Prepared by: Jennifer Yorke B. Sc. (Hons. Kin.)
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Electrician's Job Demands Literature Review – Manual & Power Tools

An electrician's job is physical in nature, and the physical demands of the job are affected by the use of handheld manual and power tools such as hammers, pneumatic drills and other devices. These tools, however, are essential to the completion of an electrician's daily job activities. With increased use, comes the potential for injury.

During the month of April in 2005, the International Brotherhood of Electrical Workers (IBEW) local 353 commissioned the Toronto clinic of Occupational Health Clinics for Ontario Workers (OHCOW) to complete a musculoskeletal discomfort/symptom survey of its membership. OHCOW found that in the last year (at the time of survey), an average of 23.9% of reporting union members experienced work related aches, pain, discomfort or numbness of the elbow and 60.2% experienced work related aches, pain, discomfort or numbness of the hand and wrist that they believed to be work related. Of the reporting members, 16.2% had sought a health care professional's advice for elbow pain while 31.1% had sought a health care professional's advice for hand and wrist pain.

In a research article by Hanna et al. (2005) about the factors affecting absenteeism in electrical construction, 52% [of electricians] reported they had a work-related injury sometime during their career that caused them to miss work. Identifying potential mechanisms of injury within the job tasks of electrical work may prevent or lead to the reduction of work related injuries.

Mechanisms of Injury

There are three main injury mechanisms (McGill, 2002). Most individuals can identify the "specific incident" injury mechanism where a load greater than the individual's tissue tolerance is applied, resulting in an injury (Appendix). An injury may also occur from the continuous application of a load resulting in an injury from the reduction in an individual's tissue tolerance over time. The final injury mechanism involves repeated loading, which decreases an individual's tissue tolerance over time until an injury finally occurs (McGill, 2002).

Potential Injuries

NIOSH reported in 1997 that there is strong evidence for hand-arm vibration syndrome and repetitive strain injuries (RSIs) such as carpal tunnel syndrome, tendonitis, and epicondylitis in the elbow from a combination of repetition, force production and awkward postures (Appendix).

RSIs are sometimes called cumulative trauma disorders and overuse injuries. RSIs result when a muscle, tendon, nerve or joint is stressed and traumatized on a repeated basis for days, months or years (OHCOW, 1998).

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Carpal Tunnel Syndrome:

The carpal tunnel of the hand is a small space at the base of the palm formed by bones and ligaments of the wrist. Through this tunnel runs the median nerve, blood vessels and finger tendons. When the median nerve in this structure is compressed, perhaps because of swelling from overuse, carpal tunnel syndrome results (OCHOW, 1999).

Tendonitis:

A tendon is a group of tough elastic fibres that connect muscle to bone in the body. Repetitive movements of the wrist and forearm can cause a muscle tendon to become inflamed and painful. When this occurs, the condition is called tendonitis (OHCOW, 1999).

Epicondylitis:

Epicondylitis is a condition where the outer part of the elbow becomes painful and tender, usually as a result of a specific strain, overuse, or a direct blow.

The most common cause of epicondylitis is over use of the wrist extensor muscles which are attached to the bone at this part of the elbow. If the wrist extensors are strained or over used they become swollen, painful and tender to touch (Medinfo, 2004).

Hand Arm Vibration Syndrome:

Hand-arm vibration syndrome (HAVS) is a disease that involves circulatory disturbances, sensory and motor disturbances and musculoskeletal disturbances. It is caused by daily exposure to hand and arm vibration by workers who use vibrating tools such as jackhammers and drills, which can cause physical damage to the hands and arms resulting in tingling and numbness in the fingers, loss of grip strength and spasms (OHCOW, 1998).

Manual & Power Tool Use

Electricians use a variety of handheld manual and power tools such as screwdrivers, pliers, cutters, drills, hammer drills, saws, etc. A majority of the work conducted using handheld tools involves contact with cement and wood, which may include drilling, screwing or other manipulation methods.

Workers, supervisors and employers must be aware that many factors affect the ergonomics associated with tool use in the electrical trade. Physical factors such as temperature, tool design and job task alter the forces and physical mechanics of a job.

Manual tools are used frequently in the electrical trade. As stated in previous paragraphs, repetitive use increases the risk of injury. Many manual tools, such as hammers and screwdrivers, place a worker’s wrist in an undesirable, non-neutral position

(Leamon et al., 1994). Leamon et al. (1994) also showed that straight handled pliers, which place the wrist into ulnar deviation, were correlated with wrist related disorders. Continuous flexion of the wrist with manual tool use may also contribute to the development of carpal tunnel syndrome and increase fatigue, which may lead to other injuries.

Hammers were also reported to cause impact loading in the wrist (Leamon et al., 1994) and were responsible for eccentric loading in the forearm musculature. Straight-handed screwdrivers were also found to place the wrist in an awkward posture, which can increase the chance of developing a wrist injury (Hagberg et al., 1995).

Hand-held power tools can also contribute to worker injuries. Research by Kihlberg et al. (1996) and Barton (1997) reported incidences of carpal tunnel, tendonitis, vibration white finger and ganglionic cysts from prolonged power tool use. Vibration from power tools is especially problematic, as it reduces sensory feedback in the fingers (Chengalur et al., 2004). Reduced sensory information can cause a worker to increase force output, such as their grip force on the tool, increasing the potential for injury. Vibration from handheld power tools can also potentially cause microfractures in the forearm or hand (Kihlberg et al., 1996). Lastly, if a worker is required to use a tool that vibrates while their hands are cold, the risk of injury to the hand and forearm increases substantially (Astrand et al., 1986).

For both manual and power hand tools, pressure points of > 22psi or 150 kPa stemming from tool use increase user discomfort and may potentially press on blood vessels decreasing blood flow or blocking nerves, especially at the base of the hand (Chengalur et al., 2004).

Temperature:

Weather, more specifically ambient temperature, is a factor in most electrical work as much of an electrician's work is completed in unfinished buildings. For example, temperatures below 0 degree Celsius can cause vasoconstriction of the arteries in the hand, which diminishes blood flow. Decreased blood flow reduces oxygen flow to the muscles required to pinch, grip or hold tools or electrical components, leading to muscular fatigue and potential injury (Astrand et al., 1986). Although gloves can provide protection from the elements, they also reduce hand dexterity and gloves also increase the amount of force an individual has to produce in order to complete a job. This increase in force raises the potential for a musculoskeletal disorder (MSD) with repetitive or continuous use.

Tool Design:

Tool design plays a large role in the augmentation of workplace ergonomics. Chengalur et al. (2004) highlighted the importance of designing tools to utilize the largest muscle group to complete a task. For example, if a worker were required to dig a hole during meter base installation, a shovel edge with an area large enough for the foot would

allow the worker to employ their quadriceps muscles to push the shovel into the earth. If the shovel only allowed enough area for the toe, the worker would rely on the smaller muscles of the calf to push the shovel into the earth, requiring the same amount of force from a smaller muscular group, increasing the risk of injury.

Chengalur et al. (2004) listed the following points for good tool design:

- Make handle diameters 3.75cm and the span on double-handled tools from 5 to 6.25cm
- Make handles about 10cm long to avoid pressure to the base of the hand
- Orient the tool so it can be used with a neutral wrist posture
- Design the tool with textured handles to reduce excess force production from cold or wet environments
- Reduce tool vibration as much as possible

Job Tasks:

A required component of an electrician's job is overhead work. Overhead work places an electrician's shoulders in an awkward, far reaching position, increasing the forces on the shoulder capsule and musculature. Repetition or continuous work in an overhead position increases the potential for a shoulder injury (CCOHS, 2005). Overhead work or work involving stripped materials, such as stripped fastening screws, also require increased muscular force production, which further complicates the potential for injury due to increased joint loading during force production (Lin et al., 2003).

Repetition:

Workers, supervisors and employers should also be aware that current research does not define low or high levels of repetition. According to the Canadian Center for Occupational Health and Safety (CCOHS) (2005), "Some researchers classify a job as "high[ly] repetitive" if the time to complete such a job is less than 30 seconds" and the cycle is repeated for two hours or more (Chengalur et al., 2004). With respect to electrical work, a larger task such as 'installing switches' may be broken down into component parts to determine the time associated with each subtask. This may allow for each subtask to be compared to the CCOHS statement. CCOHS (2005) also states "Although no one really knows at what point MSDs may develop, workers performing repetitive tasks are at risk for MSDs." The effect of repetition is also worsened if the individual is working in an awkward posture or is using increased force. As such, potential risks should be examined.

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Appendix:

Table 1. Evidence for causal relationship between physical work factors and MSDs

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	✓			

Source: NIOSH, 1997

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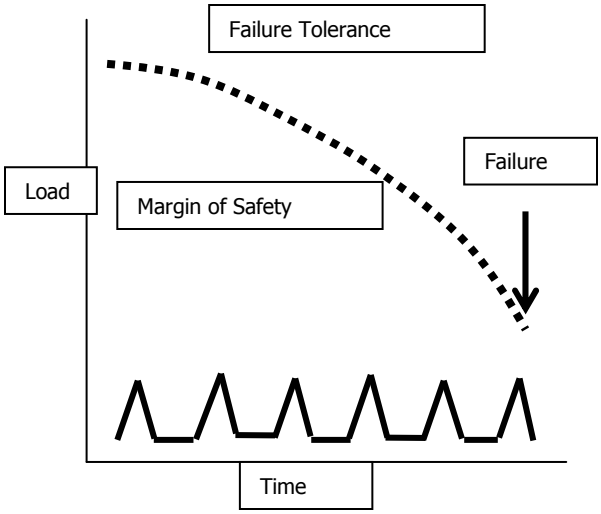
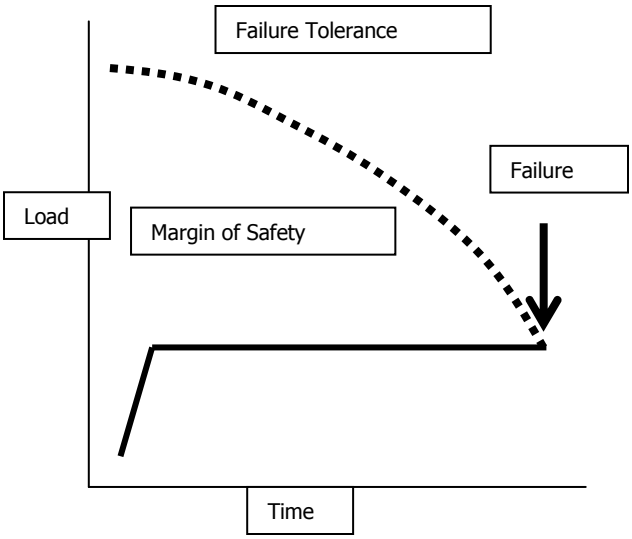
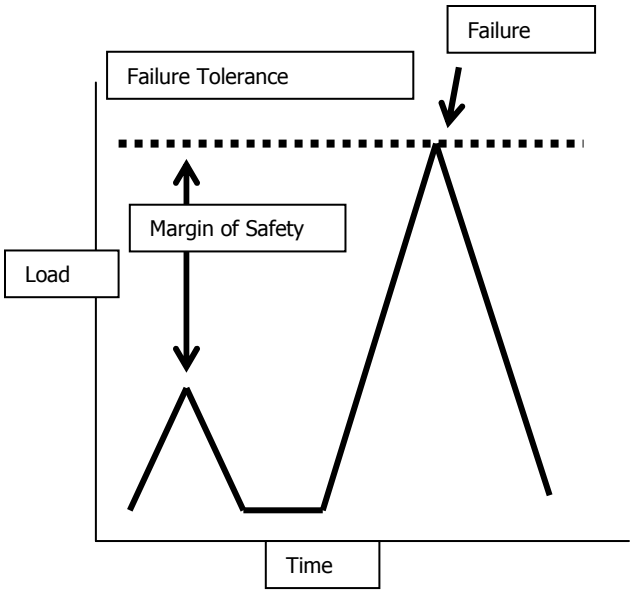
Injury Mechanisms (McGill, 2002)







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Handheld Manual & Power Tool Photographs

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