Journal of Bodywork & Movement Therapies xxx (xxxx) xxx

Contents lists available at ScienceDirect

Journal of Bodywork & Movement Therapies

journal homepage: www.elsevier.com/jbmt

Impact of electrodiagnostic (EMG/NCS) tests on clinical decision-making and patient perceived benefit in the outpatient physical therapy practice

Mohini Rawat [a, *], Dimitrios Kostopoulos [b], Konstantine Rizopoulos [b], William Dodson [c], Kathy Blair [d], Josh Henderson [d], Marissa Grow [d], Chirag Upreti [e]

[a] PT PC, New York, USA
[b] Hands-On Physical Therapy, Hands-On Diagnostics, USA
[c] Paradigm Physical Therapy & Sports-Wellness Center, USA
[d] Wind City Physical Therapy, USA
[e] Department of Neuroscience, New York State Psychiatric Institute, USA

ARTICLE INFO

Article history:
Received 26 December 2019
Accepted 26 December 2019

ABSTRACT

Background: Utilizing Electromyography and Nerve Conduction Study (EMG/NCS) tests, when indicated, may have implications for efficient patient management and assist in more efficient referral to appropriate providers or specialists.
Objective: To investigate the impact of Electromyography and Nerve Conduction Studies (EMG/NCS) on clinical decision-making and patient perspectives within PT practice settings.
Methods: 462 patients, who were candidates for diagnostic testing (EMG/NCS) were included in this outcome study and questionnaire-based survey design. Pre-test diagnosis was compared to post-test diagnosis. Post-test, patients were asked to rate their perceived benefit of the testing.
Results: Management was changed in 60.61% of patients post EMG/NCS testing ($p < 0.0001$). The diagnosis was changed post-EMG/NCS test in 39% of the patients with a change in management, which is greater than expected ($p < 0.0004$). There was no effect of gender or age ($p > 0.05$) on change in treatment (tx) or diagnosis (dx). 89.8% of patients agreed, or strongly agreed, that they were better able to understand their condition; 92.4% strongly agreed, or agreed, that they were reassured about their condition; 89.1% strongly agreed, or agreed, that they were better able to manage their condition and 92% reported very high, or high, value perceived from the EMG/NCS test administered.
Conclusion: This study demonstrates that EMG/NCS testing appears to have a significant impact on clinical decision-making, and higher scores on the patient perceived benefit.

Electrodiagnostic tests assess the electrical activity of the nerves and muscles, both at rest and during activity. These tests provide data about the specific location and underlying pathophysiology of peripheral nerve problems, which is then used for best-practice interventions in the treatment and management of abnormalities of nerves and muscles (Ellison et al., 2010).

EMG/NCS (electromyography and nerve conduction studies) have been used for many years by various healthcare providers such as neurologists, physiatrists, physical therapists, chiropractors and others who are trained to appropriately select patients, perform, interpret and apply gained information to inform clinical decision-making in patient care. Healthcare providers who perform EMG/NCS become qualified, via training and examinations, to recognize signs, symptoms and indications for electrodiagnosis. For example, physical therapists undergo extensive training, a rigorous process of more than 2000 patient hours, 500 mentored studies and a qualifying score in three case studies, in order to be eligible to sit for the EMG/NCS board certification examination to become EMG/NCS providers in the United States. (Armantrout et al., 2008).

The APTA (American Physical Therapy Association) House of Delegates' statement on diagnosis indicates that the physical therapist's responsibility in the diagnostic process is to organize and interpret all relevant information collected. The diagnostic process includes obtaining relevant history and performing

* Corresponding author.
E-mail address: mohinirawat@gmail.com (M. Rawat).

https://doi.org/10.1016/j.jbmt.2019.12.002
1360-8592/

systems review, while also selecting and administering specific tests and measures (HOD, 2012).

As clinicians we realize the importance that proper patient management and treatment outcomes have in our daily interactions with patients. There is limited literature documenting investigation of the effect of EMG/NCS testing on patient management; further, no studies to date have reported patients' perceptions of such tests. In a clinical setting, patient perceptions about treatment or perceived benefit of treatment is one of the predictors of health-related behavior and compliance with the care that patients receive. Patients' concerns, expectations and unique preferences are important factors to be considered in their management. When performed by a qualified provider, clinical testing, such as EMG/NCS, offers the patient more information about their condition and helps them to understand it better. The communication between clinician and patient about the purposes of testing as well as the testing results, leads to a better relationship between provider and patient. That, in turn, leads to better patient management (Mcmillen and Fisher, 1998; Leung, 2013; Wheeler, 2010). We, therefore, aim to study the patient's experience and perceived value of the test.

No published studies exist, to our knowledge, that report the impact of electrodiagnostic (EMG/NCS) studies on clinical decision-making and patient-perceived benefit, when those studies are performed by a physical therapist in an outpatient setting.

In this multicenter study conducted in outpatient physical therapy (PT) clinics in the United States, we investigated the impact that EMG/NCS examination results have on clinical decision-making and patient perceived benefit. We hypothesized that there would be no change in management post-EMG/NCS tests.

1. Methods

During a twelve-month period, this study included 462 patients, in a sample of convenience. They had originally been referred by primary-care physicians to five independent outpatient PT clinics, and were candidates for the electrophysiological examination, as described in a position statement by AANEM (1999). Their distribution data was as follows: 210 from CLINIC 1; 113 from CLINIC 2; 99 from CLINIC 3; 23 from CLINIC 4 and 17 from CLINIC 5. Each location used a similar spreadsheet and reported to the principal investigator (first author). The first author of the paper was responsible for the study design, implementation, instructions and data accuracy. The authors of the study exerted no influence on any part of the patient assessment or management and therefore, in its capacity as a retrospective, strictly anonymized study, no ethical approval was necessary.

Patients were managed based on regular, standard protocols as practiced at the clinics to which they were referred; the authors of this study observed which type of treatments were offered post-testing and scored them based on the scales described in the study. The only instructions given to participating clinics consisted of how to use the scale for data collection during the twelve-month period and how to transfer the data in coded form for analysis. The EMG/NCS exam was performed by an ABPTS Board-certified specialist or by an EMG/NCS certified physical therapist under the supervision of a Board-certified specialist.

Patient demographics are described in Table 1. All the patients provided consent to participate in the study and the rights of subjects were protected. Data entered into the spreadsheet was devoid of personal patient information, as guided by the Health Insurance Portability and Accountability Act (HIPAA).

For the post-EMG/NCS study (following discussion of the results and the next steps in management with the patients), non-clinical reception staff asked patients to answer four simple multiple-choice questions rating their experiences. The questionnaire answers were anonymized and were not linked to the codes of the clinical decision-making scale. Non-clinical reception staff reassured the patients that their answers would not affect their level of care and would be anonymized. The questions asked are included in Table 2.

Table 1
Patient demographics.

Demographics	Data
Age in years, mean (SDev)	50.5 (17.4)
Female %	49.13%
Male %	50.87%

Patients were then followed to identify: (1) the type of treatment that was offered post-EMG/NCS exam and (2) whether the initial diagnosis was changed post-EMG/NCS exam. The assigned clinician from each location entered the clinical decision scores for each patient. The scale used is shown here:

1.1. Impact on clinical decision-making grading scale

0 = No change.
1 = Change in conservative PT treatment.
2 = Referral to physician with subsequent conservative treatment, such as injection.
3 = Referral to physician with subsequent non-conservative treatment, such as surgery.
4 = Change in Diagnosis.

1.2. Statistical methods

We analyzed data using descriptive statistics in Stata version 14 (StataCorp LP, College Station, TX). The decision-making scale reflects a binary variable— “clinical change” or “no clinical change”. The scale was analyzed as categorical variable data. To determine if the number of subjects with changed treatment (tx) or diagnosis (dx) following the EMG/NCS test was greater than expected by chance (assuming equi-probability models), we employed one sample proportion z-test, with $p < 0.05$ as the criterion for significance. Specifically, we first tested whether the number of subjects who experienced a clinical change was more than would be expected by chance. Then, investigating only those who experienced a clinical change, we tested whether or not a particular outcome (from the scale 1–4 above), occurred more often than would be expected by chance. We employed Bonferroni corrections to adjust for multiple z-tests. The impact of the demographic variables (age and gender) on clinical change was assessed via logistic regression; in each case, we tested whether the variable significantly predicted clinical change (binary dependent variable of “no change” versus “change”).

Patients’ responses on the Likert scales were analyzed separately for each statement, assuming equi-probability models and χ^2 tests. Ordered logistic regression was then employed to test the significance of age and gender on patient response outcomes.

2. Results

In total, 462 patients took part in this study, which endeavored to (1) determine if including EMG/NCS testing in a PT practice significantly impacted the treatment plan or management of the patient and (2) to evaluate patient perceived benefit. 50.54% of the sample were males, with an average age of 50.54 ± 17.43 years.

Please cite this article as: Rawat, M et al., Impact of electrodiagnostic (EMG/NCS) tests on clinical decision-making and patient perceived benefit in the outpatient physical therapy practice, Journal of Bodywork & Movement Therapies, https://doi.org/10.1016/j.jbmt.2019.12.002

Table 2
Patient perceived benefit questionnaire.

Question	Response				
	A	B	C	D	E
1. Do you feel that you are better able to understand your problem after having the EMG/NCS exam in the clinic today?	Strongly agree	Agree	Neither	Disagree	Strongly disagree
2. Do you feel that you are more re-assured about your problem after having the EMG/NCS exam in the clinic today?	Strongly agree	Agree	Neither	Disagree	Strongly disagree
3. Do you feel that you are better able to manage your problem after having the EMG/NCS test in the clinic today?	Strongly agree	Agree	Neither	Disagree	Strongly disagree
4. Do you, as a patient, feel that the EMG/NCS exam that you have had in the clinic today was of any value to you?	Very high value	High value	Moderate value	Low value	No value

2.1. Impact on clinical decision-making

To explore the overall clinical impact, we tested whether or not the number of patients who experienced either a change in treatment or in diagnosis following EMG/NCS testing were higher than expected by chance (Fig. 1). 60.61% of all subjects experienced a change in treatment from their initial diagnoses (see Table 3), reflecting a significantly greater number of subjects than expected by chance ($p < 0.0001$). Neither age nor gender predicted clinical change (Table 4).

Next, of those subjects who experienced a clinical change, we tested to see if any particular change outcome occurred more often than by chance. Interestingly, of those subjects who experienced a change in their management plan and/or diagnosis following EMG/NCS testing, 16% of the subjects were referred to a physician with a change in conservative treatment, which was significantly lower than expected (adjusted $p = 0.024$). Conversely, 39% of subjects experienced an actual change in diagnosis, which was significantly higher than expected by chance (adjusted $p < 0.004$).

The combined results observed in all Clinical Decision-making grades suggests that administration of the EMG/NCS test provides a significant diagnostic benefit.

2.2. Patient perceived benefit following EMG/NCS

Next, we evaluated whether undergoing EMG/NCS testing is associated with patient opinions regarding: Q1. understanding their problem; Q2. reassurance about their problem; Q3. their management of the problem; and, Q4. the value of the test for them. As shown in Fig. 2, for each question (Q) there was a significant difference in the proportion of patients' responses (adjusted $p < 0.004$), with significantly more subjects strongly agreeing with each of the statements. Finally, we employed an ordered logistic regression model to test the potential for demographic characteristics to predict the patient responses for each separate statement. As found for overall clinical change, neither age nor gender had a significant effect on the patient response to Q's 1–4 ($p > 0.05$).

Table 3
Demographic characteristics of the study sample (n = 462).

	No change (n = 182)	Clinical Change[a] (n = 280)
Women, %	36.6	63.4
Age, years (mean ± SD)	49.9 ± 17.15	50.9 ± 17.6

[a] Clinical Change comprises subjects with one of the following: Change in conservative PT treatment; Referral to physician with subsequent conservative treatment; Referral to physician with subsequent non-conservative treatment, such as surgery; Change in Diagnosis.

Table 4
Logistic regression for clinical change (n = 462).

Dependent Variable	Odd's ratio	SE	Test statistic (Z)	p-value
Gender	1.26	0.24	1.22	0.221
Age	1.003	0.005	0.62	0.534

3. Discussion

There is no known study in the literature investigating the

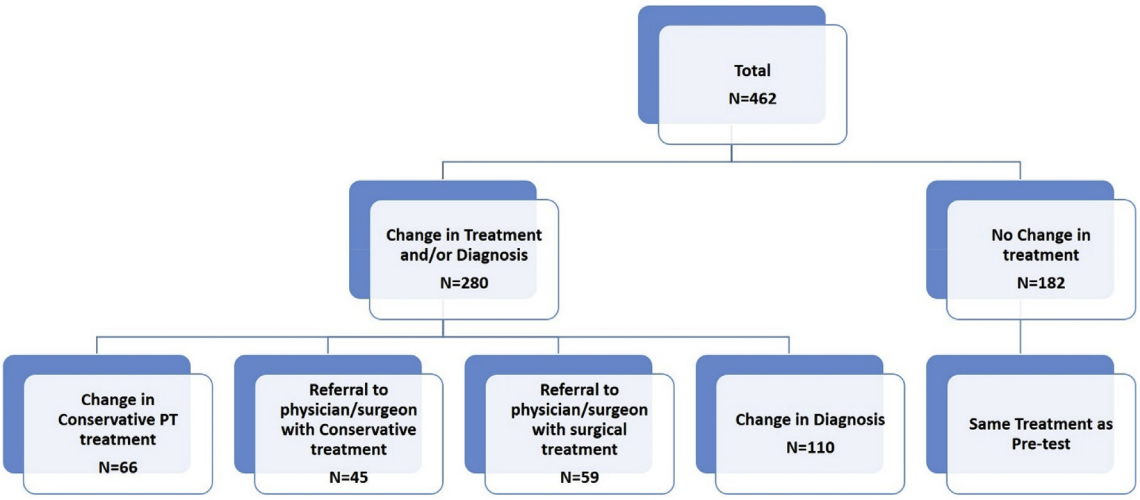

Fig. 1. Change in Clinical Decision making.

Please cite this article as: Rawat, M et al., Impact of electrodiagnostic (EMG/NCS) tests on clinical decision-making and patient perceived benefit in the outpatient physical therapy practice, Journal of Bodywork & Movement Therapies, https://doi.org/10.1016/j.jbmt.2019.12.002

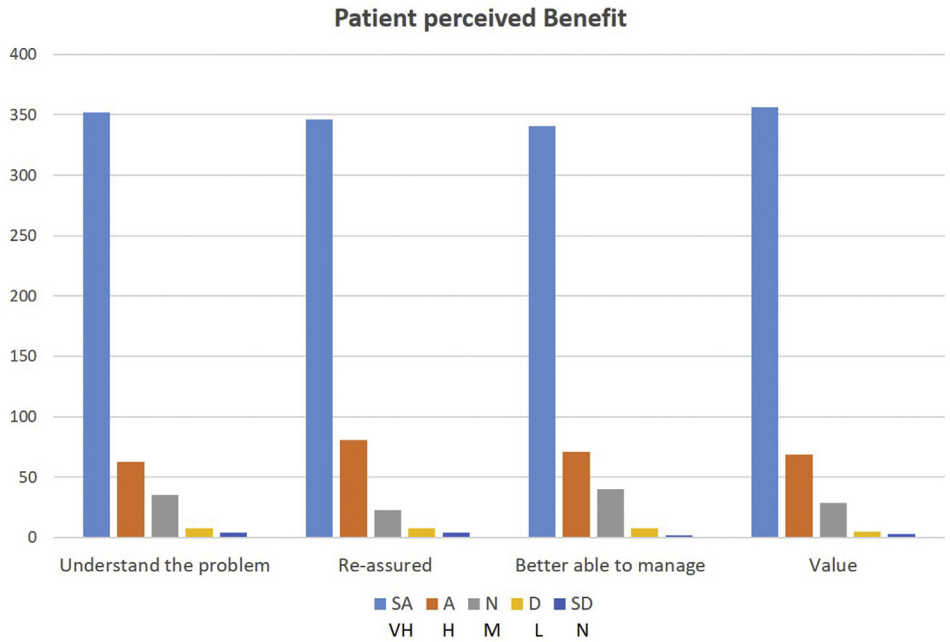

Fig. 2. Figure shows the patient response to the questions 1 to 4. X^2 test statistic scores are as below Q1: 76.19% of the patients strongly agreed, which was significantly more than expected. (Pearson $X^2(3df) = 656.98$, $p < 0.001$). Similarly, Q2: 74.89% strongly agreed with the statement (Pearson $X^2(4df) = 911.23$, $p < 0.001$); Q3: 73.81% of subjects strongly agreed (Pearson $X^2(4df) = 869.06$, $p < 0.001$); Q4: 77.06% of subjects strongly agreed (Pearson $X^2(4df) = 970.60$, $p < 0.001$).

change in management when EMG/NCS tests are done in outpatient physical therapy clinics and what the patients' perspectives are regarding the tests administered. There is limited literature looking at the change in management post-EMG/NCS tests in a hospital setting; however, they do not present the patients' perspectives. Lindstrom and Ashworth, 2018 reported a change in management of 63.4% of patients post-EMG/NCS test which is consistent with our findings; however, they did not report the patient-perceived benefit of the EMG/NCS studies, nor was the study done in a PT outpatient setting. In many cases, especially in rural areas of the United States, physical therapy outpatient settings are the only means for patients to receive physical therapy services. Outpatient physical therapy offices also provide patients with additional access to electrodiagnostic studies. Lindstrom and Ashworth, 2018 reviewed the charts of the patients referred for electrodiagnostic studies in a hospital setting for a period of one year to determine whether electrodiagnostic tests led to change in management, which was categorized into three categories: (1) changed, (2) confirmed or (3) no added value. Another study followed 100 patients post-EMG/NCS study in a hospital setting and reported that the management of 55% changed post-test, and the diagnosis was changed for 37% of cases (Kothari et al., 1998). Neither of those studies assessed the changes in management in physical therapy outpatient settings. Our study does report on this change in PT outpatient settings, with a high degree of ecological validity, as these changes were observed as part of regular clinical practice (Andrade, 2018). Electrodiagnostic testing in many of these patients revealed findings that otherwise would have been missed, leading to less accurate and potentially less effective treatments. That would have potentially prolonged the pain and suffering of patients unnecessarily and although this study did not investigate the financial implications of potentially less effective treatments, one can safely assume that when treatments are selected based on incomplete or incorrect data, there will be negative financial implications for the healthcare system.

The results of our study rejects the null hypothesis. Our study shows a positive impact on clinical decision-making, a greater understanding on the part of the patient about their condition and higher patient satisfaction reported post-EMG/NCS tests in a PT outpatient setting. Successful outcomes in patient management depend on patient adherence to recommended treatment. The patient's adherence is largely dependent upon their knowledge and understanding of the problem, effective communication between health professionals and the patient, and trust in therapeutic relationship (Martin et al., 2005). Mutual collaboration and successful communication promote greater patient satisfaction with the care, which is viewed as the precursor to positive health outcomes (Jahng et al., 2005). When the clinician explained the electrodiagnostic study results to patients participating in the study, and their meaning with regard to their condition, participants gained a more meaningful and concrete understanding about their condition and its management. The results of this study suggest that this communication between clinician and patient has a positive effect on patients' understanding, compliance, and satisfaction with regard to their care.

Patients who were not candidates for conservative management were identified early on and were referred to the appropriate provider. This may have implications for healthcare service utilization, with the potential to save time and money, resulting in more effective management. Interprofessional care may result in improved resource utilization, health outcomes, and patient satisfaction (Howard and Potts, 2019).

3.1. Limitations

A possible limitation of our grading scale is that it does not reflect a greater degree of change in management from Grades 1 to 4. It includes both change in treatment and change in diagnosis. Grades 1 through 4 affect the way a patient is managed; however, in some cases, Grade 4 might not impact the clinical decision or management more than Grade 1; or there might be a greater change in management in Grades 3 or 2 compared to Grade 4. We were investigating whether EMG/NCS testing changes the decision-making process, and then analyzing which type of change was

Please cite this article as: Rawat, M et al., Impact of electrodiagnostic (EMG/NCS) tests on clinical decision-making and patient perceived benefit in the outpatient physical therapy practice, Journal of Bodywork & Movement Therapies, https://doi.org/10.1016/j.jbmt.2019.12.002

observed more than others. The authors do not believe that categorizing the precise change in diagnosis would have added any notable difference to the study, since the hypothesis is testing if there is any change in management post-EMG. The type of diagnosis change can be studied in detail in a future study with a larger sample size.

A cost-benefit analysis was not performed in this study and warrants a more extensive future study to understand the cost-saving benefits of providing electrodiagnostic services to appropriate patients in outpatient PT clinics.

4. Conclusion

There is a significant impact on the management of the patient, as well as high levels of patient satisfaction reported with the use of PT practice-based EMG/NCS studies when indicated and when these tests are offered by the qualified PT provider. We also believe this testing could likely improve overall effectiveness and efficiency of patient management with the potential of cost savings to the system. Future studies are needed to identify and evaluate the degree and type of change in conservative management post-EMG/NCS tests and to conduct a cost-benefit analysis.

Clinical relevance

- EMG/NCS studies, when indicated, lead to better patient management
- Patient perspective is an important part of patient management and might have implications for treatment adherence.

Declaration of competing interest

The authors declare no conflicts of interest.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.jbmt.2019.12.002.

References

AANEM, 1999. Guidelines in electrodiagnostic medicine. Recommended policy for electrodiagnostic medicine. Muscle Nerve Suppl 8, S91–S105.
Andrade, C., 2018. Internal, external, and ecological validity in research design, conduct, and evaluation. Indian J. Psychol. Med. 40, 498–499.
Armantrout, E.A., Hummel-Berry, K., Underwood, F., Nelson, C., 2008. Physical therapist compliance with electromyography guidelines. J. Neurol. Phys. Ther. 32, 177–185.
Ellison, D., Williams, M.L., Moodt, G., Farrar, F.C., 2010. Electrodiagnostic studies. Crit. Care Nurs. Clin. 22, 7–18.
HOD, A., 2012. DIAGNOSIS BY PHYSICAL THERAPISTS HOD P06-12-10-09 [Amended HOD P06-08-06-07; HOD P06-97-06-19; HOD 06-95-12-07; HOD 06-94-22-35; Initial HOD 06-84-19-78] [Position]. APTA Governance.
Howard, I., Potts, A., 2019. Interprofessional care for neuromuscular disease. Curr. Treat. Options Neurol. 21, 35.
Jahng, K.H., Martin, L.R., Golin, C.E., Dimatteo, M.R., 2005. Preferences for medical collaboration: patient-physician congruence and patient outcomes. Patient Educ. Couns. 57, 308–314.
Kothari, M.J., Blakeslee, M.A., Reichwein, R., Simmons, Z., Logigian, E.L., 1998. Electrodiagnostic studies: are they useful in clinical practice? Arch. Phys. Med. Rehabil. 79, 1510–1511.
Leung, Y., 2013. Perceived benefits. In: Gellman, M.D., Turner, J.R. (Eds.), Encyclopedia of Behavioral Medicine. Springer New York, New York, NY.
Lindstrom, H., Ashworth, N.L., 2018. The usefulness of electrodiagnostic studies in the diagnosis and management of neuromuscular disorders. Muscle Nerve 58, 191–196.
Martin, L.R., Williams, S.L., Haskard, K.B., Dimatteo, M.R., 2005. The challenge of patient adherence. Ther. Clin. Risk Manag. 1, 189–199.
Mcmillen, J.C., Fisher, R.H., 1998. The Perceived Benefit Scales: measuring perceived positive life changes after negative events. Soc. Work Res. 22, 173–186.
Wheeler, P., 2010. What do patients think about diagnostic ultrasound? A pilot study to investigate patient-perceived benefits with the use of musculoskeletal diagnostic ultrasound in an outpatient clinic setting. Int. Musculoskelet. Med. 32, 68–71.

Please cite this article as: Rawat, M et al., Impact of electrodiagnostic (EMG/NCS) tests on clinical decision-making and patient perceived benefit in the outpatient physical therapy practice, Journal of Bodywork & Movement Therapies, https://doi.org/10.1016/j.jbmt.2019.12.002