Quantifying Neurological Examination in 21st Century:Yilmaz-Ilbay Plantar Flexion Test, A Reliable Test for Evaluating Plantar Flexion in L5-S1 Disc Herniation

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Method Article

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Abstract

Objectives

To evaluate a new examination technique that can quantitatively measure plantar flexion in L5-S1 disc herniation.

Materials and methods

In this study only subjects with L5-S1 disc herniations were included total number of patients was 32 and 18 had left sided herniations while 14 had right sided herniations. The patient to be tested stands next to a table on which they can lean with their hands. The leg closer to the table is fully flexed at the knee and the other foot is brought to maximum plantar flexion on the toes. At this point a stopwatch is started to measure the time that passes until the muscles fatigue and the heel falls. During the application of the test, the differences between the right and left plantar flexion times were noted. At the same time, three different physicians graded muscle strength with the classical "The Medical Research Council of the United Kingdom" method. All findings were recorded.

Results

Yilmaz-Ilbay plantar flexion test gave the correct classification for all cases. In our series, the average age was 49.4 years (range: 23 to 78). In all patients, the time until fatigue in right and left plantar flexion was measured with the method we described, and video recording of each test was taken with the permission of the patients. Data gathered from the patients were analyzed.

Conclusions

We suggest our novel method “Yilmaz-Ilbay plantar flexion test” as a useful, practical and effective test to detect quantitative evaluation of plantar flexion in L5-S1 herniation.

Introduction

From comparing patients’ preoperative to postoperative changes to quantifying the amount of disability of a person, measuring muscle strength in a neurologic examination is required for a variety of reasons. To this end distal strength can be measured semi-quantitatively with a handheld ergometer or with an inflated blood pressure cuff gripped by the patient. Furthermore, muscle strenght and disability can be assessed using different moves and the number of moves a patient can perform (eg, number of squats done or steps climbed). For example getting up from a squatting position or stepping on a chair tests proximal leg strength; walking on heels and toes tests distal strength. However, a more impartial method is required for both clinical excelence and medicolegal reasons. Muscle strength scale, originally developed by The Medical Research Council of the United Kingdom, is now used universally (Table 1).

Table 1
Grading muscle tone and strength (The Medical Research Council of the United Kingdom strength examination scale)

Grade	Ability to move
0	No visible muscle contraction
1	Visible muscle contraction with no or trace movement
2	Limb movement, but not against gravity
3	Movement against gravity but not resistance
4	Movement at least some resistance supplied by the examiner
5	Full strength

It is used when evaluating the strength of the muscles performing plantar flexion as a standard. However, since this examination technique is a subjective and qualitative evaluation, the results may be variable according to the perceptions of the clinician performing the examination. Measuring plantar flexion with the method we have developed, provides quantitative results.

Muscles involved in plantar flexion: Musculus (M) gastrocnemius and M. soleus. Some anatomists consider both to be a single muscle- the triceps surae. M. triceps surae is innervated from Nervus tibialis. In L5-S1 disc hernias, there may be varying degrees of strength loss in the M. triceps surae. In addition, there are auxiliary muscles such as M. tibialis posterior, M. peroneus longus and brevis, M. flexor hallucis longus, M. flexor digitorum longus, M. plantaris that support plantar flexion. While performing this test, it should be kept in mind that when the patient's knee is in full extension, the M. gastrocnemius muscle participates in the movement dominantly, and when the knee is in slight flexion, the M. soleus muscle participates in the movement dominantly.

In the current study, we aimed to evaluate a new examination technique that can quantitatively measure plantar flexion in L5-S1 disc herniation using a novel procedure and to share our experience with this method with a brief review of current literature.

Materials And Methods

This prospective study has been performed per the principles of the Helsinki Declaration after the approval of the local institutional review board (2021/19–44) and the informed consent has been obtained from all patients or relevant persons for publication. Subjects were 32 patients presenting with L5-S1 disk herniation, between 2020 and 2021. 18 had left sided herniations while 14 had right sided herniations. Twenty patients were male and 12 were female.The patient to be tested stands next to a table on which they can support themselves usingtheir hands. The leg closer to the table is fully flexed at the knee and the other foot is brought to maximum plantar flexion or colloquially, patient is instructed to stand on one leg and raise to tip-toes. Starting from this moment the timeis measured using a stopwatch (Figure [video]1 and 2) until the heel yields to the gravity and is level with the toes. During the application of the test, the differences between the right and left plantar flexion times are noted. At the same time, three different physicians graded muscle strength with the classical "The Medical Research Council of the United Kingdom" method. All findings were recorded.

The examination results of three different physicians varied in many patients. Patients without deficits in classical examination and quantitative measurement were not included in the study.

Statistical analysis:

Our data was analyzed using Statistical Package for Social Sciences program version 21.0 (*SPSS Inc., Chicago, IL; USA*). The values were expressed as mean ± standard deviation or median, minimum, and maximum.

Results

Yilmaz-Ilbay plantar flexion test gave the correct classification for all 32 cases. The baseline descriptives and clinical data in our series are displayed in **Table 2**. Our population consisted of 20 men and 12 women with a mean age of 49.4 years (range: 23 to 78). All patients presented with L5-S1 disk herniation.

In all patients, the time of standing in right and left plantar flexion was measured with the method we described, and camera images were taken with the permission of the patients. Data gathered from a total of 32 patients were analyzed.

In 27 cases (84.37%), there was a difference of more than 25 seconds between the right and left plantar flexion test. The average duration difference between right and left plantar flexion was statistically significant (from 20 to 102, $p < 0.001$).

Table 2. Comparative overview of the evaluation of patients in whom plantar flexion was tested quantitatively

(N/A: non applicable).

Patients no	Pathologic level and side	Fatigue duration in plantar flexion (Second)		First Physician	Second Physician	Third Physician	Age	Sex	Weight of Patient (kg)	Duration of the symptoms (Month : m) (Day : d)	Accompanying systemic diseases
		Left	Right	Left Right	Left Right	Left Right					
1	Left L5-S1	12	100	4/5–5/5	4/5–5/5	3/5–5/5	35	M	80	6 m	N/A
2	Right L5-S1	75	45	5/5–5/5	5/5–5/5	5/5–5/5	45	M	76	10 d	DM, HT, ICD
3	Left L5-S1	25	72	5/5–5/5	5/5–5/5	4+/5–5/5	52	M	80	3 m	N/A
4	Left L5-S1	10	30	4/5–5/5	4/5–5/5	4/5–5/5	63	F	74	4 m	N/A
5	Right L5-S1	60	45	5/5–5/5	5/5–5/5	5/5–4/5	52	M	82	12 m	N/A
6	Right L5-S1	66	40	5/5–4/5	5/5–5/5	5/5–5/5	54	F	65	5 m	N/A
7	Left L5-S1	18	120	3/5–5/5	4/5–5/5	4/5–5/5	48	M	90	1 m	N/A
8	Right L5-S1	68	36	5/5–4/5	5/5–5/5	5/5–4/5	36	F	56	2 m	N/A
9	Left L5-S1	25	95	3/5–5/5	4/5–5/5	4/5–5/5	33	F	61	14 m	N/A
10	Left L5-S1	30	70	4/5–5/5	4/5–5/5	4/5–5/5	41	M	70	15 d	N/A
11	Right L5-S1	85	40	5/5–5/5	5/5–4/5	5/5–4/5	56	M	77	4 m	N/A
12	Right L5-S1	95	40	5/5–4/5	5/5–5/5	5/5–4/5	36	M	56	7 m	N/A
13	Right L5-S1	70	30	5/5–4/5	5/5–4/5	5/5–3/5	65	M	73	4 m	N/A
14	Right L5-S1	90	55	5/5–4/5	5/5–3/5	5/5–4/5	43	F	67	20 d	N/A
15	Left L5-S1	35	60	4/5–5/5	5/5–5/5	4/5–5/5	55	F	68	3 m	N/A
16	Left L5-S1	50	80	4/5–5/5	4/5–5/5	4/5–5/5	60	M	88	1 m	HT
17	Right L5-S1	70	45	5/5–4/5	5/5–3/5	5/5–4/5	51	M	79	20 d	N/A
18	Right L5-S1	65	35	5/5–3/5	5/5–4/5	5/5–3/5	23	M	65	15 d	N/A
19	Right L5-S1	50	32	5/5–3/5	5/5–4/5	5/5–4/5	34	F	55	2 m	N/A
20	Left L5-S1	35	85	4/5–5/5	4/5–5/5	3/5–5/5	56	F	66	6 m	N/A
21	Right L5-S1	70	40	5/5–4/5	5/5–3/5	5/5–4/5	59	M	70	6 m	N/A
22	Left L5-S1	42	100	3/5–5/5	4/5–5/5	3/5–5/5	45	M	76	4 m	N/A
23	Right L5-S1	66	35	5/5–4/5	5/5–3/5	5/5–4/5	33	F	55	1 m	N/A
24	Right L5-S1	90	55	5/5–4/5	5/5–4/5	5/5–4/5	57	F	69	7 d	N/A
25	Left L5-S1	33	60	4/5–5/5	3/5–5/5	4/5–5/5	78	M	77	3 m	DM

Patients no	Pathologic level and side	Fatigue duration in plantar flexion (Second) Left Right		First Physician Left Right	Second Physician Left Right	Third Physician Left Right	Age	Sex	Weight of Patient (kg)	Duration of the symptoms (Month : m) (Day : d)	Accompanying systemic diseases
26	Right L5-S1	75	50	5/5–4/5	5/5–4/5	5/5–4/5	58	F	62	12 m	N/A
27	Left L5-S1	48	88	3/5–5/5	4/5–5/5	4/5–5/5	51	M	80	15 d	N/A
28	Left L5-S1	33	56	4/5–5/5	4/5–5/5	5/5–5/5	45	M	61	1 m	N/A
29	Right L5-S1	66	45	5/5–4/5	5/5–4/5	5/5–4/5	72	M	67	6 m	HT
30	Right L5-S1	70	52	5/5–4/5	5/5–4/5	5/5–4/5	47	M	78	1 m	DM, HT, ICD
31	Right L5-S1	65	43	5/5–4/5	5/5–5/5	5/5–4/5	43	F	64	12 d	N/A
32	Left L5-S1	10	80	4/5–5/5	3/5–5/5	3/5–5/5	55	M	90	8 m	DM

DM: Diabetes Mellitus, HT: Hypertension, ICD: Ischemic Cardiac Disease

Discussion

The purpose of this test is to quantitatively evaluate the loss of strength in L5-S1 unilateral discal hernias. In L5-S1 disc hernias, especially plantar flexion examination should be done in detail. Examination results made with today's technique are highly subjective and qualitative. With the new examination method we have developed (Yilmaz-Ilbay plantar flexion test), the strength loss in plantar flexion can be measured exact and quantitatively in patients with L5-S1 discal hernia.

Is neurological examination important?

No matter how technology advances, it is essential to take a proper history and perform a detailed examination in diagnosing a patient (1). A neurologic examination (NE) consists of identified steps including inspections, history, and maneuvers. The stages of the NE test the circuits that mediate the patient's mental, motor, and sensory functions and detect changes in the patient's body configuration and measurements. Considering the circuitry of the central nervous system provides an important feature to neuroscientists (2).

Babinski sign was described in 1899 by neurologist Joseph Babinski. Since then, it has been a sine qua non of the standard neurological examination and it is easy to implement without complicated equipment (3).

Today, it is a proven fact that the Babinski sign is an indicator of dysfunction of the fibers in the pyramidal system. It is surprising even today that the Babinski sign which is objective clinical signs that cannot be mimicked by the patient, consciously or unconsciously is a reliable finding for such precise localization of central nervous system dysfunction (4, 5).

The abductor sign is a perfect test to detect non-organic paresis, because it is imposible for a hysterical patient to deceive the examiner (6).

A test called the "Barré test" is routinely used in clinical practice to find subtle hemiparesis in the arms and legs (7).

Similarly, Mingazzini's arm and leg tests were described by Giovanni Mingazzini in 1937 and are still used as an invaluable method in neurological examination today (7).

Although examination styles vary over time all over the world, specific examinations for the patient's symptoms and signs are important (8).

Since the examination methods found a hundred years ago are still used today and provide benefits in the diagnosis and treatment of patients, the quantitative measurement of plantar flexion will make an important contribution to the diagnostic methods.

The most important limitation of the test is that it is not possible to quantitatively evaluate patients with a strenght loss of more than 3/5 on one side, that is, those who cannot overcome gravity.

Conclusions

We suggest our novel method “Yilmaz-Ilbay plantar flexion test” is a useful, practical and effective test to detect quantitative and exact evaluation of strength loss in plantar flexion in patients with L5-S1 discal herniation. Further trials are warranted to evaluate the efficacy of this method to overcome the test problems associated with measuring strenght loss in plantar flexion.

Declarations

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Conflicts of Interest Disclosure: The authors declare no competing interests.

Statement of ethics

This study has been performed in accordance with the guidelines declared by World Medical Association Declaration of Helsinki. The approval of the local institutional review board had been obtained before the study (2021/19-44).

Availability of data and material: The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Videos

Figures [videos] 1 and 2 are available in the Supplementary Files section.

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- VIDEO1Examinationofleftplantarflexionusingachronometer.mp4
- VIDEO2Examinationofrightplantarflexionusingachronometer.mp4