Title: Acupuncture and ergonomic interventions in the management of carpal tunnel syndrome among industrial workers - Case studies

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Abstract

Background: There are several studies on carpal tunnel syndrome (CTS), but considerable uncertainties and controversies exist regarding prevention, appropriate treatment strategies and outcome of various treatment methods. The efficacy of ergonomic job analysis and acupuncture in the prevention and treatment of mild to moderate CTS among industrial workers appears not to have been widely investigated.

Objectives: These case studies assessed the short-term effects of acupuncture treatment and application of ergonomic job analysis in the management of CTS among industrial workers.

Methods: Subjects for this study were three industrial workers with a diagnosis of CTS of more than 3 months duration. Ergonomic work analysis was carried out to analyze and prescribe corrective measures for musculoskeletal and postural load in the subjects' area of work. Subjects also underwent acupuncture treatment twice weekly for 8 weeks. The clinical symptoms of CTS were assessed using the global symptom score (GSS) at baseline and at 8 weeks (after the intervention). The main outcome measures used were GSS scores and ergonomic job analysis worksheet.

Results: All the subjects in this study completed the 8-week intervention and were evaluated for pain, weakness, numbness, frequency of wakening up at night and paresthesia. The 3 subjects showed improvement with recovery from symptoms at the end of 8 weeks of treatment. Two of the 3 participants reported more than 80% reduction in pain intensity while one of the 3 reported complete recovery (100%) from pain. Numbness and paresthesia were reportedly reduced by not less than 50% at the end of 8 weeks of treatment in all the subjects. One of the participants recorded 85% (highest) reduction in the overall GSS scores while another recorded 75% reduction (lowest) at the end of the 8-week treatment. Two of the 3 participants also showed complete recovery from weakness in hand grip strength due to CTS. Frequency of wakening up at night was reduced to zero in all 3 participants.

Conclusions: Findings from this study indicated that acupuncture and application of ergonomic job analysis improved the overall symptoms among industrial workers suffering with CTS.

Key Words: Acupuncture, Carpal Tunnel Syndrome, Ergonomics, Global Symptom Score, Physiotherapy

Introduction

Ergonomic job analysis is a mechanism that may be used to facilitate the identification of particular problems in the workplace through a systematic recording of the specific aspect of the work done or of the effects of the work on that person (Margaret, 1990). In this manner, ergonomic defects and possible health hazards can be defined and subsequently eliminated (Margaret, 1990). Carpal tunnel syndrome (CTS) is the most prevalent form of work-related upper extremity disorder and is characterized by numbness, tingling, hand pain, and muscular dysfunction (Palmer, Harris, and Coggin, 2007). CTS arises from the intermittent or continuous compression or entrapment of the median nerve as it passes through the carpal tunnel from the wrist to the hand. Increased pressure on the median nerve in the carpal tunnel can result in progressive sensory and motor disturbances in parts of the hand innervated by this nerve, leading to pain and loss of function (Palmer, Harris, and Coggin, 2007).
Despite the large number of original research studies on CTS, controversy persists about its extent and etiology, the contribution of work and non-work risk factors to its development, the criteria used to diagnose it, the outcomes of various treatment methods, and the appropriate strategies for intervention and prevention. According to the World Health Organization, CTS is a multifactorial disease that may frequently be work-related and occurs among the general population. CTS may be partially caused by adverse working conditions, can be aggravated, accelerated or exacerbated by workplace exposures, and may impair working capacity (WHO, 1985). It is important to note that personal characteristics and other environmental and sociocultural factors usually play a role as risk factors for this type of disease (WHO, 1985). At work, static muscle loading may occur because of prolonged awkward postures or the need to stabilize or manipulate tools or controls. It may also be induced by concentration or working faster than a comfortable pace (Waersted, Bjorklund, and Westgard, 1986). Diffuse pain and discomfort has been shown to arise from the

maintenance of extreme flexion postures, a posture similar to that commonly adopted at work (Chapell and Bruening, 2003). The symptoms of CTS originate from the mechanical load on passive joint or connective tissue structures rather than sustained muscle activity (Chapell and Bruening, 2003). Static muscle loading leads to more rapid fatigue than dynamic work due to simultaneous constriction of the circulation with increased demands by the muscle for oxygen and nutrients as well as the need to disperse waste product resulting from muscle activity (Chapell and Bruening, 2003). Bekkelund and Pierre-Jerome (2001) identified three main factors associated with an apparently high prevalence of symptoms of work-related CTS to be poor ergonomic/work place design, lack of task variation and insufficient rest breaks. On the other hand, work-related psychosocial factors that have been reported to have strong correlation with CTS are absenteeism, decreased job satisfaction, increased errors, signs of deteriorating mental health such as anxiety, frustration, aggressiveness, irritability, tendency to depression and psychosomatic complaints as well as pain in the neck, shoulder and arms (Margaret, 1990). In suggesting how work-related CTS can be prevented, strategies such as redesigning of the work place, early reporting of symptoms and redeployment and task alternation have been suggested by Margaret (1990). In a similar vein, Maghsoudipour, et al., (2008) emphasized two approaches, the use of appropriate ergonomic design of tools, furniture and equipment, and a thorough training of workers in correct posture and work techniques. While CTS is believed be a common clinical condition, its prevalence and incidence in the general and working populations have not been reliably established by epidemiological studies (Bland 2007; Keith, et al., 2009). A general 1997 health survey in southern Sweden found that 354 responders (prevalence14.4%) reported pain, numbness and/or tingling in the median nerve distribution in the hands of the positive responders. Nerve conduction testing showed median neuropathy at the carpal tunnel in 120 symptomatic subjects (prevalence 4.9%). In another study in Rochester, Minnesota, USA, women

accounted for 78.5% of the cases, with prevalence peaking dramatically during middle age (45-55 years of age) and then leveling off. The prevalence for men generally increased steadily with rising age (Nathan and Keniston, 1992). In 1992, repetitive motion disorders, stresses and strains resulting from free bodily movement with no impact involved were surveyed by the US Bureau of Labor Statistics, and nearly 90,000 cases resulting in lost work time were found. In addition, CTS was the most common disabling condition at 36% of the total, and resulted in more lost work than any other illness or injury reported in 2.3 million cases. CTS has since emerged as a significant and increasing source of claims in workers' compensation systems worldwide.

There are three stages in the evolution of the progressive form of CTS. In stage 1 CTS, transient epineural ischemic episodes cause intermittent pain and paresthesia in the median nerve's field in the hand. These symptoms typically occur at night, or following specific activities such as driving a car or holding a book or newspaper, and suggest the presence of nerve transmission disorders (Szabo, 1998).

In stage 2 CTS, there is constant paresthesia and tingling, corresponding to disturbed intraneural and epineural microcirculation concomitant with intrafascicular edema (Szabo, 1998) while in stage 3, sensory and motor function are permanently damaged, and there is atrophy of the thenar eminence. Electrodiagnostic tests are abnormal, and demyelinisation and axonal degeneration secondary to prolonged endoneural edema may be present (Szabo, 1998).

CTS can be diagnosed by provocative clinical tests such as Phalen and Tinel signs, sensory tests, electrodiagnostic studies, nerve conduction study, electromyogram and imaging tests (Chapell and Bruening, 2003). However, the best way to confirm the diagnosis of CTS is to perform a median nerve conduction study across the transverse carpal ligament. The purpose of this study is to determine if there is a time delay, a change in intensity, or a reduction in

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velocity of a nerve impulse between one section of a peripheral nerve and another. In the case of CTS, any delay of motor and sensory impulses traveling across the carpal tunnel is of interest. A characteristic of the condition is a focal conduction slowing in the nerve conduction study across the wrist segment (Chapell and Bruening, 2003).

Surgical intervention is only indicated in cases of very severe and/or failed conservative treatments (Sim et al 2011). Conservative treatments that are commonly used in mild and moderate CTS include exercises (Rozmaryn and Dovelle, 1998; Akalin and El, 2002), wrist splints (Walker and Metzler, 2000), injection of anti-inflammatory steroids (Chang, et al., 2002; Yang, et al., 2011), therapeutic ultrasound (Oztas and Turan, 1998; Ebenbichler and Resch, 1998), activity or ergonomic modification (Maghsoudipour, et al., 2008), anti-inflammatory drugs (Wong and Hui, 2001), vitamins, laser therapy and transcutaneous electrical nerve stimulation (TENS) (Naeser, et al., 2002), chiropractic treatment (Davis and Hulbert ,1998) and neuromagnetic therapy (Weintraub and Cole, 2000). Among several non-surgical interventions for pain management, acupuncture has received special attention. Acupuncture is the most familiar complementary and alternative medicine, especially in Chinese medical treatments (World Health Organization, 2002). The efficacy of acupuncture in management of mild to moderate CTS has been investigated in a limited number of studies (Freedman, 2002; Naeser, et al., 2002; Schulman, Liem, and Moroz, 2008), and mixed results have been reported (O'Connor, Marshall, and Massy-Westropp, 2003; Yang, et al., 2009; Ernst, 2009; Kumnerddee and Kaewtong, 2010; Sim. et al., 2011).

The aim of this study was to assess the short-term effects of ergonomic job analysis and acupuncture in treatment of mild to moderate CTS in patients who are industrial workers.

Methods

Approval to carry out this study was obtained from the Cummins Research Ethical Committee. Subjects received information about enrollment in the study and the procedures

of the study via posters displayed at the Occupational Health Department, Cummins Engine Inc. The subject's information sheet was provided to explain the purpose of the study, the effects of acupuncture treatment and its possible side effects prior to obtaining informed consent.

Subjects

Three subjects (subject 1, subject 2 and subject 3) participated in the study. They were employed at Cummins Engine Inc, UK. Their job tasks involved fixing of different parts of an engine, lifting and coupling of different parts of the engine. The subjects' ages ranged from 23 to 65 years. They presented with over 3 months' history of CTS and were unresponsive to various nonsurgical treatments. They were unwilling to undergo surgical treatment but willing to undergo acupuncture and ergonomic job intervention procedures. All participants presented with clinical symptoms and signs of CTS such as numbness, tingling pain, or paresthesia in the median nerve distribution. Precipitation of these symptoms occured by repetitive hand activities and could be relieved by resting, rubbing, and shaking the hand. They all presented with nocturnal awakening caused by sensory symptoms, positive Tinel and phalen signs. Although all the subjects presented with weakness in hand grip strength at varying degrees, functional limitations were not reported.

In order to rule out conditions that could mimic CTS, such as cervical radiculopathy, proximal median neuropathy, or significant polyneuropathy, subjects were also referred for further electro-diagnostic tests to confirm the diagnosis of CTS based on the presence of at least one of the following primary symptoms: Ii) prolonged distal motor latency (DML) to the abductor pollicis brevis (APB) (abnormal Z4.7 ms, stimulation over the wrist, 8 cm proximal to the active electrode), ii) prolonged antidromic distal sensory latency (DSL) to the second digit (abnormal Z3.1 ms; stimulation over the wrist, 14 cm proximal to the active electrode);

and iii) prolonged antidromic wrist-palm sensory nerve conduction velocity (W-P SNCV) at a distance of 8 cm (W-P SNCV, abnormal <45 m/s).

Assessments and Outcome Measures

The clinical symptoms of CTS were assessed using GSS by a specialist physiotherapist with more than 16 years of clinical experience in the assessment and treatment of patients with CTS. GSS was administered at baseline and after 8 weeks of intervention. This scoring system rates clinical symptoms from 0 (no symptoms) to 10 (very severe symptoms) in the following 5 areas: pain, numbness, tingling, weakness/clumsiness, and nocturnal awakening. Therefore, the maximum score of 50 indicated the most severe symptoms and the minimum score was 0, which showed an absence of symptoms.

Test-retest reliability of GSS was studied in a subsample of 22 patients on two occasions, on a 1-3-week interval, and showed good agreement between the scores. Internal consistency of the scales was high (Cronbach alpha 0.80-0.95). Validity of the scales was evaluated using the SF-36 general health questionnaire in a subgroup of 48 patients, showing the expected relationships between these measures. Responsiveness of the scales to clinical change, estimated by the effect size and standardized response mean, was large (0.94-1.7) (Atroshi et al 1998).

Ergonomic Job Analysis

The purpose of ergonomic job analysis in this case study was simply to prevent/ameliorate discomfort associated with work-related CTS. A simple ergonomic job analysis worksheet was utilized in this study (Margaret, 1990). The worksheet comprises 4 main sections: job title and description, risk factors (by elements and body parts) associated with the job being analyzed, causes of the risk factors (by elements and risk factors) and possible solutions (by cause and risk factors) to prevent and/or ameliorate risk factors and associated work-related musculoskeletal disorders. Details of the findings are presented in the appendices.

Acupuncture Intervention

Acupuncture consisted of 16 sessions of 30-minute duration, administered over 8 weeks (2 sessions per week). Each subject had fixed and classic acupuncture points [PC-7 (Daling), PC-6 (Neiguan)] on the affected side in their 16 sessions without modification for the specific symptoms of the subjects. Subjects were placed in the supine position to make them more comfortable. Sterile disposable steel needles (gauge and size: 0.25g, 40 mm) were used. At each point, the skin was wiped with alcohol, and needles were inserted perpendicularly at PC-6 to a depth of 1.0 to 1.5 inch and at PC-7 to a depth of 0.5 to 1.0 inch, according to the thickness of the patient's wrist. The needles were manipulated by twirling with lifting-thrusting methods to produce a characteristic sensation known as de qi (an awareness of numbness, soreness, swelling, heaviness, or radiating feeling from the point of needling deemed to indicate proper needle position and effective needling). Needles were then left in place for 30 minutes on the affected side. No subject presented with bilateral CTS. Compliance with the application standards of acupuncture (MacPherson, White, and Cummings, 2002; Asghar, et al., 2010) was observed by satisfying the conditions for application of standard acupuncture treatment such as using fixed and classic acupuncture points throughout the treatment, eliciting the de qi sensation responses by manual twirling with the lifting and thrusting method of stimulation, and retaining the needles for not less than 20-30 minutes. The acupuncture treatment was carried out by a physiotherapist who was license-certified by the Acupuncture Association of Chartered Physiotherapists, United Kingdom.

Ergonomic Job Advice/Intervention

Based on the findings from the analysis carried out with the ergonomic job analysis worksheet, ergonomic adjustment and advice tailored towards each subjects were given in

addition to common interventions provided to all the subjects which include, restriction, treatment, job modification and phase return

Restriction: Avoidance of identified work related factors associated with the development and aggravation of CTS for a period of 6-8 weeks when physiotherapy treatment is ongoing.

Treatment: Physiotherapy treatment while treatment and rehabilitation for the tennis elbow for 6-8 weeks period

Job modification: During the 6-8 weeks period while undergoing treatment, employee were assigned to carry out a new job role or with the intention of reducing exposure to the work related factors capable of aggravating symptoms of CTS

Phase Return: Employee commenced phase return to previous job role after 6-8 weeks of treatment and rehabilitation

Data Collection and Analysis

Demographic data were collected. Participants' ratings of the severity of symptoms such as pain paresthesia, numbness and awakeness as well as overall GSS scores were collected with GSS questionnaires and are presented in Table 1. The percentage change in the overall GSS score as well as in the different symptoms were calculated.

Results

The basic characteristics of the three subjects, including age, sex, and duration of CTS prior to participation in the study, is presented in Table 1.

Table 1: Characteristics of subjects

	Subjects		
Variable	1	2	3
Age (years)	45	23	65
Sex	Male	Female	Female
Duration of CTS (months)	12	5	18

The identified symptoms based on ergonomic job analysis in all the subjects include:

1. Stressful posture and repeated exertion to the wrist and the other joints in the upper extremity due to awkward positioning of the wrist and elbow joints when fixing different parts of the engine.

2. Forceful exertion and repeated exertion to the wrist and elbow joints and the other joints of the upper extremity caused by the effort required to lift and transfer some of the engine parts.

Table 2 shows the GSS for the subjects. The maximum GSS score of 22 at baseline was recorded by Subject 1, and the lowest score of 20 was recorded by Subject 3. Following the 8-week treatment, the symptom of awakening at night was completely abolished in all three subjects. Pain intensity was reduced by greater than 80% in Subject 2 and Subject 3 and no pain was reported by Subject 1. Numbness, paresthesia and weakness in the hand grip strength due to CTS were also remarkably reduced by more than 50% at the end of 8-week treatment in all 3 subjects.

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Table 2: Changes in GSS following treatment

	Subjects	GSS scores	GSS Numbness	Pain	Paresthesia	Weakness	Awakening
Baseline	1	24	5	8	5	4	2
Scores	2	22	4	7	6	3	2
	3	20	2	6	5	3	4
8 week	1	6	2	0	2	2	0
Scores	2	5	1	1	3	0	0
	3	3	0	1	2	0	0

% change in GSS after 8 weeks of treatment

Subjects	GSS Scores	Numbness	Pain	Paresthesia	Weakness	Awakening
1	75	60	100	60	50	100
2	77	75	86	50	100	100
3	85	100	83	60	100	100

Discussion

The aim of this study was to assess the short-term effects of ergonomic job analysis and acupuncture treatment in the management of mild to moderate CTS among industrial workers. The results of this study showed that a combination of ergonomic job analysis and acupuncture treatment might lead to improvement in clinical symptoms of CTS, especially among industrial workers who choose not to undergo surgical intervention as the last resort line of management. The result of this study was in line with previous research studies. One randomized trial study with long-term follow-up (13 months) compared acupuncture with oral steroids in management of CTS (Naeser, et al., 2002), and another randomized controlled trial study compared efficacy of acupuncture with night splinting (5 weeks) for CTS (Schulman, Liem, and Moroz, 2008). Both studies found that electro-acupuncture was more effective in mild to moderate CTS. On the other hand, some evidence did not demonstrate a benefit in symptom relief with acupuncture intervention when compared to placebo or control. Weinstein, Pan, and Richardson (2003) evaluated the effect of manual acupuncture in comparison with sham acupuncture and found no statistical difference between the real and sham groups. Another randomized controlled trial study found no significant differences

between laser acupuncture and placebo on night pain at 3 weeks of follow-up (Aigner, Zöch, and Fialka, 1998). Lack of significant results with the study by Aigner and colleagues could be partly due to the inclusion of placebo control (sham acupuncture). Tsukayama, Yamashita, and Kimura (2006) found that most people who have knowledge about acupuncture and have received acupuncture treatment could distinguish between sham and genuine needling; thus, it is possible that patients that the patients involved in the Aigner study were also able to make this distinction, which could have influenced the outcome of treatment in this study. In the present study, sham acupuncture was not involved.

Ergonomic intervention is one of the strategies to reduce the menace of work-related musculoskeletal disorders in an industrial setting. Thus, the present study investigated, in case studies, if acupuncture combined with ergonomic intervention would improve outcomes among industrial workers with mild-to-moderate CTS. In many instances among industrial workers whose job tasks involve the use of an impact gun, air gun, screw drivers and other similar hand-held devices, the wrist is usually forced into an unnatural position. As a result of this there is an increased workload for the small muscles in the hand and the muscles that bend the fingers and stabilize the wrist. Also, there is a harmful load for the tendons and joints in the hand and wrist coupled with the risk of nerve compression and increased static muscular strain in the muscles to compensate for the distorted work position (Margaret, 1990). One of the major postural health hazards among industrial workers is static muscle work. It can be caused by improper design of the worksite, poor organization of work or working methods and poor individual working techniques (Margaret, 1990). Static compression of the muscle compresses the blood vessels and thus reduces blood flow to the muscles. The supply of oxygen and energy is reduced while the waste products of the working muscle accumulate in the muscles. These wastes hasten muscle fatigue and can eventually cause pain, hardening, and cramps (Margaret, 1990).

Recommendations given to proffer solutions to the improper ergonomic approach to work among the subjects in the present study included provision of a lift/tilt/rotatory device to adjust the orientation of the engine prior to bolting the different parts, to eliminate the need to put the wrist and other body parts in awkward positions, using a work-rest cycle, and job rotation.

The results of the current study showed that there was a high percentage of improvement with reductions in the CTS symptoms among industrial workers following the management approach incorporating ergonomic job analysis and acupuncture treatment. Although the present cases studied showed promising results, a larger randomized control trial with larger sample size at a different industrial setting will be needed before the findings can be generalized for other industrial workers suffering from work-related CTS.

Limitations and Recommendations for Future Studies

Although findings from this study suggest that ergonomic intervention combined with short-term acupuncture treatment is an effective treatment for symptomatic relief in CTS, some questions remain unanswered.

1. Is acupuncture therapy effective for long-term symptom relief of CTS?
2. Do symptoms recur once acupuncture is discontinued, and is further acupuncture therapy effective in patients experiencing a recurrence?
3. In light of the fact that the study had a small sample size, are the findings from the study applicable to a wider population of individuals with CTS in an industrial setting?

To answer these questions, future studies in the form of a randomized controlled trial involving larger sample size should be carried out. Future studies may also consider additional assessments of functional limitations due to CTS using validated, commonly used disability scales such as the SF-36, Disability of Arm, Shoulder and Hand questionnaire to make a comparison of the data to other published literature more relevant.

Conclusion

The results of these case studies are suggestive that a combination of ergonomic job analysis and acupuncture can relieve the overall subjective symptoms of CTS and could be adopted in comprehensive care programs for industrial workers.

Conflicts of interest: None declared.

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