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Nerve Conduction Studies and Surface Electromyography in Barbers

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ABSTRACT

Background: Prolonged standing can have deleterious effects on the muscles and peripheral nerves of lower limbs leading to peripheral neuropathy. Barbers stand for quite a long period as due to their occupation which can expose them to neuromuscular disorders.
Aims: To study nerve conduction and surface electromyography of lower limbs; and psychological fatigue in barbers.
Materials and methods: This cross sectional study included 26 barbers and 30 healthy controls. Anthropometric, nerve conduction and surface EMG variables were recorded in both groups. Compound muscle action potential (CMAP) and sensory nerve action potential (SNAP) of peripheral nerves of both limbs and motor unit action potentials (MUAPs) of gastrocnemius muscles were recorded. Psychological fatigue was assessed using the Borg scale in the barbers. The unpaired "t" test was applied for comparing anthropometric, cardio respiratory, nerve conduction and surface EMG variables between barbers and controls. Pearson's correlation was applied for finding association between fatigue score and surface EMG variables in barbers.
Results: CMAP and SNAP responses of peripheral nerves of lower limbs were low in barbers as compared to controls ($p < 0.05$). MUAPs amplitude of left gastrocnemius muscles on activity and recruitment and also, amplitude of right gastrocnemius muscle on activity were high in barbers as compared to controls ($p<0.05$). Frequency of MUAPs of both gastrocnemius muscles on recruitment positively correlated with fatigue score in the barbers.
Conclusion: The decrease in CMAP and SNAP amplitudes of peripheral nerves in barbers might be due to repetitive stress in the form of prolonged standing leading to entrapment neuropathies. Surface EMG findings showing an increase in MUAP amplitude of both gastrocnemius muscles are an indication of muscle fatigue.

Key words: muscle fatigue; prolonged standing

INTRODUCTION

Musculoskeletal disorders (MSD) are injuries or dysfunctions affecting muscles, bones, nerves, tendons, ligaments, joints, cartilages and spinal discs. MSD includes sprains, strains, tears and connective tissue injuries. [1,2] MSD may occur as a result of overexertion, cumulative load, contact of body parts with equipment or furniture, or as a result of falls. Activity demands can cause or aggravate MSD. [3] Physical load is influenced by the task, environment, tools and devices, and by personal characteristics. Awkward, repeated and prolonged postures, overstressing movements, high repetition or forces can overload the tissues and exceed their threshold of tolerable stress, resulting in MSD. [4]

Szeto GP et al did a comparative study on neck and shoulder muscle recruitment patterns among symptomatic and asymptomatic office workers performing monotonous keyboard work. Surface electromyography of 4 major neck-shoulder muscles was done. The symptomatic group (n=23) showed higher activity in the right upper trapezius while the asymptomatic or control group (n=20) showed more symmetrical muscle activity between left and right trapezius. The symptomatic group was subdivided into "High Discomfort" and "Low Discomfort" groups based on their discomfort scores. The High Discomfort group had significantly higher right upper trapezius activity compared to the Low Discomfort group and controls. [5]

The subjects of the present study, the barbers, do have a job that requires prolonged standing posture for a substantial duration. As such, they are likely to be exposed to WMSDs along with psychological fatigue. Psychological fatigue is experienced by the workers while performing jobs in prolonged standing posture leading to decline in alertness, concentration and motivation. [6] The effects of prolonged standing on nerves can be assessed by nerve conduction studies (NCS) and on muscle by surface electromyography (EMG). NCS are conventionally performed with EMG, which are electrodiagnostic studies; provide a comprehensive evaluation of suspected nerve, muscle and/or neuromuscular impairment. [7]

Wiggerman et al did a pilot study on 10 healthy college students (5 men and 5 women) to see the effect of prolonged standing on the touch sensitivity threshold of the foot. Semmes-Weinstein monofilament tests were administered at 12 locations on the dorsal and plantar surfaces of the foot before and after 4 hours of standing. It was found that the average of all sensitivity thresholds on the plantar surface of the foot decreased (indicating increased sensitivity) from 0.56 to 0.36 g ($p<0.01$) after 4 hours of prolonged standing. [8]

Colak T et al did a neurophysiologic study consisting of motor and sensory nerve conduction of medial and plantar nerves, sensory nerve conduction of sural and superficial peroneal nerves, and motor nerve conduction of common peroneal nerve on 14 asymptomatic male middle-distance runners and 14 non active subjects. The medial plantar (sensory) nerve and sural nerve latencies were significantly prolonged and sensory conduction velocities were significantly delayed in the runners compared with the control subjects. [9]

Cartwright et al did a study to see the incidence of carpal tunnel syndrome (CTS) over 1 year in Latino poultry processing workers and other Latino manual workers. It was found that the incidence of CTS was higher in poultry processing workers and this effect might result from repetitive and strenuous nature of poultry processing work. [10]

Carpal tunnel syndrome, an entrapment neuropathy of the median nerve has been studied in different occupations. Also, surface EMG has been studied in different occupations. However, nerve conduction and surface EMG of the lower limbs have not been studied in barbers who are exposed to prolonged standing as due to their occupation. Therefore, we aimed to investigate the NCS as well as surface EMG variables in barbers and also to assess the psychological fatigue level in the barbers.

MATERIALS AND METHODS

Electrodiagnostic studies are powerful tools used to objectively examine the physiologic status of nerve and muscles. NCS evaluates motor and sensory parameters of the nerve and surface EMG evaluates the electrical activity in the muscles. [11] In motor NCS, bilateral common peroneal and tibial nerves while in sensory NCS, bilateral sural nerves were assessed. Surface EMG of bilateral gastrocnemius muscles was recorded.

This study was done in a period of 1 year from July 2013- July 2014. Twenty six healthy male barbers of 20-50 years from Dharan municipality were selected by a convenient sampling method. Those barbers with history of diabetes, neuropathy or neuromuscular disorder were excluded. Our postgraduate students and faculty members from different departments were taken as healthy controls. These subjects are not exposed to prolonged standing. Ethical approval was taken from IRC (Institute Review Committee), BPKIHS. Subjects were explained about the study procedure in detail and informed written consent was taken before the electrophysiological test.

Anthropometrical, NCS and surface EMG variables were studied. Both NCS and surface EMG of both limbs were recorded using Digital Nihon Kohden (NM-420S, H636, Japan) in Neurophysiology Lab II, BPKIHS. Both tests were performed by placing the participants in lying down position.

Recording of motor NCS [11]

The stimulating electrodes were placed on the skin overlying the nerve at two sites along the course of tibial and common peroneal nerves. The recording and reference electrodes were placed on specific sites for different nerves using belly tendon montage. The ground electrode was placed between stimulating and recording electrodes before applying electrical stimulus. The current of stimulator was initially set to zero, then gradually increased with successive stimuli. A compound muscle action potential (CMAP) appeared that grew larger and larger with the increasing current. When current was increased to the point that CMAP was no longer increasing in size, the current was increased by another 20% to ensure supra maximal stimulation. For each site of stimulation, latency, and amplitude of CMAP were recorded. The trace was stored and the stimulating electrode moved proximally to a second stimulation site. Distance between the two sites was measured and fed into the machine for calculation of nerve conduction velocity (NCV).

For the recording of F-waves of motor nerve, the stimulator was placed at the distal site of stimulation with cathode facing proximally. Minimum, maximum and mean latencies of F waves were recorded.

Recording of sensory NCS [11]

Antidromic method of stimulation was employed for sensory NCS. Twenty stimuli were averaged. Onset latency, sensory nerve action potential (SNAP) amplitude and NCV were recorded.

Recording of surface EMG [12]

Surface EMG of bilateral gastrocnemius muscle was done. The skin over the muscle was cleaned with Skin Pure gel. Electrodes were placed and secured using a tape. Active electrode was placed on the belly of the muscle and a reference electrode placed over the tendon thus the placement known as belly tendon montage. A ground electrode was also placed on a limb. The electrode diameter was about 12 mm and kept 20 mm apart on the muscle to be tested.

The sensitivity and the speed were kept at 100 microvolts and 10 milliseconds per division respectively. Motor unit action potentials (MUAPs) were assessed for its frequency, amplitude and duration during voluntary activation and forceful contraction. These assessments are done manually according to the machine calibration.

Psychological fatigue was assessed in barbers by using Borg scale.

Statistical Analysis

The data were entered into MS Excel and analyzed by SPSS 11.5 version. Unpaired ‘t’ test was used to compare the anhropometric, NCS and surface EMG variable between the groups as the data were normally distributed. Similarly, Pearson’s correlation was applied for correlating psychological fatigue and muscle fatigue in the barbers. The difference was considered significant at p value < or = 0.05.

RESULTS

Table 1. Comparison of anthropometric variables between barbers and controls.

Variables	Barbers (n=26) (Mean ± S.D)	Control (n=30) (Mean ± SD)	P value
Age (years)	31.96±9.21	29.27±5.21	NS
Weight (kg)	63.73±8.93	62.7±10.73	NS
Height (cm)	156.5±5.54	159.7±7.06	NS
BMI (kg/m^2)	23.15±2.41	23.58±1.63	NS

***kg- kilogram, cm-centimeter, BMI- body mass index, m-meter**

Anthropometric variables of barbers and controls were comparable in both the groups as shown in table 1. Amplitude of bilateral tibial, common peroneal and sural nerves were low in barbers as compared to controls which were statistically significant (as shown in table 2). Amplitude of left gastrocnemius on activity as well as on recruitment and the amplitude of left gastrocnemius on activity is higher in barbers as compared to controls (as shown in table 3). Frequency of right and left gastrocnemius on recruitment was positively correlated with the fatigue score in barbers (as shown in 4 and 5)

Table 2. Comparison of motor and sensory NCS variables between barbers and controls.

Variables	Barbers (n=26) (Mean ± SD)	Controls (n=30) (Mean ± SD)	P value
LCPDAMP (mv)	5.21± 1.69	8.63± 1.85	**0.001**
LCPDL (ms)	3.2±0.43	3.2±0.63	0.99
LCPNCV (m/s)	46.79±4.09	49±6.12	0.12
RCPDAMP (mv)	5.92±1.2	8.72±2.11	**0.001**
RTCPDL (ms)	3.18±0.41	3.3±0.6	0.41
RTCPNCV (m/s)	48.14±4.42	49.07±5.84	0.5
LTDAMP (mv)	11.74±3.35	15.06±3.52	**0.001**
LTDL (ms)	3.15±0.54	3.5±0.88	0.08
LTNCV (m/s)	44.49±6.18	45.28±5.34	0.61
RTDAMP (mv)	12.65±3.33	15.29±2.79	**0.002**
RTDL (ms)	3.3±0.566	3.43±0.7	0.44
RTNCV (m/s)	42.49±5.04	45.37±6.5	0.08
LSOL (ms)	2.58±0.33	2.63±0.44	0.622
LSMP (mv)	13.54±7.84	19.82±4.84	**0.001**
LSNCV (m/s)	55.12±7.29	53.89±8.18	0.557
RSOL (ms)	2.61±0.33	2.58±0.4	0.75
RSAMP (mv)	15.23±8.71	23.49±6.51	**0.001**
RSNCV (m/s)	54.39±7.35	55.13±8.52	0.73

†mv- millivolt, ms- millisecond, m/s- meter per second, LCPDAMP- left common peroneal distal amplitude, LCPDL- left common peroneal distal latency, LCPNCV- left common peroneal nerve conduction velocity, RCPDAMP- right common peroneal distal amplitude, RCPDL- right common peroneal distal latency, RCPNCV- right common peroneal nerve conduction velocity, LTDAMP- left tibial distal amplitude, LTDL- left tibial distal latency, LTNCV- left tibial nerve conduction velocity, RTDAMP- right tibial distal amplitude, RTDL- right tibial distal latency, RTNCV- right tibial nerve conduction velocity, LSOL- left sural onset latency, LSAMP- left sural amplitude, LSNCV- left sural nerve conduction velocity, RSOL- right sural onset latency, RSAMP- right sural amplitude, RSNCV- right sural nerve conduction velocity

Table 3. Comparison of surface EMG variables of gastrocnemius muscles between barbers and controls

Variables	Barbers (n=26) Mean±SD	Controls (n=30) Mean±S.D	P value
LGFROAT (Hz)	302.69±86.28	275.33±43.45	0.132
LGAMPOAT (µv)	456±132.62	339±71.96	**0.001**
LGDROAT (ms)	2.64±0.54	2.78±0.46	0.294
LGFRORC (Hz)	322.31±100.57	304±45.38	0.373
LGAMPORC (µv)	565±126.01	445±97.19	**0.001**
LGDRORC (ms)	2.25±0.34	2.31±0.41	0.551
RGFROAT (Hz)	300.38±86.97	296.33±41.23	0.821
RGAMPOAT (µv)	477±120.41	387±113.57	**0.006**
RGDROAT (ms)	2.57±0.33	2.71±0.49	0.236
RGFRORC (Hz)	333.85±77.36	321.33±35.89	0.431
RGAMPORC (µv)	570±143.83	503±139.39	0.081
RGDRORC (ms)	2.25±0.27	2.18±0.28	0.335

‡ Hz- Hertz, µv- microvolt, ms- millisecond, LGFROAT- left gastrocnemius frequency on activity, LGAMPOA- left gastrocnemius amplitude on activity, LGDOAT- left gastrocnemius duration on activity, LGFRORC- left gastrocnemius frequency on recruitment, LGAMPORC- left gastrocnemius amplitude on recruitment, LGDRORC- left gastrocnemius duration on recruitment, RGFROAT- right gastrocnemius frequency on activity, RGAMPOA- right gastrocnemius amplitude on activity, RGDROAT- right gastrocnemius duration on activity, RGFRORC- right gastrocnemius frequency on recruitment, RGAMPORC- right gastrocnemius amplitude on recruitment, RGDRORC- right gastrocnemius duration on recruitment

Table 4. Fatigue scores in barbers as assessed by Borg Scale

Barbers (n=26)	Fatigue scores
1	14
2	16
3	17
4	15
5	14
6	13
7	15
8	16
9	15
10	14
11	13
12	14
13	17
14	13
15	18
16	17
17	14
18	13
19	12
20	13
21	14
22	18
23	12
24	15
25	17
26	18

Table 5: Correlation of Fatigue score with surface EMG variables in barbers.

Variables	**Pearson Correlation**	**P value**
RGFROAT (Hz)	0.341	0.088
RGAMPOAT (µv)	0.18	0.379
RGDROAT (ms)	-0.04	0.846
RGFRORC (Hz)	0.397	**0.044**
RGAMPORC (µv)	0.26	0.2
RGDRORC (ms)	0.199	0.329
LGFROAT (Hz)	0.242	0.233
LGAMPOAT (µv)	0.05	0.807
LGDROAT (ms)	0.025	0.905
LGFRORC (Hz)	0.377	**0.05**
LGAMPORC (µv)	-0.116	0.572
LGDRORC (ms)	-0.071	0.73

DISCUSSION

This study was carried out to see the effect of prolonged standing on peripheral nerves and muscles of the lower limbs of barbers. In this context, electrodiagnosis is having an immense value in testing peripheral nerves, Neuro muscular junction, muscle, plexus, root or central pathways. [13] NCS and surface EMG were carried out to see the effect of prolonged standing on peripheral nerves and muscles. NCS parameters have been extensively studied in healthy human being in different sports, however the effect of prolonged standing as an occupation on nerve conduction parameters of barbers is poorly known.

The study showed a decrease in CMAP and SNAP amplitudes in the tested peripheral nerves of both lower limbs of barbers. These changes in amplitude might be due to the effect of poor circulation to the nerves thus resulting in oxygen deprivation due to sustained (static) contraction of certain group of muscles of lower limbs while standing for long period. Repetitive stress in the form of prolonged standing, can lead to entrapment neuropathies, a special category of compression injury. The resulting irritation may cause ligaments, tendons, and muscles become inflamed and swollen, constricting the narrow passageways through which some nerves pass resulting in neuropathy. [14]

A research conducted on rickshaw pullers concluded that muscle hypertrophy produced by hyperactivity has an influence on nerves supplying the muscles with changes in conduction velocity. [15]

Soodan et al found the motor NCV of ulnar nerve to be higher in sprinters as compared to distance runners while motor NCV of common peroneal nerve to be higher in distance runners as compared to sprinters. Motor nerve conduction velocities of ulnar and common peroneal nerves were higher in dominant limbs (i.e. arms and legs) of both sides of body as compared to non dominant limbs. [16]

Surface EMG study showed an increase in amplitude of MUAPs of both gastrocnemius muscles on activation along with increase in MUAPs on recruitment of left gastrocnemius muscle. The repeated intensive use of muscles leads to a decline in performance known as muscle fatigue. Surface EMG is one of the reliable techniques that can be used to evaluate muscle fatigue. When signal amplitude increases and power spectrum shifts to lower frequency, it indicates that assessed muscle are in fatigue condition. [17,18] And these features are in accordance with our study which showed an increase in amplitude of both gastrocnemius muscles in barbers. In contrast, frequencies of MUAPs were comparable between the groups.

Muscle fatigue may be due to the effect of ionic changes in action potentials, failure of sarcoplasmic reticulum calcium release by various mechanisms and the effects of reactive oxygen species is implemented for the possible mechanism of muscle fatigue. [19]

The muscle fatigue can be linked to psychological fatigue and this has been recognized as a factor in the decline of alertness, mental concentration and motivation. Psychological fatigue can be assessed subjectively through questionnaire surveys, uses of the Borg scale, use of the Body Part Symptom or use of the visual analogue scale (VAS). [7] We assessed psychological fatigue using Borg scale in barbers. Our study showed a positive correlation between frequencies of MUAPs and fatigue score. Fatigue is produced in part by bombardment of the brain by neural impulses from muscles. [20] Hence, more firing of MUAPs, more bombardment of neurons of the brain thus, earlier the fatigue appears.

This study gives an insight on the potential risk of peripheral neuropathy and muscle fatigue in barbers possibly caused by prolonged standing posture due to their occupation.

CONCLUSION

Static posture for a long period of time can have deleterious effects on peripheral nerves and muscles as shown by our study. Nerve conduction studies of the peripheral nerves of lower limbs showed a decrease in amplitude while surface EMG of the muscles showed an increase in amplitude and increased frequency of firing of motor unit action potentials.

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