A primer on the in-home teleneurologic examination: A COVID-19 pandemic imperative

Authors: Christopher J. Boes, MD; Andrea N. Leep Hunderfund, MD, MHPE; Jennifer M. Martinez-Thompson, MD; Neeraj Kumar, MD; Rodolfo Savica, MD, PhD; Jeremy K. Cutsforth-Gregory, MD, Lyell K. Jones, Jr., MD

Christopher J. Boes, Mayo Clinic, Department of Neurology, Rochester, MN, USA
Andrea N. Leep Hunderfund, Mayo Clinic, Department of Neurology, Rochester, MN, USA
Jennifer M. Martinez-Thompson, Mayo Clinic, Department of Neurology, Rochester, MN, USA
Neeraj Kumar, Mayo Clinic, Department of Neurology, Rochester, MN, USA
Rodolfo Savica, Mayo Clinic, Department of Neurology, Rochester, MN, USA
Jeremy K. Cutsforth-Gregory, Mayo Clinic, Department of Neurology, Rochester, MN, USA
Lyell K. Jones, Jr., Mayo Clinic, Department of Neurology, Rochester, MN, USA

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Corresponding author:
Christopher J. Boes
Mayo Clinic
200 First Street SW
Rochester, MN 55905
Phone: 507-284-1005
boes.christopher@mayo.edu
leep.andrea@mayo.edu
martinezthompson.jennifer@mayo.edu
kumar.neeraj@mayo.edu
savica.rodolfo@mayo.edu
jeremycg@mayo.edu
jones.lyell@mayo.edu

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Abstract

It is imperative in the COVID-19 pandemic that we serve our patients by implementing teleneurology visits for those who require neurologic advice but do not need to be seen face-to-face. The authors propose a thorough, practical, in-home, teleneurologic examination that can be completed without the assistance of an on-the-scene medical professional, and can be tailored to the clinical question. We hope to assist trainees and practicing neurologists doing patient video visits for the first time during the COVID-19 pandemic, focusing on what can, rather than what cannot, be easily examined.

Introduction

The current bedside neurologic examination originated in the late 1800s from the work of Wilhelm Erb, Joseph Babinski, and William Gowers, and was refined by Gordon Holmes in the first half of the 1900s.1,2 Neurologists pride themselves on their bedside examination skills, and numerous books have been written on the topic.3-12 Specialists in diseases of the nervous system entered the telemedicine scene in the late 1990s with the advent of telestroke,13 but until recently the broad application of telemedicine in other neurologic subspecialty areas has been limited.14 With the onset of the COVID-19 pandemic, teleneurology has become essential to serve our patients while practicing physical distancing.15 Neurologists who had never performed video visits before started doing so in a matter of days, limiting face-to-face visits to patients with urgent (in the clinic) or emergent (in the emergency department or hospital) neurologic conditions. For non-urgent patients, the bedside, face-to-face examination became virtual seemingly overnight. This transition, an imperative during the COVID-19 pandemic, will likely continue to have a role even after physical distancing rules are relaxed.
Some articles have outlined the teleneurologic exam, and online videos discussing the topic have been produced. However, these often involved the neurologist viewing some parts of the exam completed by a medical professional present with the patient (a telepresenter), which has limited application when virtually examining patients within their homes. In this article, we first provide some general tips for video interactions, then outline a thorough teleneurologic examination. Having performed these maneuvers during in-home virtual visits, we focus on what can be easily examined, which can be tailored to the clinical question asked. It is a practical and therefore not exhaustive list, and individual practitioners will add their own favorite exam maneuvers. This teleneurologic exam does not replace the face-to-face exam, but as Voltaire said “the best is the enemy of the good,” and a good deal of information can be gleaned through a video interaction.

**General tips for video interactions**

You will naturally look at the video image of the patient, as you should for observation purposes. However, be sure to occasionally look directly at the camera because that is the equivalent of making eye contact during a face-to-face visit. Tell the patient when you are going to look away to take notes or view the electronic health record, as otherwise they may think you are not paying attention to them. There may be an audio lag, so waiting a few seconds after the patient stops speaking before you begin to speak is also recommended. Patients should wear their hearing aids and glasses.

**Overview of the teleneurologic examination**

Maneuvers amenable to inclusion in a teleneurologic examination are listed below, grouping certain parts of the examination to minimize the number of times the patient has to change position or camera angles. Your personal examination might use a different order or only employ certain components, based on the patient’s presenting symptoms and time available for the video interaction. This approach
is most relevant when there is not a medical professional assisting with the examination in the patient’s home, which is the most common situation when doing outpatient teleneurology.

The gait, station, and motor exams are limited by the degree of patient unsteadiness, the size of the patient room, how far the patient can get from the camera, the device/camera used by the patient, and the ability of the patient to adjust the angle of the camera. If the patient is alone during the video visit and has a history of falls with significant unsteadiness, it is best to avoid gait and Romberg testing. If the patient is sitting at a desk and connects via their desktop computer with a wall behind them, it will also be very difficult to see their entire body during the gait exam. Even then, many of the examination maneuvers described in this article can be performed.

Our appointment coordinators ask the patient to connect via desktop only if that is their sole option. If the patient connects via laptop, tablet, or smart phone, it is easier for the camera to be manipulated to show more of the gait, station, and motor exams, if a family member or friend is also physically present to control the camera. Keep in mind that an additional companion may be needed to ensure patient safety while walking, if the patient is significantly unsteady.

If the virtual application being used to establish a video/audio connection allows the provider to share images or documents electronically with the patient, this may provide an alternative means to conduct portions of the neurologic examination outlined below. In those instances, the provider could forego using physical documents (e.g., printed images shown to the camera for mental status or language testing) to conduct the examination.

Table 1 lists items that the patient might need for the examination, and table 2 lists tools that the examiner might need. Table 3 summarizes the parts of the exam that can and cannot be easily completed during an in-home teleneurologic examination. Table 4 outlines a routine teleneurologic examination that includes some of the maneuvers described below, and takes about 8-10 minutes to perform initially.
The in-home teleneurologic examination

**Vitals**
- If available, have patient use automated blood pressure machine that also checks heart rate
- Alternatively, have patient check their radial pulse for 15 seconds
- Have patient check temperature with thermometer if available

**Mental status**
- Perform short test of mental status as described by Dr. Emre Kokmen, or other standardized mental status test (mini-mental state examination, Montreal cognitive assessment blind)
  Interpreting these tests requires knowledge of the patient’s vision and hearing abilities, and an understanding that this test administration is nonstandardized.
- Hold any images required (e.g. cube drawing) to complete mental status testing directly up to the camera, or share screen with patient
- Patient will need a piece of paper and pen
- Patient will need to show the camera what they drew

**Speech and language**
- Examine per usual. Show language examination cards to the camera or share screen with patient.
- Patient will need to show camera what they wrote

**Cranial nerves**
- Ask if they can smell coffee (whole beans or ground) or scented soap/shampoo. Check one nostril at a time by occluding contralateral nostril.
- Find out what they can see out of one eye and then the other (e.g., have them describe your hair or shirt color, count fingers)

- The American Academy of Ophthalmology website has printable Snellen charts and instructions on how a patient can check their own visual acuity.²⁷

- Check for visual neglect
  - Have patient perform line bisection test for visual neglect¹⁸

- Check for red desaturation in either eye with a red-tipped pin, red pen, or equivalent digital image
  - Compare red color in each eye, one eye at a time

- Check Ishihara plates in one eye, then the other (if worried about optic neuropathy)

- Spinning drum test/optokinetic nystagmus (OKN) strip
  - Hold the OKN strip or phone with OKN app towards the top of your image with lines moving to the left, allowing you to see patient’s OKN
  - Repeat with lines moving right, up, and down, looking for OKN in each direction

- Check eye movements, observe for nystagmus
  - For smooth pursuit, best to tell them to look left (then up and down) and look right (then up and down) rather than having patient try to follow your finger because your finger will disappear off their screen
  - For saccades, have patient keep their head still and look back and forth between the wall on their left and the wall on their right, then the ceiling and the floor. Encourage them to open their eyes widely, especially for vertical saccades.
  - Check convergence by having patient “look at their nose” or hold a pen in front of their face and watch it as they slowly move it toward their nose
  - Have patient fixate on camera and rotate head from side to side and then nod head up and down
• Observe for ptosis
• For the pupillary light reflex, have the patient hold the flashlight under one eye, angled upwards, so that you can still see their eye to observe for pupillary constriction. Repeat with the other eye. You can try having the patient close the other eye when checking the pupillary light response, but in doing so many patients squint the eye you are interested in, which impairs your view of the pupil.
• Use ice pack and cotton ball for cranial nerve V sensory testing. Compare side to side in V1, V2, and V3 distributions.
• Have patient open mouth and look for jaw deviation. Look for masseter and temporalis atrophy by having them clench teeth.
• Test facial strength per usual (raise eyebrows, squeeze eyes shut, show teeth, contract platysma)
• Have patient rub fingers near ears on either side, or at least check if intact to voice (a confounder of the latter is that the examiner cannot know the volume adjustments made by the patient)
• Have patient open mouth, and bring it close to the camera
  o Observe for tongue atrophy or fasciculations with tongue in mouth. You might need the patient to shine the flashlight in their mouth to improve visualization.
  o Have patient stick out tongue a bit. Have patient say “ahhh” quietly. Observe palate movement.
• Have patient place their hand on their cheek and then try to turn their head, using their hand to provide resistance. Look for sternocleidomastoid contraction.
• Have patient shrug their shoulders
• Have patient extend arms in front with palms touching. If there is a unilateral spinal accessory nerve paralysis, the fingertips on the affected side extend beyond those on the healthy side because of shoulder drop. If patient stands with hands at sides, the fingertips touch the thighs at a lower level than on the healthy side.
• Have patient protrude tongue. Look for tongue deviation. Have them move tongue side to side.

Motor, gait, station, coordination, alternate motion rates/rapid alternating movements (AMRs)

Seated position, farther from camera with upper extremities in view:

• Note station while seated
• Observe range of motion of upper extremity joints, looking for muscle activation against gravity (for example, if they have wrist drop)
• Inspect muscle bulk and watch for fasciculations
  o Easier if patient in short-sleeved shirt or tank top, latter if worried about shoulder girdle weakness or scapular winging
  o Oblique lighting may be employed by the patient or companion to better see fasciculations
• Check for pronator drift
• Look for Alter sign (digiti quinti minimi sign) of mild hemiparesis\(^{28}\)
  o Ask patient to extend the arms and fingers forward with palms down
  o Sign consists of abduction of the little finger on the side of mild hemiparesis
  o If the fifth finger is abducted on both sides when arms are extended, the abduction has no clinical significance
  o This might be the only objective sign of hemiparesis, but usually other signs like flattening of the ipsilateral nasolabial fold are also present
  o Not seen with hemiplegia or profound hemiparesis\(^{28}\)
• Look for postural tremor of hands with arms outstretched and when held in “chicken wing position” close to face
• Check forearm, finger, and thumb rolling tests for subtle hemiparesis\(^{29}\)
  o Five seconds in each direction
In the presence of a unilateral upper motor neuron lesion, the contralateral forearm/finger/thumb remains relatively stationary while the normal forearm/finger/thumb orbits around the affected forearm/finger/thumb.

- Studied in patients without spinal cord or peripheral nervous system lesions
- Sensitivity has varied in different studies but in general forearm and finger rolling are more likely to be abnormal than abnormal power, tone, and reflexes in a patient with a focal brain lesion
- Finger rolling test is more sensitive than forearm rolling. Thumb rolling may be more sensitive than index finger rolling to detect a subtle lesion of the cerebral corticospinal tract in patients with mild pure motor stroke affecting the upper limb.

- Check hand and finger AMRs
- Have patient squeeze one hand and look for mirror movement in the other. Repeat on other side.
- Check finger-to-nose with eyes open, then closed
- Check finger-to-nose-to-camera (have patient aim for the circle that houses the camera lens; you can tell if they miss the target as their image will not be blocked out fully)
  - Look for kinetic and/or terminal tremor

**Seated position, with lower extremities in view:**

- Observe range of motion of lower extremity joints, looking for muscle activation against gravity (for example, if they have foot drop)
- Inspect muscle bulk and watch for fasciculations (if patient in shorts)
- Compare foot tapping (AMRs) side to side.
  - In one study comparing plantar response to foot tapping to detect an upper motor neuron lesion, Babinski testing had a sensitivity of 35% and a specificity of 77%, while foot tapping was found to be more reliable, with sensitivity of 86% and specificity of 84%
• Have patient do heel-to-shin while seated

_Standing position, farther from camera with whole body in view:_

• Have patient stand from chair with arms crossed (looking for proximal lower extremity weakness)
  - If no concerns about significant unsteadiness and patient alone, they will need to adjust the angle of their camera so that their whole body is in view
  - If companion present, they can run camera and/or accompany unsteady patient to ensure safe ambulation

• Check gait as usual, including tandem and walking on heels and toes
  - It is ideal to watch the patient walking to and from the camera in a hallway, but that may not be possible
  - Heel and toe walking can enable inspection of muscle bulk in the anterior and posterior leg compartments if the patient is wearing shorts and camera angle allows
  - Gait testing is the main way to look for spasticity during the teleneurologic exam

• Check Romberg test
  - Can have patient do finger-to-nose with eyes closed when doing Romberg testing
  - Resolution of sway during finger-to-nose with eyes closed suggests functional overlay or functional neurological disorder
  - Finger-to-nose with eyes closed usually makes a patient with sensory ataxia sway more

_Other motor exam maneuvers for some patients, based on history_

• Look for Froment sign of ulnar neuropathy
  - Patient employs flexor pollicis longus primarily instead of the adductor pollicis to keep a piece of paper held tightly between their thumb and index finger

• Look for Wartenberg sign of ulnar neuropathy
• Also called abduction position of little finger

• Ask patient to hold hands in front, palms forward, and fingers extended (like when stopping an oncoming vehicle)

• Tell patient to keep fingers together without exerting any force

• The little finger (and sometimes ring finger) shows a tendency to abduct on the affected side\(^8\), \(^32\)

• Look for Wartenberg sign of median neuropathy\(^8\)
  
  • Ask patient to hold hands in front of them, palms out, making a diamond between the index fingers and thumbs (as when catching an American football thrown at one’s head)

  • Usually the tips of the index fingers and thumbs touch each other

  • In a unilateral median neuropathy, there can be thumb abduction weakness, so the thumbs do not touch. The thumb on the affected side remains above (higher than) the thumb on the healthy side.\(^8\)

• Do Phalen test for carpal tunnel syndrome (not a motor test but fits best here)\(^32\)
  
  • Have patient press dorsum of both hands together for one minute

  • Test is positive when paresthesias in a median nerve distribution are produced

• Do pinch test for anterior interosseous neuropathy
  
  • A patient with an anterior interosseous neuropathy cannot form an “O” with the index finger and thumb due to weakness of the flexor pollicis longus and the radial flexor digitorum profundus\(^33\), \(^34\)

  • Pinch test is positive when patients cannot give the “OK” sign and instead demonstrate apposition of the pads of the finger and thumb related to this pattern of weakness\(^33\), \(^34\)

• Look for Trendelenburg sign when patient walking away from you
  
  • If the left hip abductors are weak, the pelvis will tilt to the right during the swing phase\(^32\)
• Have patient stand or hop on one leg, then the other (if no safety concerns)
• Have patient perform one or more squats (if no safety concerns)
• Look for paradoxical abdominal movements during deep breathing in supine position (if worried about respiratory muscle weakness)
• Lower extremity drift can be checked with patient either on their back or stomach with knees flexed.[12] Patient and camera positioning for this is difficult unless family member/friend is running camera.
• Look for eye closure and grip myotonia
• If worried about myasthenia gravis:
  o Have the patient hold their arms outstretched for one to two minutes while you are talking to them. The arms will start to drop if there is limb involvement.
  o Have patient perform sustained upgaze after you have checked eye movements. Look for fatigable ptosis.
  o Perform an ice pack test
  o If patient can feasibly lie down, test neck flexor strength and fatigability by having them lift their neck from the bed several times and holding it against gravity for five to ten seconds

Reflexes
• Have patient use the side of their hand or a long-handled, rubber-headed spatula to check their knee jerks. You will need to demonstrate the maneuver. Patient can try to elicit their own knee jerks with their feet on the ground, or with their legs crossed. Instruct patient to hold spatula at the end of the handle, then strike below patella with the edge/side of the spatula.[35] Interpret with caution.
Inadequate relaxation may prevent a reflex from being manifested.[3] Anticipation or a predisposition toward exaggerated startle may result in the mistaken impression of a brisk reflex.[3] Some examiners
are skilled enough to have their patients check biceps, triceps, brachioradialis, and gastrocnemius reflexes during video visits.\textsuperscript{36}

- Patient can check their own plantar response (both Babinski and Chaddock signs) with a toothpick. Have patient grab their foot and put it on their knee. They should hold the toothpick between their thumb and index finger, then scrape in the usual “J” shape to try to elicit the Babinski sign, starting at the lateral heel. Patients often have little withdrawal when checking their own plantar responses. The patient can then perform the Chaddock maneuver along the lateral side of the foot.\textsuperscript{37,38}

**Sensory**

- This is a challenging exam, but you can ask the patient to show you where they feel numb and then use an icepack and cotton ball to check small and large fiber modalities. Safety pins or similar sharp objects should be avoided or used with caution due to risk of inadvertent injury.
- Look for parietal or thalamic updrift of upper extremity contralateral to lesion\textsuperscript{12}
- Look for pseudoathetosis of outstretched hands, which is seen in severe proprioceptive loss
- Romberg test was checked during station exam

**Other**

- Observe for rest tremor
  - Have patient rest hands on lap, close eyes, and state months in reverse order starting with December (you can also watch for rest tremor during gait exam)
- Observe for generalized bradykinesia
- Assess cervical range of motion
- Assess lumbar range of motion
- Comment on kyphosis, scoliosis
• Apraxia testing (ask patient to salute, act out using a comb or hammering a nail)

Conclusion

It is imperative during the COVID-19 pandemic that we continue to serve our patients. We can do this by implementing teleneurology visits. This article outlines how a relatively complete neurologic examination can be performed, with some limitations, via video in a patient’s home without the assistance of an on-site medical professional. Preparation on the part of the patient and the examiner is necessary, and ensuring patient safety during gait, station, and motor testing is paramount. Establishing competence in the teleneurologic examination will be important, as virtual care is likely to become more commonplace in the post-COVID-19 era.

Appendix 1. Authors

<table>
<thead>
<tr>
<th>Name</th>
<th>Location</th>
<th>Role</th>
<th>Contribution</th>
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<tbody>
<tr>
<td>Christopher J. Boes</td>
<td>Mayo Clinic,</td>
<td>Author</td>
<td>Background research;</td>
</tr>
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<td></td>
<td>Rochester, MN</td>
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<td>first draft of the manuscript; revision</td>
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<tr>
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<td>Mayo Clinic,</td>
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</table>
References


Table 1. Items the patient might need for the teleneurologic examination

<table>
<thead>
<tr>
<th>A companion</th>
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</thead>
<tbody>
<tr>
<td>• Assessment of gait is important since it encompasses so many exam domains</td>
</tr>
</tbody>
</table>
- Another person is needed for safety purposes when patient walks and to control the camera
- Appointment coordinator asks patient to have someone with them if at all possible
- Patient and companion should wash hands thoroughly before and after encounter

<table>
<thead>
<tr>
<th>Automatic blood pressure/pulse machine</th>
</tr>
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<tbody>
<tr>
<td>Thermometer</td>
</tr>
<tr>
<td>Piece of paper and pen for short test of mental status and language exam</td>
</tr>
<tr>
<td>Coffee or scented soap/shampoo if smell will be tested</td>
</tr>
<tr>
<td>Flashlight</td>
</tr>
<tr>
<td>Ice pack and cotton ball for cutaneous sensory testing</td>
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<tr>
<td>Long-handled, rubber-headed spatula</td>
</tr>
<tr>
<td>Toothpick for plantar response</td>
</tr>
<tr>
<td>Short-sleeved shirt (or tank top) and shorts to enable examination of muscle bulk, scapular winging, and fasciculations</td>
</tr>
</tbody>
</table>

**Table 2.** Items the examiner might need for the teleneurologic examination

<table>
<thead>
<tr>
<th>Card with picture of cube on it, or piece of paper and pen to draw cube and show patient as part of short test of mental status</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cards used for language exam</td>
</tr>
<tr>
<td>Red-tipped pin, red pen, or equivalent</td>
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</tbody>
</table>
Ishihara plates or equivalent

Optokinetic nystagmus (OKN) strip or equivalent

Note: The examiner can screen share images saved on their desktop with the patient during the video visit, with high resolution. Alternatively, the examiner can use an app on their smart phone for red desaturation test, Ishihara plates, and OKN strip.

<table>
<thead>
<tr>
<th>Examination domain(s)</th>
<th>Can be easily examined/performed</th>
<th>Cannot be easily examined/performed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mental status, speech, language</td>
<td>Cognitive, speech, and language screening can be completed</td>
<td></td>
</tr>
</tbody>
</table>
| Cranial nerves | Cranial nerves I-XII  
  - Cranial nerve I self-examined  
  - Partial evaluation cranial nerves II, VIII |  
  - Visual fields via confrontation testing especially if patient screen is small |
| Sensory component cranial nerve V self-examined | Optic disc and retina through fundoscopy  
Corneal reflex, jaw jerk  
Head impulse test, Dix-Hallpike maneuver |
|-----------------------------------------------|----------------------------------------------------------------------------------|
| Motor                                          | Muscle bulk, fasciculations  
Functional components of strength  
Signs of subtle hemiparesis  
Signs of median and ulnar neuropathies  
Spasticity, Trendelenburg sign, foot drop during gait exam*  
Bradykinesia  
Involuntary movements like tremor  
Eye closure and grip myotonia |
| Reflexes                                       | Direct strength testing with resistance from the examiner  
Evidence of give-way weakness  
Percussion myotonia  
Detailed tone testing |
| Sensation                                      | Vibration  
Joint position  
Pain/pinprick (for safety reasons)  
Extinction, stereognosis, |

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<table>
<thead>
<tr>
<th>Exam domain(s)</th>
<th>Exam maneuvers in order of performance</th>
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</thead>
<tbody>
<tr>
<td>Mental status, speech, language</td>
<td>Formal testing only needed if cognitive or language concerns</td>
</tr>
</tbody>
</table>
| Cranial nerves, coordination | • Ask patient to describe examiner shirt color  
• Smooth pursuits and saccades  
• Observe for ptosis  
• Pupillary light reflex  
• Use ice pack and cotton ball to check facial sensation  
• Test facial strength |

*can be examined in patient with history of significant unsteadiness only if companion present*
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<tr>
<th>Station, motor, coordination, and sensation</th>
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<tbody>
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<td>• Patient seated, farther from camera with upper extremities in view</td>
<td>• Observe range of motion of lower extremity joints</td>
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<tr>
<td>• Have patient rub fingers near ears</td>
<td>• Note station while seated</td>
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<tr>
<td>• Have patient open mouth</td>
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<td>o Observe palate movement</td>
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<td>• Check hand and finger alternate motion rates (AMRs)</td>
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<tr>
<td>• Finger-to-nose-to-camera</td>
<td>• Check finger-to-nose with eyes open, then closed</td>
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<td></td>
<td>• Employ icepack and cotton ball if patient feels numb in upper extremities</td>
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<tr>
<td>Sensation</td>
<td>Motor, gait, and station</td>
</tr>
<tr>
<td>------------------------------------------------</td>
<td>-----------------------------------------------</td>
</tr>
<tr>
<td>• Patient seated, with lower extremities in view</td>
<td>• Have patient stand from chair with arms crossed*</td>
</tr>
<tr>
<td>• Inspect muscle bulk and watch for fasciculations</td>
<td>• Check gait, including tandem and walking on heels and toes*</td>
</tr>
<tr>
<td>• Compare foot tapping side to side (AMRs)</td>
<td>• Romberg test*</td>
</tr>
<tr>
<td>• Have patient do heel-to-shin while seated</td>
<td></td>
</tr>
<tr>
<td>• Self-examined knee jerks and plantar responses</td>
<td></td>
</tr>
<tr>
<td>• Employ icepack and cotton ball if patient feels numb in lower extremities</td>
<td></td>
</tr>
</tbody>
</table>

*can be examined in patient with history of significant unsteadiness only if companion present
A primer on the in-home teleneurologic examination: A COVID-19 pandemic imperative
Christopher J. Boes, Andrea N. Leep Hunderfund, Jennifer M. Martinez-Thompson, et al.
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