A Cross-Sectional Study to Assess Motor Performance of the Hands and Its Association with Workplace Factors in the Laboratory Workers of Jawaharlal Nehru Medical College, Belagavi

Seema Venkaraddi Kamaraddi[1], Basavaraj Malakajappa Kajagar [2]

[1] Department of Physiology, KAHER J.N. Medical College, Belagavi, Karnataka, India.
[2] Department of Surgery, KAHER J.N. Medical College, Belagavi, Karnataka, India.

ABSTRACT

BACKGROUND
Human motor performance (MP) and motor skills are essential aspects of the various daily activities. Skilled laboratory workers involved in prolonged duration of skillful, repetitive work by hands are susceptible to carpal tunnel syndrome (CTS). This study was conducted to assess MP of the hands and determine the relation between MP and workplace factors.

METHODS
Present cross-sectional study was conducted among 94 laboratory workers (technicians and attenders). Participants were categorised into two groups namely, attenders and technicians, each of which was further divided into two sub-groups of normal participants and those diagnosed with CTS. MP was assessed by median motor nerve conduction velocity (MNCV), work done and fatiguability, hand grip strength and bimanual coordination. Unpaired 't' test / analysis of variance (ANOVA) was used to compare the mean values of selected parameters at a P < 0.05 threshold of significance.

RESULTS
Mean values of median MNCV, work done and time for onset of fatigue were similar across both groups. In the CTS group, hand grip strength (19.00 ± 5.94 Kg) and efficiency index (89.54 ± 8.47) were slightly diminished, while the duration of error in task execution (29.20 ± 21.67 sec) was slightly more than the normal group; however, these differences were statistically insignificant (P > 0.05). Work done, hand grip strength, error and efficiency index significantly differed between technicians and attenders (P < 0.05).

CONCLUSIONS
Most of MP measures being normal in those with CTS suggest that they are at early stages of development of CTS, hence requiring suitable preventive measures. Moreover, workplace factors may adversely affect their work performance.

KEYWORDS
Motor Performance (MP), Median Motor Nerve Conduction Velocity (MNCV), Mosso's Ergography, Hand Grip Strength, Bimanual Coordination

Corresponding Author:
Dr. Seema Venkaraddi Kamaraddi,
Associate Professor,
Department of Physiology,
KAHER J.N. Medical College,
Belagavi - 590010, Karnataka, India.
E-mail: kamaraddidrseema@yahoo.com

DOI: 10.18410/jebmh/2021/170

How to Cite This Article:
Kamaraddi SV, Kajagar BM. A cross-sectional study to assess motor performance of the hands and its association with workplace factors in the laboratory workers of Jawaharlal Nehru Medical College, Belagavi. J Evid Based Med Healthc 2021;8(14):871-876. DOI: 10.18410/jebmh/2021/170

Submission 23-11-2020,
Peer Review 01-12-2020,
Acceptance 09-02-2021,
Published 05-04-2021.

BACKGROUND

Human motor performance (MP) and motor skills are essential aspects of the various daily activities which may be unimanual or bimanual i.e. one hand or both the hands. Quality of performance in daily living skills, recreational and vocational pursuits is influenced by adequate hand function.[1] Ability of a person to use his hands effectively in all these everyday activities depends on various factors.[2]

One of the motor performance associated disorder is carpal tunnel syndrome (CTS). CTS is defined as an entrapment neuropathy arising from the local compression and agitation of the median nerve as it passes through the carpal tunnel beneath the flexor retinaculum. This prolonged pressure on the median nerve ultimately results in local ischemia and loss of function.[3]

Documented risk factors include hypothyroidism, diabetes, rheumatoid arthritis, pregnancy and occupational roles.[4] Workers exposed to occupational hazards encompassing repeated flexing of the wrist, strenuous manual exertion and hand-arm vibrations for long hours are predisposed to developing CTS.[4,5] Forestry workers, food processing workers, machine operators, hairdressers, electricians, welders, carpenters, cleaners, laboratory technicians, surgeons, miners and typists constitute the vulnerable occupational groups.[5] Laboratory workers on account of performing repetitive and precise hand motions daily for several hours, are one among those occupations who are at greater risk for developing CTS.[6] CTS is the most common peripheral mononeuropathy prevalent in the laboratory workers (21.5 %), computer professionals (13.1 %) and attenders (12 %).[7]

Unsurprisingly, higher susceptibility of laboratory technicians to CTS is attributable to the fatigue experienced by the hands following routine procedures like pipetting, microscopy, transferring, mixing and dispensing. Pipetting for approximately five to six hours per week significantly heightens the risk of developing hand and shoulder ailments.[8] Despite previous studies reporting risk factors for CTS among laboratory workers, most have not been backed by assessment of motor performance in their hands as actionable evidence.[9] Due to prolonged duration of work, the motor skills displayed by the hands of laboratory workers deteriorate over a period of time.

The laboratory workers form an important part of institutional set-up and they are actively involved in skilful, repetitive work involving both hands for 4 - 6 hours a day. However, although they play crucial roles in progress of healthcare, their occupational hazards are often overlooked. The lack of literature documenting the motor performance in the hands of laboratory workers and their subsequent susceptibility to work-related sensory and motor nerve neuropathies has inspired this study. As CTS is associated with sensory and motor abnormalities, it is anticipated that MP may be less in the laboratory workers, especially in those with associated CTS.

Thus, the primary objective of the study was the assessment of MP in the hands by median motor nerve conduction test, work done and fatigability of flexors of the fingers, power of hand muscles by hand grip strength, and time for completion of the task, duration of error in executing the task and efficiency index during bimanual coordination test. Evaluation of the association if any, between measures of motor performance in both the hands and workplace factors namely, work pattern, average number of working hours per week and years of employment was also conducted.

METHODS

This was a cross-sectional study conducted over a period of one year from January 2016 to December 2016. The sample size of 94 included all the laboratory workers (technicians and attenders) from the Departments of Anatomy, Physiology, Biochemistry, Pathology, Microbiology, Pharmacology, Forensic Medicine and Preventive and Social Medicine. Due to exclusion of one participant on grounds of possibly experiencing carpal tunnel syndrome (CTS) symptoms following fracture of the right scaphoid, only 93 participants were included in the analysis. The requisite sample size to detect a prevalence of 0.53 % (53 per 10,000) at $\alpha = 0.05$ (significance) and $\beta = 0.8$ (power) following adjustment for the finite population, was estimated to be 94. Laboratory workers, including technicians and attenders working with laboratory equipment for at least 5 to 6 hours / week (that is around 300 hours per year) were included in the study. Those with any physical deformity which prevented the performance of study tasks were excluded.

The study was approved by institutional ethics committee on Human Subjects (IEC No. MDC / PG / 5499) Research and the written informed consent was obtained from the participants enrolled for the study. The cohort of 93 participants were categorised as technicians [N = 43] and attenders [N = 50] depending on their nature of work which included pipetting, opening and closing of bottles, using keyboard, writing reports, microscope work, cleaning instruments, sweeping and mopping the floor. In each group, participants were further divided into two groups namely normal and CTS based on symptoms of hand / wrist pain, numbness, hand weakness, tingling, nocturnal exacerbations, difficulty in holding things, thenar muscle and motor weakness. Technicians comprised of 29 participants in the normal sub-group and 14 in the CTS subgroup whereas among attenders normal and CTS subgroups included 44 and 6 participants respectively.

Additionally, participants were classified into those working for less than 24 hours [N = 41] and for 24 hours and above [N = 52] after looking at their work schedule. Among the cohort working less than 24 hours, 36 and 5 participants belonged to normal and CTS subgroups, while normal and CTS subgroups of those working for 24 hours and above included 37 and 15 participants respectively.

Descriptive data of the participants like name, age, sex, occupational history regarding work pattern, instruments commonly handled, average number of working hours per week and years of employment were recorded on a pretested questionnaire.

Assessment of motor performance in the hands was done by adjudging multiple parameters such as median motor nerve conduction velocity (MNCV), work done and time taken for the onset of fatigue in flexors of the fingers, hand grip strength and time taken and duration of error in executing the task during bimanual coordination and the efficiency index (EI). These tests were selected on virtue of their simplicity, ease of performance, non-invasiveness and reliability.

MNCV was determined using Neurocare^{TM} 2000 Computerised EMG / NCV / EP equipment [Bio-Tech^{TM}, Mumbai, India].[5,10] During the recording, the median nerve was stimulated using surface electrodes, first at the wrist i.e. three cms proximal to distal wrist crease and then at the elbow i.e. near the volar crease of brachial pulse. The resulting electrical activity was recorded as waveform traced on waveform window.

In the calculation window, velocity was calculated by using segmental latency and distance. Distance between wrist and elbow points of stimulation was measured in millimetres (mm). Proximal latency i.e. the conduction time from more proximal stimulus point to the muscle and distal latency i.e. from distal stimulus point to the muscle, both in milliseconds (m sec) were estimated.

$$Median\ MNCV\ (m/sec) = \frac{\text{Distance between Proximal and distal Stimlation in mm}}{\text{Proximal latency} - \text{Distal latency}}$$

Work done and time taken for the onset of fatigue in flexors of the fingers was determined using Mosso's Ergograph. As a part of this procedure, middle finger of participant was put in the loop while index and ring fingers were placed into the finger holders. With the middle finger extended, weight (2 to 3 Kgs) was suspended according to the individual's requirement. Some of them were able to lift 2 Kgs and others 3 Kgs.

Then metronome was set at one beat per two seconds i.e. frequency of 30 / minute. Participant was then asked to make maximal contractions without moving the shoulders at regular intervals following the beat of the metronome. Contractions were made till fatigue sets in i.e. weight could no longer be lifted. Movements were recorded on a kymograph apparatus namely Sherrington recording drum (Orchid Scientific and Innovative India Pvt Ltd., India)

Hand grip strength was measured using Jamar Hydraulic Hand Dynamometer Model 5030 (Jamar Medical Inc., USA). Participants were asked to hold the instrument at the side with the elbow slightly flexed, but the instrument was not allowed to come in contact with other parts of the body. Then, they were asked to exert most forceful grip both with right and left hands separately. Hand grip strength (maximum voluntary contraction) was measured, and the reading was noted in kilograms (Kgs).

The time taken and duration of error in executing the task during bimanual coordination and the corresponding efficiency index (EI) were evaluated using Two-Hand Coordination Test Apparatus with Electronic Chronoscope [Anand Scientific Apparatus Manufacturers, Pune, India]. Participant were asked to trace the figure on the apparatus with the help of a pointer from the start to the end using two handles with both the hands simultaneously. Time taken to complete the task was recorded in minutes by stopwatch and this was converted to seconds for calculating the efficiency index. Duration of error while performing the task was measured in seconds by electronic chronoscope. Thus, Efficiency Index (EI) to assess the overall performance was calculated by using the formula:

$$EI\ (\%) = \frac{\text{Time} - \text{Error} \times 100}{\text{Time}}$$

Statistical Analysis

Statistical analysis of collected data was analysed using R software version 3.6.3 and Excel. Mean comparison of the parameters studied was done by means of an unpaired 't' test / analysis of variance (ANOVA) at a $P < 0.05$ threshold of significance. Shapiro-Wilk test / Quantile-Quantile (QQ) plot was utilised to check the normality of variables.

RESULTS

Out of 94, 21 participants were diagnosed with CTS. However, one participant had noticed symptoms and signs of CTS following the fracture of right scaphoid and he was left-handed. Thus, total of 93 participants were included in the analysis. Mean age of the cohort was 40 years. A notable male preponderance of 77 patients (82.8 %) in comparison to 16 females (17.2 %) was observed.

Table 1 shows that when the motor performance measured in the CTS group were compared with the normal group, it was found that in both the groups, mean values of median MNCV (55.56 ± 8.15 m / sec of CTS vs 55.07 ± 5.79 m / sec in normal right, 53.65 ± 7.65 m / sec in CTS vs 53.0 ± 4.83 m / sec in normal left), work done (1.33 ± 0.64 Kg-m in CTS vs 1.30 ± 0.73 Kg-m in normal right, 1.27 ± 0.66 Kg-m in CTS vs 1.07 ± 0.67 Kg-m in normal left) and time taken for the onset of fatigue (27.25 ± 9.40 sec in CTS vs 26.83 ± 10.13 sec in normal right, 18.95 ± 6.67 sec in CTS vs 20.06 ± 6.49 sec in normal left) in flexors of the fingers were normal in both the hands.

However, in the CTS group, mean values of handgrip strength was slightly less in both the hands [right - 19.00 ± 5.94 Kg and left - 18.95 ± 6.67 Kg] and for bimanual coordination, mean values for duration of error was more and efficiency index was less [error - 29.20 ± 21.67 sec and EI - 89.54 ± 8.47 %]. But in both hands, difference in mean values was not statistically significant for any of the measures.

Compared to the technicians, work done by attenders in both the hands of the CTS group was less [right: technicians - 1.56 ± 0.60 Kg-m & attenders - 0.77 ± 0.29 Kg-m, P = 0.007 / left: technicians - 1.46 ± 0.65 Kg–m & attenders - 0.81 ± 0.47 Kg-m, P = 0.0002] and onset of fatigue was early [right: technicians - 29.3 ± 9.62 sec & attenders - 22.2 ± 7.25 sec / left: technicians - 24.9 ± 7.96 sec & attenders - 19.8 ± 7.52 sec] and for bimanual coordination test, time for completion of task was more, duration of error was more and efficiency index was slightly less in them. However, difference in the mean values was not statistically significant for any of the other measures (Table 2).

Compared to the group with working hours < 24, in the group with working hours ≥ 24, mean values of work done by both the hands was more in the CTS group and this difference was statistically significant in the left hand [right: ≥ 24 hours - 1.41 ± 0.59 Kg-m & < 24 hours - 1.05 ± 0.78 Kg–m / left: ≥ 24 hours - 1.31 ± 0.63 Kg-m & < 24 hours - 1.15 ± 0.82 Kg-m, P = 0.039]. In addition, time for onset of fatigue was more but hand grip strength was less in both the hands in the CTS group. For bimanual coordination, time for completion of task was less, duration of error was less, and efficiency index was more in group with working hours ≥ 24. However, difference in the mean values between both the groups was not statistically significant for any of the measures (Table 3).

Years of employment were categorised into three groups for comparison: < 5 years, 5 - 10 years and > 10 years (Table 4). Mean duration of years of employment in each group was as follows: < 5 years [normal: 2.18 years & CTS: 02 years], 5 - 10 years [normal: 08 years & CTS: 06 years] and > 10 years [normal: 22.86 years & CTS: 25.55 years]. Comparison was not possible in groups with < 5 and between 5 to 10 years of employment because of inadequate sample size in the CTS group. In the group with > 10 years of employment, when normal group was compared with CTS group, only mean values of efficiency index decreased in the CTS group [normal - 89.1 ± 14.9 % & CTS - 87.9 ± 8.14 %] though it was statistically insignificant (P < 0.05).

Motor Performance			Normal (n=73)	CTS (n=20)	Total (n=93)
Median MNCV (m/sec)		Right	55.07 ± 5.79	55.56 ± 8.15	55.17 ± 6.32
		Left	53.0 ± 4.83	53.65 ± 7.65	53.14 ± 5.51
Mosso's ergograph	Work Done (Kg-m)	Right	1.30 ± 0.73	1.33 ± 0.64	1.13±0.71
		Left	1.07 ± 0.67	1.27 ± 0.66	1.11±0.67
	Time for Fatigue (sec)	Right	26.83 ± 10.13	27.25 ± 9.40	26.91±9.93
		Left	21.71 ± 8.11	23.40 ± 8.00	22.07±8.08
Hand grip strength (Kgs)		Right	21.55 ± 6.32	19.00 ± 5.94	21.00 ± 6.30
		Left	20.06 ± 6.49	18.95 ± 6.67	19.82 ± 6.51
Bimanual coordination		Time (min)	5.09 ± 1.91	4.93 ± 1.65	5.06 ± 1.85
		Error (sec)	28.28 ± 37.18	29.20 ± 21.67	28.48 ± 34.34
		EI (%)	90.31 ± 12.80	89.54 ± 8.47	90.14 ± 11.96

Table 1. Motor Performance Measures

CTS=Carpal Tunnel Syndrome N=Number EI=Efficiency Index

Motor Performance				Work Pattern: Technicians (N = 29, CTS = 14)	Work Pattern: Attenders (N = 44, CTS = 6)
Median MNCV (m/sec)		Right	N	53.4 ± 4.29	56.1 ± 6.41
			CTS	55.2 ± 6.34	56.1 ± 12.1
		Left	N	51.9 ± 3.52	53.9 ± 5.36
			CTS	52.5 ± 7.21	56.2 ± 8.74
Mosso's ergography	Work done (Kg-m)	Right	N	1.11 ± 0.44	1.43±0.85
			CTS	1.56 ± 0.60*	0.77±0.29
		Left	N	0.83 ± 0.38	1.23±0.77
			CTS	1.46 ± 0.65**	0.81±0.47
	Time for fatigue (sec)	Right	N	24.8 ± 8.24	28.1±11.0
			CTS	29.3 ± 9.62	22.2±7.25
		Left	N	19.7 ± 7.86	22.9±8.11
			CTS	24.9 ± 7.96	19.8±7.52
Hand grip strength (Kgs)		Right	N	19.8 ± 7.23	22.6 ± 5.47
			CTS	18.9 ± 6.84	19.1 ± 3.54
		Left	N	18.1 ± 7.30	21.3 ± 5.65
			CTS	18.1 ± 6.99	20.8 ± 6.01
Bimanual coordination		Time (min)	N	4.70 ± 1.91	5.35 ± 1.89
			CTS	4.86 ± 1.85	5.08 ± 1.21
		Error (sec)	N	19.5 ± 22.1	34.0 ± 43.7
			CTS	21.9 ± 16.1	46.0 ± 24.8
		EI (%)	N	92.9 ± 7.84	84.1 ± 10.1
			CTS	91.8 ± 6.80	88.0 ± 14.5

Table 2. Comparison between Work Pattern and Motor Performance

N = Normal CTS = Carpal Tunnel Syndrome EI = Efficiency Index * P = 0.008 ** P = 0.0002

Motor Performance				Working Hours per Week: < 24 hours (N = 36, CTS = 5)	Working Hours per Week: ≥ 24 hours (N = 37, CTS = 15)
Median MNCV (m / sec)		Right	N	56.4 ± 6.38	53.7 ± 4.89
			CTS	50.4 ± 6.42	57.2 ± 8.13
		Left	N	59.0 ± 5.33	52.0 ± 4.11
			CTS	50.6 ± 6.03	54.6 ± 8.05
Mosso's ergograph	Work done (Kg-m)	Right	N	1.45 ± 0.87	1.16 ± 0.53
			CTS	1.05 ± 0.78	1.41 ± 0.59
		Left	N	1.22 ± 0.74	0.93 ± 0.57
			CTS	1.15 ± 0.82	1.31 ± 0.63*
	Time for fatigue (sec)	Right	N	28.8 ± 11.2	14.8 ± 8.57
			CTS	25.0 ± 10.8	28.0 ± 9.15
		Left	N	23.6 ± 7.79	19.8 ± 8.08
			CTS	22.3 ± 9.63	33.7 ± 7.33
Hand grip strength (Kgs)		Right	N	22.3 ± 6.06	20.7 ± 6.56
			CTS	20.0 ± 2.73	18.6 ± 6.73
		Left	N	20.9 ± 6.58	19.2 ± 6.39
			CTS	22.2 ± 5.58	17.8 ± 6.82
Bimanual coordination		Time (min)	N	5.31 ± 2.11	4.88 ± 1.71
			CTS	5.16 ± 1.46	4.85 ± 1.76
		Error (sec)	N	37.9 ± 47.1	18.8 ± 20.4
			CTS	38.4 ± 24.1	26.1 ± 20.7
		EI (%)	N	87.6 ± 16.1	92.9 ± 7.82
			CTS	86.0 ± 11.6	90.6 ± 7.29

Table 3. Comparison between Working Hours per Week and Motor Performance

N = Normal CTS = Carpal Tunnel Syndrome EI = Efficiency Index; * P = 0.039

Years of Employment	Median MNCV (m / sec) Right N	Median MNCV Right CTS	Median MNCV Left N	Median MNCV Left CTS	Mosso's Ergograph Work Done (Kg-m) Right N	Work Done Right CTS	Work Done Left N	Work Done Left CTS	Time for Fatigue (sec) Right N	Time for Fatigue Right CTS	Time for Fatigue Left N	Time for Fatigue Left CTS	Hand Grip Strength (Kgs) Right N	Hand Grip Right CTS	Hand Grip Left N	Hand Grip Left CTS	Bimanual Coordination Time (min) N	Time (min) CTS	Error (sec) N	Error (sec) CTS	EI (%) N	EI (%) CTS
< 5 Yrs. (N = 11, CTS = 1)	57.2 ± 6.67	61.3 ± 0.00	54.4 ± 5.93	59.3 ± 0.00	1.31 ± 0.55	0.35 ± 0.00	1.04 ± 0.56	0.19 ± 0.00	24.3 ± 9.02	23.5 ± 0.00	19.6 ± 6.67	10.5 ± 0.00	18.8 ± 6.01	22.0 ± 0.00	18.7 ± 7.79	25.0 ± 0.00	5.95 ± 1.86	4.40 ± 0.00	30.1 ± 24.6	6.46 ± 0.00	91.7 ± 6.55	97.5 ± 0.00
5 – 10 (N = 18, CTS = 2)	55.1 ± 6.22	56.2 ± 4.06	53.0 ± 5.16	50.6 ± 0.84	1.29 ± 0.76	0.84 ± 0.33	0.95 ± 0.53	0.50 ± 0.00	26.8 ± 8.57	21.0 ± 8.08	21.3 ± 5.68	14.2 ± 0.35	19.0 ± 5.80	22.1 ± 8.78	20.2 ± 9.25	11.5 ± 0.70	4.37 ± 1.93	5.10 ± 0.84	16.7 ± 22.2	1.96 ± 1.20	92.3 ± 9.63	99.3 ± 0.29
> 10 (N = 44, CTS = 17)	54.4 ± 5.36	55.1 ± 8.69	52.6 ± 4.42	53.6 ± 8.14	1.31 ± 0.77	1.44 ± 0.61	1.13 ± 0.75	1.42 ± 0.59	27.4 ± 11.0	28.2 ± 9.86	22.3 ± 9.25	25.3 ± 7.18	14.5 ± 0.71	21.9 ± 5.08	20.3 ± 4.69	19.4 ± 6.58	5.17 ± 1.85	4.94 ± 1.79	32.5 ± 43.6	33.7 ± 20.2	89.1 ± 14.9	87.9 ± 8.14

Table 4. Comparison between Years of Employment and Motor Performance

N = Normal, CTS = Carpal Tunnel Syndrome, EI = Efficiency Index, MNCV = Motor Nerve Conduction Velocity

DISCUSSION

Human MP and motor skills are essential aspects of the various daily activities which may be unimanual (writing, picking up an object, eating etc.) or bimanual (driving a car, playing musical instruments, preparing food, getting dressed, typing, manipulating tools and instruments etc.). Hand forms an integral part of all these normal human functioning. Thus, the quality of performance in daily living skills, recreational and vocational pursuits is influenced by adequate hand function.[1] Ability of a person to use his hands effectively in all these everyday activities depends on various factors.[2]

Certain occupational groups have been found to be at higher risk for developing CTS because of their hand intensive work. Risk of developing CTS is higher in these occupations due to repetitive hand movements, forceful work, hand / wrist vibrations and extreme postures.[11] In an institutional set-up like ours, laboratory workers form one such group performing intricate work requiring higher degree of manual dexterity.

In the laboratory set-up, most of the work requires intricate and repetitive use of both the hands. Irrespective of the instrument used, procedures like pipetting, microscopy, transferring, mixing and dispensing are part of routine work carried out in most medical laboratories. In addition, with the computerisation of most of the laboratories, laboratory workers are also required to use keyboards to operate the instruments, to record and process data and to generate reports for long hours.[12]

One of the previous studies done had determined the prevalence of CTS in the laboratory workers to be 21.5 %, very high than that found in the general population.[7]

Also previous studies done on laboratory workers have examined the risk factors for development of CTS and measures that can be employed to prevent it, they have not assessed the MP in their hands.[9]

Thus, as the laboratory workers form an important part of institutional set-up and as laboratory workers are required to have high degree of manual dexterity during their discharge of work-related tasks, we assessed MP in both the hands in them and comparison was made between MP measures and workplace factors. As they are actively involved in skilful, repetitive work involving both hands for 4 - 6 hours a day and as CTS is associated with sensory and motor abnormalities, we anticipated the MP to be less in the laboratory workers, especially in those with associated CTS.

For assessing the motor performance in both the hands, four parameters namely median MNCV, work done and time taken for the onset of fatigue in the flexors of fingers, handgrip strength and bimanual coordination were included as they were simple, easy to perform, non-invasive and reliable.

In the present study, median MNCV was within the normal range in the CTS group in both the hands. Previous studies have shown that in patients with mild CTS, there were only sensory abnormalities in the nerve conduction studies.[13] A study by Lee et al. inferred that the median MNCV decreased with increase in severity ($P < 0.05$).[14] However, due the lack of a control cohort to provide baseline values, the difference in median MNCV between normal individuals and those with mild CTS could not be compared in the latter study. Maincent et al. reported that a drop in median distal MNCV below a limit of 14 m / s results in true distal conduction slowdown, which may not be seen in the early stages of CTS.[15] Further, compared to the left hand, velocity was more on the right side. This may be due to the presence of a greater number of right-handed individuals in the study group. Work done and time taken for the onset of fatigue in both the hands was almost same in CTS group when compared to the normal. A study by Mattos et al. demonstrated a drastic reduction in grip force of fatigued hands with carpal tunnel syndrome.[16] In agreement with which, the hand grip strength was found to decline in both the hands of the CTS group of the present study. A number of previous studies have also reported exacerbated weakness or loss of grip in occupations involving repetitive work.[13,16,17,18]

Time taken for completion of the task was nearly the same in both the CTS and normal groups but duration of error in executing the task was more and efficiency index was slightly less in CTS group. Nataraj et al. while studying the effects of carpal tunnel syndrome on reaching and grasping the objects found a reduction of 41 % in the accuracy and 33 % in the precision of performing the task by the CTS group.[19] Compared to the left hand, MP was better on the right side. This may be because right hand being the dominant one is 10 % stronger than the non-dominant left hand.[20]

Compared to the technicians, only work done was less and onset of fatigue was early in the attenders in both the hands in the CTS group and for bimanual coordination test, time for completion of task was more, duration of error was more and efficiency index was slightly less in them. This decline in the MP in the attenders can be attributed as due to various factors including nutritional status, work pattern, socio-economic status etc.

With the increase in the number of working hours per week, MP was better for work done, time taken for onset of fatigue and bimanual coordination even in those with CTS, which can be explained by their prolonged duration of exposure to the hand intensive work. This is consistent with the previous studies where it has been observed that with practice and training, MP will be better.[21]

With the increase in the years of employment, only the efficiency index decreased which can be attributed to the age related changes.

Thus, the findings of the present study are by and large in agreement with the previous studies. The fact that the prevalence of CTS was found to be high in the laboratory workers but most of MP measures being normal in those with CTS, implies that they are at early stages of development of CTS. If proper preventive measures are not initiated, they may progress and may lead to late stages which can be quite debilitating.

In addition, as MP is associated with workplace factors and based on the impact of work factors on the laboratory workers in developing CTS, we suggest that further studies be carried out to develop preventive strategies in the workplace which will result in their better work performance. This study is the first of its kind as it comprehensively explores the vulnerability of laboratory workers to sensory and motor neuropathies such as CTS by assessing the motor performance of hands in terms of median motor nerve conduction velocity, work done and time taken for onset of fatigue, hand grip strength duration of error and efficiency index.

CONCLUSIONS

Although multiple parameters of motor performance in the laboratory workers seem normal among individuals with CTS, pivotal differences in the motor performance and capacity indicate early stages of CTS progression. Additionally, this study succeeds in delineating the possible work patterns that can serve as potential risk factors for decline in motor performance. This would facilitate the timely screening and diagnosis of laboratory workers who are at risk of developing sensory and motor neuropathies like CTS and in designing suitable management plans.

Data sharing statement provided by the authors is available with the full text of this article at jebmh.com.
Financial or other competing interests: None.
Disclosure forms provided by the authors are available with the full text of this article at jebmh.com.

REFERENCES

[1] Shiffman LM. Effects of aging on adult hand function. Am J Occup Ther 1992;46(9):785-792.
[2] Jebsen RH, Taylor N, Trieschmann RB, et al. An objective and standardized test of hand function. Arch Phys Med Rehabil 1969;50(6):311-319.
[3] Ahamed SS, Anas MB, Aref AA, et al. Prevalence and associated factors of Carpal Tunnel Syndrome (CTS) among medical laboratory staff at King Saud University Hospitals, KSA. Pak J Med Sci 2015;31(2):331-335.
[4] El-Helaly M, Balkhy HH, Vallenius L. Carpal tunnel syndrome among laboratory technicians in relation to personal and ergonomic factors at work. J Occup Health 2017;59(6):513-520.
[5] Palmer KT. Carpal tunnel syndrome: the role of occupational factors. Best Pract Res Clin Rheumatol 2011;25(1):15-29.
[6] Franklin GM, Friedman AS. Work-related carpal tunnel syndrome: diagnosis and treatment guideline. Phys Med Rehabil Clin North Am 2015;26(3):523-537.
[7] Kamaraddi SV, Latti RG, Kodliwadmath MV, et al. Determination of the prevalence of Carpal Tunnel Syndrome in the laboratory workers of Jawaharlal Nehru Medical College, Belgaum – a cross sectional study. Asian J Exp Biol Sci 2010;1(4):740-746.
[8] Björksten MG, Almby B, Jansson ES. Hand and shoulder ailments among laboratory technicians using modern plunger-operated pipettes. Appl Ergon 1994;25(2):88-94.
[9] Hoskins DB, Erickson J. Laboratory ergonomics – The wake-up call: a case study – How one company relieved stress and strain on its employees? Chemical Health and Safety 1998;5(1):20-23, 38.
[10] Oh SJ. Nerve conduction in focal neuropathies. In: Oh SJ, edr. Clinical electromyography nerve conduction studies. Philadelphia, PA, USA: Lippincott Williams & Wilkins 2003: p. 623-632.
[11] Macfarlane GJ. Identification and prevention of work-related carpal tunnel syndrome. The Lancet 2001;357(9263):1146-1147.
[12] Goldwyn L. Repetitive stress injuries in the laboratory setting. http://jclauson.com/msqa/term_papers/repetitive_stress_injuries_in_the_laboratory_setting.pdf. [Accessed on Aug 2004]
[13] Ashworth NL. Clinical evidence: Carpal Tunnel Syndrome. Issue - 13. London, England: BMJ Publishing 2005.
[14] Lee HJ, Kwon HK, Kim DH, et al. Nerve conduction studies of median motor nerve and median sensory branches according to the severity of carpal tunnel syndrome. Ann Rehabil Med 2013;37(2):254-262.
[15] Maincent K, Héron B, de Villemeur BT, et al. Early detection of median nerve compression by Electroneurography can improve outcome in children with Mucopolysaccharidoses. Orphanet J Rare Dis 2018;13:209.
[16] Mattos DJS, Domenech SC, Borges Jr NG, et al. Effect of fatigue on grip force control during object manipulation in carpal tunnel syndrome. Motor Control 2012;16(4):521-536.
[17] Silverstein BA, Fine LJ, Armstrong TJ. Occupational factors and carpal tunnel syndrome. Am J Ind Med 1987;11(3):343-358.
[18] Singh GK, Srivastava S. Grip strength of occupational workers in relation to Carpal Tunnel Syndrome and individual factors. Int J Occup Saf Ergon 2020;26(2):296-302.
[19] Nataraj R, Evans PJ, Seitz Jr WH, et al. Effects of Carpal Tunnel Syndrome on reach-to-pinch performance. PLoS One 2014;9:e92063.
[20] Dawson DM, Hallet M, Millender L. Entrapment neuropathies. 1ST edn. Boston: Little Brown and Company 1983.
[21] Pal GK. Pulmonary function tests. In: Pal GK, Pal P, Nanda N, eds. Textbook of Practical Physiology. 2nd edn. Chennai: Orient Longman Publications 2005: p. 154-161.