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**ORIGINAL REPORT**

# PREVALENCE AND RISK FACTORS FOR UPPER EXTREMITY ENTRAPMENT NEUROPATHIES IN POLIO SURVIVORS

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***Objective:*** **To investigate the electrophysiological prevalence and associated risk factors of upper extremity entrapment neuropathies in a cohort of Taiwanese patients with prior paralytic poliomyelitis.**

***Design:*** **Cross-sectional study involving a consecutive series of patients.**

***Subjects:*** **Ninety-seven polio survivors.**

***Methods:*** **Demographic factors, medical and work history were recorded. Symptoms and functional deficits of the hand, mobility impairment level, physical activity level and manual muscle testing were assessed, and nerve conduction studies were performed.**

***Results:*** **The electrophysiological prevalence of nerve entrapment among the polio survivors was 80%. The most common electrodiagnostic dysfunction was median neuropathy at the wrist (62%), followed by ulnar neuropathy at the elbow (41%) and ulnar neuropathy at the wrist (38%). In multiple logistic regression, subjects who reported that their jobs involved repetitive hand movements, had a body mass index greater than 24 kg/m², or used a cane/crutch were at increased risk of both median neuropathy at the wrist and ulnar neuropathy at the wrist. Subjects who used a wheelchair were also at increased risk of ulnar neuropathy at the wrist.**

***Conclusion:*** **These results indicate a high occurrence of upper extremity entrapment neuropathies in polio survivors. The documentation of risk factors in this study provides support for screening of at-risk subjects.**

*Key words:* poliomyelitis, entrapment neuropathy, median neuropathy at the wrist, risk factor.

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## INTRODUCTION

Upper extremity entrapment neuropathies are common in people with chronic motor disability of the legs. The prevalence of carpal tunnel syndrome in disabled populations such as patients with poliomyelitis and spinal cord injuries ranges from 22% to 64% (1–6). Ulnar nerve injury has also been reported in disabled patient cohorts (5–7). These injuries can have significant consequences, as individuals with lower extremity weakness may be partially or fully dependent on their upper limbs for mobility, activities of daily living, and employment. Treatment of patients with upper extremity entrapment neuropathies superimposed on a pre-existing disability poses special problems. Upper limb pain has been shown to negatively affect functional status and quality of life in patients with long-term poliomyelitis (8). While the primary injury itself limits the patient's independence, further functional limitation due to secondary complications, such as peripheral nerve entrapments, can markedly worsen the patient's quality of life.

Poliomyelitis is a severe viral infection of the central nervous system and affects the lower extremities twice as often as the upper extremities (9). Polio epidemics occurred worldwide in the 1940s and 1950s (10), and polio survivors are still one of the largest groups of disabled people in the world. Those with paralytic polio have now reached middle-age, and many have developed new upper extremity symptoms, such as pain, numbness, and weakness. To date, only one study has been reported in the literature specifically examining the prevalence and risk factors of upper extremity entrapment neuropathy in polio survivors (1). This study, however, was a retrospective evaluation of medical records that were often incomplete. Moreover, the study did not establish simultaneous control for possible confounders in multivariate models. Better knowledge of these matters would contribute to better management strategies for these patients. Therefore, the objectives of the present study were: (*i*) to determine the prevalence of upper extremity entrapment neuropathies in polio survivors by electrophysiological criteria; and (*ii*) to identify clinical risk factors associated with electrodiagnostic evidence of nerve entrapment in a cohort of adult Taiwanese polio survivors.

## MATERIAL AND METHODS

### *Participants*

A cross-sectional study design was used. A total of 108 subjects with antecedent poliomyelitis were recruited consecutively over the 24-

month period between 1 January 2005 and 30 December 2006 from patients of the physical medicine and rehabilitation clinic of the Cheng Hsin Rehabilitation Medical Center, Taipei, Taiwan. Inclusion criteria were as follows: (*i*) a history of paralytic poliomyelitis, with residual limb muscle weakness; (*ii*) no other neurological diseases or medical conditions, such as stroke, amputation, inflammatory arthritis, plexopathy or polyneuropathy that could cause muscle weakness; (*iii*) no serious illness, such as heart or lung disease, that would make a maximal strength test unsafe; and (*iv*) no fracture or surgeries within the past 3 years. Of the 108 polio survivors initially screened, 97 participated in this study. Seven individuals were excluded because they did not meet the inclusion criteria. The other 4 did not participate because they did not attend scheduled appointments. All subjects provided written informed consent prior to inclusion in the study.

*Procedure and measurement instruments*

The study was approved by the institutional review board of Cheng Hsin Rehabilitation Medical Center. All subjects underwent medical and symptoms history review, physical examinations, and nerve conduction studies by 2 experienced rehabilitation physicians. The following potential risk factors were collected at baseline: age, gender, work history, years since onset of polio, number of extremities with residual paresis, use of canes or crutches, use of wheelchairs, use of lower extremity orthoses. Subjects were classified as cane/crutch, wheelchair, or lower extremity orthosis users if they had used these assistive devices for mobility for at least one year, and, for cane/crutch users, if the device was used with the studied upper extremity. Measurements were performed as described below.

*Job analysis.* Subjects were asked to rate exposure to hand-repetition jobs on a 1–10 scale, in terms of frequency of hand repetition, where 0 = idle, no regular exertions; 2 = very slow motion, frequent pauses; 4 = slow steady motion, frequent brief pauses; 6 = steady motion, infrequent pauses; 8 = rapid steady motion, no regular pauses; and 10 = rapid steady motion, difficulty keeping up (11). High repetition was defined as a rating of 6 or greater. Ratings of repetition take into consideration 2 factors: (*i*) amount of recovery time within the work cycle, and (*ii*) how fast the hands are moving. A detailed description of the assessment strategy was provided, and subjects viewed videotaped examples of various rating levels (for example, typing with long rest pauses was rated 2, case packing was rated 4, moving objects from a conveyer to racks was rated 6, and fitting plastic clips to parts in an automobile assembly line was rated 8). Examples of high-repetition work were sewing-machine work, packing, manual machine feeding, and continuous typing. Low-repetition work included practising law, accounting, managerial work, lecturing, varied office work, and different kinds of maintenance work.

*Mobility impairment scale.* Mobility level was assessed using the mobility impairment scale developed by Klein et al. (12) for measuring mobility level in polio survivors. This scale consists of 5 mobility-related tasks including walking 3–4 city blocks, climbing and descending a flight of 10–12 stairs, pushing a large object such as a small sofa, stooping down to pick up a small object such as a pen or pencil from the floor, and carrying a 4.5 kg bag of groceries. Subjects were asked to rate their ability to perform these 5 mobility-related tasks on a scale from 1 (no difficulty) to 5 (unable). Scores range from 5 to 25, with high scores indicating more mobility impairment.

*Physical activity level.* Physical activity was measured using the Physical Activity Scale modified from the physical activity scale for the Elderly (PASE) (13) and based on self-reported time in walking and standing. The scale consists of 2 items including walking and standing and subjects were asked to rate how many hours per day they spent in each item. The responses were indicated using a 4-pont scale: 1 = < 1 h; 2 = 1 < 2 h; 3 = 2–4 h; and 4 = > 4 h. Items were summed to obtain a scale score ranging from 2 to 8, with higher scores indicating higher activity levels.

*Upper limb symptoms severity scale.* The upper limb symptoms severity scale is a self-report measure of carpal tunnel syndrome-related symptom severity (14). The scale consists of 11 statements related to pain, paraesthesia, numbness, weakness, nocturnal symptoms in upper limbs and subject's level of agreement measured on a 5-point scale (1 indicating "no symptoms", 5 indicating "most severe"). Scores range from 11 to 55, with high scores indicating more severe symptoms. Subjects answered the questions for each hand, but in data analyses only responses for the most affected hand (based on electrodiagnostic reports) were considered.

*Upper limb functional status scale.* The upper limb functional status scale evaluates the severity of functional status of the hand in carpal tunnel syndrome (14). The scale consists of 8 items and the subjects were asked to rate their upper limb performance of activities of daily living on a 5-point grading scale describing how easy or difficult it is to perform the activity (1 = no difficulty with the activities, 5 = cannot perform the activities at all). Scores range from 8 to 40, with high scores indicating more upper limb functional impairment. Only responses for the most affected hand (based on electrodiagnostic reports) were considered.

*Physical examination.* Weight and height were determined with subjects lightly dressed but without shoes, using a standard scale. Body mass index (BMI) was calculated according to the formula of body weight (kg)/height ($m^2$). A BMI equal to or exceeding 24 $kg/m^2$ was considered overweight. Wrist measurements were made at the distal wrist crease by a ruler in clamp form, and a wrist index was calculated by dividing depth by width. Muscle strength of the hip flexors, hip extensors, hip abductors, knee extensors and ankle dorsiflexors were measured bilaterally by manual muscle testing (MMT) by the same physiatrist, according to the Medical Research Council Scale. A sum score was obtained by adding the scores of all muscle groups tested (maximum score = 50). For the multiple regression analysis, MMT sum scores were dichotomized into those equal to or exceeding 30 (average resistance to gravity) vs those less than 30.

*Electrophysiological methods.* Electrodiagnostic studies of the median and ulnar nerves were conducted bilaterally by a board-certified rehabilitation physician blinded to the clinical data using a Viking 4 apparatus (Nicolet, Madison, WI, USA). Palmar temperature was kept constant at approximately 32ºC. For motor nerve conduction studies, the median nerve was stimulated at the wrist 6 cm proximal to the recording electrode (abductor pollicis brevis) and the antecubital fossa. The ulnar nerve was stimulated 6 cm proximal to the recording electrode (abductor digiti minimi (ADM) or first dorsal interosseous (FDI)), 2 cm distal to the medial epicondyle (below elbow), and then 10 cm proximal to that site (above elbow). Sensory nerve action potentials (SNAPs) were obtained antidromically, after stimulation at the wrist (14 cm proximal to the recording electrode) and elbow, and recording from digit 2 for the median nerve, digit 5 for the ulnar nerve. Dorsal ulnar cutaneous nerve SNAP was recorded between the fourth and fifth metacarpals and was stimulated 10 cm from the active electrode. In addition, median sensory conduction from the palm to the wrist was measured over an 8-cm conduction distance. These methods follow the guidelines of the American Academy of Electrodiagnostic Medicine (AAEM) (15, 16).

When clinically necessary, peroneal motor conduction and sural sensory conduction studies were performed to exclude polyneuropathy and electromyography (EMG) of biceps brachii, triceps brachii, extensor digitorum comunis and flexor superficialis digitorum muscles were performed to exclude plexopathy.

Electrophysiological diagnostic criteria of median neuropathy at the wrist (MNW) was made on the basis of at least one of the following (17, 18): (*i*) prolonged distal motor latency (DML) of median nerve greater than 4.2 ms; (*ii*) prolonged median nerve digit 2 sensory peak latency greater than 3.6 msec or slow sensory nerve conduction velocity (SNCV) less than 40 m/sec; or (*ii*) prolongation of the median SNAP of digit 2 relative to the ulnar SNAP of digit 5 greater than 0.4 msec or prolonged median mid-palm latency greater than 2.2 cm. Normal median conduction along the forearm was obligatory.

Electrophysiological diagnostic criteria of ulnar neuropathy at the elbow (UNE) was made on the basis of at least one of the following (19): (*i*) reduction of motor nerve conduction velocity (MNCV) from above elbow to below elbow (MNCV less than 50 m/sec); or (*ii*) MNCV from above to below elbow more than 10 m/sec slower than MNCV from below elbow to wrist.

Electrophysiological diagnostic criteria of ulnar neuropathy at the wrist (UNW) requires at least one of the following (20, 21): (*i*) prolonged wrist to ADM latency greater than 3.7 ms; (*ii*) prolonged wrist to FDI latency greater than 4.5 ms; or (*iii*) slow wrist to digit 5 SNCV less than 40 m/sec. Normal dorsal ulnar cutaneous SNCV was obligatory.

The electrophysiological severity of MNW was assessed by the following 6-point rating scale (22): 1, median-nerve SNCV and DML normal, but significant difference in median and ulnar SNAP latency; 2, slowing SNCV, normal DML; 3, DML > 4.2 msec and < 6.5 msec with preserved SNAP; 4, DML > 4.2 msec and < 6.5 msec with absent SNAP; 5, DML > 6.5 ms; and 6, compound muscle action potential (CMAP) < 0.2 mV.

For patients with MNW or UNW on both sides, we used electrodiagnostic, wrist anthropometric, symptoms severity and functional status data from the most severely affected wrist for statistical evaluation. We defined most severe as based on electrodiagnostic reports.

### *Statistical analysis*

Data were analysed using the SPSS for Windows, Release 12.0 (Statistical Package for Social Sciences Inc., Chicago, IL, USA). The following variables were evaluated as potential risk factors for MNW or UNW according to International Classification of Functioning, Disability and Health (ICF) categories: age at interview, gender, work status (job with repetitive hand movements) (ICF personal factors); age at polio onset, duration of disability, number of extremities with residual paresis (ICF health condition variables); leg muscle strength, BMI, wrist index (ICF body functions and structures); mobility impairment, physical activity (ICF activities and participation); use of cane/crutch, use of wheelchair, and use of lower extremity orthosis (ICF environmental factors). The upper limb symptoms severity scale and upper limb functional status scale were considered as outcome measures for MNW. Student's *t*-test was used for continuous variables and Fisher's exact test was used to analyse categorical variables. The variables for potential risk factors that were found to show statistically significant differences between groups (job with repetitive use of hands, MMT sum score less than 30, BMI greater than 24 kg/m$^2$, cane/crutch use, and lower extremity orthosis use for both MNW and UNW; wheelchair use for UNW) were subsequently analysed in the multiple logistic regression analysis. To analyse possible multicollinearity between the above variables studied, Spearman correlation coefficients between the variables were first analysed. No 2 variables were correlated at more than 0.20 ($p > 0.1$), which was adequate for the subsequent analysis. Multiple logistic regression analysis with backward elimination procedure was then performed to evaluate the association between MNW or UNW and various risk factors while controlling for potential confounding effects of other covariates. Adjusted odds ratios (ORs) were calculated to determine the relative risk from regression coefficients, and associated standard errors were used to determine 95% confidence intervals (CIs).

## RESULTS

Ninety-seven polio survivors (59 women and 38 men) were recruited. Subjects' mean age was 43.5 (range 25–67) years and the mean time since onset was 40.7 (range 24–66) years. Mean age at onset of polio was 2.1 (range 0.5–16) years. Upper and lower extremities were affected in 5 subjects (5%), only the lower extremities in 90 subjects (93%), and only the arms in 2 subjects (2%). All 7 subjects with upper extremity involvement had only one arm affected and were able to use mobility devices.

Electrophysiological examination showed that 78 of 97 (80%) subjects had upper limb entrapment neuropathy (Table I). Of the 97 individuals, 60 (62%) had MNW (bilaterally in 50 and unilaterally in 10). The neurophysiological severity classification revealed that the largest number of MNW subjects were in stage 3 (stage 5, 5% of cases, 2% in dominant hand and 3% in non-dominant hand; stage 4, 1% in non-dominant hand; stage 3, 57%, 34% in dominant hand and 23% in non-dominant hand; stage 2, 17%, 8% in dominant hand and 9% in non-dominant hand; stage 1, 20%, 6% in dominant hand and 14% in non-dominant hand). With the ulnar nerve, UNW was diagnosed in 37 subjects (38%) (bilaterally in 16 and unilaterally in 21) and UNE was diagnosed in 40 subjects (41%) (bilaterally in 6 and unilaterally in 34, 26 in dominant side and 20 in non-dominant side) (Table I). Among these 60 subjects with MNW, 31 also had UNW and 27 also had UNE. There were 14 subjects with 3 kinds of entrapment neuropathies (MNW, UNW and UNE).

Upper limbs symptom scale was abnormal (> 11 score point) in 65 subjects (67%) (41 in both hands and 24 in one hand) and functional status scale was abnormal (> 8 score point) in 30 subjects (31%) (20 in both hands and 10 in one hand). The subjects with MNW had significantly higher upper limb symptoms scores compared with the control cohort ($p < 0.01$) (Table II). However, no significant difference in the upper limb functional scores was noted between the 2 groups. All subjects with MNW, UNW and UNE had abnormal upper limb symptoms scale.

Table II shows the demographic, functional, and clinical characteristics of the subjects with and without MNW or UNW. Regarding the potential risk factors for MNW, the MNW cohort had significantly higher percentages of subjects who reported jobs with repetitive hand movements, had a BMI greater than 24 kg/m$^2$, had an MMT sum score less than 30, used a cane/crutch, or used a lower extremity orthosis. The results of multiple logistic regression are presented in Table III. Significant independent risk factors for MNW included having a job with repetitive hand movements (OR 6.1, 95% CI 2.1, 17.5), having a BMI greater than 24 kg/m$^2$ (OR 5.5, 95% CI 1.6, 19.1), and cane/crutch use (OR 6.2, 95% CI 1.6, 23.4). Although higher proportions of subjects with MMT sum scores less than 30 and lower extremity orthosis use were noted in the MNW cohort, these differences did not reach the level of statistical significance in the multiple logistic regression analysis. With the numbers and percentages of the potential risk factors for UNW, UNW cohort had significantly higher percentages of subjects who reported jobs with repetitive hand movements, had a BMI greater than 24 kg/m$^2$, had an MMT sum score less than 30, used a cane/crutch, used a wheelchair, or used a lower extremity orthosis (Table II). Significant independent risk factors for UNW in-

Table I. *Electrodiagnostic findings in 97 polio subjects*

| | Median-wrist ($n$=60) $n$ (%) | Ulnar-wrist ($n$=37) $n$ (%) | Ulnar-elbow ($n$=40) $n$ (%) |
|---|---|---|---|
| Bilateral | 50 (52) | 16 (16) | 6 (6) |
| Unilateral | 10 (10) | 21 (22) | 34 (35) |
| None | 37 (38) | 60 (62) | 57 (59) |

Table II. *Characteristics of subjects with median neuropathy at wrist (MNW) and ulnar neuropathy at wrist (UNW)*

| | MNW | | | UNW | | |
|---|---|---|---|---|---|---|
| Variable | With ($n$=60) | Without ($n$=37) | $p$* | With ($n$=37) | Without ($n$=60) | $p$* |
| *Personal factors, n (%)* | | | | | | |
| Age, years | | | | | | |
| 20–39 (referent) | 12 (20) | 11 (30) | 0.28 | 7 (19) | 16 (27) | 0.47 |
| 40–70 | 48 (80) | 26 (70) | | 30 (81) | 44 (73) | |
| Gender, male | 25 (42) | 13 (35) | 0.67 | 14 (38) | 24 (40) | 1 |
| Job with high repetition | 44 (73) | 13 (35) | <0.01 | 29 (78) | 28 (47) | <0.01 |
| *Health condition variables* | | | | | | |
| Age at polio onset, years, mean (SD) | 1.9 (1.2) | 2.3 (3.3) | 0.43 | 1.8 (1.4) | 2.2 (2.7) | 0.29 |
| Duration of disability, years | | | | | | |
| <30 (referent) | 1 (2) | 5 (13) | 0.28 | 0 | 6 (10) | 0.21 |
| 30–39 | 15 (25) | 11 (30) | | 7 (19) | 19 (32) | |
| 40–49 | 36 (60) | 21 (57) | | 28 (76) | 29 (48) | |
| ≥50 | 8 (13) | 0 | | 2 (5) | 6 (10) | |
| Extremities with residual paresis, mean (SD)† | 1.6 (0.5) | 1.4 (0.6) | 0.54 | 1.5 (0.5) | 1.6 (0.6) | 0.54 |
| *Body functions and structures* | | | | | | |
| MMT sum scores <30, n (%) | 40 (67) | 16 (43) | 0.03 | 30 (81) | 28 (47) | 0.001 |
| BMI >24 kg/m$^2$, $n$ (%) | 24 (40) | 6 (16) | <0.01 | 16 (43) | 14 (23) | <0.05 |
| Wrist index, mean (SD) | 0.7 (0.0) | 0.7 (0.0) | 0.47 | 0.7 (0.0) | 0.7 (0.0) | 0.58 |
| *Activities and participation, mean (SD)* | | | | | | |
| Mobility impairment scores | 9.4 (5.4) | 8.6 (5.2) | 0.44 | 10.2 (6.4) | 8.4 (4.4) | 0.14 |
| Physical activity scores | 4.8 (1.6) | 4.1 (1.8) | 0.06 | 4.3 (1.7) | 4.7 (1.7) | 0.19 |
| *Environmental factors, n (%)* | | | | | | |
| Crutch or cane use | 34 (57) | 6 (16) | <0.01 | 24 (65) | 16 (27) | <0.001 |
| Wheelchair use | 7 (12) | 7 (19) | 0.38 | 9 (24) | 5 (8) | <0.05 |
| Lower extremity orthosis use | 25 (42) | 7 (19) | 0.03 | 17 (46) | 15 (25) | <0.05 |
| *Outcomes of MNW, mean (SD)* | | | | | | |
| Upper limb symptoms scores | 17.2 (6.3) | 13.3 (4.4) | <0.01 | 17.0 (6.6) | 14.9 (5.4) | 0.11 |
| Upper limb functional scores | 9.5 (2.6) | 8.8 (2.0) | 0.15 | 9.5 (2.5) | 9.1 (2.4) | 0.42 |

*$p$-value based on Fisher's exact test for categorical variables and Student's $t$-test for continuous ones.
†Range 0–4 (4 extremities).
SD: standard deviation; MMT: manual muscle testing; BMI: body mass index.

cluded having a job with repetitive hand movements (OR 6.5, 95% CI 1.9, 22.8), having a BMI greater than 24 kg/m$^2$ (OR 3.3, 95% CI 1.0, 10.9), cane/crutch use (OR 13.7, 95% CI 2.9, 64.2) and wheelchair use (OR 40.3, 95% CI 5.1, 318.79) (Table III).

## DISCUSSION

Our results show that the prevalence of electrophysiological upper limb nerve entrapments in polio survivors is 80% and most people have 2 or more types of entrapments. The most common electrodiagnostic dysfunction was MNW (in 62% of subjects), followed by UNE (41%) and UNW (38%). While MNW and UNW were often bilateral, UNE was mostly unilateral. Both MNW and UNW shared the same risk factors, including having a job with repetitive hand movements, having a BMI greater than 24 kg/m$^2$, and cane/crutch use. Wheelchair use also increased the risk of UNW. To our knowledge, this is the largest study of the prevalence and risk factors for upper limb entrapment neuropathy in polio survivors of an Asian population. The strengths of this study were the use of patient interview, clinical and electrophysiological investigation data and the ability to control for possible confounding factors.

Table III. *Results of multiple logistic regression analysis*

| | MNW | | UNW | |
|---|---|---|---|---|
| Variable | Adjusted OR | 95% CI | Adjusted OR | 95% CI |
| Jobs with high repetition | 6.1 | 2.1–17.5 | 6.5 | 1.9–22.8 |
| MMT sum scores <30 | 1.6 | 0.6–4.8 | 1.0 | 0.2–4.1 |
| High body mass index (>24 kg/m$^2$) | 5.5 | 1.6–19.1 | 3.3 | 1.0–10.9 |
| Crutch or cane use | 6.2 | 1.6–23.4 | 13.7 | 2.9–64.2 |
| Lower extremity orthosis use | 0.9 | 0.3–3.3 | 1.5 | 0.4–6.2 |
| Wheelchair use | | | 40.3 | 5.1–318.7 |

MNW: median neuropathy at wrist; UNW: ulnar neuropathy at wrist; OR: odds ratio; CI: confidence interval; MMT: manual muscle testing.

The prevalence of MNW in this study was higher than that previously reported (1, 3). Werner et al. (1) studied 148 post-polio survivors and reported a prevalence rate of 22%. The discrepancy in prevalence may be a function of different populations and differences in case definition. In the study of Werner et al. (1), only one-third of subjects (50/148) underwent nerve conduction studies and the diagnosis criteria of MNW was based on a combination of clinical history and abnormal electrodiagnosis, whereas our study specifically looked at electrophysiological prevalence. Since Werner et al.'s study (1) was retrospective and performed as chart reviews, prevalence could

be underestimated if staff did not record symptoms of MNW. Also, our electrodiagnostic criteria consisted of a slow SNCV or prolonged distal motor latency, while Werner et al. (1) assessed only sensory parameters. This may again have under-reported their estimated prevalence of median neuropathy, since some patients with MNW present with predominant compression of the motor branch (23). Another possible explanation for our higher prevalence could be case concentration, since Cheng Hsin Rehabilitation Medical Center is one of the largest referral centres for poliomyelitis in Taiwan. Nevertheless, our numbers are similar to those found by other investigators who used nerve conduction velocities to look at MNW in chronic paraplegics; for example, 63% in 47 paraplegics below the T2 level (4), and 55% in 31 paraplegics below the T1 level (6).

The present study identified a significant association between repetitive work and MNW, in contrast to a previous study showing that work history did not significantly influence the relative risk of MNW in post-poliomyelitis patients (1). One possibility for this discrepancy is that we used a rating method to quantify the repetition of hand work on a continuous scale from 1 to 10, while the previous study defined repetitiveness solely in qualitative term (mild/strenuous). Our findings are in keeping with several epidemiological studies in industrial medicine (24, 25), which demonstrated an association between repetitive tasks and the development of MNW. The proposed mechanism is that microtrauma elicited by repetitive manual work can produce transient modification of median nerve conduction, which could later develop into either nerve conduction block or return to normal (25, 26). Work modifications, such as flexibility in the scheduling of tasks or a reduced work schedule, have been shown to improve the symptoms and nerve conduction abnormalities associated with MNW in assembly line workers (25). This issue should be explored in future research involving post-poliomyelitis patients.

Although previous studies have shown that a higher BMI is an independent risk factor for MNW in general populations (27), to our knowledge, our study is the first to show that this effect also occurs in polio survivors. The association between increased BMI and MNW could be explained by accumulation of fatty tissue within the carpal canal and increased hydrostatic pressure throughout the carpal canal in obese individuals (28). Our findings suggest that weight loss may prevent median nerve injury in polio survivors. However, this needs to be investigated further.

Consistent with previous reports (1), we found that use of canes or crutches carried an increased risk of developing MNW in polio survivors. This mechanism probably relates to extreme wrist extension and isometric forearm muscle contraction, as well as frequent direct pressure applied to the carpal tunnel when using canes or crutches. Increased carpal tunnel pressure is suggested to be an important factor in median nerve entrapment pathophysiology (28). Passive wrist extension, as well as isometric contraction of the finger flexors that travel within the carpal tunnel, has been demonstrated to markedly increase carpal tunnel pressure (29, 30). In addition, tenosynovitis due to repetitive strain and overuse of the flexor tendons and degenerative arthrosis of the hand and wrist, both of which have been observed to be more frequent among the disabled using upper extremity dependent mobility aids, may contribute to the development of median neuropathy by decreasing the carpal tunnel lumen (8). As is recommended for wheelchair users, compressive median neuropathy can be prevented or reduced by frequently changing one's position in relation to the hand grip (31). The use of a glove with wrist supports and padding over the heel of the hand may also prevent compression neuropathies at the wrist (31).

Several reports have shown that disability duration is significantly associated with electrophysiological median nerve dysfunction in disabled patients (4, 32), but the mechanism underlying this association has not been determined. In this study there were more subjects with disability durations of 40–49 years and 50 or more years in the MNW cohort than in the control cohort, but the difference did not reach the level of statistical significance. Controlling confounding factors such as BMI and mobility device use may have reduced the magnitude of the association between disability duration and median nerve dysfunction. However, the relatively small sample size of this study may have limited the ability to detect significant differences between the MNW and control groups.

In our study, the electrophysiological prevalence of UNW and UNE was 38% and 41%, respectively. Given the similar anatomical position of the ulnar nerve and the median nerve at the wrist, the risk factors involved in polio survivors are similar. The prevalence of UNE (41%) was lower than that of MNW (62%) in the polio population, presumably because repetitive movements typical for this group stress the elbow less than the wrist. With regard to the distribution, in our study MNW was mostly bilateral, UNE mostly unilateral, and UNW did not show a clear predominance. Although it is not clear what the mechanism of action is, these findings are similar to those for industrial workers (33, 34). A possible explanation for bilateral involvement of MNW in the polio population is repeated extreme extension of both wrists during transferring or pressure relief. Alternatively, it may be due to work-related repetitive movement of both hands or accumulation of fatty tissue within both wrists, as we demonstrated that there was an association between MNW and work characteristics or a higher BMI. There is little literature on UNE in the disabled population. We found that UNE was mostly unilateral, which suggests that anatomy has little influence on the development of UNE in the polio population. Unilateral action such as heavy, repetitive contraction of the flexor carpi ulnaris muscle and abnormal elbow mechanics with the use of mobility devices may be contributing factors. Further studies are required to determine the aetiology of UNE in polio survivors.

This study has several limitations. First, as a hospital-based study, it may be affected by selection bias that hinders the generalizability of the results to the entire polio population, although the method used to assess risk factors is valid. Secondly, some variables such as job analysis were assessed by self-report and were, therefore, prone to a certain degree of subjectivity. Finally, the small sample size limits the statistical power to identify risk factors. A multicentre study would be needed to increase the sample size, but reliability could be affected.

In conclusion, this study demonstrates that the polio population has a high prevalence (80%) of nerve entrapment

electrodiagnostically. The most common electrodiagnostic dysfunction was MNW (62%), followed by UNE (41%) and UNW elbow (38%). Subjects who reported jobs with repetitive hand movements, had a higher BMI, or used mobility devices were at risk of both MNW and UNW. This study provides useful clinical information for practitioners counselling the polio population regarding nerve entrapment. Our results suggest that weight loss, changes in mobility aids biomechanics and working a reduced schedule may help prevent median and ulnar nerve injury in polio survivors. In addition, the association documented here provides compelling support for screening at-risk subjects. Further study to assess the effects of possible prevention and specific therapies for entrapment neuropathy in polio patients is needed to help them live healthier lives.

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