action if >20° >1 hours/day.)	4	4A	(4B)
Head and neck are bent back. (Monitor if < 10°; take action if >10°.)	(4)	4B	4B
Head and neck are bent sideways. (Monitor if < 20°; take action if >20°.)	(4)	4C	4C
Head and neck are twisting. (Monitor if < 20°; take action if >20°.)	4	4D	(4D)
5. Hands (palms) are vertical. (Monitor if hands rotate < 20°; take action if hands rotate >20°.)	5	5A	(5B)
6. Wrists are straight. (Monitor if wrists are bent, extension/flexion, < 20° for 5-30 times/minute; take action if bent >20° or >30 times/minute.)	(6)	6A	6A
Wrists move sideways, ulnar/radial. (Monitor if < 20° and 5-30 times/minute; take action if bent >20° or >30 times/minute.)	(6)	6B	6B
Vibration			
7. No hand or arm vibration. (Monitor if occasional; take action if constant.)	(7)	7A	7B
8. No whole body vibration. (Monitor if occasional; take action if constant.)	(8)	8A	8B
Reach			
9. Arms positioned at elbow level. (Monitor if up to 45° or frequently out of ideal position for more than 4 hours/day; take action if arms are forward >45° or constantly out of ideal position >2 hours/day.)	9	9A	(9A)
Arms back. (Monitor if arms back up to 20° between 2-4 times/minute for more than 4 hours/day; take action if arms back >20° or >4 times/minute for more than 2 hours/day.)	(9)	9B	9B
Elbows bent upward. (Monitor if elbows bent up to 20% above or below ideal position >4 hours/day; take action if bent upward >25% above or below ideal position >3 hours/day.)	9	9C	(9C)
Elbows away from body. (Monitor if elbows are up to 45° away from body >4 hours/day; take action if elbows are >45° away from body >2 hours/day.)	(9)	9D	9D
10. No twisting, reaching or bending, twisting/repetitive. (Monitor if twisting up to 45° or 2-4 times/minute; take action if >45° or >4 times/minute.)	(10)	10A	10A
Reaching/bending forward. (Monitor if bending/reaching forward up to 45° or 2-4 times/minute or >10° for >4 hrs/day w/out support; take action if >45° or >4 times/minute or >2 hrs/day w/out support.)	10	10B	(10B)
Reaching/bending to the side. (Monitor if up to 20° or 2-4 times/minute; take action if >20° or >4 times/minute.)	(10)	10C	10C
Force			
11. Objects lifted by hand weigh less than one pound. (Monitor if objects weighing < 1 lb. are lifted up to 20 times/hour; take action if objects weigh >1 lb. or lifting occurs >20 times/hour.)	(11)	11A	11B
12. Objects lifted by the back weigh less than 5 pounds. (Monitor if objects weigh 5-25 lbs. or lifting occurs up to 20 times/hour; take action if objects weigh >25 lbs. or lifting occurs >20 times/hour.)	(12)	12A	12B
13. No pinch grip used. (Monitor use of pinch grip with < 2 lbs. of force; take action if pinch grip with >2 lbs. of force is used.)	13	(13A)	13A
Wide pinch grip used. (Monitor if slightly too wide; take action if extremely wide.)	(13)	13B	13B
14. Power grip used with no force. (Monitor if power grip with < 10 lbs. force is used and forearm rotation force is < 5lbs.; take action if power grip with >10 lbs. force is used and forearm rotation force is >5 lbs.)	(14)	14A	14B
15. Entire hand controls trigger. (Monitor if thumb controls; take action if finger(s) control.)	(15)	15A	15B
16. Tools or objects have rounded, padded handles. (Monitor if handles are awkward; take action if there are no handles or handles concentrate force.)	(16)	16A	16B
17. Gloves do not need to be worn at any time. (Monitor if gloves are needed but fit well; take action if gloves fit poorly.)	17	(17A)	17B
Static Loading and Fatigue			
18. Constant position, tool or object is held less than 6 seconds. (Monitor if held between 6-10 seconds; take action if held >10 seconds.)	(18)	18A	18B
19. Less than 20% of the task is repetitive. (Monitor if 21-40%, repetitive; take action if >40%, repetitive.)	19	19A	(19B)
Pressure/Contact Stress/Repeated Impacts			
20. No contact/impact stress. (Monitor if occasional pressure or body part is used as hammer < 2 hours/day; take action if constant pressure or body part is used as hammer >2 hours/day.)	20	20A	(20B)

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Lifting and Materials Handling			
21. No lifting or lowering of materials. (Monitor if occasional and/or no more than 20 times/hour; take action if constant and/or greater than 20 times/hour.	21	21A	(21)
22. No pushing or pulling of materials. (Monitor if pushing/pulling 10-50 carts/shift; take action if pushing/pulling more than 50 carts/shift.)	(22)	22A	22B
23. Slight force is required to push or pull materials. (Monitor if moderate force is required; take action if high force is required.)	(23)	23A	23B
Environment			
24. Worker has adequate control over workplace. (Monitor if worker has some control; take action if worker has no control.)	(24)	24A	24B
25. Lighting is adequate for the task. (Monitor if slightly too dark or bright; take action if significantly too dark or bright.)	(25)	25A	25B
26. Temperature is comfortable. (Monitor if slightly too cold or hot; take action if significantly too cold or hot.)	(26)	26A	26B
27. Work area is quiet. (Monitor if slightly too noisy; take action if significantly too noisy.)	27	27A	(27)
28. Flooring provides good traction. (Monitor if flooring is slightly slippery; take action if moderately to extremely slippery.)	(28)	28A	28B
29. Flooring is sufficiently padded to relieve stress on back and legs. (Monitor if slight stress to back and legs; take action if moderately to extreme stress.)	(29)	29A	29B
30. Floor mats are provided. Employee can alternate between sitting and standing. (Monitor if employee is standing up to 50% of shift without floor mats or other stress relief for back and legs; take action if standing >50% of shift without floor mats or other relief for back and legs.	(30)	30A	30B

Action Plan

Today's date: 4/2/2019 Date Solution to be Completed _____

Location/Department: _____

Job/Task Title: Cold bar and Sandwich building

Evaluator: Matt Krueger

Describe MSD in previous 24 months: _____

Task: _____

Summary of Problem: _____

Alternative Solution and Costs: _____

Recommended Solution: 1) Engineering _____

2) Administrative: _____

3) Use of personal protective equipment _____

Date Solution Actual/ Completed: _____ Actual Cost: _____

GREAT AMERICAN INSURANCE GROUP

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Repetition			
1. No repetitive hand or arm motions. (Monitor if repetitive cycle every 30-60 seconds; take action if repetitive cycle of less than 30 seconds.)	1	1A	(1B)
Posture			
2. Standing, with knees straight but not locked. (Monitor if standing with knees partially bent; take action if using a foot pedal or squatting or kneeling more than 3 hours/day.)	2	~~2A~~	(2B)
3. Sitting, back and legs comfortably supported, feet flat on floor/foot rest. (Monitor if back partially supported or feet not flat on floor; take active if little support for back and legs, feet not touching floor.)	~~3~~	~~3A~~	~~3B~~
4. Head and neck are upright and straight. (Monitor if head and neck are bent forward = 20°; take action if >20° >1 hours/day.)	4	(4A)	4A
Head and neck are bent back. (Monitor if = 10°; take action if >10°.)	(4)	4B	4B
Head and neck are bent sideways. (Monitor if = 20°; take action if >20°.)	(4)	4C	4C
Head and neck are twisting. (Monitor if = 20°; take action if >20°.)	(4)	4D	4D
5. Hands (palms) are vertical. (Monitor if hands rotate = 20°; take action if hands rotate >20°.)	5	5A	(5B)
6. Wrists are straight. (Monitor if wrists are bent, extension/flexion, = 20° for 6-30 times/minute; take action if bend >20° or >30 times/minute.)	(6)	6A	6A
Wrists move sideways, ulnar/radial. (Monitor if = 20° and 6-30 times/minute; take action if bent >20° or >30 times/minute.)	(6)	6B	6B
Vibration			
7. No hand or arm vibration. (Monitor if occasional; take action if constant.)	(7)	7A	7B
8. No whole body vibration. (Monitor if occasional; take action if constant.)	(8)	8A	8B
Reach			
9. Arms positioned at elbow level. (Monitor if up to 45° or frequently out of ideal position for more than 4 hours/day; take action if arms are forward >45° or constantly out of ideal position >3 hours/day.)	9	9A	(9B)
Arms back. (Monitor if arms back up to 20° between 2-4 times/minute for more than 4 hours/day; take action if arms back >20° or >4 times/minute for more than 3 hours/day.)	(9)	9B	9B
Elbows bent upward. (Monitor if elbows bent up to 20% above or below ideal position >4 hours/day; take action if bent upward >25% above or below ideal position >3 hours/day.)	9	9C	(9C)
Elbows away from body. (Monitor if elbows are up to 45° away from body >4 hours/day; take action if elbows are >45° away from body >3 hours/day.)	(9)	9D	9D
10. No twisting, reaching or bending, twisting/repetitive. (Monitor if twisting up to 45° or 2-4 times/minute; take action if >45° or >4 times/minute.)	10	(10A)	10A
Reaching/bending forward. (Monitor if bending/reaching forward up to 45° or 2-4 times/minute or >10° for >4 hrs/day w/out support; take action if >45° or >4 times/minute or >2 hrs/day w/out support.)	10	10B	(10B)
Reaching/bending to the side. (Monitor if up to 20° or 2-4 times/minute; take action if >20° or >4 times/minute.)	(10)	10C	10C
Force			
11. Objects lifted by hand weigh less than one pound. (Monitor if objects weighing = 1 lb. are lifted up to 20 times/hour; take action if objects weigh >1 lb. or lifting occurs >20 times/hour.)	(11)	11A	11B
12. Objects lifted by the back weigh less than 5 pounds. (Monitor if objects weigh 5-25 lbs. or lifting occurs up to 20 times/hour; take action if objects weigh >25 lbs. or lifting occurs >20 times/hour.)	(12)	12A	12B
13. No pinch grip used. (Monitor use of pinch grip with = 2 lbs. of force; take action if pinch grip with >2 lbs. of force is used.)	(13)	13A	13A
Wide pinch grip used. (Monitor if slightly too wide; take action if extremely wide.)	(13)	13C	13B
14. Power grip used with no force. (Monitor if power grip with = 10 lbs. force is used and forearm rotation force is = 5lbs.; take action if power grip with >10 lbs. force is used and forearm rotation force is >5 lbs.)	(14)	14A	14B
15. Entire hand controls trigger. (Monitor if thumb controls; take action if finger(s) control.)	(15)	15A	15B
16. Tools or objects have rounded, padded handles. (Monitor if handles are awkward; take action if there are no handles or handles concentrate force.)	(16)	16A	16B
17. Gloves do not need to be worn at any time. (Monitor if gloves are needed but fit well; take action if gloves fit poorly.)	17	(17B)	17B
Static Loading and Fatigue			
18. Constant position, tool or object is held less than 6 seconds. (Monitor if held between 6-10 seconds; take action if held >10 seconds.)	18	(18A)	18B
19. Less than 20% of the task is repetitive. (Monitor if 21-50% repetitive; take action if >50% repetitive.)	19	19A	(19B)
Pressure/Contact Stress/Repeated Impacts			
20. No contact/impact stress. (Monitor if occasional pressure or body part is used as hammer = 2 hours/day; take action if constant pressure or body part is used as hammer >2 hours/day.)	20	(20A)	20B

Summary Worksheet Date _____

Condition	Ideal	Warning Level	Take Action
Lifting and Materials Handling			
21. No lifting or lowering of materials. (Monitor if occasional and/or no more than 20 times/hour; take action if constant and/or greater than 20 times/hour.)	21	21A	(21B)
22. No pushing or pulling of materials. (Monitor if pushing/pulling 10 to carts/shift; take action if pushing/pulling more than 10 carts/shift.)	(22)	22A	22B
23. Slight force is required to push or pull materials. (Monitor if moderate force is required; take action if high force is required.)	(23)	23A	23B
Environment			
24. Worker has adequate control over workplace. (Monitor if worker has some control; take action if worker has no control.)	(24)	24A	24B
25. Lighting is adequate for the task. (Monitor if slightly too dark or bright; take action if significantly too dark or bright.)	(25)	25A	25B
26. Temperature is comfortable. (Monitor if slightly too cold or hot; take action if significantly too cold or hot.)	26	(26A)	26B
27. Work area is quiet. (Monitor if slightly too noisy; take action if significantly too noisy.)	27	27A	(27B)
28. Flooring provides good traction. (Monitor if flooring is slightly slippery; take action if moderately to extremely slippery.)	(28)	28A	28B
29. Flooring is sufficiently padded to relieve stress on back and legs. (Monitor if slight stress to back and legs; take action if moderately to extreme stress.)	(29)	29A	29B
30. Floor mats are provided. Employee can alternate between sitting and standing. (Monitor if employee is standing up to 50% of shift without floor mats or other stress relief for back and legs; take action if standing >50% of shift without floor mats or other relief for back and legs.	(30)	30A	30B

Action Plan

Today's date: 4/2/2009 Date Solution to be Completed _____

Location/Department: _____

Job/Task Title: Hamburger Patty Manipulation

Evaluator: Matt Krueger

Describe MSD in previous 24 months: _____

Task: _____

Summary of Problem: _____

Alternative Solution and Costs: _____

Recommended Solution: 1) Engineering _____

2) Administrative: _____

3) Use of personal protective equipment _____

Date Solution Actually Completed: _____ Actual Cost: _____

GREAT AMERICAN INSURANCE GROUP

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Repetition			
1. No repetitive hand or arm motions. (*Monitor if repetitive cycle every 30-60 seconds; take action if repetitive cycle of less than 30 seconds.*)	(1)	1A	1B
Posture			
2. Standing, with knees straight but not locked. (*Monitor if standing with knees partially bent; take action if using a foot pedal or squatting or kneeling more than 1 hours/day.*)	2	(2A)	2B
3. Sitting, back and legs comfortably supported, feet flat on floor/foot rest. (*Monitor if back partially supported or feet not flat on floor; take action if little support for back and legs, feet not touching floor.*)	~~3~~	~~3A~~	~~3B~~
4. Head and neck are upright and straight. (*Monitor if head and neck are bent forward = 20°; take action if >20° >1 hours/day.*)	4	(4A)	4A
Head and neck are bent back. (*Monitor if = 10°; take action if >10°.*)	4	4B	(4B)
Head and neck are bent sideways. (*Monitor if = 20°; take action if >20°.*)	(4)	4C	4C
Head and neck are twisting. (*Monitor if = 20°; take action if >20°.*)	(4)	4D	4D
5. Hands (palms) are vertical. (*Monitor if hands rotate = 20°; take action if hands rotate >20°.*)	5	5A	(5B)
6. Wrists are straight. (*Monitor if wrists are bent, extension/flexion = 20° for 6-30 times/minute; take action if bent >20° or >30 times/minute.*)	(6)	6A	6A
Wrists move sideways, ulnar/radial. (*Monitor if = 20° and 6-30 times/minute; take action if bent >20° or >30 times/minute.*)	(6)	6B	6B
Vibration			
7. No hand or arm vibration. (*Monitor if occasional; take action if constant.*)	(7)	7A	7B
8. No whole body vibration. (*Monitor if occasional; take action if constant.*)	(8)	8A	8B
Reach			
9. Arms positioned at elbow level. (*Monitor if up to 45° or frequently out of ideal position for more than 4 hours/day; take action if arms are forward >45° or constantly out of ideal position >3 hours/day.*)	9	9A	(9B)
Arms back. (*Monitor if arms back up to 20° between 2-4 times/minute for more than 4 hours/day; take action if arms back >20° or >4 times/minute for more than 3 hours/day.*)	(9)	9B	9B
Elbows bent upward. (*Monitor if elbows bent up to 20% above or below ideal position >4 hours/day; take action if bent upward >25% above or below ideal position >3 hours/day.*)	9	9C	(9C)
Elbows away from body. (*Monitor if elbows are up to 45° away from body >4 hours/day; take action if elbows are >45° away from body >2 hours/day.*)	9	(9D)	9D
10. No bending, reaching or twisting. Twisting/repetitive. (*Monitor if twisting up to 45° or 2-4 times/minute; take action if >45° or >4 times/minute.*)	(10)	10A	10A
Reaching/bending forward. (*Monitor if bending/reaching forward up to 45° or 2-4 times/minute or >10° for >4 hrs/day w/out support; take action if >45° or >4 times/minute or >2 hrs/day w/out support.*)	(10)	10B	10B
Reaching/bending to the side. (*Monitor if up to 20° or 2-4 times/minute; take action if >20° or >4 times/minute.*)	10	(10C)	10C
Force			
11. Objects lifted by hand weigh less than one pound. (*Monitor if objects weighing < 1 lb. are lifted up to 20 times/hour take action if objects weigh >1 lb. or lifting occurs >20 times/hour.*)	(11)	11A	11B
12. Objects lifted by the back weigh less than 5 pounds. (*Monitor if objects weigh 5-25 lbs. or lifting occurs up to 20 times/hour; take action if objects weigh >25 lbs. or lifting occurs >20 times/hour.*)	(12)	12A	12B
13. No pinch grip used. (*Monitor use of pinch grip with < 2 lbs. of force; take action if pinch grip with >2 lbs. of force is used.*)	(13)	13A	13A
Wide pinch grip used. (*Monitor if slightly too wide; take action if extremely wide.*)	(13)	13B	13B
14. Power grip used with no force. (*Monitor if power grip with < 10 lbs. force is used and forearm rotation force is < 5lbs.; take action if power grip with >10 lbs. force is used and forearm rotation force is >5 lbs.*)	(14)	14A	14B
15. Entire hand controls trigger. (*Monitor if thumb controls; take action if finger(s) control.*)	(15)	15A	15B
16. Tools or objects have rounded, padded handles. (*Monitor if handles are awkward; take action if there are no handles or handles concentrate force.*)	(16)	16A	16B
17. Gloves do not need to be worn at any time. (*Monitor if gloves are needed but fit well; take action if gloves fit poorly.*)	(17)	17A	17B
Static Loading and Fatigue			
18. Constant position, tool or object is held less than 6 seconds. (*Monitor if held between 6-10 seconds; take action if held >10 seconds.*)	(18)	18A	18B
19. Less than 25% of the task is repetitive. (*Monitor if 25-50%, repetitive; take action if >50%, repetitive.*)	(19)	19A	19B
Pressure/Contact Stress/Repeated Impacts			
20. No contact/impact stress. (*Monitor if occasional pressure or body part is used as hammer < 2 hours/day; take action if constant pressure or body part is used as hammer >2 hours/day.*)	(20)	20A	20B

Summary Worksheet

Date _____

Condition	Ideal	Warning Level	Take Action
Lifting and Materials Handling			
21. No lifting or lowering of materials. (Monitor if occasional and/or no more than 20 times/hour; take action if constant and/or greater than 20 times/hour.	21	21A	21B
22. No pushing or pulling of materials. (Monitor if pushing/pulling 10-50 carts/shift; take action if pushing/pulling more than 50 carts/shift.)	22	22A	22B
23. Slight force is required to push or pull materials. (Monitor if moderate force is required; take action if high force is required.)	23	23A	23B
Environment			
24. Worker has adequate control over workplace. (Monitor if worker has some control; take action if worker has no control.)	24	24A	24B
25. Lighting is adequate for the task. (Monitor if slightly too dark or bright; take action if significantly too dark or bright.)	25	25A	25B
26. Temperature is comfortable. (Monitor if slightly too cold or hot; take action if significantly too cold or hot.)	26	26A	26B
27. Work area is quiet. (Monitor if slightly too noisy; take action if significantly too noisy.)	27	27A	27B
28. Flooring provides good traction. (Monitor if flooring is slightly slippery; take action if moderately to extremely slippery.)	28	28A	28B
29. Flooring is sufficiently padded to relieve stress on back and legs. (Monitor if slight stress to back and legs; take action if moderately to extreme stress.)	29	29A	29B
30. Floor mats are provided. Employee can alternate between sitting and standing. (Monitor if employee is standing up to 50% of shift without floor mats or other stress relief for back and legs; take action if standing >50% of shift without floor mats or other relief for back and legs.	30	30A	30B

Action Plan

Today's date: 4/2/2019 Date Solution to be Completed _____

Location/Department: _____

Job/Task Title: Childcare building

Evaluator: Matt Krueger

Describe MSD in previous 24 months: _____

Task: _____

Summary of Problem: _____

Alternative Solution and Costs: _____

Recommended Solution: 1) Engineering _____

2) Administrative: _____

3) Use of personal protective equipment _____

Date Solution Actually Completed: _____ Actual Cost: _____

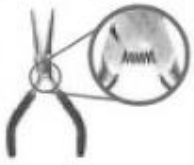
GREAT AMERICAN INSURANCE GROUP

Appendix E: Completed California OSHA and NIOSH Tool Checklist for Hand Tool Selection Forms

Fry Scoop

Use **BOTH** sides of the **checklist** to compare similar tools. For example, if you have two pliers and want to select the best of the two, compare each tool against the features on the checklist. The more "Yes" answers the tool has, the better the tool.

Refer to Section D, **Tips for Selecting Hand Tools**, for more details.

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers.		**Examples**	Check if "YES"			
			Single-handle tools		Double-handle tools	
			Tool 1	Tool 2	Tool 1	Tool 2
1	For single-handle tools used for power tasks: Does the tool feel comfortable and have a handle diameter between 1 1/4 inches and 2 inches? (pg. 8)		NA			
2	For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/2 inch? (pg. 8)		Yes			
3	For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg. 8)		NA			
4	For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg. 9)		NA			
5	For double-handle tools: Is the handle spring-loaded? (pg. 9)		NA			

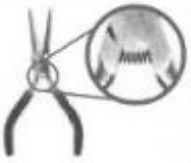
COMPLETE BOTH SIDES 13

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers		Examples	Check if "YES" for all tools	
			Tool 1	Tool 2
6	Is the tool handle without sharp edges or finger grooves? (pg. 9)		Yes	
7	Is the tool handle coated with soft material? (pg. 9)		Yes	
8	Can the tool be used while keeping your wrist straight? (pg. 10)		Yes	
9	Can the tool be used with your dominant hand or with either hand? (pg. 10)		No	
10	For high-force tasks: Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg. 11)		Yes	
11	Does the tool handle have a non-slip surface? (pg. 11)		No	

Tongs

Use **BOTH** sides of the **checklist** to compare similar tools. For example, if you have two pliers and want to select the best of the two, compare each tool against the features on the checklist. The more "Yes" answers the tool has, the better the tool.

Refer to Section D, **Tips for Selecting Hand Tools**, for more details.

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers.		**Examples**	Check if "YES"			
			Single-handle tools		Double-handle tools	
			Tool 1	Tool 2	Tool 1	Tool 2
1	For single-handle tools used for power tasks: Does the tool feel comfortable and have a handle diameter between 1 1/4 inches and 2 inches? (pg. 8)		NA			
2	For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/2 inch? (pg. 8)		Yes			
3	For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg. 8)		NA			
4	For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg. 9)		NA			
5	For double-handle tools: Is the handle spring-loaded? (pg. 9)		NA			

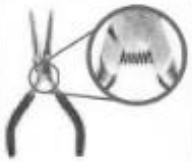
COMPLETE BOTH SIDES 13

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers		**Examples**	Check if "YES" for all tools	
			Tool 1	Tool 2
6	Is the tool handle without sharp edges or finger grooves? (pg. 9)		Yes	
7	Is the tool handle coated with soft material? (pg. 9)		No	
8	Can the tool be used while keeping your wrist straight? (pg. 10)		Yes	
9	Can the tool be used with your dominant hand or with either hand? (pg. 10)		Yes	
10	For high-force tasks: Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg. 11)		NA	
11	Does the tool handle have a non-slip surface? (pg. 11)		No	

Lodle

Use **BOTH** sides of the **checklist** to compare similar tools. For example, if you have two pliers and want to select the best of the two, compare each tool against the features on the checklist. The more "Yes" answers the tool has, the better the tool.

Refer to Section D, **Tips for Selecting Hand Tools**, for more details.

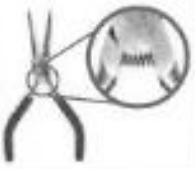
	Checklist for Hand Tool Selection Select the tool that has the most "YES" answers.	**Examples**	Check if "YES" Single-handle tools Tool 1	Tool 2	Double-handle tools Tool 1	Tool 2
1	For single-handle tools used for power tasks: Does the tool feel comfortable and have a handle diameter between 1 1/4 inches and 2 inches? (pg. 8)		NA			
2	For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/2 inch? (pg. 8)		Yes			
3	For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg. 8)		NA			
4	For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg. 9)		NA			
5	For double-handle tools: Is the handle spring-loaded? (pg. 9)		NA			

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers		Examples	Check if "YES" for all tools	
			Tool 1	Tool 2
6	Is the tool handle without sharp edges or finger grooves? (pg. 9)		No	
7	Is the tool handle coated with soft material? (pg. 9)		No	
8	Can the tool be used while keeping your wrist straight? (pg. 10)		No	
9	Can the tool be used with your dominant hand or with either hand? (pg. 10)		Yes	
10	For high-force tasks: Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg. 11)		NA	
11	Does the tool handle have a non-slip surface? (pg. 11)		No	

Spatula

Use **BOTH** sides of the **checklist** to compare similar tools. For example, if you have two pliers and want to select the best of the two, compare each tool against the features on the checklist. The more "Yes" answers the tool has, the better the tool.

Refer to Section D, **Tips for Selecting Hand Tools**, for more details.

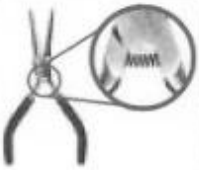
Checklist for Hand Tool Selection Select the tool that has the most "YES" answers.		**Examples**	Check if "YES"			
			Single-handle tools		Double-handle tools	
			Tool 1	Tool 2	Tool 1	Tool 2
1	For single-handle tools used for power tasks: Does the tool feel comfortable and have a handle diameter between 1 1/4 inches and 2 inches? (pg. 8)		Yes			
2	For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/2 inch? (pg. 8)		Na			
3	For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg. 8)		Na			
4	For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg. 9)		Na			
5	For double-handle tools: Is the handle spring-loaded? (pg. 9)		Na			

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers		Examples	Check if "YES" for all tools	
			Tool 1	Tool 2
6	Is the tool handle without sharp edges or finger grooves? (pg. 9)		Yes	
7	Is the tool handle coated with soft material? (pg. 9)		Yes	
8	Can the tool be used while keeping your wrist straight? (pg. 10)		Yes	
9	Can the tool be used with your dominant hand or with either hand? (pg. 10)		Yes	
10	For high-force tasks: Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg. 11)		NA	
11	Does the tool handle have a non-slip surface? (pg. 11)		No	

Grill Scraper

Use **BOTH** sides of the **checklist** to compare similar tools. For example, if you have two pliers and want to select the best of the two, compare each tool against the features on the checklist. The more "Yes" answers the tool has, the better the tool.

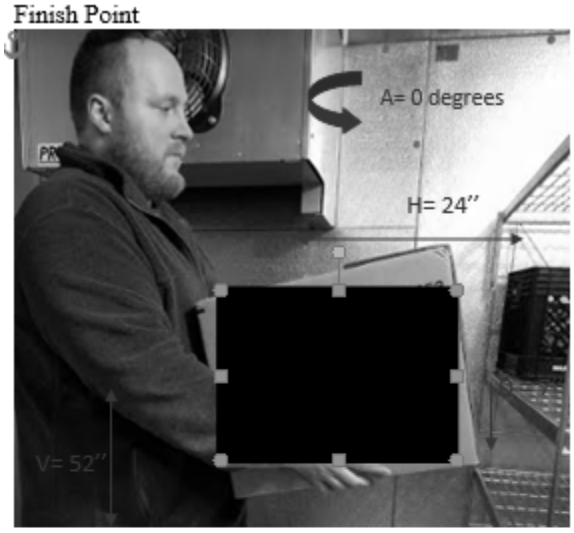
Refer to Section D, **Tips for Selecting Hand Tools**, for more details.

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers.		**Examples**	Check if "YES"			
			Single-handle tools		Double-handle tools	
			Tool 1	Tool 2	Tool 1	Tool 2
1	For single-handle tools used for power tasks: Does the tool feel comfortable and have a handle diameter between 1 1/4 inches and 2 inches? (pg. 8)		NA			
2	For single-handle tools used for precision tasks: Is the handle diameter between 1/4 inch and 1/2 inch? (pg. 8)		NA			
3	For double-handle tools used for power tasks: Is the grip span at least 2 inches when closed and no more than 3 1/2 inches when open? (pg. 8)		No			
4	For double-handle tools used for precision tasks: Is the grip span no less than 1 inch when closed and no more than 3 inches when open? (pg. 9)		NA			
5	For double-handle tools: Is the handle spring-loaded? (pg. 9)		NA			

Checklist for Hand Tool Selection Select the tool that has the most "YES" answers		**Examples**	Check if "YES" for all tools	
			Tool 1	Tool 2
6	Is the tool handle without sharp edges or finger grooves? (pg. 9)		Yes	
7	Is the tool handle coated with soft material? (pg. 9)		No	
8	Can the tool be used while keeping your wrist straight? (pg. 10)		Yes	
9	Can the tool be used with your dominant hand or with either hand? (pg. 10)		Yes	
10	For high-force tasks: Is the handle longer than the widest part of your hand (usually 4 inches to 6 inches)? (pg. 11)		Yes	
11	Does the tool handle have a non-slip surface? (pg. 11)		No	

Appendix F: Revised NIOSH Lifting Equation Data

Fry Box Lift 1
Finish Point



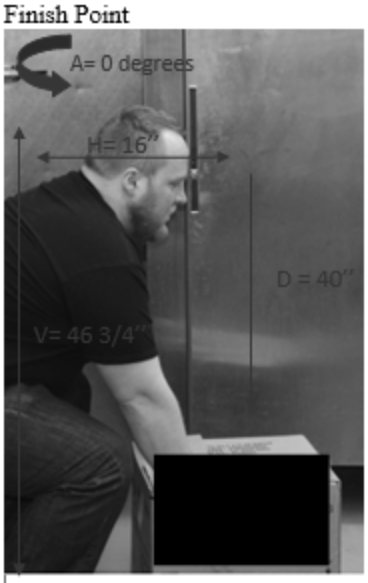
LC= Constant of 51 pounds (represents the maximum recommended load weight to be lifted under ideal conditions)
H= Horizontal location of the object relative to the body
V= Vertical location of the object relative to the floor
D= Distance the object is moved vertically
A= Asymmetry angle or twisting requirement
F= Frequency and duration of lifting activity
C= Coupling or quality of the workers grip on the object
RWL= Recommended Weight Limit
LI (Lifting Index)= **LI** = *Load weight (weight of load in pounds or kilograms)/RWL* (< 1 = Acceptable weight; > 1 = Increase risk musculoskeletal disorders)

LC=51 **H**= 24'' **V**=52'' **D**=7''**A**= 1 (0 degrees) **FM**= .55 (3 reps between 2 and 8 hours) **CM**= .90 (poor)

LC	HM	VM	DM	AM	FM	CM
51	(10/H)	1-(.0075 [V-30])	.82+(1.8/D)	1-(.0032A)	FM	CM
51	(10/24)	1- (.0075[52-30])	.82+(1.8/7)	1- (.0032x1)	.55	.90 (poor)
51	.417	.835	1.07	.997	.55	.90

RWL=51 x .417 x .835 x 1.07 x .997 x .55 x .90
RWL= 9.38 lbs
LI= 36 lbs (weight of box)/9.38
LI= 3.84 Increased risk of musculoskeletal disorders

Fry Box Lift 2
Finish Point



LC= Constant of 51 pounds (represents the maximum recommended load weight to be lifted under ideal conditions)
H= Horizontal location of the object relative to the body
V= Vertical location of the object relative to the floor
D= Distance the object is moved vertically
A= Asymmetry angle or twisting requirement
F= Frequency and duration of lifting activity
C= Coupling or quality of the workers grip on the object
RWL= Recommended Weight Limit
LI (Lifting Index)= **LI** = *Load weight (weight of load in pounds or kilograms)/RWL* (< 1 = Acceptable weight; > 1 = Increase risk musculoskeletal disorders)

LC=51 **H**= 16'' **V**= 46.75'' **D**=40''**A**= 1 (0 degrees) **FM**= .55 (3 reps between 2 and 8 hours) **CM**= .90

LC	HM	VM	DM	AM	FM	CM
51	(10/H)	1-(.0075 [V-30])	.82+(1.8/D)	1-(.0032A)	FM	CM
51	(10/16)	1- (.0075[46.75-30])	.82+(1.8/40)	1- (.0032x1)	.55	.90
51	.625	.874	.865	.997	.55	.95

RWL=51 x .625 x .874 x .865 x .997 x .55 x .90
RWL= 11.89 lbs
LI= 36 lbs (weight of box)/11.89
LI= 3.02 Increased risk of musculoskeletal disorders

Patty Box Lift 1
Finish Point

LC= Constant of 51 pounds (represents the maximum recommended load weight to be lifted under ideal conditions)
H= Horizontal location of the object relative to the body
V= Vertical location of the object relative to the floor
D= Distance the object is moved vertically
A= Asymmetry angle or twisting requirement
F= Frequency and duration of lifting activity)
C= Coupling or quality of the workers grip on the object
RWL= Recommended Weight Limit
LI (Lifting Index)= **LI** = *Load weight (weight of load in pounds or kilograms)/RWL* (< 1 = Acceptable weight; > 1 = Increase risk musculoskeletal disorders)

LC=51 **H**= 16'' **V**= 46.75'' **D**=40''**A**= 1 (0 degrees) **FM**= .45 (4 reps between 2 and 8 hours) **CM**= .90

LC	HM	VM	DM	AM	FM	CM
51	(10/H)	1-(.0075 [V-30])	.82+(1.8/D)	1-(.0032A)	FM	CM
51	(10/16)	1- (.0075[46.75-30])	.82+(1.8/40)	1- (.0032x1)	.45	.90
51	.625	.874	.865	.997	.45	.90

RWL=51 x .625 x .874 x .865 x .997 x .45 x .90
RWL= 9.73 lbs
LI= 20 lbs (weight of box)/9.73
LI= 2.06 Increased risk of musculoskeletal disorders

Patty Box Lift 2
Finish Point

LC= Constant of 51 pounds (represents the maximum recommended load weight to be lifted under ideal conditions)
H= Horizontal location of the object relative to the body
V= Vertical location of the object relative to the floor
D= Distance the object is moved vertically
A= Asymmetry angle or twisting requirement
F= Frequency and duration of lifting activity
C= Coupling or quality of the workers grip on the object
RWL= Recommended Weight Limit
LI (Lifting Index)= **LI** = *Load weight (weight of load in pounds or kilograms)/RWL* (< 1 = Acceptable weight; > 1 = Increase risk musculoskeletal disorders)

LC=51 **H**= 37'' **V**= 46.75'' **D**=30''**A**= 1 (0 degrees) **FM**= .45 (4 reps between 2 and 8 hours)
CM= .90

LC	HM	VM	DM	AM	FM	CM
51	(10/H)	1-(.0075 [V-30])	.82+(1.8/D)	1-(.0032A)	FM	CM
51	(10/37)	1- (.0075[46.75-30])	.82+(1.8/30)	1- (.0032x1)	.45	.90
51	.270	.874	.880	.997	.45	.90

RWL=51 x .270 x .874 x .880 x .997 x .45 x .90
RWL= 4.86 lbs
LI= 20 lbs (weight of box)/4.86
LI= 4.11 Increased risk of musculoskeletal disorders