Contact heat evoked potentials in knowledge workers and unskilled labors

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Abstract

Background: Whether occupation has an impact on contact heat evoked potential (CHEP) results has not been investigated. In this study, we investigated the difference of CHEP parameters between knowledge workers and unskilled labors.

Methods: A total of 137 healthy participants were recruited between November 20, 2014 and December 31, 2016. All participants underwent neurologic examination, laboratory examination, and nerve conduction studies. CHEP was performed on four body sites: the upper border of the distal third of the volar forearm, the upper border of the distal third of the lateral leg, the spinous process of seventh cervical vertebrae (C7), and the spinous process of 12th thoracic vertebrae (T12). Independent *t* test and nonparametric test were performed using SPSS software to compare the difference of the CHEP parameters between knowledge workers and unskilled labors.

Results: The "N_2 latency/height" ($Z = -2.290$, $P = 0.022$) and "P_2 latency/height" ($Z = -2.020$, $P = 0.043$) on the volar forearm of unskilled labors significantly increased than those of knowledge workers. The "N_2 latency/height" ($F = 6.348$, $P = 0.016$) and "P_2 latency/height" ($F = 5.920$, $P = 0.018$) in the distal leg of unskilled labors significantly prolonged than those of knowledge workers. The N_2-P_2 amplitude ($F = 5.797$, $P = 0.020$) in the distal leg of unskilled labors significantly decreased than those of knowledge workers.

Conclusions: Our study found that significantly prolonged N_2 latency and P_2 latency and significantly decreased N_2-P_2 amplitude in the distal leg and the volar forearm in unskilled labors as to knowledge workers.

Keywords: Contact heat evoked potential; Occupation; Nerve conduction studies

Introduction

The contact heat evoked potential (CHEP) is a neurophysiologic technique to evaluate the function of Aδ fibers. The stimulator placed on skin surface elicits heat-pain stimuli via rapidly changed temperature (70°C/s) to generate cerebral electroencephalographic responses,[1,2] including parameters of N_2 latency, P_2 latency, and N_2-P_2 amplitude.[3-6] CHEP is a simpler, safer, and more objective approach than laser evoked potential to evaluate the function of peripheral small nerve fibers.[7-11]

Small-fiber neuropathy (SFN) is defined as polyneuropathy of small diameter unmyelinated C and thinly myelinated Aδ fibers as a result of various etiologies.[12-14] Huge interest in SFN has been raised since the application of intra epidermal nerve fiber density (IENFD) assessment via skin biopsy. It is a consensus that CHEP is an objective and sensitive technique and correlate with IENFD,[3-6] which has become an important diagnostic approach for SFN recently.

Normal values of CHEP have been established in some single- and multi-center studies,[1,2,15-17] which facilitates diagnosis of SFN. The effects of different factors, such as gender, age, body height, on CHEP parameters have been evaluated, and different studies have revealed conflicting results.[1,2,15-17] Furthermore, CHEP has been used in various diseases except SFN, for example, spinal cord lesions, amyotrophic lateral sclerosis, and Guillain-Barre syndrome.[18-20] CHEP parameters can be affected by a series of factors, such as age, gender, and body height. However, the fact that whether occupation has an impact

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on CHEP parameters has not been investigated. In this study, we applied CHEP stimulations on knowledge workers and unskilled labors and compared their CHEP parameters separately, which was able to evaluate the effect of occupation on CHEP parameters.

Methods

Ethical approval

This study was approved by the Ethics Committee of Chinese People's Liberation Army (PLA) General Hospital (No. s2016-021-01), in compliance with the principles in the *Declaration of Helsinki*. All participants included in the current study signed the informed written consent.

Participants

In this prospective study, we recruited healthy participants between November 20, 2014 and December 31, 2016, and they were divided into knowledge worker group and unskilled labor group. Teachers, physicians, college students, lawyers, accountants, and programmers were included in knowledge worker group, while builders, cleaners, chefs, soldiers, and lathemen were included in unskilled labor group. Labor intensity of the unskilled labor group was categorized into grades II to III, according to the classification of physical work intensity of People's Republic of China (GB 3869-1997). Knowledge workers and unskilled labors have been taking their work for more than 3 years. All participants underwent neurologic examination, laboratory examination, and nerve conduction studies (NCS) to ensure the eligibility of recruitment. Eligibility criteria includes: (1) age ≥18 years; (2) no sensory abnormalities/deficit on neurologic examination; (3) normal results of laboratory tests (see details in the following section); (4) normal results of NCS; (5) no conditions that cause polyneuropathy (eg, metabolic syndrome, diabetes mellitus, or systemic illnesses like sarcoidosis or malignancy); (6) no excessive alcohol use or abuse (refers to drinking at least 4 international units per day)[21] or smoking history; (7) no history of hereditary diseases (eg, hereditary motor and sensory neuropathy, hereditary sensory and autonomic disease, inclusion disease such as Fabry disease); (8) no neurotoxic medications or drugs; (9) no skin lesion on stimulation sites of CHEPs.

Laboratory examinations

Laboratory tests included analysis of the complete blood count, erythrocyte sedimentation rate, C-reactive protein, renal and liver function test, lipid profile, fasting glucose, glycosylated hemoglobin (hemoglobin A1c), oral glucose tolerance test, folate and vitamin B12, thyroid function, antinuclear antibody, anti-extractable nuclear antigen antibody, serum protein electrophoresis, and tumor markers. The diagnosis of impaired fasting glucose, impaired glucose tolerance, and diabetes were based on comparisons with the diagnostic criteria published by the World Health Organization (WHO).[22]

Electrophysiologic examination

NCS were conducted on all enrolled participants. The Keypoint electromyography (EMG) system (Medtronic, Inc., Minneapolis, MN, USA) was used to assess the tibial, peroneal, sural, ulnar, and median nerves. The skin temperature was required to keep at 32°C or above during the process. The NCS results were compared with the normal reference values of the EMG laboratory of Chinese PLA General Hospital (tibial motor nerve: amplitude ≥5.0 mV, velocity ≥40.0 m/s; peroneal motor nerve: amplitude ≥3.0 mV, velocity ≥45.0 m/s, median motor nerve: amplitude ≥5.0 mV, velocity ≥50.0 m/s; ulnar motor nerve: amplitude ≥5.0 mV, velocity ≥50.0 m/s; median sensory nerve: amplitude ≥5.0 μV, velocity ≥50.0 m/s; ulnar sensory nerve: amplitude ≥5.0 μV, velocity ≥50.0 m/s; and sural sensory nerve: amplitude ≥6.0 μV, velocity ≥50.0 m/s). NCS results were considered abnormal if any parameters fall below the above range.

Contact heat evoked potential

CHEP was performed at a room temperature between 20°C and 24°C. A CHEP stimulator (PATHWAY, Sensory Analyzer System; Medoc, Ramat Yishai, Israel) was used to apply heat pulses on four body sites: the upper border of the distal third of the volar forearm, the upper border of the distal third of the lateral leg, the spinous process of seventh cervical vertebrae (C7), and the spinous process of 12th thoracic vertebrae (T12). The thermode, with a diameter of 27 mm and an area of 572.5 mm^2, delivered direct heat stimuli by increasing baseline temperature of 32°C to the peak temperature of 51°C at a rate of 70°C/s. CHEPs were analyzed by the Keypoint EMG system (Medtronic, Inc.), using a sensitivity of 20 μV/div and a band pass filter between 0.1 and 50.0 Hz. According to the international 10 to 20 system, the electrodes were placed on Cz and Fz. Before formal stimulation, all participants received two stimuli per each body site. During the test, the participants were required to keep their eyes open in a neutral, fixed station to avoid artifacts of blink. The participants did not know when CHEP stimuli would be given. To avoid habituation affecting results, the thermode was moved slightly after each stimulus, about 0.5 cm away from previous stimulation site. The interstimulus interval was set between 10 and 18 s. The technician kept the thermode attached to skin surface. Recordings affected by blink, muscle, and movement artifacts or other stimulation or recording interference were eliminated. Impedance was kept below 5 kΩ during the test. N_2 latency, P_2 latency, and N_2-P_2 amplitude were determined by two independent clinicians. Disagreements were resolved by consultation. The clinicians are blind to the occupation of the subjects.

Visual analog scale

The visual analog scale (VAS) was used to assess pain during the above sessions. The VAS comprises a horizontal line 10 cm in length, which is anchored by verbal descriptors of no pain (score of 0) and worst imaginable pain (score of 10). The participants were asked to place a line perpendicular to the VAS line at the point that represented the average pain during CHEP stimulation.

Table 1: Comparison of CHEP parameters between knowledge workers and unskilled labors.

Sites	Knowledge workers ($n=74$)	Unskilled labors ($n=65$)	Statistics	P
FA				
NL/H	2.06 ± 0.18	2.21 ± 0.40	−2.290*	0.022
PL/H	2.67 ± 0.34	2.83 ± 0.39	−2.020*	0.043
N-P	39.57 ± 17.22	50.6 ± 19.43	0.543†	0.463
VAS	5.06 ± 2.01	5.27 ± 1.93	−0.368*	0.700
C7				
NL/H	1.87 ± 0.21	1.88 ± 0.49	−0.785*	0.432
PL/H	2.56 ± 0.27	2.55 ± 0.48	−0.961*	0.336
N-P	38.77 ± 15.23	41.68 ± 19.58	0.953†	0.333
T12				
NL/H	2.13 ± 0.21	2.13 ± 0.24	0.082†	0.776
PL/H	2.79 ± 0.26	2.81 ± 0.37	2.014†	0.161
N-P	38.16 ± 16.07	37.84 ± 20.68	−0.209*	0.834
LE				
NL/H	2.7 ± 0.3	2.8 ± 0.5	6.348†	0.016
PL/H	3.37 ± 0.27	3.41 ± 0.52	5.920†	0.018
N-P	39.49 ± 25.38	30.87 ± 17.18	5.797†	0.020

Data are presented by mean ± standard deviation. * Z. † t. FA: The upper border of the distal third of the volar forearm; C7: The spinous process of seventh cervical vertebrae (C7); T12: The spinous process of 12th thoracic vertebrae (T12); LE: The upper border of the distal third of the lateral leg; NL/H: N_2 latency/height (ms/cm); PL/H: P_2 latency/height (ms/cm); N-P: N_2-P_2 amplitude (μV); VAS: Visual analog scale..

Statistical analysis

SPSS software (version 19.0; SPSS Inc., Chicago, IL, USA) was used to perform statistical analysis. Test of normality was performed. The data were shown as mean ± standard deviation. Independent t test and nonparametric test were performed to compare the difference of the CHEP parameters between knowledge workers and unskilled labors. A two-tailed $P < 0.05$ was considered to be statistically significant.

Results

Seventy-two (male 39) and 65 (male 33) healthy participants were enrolled in knowledge worker group and unskilled labor group, separately. The average age was 38 ± 12 and 34 ± 14 years, respectively. There is no significant difference between age, gender, and body height of the two groups. The CHEP test was well tolerated by all of the participants. The data were presented as "N_2 latency/height" and "P_2 latency/height" instead of N_2 and P_2 latency to exclude the effect of body height.[1]

The "N_2 latency/height" on the volar forearm of unskilled labors was 2.21 ± 0.40 ms/cm, and the "N_2 latency/height" on the volar forearm of knowledge workers was 2.06 ± 0.18 ms/cm. The "P_2 latency/height" on the volar forearm of unskilled labors was 2.83 ± 0.39 ms/cm, and the "P_2 latency/height" on the volar forearm of knowledge workers was 2.67 ± 0.34 ms/cm. The "N_2 latency/height" ($Z = -2.290$, $P = 0.022$) and "P_2 latency/height" ($Z = -2.020$, $P = 0.043$) on the volar forearm of unskilled labors significantly increased/prolonged than those of knowledge workers, as shown in Table 1. However, the N_2-P_2 amplitude ($F = 0.543$, $P = 0.463$) and VAS score ($Z = -0.368$, $P = 0.700$) on the volar forearm were not significantly different between the two groups [Table 1].

The "N_2 latency/height" ($Z = -0.785$, $P = 0.432$), "P_2 latency/height" ($Z = -0.961$, $P = 0.336$), and N_2-P_2 amplitude ($F = 0.953$, $P = 0.333$) at the spinous process of seventh cervical vertebrae (C7) were not significantly different between the two groups [Table 1].

The "N_2 latency/height" ($F = 0.082$, $P = 0.776$), "P_2 latency/height" ($F = 2.014$, $P = 0.161$), and N_2-P_2 amplitude ($Z = -0.209$, $P = 0.834$) at the spinous process of T12 were not significantly different between the two groups [Table 1].

The "N_2 latency/height" in the distal leg of unskilled labors was 2.80 ± 0.49 ms/cm, and the "N_2 latency/height" in the distal leg of knowledge workers was 2.70 ± 0.32 ms/cm. The "P_2 latency/height" in the distal leg of unskilled labors was 3.41 ± 0.52 ms/cm, and the "P_2 latency/height" in the distal leg of knowledge workers was 3.37 ± 0.27 ms/cm. The "N_2 latency/height" ($F = 6.348$, $P = 0.016$) and "P_2 latency/height" ($F = 5.920$, $P = 0.018$) in the distal leg of unskilled labors significantly prolonged than those of knowledge workers, as shown in Table 1. The N_2-P_2 amplitude in the distal leg of unskilled labors was 30.87 ± 14.18 μV, and the N_2-P_2 amplitude in the distal leg of knowledge workers was 39.49 ± 25.38 μV. The N_2-P_2 amplitude ($F = 5.797$, $P = 0.020$) in the distal leg of unskilled labors significantly decreased than those of knowledge workers, as shown in Table 1.

Discussion

The effects of gender, age, and body height on CHEP parameters have been evaluated in previous studies but results were conflicting. Age is recognized as an influential

factor in CHEP studies, however, whether sex and body height affect CHEP parameters are controvertial.[1,2,15] The subjects enrolled in the two groups were comparable in age, sex, and body height. There were no articles focusing occupational effect on CHEP parameters until now. Our study investigated the effect of knowledge workers and unskilled labors on CHEP parameters and data suggested CHEP parameters differed significantly at the distal lateral leg and the volar forearm between the two groups. Unskilled labors tended to have increased/prolonged N_2 latency and P_2 latency and decreased N_2-P_2 amplitude.

The reasons for the differences of CHEP parameters between knowledge workers and unskilled labors were not clear. Our hypothesis is that unskilled labors perhaps are more vulnerable to injury than knowledge workers at work, and they tend to habituate to pain. Therefore, when they are confronted with nociceptive stimuli, the activated Aδ fibers in unskilled labors are fewer, or the conduction of Aδ fibers is slower than those in knowledge workers, or the activity of pain-related brain area, such as the insula, thalamus, and secondary somatosensory cortices in unskilled labors decreases as well.[23] Furthermore, the keratoderma of unskilled labors may be thicker than that of knowledge workers, thus, the N_2-P_2 amplitude decreased in these group of people. There were differences of CHEP parameters between knowledge workers and unskilled labors on the volar forearm and distal leg, but not at the spinous process of C7 and T12. The reason may be that the distal forearm and leg were exposed to external environment, while the C7 and T12 were not.

This study investigated the correlation between occupation and CHEP parameters. Data suggested significant differences of CHEP parameters between knowledge workers and unskilled labors, which is not studied or discovered in the past. Further investigation like functional brain imaging might shed some light on pain related brain activity is reduced in unskilled labors.

Our study investigated the effect of knowledge workers and unskilled labors on CHEP parameters for the first time and found that compared to knowledge workers, N_2 latency, and P_2 latency significantly increased in both distal lateral leg and volar forearm and N_2-P_2 amplitude significantly decreased at the distal lateral leg for unskilled labors. Further studies are required to discuss this issue and to explain the reason why unskilled labors have longer N_2 latency and P_2 latency and lower N_2-P_2 amplitude.

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Conflicts of interest

None.

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