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Cutaneous sensory perception threshold in people with mild and moderate carpal tunnel syndrome

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Abstract:

There is no study comparing the sensory threshold in people with mild to moderate carpel tunnel syndrome (CTS) with the healthy population. Thus, the aim of this study was to assess cutaneous sensory perception threshold in people with mild and moderate CTS compared to the healthy population. The CTS diagnosis was made by a specialist based on the history of the interview, physical examination and nerve conduction study (NCS). Baseline 'West-hand' monofilaments (Semmes–Weinstein-type monofilaments) were used to assess cutaneous sensory perception threshold. The test was performed on the fingertips of the thumb, index finger and middle finger of both hands. Comparative analysis of cutaneous sensory perception threshold showed significantly worse results in the CTS group compared to healthy group (in each case $p < 0.001$). There were also significant differences in cutaneous sensory perception threshold assessed using Semmes–Weinstein monofilaments in people with mild to moderate CTS compared to healthy peopleIn mild and moderate forms, CTS cutaneous sensory perception is diminished if we compared with healthy persons. Semmes–Weinstein monofilaments can be a useful diagnostic tool for assessing sensory threshold disorders in people with mild to moderate CTS.

Keywords:

carpal tunnel syndrome, cutaneous sensory perception threshold, Semmes–Weinstein monofilaments

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Introduction

Carpal tunnel syndrome (CTS) is a chronically progressive peripheral neuropathy, which begins most often with subjective pain symptoms and paresthesia, gradually leading to serious sensory and hand movement disorders [1]. Such a course of the disease over time leads to a decrease in hand dexterity, which results in an adverse effect on professional life and everyday activities. CTS most often affects people (especially women) of working age, which is a serious socio-economic and social problem [2,3], especially since the frequency of this neuropathy is relatively high and estimated in the general population at 1.5% –3.8% [4–6]. People with CTS also experience a decrease in many physical and mental components of overall quality of health [7], which in turn can significantly reduce their quality of life. Therefore, rapid diagnosis is important in capturing even subtle sensory and motor disorders, and undertaking effective treatment, which in the initial period of so-called mild and moderate forms of CTS are usually conservative [8]. CTS is usually diagnosed on the basis of information provided in the interview, various functional tests (Phalen's test, Tinel's sign and nerve conduction (NCS) [9,10]. In the subjective assessment of the severity of symptoms and functional status, the Boston Carpal Tunnel Questionnaire (BCTQ)–) is most often used [8,11-13], and the Disabilities of the Arm, Shoulder and Hand questionnaire DASH (is used by many researchers and clinicians to assess hand function disorders, [12,14]. However, the multitude of sensory and motor disorders of CTS requires a much more detailed assessment. Therefore, the study is supplemented with an assessment of pain sensation [14,15], two-point discriminatory (2PD) sensation [1,11,16], sensory threshold [12,14,15], various types of kinesthetic sensation [1,17], and also for the assessment of muscle strength [8,11,12,14,15] and range of motion [17,18].

Cutaneous sensory perception threshold is used for the quantitative evaluation of sensation within the hand using Semmes–Weinstein monofilaments (SWM). Thanks to this test, we can assess the sensitivity of the skin of the hand (fingers), and thus the degree of peripheral nerve damage [19, 20]. Gellman et al. proved the sensitivity and specificity of the study using SWM [21]. Raji et al. in their research presented a significant relationship between SWM and NCS and showed that the SWM is a reliable test for assessing sensation in patients with CTS [20]. In turn, Yildrim and Gunduz showed a correlation between NCS and sensory threshold testing using SWM and suggested that SWM could be a valuable quantitative method to assess the severity of CTS. In several randomized clinical trials, the SWM study was also used to assess the effectiveness of physiotherapy [12,14,15,22,23]. To the best of our knowledge, no one has compared the sensory threshold in people with mild to moderate CTS with the healthy population so far. Therefore, the purpose of this work is to evaluate cutaneous sensory perception threshold in people with mild and moderate carpal tunnel syndrome compared to healthy volunteers.

Materials and Methods

The study was authorized by the Bioethics Committee for Scientific Studies at the Jerzy Kukuczka Academy of Physical Education in Katowice on 31 May 2007 (Decision No. 16/2007). All study procedures were performed according to the Helsinki Declaration of Human Rights of 1975, modified in 1983. All participants gave their signed informed consent to participate in the research.

Research participants

In total, 146 people participated in

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the study: 70 people diagnosed with CTS (CTS group) and 76 healthy people. In the CTS group there were 18 people with bilateral CTS (26% of respondents), therefore the number of hands tested was 88. In the healthy group, 26% were randomly selected, in which both hands were examined (thus 96 hands were evaluated). Neither group differed in terms of basic biometric data, such as sex, age, body weight, body height and BMI (in all cases $p \leq 0.05$). The average stage of CTS according to the Historical-Objective (Hi-Ob) scale was $\bar{x} = 2.19$ (min / max 1–3, SD = 0.56). In the CTS group, the severity of symptoms assessed by means of the Symptom Severity Scale (SSS) on the BCTQ was on average $\bar{x} = 2.97$ (min / max 1.54–4.64, SD = 0.63), and the impairment of functions was assessed by the FSS (Functional Status Scale) on the BCTQ. The BCTQ averaged $\bar{x} = 2.81$ (min / max 1.27–4.62, SD = 0.69) (both scales have a minimum value of 1 and a maximum of 5.) The mean pain estimated using the Numerical Pain Rating Scale (NPRS) in the CTS group was $\bar{x} = 5.72$ (min / max 1 –10, SD = 1.49) The conduction velocity in sensory fibers in the CTS group was slowed relative to normal values (≥ 50 m / s) and was on average $\bar{x} = 26.2$ (min / max 0–49, SD = 17.7). The speed of conduction in motor fibers in this group was within normal values (≥ 50 m / s) and in y was average $\bar{x} = 53.2$ (min / max 36–64, SD = 7.84). Motor latency was lower than normal (≤ 4.0 milliseconds) and was on average $\bar{x} = 5.61$ (min / max 4.4–8.6, SD = 1.08). The characteristics of the subjects and the results of homogeneity tests of the groups under study are presented in Table 1.

Table 1. Participants characteristics – mean value and standard deviation (SD), minima and maxima as well as mean of differences (95% CI) between groups along with the T-test and Chi^2 result for independent samples

Characteristics	Group			
	EXP (n=70)	CON (n=76)	EXP/CON Groups differences 95% CI	Signifi-cance level
Women (%)	62 (89)	65 (85)	3	0.8446[2]
Men (%)	8 (11)	11 (15)		
Age (*years*)	54.1 (8.71) 35-64	52.5 (7.66) 36-59	1.6 (1.29 – 3.89)	0.7923[1]
Weight (*kg*)	72.2 (11.1) 50-97	73.8 (13.5) 48-105	1.6 (-3.65 – 4.12)	0.9049[1]
Height (*m*)	164 (6.42) 148-180	166 (5.57) 153-184	2 (-1.92 – 1.74)	0. 9249[1]
BMI	26.9 (4.18) 17.8-41.1	26.6 (4.75) 17.2-38.3	0.5 (-1.11 – 1.68)	0.6836[1]

Legend: EXP - carpal tunnel syndrome patients group; CON – healthy volunteers control group; statistically significant difference; [1] T-Student test, [2]; Chi^2 test*

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CTS diagnostic criteria

The CTS diagnosis was made by a specialist based on the history of the interview, physical examination and nerve conduction study (NCS) [9,10].

The interview and physical examination evaluated symptom severity and physical capacity using the Boston Carpal Tunnel Questionnaire (BCTQ) [24]. The NPRS (0: no pain, 10: maximum pain) was used to assess current hand pain (strongest during last week) [25].

Five criteria proposed by Chang et al. were also used (two or more positive symptoms from the following list indicates the presence of CTS):

1. Numbness and tingling first in the area of the median nerve innervation;
2. Night paresthesia;
3. A positive Phalen test;
4. A positive Tinel sign;
5. Pain around the wrist radiating to the shoulder [26].

Neuro-MEP equipment was used to perform NCS examinations, using an antidromic method with superficial electrodes. The temperature in the room where the test was performed was 24 °C to 26 °C. Before examination, patients were acclimatized for 10 to 15 minutes. The skin temperature was measured by means of a surface thermometer and fluctuated between 32 °C and 34 °C. The following values were accepted as normative as recommended by the laboratory: sensory conduction velocity ≥50m/s; motor conduction velocity ≥50m/s; and distal motor latency ≤4.0 milliseconds. The latency of the F wave was also evaluated to eliminate the cervical nerve roots compression [9,10].

Patients who qualified for the study were diagnosed with mild to moderate CTS, meeting the diagnostic criteria. A mild degree of severity of CTS symptoms was evaluated using the Hi-Ob scale. For mild and moderate forms of CTS, the qualifying individuals obtained results equal to 1–3 on the Hi-Ob scale [27].

The criteria for exclusion from the study included the following: previous surgery or the use of orthotics; pharmacological steroid and non-steroidal treatment; the presence of cervical radiculopathy, cervical myelopathy, polyneuropathy, thoracic outlet syndrome, inflammation of the tendon sheath, rheumatoid diseases (rheumatoid arthritis), diabetes, thyroid diseases, pregnancy; history of wrist injuries (fractures); thenar eminence muscle atrophy; fibromyalgia; and mental illness.

Study methodology

Baseline 'West-hand' monofilaments (aesthesiometers) were used to assess cutaneous sensory perception threshold. This is a Semmes–Weinstein type monofilaments. The 'West-hand' device delivers the right pressure without damaging the skin due to its five calibrated fibers. Each fiber is color-coded and creates pressure on the skin. Green fiber causes a pressure of 0.07 g and indicates the correct sensor perception. Blue fiber exerts a pressure of 0.2g and if we do not have any sensations from the green fiber, it proves a limited delicate touch. Pink fiber causes pressure of 2.0g, and if we do not feel blue fiber it indicates limited protective sensation, Red fiber causes 4.0g pressure and if we do not feel pink fiber it indicates loss of protective sensation. The orange fiber causes a pressure of 200 g, and if we do not feel the red fiber, it means that only a residual sensation is preserved. The test was performed on the fingertips of the thumb, index finger and middle finger of both hands. Participants closed their eyes and were instructed to verbally indicate if they felt the monofilament. The monofilament was applied perpendicularly to the fingertip with such force until it bends. The study was started with a blank test, in which the fingertip was not touched, and the question was asked which

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finger was touched. The study began with the thinnest fiber, and if the subject did not feel the touch, then the appropriate thicker one was used until the sensory threshold was established. Each finger was examined three times, and the thinnest monofilament that the subject felt was taken for analysis [12,14,15].

Statistical analysis

All the obtained results were statistically analysed. The homogeneity of the groups was checked using t-test for independent samples and chi^2 test for qualitative variables. Nominal values, percentages and chi^2 test for independent samples were used to assess the sensory threshold. The critical level of the p-value was set at 0.05

Results

Comparative analysis of cutaneous sensory perception threshold showed significantly worse results in the CTS group compared to the healthy group (in each case $p < 0.001$). In the CTS group only 6.33% of respondents had a correct values (green monofilament) cutaneous sensory perception threshold, and 56.6% in the healthy group. On average, 46% of respondents had limited delicate touch (blue monofilament) in the CTS group, and 41% in the healthy group. On average, 36.3% of respondents had limited protective sensation (pink monofilament) in the CTS group, and only 1.66% in the healthy group. The loss of protective sensation (red monofilament) in the CTS group affected on average 8.6% of the subjects and there were no such cases in the healthy group. Detailed results of the cutaneous sensory perception threshold are presented in Table 2.

Table 2. Sensory threshold (ST) – nominal and percentage values and Chi^2 result for independent samples

ST	Group	G	B	P	R	O	Significance level
Finger I	EXP (n=70)	6 (7)	40 (45)	35 (40)	7 (8)	0 (0)	***
	CON (n=76)	51 (52)	44 (45)	3 (3)	0 (0)	0 (0)	
Finger II	EXP (n=70)	3 (3)	40 (45)	36 (41)	9 (10)	0 (0)	***
	CON (n=76)	60 (61)	38 (39)	0 (0)	0 (0)	0 (0)	
Finger III	EXP (n=70)	8 (9)	48 (55)	25 (28)	7 (8)	0 (0)	***
	CON (n=76)	56 (57)	40 (41)	2 (2)	0 (0)	0 (0)	

*Legend: ST – sensory threshold; EXP - carpal tunnel syndrome patients group; CON – healthy volunteers control group; G – green (0.07g), B blue (0.2g), P – pink (2.0g), R – red (4.0g), O – orange (200g); ST – sensory threshold; ***p<0.001*

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Discussion

The main purpose of this study was to evaluate the cutaneous sensory perception threshold in people with CTS compared to the healthy population. The obtained research results indicate that already in mild and moderate forms of CTS sensory threshold disorders occur. The correct sensory threshold values in the CTS group had a small number of subjects (over 6%), and in the healthy group over half of the subjects. A limited soft touch occurred in both groups in a comparable percentage of cases (6% more in the CTS group). However, the CTS group is disturbed by a significant percentage of people with limited protective feeling and loss of protective feeling, since in total it is almost 45% of respondents. If we consider that a limited soft touch is not something abnormal and dangerous to health, then certainly the disturbance of protective feeling and its loss significantly increases the risk of injury, both in professional work and during everyday activities. It should be remembered that people with CTS constitute a significant percentage of the professionally active population (in this study, the average age in the CTS group was $\bar{x} = 54.1$, the youngest person was 35 years old and the oldest 64 years old), and therefore more often exposed to hand injuries, which among professionally active people are the most common, especially among people performing manual work [28]. Therefore, in a comprehensive assessment of people with CTS symptoms even in the early stages of this peripheral neuropathy, the sensory threshold test should be one of the basic studies.

There are many different ways to assess sensation, but testing the sensory threshold using MSW allows you to obtain an objective result of hand skin sensitivity. Thanks to this study, we can get information about sensory abnormalities at an early stage of CTS, we can quantify the degree of sensation loss, and assess the effectiveness of the treatment used. As stated in the introductory part of the study, there is a significant relationship between NCS and the sensory threshold assessed by the SWM [20]. In addition, a correlation between the sensory threshold test and the degree of CTS severity was demonstrated [19]. Many authors also point to the high reliability of testing the sensory threshold using SWM [21, 29-31]. Although NCS is the gold standard in the diagnosis of CTS and other peripheral neuropathies, and its reliability is high, its disadvantage is definitely lower availability, higher examination price, longer examination time and unpleasant sensations during its performance [32]. In addition, the NCS test must be ordered by a physician, performed by specially trained personnel, and described and interpreted by a physician. In contrast NCS, sensory threshold testing using SWM is inexpensive, simple to perform, easily accessible, can be repeated often, and with relatively high reliability, and is very useful, especially in physiotherapy offices, in both functional diagnostics and evaluation of the effects of applied therapy. Wolny et al. in previous studies, have shown great utility of the discriminatory sensing sensation (2PD) study in mild forms of CTS [33] and its high reliability [34]. Therefore, the high value of both sensory tests (sensory threshold and 2PD) should be emphasized once again in early diagnosis and the evaluation of the effects of therapy in people with CTS and other peripheral neuropathies.

Several studies have assessed the effectiveness of different types of therapy using SWM [12,14,15,23]. Horng et al. assessed the impact of the use of orthosis, paraffin and exercise compared to autoneuromobilization on the change in sensory threshold in people with CTS. However, no significant changes were obtained after the applied cycle of therapy

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[12]. Bialosky et al. compared the effectiveness of neurodynamic techniques with branded therapy and also pointed to the lack of differences in the sensory threshold assessed by SWM in people with CTS [14]. In turn, Pinar et al. assessed the effectiveness of an orthosis application in combination with an instructor on activity modification (control group) and enrichment of this therapy with auto-neuromobilization (experimental group). After using the therapy in both groups, a significant improvement in sensory threshold was achieved in each group, but there were no intergroup differences [15]. Konrad and Ziółkowska assessed the effectiveness of conservative and surgical treatment in people with CTS using von Frey monofilaments, which are modified filaments of the SWM. Both after using physiotherapy (spot hydromassage, nerve electrostimulation and kinesitherapy) as well as surgical treatment, a significant improvement in the sensory threshold was obtained, which was slightly better after surgery [23].

Monofilaments were originally used to diagnose sensory disorders in leprosy [35]. Currently, they are widely used worldwide in screening studies for sensory disorders in the diabetic foot [36]. They are also used to assess the effectiveness of various types of therapy in people with CTS [12,14,15,23]. In this study it has been shown that already in mild and moderate forms of CTS there is a sensory threshold disorder compared to healthy people. Therefore, disorders can be detected at an early stage of CTS, which also indicates the legitimacy of their use in the physiotherapeutic diagnosis of this neuropathy, in order to be able to implement the appropriate therapy as soon as possible. In a comprehensive clinical assessment of a patient with CTS (especially if there is no NCS examination), they should become, along with 2PD study, pain assessment, subjective symptoms, and functional disorders, a basic test performed as standard.

In conclusion, there are significant differences in cutaneous sensors' perception threshold assessed using Semmes–Weinstein monofilaments in people with mild to moderate CTS compared to healthy people. Semmes–Weinstein monofilaments can be a useful diagnostic tool for assessing sensory threshold disorders in people with mild to moderate CTS.

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