A Review Of Influence Of Hand Transmitted Vibration On Health: Due To Hand Held Power Tools

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RUNNING HEAD: ISSUES IN SEGMENTAL VIBRATION

ABSTRACT:

Workers have to often work with hand held power tools such as hand grinders, hand drills, concrete breakers, chain saws, chipping tools, jackhammers, jack leg drills, and many other. During the working with such hand held tools contact with tools transfers' vibration energy to a person's body. The exposure to vibration, depending on various parameters of vibration, may affect major part of worker's body or only a particular organ. This exposure to part body of operator is called as 'Segmental vibration. The most common consequences of such exposure are 'hand-arm vibration syndromes' (HAVS), which affects the hands and arms. The major effects of segmental vibration can be classified as vascular and neurological. Segmental vibration not only influences the health but also efficiency and social life of workers. . Paper is a review of various literatures available on segmental vibration and its effects.

KEYWORDS:

Hand held power tools, Segmental vibration, Hand arm vibration syndrome (HAVS)

1.0 INTRODUCTION

Vibration exposure is possible in many occupations where a worker comes in contact with vibrating machinery or equipment. In certain occupations its affects hand and arm where as in certain occupations its affects whole body, previous vibration is termed as 'segmental vibration' and later as 'whole body vibration'. **[1, 2].**

This article is an effort to review the problem and evaluate the risk of vibration while working with power driven hand tools. The aim of this paper is to study the causes and effect of segmental vibration on workers life both professional as well as social. It focuses on how segmental vibration results in various Hand arm vibration syndromes (HAVS). It explains how HAVS are function of various parameters of vibration. It signifies how various symptoms of HAVS can be identified at early stage of occurrence, which would be helpful in controlling future serious consequences

Depending on how the exposure occurs, vibration may affect a major part of the worker's body or only a particular organ. Segmental vibration exposure affects an organ, part or "segment" of the body. The most widely studied and most common type of segmental vibration exposure is hand-arm vibration exposure which affects the hands and arms. Hand-arm vibration exposure affects the blood flow (vascular effect) and causes loss of touch sensation (neurological effect) in fingers. Vibration-induced white finger (VWF) is the most common condition among the operators of hand-held vibrating tools. **[1, 2].**

The severity of hand –arm vibration syndrome depends on several other factors, like vibration exposure, work practice, personal history and habits The threshold value of vibration is the level below which there is no risk of vibration syndrome **[1,2].**

At low frequency the perception is transmitted to the arm, the perception greatly decreases with frequency with the reduction of vibration transmissibility throughout the hand arm system. However some researchers noted that VWF hazards associated with some low frequency tools such as breakers or rammers are low. Analysis of epidemiological data to investigate the best fit of different combinations of physical parameters is never easy because of the many cofactors which may contribute to the observed health effects **[3]**

In annex A of the ENV 25349 the predicted prevalence of finger blanching is assumed to be directly proportional to the daily duration of vibration exposure, proportional to the square of the acceleration magnitude, proportional to the square of the years of exposure, and inversely proportional to the square of the vibration frequency (at frequencies above 16 Hz). **[3]**

It is found that higher a threshold shift after the grinder exposure (at 137 Hz) than after the chipping hammer exposure(at 50 Hz) with a testing frequency of 100 Hz. including pauses in operation. Correct assessment of durations should be done through direct observation of operation and deduced from knowledge of number of daily work cycles. **[3]**

2.0 POWER DRIVEN HAND TOOLS AND PRODUCTIVITY

The problem could be realized in the occupations where the power operated hand tools are used. The development of these tools is discussed in this section.

2.1 DESIGN OF PORTABLE POWER TOOLS

Portable power tools were designed to decrease a high expenditure of human energy in tool operation and bring about higher productivity. Machine tool technology has given the world, for example, engine or electric motor- driven chain saws to replace hand saws and hatchets, compressed air driven rock drills, pneumatic hammers instead of hammers, mauls, drills and chisels, electric motor- or pneumatic-driven grinders to replace files, sandpapers and grindstones and pneumatic-driven impact wrenches instead of screw drivers, wrenches and spanners. **[4]**

2.2 INTRODUCTION OF PORTABLE POWER TOOLS

In the late half of the nineteen century, pneumatic-driven portable tools were introduced in the mining and construction industries, and then electric motor-driven tools in the metal industries. After World War II, small motor- and pneumatic driven tools were introduced widely in many industries. Among new technical innovation in the 1950s, the introduction of portable power tools began on a large scale around the world. These were mainly drilling tools (rock drills, chipping hammers etc.), cutting tools (chain saws and bush cutters, etc.), fastening tools (impact wrenches, etc.) and grinding tools. **[4]**

2.3 ADVANTAGES FOR PRODUCTION AND RISKS TO HEALTH

The introduction of portable power tools served to increase production and decrease the expenditure of human energy, resulting in higher productivity. Rock-drilling experiments, for example, showed that human energy expenditure decreases one third to one sixth, and production increases two to three times. It may mean that productivity rises from four or six to twelve times (Table. 1). In practice, from the viewpoint of safety, productivity is about one half in experimental production. **[4]**

3.0 RISK ASSOCIATED WITH POWER DRIVEN HAND TOOLS

Though power driven hand tools have several advantages there are various risks associated with these tools, which are explained below. **[4]**

3.1 RISKS FROM TECHNOLOGICAL FACTORS

The technological risks are high levels of vibration and noise, and weight. Weight relates to the human-engineering risk in operation. High-level vibration exposure causes a contraction of peripheral blood vessels in the hand it also results in the loss of sensations of touch, pain, vibration and heat, abnormal sensations (numbness and tingling) in the finger and hand which continue long after the end of vibration exposure. **[4]** These phenomenon referred as vascular and neurological symptoms are explained latter.

Vibratory shock on the joints with circulatory disturbance causes deformation, difficulty in mobility, and joint pain. High-level noise causes hearing loss. The combined effects of noise and vibration exposure cause a greater contraction of blood vessels in the inner ear than noise exposure alone and aggravate hearing loss. **[4]**

3.2 RISKS FROM WORKING CONDITIONS

Continuous and long-term vibratory exposure can have severe effect. Limitations on operation time in continuous, daily, weekly and yearly work are necessary for the prevention of vibration hazards. Piecework rates encouraging longer working days enhance the likelihood of vibration hazards. Bad footing in working places brings a poor working posture and increases musculo-skeletal strain. **[4]**

3.3 RISKS FROM INADEQUATE HEALTH CARE

Poor health care results in failure to detect find early signs of vibration hazards and preclude chance of early therapy. Vibration syndrome in its advanced stage involves irreversible dysfunctions having grave consequences. Thus, early check ups and early therapy are vital elements of health care. **[4]**

3.4 METEOROLOGICAL RISKS

Cold is essential factor in constriction of peripheral blood vessels. Continuous vibration exposure to cold or wet weather aggravates peripheral vasoconstriction, and reinforces hypersensitivity to cold through the elevation of the autonomic nervous system. Lack of protection against cold at work and in daily life poses severe risks for vibration hazards. **[4]**

3.5 RISKS FROM LACK OF EDUCATION

Both manufacturers and workers need information about the risks of portable power tools to the health and safety. Technical and hygienic education in operation is very important for reducing the length of exposure to vibration and muscle strain, and for protection against cold. Lack of such education reduces the chance of early intervention, allowing the unchecked development of vibration syndrome. The risk factors arise from technical, medical, working, meteorological and educational conditions. In practice, those conditions always combine to produce complicated effects (Fig. 1). **[4]**

4.0 THE OVERALL CONSEQUENCES OF VIBRATION

The various effects due to vibration may be categorized as follows.

4.1 EFFECT ON PRODUCTIVITY/EFFICIENCY

The symptoms in vessels, nerves, muscles and joints can result in weakness, clumsiness, pain and loss of hand coordination. At work, this is manifested as difficulties in performing manual work and handling tools and machines. The symptoms might cause problems for persons in certain occupations requiring high manipulative skills and the ability to perform fine precision movements, such as dentists and electricians. Outdoor work, e.g. on construction sites, might be impossible especially for persons suffering from white fingers. Decreased precision and weakness might also involve an accident risk. A proper hand function is also needed when performing household chores and leisure activities. **[4]**

4.2 EFFECT ON PERSONAL AND SOCIAL LIFE

The medical consequences of HAVS have been thoroughly described, but the social consequences have seldom been studied. Some studies showed that HAVS affects sleep and social life. There may be decrease in the quality of life, which may include everyday activities. The everyday activities which could prove most difficult to perform may be, being outdoors in cold weather, lifting and carrying objects, writing by hand and picking up small items. **[4]**

4.3 EFFECT ON HEALTH

The different symptoms of HAV may appear separately or combined. HAVS is to some extent reversible after discontinuation of the exposure. **[4]**

5.0 TYPE OF DISORDERS DUE TO VIBRATIONS

Continuous vibration exposure leads towards various disorders , which are describe below.

5.1 VASCULAR

Workers exposed to hand-transmitted-arm vibration may complain of episodes of whitening (blanching) of the fingers, usually triggered by cold exposure. This symptom is caused by temporary closing down of blood circulation to the fingers. Various terms have been used to describe vibration-induced vascular disorders: (Figure 2)

- Dead or white finger
- Raynaud's phenomenon of occupational origin
- Vibration-induced white finger

Initially attacks of blanching involve the tips of one or more fingers, but, with continued exposure to vibration, the blanching can extend to the base of the fingers.

As the blood flow returns to the fingers (this is commonly initiated by warmth or local massage) the fingers turn red, and are often painful. The blanching attacks are more common in winter than in summer. The duration varies with the intensity of the vibration stimuli from a few minutes to more than one hour. If vibration exposure continues, the blanching attacks become more frequent affecting more of the fingers. The attacks may occur all year around with quite small reductions of temperature. During a blanching attack the affected worker can experience a complete loss of touch sensation and manipulative dexterity, which can interfere with work activity increasing the risk for acute injuries due to accidents. **[1, 5, 6, 7, 8]**

5.2 NEUROLOGICAL DISORDERS

Workers exposed to hand-transmitted arm vibration may experience tingling and numbness in their fingers and hands. Vibration exposed workers may exhibit a reduction in the normal sense of touch and temperature as well as an impairment of manual dexterity (Figure 3) **[1, 5, 6, 7, 8]**

.5.3 CARPAL-TUNNEL SYNDROME

Epidemiological research in workers has also shown that use of vibrating tools in combination with repetitive movements, forceful gripping, awkward postures may increase the risk of carpal tunnel syndrome. (Figure 4) **[1, 5, 6, 7, 8]**

5.4 MUSCULOSKELETAL DISORDERS

Workers with prolonged exposure to vibration may complain of muscular weakness, pain in the hands and arms, and diminished muscle strength. These disorders seem to be related to ergonomic stress factors arising from heavy manual work. Excess occurrence of wrist and elbow osteoarthritis as well as hardening of soft tissue (ossification) at the sites of tendon attachment, mostly at the elbow, have been found in miners, road construction workers and metal-working operators of percussive tools. (Figure 5**) [1, 5, 6, 7, 8]**

6.0 SYMPTOMS OF HAND-ARM VIBRATION SYNDROME (HAVS) AND CLASSIFICATION

Hand-arm vibration exposure affects the blood flow (vascular effect) and causes loss of touch sensation (neurological effect) in fingers. One of the earliest methods used for identifying the severity of these symptoms was the Taylor-Pelmear classification method. Table 2, shows the Taylor-Pelmear classification of the clinical stages of vibration induced white finger. This classification was widely used in the past. **[1, 6, 9]**

In 1986, a new classification, known as Stockholm classification was introduced. In this classification, vascular (blood flow) changes and neural (feeling of touch, heat, cold, etc.) changes are considered separately (Tables 3& 4) **[1, 6, 9]**

Hand-arm vibration is the transfer of vibration from a tool or work piece to a worker's hands and arms. The level of hand-arm vibration is determined by measuring the acceleration of the tool or object grasped by the worker. **[1, 6, 9]**

Hand-arm vibration syndrome is a disease that involves circulatory disturbances, sensory and motor disturbances and musculoskeletal disturbances. While it has been known since the beginning of the 20th century that vibration affects the hands and arms, it was not until 1983that scientists agreed on a definition of HAVS that includes the circulatory, nervous and musculoskeletal systems. Numbness, with or without tingling happens, before, during or after blanching. Attacks, more common in winter, but eventually may occur year round. Palms of the hands are rarely affected. Sense of touch and pain perception reduced, sometimes forever. Depending on the conditions of exposure, 6 to100 percent of workers can suffer from HAVS after using vibrating power tools. On average, about 46 percent get HAVS symptoms. Reynard's Phenomenon can occur from O% to 14% with a mean of 5.4%, in workers who are not exposed to hand-arm vibration because it may be caused by other diseases, e.g. constitutional white finger (Raynaud's disease). The high incidence of HAVS in the hand-arm vibration exposed group clearly confirms an association between HAVS and exposure to hand-arm vibration from handheld vibrating tools or objects**. [1, 6, 9]**

7.0 HAVS AND VARIOUS OPERATIONAL VARIABLES

As discussed earlier HAVS is a function of various operating parameters like Hand tool condition, operators' variables, working condition some of the significant parameters are discussed below.

7.1 HAVS AND VARIOUS VIBRATION PARAMETERS

Human response to HAV depends on the magnitude of the vibration, most often expressed in terms of acceleration in the SI unit m/s^2, and on the frequency (Hz). The exposure time is also of importance for possible consequences. The vibration is also expressed in terms of direction (Xh, Yh and Zh). Vibration in the frequency range of about 6-

20 Hz is considered to be the most harmful, while the effect progressively decreases with higher frequency (ISO 2001). **[8, 10, 11]**

An alternative approach to the assessment of vibration exposure is to measure the vibration power absorbed in the hand and arm. It has been suggested that this assessment gives more information about the risk of injuries compared to the conventional measurements. The assumption is that the energy dissipated in the hand and the arm is causing the damage. **[8, 10, 11]**

Apart from the vibration level, frequency and direction, the amount of absorbed power is also related to grip force and body posture. Attacks of finger blanching, also referred to as white fingers or secondary Raynaud's phenomenon, and are the most thoroughly investigated symptoms related to HAV. **[8, 10, 11]**

7.2 HAVS AND WOMEN

Work places and equipment are designed for men, since the labor market historically has been a male arena. A woman working at a work station designed for a man will encounter problems, due to the biological differences between women and men in average height and muscle strength. Preventive action has mainly been taken in male-dominated occupations in some of the few studies that have compared women and men; it has been shown that women have a shorter latency time to the development of symptoms and a higher prevalence of symptoms compared to men performing the same work. Handle size, anthropometric measures and maximum grip strength had more influence on the female subjects' results and ratings than on those of the male subjects. **[8]**

7.3 HAVS AND HAND TOOL DESIGN

The use of hand tools is necessary and poorly designed hand tools in an industrial plant may affect more than 10% of workers per year. Poor Design - may cause decreases in productivity with slower work and more errors. Increases in injuries to the wrist, forearm, and shoulders may also occur. Forceful grip exertions of hand rely on muscle contractions in forearm, and muscle forces are transferred to fingers via tendons. Hand tool weight - Effects of tool weight can aggravate muscle actions necessary to precisely position and stabilize the tool during operation. Tool balancers which counterbalance a tool may be effective depending on how the tool is to be used, how often and how long. Use of rests, supports, two hand grips, etc. can all help to decrease the effort required to use heavy tools. Right vs. Left-handed Tools - Try to design tools for operation with both hands. When only right-handed users are considered, left-handers may be at an increased risk of injury. Left-handed people are 5 times more likely to suffer injuries trying to cope with right handed products **[12]**

Poor hand tool design results in lost productivity like slower work, more errors more injuries, more illness (increased long term illness e.g. vibration syndrome), more accidents (9% of all disabling injuries related to poor hand tool design), more costs (worker's compensation, litigation). Hand grip strength depends on forearm muscles. **[12]**

Grip configuration determines strength requirements. Wrist posture affects strength and injury risks - straight wrist operation is always preferred. Ergonomic Design: Handles can help to improve grip possibilities. Handles should be designed for bare or gloved hand operation. Handles should be located at or above the center of gravity of the load. Handles should be textured to reduce slippage, but should NOT be contoured. **[12]**

7.4 HAVS AND HAND GRIP

The amount of vibration actually transmitted to the hand–arm system is dependent on the coupling forces at the hand–handle interface. The international standard for assessing exposure to hand-transmitted vibration, ISO 5349-1 (2001), indicates that hand coupling forces in, hence the vibration energy transmitted to the hand. An understanding of the nature of hand forces applied to tools is essential for developing appropriate strategies and working procedures geared to minimize stress and transmitted vibration. **[13, 14]**

Unfortunately, there has been no consensus as to how to best measure those forces. While hand forces can be effectively and accurately measured with dynamometers and handgrip and pinch strength meters, it remains a formidable task to quantify hand forces applied to vibratory tools in the workplace. Several methodologies have been utilized for measuring hand coupling forces on tool handles. One way is to a. x strain gauges or force transducers to tool handles. However, the application of tool handle instrumentation may alter the hand postures and contact areas on the handle surface such that the measured forces may not offer an accurate account of the coupling forces actually utilized by workers. One promising force measurement alternative involves the psychophysical method of force recall. With this type of measurement, a subject applies hand forces to a tool handle while performing a real or simulated work task; then they are asked to recall and reproduce the hand forces with a similar posture and coupling action on a grip strength meter or handle dynamometer. **[13]**

Hand grip strength could be measure by handgrip dynameters with parallel bars – Lafayette or steeling dynamometer or slightly curve bars – jam mar dynamometer.

Gripping with single or double hands and squeezing with both hands, helps for evaluating bilateral muscular efforts. These data helps while designing equipment and task. **[14]**

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LIST OF TABLES:

Table 1 Advantage Of Portable Power Tools

Tool	Human energy expenditure	Production	Productivity
Traditional manually operated hand tools	1	1	1
	1/6-1/3	2-3	6-12
Power operated hand tools	1	1	1
	1/2-1/3	3-4	6-12

Table 2 Tayler-Pelmear Classification Of Vibration Induced White Fingers By Stages

Stage	Signs and Symptoms	Interference with Activities
0	None	None
OT	Intermittent tingling	None
ON	Intermittent numbness	None
OTN	Tingling and numbness	None
1	Blanching of one or more fingertips with or without tingling and numbness	None
2	Blanching of one or more fingers with numbness, usually during winter only	Slight interference with home and social activities; no interference with work

3	Extensive blanching with frequent episodes during both summer and winter	Definite interference with work, home and social activities; restricted hobbies
4	Extensive blanching of most fingers; frequent episodes during summer and winter; finger ulceration	Occupation change required to avoid further vibration exposure

Table 3 The Stockholm Workshop Classification Scale For Cold-Induced Vascular (Blood Flow) Symptoms In Fingers With Hand –Arm Vibration Syndrome

Stage	Grade	Description
0	(none)	No attacks
1	Mild	Occasional attacks affecting only the tips of one or more fingers
2	Moderate	Occasional attacks affecting finger tips and middle of the finger and rarely also the finger parts close to the palm
3	Severe	Frequent attacks affecting most fingers
4	Very Severe	Same symptoms as in stage 3 with degenerate skin changes in the finger tips.

Table 4 The Stockholm Workshop Classification Scale For Sensor Neural Changes In Fingers Due To Hand-Arm Vibration Syndrome

Stage	Symptoms
0SN	Exposed to vibration but no symptoms
3SN	Intermittent or persistent numbness, reduced tactile discrimination and/or manipulative dexterity
2SN	Intermittent or persistent numbness, reduced sensory perception
1SN	Intermittent numbness, with or without tingling

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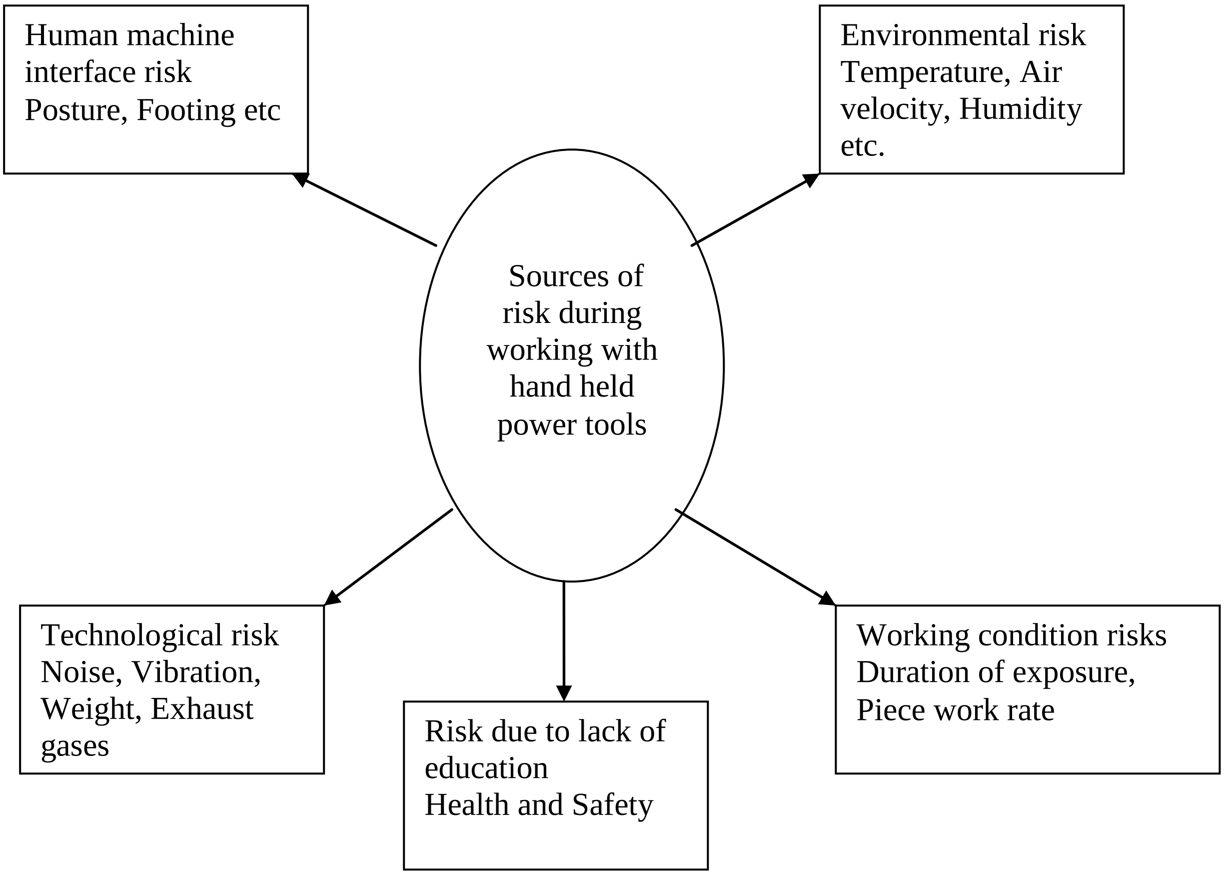

Figure 1 Sources of Various Risks Involved In Vibration Environment

Figure 2 Vascular Disorder

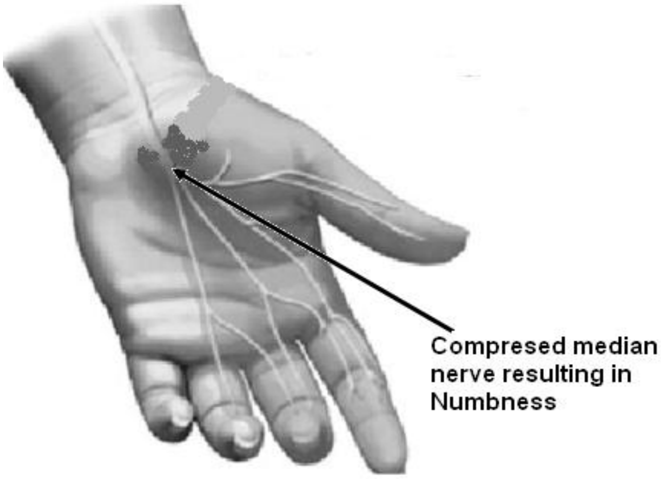

Figure 3 Neurological Disorders

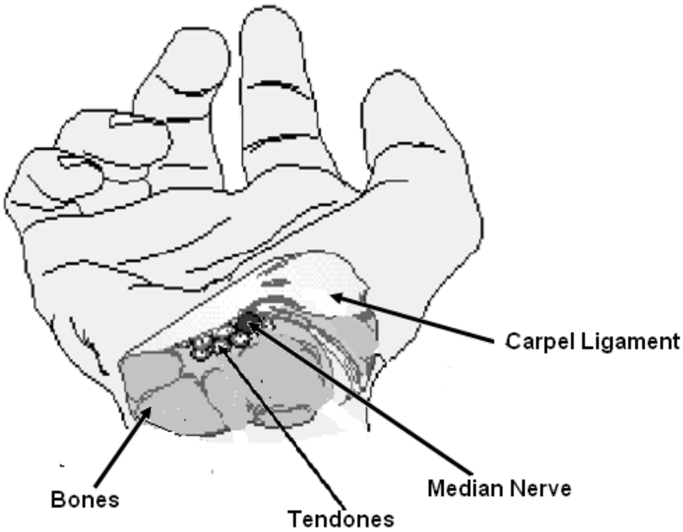

Figure 4 Carpel Tunnel Syndromes

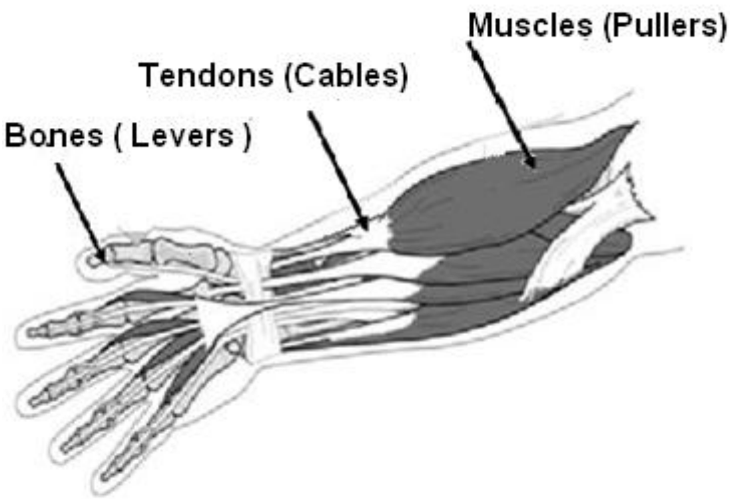

Figure 5 Musculoskeletal Syndrome