La Medicina del Lavoro

Med Lav 2007; *98*, 2: 118-126

Relationship between symptoms and instrumental findings in the diagnosis of upper limb work-related musculoskeletal disorders

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Key words

Musculoskeletal disorders; occupational medicine; case definition; diagnostic tests; symptoms

Summary

Background: *Upper limb work-related musculoskeletal disorders (UL-WRMSDs) are common among workers performing repetitive and forceful manual work. The diagnosis of UL-WRMSDs is mainly based on clinical features but its accuracy is further increased by physical examination and instrumental analysis.* **Discussion and Conclusions:** *In the occupational setting, several case definitions for UL-WRMSDs, based on different combinations of symptoms, physical examination findings and instrumental test results, have been proposed and published in the literature. Case definitions based on a combination of clinical history and instrumental findings would be preferred both for surveillance and epidemiological purposes. However, the use of instrumental tests introduces the issue of the poor level of agreement between symptoms and instrumental findings. Moreover, in the course of time both symptoms and instrumental findings tend to fluctuate and can be affected by several variables: exposure, individual factors, criteria used for data collection and time of examination in relation to work shift. As a paradigmatic example of UL-WRMSDs, the case of Carpal Tunnel Syndrome is discussed. In an improvement perspective, we suggest to focus on the following aspects: the monitoring of exposure assessment, the time of data collection in relation to work shift, the opportunity to collect clinical and instrumental data at the same time and the selection of normative data and of the best informative parameters for epidemiological studies.*

Riassunto

«Correlazione tra sintomi e reperti strumentali nella diagnosi delle patologie muscolo-scheletriche dell'arto superiore correlate al lavoro». *Le patologie muscolo-scheletriche dell'arto superiore correlate al lavoro si riscontrano con grande frequenza nei lavoratori che svolgono compiti manuali ripetitivi e che richiedono l'uso di forza. Si tratta di un gruppo eterogeneo di patologie che possono colpire diversi tessuti (muscoli, tendini, nervi periferici…); la diagnosi si basa principalmente sulla raccolta di dati clinici, tuttavia l'esame fisico e l'uso di tecniche di diagnostica strumentale (quali ad esempio l'ecografia e l'elettromiografia) possono costituire un'utile complemento. In ambito occupazionale sono state proposte diverse classificazioni di queste patologie basate su una diversa combinazione di sintomi, segni e reperti strumentali. Le definizioni diagnostiche costruite sulla contemporanea presenza di dati clinici e di reperti strumentali sono preferibili in quanto offrono un contributo oggettivo alla diagnosi. Accade tuttavia che non sempre ci sia corrispondenza tra dati clinici e strumentali e che tutti questi reperti presentino un'ampia flut-*

Pervenuto il 14.12.2006 - Accettato il 3.1.2007

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tuazione nel corso del tempo. Questo fenomeno, ampiamente descritto in letteratura in particolare per la Sindrome del tunnel carpale, pone il problema della gestione dei dati clinico-strumentali discordanti. Prendendo la Sindrome del tunnel carpale come paradigma di questo gruppo di patologie, vengono discussi i diversi fattori che possono influenzare il quadro clinico e i reperti strumentali: il livello di esposizione a fattori di rischio di natura biomeccanica, i fattori individuali predisponenti, i criteri e gli strumenti usati per la raccolta dei dati clinici e strumentali, compreso il momento scelto per l'esame in relazione al turno di lavoro. Si assume di conseguenza che tutti gli aspetti sopra elencati debbano essere valutati in sede di sorveglianza sanitaria e in ambito epidemiologico.

INTRODUCTION

Upper limb work-related musculoskeletal disorders (UL-WRMSDs) are common among workers performing repetitive and forceful manual work (1, 11, 20). Accurate and efficient diagnosis of these disorders is essential both for research and clinical practice, although with different goals. The main objectives of epidemiological studies are: to describe the distribution of injuries and diseases in the working population, to identify populations at risk for a particular outcome, to provide evidence for causal associations, to estimate the dose-response relationship and test the effectiveness of preventive measures. Aims of workplace surveillance are the identification of possible risk factors and at-risk jobs, the evaluation of intervention and control programs and the monitoring of trends, while workers surveillance is performed, on an individual level, both for diagnosing and treating occupational diseases and for improving workers' awareness of risk factors and prevention behaviors (12).

The outcomes of workplace surveillance and epidemiologic research are significantly affected by the validity and the combination of the screening techniques employed: symptoms surveys, physical examination procedures and instrumental tests. Symptoms surveys collect information on location, frequency and intensity of symptoms; they usually gather additional information on demographic data, anthropometric characteristics, medical history, work history and other activities (hobbies, sports). Physical examination procedures use inspection, palpation and specific maneuvers to test strength, range of motion and sensibility and to determine the exact distribution of symptoms (i.e. Tinel's test for Carpal Tunnel Syndrome). Instrumental diagnostic tests should be ordered for specified clinical indications, be sufficiently accurate to be efficacious for such indications, and be the least expensive and risky of the available tests. No diagnostic test is totally accurate, and physicians often have difficulty interpreting test results. The accuracy of diagnostic tests reported in the literature is commonly expressed in terms of positive and negative predictive values; however, these calculated values are dependent on the prevalence of the disease in the population studied. A test with a particular specificity and sensitivity has different positive and negative predictive values when applied to populations with different disease prevalence rates. Although the specificity and sensitivity of a test do not depend on the prevalence (or percentage of tested patients with disease) they do depend on the spectrum of patients in whom the test is being evaluated (9, 29).

THE DIAGNOSIS OF UPPER LIMB WORK-RELATED MUSCULOSKELETAL DISORDERS

UL-WRMSDs are an heterogeneous group of disorders affecting not only the musculoskeletal system but also the peripheral nervous system; they are characterized by a multifactorial nature, in which the working activity is one out of a number of factors contributing to the causation of the disease (age, gender, anthropometric features, predisposing diseases, etc.) (11, 20).

The diagnosis of UL-WRMSD is mainly based on clinical features but its accuracy is further increased by physical examination and instrumental analysis. Case definitions with the greatest possible sensitivity and specificity are preferred both for individual surveillance and for epidemiological purposes, though, in the latter case, diagnostic strategies should be accurate but also simple and inexpensive. In this context, false negative and false positive results may compromise estimates of risk but do not adversely affect individual workers.

When adopting a case definition, several aspects should be taken into account: objective of the study, prevalence of the disease in the study population, size of the study population, resources available. As a consequence, the disease studied is framed on the basis of a different combination of outcomes.

On the other hand, only the uniformity of case definitions would allow a wide comparison of results across epidemiological studies and a better understanding of the dose-response relationship.

Several case definitions for UL-WRMSD have been proposed and published in the literature; definitions based on different combinations of symptoms, physical examination findings and instrumental test results.

In 1996, Hudak et al. proposed the “DASH (disabilities of the arm, shoulder and hand) Outcome Measure”: a self-report questionnaire designed to measure physical function and symptoms in people with any of several musculoskeletal disorders of the upper limb that can be used for clinical and/or research purposes (16).

In 1996, Buchbinder et al. proposed rubric criteria by which classification systems of soft tissue disorders of the neck and upper limb might be critically assessed and concluded that future work should be directed toward improving existing classification systems and/or developing new ones that fulfil basic measurement criteria (4).

In 1998, Rempel et al. published the “Consensus criteria for the classification of carpal tunnel syndrome”, underlining the need to diagnose carpal tunnel syndrome on the basis of a combination of symptoms and median nerve conduction studies (24).

In 1998, Harrington et al. developed a consensus definition (The “Birmingham criteria”) for a selected number of upper limb pain syndromes (carpal tunnel syndrome, tenosynovitis of the wrist, de Quervain’s disease of the wrist, epicondylitis, shoulder capsulitis (frozen shoulder), and shoulder tendonitis) using the Delphi technique. This classification, intended for epidemiological purposes and useful in surveillance programs, was defined by a consensus workshop of health professionals from different disciplines, convened by the Health and Safety Executive (13).

In 1999, Palmer et al. tested the repeatability and validity of a modified Nordic-style questionnaire for upper limb and neck discomfort (21). Following a consensus statement from a multidisciplinary UK workshop, a structured examination schedule was developed for the diagnosis and classification of musculoskeletal disorders of the upper limb and was validated in a hospital setting. “The Southampton examination schedule for the diagnosis of musculoskeletal disorders of the upper limb” derived from the “Birmingham criteria” (22). The reliability of the Southampton examination schedule was then tested in the general population (34).

A “European” consensus document, “Criteria Document for the Evaluation of the Work-Relatedness of Upper Extremity Musculoskeletal Disorders”, was published in 2001 by Sluiter JK et al (26).

In 2003, Helliwell et al. presented a different approach to classification criteria of soft-tissue disorders of the upper limb, no longer based on a consensus statement, but on multivariate modeling (14).

In 2003, Van Eerd et al. published a review of the available classification systems for upper-limb musculoskeletal disorders in workers, to describe the similarities and differences in the structure of these systems. They found twenty-seven classification systems that described disorders of the muscle, tendon, or nerve that may be caused or aggravated by work. The systems differed in the disorders included, the labels employed to identify disorders, and the criteria used to describe them (28).

In 2003, Walker-Bone et al. published a review of the criteria used to diagnose nonarticular soft-tissue rheumatic disorders of the neck and upper limb. They concluded that the diagnosis of most of these conditions heavily relied on the clinical opinions of investigators and data were insufficient to indicate repeatability, sensitivity or specificity of criteria (35).

A recently published review on the assessment of case definitions in the absence of a diagnostic gold standard concluded that the best case definition for a disorder may vary according to the purpose for which it is being applied (6).

In the occupational settings, where reporting of symptoms could be influenced by non-exposure-related factors such as psychosocial factors (job satisfaction, work organization, relationship with supervisors and colleagues) or by particular expectations (restricted work activities), an objective diagnostic tool is of fundamental importance.

Objective instrumental findings can contribute to the diagnosis of UL-WRMSDs adding important information on the severity of the disorder, its pathogenesis and the mechanisms through which job may affect tissues over time.

Furthermore, the term work-related musculoskeletal disorders refers to conditions potentially affecting different tissues (nerves, tendons, muscles) at the same time and in the same body area. This is the case, for example, of hand-wrist tendonitis that may be associated with carpal tunnel syndrome, a compression of the median nerve at the wrist level, in workers performing highly repetitive and forceful hand-wrist exertions. The resulting clinical pattern could be generated by tendon inflammation, by nerve compression or by the combination of the two. In this specific context, nerve conduction studies and ultrasound examination would contribute to a more accurate diagnosis.

According to these considerations, case definitions based on a combination of clinical history and instrumental findings would be preferred both for surveillance and epidemiological purposes. However, some limitations must be taken into account: the use of instrumental tests is time consuming and expensive and introduces the issue of the level of agreement between symptoms and instrumental findings. In fact, while in the clinical/surveillance context patients with a positive clinical history are usually referred for instrumental assessment to confirm the diagnosis, epidemiological surveys can detect asymptomatic subjects/workers with positive instrumental results.

Poor agreement between symptoms and instrumental findings is widely reported (15, 31). As a paradigmatic example of UL-WRMSDs, we will describe the case of Carpal Tunnel Syndrome (CTS) a common entrapment neuropathy, prevalent both in the general population and in working populations exposed to repetitive manual work.

Although discordances are known to exist between the presence of clinical symptoms of CTS and the presence of instrumental (electrodiagnostic) abnormalities both in the general population and in at-risk groups of workers, a major review by the American Association of Electrodiagnostic Medicine (AAEM) provided convincing evidence that median nerve conduction studies can confirm a clinical diagnosis of CTS with a high degree of sensitivity and specificity (17).

As reported above, the same criteria are valid for epidemiologic research in the occupational setting (24).

Several studies are reported in the literature on the diagnosis of CTS and the disagreement between symptoms and the results of electrodiagnostic tests both in the general population and in the occupational setting.

Redmond and Rinver found that among 50 normal subjects, 23 (43%) had at least one false positive electrodiagnostic test for CTS assessed by different techniques. Authors concluded that certain reported criteria for CTS are abnormal in a high percentage of normal subjects (23).

On the other hand, cases of symptomatic patients with normal nerve conduction values who responded to carpal tunnel release are reported (10).

Glowacki et al. examined the correlation of electrodiagnostic test results and symptom outcome after carpal tunnel release in 167 patients (227 hands). 93% of the 99 hands with a positive electromyographic/nerve conduction velocity study had resolved or improved symptoms. Of the 27 hands with a negative electromyographic/nerve conduction velocity study, the same proportion (93%) showed resolution or improvement in postoperative symptoms. This study showed no significant differences in final symptom status after carpal tunnel release when comparing patients who had positive or negative electrodiagnostic preoperative testing (8).

Poor overlap between reported symptoms and electrodiagnostic results consistent with CTS has been reported also in the working population.

Significantly, reduced mean sensory amplitudes and prolonged motor and sensory distal latencies of the median nerve were found in asymptomatic hands of industrial workers (27).

Franzblau et al. found that about 25% of active workers in several industrial sites had a median mononeuropathy (slowing of sensory nerve conduction velocity) in one or both hands and that about half of these subjects did not report any symptoms consistent with CTS in wrist, hand or fingers (7).

Bingham et al. found abnormal median nerve conduction values in 17.5% of applicants for industrial jobs, of whom 90% were asymptomatic (2).

In a population of meat workers at high risk of CTS, high discordance rates between median nerve conduction studies and symptoms have been recorded both in dominant and non-dominant hands (30).

In another study, carried out among 121 subjects (60 assembly line workers and 61 workers engaged in light manual work and office duties) of a company producing electric powered tools, a large proportion of subjects showed a poor correlation between symptoms and electrodiagnostic findings (3).

The phenomenon is not specific for CTS, but has also been observed for hand-wrist tendonitis in manual workers (31).

Only few studies have been carried out to analyze the pattern of symptoms and instrumental findings in the course of time and to evaluate whether asymptomatic workers with abnormal median nerve conduction studies (NCS) at the wrist level are at risk for developing CTS.

Werner et al. performed a case-control-study in a large group of industrial workers to compare asymptomatic workers with electrodiagnostic findings of median mononeuropathy (cases) with asymptomatic workers with normal median sensory nerve conduction (controls). After a baseline survey workers were re-examined 17 and 70 months later. At the first follow-up no significant difference in the development of symptoms was recorded between cases (12%) and controls (10%) (32). The second follow-up showed that 23% of cases and 6% of controls had developed symptoms and the difference was significant. Authors concluded that there is an increased risk of developing CTS symptoms in workers with previous abnormal findings, although the vast majority of workers with an abnormal sensory latency at baseline did not go on to develop symptoms of CTS (33).

Bonfiglioli et al. examined a group of assembly line workers to evaluate whether CTS symptoms and median NCS could be affected by a significant reduction of exposure. Results showed that the majority of hands without symptoms at the first examination remained asymptomatic, while a large proportion of symptomatic hands became asymptomatic. As for symptoms, the majority of NCS parameters tended to remain normal. Among changes, a statistically significant proportion of hands presenting NCS abnormalities at the first examination showed normal NCS parameters (3).

In a longitudinal study on median nerve sensory conduction, hand/wrist symptoms and carpal tunnel syndrome (CTS) in a group of industrial workers followed for 11 years, Nathan et al. observed that the trend tended to increase for median nerve conduction abnormalities and to decrease and widely fluctuate for symptoms. Authors concluded that changes in median nerve conduction occur naturally with increasing age and do not necessarily lead to symptoms and CTS (19).

On the basis of the above-mentioned studies, a further aspect that needs to be noted is that in the course of time both symptoms and instrumental findings tend to fluctuate and there are several variables that can affect these parameters.

The first variable to be taken into account is exposure. Worker's exposure is a combination of past/cumulative exposure (working history) and present exposure (current job). Current exposure estimates alone can be used to study acute effects while cumulative exposure estimates (job history) can be used to study chronic effects.

Exposure is often indicated as "job title" without any further assessment of intensity or duration, thus hindering the possibility to perceive possible changes occurring over time. As a result, history of employment is sometimes used as a crude surrogate for exposure and duration of exposure as a dose surrogate.

The measurement of actual exposure would improve exposure estimate and variation of exposure between days or within a given day could be used to adjust job-specific exposure estimates.

Individual factors (i.e. age, BMI) may also play an important role in determining the possible onset of UL-WRMSDs. Since these factors are subject to change over time, the outcome may be affected accordingly.

Other possible variables are the criteria used for data collection, including duration and symptoms characteristics, as well as the time of clinical and instrumental examination in relation to work shift and the possible influence of fatigue. Defining standardized techniques, reference parameters and examination times is then of fundamental importance.

In order to clarify the poor agreement between symptoms and instrumental findings, some explanations can be hypothesized.

We can assume that symptoms and instrumental findings represent different features of the disease. In the case of CTS, for example, symptoms can be explained by the ectopic impulse following altered post-ischemic membrane excitability, while the slowing of median nerve conduction is produced by the disruption of myelin sheets or axonal damage (25).

Biomechanical overload due to repetitiveness and force may affect soft tissues, such as nerve and tendons, and modify their structure and function without involving workers ability to perform activity and without causing symptoms.

Moreover, population based normative data may not be appropriate for manual workers. We can hypothesize that occupational overuse could expose the median nerve to mechanical trauma at the wrist level, consequently modifying median nerve conduction. Previous studies on the pathogenesis of CTS have shown that both mechanical and ischemic events first produce structural abnormalities in large calibre (fast conducting) myelinated fibres; the effects of mechanical overload may produce nerve conduction slowing without symptoms (25).

The literature reports a large proportion of industrial asymptomatic workers with median nerve conduction slowing at the wrist level (6, 7, 32, 33). In a group of meat industry workers, highly significant differences between symptomatic and asymptomatic hands were found for median wrist sensory and motor parameters, with mean values recorded in the asymptomatic hands falling between mean values recorded in the general population and in the symptomatic hands (29, 30). Manual asymptomatic workers may thus represent our reference population.

Some considerations should also be made on the significance of symptoms. Symptom reporting is affected by past experience, coping mechanisms, fear of disability and by the concern about the social and financial consequences of the illness, particularly in the occupational setting, where legal controversy may arise. To make matters worse is the concept of pain. Pain is not only a sensation, but an individual's complex "perception". The International Association for the Study of Pain has defined pain as "An unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (18).

Nociceptors are located in the muscles, tendons and perivascular sites (thin myelinated Aα and non-myelinated C fibres); these nerve endings are inflamed by endogenous algesic chemical substances (bradikinin, prostaglandins, leukotrienes, potassium ions, serotonin and interleukin I) released after tissue damage. After acute trauma or injury, pain is generated peripherally and transmitted centrally, where pain modulation occurs. Acute injury effects usually resolve in days or weeks.

On the other hand, repetitive trauma or injury may decrease the sensory threshold of nociceptor fibres and induce hyperalgesia (an increased response to a stimulus that is normally painful); they can also increase pain to suprathreshold stimuli and produce ongoing pain after the stimulus has been removed. Thus, the pain becomes chronic; it can be greater than expected and persist after the injury has healed. The area of tenderness may also extend to the adjacent non-injured tissues (5).

Upper limb WRMSDs are mainly chronic disorders, they reflect the effect of repeated and sustained trauma to the musculoskeletal system. Therefore, a disproportion between muscle-tendon abnormalities observable during ultrasound examination and hand-wrist chronic pain may be postulated.

Conclusions

Upper Limb WRMSDs are a heterogeneous group of disorders, multifactorial in nature, and common in workers performing repetitive manual jobs.

Proposed case definitions are based on different combinations of symptoms, physical examination findings and the results of instrumental tests. Poor agreement between symptoms and instrumental findings and their tendency to fluctuate over time are widely reported.

However, as symptoms may arise from different tissues in the same body region exposed to biomechanical overload, both physical and instrumental examinations can contribute to the diagnosis, providing important information on the structure and functioning of nerves and soft tissues.

In an improvement perspective, although several problems are related to this topic, a few aspects have to be taken into account.

The need to better understand the dose-response relationship and to relate exposure to outcome imposes, particularly in perspective studies, the monitoring of exposure assessment.

Further studies are required to determine whether population based data can be used for manual workers or specific normative data sets are needed. If this is the case, asymptomatic workers exposed to different biomechanical overload may represent our reference population.

Another issue is the need to introduce standardized parameters concerning the time of data collection in relation to work shift. Prolonged biomechanical overload could indeed influence the structure and functioning of tissues, while symptom reporting may be affected by fatigue.

A further element to be taken into account is the selection of instrumental findings. Studies that evaluate the agreement among several parameters and the presence of a corresponding clinical picture together with the evaluation of the sensitivity and specificity of a test may be useful for the selection of the best informative parameters for epidemiological studies.

Finally, the wide range of factors affecting the trend of symptoms and instrumental findings suggests the opportunity to collect clinical and instrumental data at the same time.

No potential conflict of interest relevant to this article was reported

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Acknowledgment: *We are grateful to Chiara Scardoni for scientific editing*