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Do we underestimate influences of diabetic mononeuropathy or polyneuropathy on hand functional performance and life quality?

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ABSTRACT

Aims/Introduction: The purpose of the present study was to identify whether there are differences in hand dexterity, hand functional performance and quality of life between diabetes patients with mononeuropathy and polyneuropathy of their hands to further present the importance regarding the impacts of diabetic neuropathic deficits on patients' functional capacity.

Materials and Methods: The neurological deficits of 127 patients with type 2 diabetes were examined by electrophysiological tests for the median and ulnar nerves, and were stratified into the diabetic mononeuropathy, diabetic polyneuropathy and non-diabetic neuropathy groups by sensory amplitude of these nerves. The Purdue pegboard test, Michigan Hand Outcomes Questionnaire, and Diabetes-39 were carried out to understand patients' hand dexterity, functional hand performance and quality of life, respectively.

Results: The results showed significant differences in all subtests of the Purdue pegboard test among the three groups. Furthermore, aesthetics, patient's satisfaction of the Michigan Hand Outcomes Questionnaire and diabetes control, sexual functioning, energy, and mobility of the Diabetes-39 also showed significant differences among the three groups.

Conclusions: The present study shows the patients with polyneuropathy suffer from more negative impacts on hand functional performance and quality of life than those with mononeuropathy and without neuropathy. These findings might assist both patients and clinicians in better realizing the impacts of neuropathic hands, and planning suitable strategies of intervention or health education to prevent declines in hand functions.

INTRODUCTION

Diabetes mellitus, a comprehensive and heterogeneous disease characterized by a condition of hyperglycemia, usually results in numerous complications. One of the most common complications is neuropathy[1–3], which is estimated to have a 5–80% prevalence rate among diabetes patients[4]. As the number of diabetes patients has increased rapidly in recent years, and the accompanying complications can seriously disturb daily routines and quality of life, both patients and medical professions have noted that this easily neglected, but difficult to detect, condition regarding functional hand disabilities might be induced by diabetic neuropathies[5].

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Some previous works have shown that dexterity, which is one of the important hand functions for carrying out therapeutic and daily tasks, is easily affected and consequently influences patients' hand functional performances and quality of life in the process of diabetes mellitus[6–8]. These studies showed how neuropathic hands can disturb the functional hand performance and quality of life of diabetes patients, with negative effects on carrying out therapeutic procedures and daily tasks, even with only slight neuropathic deficits of the hands[5,9]. A recent study showed that hyperglycemia and disease chronicity significantly impact the sensorimotor control of the hand, and also the sensory and motor nerve conduction studies[10]. The median nerve is well known as one of the critical nerves that contribute to various hand manipulation functions. The prevalence of median

neuropathy among diabetes patients has been reported to be approximately 58–82%, based on an electrophysiological study[11]. Electrophysiological measurements can be used to show abnormalities of nerve functioning in the hand, especially with regard to the sensory amplitude of nerve conduction[12–14]. The consequences of abnormal sensory functioning of the nerve system as a result of the involvement of an impaired median nerve, ulnar nerve or both, might gradually contribute to different severities of neuropathic signs and symptoms, finally developing as mononeuropathy or polyneuropathy[15,16].

However, the issue of whether mononeuropathy or polyneuropathy of the hand might have different influences on hand functional capacity remains unclear, and thus more evidence is required to show the impacts of these conditions on functional hand performance and quality of life[5,8,17]. The aim of the present study was therefore to identify whether diabetic mononeuropathy or polyneuropathy might have different impacts on the hand functional performance and quality of life of diabetes mellitus patients, using functional measurements. We hypothesized that diabetic mononeuropathy or polyneuropathy can influence patients' functional hand performance and quality of life to a certain extent, and thus patients with diabetic polyneuropathy might have worse hand functions and quality of life than those without neuropathy or with mononeuropathy.

METHODS

Participants

A total of 127 patients were enrolled from the Outpatient Department of Metabolism and Endocrinology in Chia-Yi Christian Hospital, Chia-Yi, Taiwan. The inclusion criteria for the patients were as follows: (i) diagnosed as diabetes mellitus type 2 based on the 1997 criteria of the American Diabetes Association; and (ii) aged >18 years, either male or female. The exclusion criteria were as follows: (i) other hand disorders or pathologies, such as muscular, vascular, inflammatory diseases and chronic alcoholism, which might influence hand functions; (ii) damaged central or peripheral nerve; for example, traumatic brain injury, stroke, Parkinson's or Alzheimer's disease, psychiatric syndromes and brachial plexus injury; (iii) previous musculoskeletal or neurological diseases of the hand, such as trigger finger or carpal tunnel syndrome, before diabetes mellitus onset; (iv) prior history of hand surgery; and (v) primary symptoms of pain over the hand and upper limbs.

This study received ethical approval from the institutional review board at Ditmanson Medical Foundation, Chia-Yi Christian Hospital. All patients were fully informed about the protocol used in this study, and signed informed consent forms before their participation.

The median and ulnar nerves are the crucial nerves in the upper extremities, and are involved in most hand manipulation functions. When one or both of these nerves is damaged, then this is clinically defined as mononeuropathy or polyneuropathy, respectively[15]. All the patients recruited in the present study were stratified into three groups: diabetic mononeuropathy (DMN), diabetic polyneuropathy (DPN) and non-diabetic neuropathy (NDN), according to electrophysiological examinations of the median and ulnar nerves. Patients in the DMN group had only median or ulnar neuropathy induced by diabetes mellitus. Patients in the DPN group had both median and ulnar neuropathy induced by diabetes mellitus. Finally, those patients without neuropathy were classified in the NDN group.

Instruments

Nerve conduction studies

The nerve conduction study was carried out by stimulating the median and ulnar nerves using surface electrodes with the Medelec Synergy N-EP system (Oxford Instruments Medical, Inc., Tubney Woods, Abingdon, Oxon, UK). Three parameters were selected to reflect the nerve response: (i) the amplitude of the sensory nerve action potential of the median nerve (SAMN) and ulnar nerve (SAUN); (ii) the peak distal latency of the SAMN/SAUN; and (iii) the conduction velocity. The SAMN and SAUN values were obtained to determine the impact of the neuropathic impairments on all participants' hands. The reference SAMN and SAUN for a healthy population are 32.1 and 28.8 μV, respectively[18].

Purdue pegboard test

The Purdue pegboard test, a standard and common hand function test, is commonly used to assess manual dexterity on the involved side as well as both sides of the hand. There are four subtests, including those for the right hand, left hand, both hands and assembly. A higher score on the Purdue pegboard test means that the patient has better hand dexterity functions. The test–retest reliability of this instrument is in the range of 0.82–0.91, and the criterion-related validity of this test is 0.73–0.9[19,20].

Michigan Hand Outcomes Questionnaire

The Michigan Hand Outcomes Questionnaire (MHQ) is a self-administered questionnaire for measuring physical hand function and patient satisfaction with regard to some disease, as well as the performances for both hands. This questionnaire contains six dimensions, which are overall hand function, activities of daily living, work performance, pain, aesthetics and patient satisfaction, and these are assessed using 37 patient-reported questions. Lower scores in all dimensions, except pain, indicate worse hand functional performance. The reliability of this test ranges from 0.81 to 0.97[21,22].

Diabetes-39

The Diabetes-39 (D-39) instrument, a self-reported assessment with five subdimensions, including diabetes control, sexual functioning, social burden, anxiety and worry, and energy and mobility, is a disease-specific questionnaire with 39 questions for assessing the quality of life among patients with diabetes. Higher scores in each dimension indicate a worse quality of life. The reliability of the Chinese version of the instrument ranges

from 0.82 to 0.93, and this questionnaire also has acceptable convergent and discriminant validity[23,24].

Data collection

The demographic data of all participants was collected through individual interviews. After the interview, each participant received a neurological electrophysiological examination, and the related nerve conduction studies examined the SAMN and SAUN for both hands. Each participant was then asked to sit comfortably in front of an examining table facing a pegboard, and the manual dexterity of their hands was examined using the Purdue pegboard test. Finally, each participant completed the MHQ and D-39 questionnaires to assess their perceptions of their hand functions and diabetes-related quality of life, respectively.

Statistical analysis

SPSS 17.0 for Windows (Statistical Package for Social Sciences Inc., Chicago, Illinois, USA) was used for the statistical analyses. The non-parametric Kruskal–Wallis test was used to assess the statistical differences with regard to the demographic results, clinical features, hand manipulative functioning and quality of life among the three groups. The statistical significance level was set at $P < 0.05$. The Mann–Whitney *U*-test was used to compare the categorical data, and the *P*-value was set at 0.0167 ($P < 0.0167$).

RESULTS

Characteristics of all participants

A total of 127 participants were enrolled in the present study, with a mean age of 58.8 ± 9.3 years (range 27–77 years). The descriptive data of disease duration and hemoglobin A1c (HbA1c) of the participants were 112.7 ± 82.3 months and 7.7 ± 1.2%, respectively. The proportions of participants showing abnormalities and normality of the evaluated median or/and ulnar nerves amplitude of the sensory nerve action potential are summarized in Table 1. The results showed that 92.9% of participants ($n = 118$) had hand neuropathy, whereas just 7.1% of participants ($n = 9$) were without hand neuropathy. Among those with hand neuropathy, 20.5% ($n = 26$) had DMN and 72.4% ($n = 92$) had DPN. In addition, 76.9% ($n = 20$) of the patients in the DMN group had median mononeuropathy and 23.1% ($n = 6$) had ulnar mononeuropathy.

Demographic and clinical features of the three groups

Table 1 shows that the mean ages were 58.4 ± 9.5, 59.4 ± 9.3, and 52.9 ± 6.5 years for the DMN, DPN and NDN groups, respectively, whereas the disease durations were 112.4 ± 78, 115.1 ± 83.7, and 88.7 ± 85.4 months for the DMN, DPN and NDN groups, respectively. The mean values of the National Glycohemoglobin Standardization Program HbA1c were 7.3 ± 1.2, 7.8 ± 1.3, and 7.5 ± 1.0 (International Federation of Clinical Chemistry HbA1c [mmol/mol]: 56.3 ± 13.6, 61.9 ± 13.8 and 59.1 ± 11.4) for the DMN, DPN and NDN groups, respectively. Accordingly, there were no statistically significant differences with respect to the disease duration and HbA1c ($P > 0.05$) among the three groups.

Comparison of hand dexterity through the purdue pegboard test among the three groups

The results of the Purdue pegboard test are shown in Table 2, and reveal significant differences in the scores in all subtests among the three groups ($P < 0.01$). The scores of all subtests in the NDN group were higher than those in the DMN and DPN groups. Significant variability between the DPN group compared with DMN or NDN groups is noted for all the subtests of hand dexterity in the Purdue pegboard test ($P < 0.0167$; Table 3). However, no significant differences in the hand dexterity performance were found between the DMN and NDN groups ($P > 0.05$).

Comparison of self-perceived hand functional outcomes through the MHQ among the three groups

With regard to the dominant and non-dominant hands, the dimensions of aesthetics with hand function in the MHQ showed significant differences among the three groups (Table 2; $P < 0.05$). The patients' satisfaction with the dominant hand also showed significant differences among those groups, but no significant difference was found with regard to the non-dominant hand. Although no statistical differences were found in the dimensions of overall hand function, activities of daily living, work performance, pain and total scores among the study groups ($P > 0.05$), higher scores for these dimensions were observed in the NDN group than for the DMN and DPN groups. Comparing the MHQ results between the DPN and DMN groups, significant differences were found in the dimensions of total score, aesthetics and patient satisfaction with the non-dominant hand (Table 3). Statistical differences in the dimensions of patient satisfaction, aesthetics, and overall hand function with the dominant hand were noted between the DPN and NDN groups (Table 3). No significant differences in the MHQ scores were found between the DMN and NDN groups ($P > 0.05$).

Comparison of self-perceived quality of life through the D-39 among three groups

The scores of the DPN group were higher than those of both the DMN and NDN groups for most dimensions in the D-39, showing that the patients with diabetic polyneuropathy had lower perceived quality of life than those with non-neuropathy or mononeuropathy did (Table 2). There were significant differences in the dimensions of diabetes control, sexual functioning, energy and mobility in the D-39 among the three groups ($P < 0.05$), whereas there were no significant differences ($P > 0.05$) for the dimensions of anxiety and worry, and social burden among the groups (Table 2). Significant differences were found in the dimensions of diabetes control, social

Table 1 | Demographic data and distribution of all study participants

Variable	All patients	Three groups		
	n = 127	DMN (*n* = 26) 26/127 (20.5%)	DPN (*n* = 92) 92/127 (72.4%)	NDN (*n* = 9) 9/127 (7.1%)
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
Age (years)	58.4 ± 9.8	58.4 ± 9.5	59.4 ± 9.3	52.9 ± 6.5
Sex (female/male)	57/68	15/11	36/56	7/2
Duration (months)	113.1 ± 80.2	112.4 ± 78	115.1 ± 83.7	88.7 ± 85.4
NGSP HbA1c (%)	7.7 ± 1.2	7.3 ± 1.2	7.8 ± 1.3	7.5 ± 1.0
IFCC HbA1c (mmol/mol)	60.4 ± 13.7	56.3 ± 13.6	61.9 ± 13.8	59.1 ± 11.4

DMN, diabetic mononeuropathy; DPN, diabetic polyneuropathy; HbA1c, hemoglobin A1c; IFCC, International Federation of Clinical Chemistry; NDN, non-neuropathy; NGSP, National Glycohemoglobin Standardization Program.

Table 2 | Means and standard deviations of the Purdue pegboard test, Michigan Hand Outcomes Questionnaire and Diabetes-39 instrument

Variable	DMN	DPN	NDN	*P*
Purdue pegboard test				
Purdue_Dom	13.6 ± 2.4	12.1 ± 2.1	14.2 ± 1.8	0.000**
Purdue_Non_Dom	13.2 ± 2.7	11.5 ± 2.3	13.9 ± 2.5	0.002**
Purdue_Both	11.2 ± 2.4	9.7 ± 2.3	11.7 ± 1.8	0.001**
Purdue_Ass	26.8 ± 8.5	22.0 ± 6.7	29.8 ± 7.6	0.001**
Michigan Hand Outcomes Questionnaire				
OVE Fun Dom	74.2 ± 24.2	67.8 ± 20.7	80.6 ± 14.2	0.077
OVE Fun Non	73.8 ± 25.5	66.4 ± 20.3	71.7 ± 19.4	0.271
ADL Dom	93.0 ± 13.6	89.7 ± 15.1	95.6 ± 5.8	0.415
ADL Non	90.8 ± 15.6	87.1 ± 17.8	90.6 ± 13.8	0.569
ADL Both	94.0 ± 14.3	91.6 ± 14.9	99.2 ± 2.4	0.158
Work	80.4 ± 26.9	79.3 ± 26.7	82.2 ± 19.1	0.961
Pain	7.7 ± 16.1	7.5 ± 17.7	4.4 ± 11.6	0.993
AES Dom	79.9 ± 19.7	74.2 ± 17.2	86.8 ± 11.5	.038*
AES Non	81.5 ± 19.1	72.8 ± 18.0	84.7 ± 14.0	.021*
SAT Dom	75.8 ± 21.7	67.7 ± 19.1	81.5 ± 13.0	.016*
SAT Non	77.3 ± 23.3	67.5 ± 19.2	76.4 ± 14.3	0.085
OVE ADL Dom	93.5 ± 13.8	90.5 ± 14.2	97.4 ± 3.2	0.243
OVE ADL_Non	92.4 ± 13.8	89.2 ± 15.6	94.9 ± 7.0	0.410
Total Score_Dom	83.3 ± 14.6	78.6 ± 13.8	87.3 ± 10.1	0.050
Total Score_Non	83.5 ± 15.4	77.9 ± 14.4	84.2 ± 11.2	0.103
Diabetes-39				
Diabetes control	23.8 ± 14.0	35.7 ± 18.4	31.7 ± 20.3	0.029*
Anxiety and worry	29.5 ± 20.9	41.0 ± 21.6	41.5 ± 20.2	0.145
Social burden	20.3 ± 14.1	30.4 ± 19.3	26.1 ± 18.2	0.121
Sexual functioning	19.5 ± 22.0	40.7 ± 27.9	36.9 ± 30.0	0.003*
Energy and mobility	26.2 ± 14.4	40.6 ± 20.0	35.0 ± 17.6	0.010*

AES, aesthetics; OVE, overall hand function; SAT, satisfaction. *$P < 0.05$; **$P < 0.01$.

burden, sexual functioning, and energy and mobility between the DPN and DMN groups, but no statistically significant differences were noted between the DPN and NDN groups, or the DMN and NDN groups (Table 3).

DISCUSSION

Although there are many studies that focus on issues related to diabetic feet, the literature has paid less attention to exploring the associations between diabetic hands and the related deficits in functional hand performance, nor the influences of different abnormalities as a result of mononeuropathy and polyneuropathy on hand functioning and quality of life[11,25]. Most patients and even clinicians thus do not have a sufficient understanding of how diabetic neuropathic hands might affect manipulation performance and various daily tasks. The results of the present study showed that the mean age and disease duration of the

Table 3 | Comparisons of the Purdue pegboard test, Michigan Hand Outcomes Questionnaire and Diabetes-39 instrument between two groups

Variable	DPN & DMN *P*	DPN & NDN *P*	DMN & NDN *P*
Purdue pegboard test			
Purdue_Dom	0.002**	0.003**	0.516
Purdue_Non_Dom	0.004**	0.017*	0.643
Purdue_Both	0.003**	0.015*	0.643
Purdue_Ass	0.005**	0.005**	0.446
Michigan Hand Outcomes Questionnaire			
OVE Fun Dom	0.162	0.044*	0.575
OVE Fun Non	0.141	0.397	0.693
ADL Dom	0.211	0.562	0.672
ADL Non	0.301	0.741	0.671
ADL Both	0.204	0.119	0.481
Work	0.774	0.974	0.917
Pain	0.906	0.993	0.932
AES Dom	0.109	0.027*	0.398
AES Non	0.024*	0.055	0.803
SAT Dom	0.055	0.014*	0.529
SAT Non	0.036*	0.309	0.827
OVE ADL Dom	0.116	0.402	0.707
OVE ADL_Non	0.226	0.479	0.876
Total Score_Dom	0.079	0.050	0.686
Total Score_Non	0.045*	0.317	0.856
Diabetes-39			
Diabetes control	0.007**	0.511	0.541
Anxiety and worry	0.059	0.821	0.153
Social burden	0.043*	0.564	0.442
Sexual functioning	0.001**	0.644	0.143
Energy and mobility	0.003**	0.476	0.203

DMN & NDN, Patients with mononeuropathy compared with patients without neuropathy; DPN & DMN, patients with polyneuropathy compared with patients with mononeuropathy; DPN & NDN, patients with polyneuropathy compared with patients without neuropathy. *P<0.05; **$P < 0.01$.

individuals in the DPN group were both greater than those seen in the NDN and DMN groups, and the HbA1c score was also highest in the DPN group. This shows that severe neuropathy might be associated with aging, longer disease duration and worse glycemic control. Poor glycemic control is one of the basic pathogenic factors in the development of diabetic neuropathy of the hands. The demographic findings of the current study are consistent with the results found by Cederlunda *et al.*[5] and Al-Matubsi *et al.*[26], which showed that poor glucose tolerance influenced the sensibility of hand nerves, and that patients with neuropathy were more likely to have been suffering from a longer disease duration.

The present clinical observations showed that 92.9% of the recruited participants had neuropathy in their hands. Among these, the prevalence of polyneuropathy (72.4%) was far higher than that of mononeuropathy (20.5%) and non-neuropathy (7.1%). In addition, a notable percentage of the mononeuropathy cases was due to median neuropathy. A similar finding was noted in a previous study, which reporetd that 84.4% of the diabetes patients examined had more than one abnormal nerve, based on electrophysiological assessments for the median, ulnar, peroneal, tibial and sural nerves. Among those patients with neuropathies, 42.2% showed median neuropathy[12]. Bertora *et al.*[11] also reported that approximately 82% of patients with diabetes were estimated to have subclinical hand neuropathy, based on the results of neurophysiological tests. Similarly, a high percentage (up to 50%) of polyneuropathy was found among type 2 diabetes mellitus patients by Tesfaye[27]. The results of these earlier works show that neuropathic hand is definitely an issue for diabetes patients. Although everyone is aware that hands play a key role in our daily lives, it is interesting to note in the literature that neither patients nor clinicians seem to take this issue as seriously as they perhaps should.

Several previous studies have shown that hand dexterity is often affected by various neurological deficits, such as carpal tunnel syndrome[28], traumatic nerve injuries or diabetes mellitus. Pfutzner *et al.*[6,7] also reported that patients with diabetes mellitus showed significant dexterity deficits, which might result in difficulties when carrying out therapeutic protocols in their daily routines (e.g., monitoring blood glucose or injecting insulin). Because the patients with polyneuropathy showed worse hand performance than those with mononeuropathy and non-neuropathy, it is noted that the greater nerve abnormalities due to hand neuropathy resulted in more serious impairments of hand dexterity, thus supporting the hypothesis of the present study. The poor hand dexterity found for the patients with polyneuropathy in the present study shows that this condition has significant effects on the performance of various activities of daily living, as well as self-perceived quality of life.

According to the results of the MHQ, the patients with polyneuropathy had more disturbances in the subdimensions of total score, aesthetics and patient satisfaction with the non-dominant hand than those with mononeuropathy. In addition, differences in the subdimensions of overall hand function, aesthetics and patient satisfaction with the dominant hand were found between patients with mononeuropathy and non-neuropathy. These results show that hand neuropathy did not seem to have any obvious influences on the hand functioning of the diabetes patients examined in the present study, based on this self-reported assessment. A similar report from Poole *et al.*[29] also found that although diabetes patients might feel some degrees of weakness or dysfunction in their hands, most of them did not seem to care about this, or perceived only a few detectable deficits, such as decreased hand dexterity or poor sensorimotor coordination of their hands. However, those patients with severe neuropathic symptoms of the hands are more likely to sense or report dissatisfaction with regard to hand performance, as a result of the apparent sensory or motor defects. Furthermore, no statistical differences were found in any of the subdimensions of the MHQ between the DMN and NDN groups. These results

indicate that the hand impairments were easily ignored, and that the patients gradually learned to adapt when carrying out their daily routines, especially for those with gradual and slow symptomatic changes, like neuropathy[8,30].

Diabetic neuropathy appears to have the most negative effect on quality of life, as compared with other complications, based on the results of the 36-item Short Form Health Survey. A previous study also noted the reduction in quality of life among diabetes patients who suffer from various different complications[31]. Some reports also showed that patients with hand neuropathy reported worse quality of life scores than those without hand neuropathy, based on both objective and patient-perceived measurements[32,33]. The results of the current study also showed that the patient-perceived quality of life, based on D-39, is influenced by diabetic polyneuropathy in the dimensions of diabetes control, sexual functioning, energy and mobility. These results are consistent with those in Ovayolu *et al.*[34], which showed that polyneuropathy significantly decreased diabetes patients' quality of life, based on assessments carried out using the 36-item Short Form Health Survey and World Health Organization Quality of Life-Brief. The present investigation showed that the sexual functioning of patients with polyneuropathy might be negatively affected, and similar results were noted by Romeo *et al.*[35], who found that patients with more severe diabetic neuropathy might have more sexual functioning impairments than those with milder symptoms. Although the present findings showed no statistical differences in the subdimension of anxiety and worry among the groups, this was the most affected subdominion in the study by Mngomezulu and Yang[36]. This might be due to the different criteria used for the recruitment of participants, and also the different cultural factors in the countries where the studies were carried out. Generally speaking, the findings of the current study support our research hypothesis that polyneuropathy will negatively affect the quality of life of patients with diabetes. However, previous studies and the contents of the D-39 instrument both pay relatively little attention to how the resulting impairments of the fine motor and functional hand performance influence the quality of life. Further modifications to the contents of the D-39 instrument with regard to quality of life related to the upper limb functions are thus recommended.

The results reported above show that the patients with diabetic mononeuropathy did not seem to suffer from any significant disturbances with regard to either hand functional performance or quality of life. This could be because some relatively slight symptoms might not be noticed by the patients, and they are able to adapt their habits to compensate for any discomfort when carrying out their routine daily activities. Although the present study provides some valuable information that reveals how neuropathy can have negative impacts on diabetes patients' hand functional performance and quality of life, it also has the following limitations. First, the sample size of the DMN and NDN groups was rather small in comparison with the DPN group. Although the Cohen's *d* in the results of DMN and NDN groups were computed as 0.016–0.661, which showed small- to medium-sized effects, increasing the sample size in these two groups could be suggested to augment statistical power in future experiments. Second, the present study focused on investigating the manipulation functions of diabetic hands so that the median and ulnar nerves were the keys to be observed. However, the radial nerve also plays a crucial role in functional performances of upper limbs, which might be another worthy issue to be investigated in the future. In addition, the cross-sectional observational design used in the present study meant that changes in the hand neuropathy of the patients with diabetes were not considered in the study.

The findings of the present study show that diabetic polyneuropathy of the hand might have significantly negative impacts on the patients' functional hand performances and perceived quality of life. As the neuropathy of diabetic hands often seems to be a neglected complication in clinical practice, it is hoped that the results of this report can help raise awareness of this issue among both diabetes patients and clinicians. Better therapeutic strategies or proper education regarding complications of diabetic hand neuropathy to reduce the progression of neuropathy and help patients to maintain proper hand functions should be required.

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DISCLOSURE

The authors declare no conflict of interest.

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