150 - PHYSICAL LOAD OF WORK: BIOMECHANICAL DETERMINANTS OF CARPAL TUNNEL SYNDROME

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1. INTRODUCTION

Occupational diseases are morbid entities that derive from professional practice and are directly linked to the physical, cognitive, psychological and social conditions of task execution. Their involvement has grown alarmingly, bringing injury to workers, companies and the public health system.

The recognition of the role of work in the determination and evolution of the workers' health-illness process has ethical, technical and legal implications, which is reflected in the organization and provision of health actions. The number of disability pensions related to occupational diseases is alarming. Repetitive Strain Injuries (RSI) and/or Work-Related Musculoskeletal Disorders (DME) have been the most prevalent in recent years according to statistics on the working population insured (INSS, 1997).

In this perspective, the establishment of the relationship between a given health event and a given work condition is the basic condition for the implementation of worker health actions. In a schematic way, this process can be initiated by the identification and control of the health risk factors present in the working environments and conditions and/or from the diagnosis, treatment and prevention of disturbances or injuries in the workers (Ministry of Health, 2001).

These disorders mainly result from inadequate use of the upper limbs, excessive use of force, maintenance of inadequate postures, high repetitiveness of the same pattern of movement and mechanical compression of the soft tissues of the upper limbs (IIDA, 2005; COUTO, 2000). The onset of musculoskeletal disorders is linked to workers' exposure to these risks and their magnitude depends on the intensity, frequency and duration of exposure, and the individual's ability to cope with work demands.

Among all the lesions diagnosed in soft tissues, the most frequent ones are those of the hands, in the most varied professions and in daily life (REGIS FILHO, 2000). For the author, Carpal Tunnel Syndrome (STC) is the most frequent of RSI/DME, being one of the most disabling and costly diseases of the upper extremities. In 1998 it represented an estimated population prevalence of 53 cases per 10,000 workers, of which 20% of the individuals reported absence to work due to this pathology. These data suggest that about 10 out of every 10,000 workers will miss work each year due to STC-related occupational activities.

One of the most reasonable ways in which repetitive manual activities could be associated with CTS is through a substantial increase in pressure in the carpal tunnel, thereby reducing the blood flow in vessels in that region and initiating a process that will result in damage , is reversible or irreversible to the median nerve. If pressure is prolonged, this reduction in flow may affect capillary circulation, resulting in increased vascular permeability and endoneural and synovial edema (REMPEL et al., 1998). If the edema becomes chronic, it may trigger an inflammation with consequent scarring by fibrosis that will damage nerve function.

Frequently, individuals affected by CTS report that the initial pain is located in a certain segment and that, later, tends to spread, occurring an advance of pain for different body regions. An explanation for this event would be the replacement of the body regions affected by healthy regions through the adoption of antalgic positions and, consequently, transfer of the overload to those other asymptomatic regions that would also be compromised (WERNER et al., 2005).

In view of the above, the study sought through a literature review, to identify the main biomechanical risk factors and to analyze their relationship with the development of this syndrome, as well as to emphasize the importance of preventive interventions in the same.

1.1 Etiology

Carpal Tunnel Syndrome (STC) is a common compressive neuropathy and has a direct connection with occupational risks, excessive force and high repetitiveness of movements, and the use of vibratory instruments and inappropriate postures contributing factors to the appearance and worsening of this syndrome (KOUYOUMDJIAN, 1999).

According to Kouyoumdjian (1999), the median nerve can be compressed in the carpal tunnel region by any tenosynovial proliferation, wrist joint abnormality, tumor or muscle anomaly. The carpal tunnel is delimited dorsally and laterally by the carpal bones and ventrally by the transverse carpal ligament. The medial nerve is passed beyond the median nerve, plus nine flexor tendons, leaving the joint space very vulnerable to compression in the median nerve.

The essential element for the characterization of CTS is the presence of pain. Its location varies according to the affected part, sometimes suggesting a central neurological disorder. As in other compressive syndromes, night pain is the most common clinical complaint. The most frequent pain is of the tingling type and can be of moderate intensity not impeding the patient's sleep or enough intense to the point of the patient waking at night because of the pain. Pain and paresthesias usually increase when there is greater use of the hand and upper limb. Its intensity and duration in the beginning are short, appearing at the end of the day and relieving with the nocturnal rest. Over time, the pain becomes more present and intense, leading to insomnia.

According to Browne et al. (1984) STC can be classified into three distinct stages: the first stage is characterized by pain and tiredness in the affected limb, without a reduction in productivity; the second stage presents recurrent pain and fatigue of greater intensity, occurring earlier in the work and persisting for longer. During this stage pain relief occurs with rest, but pain

begins to interfere with productivity; and the last and most serious stage is characterized by pain, fatigue and weakness, which persist with rest and without repetitive movements, and the symptoms may cause sleep disorders and persist for months or years.

2. METHODOLOGY

This research is a review of the literature, which was carried out through the selection of dissertations, theses and scientific articles published in journals on the Scientific Electronic Library (SCIELO), Google Academic and CAPES journals, with the objective of analyzing different positions in relation to the theme of this research.

3. RESULTS AND DISCUSSION

3.1 Impact and social impact

Musculoskeletal disorders in or out of work occur predominantly in the upper limbs (HELFENSTEIN, 1998). Among these diseases, the most evident are inflammatory tendinous diseases or compressive neuropathies, such as CTS. In the study performed by Reis et al (2000), 11% of the musculoskeletal lesions were diagnosed as CTS. It was also observed the presence of a large number of occupations in which these injuries occurred, and the five most frequent were the typist, the clerk, the janitor, the cook and the cashier.

STC affects women more often in the 4th and 5th decades of life. Men are affected in the proportion of 1:20, but usually at lower age than women. The annual incidence in the general population is 0.1% and 1 to 5%, manifested particularly among specific professions (SALIM, 2003).

Currently, STC affects more than 8 million Americans (US Department of Labor, 1999), which has a major impact on the health of professional computer users and on medical and non-medical costs related to the industry. Of the 37,804 cases of work-related STC reported in 1994, 7,897 (21%) were attributed to repetitiveness in entering data entry (FAGARASANU and KUMAR, 2003). The time of computer use was also one of the factors found by Conlon et al. (2005), as a probable cause of mononeuropathies in the pulse of typists, and the prevalence of cases was 10.3% of those evaluated.

The dominant hand, according to Pereira et al. (1993), is the most affected (61.2%), this finding seems to be related to its more frequent and intense use, leading to repetitive microtraumas of the median nerve and chronic inflammation of the flexor tendons, with consequent intracanal fibrosis. According to Fagarasanu and Kumar (2003), there is a loss in productivity before (slower typing speed), during and after STC treatment. In the United States alone, approximately 260,000 carpal tunnel release surgeries are performed each year, where 47% of the cases are work related. Faced with this information, STC was the main occupational hazard of workers in the 1990s, disabling workers in epidemic proportions (US Department of Labor, 1999).

3.2 Physical workload at STC

The workload is a quantitative and qualitative measure of the level of mental, sensory-motor and physiological activity of the operator, necessary to perform a certain work. The physical loads represent efforts developed by the worker to meet the demands of the tasks and the working conditions imposed on him by the work organization (CHAFFIN, 2001).

Static work is one of the physical burdens that can trigger injuries or musculoskeletal disorders. In static work the muscle does not elongate and its length remains in an unaltered state, producing a high tension over a long period. In this way, the blood vessels are compressed by the internal pressure against the muscular tissue, making it difficult for the blood to flow to the muscle and the supply of sugar and oxygen, thus, the muscle is obliged to use its own reserves (GRANDJEAN, 2005; COUTO , 2000).

According to Grandjean (2005), the prolonged and excessive requirement of static work may be associated with increased risk of joint inflammation, tendon sheath inflammation, tendon inflammation, chronic degenerative processes, intervertebral disc disease, and muscle cramps. For this reason, static work can not be sustained for long, as pain, in addition to forcing the worker to interrupt his work, may eventually limit his activities to the job.

The situations that propitiate the most common static efforts at work are: working with the body outside the natural vertical axis; sustain heavy loads such as upper limbs; work routinely by balancing the body on one of the feet; work with arms above shoulder level; work with arms abducted sustainably; carry out efforts to handle, lift or carry heavy loads; maintain static low intensity efforts for a long time; sitting without back support; work without support for the forearm having to support them or still work standing still (COUTO, 1995).

For Nascimento and Moraes (2000), inadequate designs of machines, seats or workbenches oblige the worker to use inappropriate static postures that, sustained for a long time, can cause severe localized pains in that set of muscles and joints most requested for conservation of posture. Thus, the onset of CTS is linked to the exposure of workers to these risks and their magnitude depends on the intensity, frequency and duration of exposure, and the individual capacity to cope with work demands (IIDA, 2005).

3.3 Risk Factors Associated With Carpal Tunnel Syndrome

Although there is no consensus in the literature, epidemiological studies have identified risk factors for CTS, pointing to these factors as the most prevalent: female gender, obesity, high body mass index (BMI), age above 30, repetitive motor activity (which is not fully established) and some systemic pathologies (BECKER et al., 2002). Individuals with CTS may have some predisposing anthropomorphic characteristics, ie anatomical differences between men and women (wrist circumference and radial bone size) may be the source of the differences observed in flexibility and in the more extreme postures adopted by women constituting factors of CTS and raising the pressure of the carpal tunnel.

On the other hand, in the study by Nakamichi & Tachibana (1995), a higher incidence of CTS was found in people of short stature, shorter hand length and lower carpal length / hand length ratio; the findings, although consistent, were not statistically significant.

Buckle (1997) described some factors for the development of CTS, which are: extension or compression of the median nerve in the wrist, ischemia, and increased carpal pressure when the pulse is in extreme postures, with pressure within the carpal tunnel being the factor more important in the pathogenesis of CTS for computer users.

Although some authors (HADLER, 1997) have questioned the non-relationship of work with CTS, there is strong evidence to support the direct relationship between related factors and the work environment (ARMSTRONG et al., 1993). The most important risk factors for CTS are presented in Table 1.

Table 1 - Risk factors associated with carpal tunnel syndrome

PERSONAL RISK FACTORS	BIOMECHANICAL FACTORS	CONDITIONS FOR RISK FACTORS
1. Gynecological surgery	1. Applied force	1. Keyboard activation force
2. Age between 40 and 50 years	2. Repeatability	2. Proprioceptive Feedback
3. Varicose veins	3. Localized mechanical compression	3. Percentage of typing time
4. Females	4. Inadequate posture	4. Speed of typing
5. Anterior Fractures in the Fist	5. Vibration	5. Use of a group of fingers
6. Previous diagnosis of musculoskeletal disorders	6. Working in cold environments	6. Strength of the keyboard
7. Diabetes	7. Working with cold hands	7. Force used in typing
8. Hand Preference	8. Time in activity	8. Movement repeatability
9. Pre-existence of joint hypomobility		9. Keyboard lift
10. Obesity and sedentary lifestyle		10. Inadequate posture
11. Weight Loss Process		
12. 6-12 months after the last menstrual period		

Source: Fagarasanu e Kumar (2003)

3.4 Risk factors associated with movement biomechanics

Manual efforts by a person at work may be occasional or rather repetitive. If the biomechanical stress of manual efforts is too high, severe and disabling injuries can occur from a gradual deterioration of tissues over weeks and even years. A wide variety of human disturbances and performance limitations have shown themselves amenable to interpretation and resolution through occupational biomechanics.

The presence of a risk factor at work is not enough to trigger CTS, for its appearance would require a certain degree of severity and a set of other factors. The risk factor presents three modulating characteristics: intensity, frequency and duration. The more intense, frequent and lasting, the higher the risk. Several risk factors associated with CTS may not directly cause the problem but favor the pathophysiological reactions that determine its onset. Repeatability is the most frequently mentioned risk factor, but it is not the only determinant biomechanical factor, since STC may also appear not related to repetitiveness, but to static loads and postures (SIMONEAU et al, 1999).

Posture is one of the most important variables, affecting both the dynamic force and the static force of an individual. When skeletal muscles act around the joints by rotating the adjacent bodily segments, the biomechanical factor can be observed by the action of muscle strength through the lever arms. With the modification of the joint angle, the power arms also change, thus modifying the action of the muscular force in the production of the movement according to the length of the lever arm. Postural biomechanical aspects are relevant in the ability to perform strenuous tasks of the workers (CHAFFIN, 2001). Table 2 shows some of the main biomechanical and environmental risk factors present in organizations considered as potential sources in the genesis of CTS.

Table 2 - Synthesis of biomechanical factors of carpal tunnel syndrome

RISK FACTORS	MODULATORS	DISEASE
Repetitiveness, effort and strength, inadequate postures, static muscle work, task invariability, shocks and impacts, mechanical pressure, vibration, cold , organizational factors.	INTENSITY DURATION	STC

Source: Simoneau et al. (1999)

Armstrong et al. (1993) evaluated 652 workers in 7 industries to evaluate the possibility of correlation between occupational factors and CTS by classifying the data in relation to strength and repeatability. Activities with high strength and high repetitiveness were the most significant biomechanical risk factors, with repetition being a greater risk than strength. For authors, strength and repeatability have a multiplier effect, since the risk for both is significantly greater than each one alone. The researchers also noted that this pathology was slightly greater in activities requiring ulnar deviation and pincer movement, but the effect was not significant.

Armstrong (1987) analyzed the anatomical relationships between carpal bones, median nerve and carpal retinaculum, demonstrating that repetitive wrist movements in extension or flexion may compress the median nerve. Flexion of the wrist causes the flexor tendons and tendinous sheaths to be displaced against the flexor retinaculum, and the extension of the wrist displaces the flexor tendons and tendon sheaths against the carpal bones.

3.5 Primary approach in STC

The preventive approach in CTS is the most effective weapon to combat this epidemic (CHAFFIN et al., 2001; LUCIRE, 1986). In that sense, it is more efficient, lasts longer and costs less, and the sooner it is deployed, the better the results. Prevention begins with the understanding that the computer user, for example, has for his or her work environment. The increasing availability of ergonomically designed equipment, furniture and computer accessories has made it easier for companies to design a safe and comfortable workplace.

The treatment should always contain the correction of the ergonomic factors and the biomechanical factors involved. In addition to the ergonomic and biomechanical measures that aim to adapt the work environment to the physiological and psychological characteristics of the human being, other measures can be taken. The control of posture during work activity constitutes an important measure of CTS prevention, since it is known that, associated with repetitive and static efforts, poor posture is a determining factor in the appearance of occupational diseases.

Administrative controls can be used in prevention, they include changes in work practice and policy, reduction of working hours or overtime, increase work by adding elements that do not require movements similar to the current work cycle, increase rest periods, relaying of workers in strenuous tasks, worker training and education in risk reduction techniques, and changes in work pattern and task time. Although administrative controls are less expensive, they should not be considered as a substitute for more effective ergonomic controls (BOWLER and CONE, 2001).

In addition to the preventive factors mentioned above, psychological support is as important as medication and

physiotherapeutic treatment, and psychotherapy should encompass relaxation techniques and enhancement of cognitive abilities to better deal with and control pain (FILDES, 1988).

According to Karolczak et al (2005), although there are several studies on CTS, there is a need for a greater number of investigations, including using new research techniques and addressing the possibility of double compression (cervical spine and carpal tunnel), which can clarify all the mechanisms involved in this pathology and, thus, help in improving the quality of life of these individuals, as well as in the efficiency of their treatments.

4. CONCLUSION

Clarity about the genesis of CTS is fundamental for effective measures to be proposed for the diagnosis, treatment, rehabilitation and prevention of CTS. Many of the attempts to intervene in pathogenic work environments aiming at the prevention of this disease have no effect, since they do not take into account work organization, biomechanical and environmental factors as primary determinants of illness. It is extremely relevant to the employer's awareness of the need to train their employees for the tasks assigned to them.

It is of paramount importance in the prevention of CTS technical preparation, postural education, adequate pace and speed, duration of the journey and appropriate work intervals, respect for ergonomic factors to provide the worker with quality of life and especially health. An ergonomic analysis will show the critical points of the work, by studying the actual activity of the workers. From then on, it will identify the risks factors, as well as the physical workloads and their modulating characteristics to detect the imbalance found between the work place and the man, being able to work in the prevention and effective treatment of this epidemic.

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ABSTRACT

Musculoskeletal disorders in or out of work occur predominantly in the upper limbs. Among these diseases, the most evident are inflammatory tendinous diseases (compressive neuropathies), such as carpal tunnel syndrome (CTS). This is a common compressive neuropathy and has direct connection with occupational hazards, excessive force and high repetitiveness of movements, being that the use of vibratory instruments and inappropriate postures contributory factors for the onset and worsening of this syndrome. The study sought to identify the main risk factors of biomechanical nature and to analyze its relationship with the development of this syndrome, as well as to emphasize the importance of preventive interventions in it.

Keywords: Physical work load, biomechanical determinants, carpal tunnel syndrome.

SOMMAIRE

Les troubles musculo-squelettiques au travail ou hors travail surviennent principalement dans les membres supérieurs. Parmi ces maladies, les plus évidentes sont les maladies tendineuses inflammatoires (neuropathies compressives), telles que le syndrome du canal carpien (CTS). Ceci est une neuropathie compressive commune et a un lien direct avec les risques professionnels, la force excessive et la répétitivité élevée des mouvements, étant que l'utilisation d'instruments vibratoires et postures inappropriées facteurs contributifs pour l'apparition et l'aggravation de ce syndrome. L'étude a cherché à identifier les principaux facteurs de risque biomécaniques et à analyser leur relation avec le développement de ce syndrome, ainsi qu'à souligner l'importance des interventions préventives.

Mots clés: Charge de travail physique, déterminants biomécaniques, syndrome du canal carpien.

RESUMEN

Las enfermedades musculoesqueléticas dentro o fuera del trabajo ocurren predominantemente en los miembros superiores. Entre estas enfermedades las más evidentes son las enfermedades tendinosas inflamatorias (neuropatías compresivas), como el síndrome del túnel carpiano (STC). Esta es una neuropatía compresiva común y tiene conexión directa con los riesgos ocupacionales, el exceso de fuerza y la alta repetitividad de movimientos, siendo que el uso de instrumentos vibratorios y las posturas inadecuadas factores contributivos para la aparición y agravamiento de este síndrome. El estudio buscó por medio de una revisión, identificar los principales factores de riesgo de naturaleza biomecánica y analizar sus relaciones con el desarrollo de este síndrome, así como enfatizar la importancia de intervenciones preventivas en la misma.

Palabras claves: Carga física de trabajo, determinantes biomecánicos, síndrome del túnel carpiano.

RESUMO

As enfermidades musculoesqueléticas dentro ou fora do trabalho ocorrem predominantemente nos membros superiores. Entre estas enfermidades as mais evidentes são as doenças tendíneas inflamatórias (neuropatias compressivas), como a síndrome do túnel do carpo (STC). Esta é uma neuropatia compressiva comum e possui ligação direta com os riscos ocupacionais, o excesso de força e a alta repetitividade de movimentos, sendo que, o uso de instrumentos vibratórios e as posturas inadequadas fatores contributivos para o aparecimento e agravamento desta síndrome. O estudo buscou por meio de uma revisão, identificar os principais fatores de risco de natureza biomecânica e analisar as suas relações com o desenvolvimento desta síndrome, assim como enfatizar a importância de intervenções preventivas na mesma.

Palavras-chave: Carga física de trabalho, determinantes biomecânicos, síndrome do túnel do carpo.

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