Efficacy of NMES Combined with Traditional Physical Therapy for a 67-Year-Old Male Following Multilevel Cervical Laminectomy and Fusion for Cervical Myelopathy

Author: Katerina A Renusch, SPT
Research Advisor: Linda M. Hall, PT, MS, DPT
Doctoral Program of Physical Therapy
Central Michigan University

HEALTH PROFESSIONS
PHYSICAL THERAPY
CENTRAL MICHIGAN UNIVERSITY

What is Cervical Myelopathy? [2, 10, 12, 20]

- A progressive condition caused by compression of the cervical spinal cord
- Most common cause of spinal cord dysfunction in adults
- Significant source of neurological impairment in older adults
- Incidence/Prevalence: Males, ~64 years

Why Neuromuscular Electrical Stimulation (NMES)? [6-8, 13, 23]

- NMES is used to facilitate muscle activation when voluntary contractions are impaired
- May improve
  - Motor unit recruitment
  - Support muscle activation
  - Reduce atrophy
- Evidence based practice
  - Used in neurological population improves motor performance when paired with active movement
  - Translational relevance to cervical myelopathy due to neurological impairments

Purpose Statement

› Describe the effects of a multimodal approach to an outpatient physical therapy program, including neuromuscular electrical stimulation, task-specific training, and strengthening to address upper extremity weakness and functional limitations in a 67-year-old male following decompressive cervical fusion for cervical myelopathy.

Case Description

67-year-old male

PMH

- Type 2 diabetes mellitus with polyneuropathy, hypertension, hyperlipidemia, vertigo, sensorineural hearing loss

Symptoms

- Gait instability, multiple falls, neck pain, hand paresthesia, decreased dexterity, dropping objects

Case Description Continued

Imaging

- Cervical kyphosis with multilevel cord compression at C4-C6

Surgery

- Cervical decompression and fusion

Returned to outpatient PT

CLINICAL IMPRESSION #1

Persistent postoperative neurological and musculoskeletal impairments were anticipated.

Expected impairments:

- Decreased cervical ROM
- Right upper-extremity weakness
- Sensory deficits

5, 12, 21, 22

CLINICAL IMPRESSION #1

5, 12, 21, 22

Anticipated functional limitations:

- Carrying objects
- Grooming and feeding
- Work-related computer tasks
- Household and community activity

Planned measures:

- ROM
- MMT
- Sensation and reflexes
- Nine-Hole Peg Test
- NDI and QuickDASH

EXAMINATION [5, 12]

Posture

- Thoracic kyphosis, scapular protraction, right shoulder elevation

Sensation

- Diminished C5-T1 dermatomes

Reflexes

- Absent: Right biceps and brachioradialis

Examination – Shoulder AROM [4, 14, 15, 18, 25, 26]

Shoulder	Initial exam Left	Initial exam Right
Flexion (C5,6)	165	60
Abduction (C6)	180	55
External rotation (C5)	55	40
Internal rotation (C6)	L2	45

Examination – Upper Extremity Strength [4, 14, 15]

Shoulder	Initial exam Left	Initial exam Right
Flexion (C5,6)	5	3-
Abduction (C6)	4-	3-
External rotation (C5)	4+	2-
Internal rotation (C6)	4+	4+
Scapular		
Rhomboids (C5)	5	3-
Middle Trapezius	4+	3-

Elbow	L	R
Flexion (C6)	5	Bicep 2+ Brachialis 3+ Brachioradialis 2-
Extension (C7)	5	5
Pronation (C7,8)	5	3+
Supination (C6)	5	2-
Wrist		
Flexion (C7,8)	5	5
Extension (C7)	5	5
Radial Deviation (C7)	5	5
Ulnar deviation (C8)	5	5

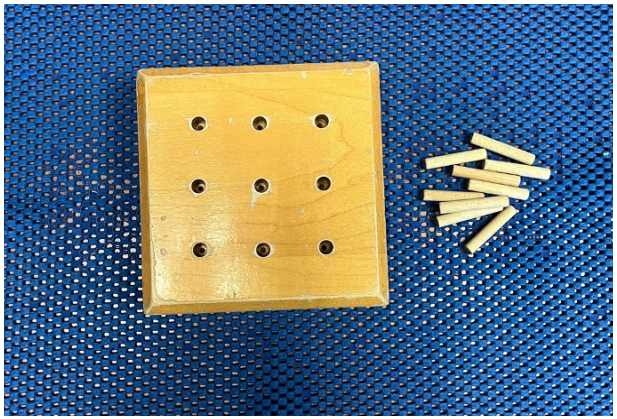
Examination – Grip and Pinch Strength

	Left	Right
Grip (pounds)	37	28
Tip Pinch (pounds)	14	8
Key Grip (pounds)	22	23

Examination & Outcomes [9, 16, 21, 22, 24]

NINE-HOLE PEG TEST

Left: 24.76 sec / 26.51 sec
Right: 34.47 sec / 31.08 sec



SELF REPORTED OUTCOMES

- Neck Disability Index (NDI): 36%
- QuickDASH: 43%

Clinical Impression #2 3, 5, 12, 20

Presentation

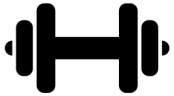
- Decreased strength
- Decreased shoulder AROM
- Decreased coordination/dexterity
- Decreased functional use of right upper extremity
- Absent reflexes/sensation C5-C6 distribution

Goals

- Pain less than 3/10.
- Report ability to perform his usual work with minimal to no difficulty
- Report moderate to minimal difficulty lifting objects from the floor
- Improve MMT to 4-/5
- Improve AROM Right shoulder abduction to 110 degrees
- Improve right grip strength equal to left
- QuickDASH to 30% or less

INTERVENTIONS [1, 3, 5, 19]

- Neuromuscular Electrical Stimulation (NMES)
- Neuromuscular Re-education
- Therapeutic Exercise
- Therapeutic Activities
- Manual Therapy
- Home Exercise Program

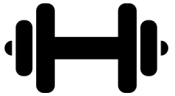


Early phase

Supported elbow flexion

Forearm supination/pronation

Supine motor retraining



Progression

Cane-assisted, manual ted strengthening

Functional reaching

Object manipulation

Multilevel reaching tasks

NMES Parameters [7, 8, 13, 17, 23]

- Symmetrical biphasic waveform
- Frequency: 35 Hz
- Pulse duration: 160-180 μs
- Ramp: 2-5 sec
- Duty cycle: 10 sec on / 30-50 sec off
- Duration: 15-25 min/session
- Paired with active movement

NMES Electrode Placement

Bicep – Elbow flexion

Supinator – Forearm supination

Outcomes [9, 16, 21, 22, 24]

FUNCTIONAL

- Right shoulder AROM
  - Flexion 60˚ to 105˚
  - Abduction 55˚ to 110˚
- MMT
  - Rhomboids: 3-/5 to 4/5
  - Elbow flexion 2+/5 to 3/5
  - Tip pinch: 8 lbs to 18 lbs
- Nine-Hole Peg Test improved

SELF-REPORTED OUTCOMES

- NDI: 36% to 32%
- QuickDASH: 43% to 34.1%
- Self-reported outcomes did not exceed MDC

PATIENT REPORTED FUNCTIONAL IMPROVEMENTS

- Feeding
- Grooming
- Reaching
- Light object manipulation

Discussion [3, 5, 7, 11, 13, 19]

- Multimodal PT approach supported improvements in:
  - ROM
  - Motor control
  - Dexterity
  - Functional arm use
- NMES likely improved motor recruitment when paired with active movement
- Task-specific training likely improved functional carryover
- Persistent proximal weakness remained
- Recovery likely influenced by chronicity and diabetic polyneuropathy

Limitations

- Sensation and reflexes not reassessed
- Occasional missed visits due to personal reasons
- Early discharge due to insurance visit conservation
- Transitioned to independent HEP before full recovery
- Limits interpretation of long-term outcomes

Conclusion [7, 13, 19]

- NMES may be a useful adjunct within a multimodal outpatient PT program for individuals with cervical myelopathy.
- Pairing NMES with task-specific training and strengthening may improve upper-extremity motor performance and function.
- Continued research is needed to better define the role of NMES in this population.

Questions?

References

- Badran A, Davies BM, Bailey HM, Kalsi-Ryan S, Kotter MR. Is there a role for postoperative physiotherapy in degenerative cervical myelopathy? A systematic review. *Clin Rehabil.* 2018;32(9):1169-1174. doi:10.1177/0269215518766229
- Baucher G, Taskovic J, Troude L, Molliqaj G, Nouri A, Tessitore E. Risk factors for the development of degenerative cervical myelopathy: a review of the literature. *Neurosurg Rev.* 2022;45(2):1675-1689. doi:10.1007/s10143-021-01698-9
- Bonosi L, Musso S, Cusimano LM, et al. The role of neuronal plasticity in cervical spondylotic myelopathy surgery: functional assessment and prognostic implications. *Neurosurg Rev.* 2023;46(1):149. doi:10.1007/s10143-023-02062-9
- Boone DC, Azen SP, Lin CM, Spence C, Baron C, Lee L. Reliability of goniometric measurements. *Phys Ther.* 1978;58(11):1355-1360. doi:10.1093/ptj/58.11.1355
- Cervellini M, Feller D, Maselli F, et al. Understanding degenerative cervical myelopathy in musculoskeletal practice. *J Man Manip Ther.* 2025;33(3):207-223. doi:10.1080/10669817.2025.2465728
- Fenton JM, King JA, Hoekstra SP, Valentino SE, Phillips SM, Goosey-Tolfrey VL. Protocols aiming to increase muscle mass in persons with motor complete spinal cord injury: a systematic review. *Disabil Rehabil.* 2023;45(9):1433-1443. doi:10.1080/09638288.2022.2063420
- Gorgey AS, Lai RE, Khalil RE, et al. Neuromuscular electrical stimulation resistance training enhances oxygen uptake and ventilatory efficiency after spinal cord injury. *J Appl Physiol (1985).* 2021;131(1):265-276. doi:10.1152/japplphysiol.01029.2020
- Gorgey AS, Venigalla S, Deitrich JN, et al. Electrical stimulation paradigms on muscle quality and bone mineral density after spinal cord injury. *Osteoporos Int.* 2025;36(6):1039-1051. doi:10.1007/s00198-025-07482-5
- Gummesson C, Ward MM, Atroshi I. The shortened DASH questionnaire (QuickDASH): validity and reliability. *BMC Musculoskelet Disord.* 2006;7:44. doi:10.1186/1471-2474-7-44

References

- Houten JK, Shahsavarani S, Verma RB. The natural history of degenerative cervical myelopathy. *Clin Spine Surg.* 2022;35(10):396-402. doi:10.1097/BSD.0000000000001405
- Johansen TO, Holmberg ST, Danielsen E, et al. Long-term results after surgery for degenerative cervical myelopathy. *Neurosurgery.* 2024;94(3):454-460.doi:10.1227/neu.0000000000002712
- Kane SF, Abadie KV. Degenerative cervical myelopathy: recognition and management. *Am Fam Physician.* 2020;102(12):740-750.
- Knutson JS, Fu MJ, Sheffler LR, Chae J. Neuromuscular electrical stimulation for motor restoration in hemiplegia. *Phys Med Rehabil Clin N Am.* 2015;26(4):729-745.doi:10.1016/j.pmr.2015.06.002
- Lemeunier N, Jeoun EB, Suri M, et al. Reliability and validity of clinical tests for cervical spine assessment. *Musculoskelet Sci Pract.* 2018;38:128-147. doi:10.1016/j.msksp.2018.09.013
- Mullaney MJ, McHugh MP, Johnson CP, Tyler TF. Reliability of shoulder ROM measurements. *Physiother Theory Pract.* 2010;26(5):327-333. doi:10.3109/09593980903094230
- Oxford Grice K, Vogel KA, Le V, Mitchell A, Muniz S, Vollmer MA. Adult norms for the Nine Hole Peg Test. *Am J Occup Ther.* 2003;57(5):570-573. doi:10.5014/ajot.57.5.570
- Popovic MR, Zivanovic V, Valiante TA. Restoration of upper limb function using FES therapy. *Front Neurol.* 2016;7:81. doi:10.3389/fneur.2016.00081
- Sakaguchi T, Heyder A, Tanaka M, et al. Rehabilitation after cervical spine surgery. *J Clin Med.* 2024;13(18):5363. doi:10.3390/jcm13185363
- Shirley Ryan AbilityLab. Neck Disability Index. Rehabilitation Measures Database. Accessed April 18, 2026.
- Shirley Ryan AbilityLab. Quick Disabilities of the Arm, Shoulder and Hand. Rehabilitation Measures Database. Accessed April 18, 2026.
- Vasanthan LT, Nehrujee A, Solomon J, Tilak M. Electrical stimulation for spinal cord injury. *Cochrane Database Syst Rev.* 2019;11:CD013481. doi:10.1002/14651858.CD013481
- Vernon H, Mior S. The Neck Disability Index: reliability and validity. *J Manipulative Physiol Ther.* 1991;14(7):409-415.

HEALTH PROFESSIONS
PHYSICAL THERAPY
CENTRAL MICHIGAN UNIVERSITY