REPORT

Musculoskeletal disorders caused by the most common job demands and ergonomic risks

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Good practices to develop physical activity programs at work

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Description	IBV is responsible for this deliverable. This document consists of several sections. It begins with a review of the main MSD's, and it continues with the concepts about job demands and capabilities. The last section presents how the MSDs are related to specific workplaces.		

Contents

1. Introduction to MSDs

Nowadays humans' life style are changing quickly, affecting to different fields such as communication, home, family, friends, hobbies, work, etc. All this human evolution has good aspects, but also and others that are not so good. Large part of people's works, job positions and developed tasks, evolved during the last decades and even during the last centuries. In many cases, that evolution was not well-designed, leading to an increment of Musculoskeletal Disorders (MSDs).

The European Agency for Safety and Health at Work (EU-OSHA), considers musculoskeletal disorders (MSDs) as the main disease, affecting millions of workers and meaning a great cost of billions of euros for the companies and for the public health system (EU-OSHA, 2017).

Companies and industries are creating new workplaces and specific positions that in many cases require specialised workers. These new tasks require, in many cases, physical conditions or capacities that usually can generate a conflictive situation for the workers' health and well-being.

Musculoskeletal disorders have determinate characteristics associated with different body parts and specific types of work. For example, low back injuries are related to weight manipulation (Jäger, P. D. I. M. et al., 2004). These disorders can be minor aches and pains or can produce serious chronic illness, which need medical treatment. If the disorder is severe, the worker can end with a disability that forces him to give up his job. (EU-OSHA, 2017).

Physical state affects to people's activities, because it can generate other associated effects such as discomfort, bad mood, frustration or depression. Physical state is conditioned by the good state of all locomotor apparatus components, muscles, tendons, ligaments, bones, nerves, etc.

Musculoskeletal disorders usually affect upper limbs, shoulders, neck, back, and in certain works, lower limbs could be damaged.

The MSDs do not appear suddenly; they develop over time when bad work habits or job conditions occur. The most relevant causes of MSDs related to work activities are (EU-OSHA, 2017):

- Handling loads, especially when bending and twisting
- Repetitive or forceful movements
- Awkward and static postures
- Vibration, poor lighting or cold working environments
- Fast-paced work
- Prolonged sitting or standing in the same position

MSDs cases are increasingly linked with psychosocial risk factors in combination with physical job demands, such as (EU-OSHA, 2017):

- High demand of work or low autonomy
- Low job satisfaction

Matt Middlesworth (2015) defines Musculoskeletal Disorders (MSDs) like 'injuries and disorders that affect the human body's movement or musculoskeletal system (i.e. muscles, tendons, ligaments, nerves, discs, blood vessels, etc.)'.

Work activities can affect different body parts depending on the task design. Complex tasks involve much more risk factors for the worker.

MSDs can classify in two main groups: back disorders related to handling weights, and upper limb disorders known as “repetitive strain injuries”.

Inside these main groups, there are many specific MSDs depending on the specific part of the body which is affected (Matt Middlesworth, 2015). In the next section §2 the most common MSDs are reviewed:

- Carpal Tunnel Syndrome
- Tendonitis
- Muscle / Tendon strain
- Ligament Sprain
- Tension Neck Syndrome
- Thoracic Outlet Compression
- Rotator Cuff Tendonitis
- Epicondylitis
- Radial Tunnel Syndrome
- Digital Neuritis
- Trigger Finger / Thumb
- DeQuervain’s Syndrome
- Mechanical Back Syndrome
- Degenerative Disc Disease
- Ruptured / Herniated Disc
- and many more.

If the MSDs are caused by the work activity, then they are known as Work-related Musculoskeletal Disorders (WMSDs). WMSDs are defined as ‘injuries or disorders of the muscles, nerves, tendons, joints, cartilage, and spinal discs associated with exposure to risk factors in the workplace’ by the US Department of Labor (USDL, 2002). Work accidents caused by stumbles, slips or falls are not considerated WMSDs (Barr et al., 2004).

Accidents occur suddenly and their effects appear immediately. However, the MSDs need a long period to start showing their effects.

The difference between Matt Middlesworth (2015) and USDL (2002) definitions, are the causes which produces the disorders. They can be produced at free time activities or at job activities, respectively. This document focuses on the WMSDs.

Working for long time periods in a given static position, such as standing just can cause discomfort, sore feet, fatigue and even pain in the lower back (CCOHS, 2017a). If the position is an awkward, it can produce a more severe disease.

Correct design of the job positions at workstations is very important to improve task conditions and get the best body posture for the worker.

There are two aspects related to the position of the body that influence the WMSDs.

The first one, occurs when the position of body part is near to their maximum range of motion. This provokes that muscles, tendons, and nerves are oppressed or forced, and the injuries’ probability is higher (CCOHS, 2017a).

Sometimes, maximum range of movement in some body part is reached making simple tasks unconsciously (e.g. carrying a heavy weight hanging on the hand, like carrying a shopping bag).

The second one is maintaining a fixed position of shoulders and neck as long as the task requires. When the arm makes a controlled movement, shoulders and neck are contracted producing muscular pain that can cause a more serious injury or disease (CCOHS, 2017a).

There are lot of tasks that require a maintained posture to perform the work accurately. For example, to drill in a wall with a drilling machine. This kind of tasks produce fatigue on the limbs in short time.

When muscles are contracted, the blood vessels are oppressed and this prevents blood from oxygenating the tissues properly. This situation accelerates arms fatigue due to the lack of oxygen in blood, and shoulders and neck are tired without making any apparent effort, only by being contracted (CCOHS, 2017a).

It is very important to know the specific requirements and task demands to avoid overexertion at the locomotor apparatus. This knowledge can reduce the injuries and help to improve of the job position.

When the mechanical stress required by a task exceeds the carrying capacity of the elements of the locomotor apparatus involved on it, a disorder or injury occurs, such as strains and breaks in fibres of the ligaments, tendons or muscles. These elements can also be inflamed, causing severe pain. The lesions can be more serious affecting the bones and produce degenerative processes and functional restrictions, for example in the joints and cartilages (Jäger, P. D. I. M. et al., 2004).

When an injury or annoyance is produced, it is important to evaluate the damage caused to the body to avoid greater damages or a chronic disorder.

Two types of injuries can be found: intense and painful, or chronic and permanent. The first ones are caused by an overexertion in a short moment that causes a failure of the body part that intervenes (e.g. a muscular tear when loading a weight suddenly,). The second type of injury occurs over time, due to small injuries that the worker does not give importance but that can lead to a chronic disease (e.g. muscle stiffness or tenosynovitis caused by repetitive stresses) (Jäger, P. D. I. M. et al., 2004).

Occupational good habits can help to prevent the disorders and reduce the costs to the company due to sick leave. Companies should inform and train their workers to prevent physical risks during the tasks development.

WMSDs are much more extended disorders than people think. The third part of sick leaves are due to pains in the body's limbs. Back related pains are the largest, reaching up to 60%, and are caused by manual material handling (MMH). Secondly, there are neck, shoulders and upper extremities injuries, such as cervical vertebrae wear, tennis elbow, carpal tunnel syndrome, etc., which are related to repetitive tasks and awkward postures, followed by less common knee and hip injuries. The job conditions and tasks, as well as the work intensity are factors that can increase the risk.

2. More common MSDs

An injury is described as mechanical disruption of tissues. That means a traumatic situation in the tissue where the operating mechanical system is disturbed. This event causes pain and inflammation, as well as biochemical responses to repair the tissues. From this definition, Kumar and Shrawan (1999) differentiate between injuries and disorders. A disorder is a malfunction of an organ or an organism, which can occur without a mechanical disturbance of the tissues. They can be problems of the central nervous system that produce inefficient functioning of the musculoskeletal system. On the contrary, the injury results in a functional disorder, which is solved when healed. Injury itself is not a disorder.

Work conditions at the workplaces can influence to provoke an injury or a disorder. Accidents are more related to cleanness and order. Otherwise, bad habits and untrained workers, can be the cause of some musculoskeletal disorders.

Disorders differ from injuries in their origin, as a disorder can be gradual from a pathogen or from a prepathological progression, but injuries happen suddenly and they are not joined to prepathogenesis. However, an injury could involve a mechanical degradation of the tissues due to overuse. Work musculoskeletal injuries make that organs and tissues to be exposed to different factors that stresses the tissues. Frequently, that exposition is repetitive and prolonged and it means a risk. At long term, many studies have shown a strong association between risk factors and the subsequent injury (Kumar and Shrawan, 1999).

Table 1 shows main upper body disorders related to WMSDs (Work-related Musculoskeletal Disorders) with their occupational risk factors and symptoms associated to them (CCOHS, 2017a).

Table 1. Most common Disorders associated with WMSDs(CCOHS, 2017a).

Identified disorders, occupational risk factors and symptoms		
Disorders	**Occupational risk factors**	**Symptoms**
Tendonitis/tenosynovitis	Repetitive wrist motions Repetitive shoulder motions Sustained hyper extension of arms Prolonged load on shoulders	Pain, weakness, swelling, burning sensation or dull ache over affected area
Epicondylitis (elbow tendonitis)	Repeated or forceful rotation of the forearm and bending of the wrist at the same time	Same symptoms as tendonitis
Carpal tunnel syndrome	Repetitive wrist motions	Pain, numbness, tingling, burning sensations, wasting of muscles at base of thumb, dry palm
DeQuervain's disease	Repetitive hand twisting and forceful gripping	Pain at the base of the thumb
Thoracic outlet syndrome	Prolonged shoulder flexion Extending arms above shoulder height Carrying loads on the shoulder	Pain, numbness, swelling of the hands
Tension neck syndrome	Prolonged restricted posture	Pain

Other authors show the main WMSDs and their risk factors attending to the anatomical structure affected (Putz-Anderson (1988); Pujol (1993); Hagberg et al.(1995)):

- Tendon. There are different kinds of illness. Tendonitis is the inflammation of the tendons or their sheaths; tenosynovitis is the inflammation of the synovial membrane that cover the tendon; and synovial cysts, which are developed over joint or tendon from the synovial liquid.
- Bursa. Its inflammation is known as bursitis.
- Muscles. Fatigue in the muscles like Tension Neck Syndrome.
- Nerve. The compression of a nerve such as Carpal Tunnel Syndrome.
- Vascular. Medical conditions that involves blood vessels, like vibration syndrome.

Table 2 shows the most common WMSDs classified according to body part affected and their anatomic structure. A description of each mentioned WMSD is provided in the next paragraphs.

Table 2. Most relevant WMSD by body part and affected anatomical structure (adapted from Nunes, 2003)(Isabel L. Nunes and Pamela McCauley Bush, 2012).

<table>
<tr><th></th><th colspan="8">WMSD</th></tr>
<tr><th>Body part / Affected structure</th><th>Neck</th><th>Shoulder</th><th>Elbow</th><th>Wrist/ Hand</th><th>Lumbar area</th><th>Hip/ Thigh</th><th>Knee</th><th>Leg/ Foot</th></tr>
<tr><td>Tendons and sheaths</td><td></td><td>Shoulder Tendonitis</td><td>Epicondylitis</td><td>De Quervain Disease
Tenosynovitis
Wrist/Hand Synovial Cyst
Trigger Finger</td><td></td><td>Piriformis Syndrome</td><td>Pre-patellar Tendonitis
Shin splints
Infra-patellar Tendonitis</td><td>Achilles Tendonitis</td></tr>
<tr><td rowspan="2">Bursa/ capsule</td><td rowspan="2"></td><td>Shoulder Bursitis</td><td>Olecranon Bursitis</td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Frozen Shoulder (adhesive capsulitis)</td><td></td><td></td><td></td><td></td><td></td><td></td></tr>
<tr><td>Muscles</td><td>Tension Neck Syndrome</td><td></td><td></td><td></td><td rowspan="3">Low back pain</td><td>Trochanteritis</td><td></td><td></td></tr>
<tr><td>Nerves</td><td>Cervical Spine Syndrome</td><td rowspan="2">Thoracic Outlet Syndrome</td><td>Radial Tunnel Syndrome
Cubital Tunnel Syndrome</td><td>Carpal Tunnel Syndrome
Gayron’s Canal Syndrome</td><td>Piriformis Syndrome</td><td></td><td></td></tr>
<tr><td>Blood vessels</td><td></td><td></td><td>Hand-Arm Syndrome (Raynaud Syndrome)
Hypothenar Hammer Syndrome</td><td></td><td></td><td>Varicose veins
Venous disorders</td></tr>
<tr><td>Bone/ cartillage</td><td></td><td></td><td></td><td></td><td></td><td>Sacroiliac Joint Pain</td><td>Pre-patellar Tendonitis</td><td></td></tr>
</table>

- Tension Neck Syndrome

Tension Neck Syndrome is a disorder that affects some muscles at neck and shoulders area, causing pain with stiffness and increased sensitivity, which sometimes produce

muscle spasms. This disorder is more common in women than in men. There are no evidences if this difference is due to genetic factors, or other professional or not professional risk factors associated to the women population, (Hagberg et al., 1995). This kind of illness is causally linked to highly repetitive tasks, as Bernard studies revealed (NIOSH, 1997). The most common example is produced at computers while users are introducing data, and adopt a tensed and awkward posture at their arms and head (Isabel L. Nunes and Pamela McCauley Bush, 2012).

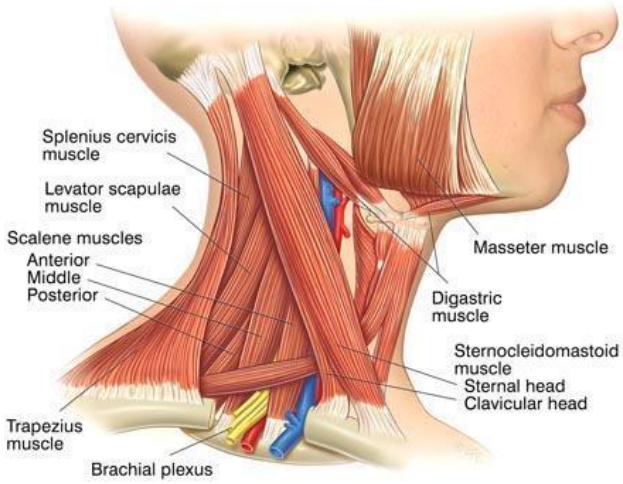

Figure 1. Neck muscles and tendons (HMSP, 2017).

- Back Injuries (McCauley-Bush, P., 2011)

Statistics indicate that back injuries or disorders are the most common body´s disease (NSC Staff, 1990). Main cause of these injuries is the overexertion, but many of them are developed over a long time period due to a repetitive loading of the vertebral discs associated with unsuitable lifting methods (Isabel L. Nunes and Pamela McCauley Bush, 2012).

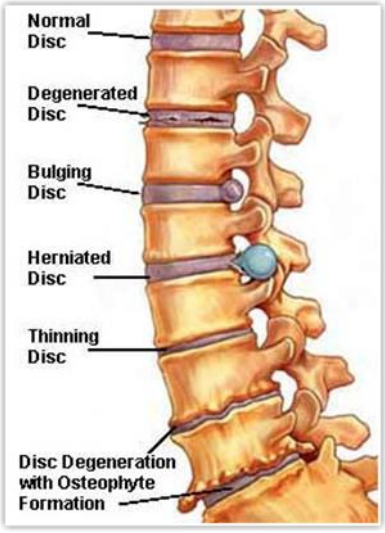

Figure 2. Different states of the disks (FHPT, 2012)

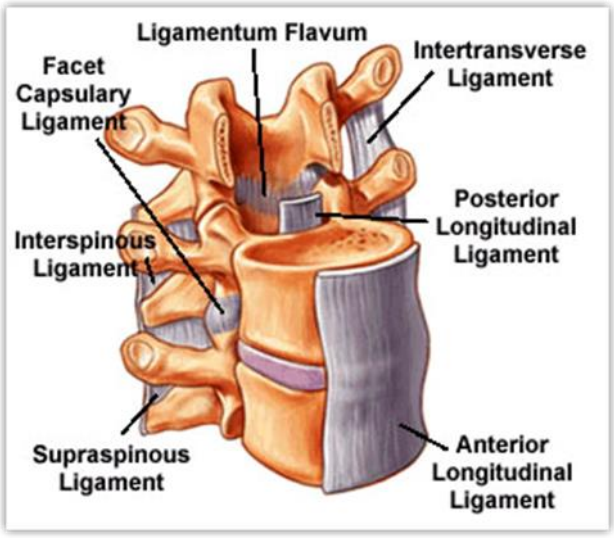

Figure 3. Different ligaments of the spine (FHPT, 2012).

Actually, a bad load lifting or manual material handling causes 27% of industrial back injuries. These disorders or injuries can be repetitive or chronic as result from years performing tasks. Normally, the worst injuries are the result of long term impact. Along the spine, the discs change of size, they are round, rubber-like pads filled with thick fluid, cushioning the impacts

or the overloads. The accumulative forces along the back could compress the discs. This compression can break the pads of discs causing a spinal nerve pressure and producing acute back pain (Isabel L. Nunes and Pamela McCauley Bush, 2012).

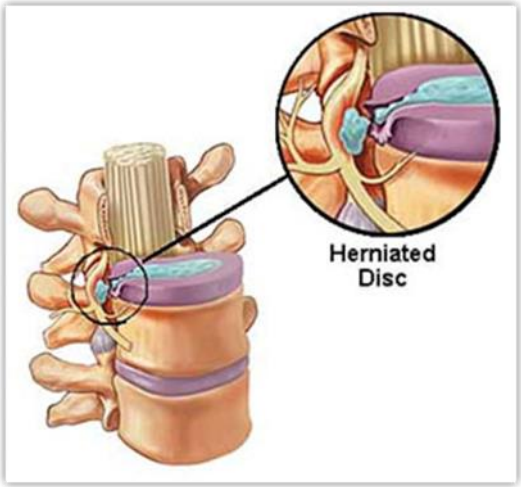

Figure 4. Herniated disc detail (FHPT, 2012).

- Carpal Tunnel Syndrome (McCauley-Bush, P., 2011)

Probably, the most knew WMSD of the arm area it is the carpal tunnel syndrome (CTS), a disorder that it is caused when median nerve is compressed by the bony carpal tunnel at the wrist. The carpal tunnel consists of eight carpal bones, disposed at two rows. Forearm muscle tendons pass through this channel to enter to the hand and are restrained on the anterior side by fascia, named flexor and extensor retinacula, which are tissue bands that restrain and protects the tendons while they pass from the forearm to the hand. This bands have the function to avoid the tendons protrude when the hand flexes or extends (Aroori & Spence, 2008). CTS starts when the synovium swelling and the space at carpal tunnel reduce the effective cross section of the tunnel. Then, median nerve is oppressed between the tendons and it produces the CTS (Isabel L. Nunes and Pamela McCauley Bush, 2012).

Numbness, tingle and burning at fingers, are the first symptoms of CTS. Subsequently, advanced problems produce local pain, wasting of the muscles at the base of thumbs, palms dry and awkwardness. The symptoms start at specific hands area, but can extend the pain to the elbows and shoulders (Isabel L. Nunes and Pamela McCauley Bush, 2012).

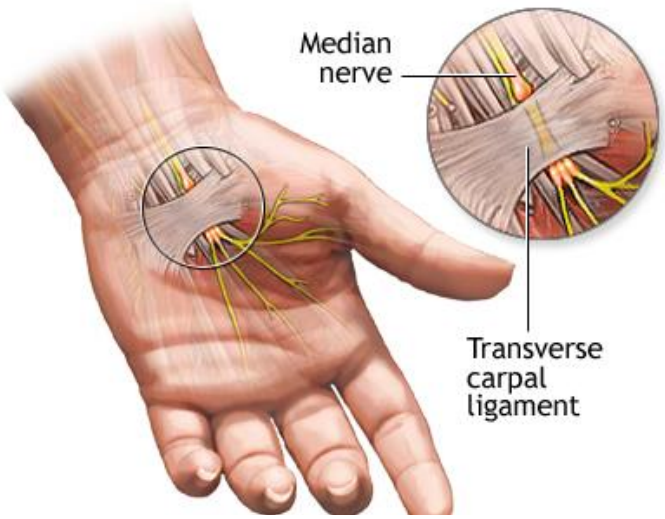

Figure 5. Carpal tunnel syndrome details (Harvey Simon, MD, 2012).

- Tendonitis (McCauley-Bush, P., 2011)

When a tendon sheath is inflamed around a joint is known as tendonitis. General symptoms are acute pain over the joint movement and sensitiveness at the inflammation point. Tendonitis can be caused by a severe trauma or an excessive joint use. Usually, it affects to wrists, elbows, shoulders, knees and ankles joints (Isabel L. Nunes and Pamela McCauley Bush, 2012).

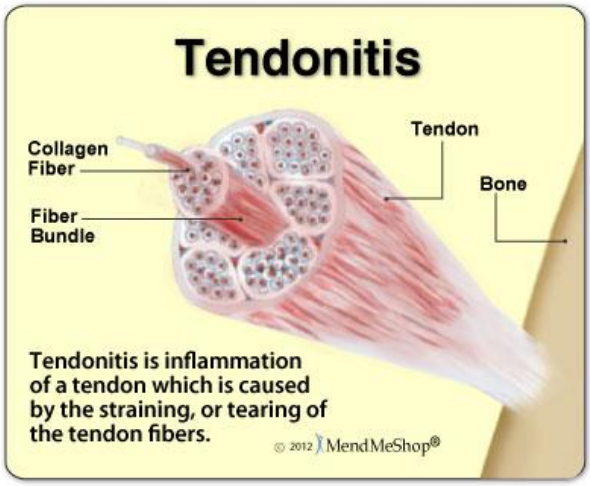

Figure 6. Tendonitis disorder detail (MendMeShop, 2012).

- Tenosynovitis (McCauley-Bush, P., 2011)

The inflammation of the tendon synovial sheath, called tenosynovitis, is caused by repetitive tasks. The best known of tenosynovitis is De Quervain's disorder. This disease is related to the thumb and wrist tendons and sheaths (Isabel L. Nunes and Pamela McCauley Bush, 2012).

- Intersection Syndrome and De Quervain's Syndrome (McCauley-Bush, P., 2011)

De Quervain's syndrome occurs when developing a hard and intensive task that require using the hands. This disorder symptoms are a chronic inflammation of muscles and tendons on the lateral of wrist and the base of the thumb. These symptoms produce numbness, tingle, swelling and discomfort when it moves the thumb (Isabel L. Nunes and Pamela McCauley Bush, 2012).

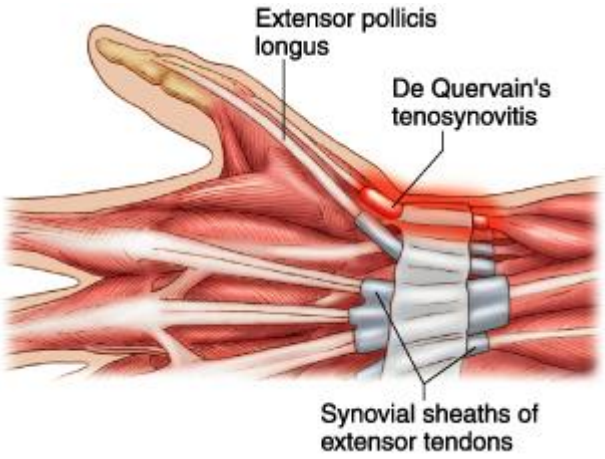

Figure 7. Radial Styloid or De Quervain's tenosynovitis (ReedGroup, 2017).

- Trigger Finger (McCauley-Bush, P., 2011)

Trigger finger can occur to individual or multiple fingers and happens when an inflammation on the tendon that do not let it runs in and out at its sheath. This disorder produces snaps and clicks in the finger when the finger bends or straightens fully, and the finger it could be lock (Isabel L. Nunes and Pamela McCauley Bush, 2012).

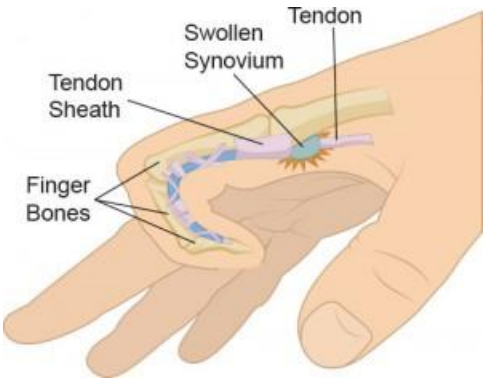

Figure 8. Trigger Finger disorder (OrthoNeuro, 2016).

- Ischemia (McCauley-Bush, P., 2011)

Ischemia happens when a tissue stops receiving blood (long enough to cause some kind of damage). Tingling, numbness and fatigue are the symptoms and their level it depends from the grade of blockage of the blood vessels or ischemia produced. Compressive forces are a common cause of ischemia, like for example at the hand's palms (Isabel L. Nunes and Pamela McCauley Bush, 2012).

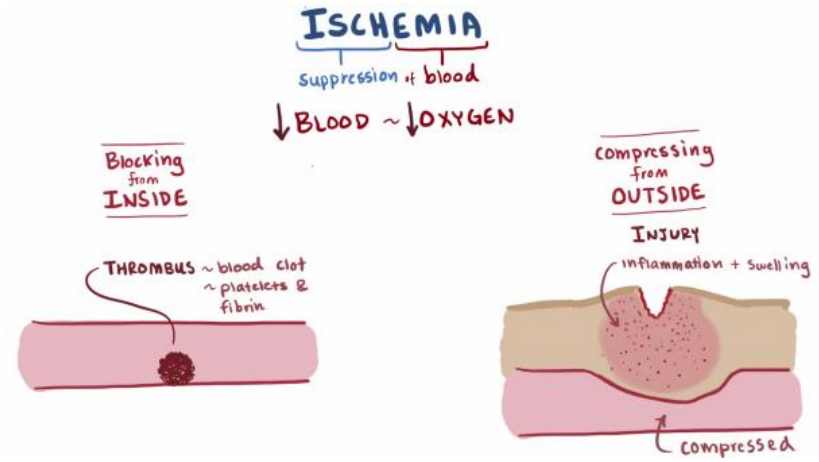

Figure 9. Ischemia graphic explanation (Osmosis, 2016).

- Vibration Syndrome (McCauley-Bush, P., 2011)

Vibration syndrome or Hand Arm Vibration (HAV) occurs when there is an excessive exposure to vibration forces or cold temperatures. Symptoms are characterized by fingers blanching due to the fingers' arteries being closed. This syndrome is known as dead finger, white finger or Raynaud's phenomenon, too (Isabel L. Nunes and Pamela McCauley Bush, 2012).

Figure 10. Vibration syndrome effects (Quality Safety Traning, 2016).

It is recommended the thermoregulation of fingers exposed to cold environments because blood flow decrease to the limbs with low temperatures and increase the symptoms (Isabel L. Nunes and Pamela McCauley Bush, 2012).

- Thoracic Outlet Syndrome (McCauley-Bush, P., 2011)

Thoracic Outlet Syndrome (TOS) describes a disorder that affects the upper limbs. It happens when the nerves (brachial plexus) and/or blood vessels (subclavian artery and vein) are oppressed (Isabel L. Nunes and Pamela McCauley Bush, 2012).

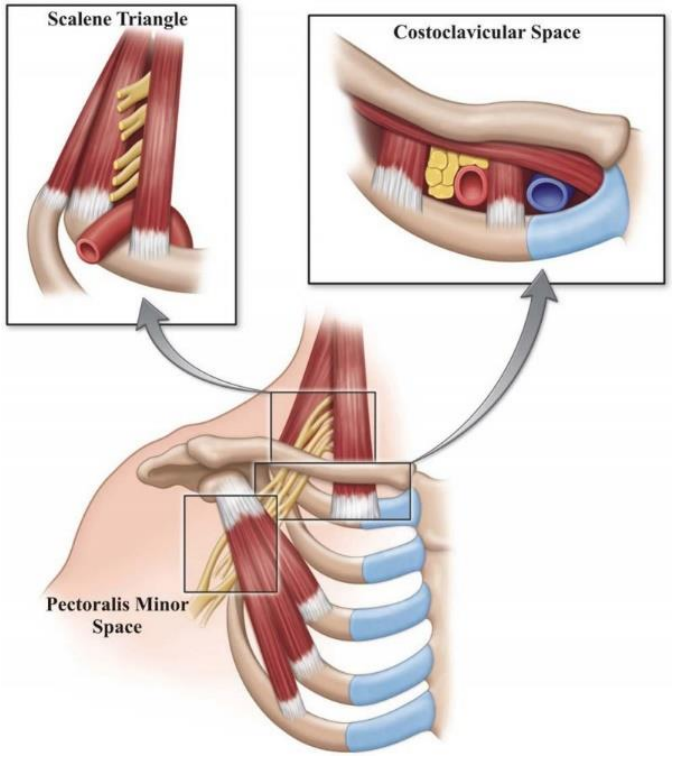

Figure 11. Thoracic Outlet Syndrome (Furor Teutonicus, 2013).

The area where this compression occurs is (thoracic outlet) between neck and shoulder. This area is limited by some structures. The clavicle, the first rib, the anterior and middle scalene muscles and the tendon of the pectoralis minor muscle. This syndrome has been questioned for some profesionals that think TOS is diagnosed when they do not know exactly the patient's disease. The symptoms include shoulder and arm pain, tingling and numbness, fatigue at the arm, swelling hand, finger rigidity or pallor at hands (Isabel L. Nunes and Pamela McCauley Bush, 2012).

- Ganglion Cysts (McCauley-Bush, P., 2011)

Ganglion is defined like a tissue's knot. Ganglion cysts are sacs full of gelatinous material. These disorders are normally close to the tendons or at the hand's palm at the fingers' start, and do not show painful. These cysts vanish alone itself, if there is a reduction of repetitive movements (Isabel L. Nunes and Pamela McCauley Bush, 2012).

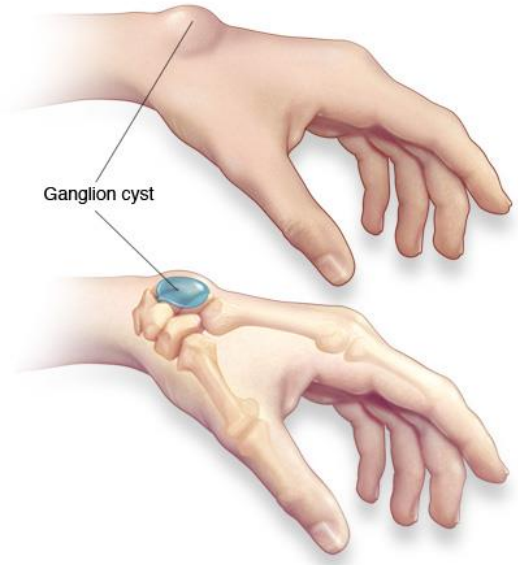

Figure 12. Ganglion cyst disorder (Mayo Clinic Staff, 2016).

- Lower limb WMSDs

Lower limb WMSDs are important disorders in different kinds of jobs and in many cases they are related with other body disorders. There are different tasks like, kneel down, bend down, climb stairs, ladders, handling loads, walk, stand up, that involve a risk to suffer a WMSD (HSE, 2009). Trips and slips are other causes which can produce a WMSD. WMSD of lower limbs are much more important than companies think, because they can cause high grades of immobility, worsening the quality of life (HSE, 2009). Most common lower limb WMSDs are (HSE, 2009) (Isabel L. Nunes and Pamela McCauley Bush, 2012):

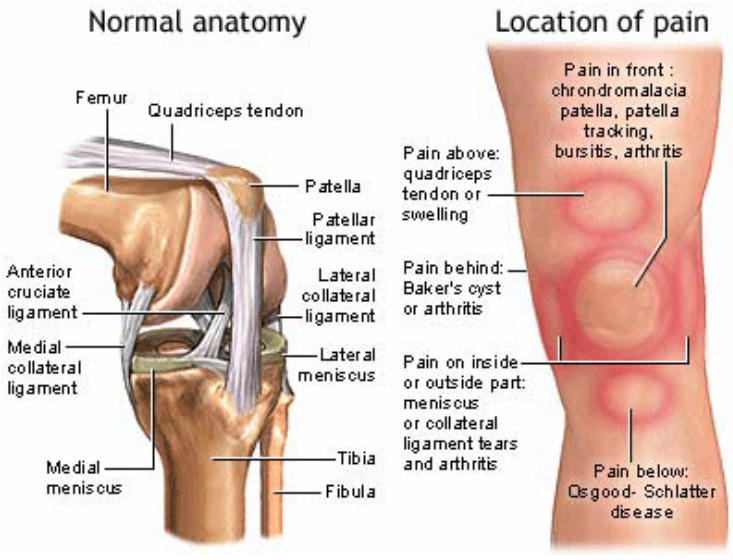

Figure 13. Some of knee injuries (Clark,T., 2017).

- Hip/thigh conditions – Osteoarthritis (most frequent), Piriformis Syndrome, Trochanteritis, Hamstring strains, Sacroiliac Joint Pain;
- Knee / lower leg – Osteoarthritis, Bursitis, Beat Knee/Hyperkeratosis, Meniscal Lesions, Patellofemoral Pain Syndrome, Pre-patellar Tendonitis, Shin Splints, Infrapatellar Tendonitis, Stress Fractures;
- Ankle/foot – Achilles Tendonitis, Blisters, Foot Corns, Halux Valgus (Bunions), Hammer Toes, Pes Traverse Planus, Plantar Fasciitis, Sprained Ankle, Stress fractures, Varicose veins, Venous disorders.

- Non-specific WMSDs

There are some disorders non-specific like WMSDs because their symptoms are not specifically on one of them. Symptoms can affect diverse anatomical structures like tendons, nerves, muscles or bones (Ring et al., 2005). The symptoms can be different, tingling, numbness, fatigue, discomfort, without any pathological appearance (Isabel L. Nunes and Pamela McCauley Bush, 2012).

3. Job demands

Ergonomics can be defined simply as the study of work. In a much more specific way, ergonomics try to fit the tasks and jobs to the workers, instead of forcing the body capacities of workers to fit the job (OSHA, 2000).

Ergonomics is something that affects to everybody and in all different environments, and many times people are not aware of its importance.

International Ergonomics Association defines ergonomics (or human factors) like a scientific discipline that studies the interactions between humans and the different elements from a given system. Ergonomics is, thus, the profession that uses methods, theories, principles and data to optimize system performance with the highest human well-being (IEA, 2017).

Figure 14. Different areas where ergonomics acts (IEA, 2017).

Companies have different environments depending on the activity that they develop. There is a great difference between the activities developed for example in an insurance company that the ones performed in a mechanical factory. Therefore, their systems will have different objects, elements, machines, risks and kind of interactions associated to each of those systems.

The main concept of ergonomics is the analysis of the interactions between the people and the system where they are. These interactions are the demands needed to perform the work, and are directly related to work's requirements (physical, psychical, environmental and organizational). The workers use with their capacities and abilities, but there are limitations, too (Acevedo, Miguel, 2013).

Besides, humans that take part in the system are different from an anthropological sight point. This reason makes ergonomics to have a relevant importance trying to adapt different humans' sizes to the same system.

In this sense, ergonomics must try to care the workers' wellness by adapting tasks, jobs, tools, machines, workstations and equipments to the workers in order to eliminate or reduce physical stress and health's risks, avoiding many of WMSDs (Work-related Musculoskeletal Disorders) (OSHA, 2000).

Technology development has changed the world many times lately. Due to this development, it is necessary that ergonomics is composed of different kinds of knowledge to be able to study the modern systems.

Ergonomics is based on a wide range of other scientific disciplines such as biomechanics, anthropometry, physiology, psychology, kinesiology and industrial hygiene (OSHA, 2000).

System requirements are in direct connection with the capabilities of the humans, machines, objects, tools, etc. Different kind of companies need different job demands. For example, an insurance company has a specific type of tasks whereas a mechanical industry requirements are much more physical. In conclusion, it is necessary to know the job demands in the different kind of job positions.

Some studies show how the PJD (Physical Job Demands) can influence the MSDs. For example Chau, Bhattacherjee, & Kunar (2009) expose at their study that:

- There was an exposure–response association between PJD and injury rates for all age groups.
- PJD and lifestyle factors had a higher impact on injury rates among workers aged ≥45 than among younger workers.
- Obesity, smoking and musculoskeletal disorders were associated with a high injury risk for workers aged ≥45.

It is necessary to develop a WPA (Workplace Assessment) to identify the job's demands and requirements. Analogously, it must be carried out a FCEs (Functional Capacity Evaluation) of workers to know their capacities and limitations related to the job's demands.

FCEs develop a theoretical model to compare job demands with worker skills and capacities. The validation of these evaluations is correct if the work simulations are detailed and accurate for the specific tasks and activities. If the evaluation criteria are subjective or not related with work performance, the results are not valid (Pransky & Dempsey, 2004).

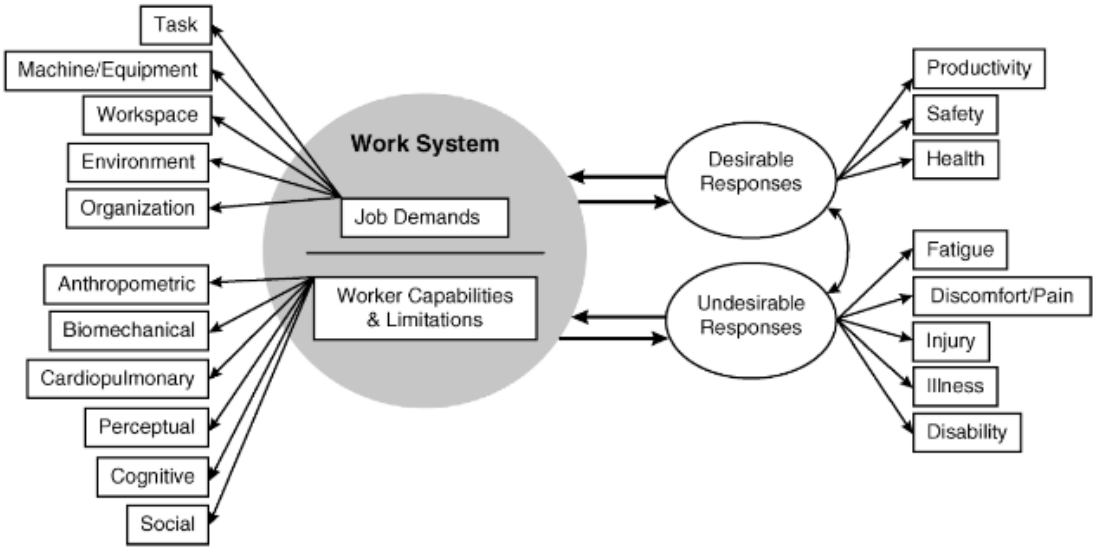

Figure 15. Conceptual model of ergonomics practice (adapted from Dempsey, P.G. et al., 2000).

Figure 15, shows the model proposed by Dempsey, P.G. et al. (2000) relating job demands with worker capacities. Worker's physical and organizational environment must be included inside the job demands. Worker's capacities and limitations can be named like 'limiting subsystem'. If there is a mismatch between them due to the human factors (Sinclair & Drury,

1979), the ideal adjustments will try fit the worker's capacities to the job demands. This will increase productive work, safety and health for long periods like shown on Figure 16 (Armstrong et al., 2001).

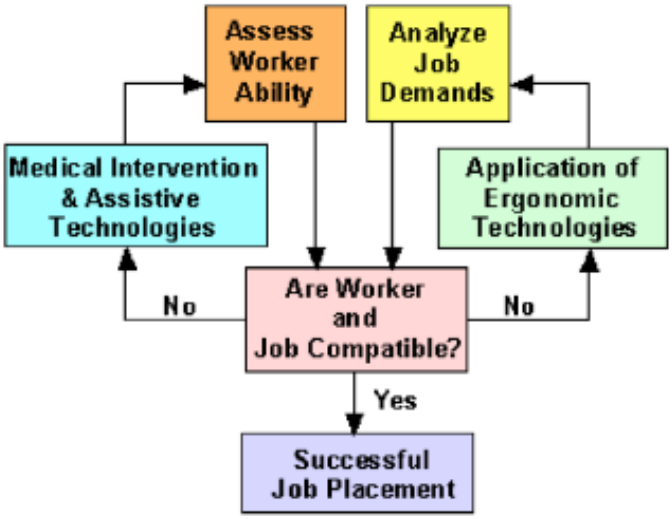

Figure 16. A model of ergonomic evaluation rehabilitation, and person-job matching (from Armstrong et al., 2001).

The concept of job assessment must be related to the job requirements. That means that magnitudes of the job demands must be identified and estimated the in the WPA. To do so, WPA must analyse each work position to determinate the task requirements in every field (physical, psychical, environmental and organizational) (Acevedo, Miguel, 2013).

In order to determine the real job demands, assessments must be total unbiased. Otherwise, assessments it will be no useful. This is the main reason why assessments must be made by professionals in ergonomics and experts in the company's specific sector.

After the demands have been measured, they must be compared with the human capacities (specific worker) to check if they are equilibrated (Acevedo, Miguel, 2013).

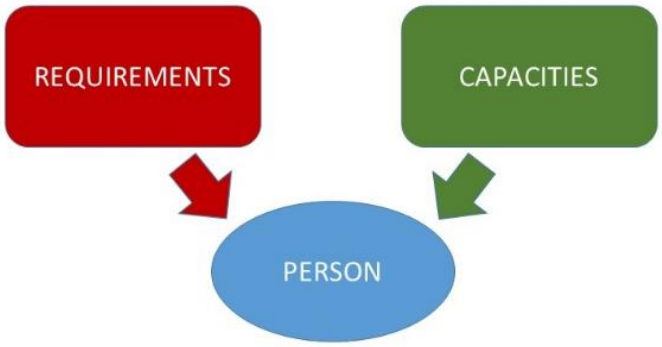

Figure 17. Jobs human factor (Acevedo, Miguel, 2013).

Human capacities can change from one worker to another for many reasons like age, sex, habits, etc. It is necessary to measure those capacities to be able to compare them with his job demands.

The problems occur when the demands exceed the worker capacities, as that imbalance will lead to fatigue, saturation, injuries, and disorders in a long term. This imbalance causes workers' unhealthy and bad-being (Acevedo, Miguel, 2013).

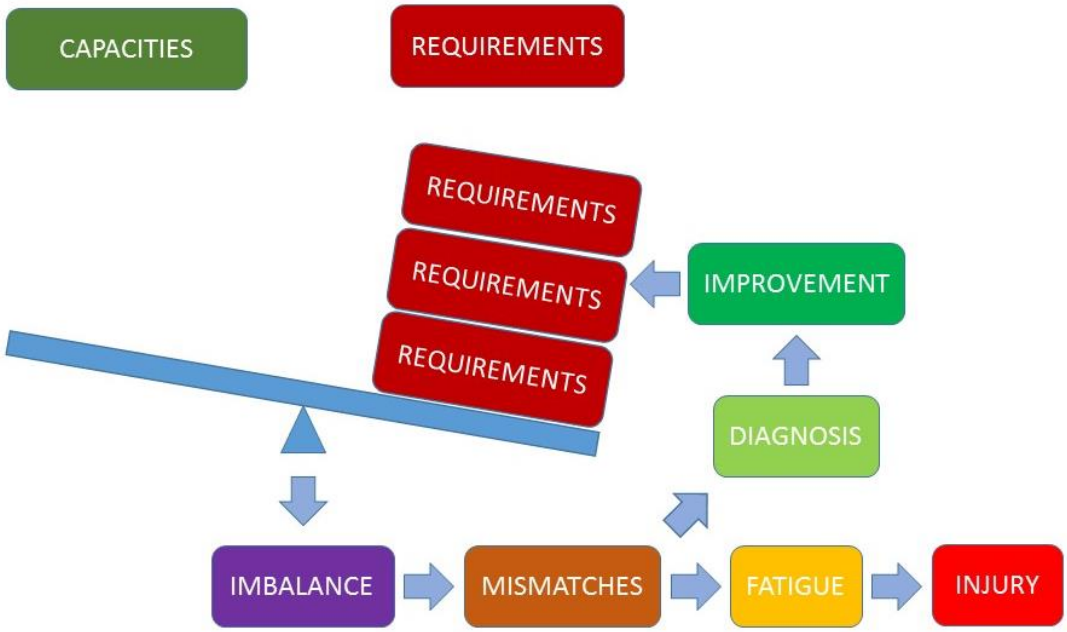

Figure 18. Consequences of the imbalance between capacities and requirements and actuation (Acevedo, Miguel, 2013).

WPA results allow to elaborate a diagnosis of the task situation, where proposals of improvement can be introduced to solve the imbalance and try to make the task healthy and safe for the worker (Acevedo, Miguel, 2013).

Once the new proposals are implemented, it is necessary to check the job position again and assess it to confirm if the improvements lead to a better results.

Figure 19 shows a generic model, similar to previous, that evaluates workers and jobs to find imbalances between capacities and demands. Applying improvements at the worksite, assistive technologies and medical treatments to redesign the workstation must correct the problem. This basic concept, comparing jobs and workers, is proposed by some authors and is similar to the one described by Weisman, G. (1990). American National Standards Institute consider this model appropriate to control of WMSDs.

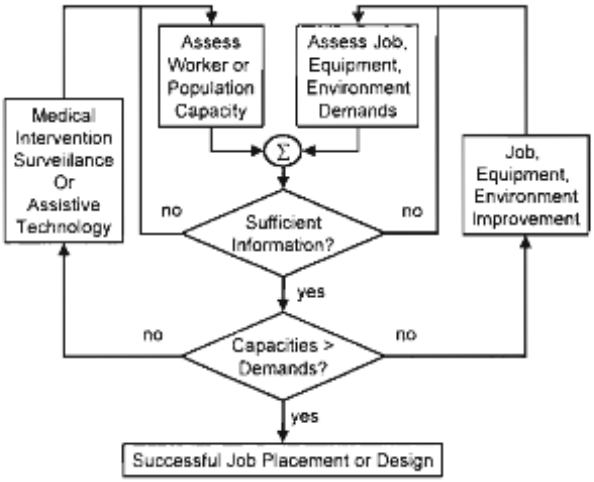

Figure 19. A generic model in which worker capacities are compared with job demands to identify barriers to employment (Weisman, G., 1990).

After the assessment of the job position, factors that can produce musculoskeletal risks can be found. It is vital to prevent, reduce and eliminate risks to determinate all these factors as sometimes they can cause a specific MSD or injury.

Maintaining one body position for long periods of time can cause fatigue and discomfort. For example, sitting could be a comfortable body position. However, sitting in front the computer for long periods can cause fatigue, inflammation of low limbs, low back pain and headache. In addition, an incorrect chair position and height can cause acute disorders (CCOHS, 2017b).

Work-related musculoskeletal disorders (WMSDs) are associated with these factors (CCOHS, 2017b):

- Work postures and movements.
- Repetitiveness and pace of work.
- Force of movements.
- Vibration.
- Temperature.
- Lack of influence or control over one's job.
- Increased pressure (e.g., to produce more).
- Lack of or poor communication.
- Monotonous tasks.
- Perception of low support (e.g., manager or co-worker).

Work conditions like worksite distribution, especially in driven work lines, weight of the loads manipulated, body position, influence all these factors. Psychosocial and physical factors can sharpen WMSDs, so it is important control them (CCOHS, 2017b).

There are different methodologies to evaluate the risks of some of these factors. These methodologies consider the load's weight, number of repetitions, limb postures, etc. to present a result after assessment.

Epidemiologic studies can help to evidence the causalities between workplace conditions and MSDs. The evaluation framework proposed by Putz-Anderson et al. (1997) include consistency, temporality, causality between exposure-response, coherence of evidence and strength of association.

If this framework is used, the links between workplace and MSDs from epidemiologic studies can be classified in these categories (Putz-Anderson et al., 1997):

- Strong evidence of work-relatedness (+++). Long-term exposure to the risk factor evidence a causal relationship between the risk factor and MSD when epidemiological criteria is used. There is a positive causality between an specific factor and MSD in studies with low chances, bias and confusing factors (Putz-Anderson et al., 1997).
- Evidence of work-relatedness (++). Some epidemiologic evidence is shown between risk factors and MSDs when causal epidemiologic criteria are used for intense or long term exposure. A positive connection is evident in studies in which chance, bias and confusing factors are not the presumable explanation (Putz-Anderson et al., 1997).
- Insufficient evidence of work-relatedness (+/0). The studies present insufficient quality, consistency, number or statistical power to evidence causal association. Some studies show some connection but bias, chance or confusing factors can explain it (Putz-Anderson et al., 1997).

- Evidence of no effect of work factors (-). Specific studies conclude that workplace risk factors have no relation with development of MSD (Putz-Anderson et al., 1997).

The results of the study made by Putz-Anderson et al. (1997) with body members and specific risks are shown at Table 3.

Table 3. Evidence for causal relationship between physical work factors and MSDs(Putz-Anderson et al., 1997).

Body part *Risk factor*	**Strong evidence (+++)**	**Evidence (++)**	**Insufficient evidence (+/0)**	**Evidence of no effect (-)**
Neck and Neck/shoulder				
Repetition		•		
Force		•		
Posture	•			
Vibration			•	
Shoulder				
Posture		•		
Force			•	
Repetition		•		
Vibration			•	
Elbow				
Repetition			•	
Force		•		
Posture			•	
Combination	•			
Hand/wrist				
Carpal tunnel syndrome				
Repetition		•		
Force		•		
Posture			•	
Vibration		•		
Combination	•			
Tendinitis				
Repetition		•		
Force		•		
Posture		•		
Combination	•			
Hand-arm vibration syndrome				
Vibration	•			
Back				
Lifting/forceful movement	•			
Awkward posture		•		
Heavy physical work		•		
Whole body vibration	•			
Static work posture			•	

Task design is very important to avoid excessive efforts of the muscles. A good design should not overload the muscles involved in the task. Well-designed tasks should try to equilibrate the effort of the different muscles.

Occupational activities and tasks in general are very complicated kinesiologically as they need to use a wide number of muscles. Due to the poor design of some activities or job demands, or even the nature of the activity itself, usually some muscles are overloaded. An example of these situations are the asymmetric tasks (Kumar & Narayan, 1998)., which will require the implementation of differential loading.

For example, in the field of professional sports, tennis players have one arm more muscled than the other one. Something similar can occur at work activities because depending on the tasks performed some muscles could be used much more than others.

Repetitive or prolonged activities will produce differential fatigue at the muscles activated for the task and differential straining at the connective tissues involved (Kumar & Narayan, 1998; Kumar, S., Zedka, M., & Narayan, Y., 1998). When a muscle is more fatigued than others, there is an imbalance or incoordination that cause variable forces and the shaking of the muscles. These situations make connective tissues to suffer variable and imbalanced stress concentration produced by their prior strain and reduced cross sectional area. This situation is the perfect scene to generate an injury. This is probably the main reason by which over 60% of all back disorders or injuries are related with trunk rotation (Manning, Mitchell, & Blanchfield, 1984).

Many authors expose trunk rotation as a predominant biomechanical factor in the low back pain. (Duncan and Ahmed, 1991 ; Frymoyer et al., 1980, 1983; Ralston et al., 1974; Schaffer, 1982; Snook et al., 1978, 1980; and others) (Kumar, Shrawan, 1999).

4. Connection between "Job demands" and MSDs

The published literature about work diseases is vast. The first one was written by Bernardino Ramazzini in 1700, and it has been cited through the years for numerous authors. Franco, Giuliano (2010) cited it arguing that Ramazzini's work showed that workers are susceptible to determinated illnesses and saw that bad postures, repetitive tasks and muscular overloads can generate MSDs (Giuliano, F., 2010). Ramazzini talked about psychological stress factor related to other factors to increase these disorders and advised to reduce labour activities to avoid risks (Collins et al., 2011).

In 1700, job demands were not the same of nowadays; work activities probably were more rudimentary and hard than today. Therefore, job demands were notably higher and caused a lot of disorders and diseases.

The book Ramazzini's De Morbis Artificum Diatriba (Diseases of workers), published in 1713 (Ramazzini, B. & Wright, W.C., 1940), has been considered a fundamental contribution to the labour healthiness, similar to Versalius' work to anatomy or Morgagni's to pathology (Rosen & Imperato, 2015). Bernardino Ramazzini (1633-1714) studied the health problems of his time (typhoid, smallpox, and plagues) (Franco, 2000), but he also went further away and researched about specific worker diseases in specific jobs (Franco, 1999). He showed other risks, such as those produced by chemical substances (mineral powder, organic particles or toxic effects of vapours at the lungs or over skin), by physical agents (cold, heat, noise and humidity), and by bad movements and awkward postures (Giuliano, F., 2010).

The most common diseases of that period were related to the first kind of industries, which were based on coal energy and characterized by the bad conditions of the job positions. This industry was very hazardous and many diseases were caused by an inadequate manipulation of loads.

Ramazzini identified the causality between repetitive movements, awkward postures, handling loads or muscular overloads and determinated disorders (hernia, sciatica, body pains, fatigue, shoulder dislocation, valgoid condition, arthritis, paralysis, hump, lameness and muscular tension). He described health anatomic problems and identified as risk factors the duration and intensity of some jobs. Table 4 shows these works (Giuliano, F., 2010).

This first connection is a first step in the labour's health problems and let differentiate the tasks from their specific sectors. There are light jobs, medium works and hard works that have different job demands and disorders associated.

Table 4. Occupations at Risk of Musculoskeletal Disorders, According to Ramazzini's De Morbis Artificum Diatriba

Occupations at Risk of Musculoskeletal Disorders, According to Ramazzini's De Morbis Artificum Diatriba
Athletes
Bakers and millers
Blacksmiths
Brick-makers
Carpenters
Coppersmiths
Farmers

Fishermen
Horsemen
Hunters
Miners
Porters
Potters
Printers
Razor and lancet grinders
Runners
Sailors and rowers
Sedentary workers
Soap-makers
The learned
Voice-trainers and singers
Weavers
Well-diggers
Workers on minutes objects
Workers who stand
Writers and notaries

Several studies from different authors written after Ramazzini's work show that wide proportion of labour population is at high risk of suffering a work-related musculoskeletal disorder (WMSD). Many activities require maintaining specific postures and perform repetitive tasks for long periods during workday. Some diseases like lower back, neck pain and carpal tunnel syndrome present high indexes of population affected (between 15%-60%) (Collins et al., 2011).

The variation of these indexes depend, as aforementioned, on the requirements and demands of the different industries. For example, office works involve tasks with very specific demands, related to specific risks that can produce determinate injuries, disorders and diseases.

In this sense, computer tasks induce to an awkward posture known like 'forward head posture'. This position is originated with the upper cervical spine extension and the lower cervical spine flexion (Szeto et al. 2002; McLean, 2005). This position causes an increase of neck and shoulder pains (Gerr et al., 2002; Brandt et al., 2004).

Awkward postures include fixed or restricted postures, postures that overload the muscles and tendons in an asymmetrical manner and postures that produce a static load on the musculature. There is a great variety of activities with awkward postures; on *Annex I. Activities with risk of awkward postures and relation with MSDs body areas*. There is a list of such occupations that includes the most outstanding among them (CC.OO, 2008).

Many times it is difficult to get the connection between job demands from specific job positions and a specific disorder or injury. Even if there are general concepts about risks, actions or postures that can cause MSDs, suffering the disorder depends on many more different factors and habits. This could explain the wide range between percentages of pathology.

The main factors that contribute to the appearance of TME defined by EU-OSHA are shown in Table 5.

Table 5. Main factors to produce TME defined by EU-OSHA (CC.OO, 2008).

Physical factors
• Loads / application of forces
• Postures: awkward, static
• Repeated movements
• Vibrations
• Cold working environments
Psychosocial factors
• High demands, under control
• Lack of autonomy
• Lack of social support
• Repetitiveness and monotony
• Job dissatisfaction
Individuals
• Medical record
Physical ability
• Age
• Obesity
• Smoking

Arvidsson et al. (2008) have reviewed some studies analysing physical capacities reduction among people affected with some WMSDs and healthy ones. These studies present opposite results trying to find a connection between neck and shoulder disorders with other motor diseases. Although there are opposite positions, it is evident that neck pain can impact on the ability to develop daily tasks and the absenteeism. Furthermore, the treatment costs entails an important economic loss to both the worker and society (Hush et al. 2009). Interventions such as adjusting seat height and curved seat pan chairs have been effective in preventing neck and shoulder pain in seated manual workers (Rempel et al., 2007).

Improvements on the job positions can reduce costs of MSDs and injuries. Sometimes simple changes lead to better results and reduce these health costs.

Between 33%-50% of disability reclamations are related to hand, wrist or upper limbs cumulative disorders (Keogh et al. 2000). Table 6 shows the most common upper extremities WMSDs (Collins et al., 2011).

Table 6. Common work-related musculoskeletal disorders that affect the upper limbs (OHCOW, 2005b).

Disorder	Symptoms	Causes
Carpal tunnel syndrome	Numbness of middle fingers, especially at night	Repetitive wrist flexion
Myofascial pain of the neck	Heaviness and aching in the shoulders, upper back and neck	Overhead work and work with extended arms Computer posture Stress reaction
Shoulder bursitis	Shoulder pain and stiffness	Repetitive shoulder movements
Rotator cuff tendinosis	Shoulder pain and stiffness	Repetitive shoulder movements with twisting and overhead activities

Lateral epicondylitis	Lateral elbow pain, especially with extended wrist	Lateral elbow pain, especially with extended wrist
Trigger finger	Locking of fingers in flexion	Repetitive hand grip

Occupational Health Clinics for Ontario Workers (OHCOW) has developed a procedure to identify the physical job demands in each specific workstation. *Annex II. Physical Demands Analysis method from OHCOW*, shows the procedure of this methodology.

There are many different kinds of job positions, which require different types of job demands. Both physical and psychical demands will produce problematic situations when they exceed the capacities of the workers, and that situations can generate a MSD.

Table 7 shows the main factors than can appear at job positions related to inadequate postures and that contribute to musculoskeletal disorders. Column with examples associates job demands with their consequences.

Table 7. Reference table: main factors contributing to musculoskeletal disorders (Jäger, P. D. I. M. et al., 2003).

Factor	Possible result or consequence	Example	Good practice example or solution
Exertion of high-intensity forces	Acute overloading of the tissues	Lifting, carrying, pushing or pulling heavy objects	Avoid manual handling of heavy objects
Handling heavy loads over long periods of time	Degenerative diseases, especially of the lumbar spine	Manual materials-handling	Reduce mass of objects or number of handlings per day
Frequently repeated manipulation of objects	Fatigue and overload of muscular structures	Assembly work, long time typing, check-out work	Reduce repetition frequency
Working in unfavourable posture	Overload of skeletal and muscular elements	Working with heavily bent or twisted trunk, or hands and arms above shoulders	Working with an upright trunk and the arms close to the body
Static muscular load	Long-lasting muscular activity and possible overload	Working overhead, working in a confined space	Repeated change between activation and relaxation of muscles
Muscular inactivity	Loss of functional capacity of muscles, tendons and bones	Long term sitting with low muscular demands	Repeated standing up, stretching of muscles, remedial gymnastics, sports activities

Monotonous repetitive manipulations	Unspecific complaints in the upper extremities (RSI)	Repeated activation of the same muscles without relaxation	Repeated interruption of activity and pauses alternating tasks
Application of vibration	Dysfunction of nerves reduced blood flow, degenerative disorders	Use of vibrating hand-tools, sitting on vibrating vehicles	Use of vibration-attenuating tools and seats
Physical environmental factors	Interaction with mechanical load and aggravation of risks	Use of hand-held tools at low temperatures	Use gloves and heated tools at low temperatures
Psychosocial factors	Augmentation of physical strain, increase in absence from work	High time pressure, low job decision latitude, low social support	Job rotation, job enrichment, reduction of negative social factors

U.S. Department of Labour Occupational Safety and Health Administration proposes to make a job hazard analysis to identify problematic jobs and factors of risk to help employers to recognize what jobs and work stations are the source of the greatest problems.

Table 8 shows different MSD with the symptoms, possible causes or job demands and the kind of workers affected by them.

Table 8. List of MSD´s and work position population affected (OSHA, 2000).

Body parts Affected	Symptoms	Possible causes	Workers Affected	Disease name
Thumbs	Pain at the base of the thumbs	Twisting and gripping	Butchers, housekeepers, packers, seamstresses, cutters	De Quervain's disease
Fingers	Difficulty moving finger; snapping and jerking movements	Repeatedly using the index fingers	Meatpackers, poultry workers, carpenters, electronic assemblers	Trigger finger
Shoulders	Pain, stiffness	Working with the hands above the head	Power press operators, welders, painters, assembly line workers	Rotator cuff tendinitis

Hands, wrists	Pain, swelling	Repetitive or forceful hand and wrist motions	Core making, poultry process-Ing, meatpacking	Tenosynovitis
Fingers, hands	Numbness, tingling; ashen skin; loss of feeling and control	Exposure to vibration	Chain saw, pneumatic hammer, and gasoline-powered tool operators	Raynaud's syndrome (white finger)
Fingers, wrists	Tingling, numbness, severe pain; loss of strength, sensation in the thumbs, index, or middle or half of the ring fingers	Repetitive and forceful manual tasks without time to recover	Meat and poultry and garment workers, upholsterers, assemblers, VDT operators, cashiers	Carpal tunnel syndrome
Back	Low back pain, shooting pain or numbness in the upper legs	Whole body vibration	Truck and bus drivers, tractor and subway operators; warehouse workers; nurses' aides; grocery cashiers; baggage handlers	Back disability

There are similar manuals or guides and other author's papers (OHCOW, 2005b) (CCOHS, 2017a) (Isabel L. Nunes and Pamela McCauley Bush, 2012) that relate the job demands of specific work positions with MSD's of specific body areas, depending of the tasks performed. Good practices at job environment are necessary to prevent and minimize the risk, reducing the number of injuries and disorders at work.

5. Conclusions

There are many evidences of the connection between job demands and MSD's among all the studies and papers reviewed at the literature. Workplaces are very different and their job demands depend on many factors like sector, job requirements, tools used, environment, etc.

In order to avoid or reduce WMSD's, it is necessary to control and ensure that the job demands fit the worker capacities. This inspection should start when the workplace is designed, estimating real job demands for the workplace and assigning the right resources to them. The risk situations occur when the job demands overcome these capacities, and they can trigger an accident, injury, disorder or disease.

It is also crucial to identify the capacities and abilities of each worker and try to find the job position that matches them. That will lead to the optimum situation for both the companies and the workers (win-win situation). Actually, companies are developing strategies to improve the fitting job-worker in order to reduce the disorders and diseases because they cost a huge economic loss. They understood that people is the most important part of their businesses and they start to care about them.

In fact, the best companies are the ones promoting good habits among their workers. The programs developed to improve the wellness and health of the workers are crucial to mitigate the risk of some WMSD's and improve the life of people in their jobs.

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Annex I. Activities with risk of awkward postures and relation with MSDs body areas.

Cervical spine
- Users of Data Visualization Screens (PVD).
- Forced manoeuvres (mechanics, maintenance, installations and assemblies).
- Archives and warehouses.
- Handling of loads on the shoulder (loading and unloading).
- Painters.
Dorsal and lumbar spine
- Personal manipulator of weights.
- Construction workers and services.
- Peonage.
- Masonry.
- Plumbing and heating.
- Shuttering and structuring.
- Drivers of vehicles.
- Farmers and ranchers.
- Marine fishing workers.
- Keepers.
- ATS / DUE.
- Health auxiliaries.
- Painters.
Shoulder and shoulder girdle
- Users of Data Visualization Screens (PVD).
- Painters.
- Housekeeping.
- Drivers of vehicles.
- Construction workers and services.
- Peonage.
- Personnel who perform repeated movements.
- Personal manipulator of weights.
- Plumbing and heating.
- Carpenters.
- Mechanics.

- Workers who use hands above shoulder height.
- Archives and warehouses.
- Workers in the textile and clothing industry.
Arm and elbow
- Mechanics.
- Plumbing and heating.
- Personnel who perform repeated movements.
- Carpenters and cabinet makers.
- Plumbers.
- Construction workers and services.
- Peonage.
- Housekeeping.
- Personal manipulator of weights.
- Archives and warehouses.
- Drivers of vehicles.
- Users of Data Visualization Screens (PVD).
- Professional sportsmen.
- Assembling of parts.
- Canning industry.
Forearm and Wrist
- Mechanics.
- Plumbing and heating.
- Personnel who perform repeated movements.
- Carpenters and cabinet makers.
- Plumbers.
- Peonage.
- Housekeeping.
- Users of Data Visualization Screens (PVD).
- Personal manipulator of weights.
- Assembling of parts.
- Canning industry.
- Painters.
- Mounting chains.
Hand and fingers
- Personnel who performs repeated movements with the hands.
- Plumbers.

- Mechanics.
- Painters.
- Plumbing and heating.
- Construction workers and services.
- Peonage.
- Housekeeping.
- Personal manipulator of weights in chain.
- Archives and warehouses.
- Drivers of vehicles.
- Users of Data Visualization Screens (PVD).
- Personal manipulator of weights.
- Professional sportsmen.
- Assembling of parts.
- Canning industry.
- Hotel staff.
- Kitchen.
Hand and fingers
- Personnel who performs repeated movements with the hands.
- Plumbers.
- Mechanics.
- Painters.
- Plumbing and heating.
- Construction workers and services.
- Peonage.
- Housekeeping.
- Personal manipulator of weights in chain.
- Archives and warehouses.
- Drivers of vehicles.
- Users of Data Visualization Screens (PVD).
- Personal manipulator of weights.
- Professional sportsmen.
- Assembling of parts.
- Canning industry.
- Hotel staff.
- Kitchen.
Hip and thigh

- Personal manipulator of weights.
- Drivers of vehicles.
- Cops.
- Watchers.
- Military personnel.
- Health personnel.
- Faculty and Technical Assistants.
- Auxiliary staff (clinical, custodians, administrative).
- Commerce.
Knee
- Drivers of vehicles and mobile machinery.
- Assemblers.
- Structurists.
- Painters.
- Plumbers.
- Mechanics.
- Electricians.
- Military personnel.
- Police.
- Watchers.
- Farmers and ranchers.
- Maintenance staff.
- Construction workers.
- Professional sportsmen.
- Unloaders.
- Personnel who move loads at a distance.
Leg, Ankle and Foot
- Drivers of vehicles and mobile machinery.
- Assemblers.
- Structurists.
- Military personnel.
- Police.
- Watchers.
- Farmers and ranchers.
- Work in irregular terrain.
- Postmen.

- Freight forwarders.
- Maintenance staff.
- Construction workers.
- Professional sportsmen.
- Hotel personnel.
- In general people who spend many hours standing or walking.
- Unloaders.
- Personnel who move loads at a distance.

Annex II. Physical Demands Analysis method from OHCOW

A Physical Demands Analysis (PDA) is a systematic procedure to quantify, and evaluate all of the physical and environmental demand components of all essential and non-essential tasks of a job. A PDA is the "cornerstone" of the analytical process used to determine compatibility between a worker and a specific job (OHCOW, 2005b). This procedure allows to get the PDD of whichever job.

A PDD, or Physical Demands Description, is a document used by employers to objectively capture and describe the physical demands that are required to perform a particular job or role. Many will be familiar with the term Physical Demands Analysis (PDA) for this type of document, however, PDD is being used intentionally. A PDD is simply a detailed, objective description of the physical aspects of a particular job; there is no analysis being performed. For this reason, the word 'Description' is used rather than 'Analysis' (OHCOW, 2005a).

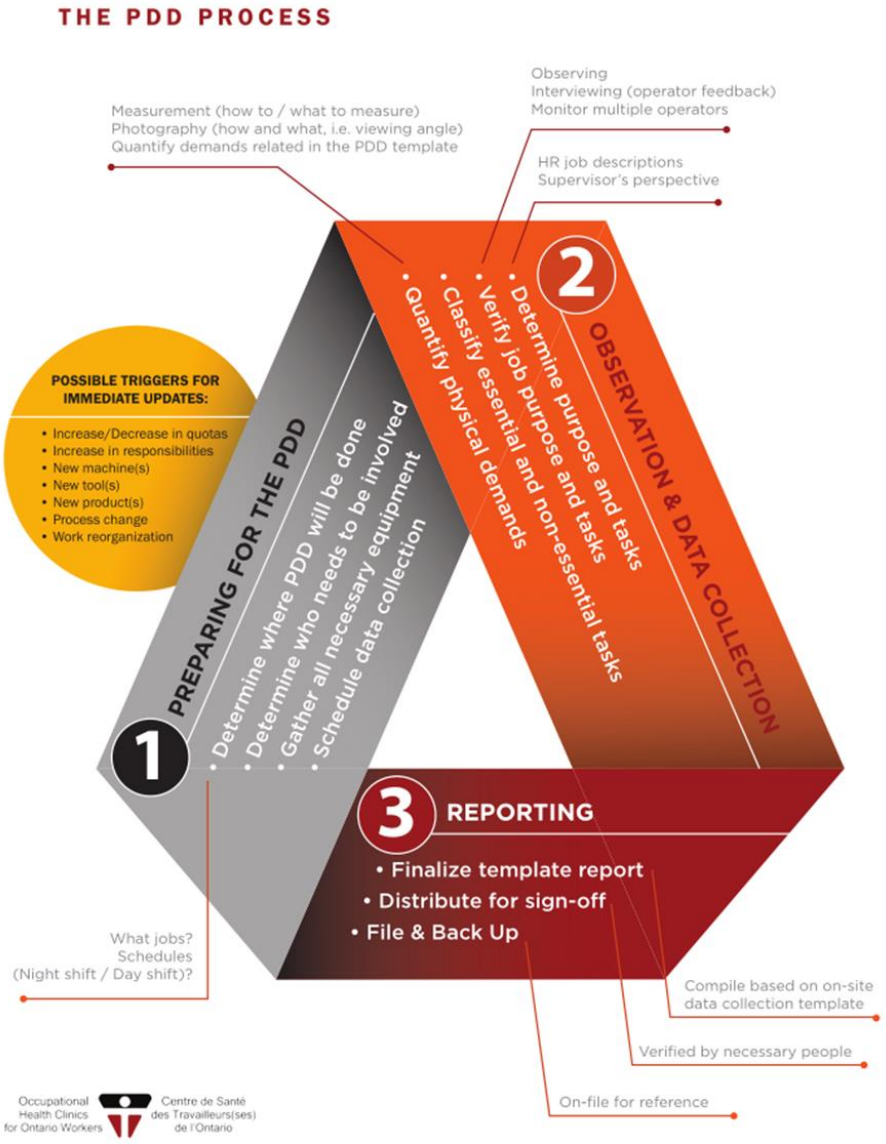

Figure 20.The Physical Demand Description (PDD) process (OHCOW, 2005a).

Figure 20 shows the OHCOW's process to get the demands description for the jobs. This process includes three steps:

- Preparing for the PDD
- Observation & data collection
- Reporting

This process allows to get a task data sheet with all the information about each task. Once the job demands are knowing, an occupational hazards prevention expert perform the detailed analysis and hazard evaluation. A significantly higher level of training and experience is required to perform such hazards assessments and implement solutions.

Figure 21 shows a task data sheet example where the relevant information is collected for a complete description of that task. This information must be as accurate as possible in order to get a precis evaluation later.

1. *Driving Loader* 	***Task Duration***	*The worker will move sand and stone from storage lots on the plant yard to an underground hopper that funnels materials onto a conveyor belt.*					
	5-15 minutes per material						
	Task Frequency						
	12 – 15 times per shift						
Task Elements	**Duration**	**Seat Height**	**Dimensions**	**Surface**			
Sit	5-15 minutes	*55-65 cm*	*45 x 45 x 12 cm*	*Cushioned*			
	Duration	**Hand Height**	**Vehicle**	**Surface**	**Surroundings**		
Driving	*5-15 minutes*	*80 – 85 cm*	*Front-End Loader*	*Gravel*	*Other Vehicles*		
	Frequency	**Force**	**Height**	**Object**	**Foot/Feet**		
Foot Action	*10 times per minute*	*25-28 kg*	*15 cm*	*Accelerator*	*Both*		

Figure 21. Task data sheet example with measurements and details (OHCOW, 2015).

It is necessary to provide a PDD template for organizations in order to use it as a standard document. It must be designed to provide measures that can be taken and used in MSD hazard or risk assessment tools later(OHCOW, 2005a).

The physical demand matrix is used to remind which measures are necessary to collect in order to detail the tasks. Figure 22 shows an example of physical demand matrix, developed for OHCOW, can be a good reference.

Figure 22. Physical demand matrix with measures to document in the PDD (OHCOW, 2015).

Physical Demand Element	Measures to Document in the PDD						
Lift/Lower	Frequency	Weight	Start Height	End Height	Hand(s) Used	Reach	Grip Type
Carry	Frequency	Weight	Height	Distance	Hand(s) Used	Reach	Grip Type
Push	Frequency	Average Force	Max Force	Height	Distance	Hand(s) Used	Grip Type
Pull	Frequency	Average Force	Max Force	Height	Distance	Hand(s) Used	Grip Type
Reach	Frequency	Height	Distance	Hand(s) Used			
Grip	Frequency	Force	Height	Direction	Hand(s) Used	Reach	Grip Type
Pinch	Frequency	Force	Height	Pinch Type	Hand(s) Used	Reach	
Write	Frequency	Duration	Height	Surface	Tool Type		
Fine Finger Movement	Frequency	Duration	Height	Finger(s) Used	Hand(s) Used	Precision Level	
Sit	Duration	Seat Height	Dimensions	Surface			
Stand	Duration	Surface	Footwear				
Walk	Duration	Distance	Surface	Footwear			
Kneel	Frequency	Duration	Knee(s) Used	Surface			
Crouch/Squat	Frequency	Duration					
Balance	Duration	Leg(s) Used	Surface				
Crawl	Frequency	Duration	Distance	Surface			
Climb	Frequency	Duration	Distance	Surface			
Taste	Frequency	Food(s)	Precision Level				
Smell	Frequency	Odour Type(s)	Precision Level				
Speech	Frequency	Information	Level of Detail				
Hear	Frequency	Duration	Sound(s)	Sound Level			
Feel/Tactile	Frequency	Duration	Material(s)	Precision Level			
Vision/Read	Frequency	Information	Level of Detail				
Data Entry	Frequency	Information	Technology	Hand(s)			
Driving	Duration	Hand Height	Vehicle	Surface	Surroundings		
Foot Action	Frequency	Force	Height	Object	Foot/Feet		
Handling of Odd Objects	Frequency	Duration	Weight	Height	Object		


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