Do standard neurological assessments tell us more than we realise?

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Abstract

Background Neurological assessments are commonly performed by podiatrists as a screening tool for peripheral neuropathy, and to identify the risk of foot ulceration and amputation. Monofilament and tuning fork assessments are routinely used to assess peripheral sensation. Whilst these assessments are commonly used to monitor foot health, there is potential for neurological results to illuminate a broader and more holistic perspective of a person's overall health status.

Methods Recruitment of fifty participants (31 female, 19 male; 71.78 ± 9.64 years) for foot health screening was associated with a foot health week promotional event at the Charles Sturt University Community Engagement and Wellness Centre. Under the guidance of registered podiatrists, fourth year podiatry students completed basic neurological assessments to determine each participant's neurological status. Participants also completed a modified Foot Health Status Questionnaire (FHSQ). Age and monofilament results were analysed using Spearman's rho, while correlations involving FHSQ data were identified using a Kruskal-Wallis test.

Results For those participants who reported an excellent rating of their own health, there was a statistically significant relationship with adequate vibration sensation ($p < 0.01$). A person's ability to get up from a sitting position ($p < 0.01$), lift and carry shopping ($p = 0.02$) and climb a flight of stairs ($p = 0.03$), was significantly correlated with more sites detected using monofilament assessment.

Discussion Significant correlations were observed between basic neurological assessments and a number of activities of daily living. While the findings reflect a correlational relationship, not causal, this still provides an opportunity for clinicians to view neurological assessment results more holistically. Whilst the immediate focus for a practitioner will be tissue viability, neurological findings may be useful to stimulate further discussion about a patient's functional capacity by exploring issues beyond the presenting condition.

Background

Neurological assessments are commonly performed by podiatrists as a screening tool for peripheral neuropathy, and can be used to identify risk of foot ulceration and amputation [1]. Monofilament and tuning fork assessments are routinely used to assess peripheral sensation [1] as they are both cheap [2] and readily available. [3] Data collected from these assessments informs patient management, review periods and education, however this also has the potential to illuminate a person's health and wellbeing more broadly. Taking a global view of neurovascular assessments may enable a more holistic approach to patient care, stimulating further conversation with the patient and reinforcing positive health messages in relation to clinical findings [4].

The use of neurological assessment results to recognise consequential features of a person's health is well reported in the literature. Known associations exist between peripheral neuropathy and reduced balance [5, 6] increased dynamic sway [7] and a greater risk of falls [6]. When considered in relation to

mobility, neuropathy is also associated with slower walking speed, shorter steps [8], reduced joint range of motion during gait [9], increased loading time [10] and an impaired ability to walk up and down stairs [7]. The flow on effect of these limitations is reduced independence, avoidance of activity, and an increase in morbidity and mortality [11].

There is increasing evidence to suggest that the peripheral impact of neuropathy extends beyond physical symptomology. People presenting with neuropathy are often identified as having lower self-esteem, an increase in depression symptomology, and as being less inclined to exercise and maintain a healthy diet [12, 13]. A cyclical situation ensues with depression leading to poorer self-care behaviours, which in turn leads to worsening neuropathy and increasingly severe depression [12]. An additional layer of complexity exists in that healthcare professionals tend to be insufficiently equipped to assist with the emotional and psychological components of self-management education [14]. The National Strategic Framework on Chronic Conditions (2017) encourages clinicians to utilise health promotion strategies, whereby a healthy lifestyle is encouraged [15] and messaging is focused towards prevention rather than the costs of not taking action [16].

In making the primary focus of neurological assessments the identification of pathology, there is the potential to overlook the subsequent health education opportunity that exists for those with neurological results considered to be within normal limits. In particular, clinicians may be missing an opportunity to promote positive health behaviours. The purpose of this study was to explore possible relationships between standard podiatric neurological assessments and positive aspects of a patient's perceived functional status.

Methods

Fifty local community members attended a health promotion event organised as part of Foot Health Week 2018, at the Charles Sturt University Community Engagement and Wellness Centre (CSU-CEW) Albury, NSW (Australia). This event was advertised as an opportunity for community members to attend the on campus clinic for a foot health screening and a health information session. The advertising material placed an emphasis on people over the age of 50, as this demographic commonly utilises the podiatry services offered at the CSU-CEW. All prospective participants over the age of 50 years were included in the study, and no prospective participants were excluded. As the event involved engagement with clinical services, all participants signed a standard clinical consent form prior to participation. Ethical approval for retrospective use of data collected was provided by the Charles Sturt University Human Research Ethics Committee (Protocol number: H19387).

Participants were asked to complete a modified Foot Health Status Questionnaire (FHSQ) prior to completion of a basic neurological assessment. Neurological assessment included manual tests for light pressure and vibration, and questioning regarding the presence of any numbness and/or paraesthesia [17]. The light pressure assessment was performed to assess large A-beta nerve fibre function using a

10 g monofilament [1, 18, 19]. Following the procedure described by Nather et al. (2011), nine sites on the plantar foot and a single site on the dorsal foot were assessed (Fig. 1) [20].

The monofilament was applied perpendicular to the skin until the filament buckled, indicating 10 g of pressure had been applied to the site [18, 20]. Following an example of the test being performed on the back of the participant's hand while their eyes were open, participants were asked to close their eyes and to respond by saying 'yes' when the pressure of the monofilament could be felt on the foot [18]. Participants were asked to identify the location of the pressure [18]; the number and location of sites correctly identified were recorded. An inability to detect the 10 g monofilament at one or more sites was interpreted as neuropathy of the large nerve fibres [19, 21]. Vibration assessment was completed by applying a vibrating 128 Hz tuning fork to the apex of the hallux [17, 18]; an additional test for large A-beta nerve fibre function [19]. A 'yes' result was recorded if the participant was able to detect vibration for five or more seconds and a 'no' recorded if the vibration sensation was experienced for under five seconds. A 'no' result would be indicative of neuropathy of the large myelinated A-beta nerve fibres. Assessment of the large A-beta nerve fibres using both the monofilament and tuning fork is in accordance with recommendations made by Boulton et al. (2008) who suggest that a neurological screen should involve the light pressure test plus one other test. Participants were also asked if they experienced numbness or paraesthesia (burning, tingling or altered sensation) in their feet. All neurovascular assessments were completed by 4th year podiatry students. A thorough clinical presentation was completed by the students identifying each participant's medical, neurological, arterial and venous assessment results. The presentation was critically examined by a registered podiatrist, and if all data reported did not correlate a request was made for assessments to be repeated.

Participants were also asked to complete a modified version of the FHSQ. The FHSQ is a tool used to measure correlations that may exist between foot health and quality of life [22], and requires participants to respond using a series of 5-point Likert scale questions [23]. The FHSQ is commonly used in clinical practice and has been shown to exhibit a high degree of construct, content and criterion validity [23]. It has also been shown to offer high re-test reliability, be responsive to pain changes in older people over time, and provides insight into the domains of pain, function, footwear and general foot health [23]. Modification of the FHSQ included removal of questions asking the participants name, address, date of birth, and date of consultation, as these details were already collected as part of the CSU-CEW clinical consent form. Socio-economic status questions in relation to pensioner or health care cards, private health insurance, and post-secondary education were also removed from the modified version as they had limited relevance to the Foot Health Week event. The research group believe the removal of questions not related to the participants health or wellbeing had no impact on the functionality of the FHSQ for the purposes of this study. Questions one to 19 of the FHSQ remained unchanged as they all focussed on health and wellbeing.

The participant's age and monofilament results were recorded as continuous values, Likert scale data were deemed ordinal, and yes or no responses were identified as nominal data. Correlations involving continuous values were analysed using Spearman's rho, while a Kruskal-Wallis analysis was used for

correlations involving ordinal and nominal data. Significance was set at $p < 0.05$. Means and medians were considered to aid interpretation of Kruskal-Wallis calculations involving nominal data. All statistical analyses were completed using R (version 3.5.3).

Results

The sample analysed included 50 participants (31 female, 71.3 ± 10.0 years; 19 male, 72.6 ± 9.1 years). Question 20 of the FHSQ required participants to identify medical conditions for which they were currently taking prescription medicine (Fig. 1). The most commonly reported conditions were hypertension (60%); hypercholesterolemia (39%); osteoarthritis (38%); and back pain (37%).

None of those assessed were current cigarette smokers and 76% of participants engaged in 'regular physical activity'. From a podiatric perspective, when questioned about the level of foot pain *during the previous week*, 38% of participants reported no pain; 24% reported very mild pain; 14% reported mild pain; 18% noted moderate pain; and 6% had experienced severe pain. For the majority of participants, foot aches (43%) and pains (38%) were occasional and most participants (45%) reported never experiencing sharp pains in their feet.

Significant correlations were identified when comparing bilateral monofilament results with 'moderate activities' ($p = 0.03$); 'lifting or carrying bags of shopping' ($p = 0.02$); 'climbing a steep hill' ($p = 0.02$); 'climbing a flight of stairs' ($p = 0.03$); 'getting up from a sitting position' ($p < 0.01$); 'walking more than a kilometre' ($p < 0.05$); and 'walking 100 meters' ($p = 0.03$) (Table 1). Positive rho values confirmed detection of more monofilament sites was correlated with positive reporting of capacity to complete those activities. Significant findings with negative correlations included 'do you have a lot of energy' ($p = 0.03$); 'I am as healthy as anybody I know' ($p < 0.01$); and 'during the past 4 weeks, how much of the time has your emotional problems or physical health interfered with your social activities (like visiting with friends, relatives, etc)?' ($p = 0.03$) (Table 1). Based on the arrangement of the Likert scale, in these cases detection of monofilament at more sites was correlated with more energy, less interference with social activities, and a high regard for personal health.

Table 1
Significant correlations with combined left and right foot monofilament results

Factor	rho	p-value
Moderate activities, such as cleaning the house, lifting a chair, playing golf or swimming	0.32	0.03
Lifting or carrying bags of shopping	0.33	0.02
Climbing a steep hill	0.33	0.02
Climbing on flight of stairs	0.31	0.03
Getting up from a sitting position	0.48	< 0.01
Walking more than a kilometer	0.29	< 0.05
Walking one hundred meters	0.35	0.01
Did you have a lot of energy?	-0.32	0.03
During the past 4 weeks, how much of the time has your emotional problems or physical health interfered with your social activities (like visiting with friends, relatives, etc)?	-0.31	0.03
I am as healthy as anybody I know	-0.46	< 0.01

When comparing those who did and did not report numbness in their feet, significant differences were noted in response to 'have your feet caused you to have difficulties in your work activities?' ($p = 0.04$); 'climbing a steep hill' ($p = 0.02$); and 'walking 100 meters' ($p = 0.04$) (Table 2). Significant differences were also noted when comparing those with and without paraesthesia in the areas of self-reported health ($p = 0.02$); limitations to climbing stairs ($p = 0.01$); and regularity of foot pain ($p = 0.03$) (Table 2). Self-reporting of health was also significantly different among those with and without adequate vibration sensation ($p < 0.01$) (Table 2).

Table 2
– Significant correlations between neurological assessments and FHSQ items.

FHSQ Item	Assessment	Result	Mean	Median	Descriptor	p-value
Have your feet caused you to have difficulties in your work or activities?	Numbness	No	2.11	2.00	2 - Slightly	0.04
		Yes	1.43	1.00	1 - Not at all	
Climbing a steep hill		No	1.77	2.00	2 - Yes, limited a little	0.02
		Yes	2.29	2.00	2 - Yes, limited a little	
Walking one hundred meters		No	2.89	3.00	3 - No, not limited at all	0.04
		Yes	2.50	3.00	3 - No, not limited at all	
How often have you had foot pain?	Paraesthesia	No	2.14	2.00	2 - Occasionally	0.03
		Yes	3.00	3.00	3 - Fairly many times	
How much does your foot health limit you climbing stairs?		No	1.63	1.00	1 - Not at all	0.01
		Yes	2.50	2.00	2 - Slightly	
My health is excellent		No	1.71	2.00	2 - Don't know	0.02
		Yes	1.00	1.00	1 - True or mostly true	
My health is excellent	Vibration > 5sec	No	3.00	3.00	3 - False or mostly false	< 0.01
		Yes	1.51	1.00	1 - True or mostly true	

Discussion

The use of light pressure and vibration threshold assessment to assess neurological status of the foot [19] is typically employed to detect risk for foot injury, ulceration [24], and likely functional limitations [5–7]. Whilst the identification of pathology is paramount, the relevance of neurological test outcomes to broader perspectives of health may be overlooked in podiatry practice. The identification of correlational relationships between sensory assessment results and activities of daily living such as carrying shopping; rising from a sitting position; and climbing a flight of stairs, may expand the way clinicians

interpret neurological assessment results. This may encourage practitioners to consider the **positive implications** of neurological test results, and provide an opportunity to promote mobility, independence and positive health behaviours with their patients.

To ascertain whether the sample tested provided a representative sample of the broader Australian population, the health status of the cohort was compared to values reported by the Australian Bureau of Statistics (ABS). In regard to relevant medical conditions for these participants, evidenced through currently prescribed medicines, the most common ailments were hypertension (59.6%); hypercholesterolemia (38.8%); osteoarthritis (37.8%); and cardiac disease (25.8%). When compared to the broader Australian population, respective proportions in the vicinity of 41.5%, 21.2%, 39.9–57.3%, and 26.1% would be expected for comparable age ranges [25]. While the prevalence of osteoarthritis and cardiac disease for this group of participants appears to be roughly equivalent to the national average, the prevalence of hypertension and hypercholesterolemia is substantially higher in the population tested in this study. A disparity was noted between the percentage of this participant group currently taking oral hypoglycaemic drugs (13.3%), and the proportion of the Australian population diagnosed with diabetes (18.7%) [25]. Given that thirty percent of people over the age of 65 with a diagnosis of diabetes manage their blood glucose levels with dietary modifications alone [26], this may account for at least part of the difference in values. The use of insulin as opposed to oral hypoglycaemic drugs may also contribute to the disparity given 13% of Australians with Type I diabetes [27] are more likely to be using insulin therapy than oral hypoglycaemic drugs.[28] The ABS also reports that 71.1% of Australians over the age of 65 years engage in regular physical activity [25], which was similar to 76.0% of participants in this study. None of the participants in this cohort reported that they were currently smoking, unlike ABS data which indicates 5.1% of males and 3.7% of females over 75 years smoke cigarettes [25]. The cohort assessed in this study appear to be a reasonable representation of the Australian population given several similarities noted within the ABS data. The accuracy of these findings may be questioned as those residing in rural and remote areas are expected to have higher levels of disease and poorer access to health services when compared to their metropolitan counterparts [29]. However, attendance at a Foot Health Week promotional event may suggest an above average level of health literacy and attention to health and wellbeing. Considering the opposing impacts of living in a regional setting, and an assumption of above average health literacy, this may account for health status results that were comparable to national averages.

The positive implications of neurological assessment results

A significant association exists between participants who believed their health was excellent, detection of vibration sensation, and the absence of paraesthesia. These results are difficult to compare to the existing literature as previous authors typically focus on the presentation of those with impaired function, rather than individuals with positive neurological test results. Recent work by Riandini et al. (2018) found peripheral neuropathy to be associated with reductions in balance confidence and health-related quality

of life, and poorer performances in the 'Timed Up and Go Test' and the 'Five Times Sit to Stand Test' [30]. The inverse was true in this study, in that an increase in the ability to get up from a seated position without limitation correlated with detection of a greater number of monofilament sites. While it is inappropriate to interpret the data as being comparable, it is probable that the clinical findings are mutually supportive. The assumption that a reduced sit to stand test result reflects limitations in balance, postural stability, mobility and functional strength [30], conversely, it is postulated that confidence in getting up from a seated position is associated with proficiency in those same functional capabilities.

It is relevant to consider that altered gait strategies have been reported among people with lower limb neurological deficits [10], and those with nerve dysfunction are more likely to fail a balance test [31]. For participants in this study, detection of more monofilament sites was strongly associated with an ability to lift or carry bags of shopping without limitation and completion of moderate activities such as playing golf, cleaning the house or lifting a chair. Accepting that people with neurological dysfunction display impaired balance [5] and poorer stability during a variety of gait activities [7], it may be reasonable to suggest that those with better neurological function are more likely to be balanced while performing a challenging task such as carrying shopping. The authors are mindful that caution should be employed when interpreting monofilament assessment findings [3]. The position statement presented by the American Diabetes Association (2017) recommends the use of 10 g monofilament assessment using four sites to identify ulceration risk among those with more advanced neuropathy. A 2010 review by Tan (2010), and a more recent systematic review and meta-analysis by Wang and colleagues (2017), indicates consensus has not been reached with regard to number of sites, site locations, and threshold values to determine peripheral neuropathy when using a 10 g monofilament [3]. Amidst the uncertainty, it would appear little difference exists between the use of four or 10 test sites, as both offer similar sensitivity [3] and inter-rater reliability [32]. Having not assessed a high risk population in this study, the authors accept the monofilament assessment is unlikely to have detected subtle changes that would indicate the presence of early neuropathy. However, the monofilament was chosen as it is convenient, easily accessible [3], low cost [2], commonly used by clinicians [32] and a generally interpreted as providing information relating to pressure sensation [18]. This may allow the findings of this study to be accessible to a wider range of clinicians.

This study identified the ability to climb a steep hill and walk 100 meters as having a significant relationship with an ability to detect light pressure and no reporting of numbness. Additionally, those able to detect a higher number of monofilament sites were found to exhibit no foot related limitations in regard to climbing stairs. Again, these findings share an inverse relationship with previous reporting of a link between peripheral neuropathy and difficulty moving up and down stairs [7]. This functional impairment is believed to stem from a significant delay in ankle and knee extensor contractions, prolonged activation of muscles [33], or an increase in dynamic sway during complex gait activities [7].

A common belief among the participants who recorded an increased sensitivity to light touch was that they were as healthy as anyone they knew, and reported no restriction of social activities due to emotional or physical factors. There is little evidence to support these findings, however, the inverse of these results

are the known links between neuropathy, low self-esteem, depression [12, 13], and nonadherence to self-care [34]. While the compounding impact of mental health issues on existing neurological pathology adds considerable complexity to a patient's management [13], this does serve to highlight the risk of dismissing the relevance of positive neurological results in the context of a person's attitude towards their own health and social engagement.

Promoting mobility, independence and positive health behaviours

Having identified a series of significant correlations between positive neurological assessment results and functional capacity in this study, this presents an opportunity for clinicians to consider the need to emphasise the importance of positive neurological outcomes with their patients. Presenting health information from a positive perspective, and placing greater emphasis on prevention rather than consequences, is found to have greater influence on an individual's behaviour [16, 35]. Emphasising the positive aspects of a neurological assessment also aligns with current communication recommendations from Diabetes Australia [36]. It is known that positive interactions and language have the power to not only persuade a person to change their behaviour but also to influence individuals at a deeper level and alter beliefs, discourse and stereotypes [36]. Furthermore, presenting such information using appropriate communication techniques empowers the individual to make informed decisions about their health and wellbeing, with increased confidence [15]. While the nature of preferred health communication methods is beyond the scope of this report, this study has identified that clinical findings may provide the basis for a constructive and positively framed conversation about a patient's foot health.

Having focused predominantly on the potential to highlight positive assessment results, the findings of this study do not detract from the need for patients to be aware of the risks associated with certain lifestyle behaviours. Patients should be equipped to follow basic self-care procedures to minimise the potential for harm [37]. Based on current guidelines, existing forms of foot health education contribute to a reduction in the incidence of ulcerations [1] and should therefore be continued.

By way of limitations, it should be noted that the significant findings reported in this paper are correlational in nature and do not necessarily represent a cause and effect relationship. It is also noted that factors such as age, loss of sensation associated with age, the presence of back pain, and diabetes status were not included for data analysis, and all have the potential to be confounding factors. The association between statins as an oral hypoglycaemic agent and neuropathy [38] is another factor that was not attended to due to the vague nature of the FHSQ question relating to diabetes medications. The authors acknowledge that the comparison to previous findings are based largely on the assumption of probable inverse relationships. The inability to offer direct comparison to previous findings is due to the majority of reported evidence focusing on neurological dysfunction and relationships with negative outcomes for health and wellbeing. Collection of data by podiatry students is also identified as a project design limitation, however, the use of final year podiatry students in consultation with a registered podiatrist is likely to have limited the potential for assessment or interpretation errors.

Conclusion

It is widely reported in the literature that primary health carers should be gearing their health promotion activities towards the prevention of ill health, rather than focussing on disease processes. The findings of this study have identified clear correlations between neurological function and confidence to complete a range of activities of daily living. These findings may stimulate further consideration of the value of basic neurological assessments and the potential opportunity that exists to promote positive health behaviours for all patients, regardless of their peripheral neurological status.

List Of Abbreviations

CSU-CEW Charles Sturt University Community Engagement and Wellness Centre

FHSQ Foot Health Status Questionnaire

Declarations

Ethics approval and consent to participate

All participants signed a standard clinical consent form to acknowledge the use of diagnostic testing, and allowing their assessment results to be used for research purposes. Ethical approval for retrospective use of data collected was provided by the Charles Sturt University Human Research Ethics Committee (Protocol number: H19387).

Consent for publication

All participants signed a clinical consent form allowing use of their data, but not their name, in a statistical capacity for research purposes. No individual person's data in any form is presented in this manuscript.

Availability of data and materials

The datasets analysed in the current study are available from the corresponding author on reasonable request.

Competing interests

The authors declare that they have no competing interests.

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Authors' contributions

All authors contributed to project design, data acquisition, interpretation and preparation of the manuscript. LD and AH contributed to collation of the data. LD liaised with a statistician for the completion of statistical analysis. All authors read and approved the final manuscript.

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Figures

Plantar sites:

1. First digit
2. Third digit
3. Fifth digit
4. First MTPJ
5. Third MTPJ
6. Fifth MTPJ
7. MLA
8. Lateral midfoot
9. Heel

Dorsal site:

10. Dorsal midfoot

Figure 1

Contact sites for standard monofilament assessment

Figure 2

Basis for participants taking prescribed medications