Review
DOI: 10.5152/tftrd.2015.65632
Turk J Phys Med Rehab 2015;61 (Supp. 1):S19-S24

Updates in ASIA Evaluation: Lower Extremity Motor Evaluation

Berrin GÜNDÜZ[1], Belgin ERHAN[1,2]

[1]*İstanbul Physical Medicine Rehabilitation Training Hospital, İstanbul, Turkey*
[2]*İstanbul Aydın University, Health Services Vocational School of Higher Education, İstanbul, Turkey*

Abstract

The most common method used for the assessment of spinal cord injury patients is International Standards for Neurological Classification of Spinal Cord Injury developed by the American Spinal Cord Association and International Spinal Cord Society. One of the important parts of this evaluation-motor evaluation of the lower extremities-is reviewed in this article.
Keywords: Spinal cord injury, ASIA evaluation, lower extremity motor evaluation

Introduction

The International Standards for Neurological Classification of Spinal Cord Injury (ISNCSCI) developed by the American Spinal Cord Association (ASIA) and the International Spinal Cord Society (ISCoS) are the most commonly used method assessment of patients with spinal cord injury (1). In the present article, motor evaluation of the lower extremities, which is one of the most important parts of this evaluation, is reviewed. In the motor evaluation of the lower extremities, key muscle functions corresponding to five myotomes (L2–S1) are evaluated, as in the upper extremities. It is recommended that each key muscle function should be evaluated in the rostral–caudal sequence and supine position and by stabilizing the muscle to be evaluated as improper positioning in stabilization can cause other muscles to be assessed by mistake (2).

A 6-point scale is used for evaluating muscle strength (Table 1). When International Standards are used for research and comparisons among clinics are made, the use of plus and minus values is not recommended in the grading of muscle strength. If more than half of the joint's range of motion (ROM) can be performed in patients with contracture, the muscle strength is evaluated; otherwise, it is evaluated as "not testable" (NE) (3).

The following muscles are bilaterally assessed. The reasons for choosing these muscles are that they are innervated with the specified segment and from at least two spinal segments, they have functional significance, and they can be easily reached and isolated in the supine position (4).

The key muscles used for motor evaluation and related roots and segments of the spinal cord are as follows:

L2: Hip flexors (iliopsoas)

L3: Knee extensors (quadriceps)

L4: Ankle dorsiflexors (tibialis anterior)

L5: Long toe extensors (extensor hallucis longus)

S1: Ankle plantar flexors (gastrocnemius and soleus)

In 2011 revision of ISNCSCI, it was recommended to pay atten-

Address for Correspondence: Dr. Berrin Gündüz, İstanbul Fizik Tedavi Rehabilitasyon Eğitim ve Araştırma Hastanesi, İstanbul, Türkiye.
Phone: +90 212 496 50 00 E-mail: gunduzberrin@gmail.com

Received: February 2015 Accepted: March 2015

Cite this article as:
Gündüz B. Erhan B. Updates in ASIA Evaluation: Lower Extremity Motor Evaluation. Turk J Phys Med Rehab 2015;61(Supp. 1):S19-S24.

Table 1. Grading muscle functions (4)

0=	Total paralysis
1=	Palpable or visible contraction
2=	Active movement, full range of motion (ROM) when gravity is eliminated
3=	Active movement, full ROM against gravity
4=	Active movement, full ROM against gravity, and moderate resistance in a muscle-specific position
5=	(Normal) Active movement, full ROM against gravity, and full resistance in a muscle-specific position expected from a healthy person
5*=	(Normal) Active movement, full ROM against gravity, and sufficient resistance to be considered normal if identified inhibiting factors (i.e., pain, disuse) were not present
NT=	Not testable (i.e., due to immobilization, severe pain that can prevent the grading of the patient, amputation of limb, or contracture of >50% of the range of motion)

tion to the following positions when evaluating muscle strength grades 4 and 5 (3-6):

L2: Hip at 90° of flexion

L3: Knee at 15° of flexion

L4: Ankle in full dorsiflexion

L5: Toe in full extension

S1: Hip in neutral rotation, neutral flexion/extension, and neutral abduction /adduction; knee in full extension; and ankle in full plantar flexion.

The positioning of these key muscles during evaluation and the points that must be considered are comprehensively explained in the motor evaluation training module of the InSTeP program, which can be accessed on the ASIA and ISCoS websites. The motor evaluation of the lower extremities starts with muscle strength grade 3. If the patient can achieve grade 3, the evaluation continues with grade 4 or 5; however, if the patient cannot achieve grade 3, the evaluation proceeds with grades 2, 1, or 0 (7).

L2 myotome: Hip flexors-iliopsoas muscle

- **Grade 3**: The patient is in the supine position, the hip is in neutral adduction/abduction, and the hip and knee are in 15° of flexion. The leg is supported to prevent heel friction to the bed (Figure 1a). The patient is asked to lift the knee toward the face. If the patient completes ROM, muscle strength is evaluated to be grade 3 (Figure 1b). While assessing hip flexion in patients with suspected acute traumatic injury below the T8 level, active or passive hip flexion above 90° should be avoided to prevent kyphotic stress increase on the lumbar spine (5).
- **Grades 4 and 5**: The patient is in the supine position, the hip is in neutral rotation and abduction/adduction, and the hip and knee are in 90° of flexion. While the contralateral hip is stabilized by one hand, pressure is applied in the opposite direction of the hip flexion above the knee (Figure 2). If the patient receives partial pressure, the muscle strength is evaluated to be grade 4, whereas if the patient receives full pressure, the muscle strength is evaluated to be grade 5.

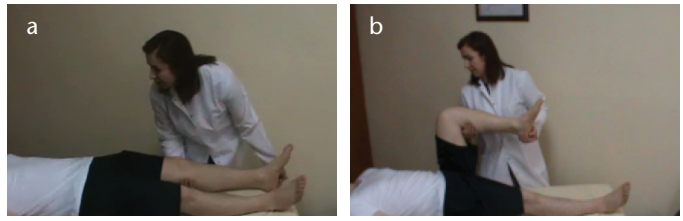

Figure 1. a, b. Evaluation of the patient's hip flexors for muscle strength grade 3; initial position (a), if the patient completes the range of motion, the grade is evaluated to be 3 (b)

Figure 2. Evaluation of hip flexion for muscle strength grades 4 or 5

- **Grade 2:** The hip is positioned in external rotation and in 45° of flexion. The knee is in 90° of flexion (Figure 3). The patient is requested to bring the knee toward the head. If the patient can achieve full ROM, the grade of muscle strength is evaluated to be 2.
- **Grades 1 and 0**: The hip is in neutral rotation and abduction/adduction. If superficial hip flexors (sartorius or rectus femoris) are palpated distal to the anterior superior iliac spine when the patient tries to bring the leg toward the abdomen, the muscle strength is evaluated to be grade 1. Considering that it is very difficult to palpate iliopsoas, which is a deep muscle, while examining muscle strength grade 1, more superficial flexor muscles are recommended to be palpated. In the absence of any contraction that can be palpated or observed, the muscle strength is graded as 0.

L3 myotome: Knee extensors-quadriceps muscle

- **Grade 3**: The patient is in the supine position. The hip is positioned in neutral rotation and abduction/adduction and in 15° of flexion. The knee is in 30° of flexion. The hand is passed under the tested knee and placed on the other knee

(Figure 4). The patient is asked to bring the knee to the extension position. If the patient can achieve full ROM, the muscle strength is graded as 3.

- **Grades 4 and 5**: The patient is in the supine position. The hip is positioned in neutral rotation and abduction/adduction and the hip and knee are in 15° of flexion. The hand is passed under the tested knee and placed on the other knee. The patient is asked to do a knee extension, and pressure is applied from the proximal side of the ankle toward the bed with the other hand (Figure 5). If the patient can feel partial pressure, the muscle strength is graded as 4, whereas in the case of full resistance, the muscle strength is graded as 5.
- **Grade 2**: The leg is supported when the hip is in external rotation and in 45° of flexion and the knee is in 90° of flexion (Figure 6). The patient is requested to perform a knee extension. If the patient can achieve full ROM, the muscle strength is graded as 2.
- **Grades 1 and 0**: The hip is in neutral rotation and abduction/adduction. The hip and knee are in 15° of flexion. The patient is asked to push the back of the leg downward toward the bed, and the patellar tendon or quadriceps is palpated, or contraction is observed. In the presence of contraction, the muscle strength is graded as 1, whereas in the absence of any contraction that is palpated or observed, the muscle strength is graded as 0.

L4 myotome: Ankle dorsiflexors-tibialis anterior muscle

- **Grade 3:** The patient is in the supine position. The hip is positioned in neutral rotation and abduction/adduction. The hip and knee are positioned in slight flexion (Figure 7). The patient is asked to pull the toes toward the face. If the patient can achieve full ROM, the muscle strength is graded as 3.
- **Grades 4 and 5:** Pressure is applied on the dorsum of the foot when the hip is in neutral rotation and abduction/adduction, the hip and knee are positioned in slight flexion,

Figure 3. Positioning for the evaluation of muscle strength grade 2 in hip flexion

Figure 4. Positioning for the evaluation of muscle strength grade 3 in knee extension

Figure 5. Evaluation of muscle strength grade 4 or 5 in knee extension

Figure 6. Positioning for the evaluation of muscle strength grade 2 in knee extension

and the ankle is in full dorsiflexion (Figure 8). If the patient feels partial pressure, the muscle strength is graded as 3, whereas if the patient feels full pressure, the muscle strength is graded as 5.

- **Grade 2:** When the hip is in external rotation and in 45° of flexion, the knee is in 90° of flexion the patient is then asked to lift the toes upward toward the face (Figure 9). If the patient can achieve full ROM, the muscle strength is graded as 2.
- **Grades 1 and 0:** The hip is in neutral rotation and abduction/adduction, and the hip and knee are in slight flexion. When the patient is asked to pull the foot toward the face, the tibialis anterior tendon or muscle is palpated (Figure 10). In the presence of contraction, the muscle strength is graded is 1, but if the contraction cannot be palpated or observed, the muscle strength is graded as 0. While evaluating for muscle strength grade 1, it should be kept in mind that the extensor hallucis longus muscle can mimic ankle dorsiflexion; therefore, it should be assured that the movement is performed from the ankle.

L5 myotome: Toe dorsiflexors-extensor hallucis longus muscle

- **Grade 3**: The patient is in the supine position. The hip is in neutral rotation and abduction/adduction, and the knee is in extension. The patient is asked to pull the first toe toward the knee. If the patient can achieve full ROM, the muscle strength is graded as 3.
- **Grades 4 and 5:** Pressure is applied when the hip is in neutral rotation and abduction/adduction, the knee is in extension, and the great toe in full extension (Figure 11). If the patient receives partial pressure, the muscle strength is graded as 4, whereas if the patient receives full pressure, the muscle strength is graded as 5.

Figure 7. Evaluation of ankle dorsiflexion for muscle strength grade 3

Figure 8. Evaluation of ankle dorsiflexion for muscle strength grade 4 and 5

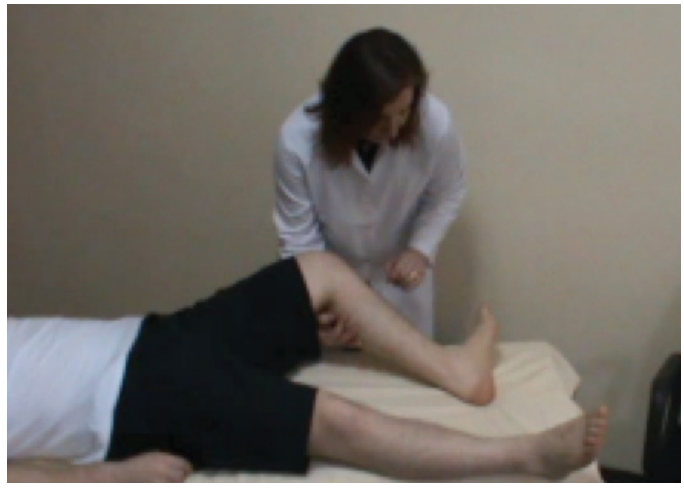

Figure 9. Evaluation of ankle dorsiflexion for muscle strength grade 2

Figure 10. Evaluation of contraction in the tibialis muscle for muscle strength grade 1 in ankle dorsiflexion

Figure 11. Evaluation of the toes for muscle strength grades 4 and 5

Figure 12. Evaluation of the toes for muscle strength grade 2

- **Grade 2:** The grade of muscle strength is 2 if the toe can achieve full extension when the hip is in external rotation, the hip and knee are in flexion, and the ankle and toes are in a relaxed position (Figure 12).
- **Grades 1 and 0:** The hip is in neutral rotation and abduction/adduction, and the hip and knee are in extension. The patient is asked to pull the toe toward the face, and the extensor hallucis longus tendon or muscle is palpated. In the presence of contraction, the muscle strength is graded as 1, whereas in the absence of any contraction that can be palpated or observed, the muscle strength is graded as 0.

S1 myotome: Ankle plantarflexors-gastrocnemius and soleus muscles

- **Grade 3**: The patient is examined in the supine position. The hip is in neutral rotation and abduction/adduction and in 45° of flexion, and the knee is in full flexion. One hand of the examiner is placed under the knee, and the other hand is under the sole of the foot. The heel remains resting on the bed (Figure 13a). The patient is asked to push the foot down and to lift the heel off the bed. If the patient achieves full ROM, the grade of muscle strength is evaluated to be 3 (Figure 13b). During this assessment, the hip flexors should be monitored to assure that they are not being used to facilitate the movement.

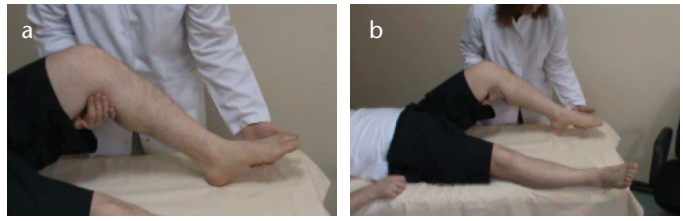

Figure 13. a, b. Positioning the ankle plantar flexors for muscle strength grade 3 (a), lifting the heel up and completing the joint's range of motion (b)

Figure 14. Evaluation of the ankle plantar flexors for muscle strength grades 4 and 5

- **Grades 4 and 5:** The hip is in neutral rotation and abduction/ adduction, the knee is in extension, and the ankle is in full plantar flexion the leg is stabilized with one hand, and pressure is applied to the sole of the foot with the other hand when (Figure 14). If the patient feels partial pressure, the muscle strength is graded as 4, whereas if the patient feels full pressure, the muscle strength is graded as 5.
- **Grade 2**: When the hip is in external rotation and the hip and knee are in flexion, the patient is asked to move the foot downward. If the patient can achieve full ROM, the muscle strength is graded as 2. During this effort, if there is a contraction in the Achilles tendon or gastrocnemius muscle, the muscle strength is graded as 1. If not, the muscle strength grade is evaluated to be 0 (7).

The results of the evaluated key muscles are noted in the separate section for motor evaluation on the ASIA assessment page (8). To avoid making mistakes during the motor evaluation, simple instructions should be given to the patient to explain what we want. Moreover, it is possible to make an inaccurate evaluation

to be performed due to various reasons, including coexisting head trauma, sedation, pain, fatigue, anxiety, previous cognitive deficit, insufficient experience of the examiner, and improper positioning and stabilizing. Moreover an inaccurate evaluation of muscle strength grade 1 due to incorrect palpation, passive ROM not previously evaluated, and the false evaluation of spasticity or reflex movement as a voluntary muscle contraction are frequently occurring problems. The use of plus (+) and minus (–) values in the evaluation of muscle strength may decrease the retest reliability of the assessment (7).

Peer-review: This manuscript was prepared by the invitation of the Editorial Board and its scientific evaluation was carried out by the Editorial Board.

Author Contributions: Concept - B.G., B.E.; Design - B.G.; Supervision - B.E.; Resource - B.G., B.E.; Materials - B.G., B.E.; Data Collection and/or Processing - B.G., B.E.; Analysis and/or Interpretation - B.G., B.E.; Literature Review - B.G., B.E.; Writer - B.G.; Critical Review - B.E.; Other - B.G.

Acknowledgment: We would like to thank Ufuk Karanfil and Dr. Alkan Öztürk for the motor evaluation photos.

Conflict of Interest: No conflict of interest was declared by the authors.

Financial Disclosure: The authors declared that this study has received no financial support.

References

1. Gündüz B. Medulla Spinalis Yaralanmalarında Sınıflama. Turk J Phys Med Rehab 2002;48:12-4.
2. Erhan B. Medulla Spinalis Yaralanmalarında Nörolojik Muayene. Turk J Phys Med Rehab 2002;48:20-3.
3. Erhan B, Gündüz B. Omurga-omurilik travmalarında klinik muayene ve sınıflama. In: Hancı M, Erhan B, editörler. Omurga ve Omurilik Yaralanmaları. İnter Tıp Kitapevi; Antalya, 2012. p.207-20.
4. American Spinal Injury Association: International Standards for Neurological Classification of Spinal Cord Injury, revised 2011; Atlanta GA.
5. American Spinal Injury Association: International Standards for Neurological Classification of Spinal Cord Injury, revised 2013; Atlanta, GA. Reprinted 2013.
6. Gündüz B, Erhan B. Omurilik Yaralanması Nörolojik Sınıflaması için Uluslararası Standartlar 2011 revizyonu: Değerlendirme Formu Türkçe çevirisi. Turk J Phys Med Rehab 2012;58:42-5.
7. InSTeP. Avalaible from: http://content.learnshare.com/courses/120/393989/player.html. Dec 1, 2014.
8. Gündüz B, Erhan B. Omurilik Yaralanması Nörolojik Sınıflaması için Standartlar Değerlendirme Formunun Güncellenmesi. Turk J Phys Med Rehab 2015;61:91-4.