

# Pediatric telerehabilitation medicine: Making your virtual visits efficient, effective and fun

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**Abstract.** The COVID-19 pandemic has accelerated many changes in medicine including the transition from providing care in person to providing care via technology enabled telemedicine. The benefits of telemedicine visits with a Pediatric Rehabilitation Medicine (PRM) provider, also known as telerehabilitation medicine visits, are numerous. Telerehabilitation medicine provides an opportunity to deliver timely, patient and family-centric rehabilitation care while maintaining physical distance and reducing potential COVID-19 exposure for our patients, their caregivers and medical providers. Telerehabilitation medicine also allows for access to PRM care in rural areas or areas without medical specialty, virtual in-home equipment evaluation, and reduced travel burden. Because of these and many other benefits, telerehabilitation medicine will likely become part of our ongoing model of care if barriers to telemedicine continue to be lowered or removed. This paper is intended to establish a foundation for pediatric telerehabilitation medicine visit efficiency and effectiveness in our current environment and into the future.

**Keywords:** Telemedicine, telehealth, telerehabilitation, virtual visit, rehabilitation, pediatrics, COVID-19, physical examination, caregivers

## 1. Introduction

The COVID-19 pandemic has accelerated many changes in medicine including the transition from providing care in person to providing care via technology enabled telemedicine, given the need to protect the health of patients and providers [1]. Telemedicine is defined as “the use of electronic information and communications technologies to provide and support health care when distance separates participants.” [2]. Prior to the COVID-19 pandemic, universal use of telemedicine was hampered by insurance restrictions, low reimbursement, HIPPA regulations, and equipment and software constraints [3]. With the enactment of the Coronavirus Preparedness and Response Supplemental Appropriations Act, the Centers for Medicare and Medicaid Services and the Health and Human Services Office for

Human Rights reduced these barriers, though only temporarily [4,5]. The acceleration in telemedicine availability has also impacted our clinic vocabulary by inserting terms such as “virtual visit” and “telerehabilitation” and also changed our documentation requirements. Virtual interactions with patients and families, new vocabulary, and changes to documentation may cause hesitation and uncertainty about how to provide high-quality care in this uncharted territory. However, telemedicine is not new. To date, telemedicine has been tried and even regularly used in a variety of clinical situations such as stroke evaluation [6], psychiatric care [7], newborn resuscitation [8], multidisciplinary care [9], and some areas of Physical Medicine and Rehabilitation [10–12].

For families who live in rural or medically underserved areas and have access to internet and technology, telemedicine is a tool to provide access to medical care. Telemedicine can also increase patient and caregiver satisfaction through reduced travel and clinic wait time and increased potential for appointment time flexibil-

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ity [13,14]. For families of children with disabilities, virtual visits via telemedicine with a Pediatric Rehabilitation Medicine (PRM) provider, also known as telerehabilitation medicine, reduces the burden of bringing the child's equipment to a medical appointment, finding care for other children in the home, and taking time off work [10]. There are times when a hands-on in person exam is necessary in the evaluation of our patients; however, virtual visits provide a unique opportunity to see the challenges and limitations patients experience in their homes along with the potential to develop more individualized solutions. Telehealth visits that include other community providers, such as a local therapist or durable medical equipment (DME) vendor, offer additional benefits to the child and their families, including convenience and reduced potential community exposure to COVID-19. The accelerated use of telerehabilitation medicine during the COVID-19 pandemic has highlighted the benefits virtual visits can provide in the care of our PRM patient population. If the barriers to telerehabilitation medicine are permanently removed, virtual visits may become part of our ongoing model of care and may influence the frequency of in person visits.

There are many resources available to guide some aspects of a telemedicine visit, including the American Telemedicine Association "Operating Procedures for Pediatric Telehealth" [15], an overview on adult rehabilitation telemedicine visits [16], telemedicine for pediatric gastroenterologists [17], and a how-to for the adult telemedicine musculoskeletal exam [18]. While these resources can help a PRM provider with telerehabilitation medicine visits for certain diagnoses or clinical scenarios, these resources do not provide specific guidance for pediatric telerehabilitation medicine. Therefore, the aim of this paper is to provide the PRM provider a comprehensive "playbook" to help make pediatric telerehabilitation medicine visits efficient, effective and fun. In this paper we will address: 1) pre-visit preparations for the patient/care giver and the provider, 2) tips and tricks for virtual physical exams, and 3) potential assessment tools for virtual gait and spasticity evaluations. Telerehabilitation medicine is a rapidly evolving practice for which the tests, exams, and assessments that are typically performed in person have not been validated or standardized in the virtual encounter. With guidance on patient- or caregiver-performed physical exam maneuvers, we provide a starting point for standardizing and trying to maintain the essential physical exam components. Furthermore, we provide documentation templates outlining "normal" virtual physical exams for a child and an infant.

## 2. Preparing for a pediatric telerehabilitation medicine visit

There are unique preparations for the provider as well as the patient and their caregiver in anticipation of the virtual pediatric telerehabilitation medicine encounter. The vast majority of pediatric telerehabilitation medicine visits will be performed in the patient's home. However, regardless of the patient's location, preparation includes gathering DME, toys, and other household items to aid in the exam, readying the patient and their caregiver(s), and navigating technical factors in using a virtual platform. Providers must be prepared to take certain steps before, during, and at the conclusion of the encounter in order to promote high-quality patient care. All of these considerations are meant to facilitate a successful interaction, foster the provider-patient relationship, and take advantage of the distinctive opportunities afforded by assessing a pediatric patient in their own environment. A video appointment workflow is outlined in Fig. 1 [19]. A preparation checklist that can be provided to the patient and family and a checklist for the provider are included in Tables 1 and 2, respectively.

These suggestions are meant to address the general pediatric rehabilitation visit. Since not all suggestions will be appropriate for each interaction, the provider should use their clinical judgment in each case. Each child is unique in their development and personality, and just as an in person visit is tailored to best connect with that individual child, the virtual visit should be individualized as well. Furthermore, to enable continuous improvement of care provided via telerehabilitation medicine, clinicians should consider surveying patients and their caregivers regarding their virtual visit experience. For example, Gordon et al identified patient challenges and concerns via a qualitative survey regarding communication, physical exam and attention, which resulted in changes to their pre-visit interventions and provider training [20].

### 2.1. For the patient/caregiver

To promote an efficient, productive, and child-centered interaction, there are a few considerations for the environment where the visit is conducted. The child should feel comfortable and safe, and ideally be easily entertained. The caregiver should ensure adequate floor space for the child to demonstrate gross motor skills, including sitting, creeping, walking, running, jumping, and/or skipping as appropriate for age and development. It is helpful to have a flat surface where the child

Table 1  
Video visit preparation checklist for patient and caregiver

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Preparing the virtual exam room

- Adequate space for exam (walking, jumping, etc.)
- Flat surface for the child to lie down during exam
- Background noise minimized (TV, radio, etc.)
- Other young children occupied for the duration of the exam
- Second adult or responsible older child available for assistance

Items that may be needed

- DME (wheelchair, walker, gait trainer, orthoses, splints, etc.)
- Shoes, socks, and clothes with buttons or zippers
- Beverage and snack such as cereal
- Kitchen utensils
- Favorite toys and books
- Paper and crayons or writing utensils
- Rubber spatula for testing reflexes
- Favorite stuffed animal or toy for show and tell
- Any other item related to a skill the child/teen is having difficulty with and would like evaluated

Preparing the child

- Child is appropriately dressed (tank top or t-shirt and shorts for older children, easily removable clothing for younger children)
- Child is fed, well rested, and, if needed, freshly diapered
- Child has been told what to expect with the virtual visit

Technical preparation

- Reliable internet connection (WiFi or Cellular Data)
- Most portable, functioning device with necessary capabilities (webcam, microphone, and speakers)
- Backup device or cell phone
- Online patient account is set up and accessible, if available
- Review instructions sent ahead of time for how and when to access the virtual platform

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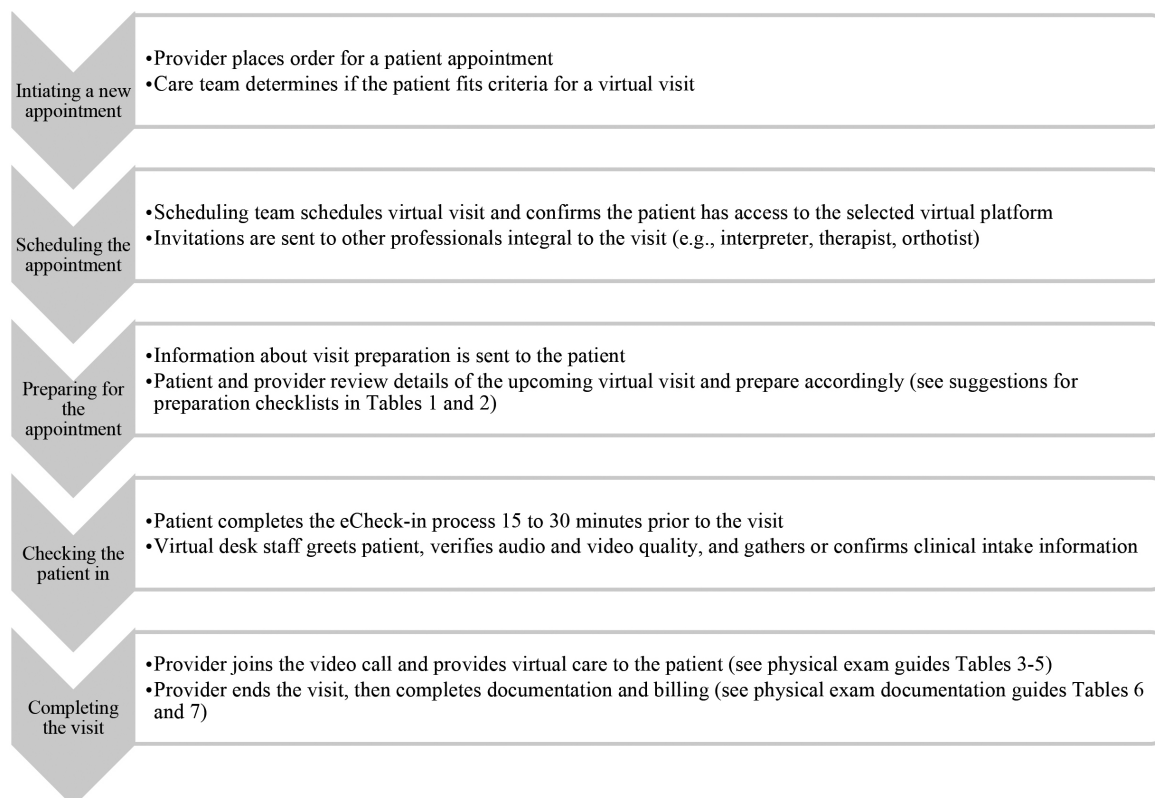


Fig. 1. Video appointment workflow.

Table 2  
Video visit preparation checklist for provider

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Technical preparation
Provider training modules completed
Reliable internet connection
Functioning and reliable equipment (computer, headset, speakers, microphone)
Familiarity with the chosen virtual platform
Familiarity with how to place virtual follow-up appointment orders
Before the visit
Background is appropriate with adequate lighting
Professional clinical attire with visible clinic affiliated name badge
Minimize background noise and risk of interruptions (consider “virtual visit in progress” door sign), including cell phones, pagers, etc.
Prepare to share screen with results to be shared with the patient (diagnostic imaging, labs, etc.)
Gather toys suited to the patient’s age
Beginning the visit
Physical exam observation begins when child appears on screen
Welcome, introduction, and identification
Ensure the patient can hear you well
Adjust the camera so that you are at a comfortable distance – not so far that the patient can see your entire torso, but not so close that only your face is visible
Complete virtual visit informed consent
Reassurance of quality, value, convenience, safety, and privacy of virtual visit
Orient the patient to the virtual visit, and ask if they are new to this type of care
Confirm accurate contact information (i.e., telephone number) as a backup plan if the video fails
Confirm street address of patient’s location in case of emergency during the visit
During the visit
Smile, talk slowly and in a normal volume, and look at the camera
Simplify and explain movements when you are doing something off camera
Listen and empathize as you would in an in person visit
Connect with the child – play peek-a-boo, share toys each of you have, give virtual high-fives, etc.
Improvise and be flexible when the child does not cooperate
Remember to stay positive and have fun
Closing the visit
Establish the plan and next steps in care
– Consider whether an in person visit is necessary
– Place orders – equipment, therapy, medication prescriptions, and consultations as appropriate
– Tap into your facility’s ability to send patient education materials via the EMR
Thank the patient and caregiver for their time and for allowing you to visit with them in their home
Answer any questions they may have
Complete documentation and billing

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can lie down or sit for examination of range of motion, strength, and postural reactions. Ideally, two caregivers will be present, one assisting with equipment and exam elements as well as audio and video operation, while the other caregiver focuses on the child and provider. It is helpful to reduce potentially distracting background noises and activities from sources such as other family members, pets and television. On the other hand, just as in the office, plan for the unexpected, such as a child’s meltdown or a chaotic environment. Always remember to thank the family for inviting you into their home.

Prepare families prior to the visit to have all equipment that needs to be evaluated during the visit on hand, such as DME. For the provider, seeing patients use their equipment in their home environment allows for assessment of fit as well as a greater understanding of current level of function along with potential barriers in that setting.

Prepare families to have other items readily available to help the child demonstrate age-appropriate gross and fine motor skills. For example, have them gather shoes and socks so the child can demonstrate donning and doffing of footwear or a beverage and snack if feeding or swallowing are concerns. For an assessment of fine motor skills, favorite toys in different sizes with features that can be pushed, pulled, opened, pieced together or otherwise physically manipulated can aid in the assessment. Clothing with buttons or zippers, books for turning pages, and paper and crayons or writing utensils can serve a similar purpose. For older children, a rubber spatula may facilitate testing reflexes. For adolescents, if there are certain activities that are a challenge, such as independence with putting their hair in a ponytail, having a hair brush and ponytail holder available to demonstrate the challenges is helpful. Some of these activities may also require the virtual visit to move to

a different room of the house in order to be able to perform the activity.

Finally, it is important to prepare the child for the virtual visit. In order to transition quickly to the physical exam when the time comes, dressing infants and toddlers in easily removable clothing and older children and teenagers in shorts and a t-shirt or tank top prior to the start of the visit is recommended. In addition, suggesting that young children are rested, fed, and freshly diapered in advance of the visit helps to create a more enjoyable overall experience for the child. Preparation of the child goes beyond their physical needs. As much as possible, the caregiver should verbally prepare the child for what to expect with a live video interaction. As many children have participated in video visits with family members through various online technology platforms, most will have some familiarity with interacting with an individual using technology. If the child has a favorite toy, they should be encouraged to bring this to their virtual appointment for a “show and tell” with the provider. Ideally, this builds the child’s excitement and their eagerness to demonstrate what they can do during the visit.

## 2.2. *For the provider*

The provider should take care to create a professional and inviting virtual space. This includes dressing in professional attire and maintaining a well-groomed appearance with a visible clinic name badge as one would in an in person clinic visit. The provider’s workspace should be clean, professional, quiet and well lit. Consider having a few toys on hand to share and discuss with the child. If available within your virtual platform and appropriate, an interesting virtual background, such as one including animals or nature, can help to capture the child’s attention. The ability to share a screen is a helpful option for reviewing imaging studies and test results with the patient and caregiver.

Despite the differences from an in person encounter, fostering a therapeutic provider-patient relationship remains vital. To that end, begin the encounter with a warm greeting to both the patient and the caregiver. Identify yourself, your institution, and your medical specialty, and then confirm the identity of the patient and anyone else who may be in the room with them. If not done by support staff prior to your visit, obtain a phone number to be used as a call back number if you get disconnected. Confirm the location address of the patient in the unlikely event that the child or care provider experiences a medical emergency during your

visit for which emergency services needs to be notified. As a matter of informed consent, briefly discuss the uniqueness of the telerehabilitation medicine encounter, including the limitations of the physical exam when not performed in person. Patients and caregivers may have some fears or reservations about the quality of care given the limitations of a virtual visit. Take a moment to orient them to how the visit will proceed and reassure them of the benefits of the virtual visit. As with an in person visit, begin observing the child as soon as the visit begins, noting the child’s candid behaviors, which can be clues to developmental milestones and level of function.

During the encounter, be creative and engage the child as much as possible. While older patients may appreciate their provider’s head steadily centered on screen, young children might enjoy a game of on screen peek-a-boo. There is some evidence that at about 16 months of age children are able to engage more interactively with the video screen [21]. Remember to smile, speak at a normal volume and tone as you would in the in person setting, and talk to the child as well as their caregivers. Looking directly at the camera, the virtual equivalent of making eye contact with the patient, is even more important when interacting with the child. Narrate any actions you take off camera, such as looking up records on another screen or writing notes, as this could be interpreted as being distracted. Non-verbal cues remain a significant part of communication, even remotely. When children have difficulty cooperating during the visit, remain calm, empathize with the caregiver, and improvise your information gathering and exam while prioritizing the child’s best interests. Flexibility is key.

When the history and exam are complete, partner with the patient/caregiver to determine the next steps. Consider a virtual or in person follow-up. Ensure all questions are answered. Utilize your facility’s ability to send patient education materials via the Electronic Medical Record (EMR). Complete any orders or prescriptions. End the visit with gratitude and appreciation toward the patient and the caregiver. Applaud the child for their participation. Many children will enjoy a virtual “high-five” as you say goodbye. Complete your documentation, including acknowledgement that the visit was performed virtually.

## 2.3. *Shared technical preparation*

Technical preparations begin well in advance of the appointment time. For the patient and caregiver, utiliz-

Table 3  
Multisystem child/infant physical examination guide

System	How to examine via telemedicine	Tips and tricks
Vital signs		
Temperature	Ask caregiver to use home thermometer.	Send caregiver instructions ahead of your appointment to complete before visit.
Height	Ask caregiver to measure height or review record for last measurement in office.	If available, send caregiver institutional video or written instructions on how to accurately measure an infant/child to complete before visit.
Weight	Ask caregiver to weigh or review record for last weight in office.	Send caregiver instructions ahead of your appointment to complete before visit.
Pulse	Instruct adult to find pulse, then have them count while you keep time on a stopwatch.	
Respiratory rate	When patient is calm, observe if rate appears fast, normal, or depressed.	Time out 15 seconds on a timer and have caregiver count the number of times the child's chest rises and falls in that time. Multiply by 4 to determine if rate is fast, slow or normal.
Blood pressure	If pediatric blood pressure cuff is available at home, ask caregiver to check blood pressure.	Send caregiver instructions ahead of your appointment to complete before visit.
General	Observe overall appearance.	Comment on where the visit is taking place and who is present with the child. Ask caregiver what size onesie or shirt and pants they wear.
HEENT	Observe for dysmorphic features, facial asymmetry including ear placement, and head shape asymmetry. For infants, instruct caregiver to palpate the anterior fontanelle, sutures, and neck muscles.	Observe if child is wearing glasses, has a tracheostomy, or is using oxygen. Ask to see transverse view of head from the top when evaluating head shape. Have the caregiver place a finger on each ear to visualize displacement.
Skin	Observe skin when patient is undressed during musculoskeletal exam.	Make sure to ask caregiver to remove braces to observe for signs of pressure. Ask caregiver to point out any birthmarks or surgical scars.
Respiratory	Observe effort of breathing, sound of breathing, and if patient is cyanotic.	Comment if breathing is noisy. Ask child to pretend to blow out birthday candles or give an effortful cough to demonstrate ability to forcefully expire.
Cardiovascular	Ask caregiver to feel if extremities are subjectively warm or cool and if temperature is symmetric. Compare size of bare legs. Ask caregiver to push with one finger on bottom of shin and observe for depression. Inspect fingers and toes.	
Abdomen	Observe for distension, ask caregiver to palpate for painful areas in each of the four quadrants and comment if gastric tube is present.	Ask child if they can show you their belly button.
Medical equipment	Ask caregiver to show provider equipment with and without child using it, especially if something needs to be replaced.	If easily accessible, ask to see equipment not typically brought to the office such as standing frame or commode chair.

ing a portable device with audio and video capabilities such as a smartphone, tablet, or lightweight laptop can allow for a more interactive visit than a stationary desk top computer, particularly during the exam. The home's internet connection should be tested ahead of time in the area of the home where the visit will be streamed. Any troubleshooting should be done in advance. If there is no access to a reliable internet connection over WiFi or cellular data network in the home, alternative sites may include local schools, libraries, or medical facilities. To ensure video and audio quality, clinic support staff should connect with the patient 15 to 30 minutes prior to the appointment time. The check-in time leading up to the appointment can be used to

verify patient identity, reason for the visit, medications, allergies, preferred pharmacy, insurance information, and contact information including a telephone number in the event the video call fails along with the patient's current physical address in case of an emergency.

The provider should also run a trial of the platform to be used, ensuring connectivity, reliably functioning equipment, and familiarity with the interface days in advance of any upcoming video visits. Complete any provider training modules prior to your first video visit encounter to allow time for questions and trouble shooting. Identify a standard communication strategy so you are alerted when the patient is ready to be seen. Know

Table 4  
Musculoskeletal and neurologic child physical examination guide

System	How to examine via telemedicine	Tips and tricks
Neurologic		
Mental status	Observe behavior, mood, attention, orientation, and level of participation during appointment.	To keep child's attention, move around the screen, change to a virtual background, or play peak-a-boo.
Speech and language	Observe verbal interaction with caregiver, ask child to identify body parts, and ask them to talk to you about their favorite toy.	Have familiar items or toys with you and ask the child to name them.
Cranial nerves	Ask caregiver to cover one eye at a time, then show child an item to see if they can name it or count fingers. Use a colorful object and ask child to track it to evaluate eye movements. Ask child to copy your facial expressions to test strength. Ask child to protrude tongue and move back and forth. Observe if shoulder shrug is symmetric.	Try having a "staring contest" with the child or ask them to make a silly face to look for facial weakness. Observe the child eating a snack. Comment if child has observable drooling or a voice that sounds wet.
Gait	Observe child walking towards and away from the camera paying attention to symmetry and joint alignment. If able, ask them to walk on toes and heels. Observe for indications of weakness, sensory loss, incoordination, spasticity, malalignment, and asymmetry.	Ask the caregiver to place the camera on ground to get a better view of feet during gait. To quantify gait, consider using a rating scale suggested in the "Gait Assessment" section of this paper.
Balance	Instruct child to perform Romberg then ask child to stand on one leg and tandem walk.	
Gross motor	Observe movements during play, noting any dystonia or tremor. Ask child to run, skip, gallop, broad jump, and hop on one foot.	Play "Simon Says". Let the child show off! Ask them to show you their favorite thing to do or how high they can jump. If able, watch the child go up and down stairs.
Fine motor	Observe the child's hand as the caregiver gives them a small item such as a sticker to demonstrate pincer grasp. Ask child to trace age-appropriate shape, draw, or write.	If child is not in the mood to draw, ask caregiver to show you some art they have made. Ask child to demonstrate turning pages of a book, using a utensil, playing with Legos, buttoning buttons, or using a zipper. Offer cereal and observe how they bring it to their mouth.
Strength	Observe child getting off the floor, jumping, and lifting a toy over their head. Ask caregiver to perform manual muscle testing for asymmetry of strength (position arms as when performing "chicken wings" to assess shoulder abduction, arms like boxer to assess elbow flexion, etc.) in upper and lower limbs. Instruct child to perform forearm rolling (satelliting) to look for subtle hemiparesis. Observe for dynamic knee valgus during single leg squat.	Make it a game by asking child to walk like a duck or jump like a frog. In an older child, ask to march in place, pretend to kick a ball, do a wall pushup, or do triceps dips.
Sensation	Ask child where they feel numb or "funny". With child's eyes closed, instruct caregiver to touch child's fingers and toes with a cotton ball and ask if they can feel the tickle. Ask caregiver to test temperature sensation with a cold item, or sharp and dull sensation with the two sides of a pencil. With eyes closed, ask the child to identify a small familiar object placed in their hand. Instruct caregiver how to test great toe proprioception.	
Coordination	Ask child to perform rapid alternating movements of hands and feet, finger-nose-finger, and heel to shin.	Ask child to perform camera-nose-camera with pointer finger. Ask caregiver to offer child cereal to observe for pincer grasp. Ask an older child to catch a ball.
Reflexes	Instruct caregiver how to use fingers or a rubber spatula to tap on tendons. Instruct caregiver to stroke lateral plantar aspect of foot with one finger and observe great toe movement.	Have a rubber spatula on hand to demonstrate reflexes on yourself first.

Table 4, continued

System	How to examine via telemedicine	Tips and tricks
Muscle tone	Observe resting posture and look for posturing or co-contraction while child is engaged with an activity. Instruct caregiver how to test for ankle clonus.	Have child in view of camera as adult dons and doffs clothing to get a sense if tone is interfering. Consider adapting a physician observation scale to track over time such as the one suggested in the "Spasticity Assessment" section of this paper.
Musculoskeletal		
Inspection	Observe for posture, limb symmetry, and skeletal deformities.	Caregiver may have to move camera to optimize angle if looking for subtle muscle atrophy or hypertrophy.
Palpation	Instruct caregiver to slowly and firmly palpate specific structures and report their observation while watching for pain behavior.	Ask caregiver or child to identify area of pain with just one finger. Make sure area being examined is in full view of camera.
Spine	Observe for scoliosis and symmetry of shoulder height, hip height, and asymmetric rib prominence. If child can follow instructions, ask them to demonstrate forward flexion, extension, and lateral bending.	Ask child to stand still in coronal and sagittal planes. If child looks asymmetric, instruct adult how to measure leg length.
Joint range of motion	<b>Shoulder and elbow</b> – Ask the child to reach for a toy or ask caregiver to assist to demonstrate full ROM in all planes. <b>Wrist/hand</b> – Instruct child to place hands in a prayer position or ask caregiver to passively flex and extend wrist and fingers. <b>Hip</b> – Instruct caregiver to demonstrate internal rotation, external rotation, and abduction while supine. <b>Knee</b> – Ask caregiver to demonstrate popliteal angle. Observe for recurvatum when standing and walking. <b>Ankle</b> – Observe alignment when standing and walking. Ask caregiver to dorsiflex ankles while knees are extended and bent.	<b>Active ROM:</b> Ask child to squat with heels glued to the ground, frog jump, sit cross legged, make arm circles, give examiner a virtual "high five", and make a fist. <b>Caregiver assisted passive ROM:</b> Have child laying on a firm surface rather than couch. Hip ROM can be demonstrated while prone. If two caregivers are present, one can hold the camera from above and the other can demonstrate thigh foot angle while prone. Consider scoring the <b>Beighton score:</b> Oppose thumbs to forearm, place hands flat on the floor with knees straight and observe for elbow extension > 10 degrees past neutral, knee extension > 10 past neutral, and pinky finger metacarpophalangeal joint extension > 90 degrees on both sides.
Special tests		
Cervical spine	Ask child to bend chin to chest and ask about symptoms. Ask caregiver to abduct arm above level of shoulder while extending shoulder, elbow, and wrist and ask about symptoms.	
Lumbar spine/SI	Instruct child to extend their lumbar spine and ask if this causes pain and where. Repeat while standing on one foot and ask child to localize pain if any. While supine, instruct child/caregiver with FABER and FADIR position. Instruct caregiver to perform straight leg raise.	Always examine the hip when a patient complains of back pain. <b>FABER</b> – Flexion, abduction, external rotation. <b>FADIR</b> – Flexion, adduction, internal rotation. <b>Straight leg raise</b> – While supine, caregiver passively lifts straight leg to observe for symptoms that travel below the knee to suggest radicular pain.
Shoulder	Observe for scapular winging and dyskinesia at rest and while demonstrating active range of motion. Instruct caregiver to assist in performing Neer, Hawkins, and O'Brien's and place child's arm in scarf position.	<b>Neer</b> – Position in 180° of forward flexion at the shoulder to test for impingement. <b>Hawkins</b> – With shoulder abducted to 90°, flex elbow 90° and rotate forearm internally to test for impingement. <b>O'Brien's</b> – With shoulder flexed to 90° and elbow fully extended with slight adduction and internal rotation, caregiver applies a downward force to test for pain from labrum. Pain should be relieved if repeated in full supination. <b>Scarf</b> – Fully adduct arm across body to test for AC joint pathology.
Hip	While supine, instruct child/caregiver to perform FABER and FADIR position as well as Stinchfield. Instruct caregiver to position for Galeazzi test while supine and perform Ely's test while prone. If able, child should single leg hop and indicate any area of pain.	Always examine the back when a patient complains of hip pain. Ask caregiver if they feel or hear hip clicks when manipulating hips. <b>Stinchfield</b> – Resisted hip flexion with knee extended while supine to suggest intraarticular hip pathology. <b>Galeazzi's test</b> – While supine, place child's feet flat on the ground close to buttocks and observe relative knee height to check for apparent leg length discrepancy. <b>Ely's test</b> – While prone,



Table 4, continued

System	How to examine via telemedicine	Tips and tricks
Knee	Observe knee for effusion and erythema by comparing to the opposite side. Observe for sag sign. With knee extended and quadriceps relaxed, observe adult pushing patella from side to side and palpate the patellar facets and medial and lateral femoral condyle. Instruct child to extend knee while seated to observe for J-sign.	flex knees to bring heels to buttocks and observe for hip flexion and assess heel to buttock distance to test flexibility of rectus femoris.  Always examine the hip when a patient complains of knee pain. <b>Sag sign</b> – While prone with knees bent 90 degrees and feet flat on the ground, observe for sagging of tibia relative to the femur to indicate PCL deficiency. <b>J-sign</b> – While seated with legs dangling, actively extend knee and observe for lateral shift of patella to indicate abnormal patellar tracking.
Ankle/Foot	When testing active ROM, consider having patient push against caregiver's hand to elicit pain in ankle sprain. Ask child/caregiver to squeeze over the metatarsals and observe for pain and click. While child kneeling on chair, ask caregiver to perform Thompson test.	Having a child hop on the affected side may help them localize the pain. <b>Thompson test</b> – Squeeze calf and observe ankle motion to indicate if Achilles tendon is ruptured.

where to get technical assistance and have the telephone number on hand.

### 3. Conducting the history and physical exam

Take the patient's history as you would in a typical in person visit. Although the telerehabilitation medicine physical examination may be challenging at first, an excellent examination can be completed through observation and partnering with a caregiver or parent. Video technology provides a window into the child's home life and environment, so use this to your advantage. The child may actually be more active in their familiar environment than in your office. Toys and snacks are readily available. All of the child's special equipment can be viewed, allowing the provider to assess condition, fit, and how the child uses it in their home. As always, tailor your examination to why you are seeing the child and the concerns raised by the family. Table 3 outlines strategies of how to conduct a comprehensive multisystem examination through observation and with assistance of an adult. Tables 4 and 5 outline the neurologic and musculoskeletal examination for a child and an infant, respectively. Suggested formats to document child and infant "normal" virtual physical examinations are listed in Tables 6 and 7, respectively.

### 4. Assessment tools

Rating scales have been adapted or developed for telemedicine assessments, such as The Unified Parkinson's Rating Scale (UPDRS) which is a visual rating tool to follow the longitudinal course of Parkinson

disease [22]. In a 2016 systematic review, Mani et al reported telerehabilitation-based physical therapy assessments in adults with caregiver assistance or self-administered tests were generally feasible with overall good validity and reliability, except for lumbar spine posture and some orthopedic tests [23]. Currently, we are unaware of any validated measures for pediatric telerehabilitation medicine-based gait or spasticity assessments. We have identified a few assessments that are relatively simple and quick to perform, adaptable for the pediatric population and virtual platform, and can be tracked across time and multiple visits (both virtual and in person). As always, it is most important to document what is observed.

This is also an opportunity for practice improvement studies and for development and validation of new tools assessing outcomes or tracking function in this population. Tools for pediatric telerehabilitation are virtually unexplored and future research is needed to develop qualitative and quantitative assessment and outcome tools for virtual visits. Examples could include assessment of tool reliability in pediatric telerehabilitation medicine (inter-location reliability comparing tools between virtual and in person visits), ease of tool use from both the patient/caregiver and provider perspective, tool use impact on care, and as previously noted, overall satisfaction and comfort level with care provided via the virtual visit.

#### 4.1. Gait assessment

The Physician Rating Scale (PRS) is an observational clinical gait evaluation tool originally proposed to assess change in gait and joint position in children with cerebral palsy after botulinum toxin injection.

Table 5  
Musculoskeletal and neurologic infant physical examination guide

System	How to examine via telemedicine	Tips and tricks
<b>Neurologic</b>		
Mental status	Observe behavior, mood, and attention. Notice if infant is looking at caregiver or interacting with caregiver. Ask caregiver to smile at infant to observe for reciprocal smile.	Ask the caregiver when the child last napped and if they may be tired or hungry.
Speech and language	Listen for coos and babbles. Ask caregiver to see if child will mimic their noises.	
Cranial nerves	Ask caregiver to show infant a toy and observe if they will track it in all four quadrants. Observe for facial or bulbar weakness. Observe if infant reacts to a surprising noise.	Have a toy on hand to move around your screen while watching eye movements.
Balance	If infant has adequate head support, ask caregiver to place in supported seated position.	
Gross motor	Observe movement patterns during play, noting any dystonia or tremor.	If mobile, comment on preferred mode of mobility.
Fine motor	Observe the infant's hands as the caregiver gives them a small item to hold, if they come to midline and to mouth, and if infant can pass an item between hands.	Ask caregiver to place pacifier in infant's hand to observe if they can place in mouth.
Strength	While infant is supine, instruct caregiver to pull infant to sit to observe head lag. While prone, observe if infant lifts head, rolls, or crawls. Observe if infant bears weight through legs when held upright.	Watching how the supine child moves while taking a history can give you information.
Sensation	Ask caregiver to lightly touch area of interest and observe for infant's reaction.	While infant is distracted, ask caregiver to passively place fingers or toes in abnormal position to see if they react to normalize position.
Reflexes	Instruct caregiver how to use fingers to tap on tendons.	
Primitive reflexes	Observe how child uses a pacifier. Instruct caregiver to gently stroke cheek and observe for rooting. Instruct caregiver how to elicit Moro reflex. Observe for palmar grasp when one finger placed in palm. Observe for plantar grasp when thumb puts pressure on plantar aspect of foot.	
Postural reflexes	If infant has adequate head control, observe for head righting, body righting, and arm movement while being held and while sitting.	
Muscle tone	Observe resting posture and look for posturing or co-contraction while child is engaged with an activity. Instruct caregiver how to test for ankle clonus.	Have child in view of camera as adult dons and doffs clothing to get a sense of if tone is interfering. Consider adapting a physician observation scale to track over time such as the one suggested in the "Spasticity Assessment" section of this paper.
<b>Musculoskeletal</b>		
Inspection	Observe for posture, limb symmetry, skin fold symmetry, and skeletal deformities.	
Palpation	Instruct caregiver to slowly and firmly palpate specific structures and report their observation while watching for pain behavior.	Ask caregiver to identify perceived area of pain with one finger. Make sure area being examined is in full view of camera.
Joint range of motion	Instruct caregiver to stabilize the joint of interest while demonstrating the end ROM in all planes for upper and lower limbs. <b>Hip</b> – Instruct adult to demonstrate internal rotation, external rotation, and abduction while supine. <b>Knee</b> – Ask caregiver to demonstrate popliteal angle. <b>Foot/ankle</b> – If feet are in an abnormal position, ask caregiver to gently manipulate them to a normal neutral position. Ask caregiver to dorsiflex ankles while knees are extended and bent.	Active: Observe how baby moves when lying supine. Passive: Have child laying on firmer surface rather than couch. Hip ROM can be demonstrated while prone.
Spine	Observe the child's preferred resting posture. Instruct caregiver to gently perform passive cervical spine ROM, then ask caregiver to move a favorite toy to observe the child's active motion. With clothing off, observe for scoliosis when prone and when held in standing position.	
<b>Special tests</b>		
Hip	Instruct caregiver to position for Galeazzi test while supine. Instruct caregiver to abduct the hips to look for symmetry. Observe for thigh skin fold symmetry.	Ask caregiver if they feel or hear hip clicks when manipulating hips. <b>Galeazzi's test</b> – While supine, place child's feet flat on the ground close to buttocks and observe relative knee height to check for apparent leg length discrepancy.

Table 6  
Child normal physical examination documentation

**Disclaimer:** We chose to include physical exam maneuvers that can reasonably be completed by the patient or caregiver with provider instruction and observation. The documentation below assumes that all hands-on maneuvers typically performed by the provider are completed by the caregiver to the best of their ability. Given that the virtual physical exam will typically not be performed by a trained clinician, findings should be documented and interpreted carefully and cautiously. You may consider putting a statement at the beginning of the exam stating, "Exam was performed virtually via my observation and/or instruction with the assistance of caregiver or self-performed by the patient."

**Vital Signs:**

Temperature: Temperature of \_\_\_ taken by home thermometer.

Height: Height today is \_\_\_ OR height was \_\_\_ at last office visit on \_\_\_ (date).

Weight: Weight today is \_\_\_ OR weight was \_\_\_ at last office visit on \_\_\_ (date).

Pulse: Pulse of \_\_\_ beats per minute.

Respiratory Rate: Patient is breathing comfortably and rate appears normal for age.

Blood Pressure: Blood pressure of \_\_\_ taken by home blood pressure cuff.

**General:** Well-developed, well-nourished child in no acute distress. Accompanied by \_\_\_ in their home for this video consultation.

**HEENT:** No dysmorphic features or significant facial asymmetry. Eyes appear normal without redness. No significant head shape asymmetry or abnormality.

**Skin:** Inspection grossly negative for erythema, breakdown, or concerning lesions in exposed area.

**Respiratory:** Breathing is comfortable and regular. No dyspnea or noisy breathing noted during examination.

**Cardiovascular:** Hands and feet are warm bilaterally. No apparent lower extremity edema. No observed clubbing or cyanosis of digits.

**Abdomen:** No abdominal distension or tenderness in any of the four quadrants.

**Medical Equipment:** Orthoses and/or mobility devices fit well and appear to be in good condition.

**Neurologic:**

Mental Status: Alert and interactive. Age appropriate mood, affect, and behavior.

Speech and Language: Normal speech and thought processing for age.

Cranial Nerves: Monocular vision and visual tracking intact for age. Extraocular movements intact. Facial movements appear symmetric and without facial or bulbar weakness. No ptosis or tongue fasciculations. Hearing grossly intact. Accessory nerve intact bilaterally.

Gait: Gait is non-antalgic and reveals normal cadence and stride. No apparent rotational abnormalities of hips, knees, or feet. Toe- and heel-walking are normal.

Balance: Tandem gait and Romberg tests are normal. Single leg stance is normal for age.

Gross Motor: Able to run, skip, and gallop. Able to broad jump and hop on one foot.

Fine Motor: Handwriting or coloring and grasp appropriate for age.

Strength: All major muscle groups of the bilateral upper and lower extremities have at least antigravity muscle strength as could be tested for child's age via video examination.

Sensation: Normal light touch and temperature sensation, sharp and dull differentiation, graphesthesia, and proprioception throughout upper and lower extremities as could be tested for child's age via video examination.

Coordination: Coordination appears normal in upper and lower extremities.

Reflexes: Bilateral upper and lower extremity muscle stretch reflexes appear physiologic and symmetric. Plantar responses downgoing bilaterally.

Tone: Normal resting posture. No posturing or co-contraction during activity. No hypertonia or hypotonia noted in axial or appendicular musculature. No ankle clonus.

**Musculoskeletal:**

Observation: No gross axial or appendicular deformities.

Palpation: Palpation of \_\_\_ did not cause pain.

ROM: Joint range of motion appears pain free without significant joint contractures in the major joints of all four extremities. Beighton Score: \_\_\_.

Spine: Range of motion appears full and pain free. No gross axial skeletal deformities such as kyphosis, lordosis, or scoliosis.

**Special Tests:**

Cervical Spine: No L'hermitte's sign or indication of upper limb neural tension.

Shoulder: No scapular winging or dyskinesia. Negative Neer, Hawkins, O'Brien's, and scarf tests.

Lumbar Spine/SI: No radiating pain with lumbar extension or straight leg raise. No pain with FABER or FADIR position.

Hip: No pain with FABER or FADIR position. Negative Galeazzi sign and Stinchfield. Ely test normal.

Knee: No knee effusions. Negative patellar apprehension and facet tenderness. Patellar tracking appears normal.

Foot/Ankle: No pes planus or cavus. No pain with resisted active range of motion and metatarsal squeeze. Negative Thompson test.

tions [24]. It has been modified by many and compared to other observational gait assessments for reliability and validity in different patient populations. It typically has high intra-observer reliability but less favorable inter-observer reliability [25–30]. The version used in Maathuis et al. takes minimal time, is straight forward to understand and use, is observation based and can be

easily documented in the patient's EMR [27]. If choosing to use this tool, observe the child's gait in sagittal and coronal planes. Score each side as listed and document individual section scores and total scores for each side for future comparison [27].

Other possible telerehabilitation medicine friendly gait assessments include the Edinburgh Visual Gait

Table 7  
Infant normal physical examination documentation

**Disclaimer:** We chose to include physical exam maneuvers that can reasonably be completed by instructing the caregiver while the provider observes. The documentation below assumes that all hands-on maneuvers typically performed by the provider are completed by the caregiver to the best of their ability. If the caregiver is having difficulty properly performing a maneuver, go ahead and move on. Consider documenting as “attempted but unable to be performed,” especially if it is a maneuver potentially critical to your evaluation. Given that the virtual physical exam will typically not be performed by a trained clinician, findings should be documented and interpreted carefully and cautiously. You may consider putting a statement at the beginning of the exam stating, “Exam was performed virtually via my observations and/or instructions with the assistance of caregiver.”

**Vital Signs:**

Temperature: Temperature of \_\_\_ taken by home thermometer.

Height: Height today is \_\_\_ OR height was \_\_\_ at last office visit on \_\_\_ (date).

Weight: Weight today is \_\_\_ OR weight was \_\_\_ at last office visit on \_\_\_ (date).

Pulse: Pulse of \_\_\_ beats per minute.

Respiratory Rate: Patient is breathing comfortably and rate appears normal for age.

Blood Pressure: Blood pressure of \_\_\_ taken by home blood pressure cuff.

**General:** Well-developed, well-nourished infant in no acute distress who is accompanied by \_\_\_ in their home for this video consultation.

**HEENT:** No dysmorphic features or significant facial asymmetry. Eyes appear normal without redness. No significant head shape asymmetry or abnormality. No palpable neck masses or ridging of sutures. Anterior fontanelle is open and flat.

**Skin:** Inspection grossly negative for erythema, breakdown, or concerning lesions in exposed area.

**Respiratory:** Breathing is comfortable and regular. No dyspnea noted during examination.

**Cardiovascular:** Hands and feet are warm bilaterally. No apparent lower extremity edema. No observed clubbing or cyanosis of digits.

**Abdomen:** No abdominal distension or tenderness in any of the four quadrants.

**Medical Equipment:** Orthoses and/or mobility devices fit well and appear to be in good condition.

**Neurologic:**

Mental Status: Alert and interactive. Age appropriate mood, affect, and behavior.

Speech and Language: Vocalization normal for age.

Cranial nerves: Visual tracking intact for age. Extraocular movements intact. Facial movements appear symmetric and without facial or bulbar weakness. Hearing grossly intact.

Strength: All major muscle groups of the bilateral upper and lower extremities have normal and symmetric muscle strength and bulk as could be tested for child’s age via video examination.

Sensation: Reacts to light touch in all four extremities.

Reflexes: Bilateral upper and lower extremity muscle stretch reflexes appear physiologic and symmetric. Babinski responses are normal for age

Primitive Reflexes: Sucking, rooting, and Moro reflexes appear normal for age. Palmar grasp and plantar grasp reflexes appear normal for age. ATNR is not obligatory. Hands open spontaneously.

Postural Responses: Postural responses appear normal for age.

Balance: Sitting balance appears normal for age.

Muscle Tone: Normal resting posture. No hypertonia or hypotonia noted in axial or appendicular musculature. No ankle clonus.

Gross Motor: Gross motor skills appear within normal limits for age.

Fine Motor: Fine motor skills appear within normal limits for age.

**Musculoskeletal:**

Inspection: No gross axial or appendicular deformities.

Palpation: Palpation to \_\_\_ did not cause pain.

Range of motion: Joint range of motion appears pain free without significant joint contractures in the major joints of all four extremities.

Spine: No torticollis. Normal pain-free range of motion. No gross axial skeletal deformities such as kyphosis, scoliosis, sacral dimpling, or hair tuft noted.

**Special Tests:**

Hips: Negative Galeazzi sign. Hip abduction and thigh skin folds are symmetric.

Analysis [31], the Modified Wisconsin Gait Scale [32, 33] and modified versions of the PRS [25,26,28–30,34]. These tests, as with the proposed PRS, have variable intra and inter-observer reliability. They also are considerably longer than the proposed PRS in terms of number of items, assessment completion time, and more complex documentation.

#### 4.2. Spasticity assessment

Spasticity can be difficult to assess. In the clinic,

the Modified Ashworth Scale and the Modified Tardieu Scale can be used, although these have varying levels of inter-rater reliability [35,36]. Additionally, these tools do not account for self or caregiver assessment of spasticity. For virtual visits, spasticity can be even more challenging to assess, given the need to physically examine the child to assess the velocity dependent component. However, there are some tools that may be adapted to provide insight into the degree of spasticity and impact on function for the child.

In lieu of a hands-on physical exam for spasticity,

**Instructions:** Please insert the following questions thinking about your muscle stiffness, tightness, or spasms over the past 1 month.

Item #	Question				
1.	How bad is the stiffness or tightness of your muscles, either at rest, when you move, or are being moved?				
	0-I don't have stiffness or tightness	1-A little stiff or tight	2-Somewhat stiff or tight	3-Very stiff or tight	4-Extremely stiff or tight
2.	How difficult is it for you to straighten, bend, or flex your limb(s) (leg[s] or arm[s]) due to stiffness or tightness in your muscles?				
	0-Not difficult at all	1-A little difficult	2-Somewhat difficult	3-Very difficult	4-I am unable to straighten, bend, or flex my limbs
3.	How bad are your spasms that occur unpredictably or are caused by movement?				
	0-I don't have spasms	1-A little bad	2-Somewhat bad	3-Very bad	4-Extremely bad
4.	Are any of the above stiffness, tightness, or spasms associated with pain? Please specify the location of the pain:				
	0- No, I don't have any pain	1-Yes, a little bit of pain	2-Yes, some pain	3-Yes, quite a bit of pain	4-Yes, a lot of pain
5.	Over the past month, how often was your sleep disrupted because of stiffness, tightness, or spasms in your muscles?				
	0-Never	1-Rarely	2-Sometimes	3-Often	4-Every night
6.	Over the last month, how bothersome was your muscle stiffness, tightness, or spasms?				
	0-Not bothersome at all	1-A little bothersome	2-Somewhat bothersome	3-Very bothersome	4-Extremely bothersome
<b>Upper limb specific</b>					
7.	How bad is your hand clenching on its own?				
	0-I don't have any hand clenching	1-It clenches a little	2-It clenches somewhat	3-It clenches quite a bit	4-It clenches all the way
8.	How difficult is it for you or your caregiver to clean the <u>palm of your hand</u> or <u>between the fingers</u> due to the tightness or clenching of the thumb, fingers, or hand?				
	0-Not difficult at all	1-A little difficult	2-Somewhat difficult	3-Very difficult	4-Extremely difficult
9.	How difficult is it for you or your caregiver to clean your armpit due to stiffness or tightness in your arm?				
	0-Not difficult at all	1-A little difficult	2-Somewhat difficult	3-Very difficult	4-Extremely difficult
10.	How difficult is it for you or your caregiver to put your arm through the <u>sleeve of your coat</u> or <u>shirt</u> due to stiffness or tightness in your arm?				
	0-Not difficult at all	1-A little difficult	2-Somewhat difficult	3-Very difficult	4-Extremely difficult
<b>Lower limb specific</b>					
11.	How bad is your foot and/or toes <u>pulling in</u> , <u>curling</u> , <u>sticking up</u> , or otherwise <u>getting stuck</u> on their own when you try to move?				
	0-My foot and/or toes do not <u>pull in</u> , <u>curl</u> , <u>stick up</u> or otherwise get <u>stuck on their own</u>	1-A little bad	2-Somewhat bad	3-Very bad	4-Extremely bad
12.	How difficult is it to walk or move your leg(s) due to stiffness or tightness in your leg(s)?				
	0-Not difficult at all	1-A little difficult	2-Somewhat difficult	3-Very difficult	4-I am unable to walk or move my legs
13.	How difficult is it for you or your caregiver to put on your pants or your shoes due to stiffness or tightness in your leg(s) or feet?				
	0-Not difficult at all	1-A little difficult	2-Somewhat difficult	3-Very difficult	4-Extremely difficult

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Fig. 2. Patient or caregiver stiffness/spasm assessment (Spasticity screening tool items: final version Zorowitz et al. 2017 – Am J Phys Med Rehabil) [37].

we propose a combination of measures including a self/caregiver administered screening tool completed before the visit and a graded scale performed by the caregiver during the visit. The combination of these tools is intended to provide an overall gestalt of the patient's spasticity and potential treatment needs. The

self/caregiver administered screening tool in Fig. 2, from Zorowitz et al., is a 13-item screening tool for adults with spasticity [37]. We propose the screening tool be completed by the patient and/or caregiver to identify the impact of spasticity on their physical function and quality of life. Ideally, it would be pro-

Using the following scale, please report the amount of difficulty you or your child has doing the following movements:

Scale:

Score	Definition	Description
0	No difficulty	Easily able to move limb. No different than any other individual.
1	A little difficulty	A little bit of stiffness present but can easily overcome it. May not always be present.
2	Somewhat difficult	Stiffness is generally always present but still able to easily move limb.
3	Very difficult	Stiffness is generally always present and causes difficulty in moving the limb.
4	Extremely difficult	Limb is very difficult to stretch or move and may not straighten out all the way.

Movements:

	Right	Left
<b>Upper limb</b>		
Raising arm		
Bending elbow		
Straightening elbow		
Straightening wrist		
Opening fingers or thumb		
Other:		
<b>Lower limb</b>		
Bending the hip		
Spreading (abducting) the hips (e.g. As when changing a diaper)		
Bending the knee		
Straightening the knee		
Bending the ankle		
Other:		

Fig. 3. Physician global assessment (PGA) scale for spasticity (adapted from Pascoe et al. 2015 – JAMA Derm) [38].

vided to the patient/caregiver in advance of the virtual appointment with instructions to interpret the questions from the patient or caregiver perspective (i.e. your/your child's or you/your caregiver), as appropriate. To complement this self-assessment, a modified Physician Global Assessment (PGA) scale can be used for assessment of spasticity. The PGA is a 0–4 observational scale to assess disease severity, more commonly in Dermatology and Rheumatology [38–40]. The PGA in Fig. 3 was modified with 0–4 scale definition and rating description prompts to help the caregiver assess velocity dependent movement in upper and lower limbs. While these tools have not been validated for use in this population, this combination of measures may support spasticity assessment in the virtual environment. Additional tools that could be considered include the Penn Spasm Frequency scale and the Spinal Cord Injury Spasticity Tool (SCI-SET) [41,42].

## 5. Conclusion

Telerehabilitation medicine provides an opportunity to deliver timely, patient and family-centric rehabilitation care while maintaining physical distancing and

reducing potential COVID-19 exposure for our patients, their caregivers and medical providers. Families may prefer the convenience of seeing their PRM provider virtually in their own home. While there are no validated tools for conducting pediatric telerehabilitation medicine visits, the compilation of patient and provider preparation instructions, tips for the virtual physical exam, and potential assessments for gait and spasticity provide a starting point for conducting meaningful virtual visits. It is not clear if the barriers for telerehabilitation medicine virtual visits will return once the COVID-19 pandemic has eased or passed. However, if telerehabilitation medicine is executed efficiently and effectively, and patients/caregivers continue to demand it, it is possible that many of the previous barriers to these types of visits will not be reinstated. Therefore, now is the time to establish a solid foundation for pediatric telerehabilitation medicine and integrate this into our standard of care for pediatric patients with disabilities.

## Conflict of interest

The authors have no conflict of interest to report.

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