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SPECIAL ARTICLE COVID-19

The Role of the Smartphone in the Diagnosis of Vestibular Hypofunction: A Clinical Strategy for Teleconsultation during the COVID-19 Pandemic and Beyond

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Abstract

Introduction Vestibular disorders (VDs) are highly prevalent in primary care. Although in general they comprise conditions that are not life-threatening, they are associated with significant functional and physical disability. However, the current coronavirus disease 2019 (COVID-19) pandemic has imposed limitations on the standard treatment of benign conditions, including VDs. In this context, other resources may aid in the diagnosis and management of patients with VDs. It is well known that teleconsultation and teletreatment are both safe and effective alternatives to manage a variety of conditions, and we maintain that VDs should be among these.

Objective To develop a preliminary model of clinical guidelines for the evaluation by teleconsultation of patients with suspected diagnosis of vestibular hypofunction during the COVID-19 pandemic and beyond.

Methods A bibliographic review of the diagnostic feasibility in VDs by teleconsultation was carried out in the LILACS, SciELO, MEDLINE, and PubMed databases; books and specialized websites were also consulted. The legal, regulatory, and technical issues involving digital consultations were reviewed.

Keywords
- COVID-19
- telemedicine
- dizziness
- therapeutics

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Results We found 6 field studies published between 1990 and 2020 in which the efficiency of teleconsultations was observed in the contexts of epidemics and environmental disorders and disadvantageous geographical conditions. After reviewing them, we proposed a strategy to examine and address vestibular complaints related to vestibular hypofunction.

Conclusion The creation of a digital vestibular management algorithm for the identification, counseling, initial intervention, monitoring and targeting of people with possible vestibular hypofunction seems to be feasible, and it will provide a reasonable alternative to in-person evaluations during the COVID-19 pandemic and beyond.

Introduction

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is the causative infectious agent of coronavirus disease 2019 (COVID-19), which is considered a pandemic by the World Health Organization (WHO). Genome sequencing led to its classification as a new genus of betacoronavirus. Viral features that enabled it to attain pandemic proportions include its high rate of transmission and the lack of specific immunity; it took over a year before specific vaccines became available.[1–4]

In an attempt to decrease the transmission rate of the virus, the World Health Organization (WHO) emphasizes the importance of social distancing,[5] social isolation,[6,7] and quarantine.[5,6] These non-pharmacological measures aim to protect everyone, especially high-risk groups.[6]

These non-pharmacological measures have played an important role in curbing the spread of the disease, though they have also had negative economic and social consequences. Social distancing and isolation have also had unintended adverse effects on public health. Another area of concern is the low rate of diagnosis of previously-frequent cardiovascular, neurological and oncological conditions. Furthermore, many people avoid going to health centers and hospitals for fear of being infected by the virus, further worsening this adverse effect.[8,9]

These direct and indirect consequences of the pandemic, such as prolonged time at home, lack of physical activity, psycho-emotional disturbances, and poor eating habits, can have adverse effects on health,[10–12] including diseases of the vestibular system.

Of the various vestibular diseases, vestibular hypofunction (VH) is one of the most prevalent, often underlying vestibular neuritis and labyrinthitis, which represent about 630 thousand cases per year in specialized clinics.[13] Vestibular hyperfunction can compromise both ears and in this situation it is estimated that its prevalence is of 28 per every 100 thousand people.[14]

Vestibular hyperfunction is characterized by a decrease in the functioning of the vestibular system, either by deterioration of the vestibular nerve, of structures of the central nervous system, or of the labyrinth; this dysfunction can be unilateral or bilateral.[15,16]

The clinical picture may vary, depending on the severity of the involvement and the topography of the lesion; however, most of the time, the patient complains of dizziness during movements, nausea, decreased visual acuity during head movements, and instability during walking.[17] Vestibular hyperfunction is associated with diminished of quality of life; its causes can be toxic (such as, ototoxic medications), vascular (labyrinthine infarct), tumoral (such as, vestibular schwannoma), labyrinthine disorders (such as, Ménière disease), and viral (vestibular neuritis), and it tends to be more frequent in the elderly.[18,19]

Vestibular rehabilitation is considered safe and effective to manage patients with VH, and it is included in most of the clinical guidelines for vestibular disorders.[13]

The indirect effects of spending more time at home, such as hypomobility, psycho-emotional stress, poor diet, and low exposure to sunlight increase the risk of vestibular disorders. Under regular (non-pandemic) conditions, the evaluation of patients with VH includes a detailed physical examination, which requires close physical contact between the examiner and the patient. This presents a risk in the current COVID-19 pandemic; therefore, the regular neurotological consultations and physical rehabilitation have often been deferred.

For this reason, teleconsultation is presented as an efficient and safe alternative, which deploys technology to provide remote health services, virtually connecting the examiner and the patient, potentially with a broad geographic reach, offering the possibility of delivering educational material, preventative counseling, diagnosis, and treatment.[20–22]

In view of the need for social distancing due to COVID-19 and the high prevalence of VH, the adaptation of the neurotological practice to a telemedicine format, especially regarding evaluations, is relevant, for ti reduces the risks of bidirectional contamination. There is emerging evidence that the effectiveness of telecare is similar to that of face-to-face services for specific diseases in particular specialties.

Objective

The aim of the present study was to provide a preliminary model of a clinical strategy to perform teleconsultations, using smartphones to diagnose VH in people aged $\geq$ 18 years during the COVID-19 pandemic and beyond.

Methods

The present original study began with queries in medical literature databases (LILACS, SciELO, MEDLINE, and PubMed), supplemented by material from books and specialized websites. The following keywords were used in the query: *COVID-19*, *telemedicine*, *vertigo*, and *therapeutics*. These were ordered and classified according to their relevance in relation to the objective defined for this investigation.

Each retrieved study was reviewed to check whether it answered the following question: how to design a clinical strategy to evaluate a patient aged $\geq$ 18 years, with suspected VH, by teleconsultation using a smartphone during the COVID-19 pandemic and beyond?

To achieve this objective, the authors discussed the information retrieved from the studies, based on international guidelines, and correlating it with the clinical practice already carried out by each one of them. Thus, a clinical strategy was developed to perform teleconsultations by smartphone for the management of VH.

Results

We only found 6 field studies published between 1990 and 2020, which gives an idea of the scarce literature on the topic of otoneurologic teleconsultations for VH. These studies were analyzed.

In these studies, we observed that practitioners' awareness of teleconsultation was greatly heightened when Hurricane Katrina hit the southern coast of the United States, in the state of Louisiana, in 2015. In this disaster, in-person evaluations by a subspecialist were very difficult to arrange, so teleconsultations were attempted (out of necessity), including the subspecialty of neurotology, and were found to be efficient.[23]

The viability of neurotological consultations is usually considered in the context of natural disasters or infectious catastrophes. However, we suggest that this viability could be easily extended to other circumstances, such as reaching patients in remote areas, or patients living far from specialized medical centers, which would be economical and would increase patient satisfaction.[24–26]

One study[27] showed the effectiveness of this remote resource in the differential diagnosis of central and peripheral vestibular disorders, with the patient using a smartphone to record eye movements during otoneurological tests. Another study[28] emphasized the positive contribution of teleconsultation in the diagnosis of chronic vestibular syndromes in adults and the elderly; in this study, all professionals were instructed to make diagnoses according to Dutch guidelines.

The retrieved studies do not present detailed information on the procedures and protocols carried out during the teleconsultation.

Discussion

In the current global context, some health care facilities continue to offer in-person assistance to patients with suspected vestibulopathies, though with a reduced volume of patients. Teleconsultation is probably a safe and effective tool to carry out patient evaluations, although the evidence for this remains limited and indirect.

The technology deployed for teleconsultation is not new in itself, but may be unfamiliar to neurotology professionals; these practitioners may require guidance or training in how to conduct a remote physical examination. The requirements for social distancing and limitations to physical contact imposed by the COVID-19 pandemic have forced health care practitioners to improve, and sometimes to create, strategies for the remote examination and treatment of patients with vestibular dysfunction.[29–31]

Bearing this in mind, we propose a strategy to provide this kind of care through the following steps:

Step 1: technical conditions and limitations

To enable teleconsultation, it is necessary to use a digital device, preferably a smartphone, as suggested in the present study, in order to facilitate the execution of certain tests, and to have a videoconferencing system (►**Fig. 1**).

The device must have an application with at least a videoconferencing function, and those that are formally guided by scientific and governmental guidelines are: WhatsApp, Zoom for Healthcare, Facetime, Facebook Messenger, Skype, Microsoft Teams, Viber, Imo, Line, Hangouts, Snapchat, Jus Talk, Zoom, Discord, and Houseparty.[32,33] These applications offer greater privacy and patient security.[34]

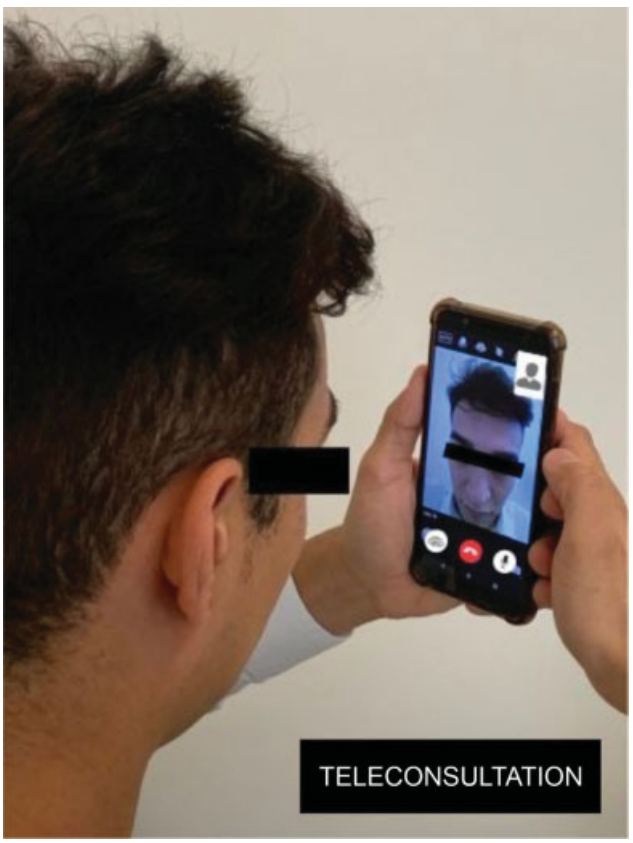

Fig. 1 Teleconsultation – videoconference system.

It is important to note that the policies and regulations for teleconsultation assistance may vary between countries. However, there is broad agreement that digital platforms that rely on open social networks are not recommended. It is desirable that the application guarantees privacy, allows data archiving, and offers greater data security to the professional and the patient (►**Fig. 1**).

Even if the technology and software are appropriate, authorization is still necessary, according to local regulations. The patient must always be informed (in advance of the teleconsultation) about the characteristics of the procedures in order to grant their informed consent.

Step 2: establishing the exam environment

For the start of the teleconsultation, it may be helpful if a relative or caregiver is present, although this is not mandatory. The presence of a family member or caregiver can facilitate the recording of eye movements and the performance of some tests, and will also provide greater patient safety, especially during the initial encounter, in case the patient does not tolerate the examination well.

The assistant or the patients themselves will transmit the image of the eyes, as directed, keeping them wide open. It is important that the location chosen for the teleconsultation has good lighting and a bed, usually the patient's bed. The highest video resolution available should be used.

Step 3: protocol approach for remote diagnosis

As shown in ►**Figure 2**, the teleconsultation protocol for patients with suspected VH is divided into several stages. First, initial contact is established with the patient and his or her assistant; if applicable, the advantages, disadvantages, and limitations of remote consultation should be clarified, and, after the patient's voluntary informed consent is obtained, the examination environment should be established (step 2). We then advance to step 3a (collection of personally identifiable information); in this step, data such as full name, date of birth, address, profession, and any other information relevant to the diagnostic process is collected.

Dizziness is a common symptom of COVID-19 infection, including acute vestibular hypofunction; therefore, associated symptoms of the infection (dyspnea, fever, headache etc.) must be assessed early in the encounter.[35]

Then, step 3b, anamnesis, begins by asking guiding questions to build the patient's current medical history. At this stage, information is also collected on the medications used, previous diagnoses, and lifestyle habits. Contraindications for neck movement must be stated.

We suggest that anamnesis follow the time, trigger, target examination (TiTRaTe) approach, which emphasizes the importance of defining the onset and duration of symptoms, what triggers them (activation), and so proceed with the otoneurological evaluation similar to the one made at the bedside. The TiTRaTe approach seeks to classify the information collected into an acute, episodic or chronic vestibular syndrome.[36]

Once the diagnostic hypothesis of vestibular hypofunction has been proposed, step 3c (evaluation: functional tests) should be performed for confirmation or exclusion. Similar to the bedside evaluation, in the teleconsultation model the evaluation is divided into five stages: I) static evaluation (head tilt, saccadic intrusions, spontaneous nystagmus); II) evaluation of the eyes only, without moving the head (spontaneous nystagmus, gaze -voked nystagmus, alternating cover test, saccadic movements, ocular pursuit, optokinetic nystagmus); III) combined evaluation of the vestibular and visual systems (suppression of the vestibular ocular reflex); IV) the Romberg test, and tests of gait and coordination, among others; V) Otolitic Evaluation.[37] Other tests can also be included, depending on the evaluation of the risk of fall, such as: IV) the Romberg test, and tests of gait and coordination, among others.[37]

In step 3c (stages I to V), the examiner should instruct the patient to position the camera so that the eye is in the center of the video frame. In order to acquire close-up images of the eye in sufficient detail, it may be necessary to bring the camera closer to the patient's eye, or to use the camera's

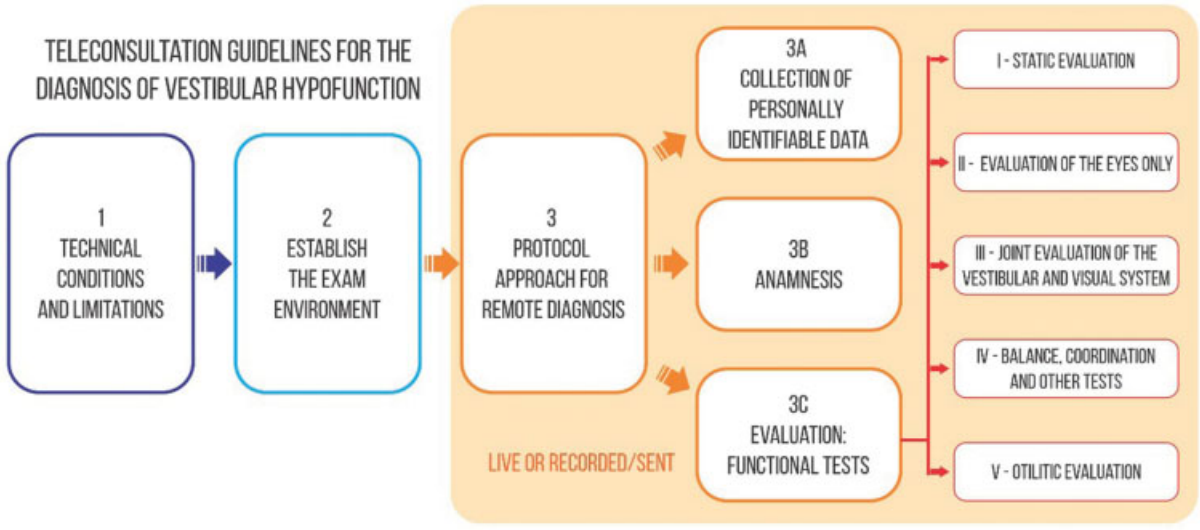

Fig. 2 Teleconsultation guidelines for the diagnosis of vestibular hypofunction.

zoom function (if available). The patient should always keep his or her eyes open. Another alternative is for the assistant to operate the device or the patient to use a smartphone stand.

As in the face-to-face evaluation, during the teleconsultation, the examiner should explain the procedure to the patient before performing it, so that the tests can be carried out smoothly. The tests related to to step 3c (stages I and II) should be carried out similarly to the face-to-face examination. The examiner should use the edges of the screen ("device screen boundary") to estimate horizontal and vertical eye movements. It is recommended that the examiner limit the patient's eye movements as much as possible for the sake of a better analysis, through the resources of the application itself or the screen recording available on the computer or in another application.

Recently, the American Academy of Neurology developed and disseminated a neurological examination model for teleconsultations.[38] Although the neurotological examination was not directly included, the model contains some of the evidence from step 3c (stages I and II), and is a relevant tool to identify signs of central lesions for remote diagnosis.[39]

For step 3c (stage III), the examiner should start with the vestibulo-ocular reflex (VOR), guiding the patient to make horizontal rotational movements of the head from 10° to 20°, slowly, keeping the eye fixed on the object presented or at the tip of the nose. The examiner should then instruct the patient to make vertical head movements (with neck flexion and extension), at the same angle and speed as the horizontal ones, and maintaining visual fixation as instructed.[40] Then, the patient should place a target before himself or herself (usually the thumb held at arm's length), at eye level, while still maintaining the same angles and speed as the slow VOR test, to perform the horizontal and vertical movements; however, then, the head and the objective must move in the same direction (for the suppression of the visual fixation). This test can also be performed with block movements.[41] The examiner should always guide the patient/assistant to keep the device static, appropriately positioned, with the eyes open, and zoom in when necessary, to visualize any eye movements (such as the appearance of saccadic intrusions).

Step 3c (stage III) is the head impulse test. In an in-person evaluation, this would be performed by the examiner as a passive movement, whose diagnostic sensitivity is higher. In contrast, teleconsultations require an active head movement (that is, the patient executes the maneuver himself or herself). This active method is less sensitive than the passive one, but, in cases of unilateral vestibular hypofunction, it can still elicit corrective refixation saccades during the impulse directed towards the side of the lesion.[40] The usual contraindications for the passive head impulse test also apply when it is performed actively (for example, known cervical spine disease, known vertebral artery occlusive disease or dissection etc.).

If, during step 2, there are complaints related to changes in static and/or dynamic equilibrium, step 3c (stage IV) can be used. At this stage, the Romberg test, an analysis of the gait through a timed-up-and-go (TUG) test, for example, and a coordination test, among others,[37] can be applied. The patient will need an assistant near him or her in order to prevent falls, and should do this in a suitable space, such as a hallway or room of sufficient length. The examiner will evaluate the pattern of oscillations to classify them as normal or pathological, as well as whether the results suggest peripheral or central deficits. In step 3c (stage IV), the device is guided by the helper. The examination of the coordination is also very important for the exclusion or confirmation of suspected cerebellar pathologies, and can be carried out during the teleconsultation, since these are "active" examination techniques (that is, requiring voluntary action on the part of the patient). Some tests in remote format have been evaluated by the American Academy of Neurology.[38,39]

The otoneurology consultation can include the subjective visual vertical test and the head heave test, which assess the function of the otolithic organs; these are less frequently discussed, but are no less relevant.[42,43] For step 3c (stage V), we suggest that the examiner present a line via the application on the phone, or ask the patient to have the application showing the line on his device. Thus, the patient should be able to guide the examiner to position the device so that he / she considers that the visualized line is totally vertical (0°), or, if he / she is doing it on his / her own device, he / she will follow the examiner's instructions and show the result obtained by the application.

For this evaluation, the application Visual Vertical can also be used. Developed by Jacob Brodsky, this application has been shown to be effective in children, adolescents and adults, and is well adapted to be used in teleconsultations. Instead of having to attach the smartphone to the bottom of a bucket, this application simply displays a line on the screen, and the patient guides the examiner until he /she perceives it to be vertical.[42] To optimize the test's sensitivity, the examiner may request that the patient perform this portion of the exam in the darkest environment available.

The head heave Test in teleconsultations is performed actively. It is advised that the patient maintain the vision fixed on a point presented by the examiner and perform linear movements (that is, translational rather than rotational) from the center to the right and from the center to the left, with low amplitude, but high velocity. The patient will report symptoms, and the examiner should monitor for the presence of corrective saccades that indicate otolithic dysfunction.[43] This test is considered by many examiners to be difficult to perform during face-to-face care. It is up to the examiner to judge the feasibility of the execution in the remote format with a given patient.

After the clinical diagnosis of unilateral or bilateral vestibular hypofunction due to peripheral or central pathologies, the practitioner must proceed with the determination of the etiology. In some cases, additional evaluations may require laboratory testing or imaging exams. As a treatment option, vestibular physiotherapy can also be performed virtually, using the videoconference system, mainly because it is usually performed in a non-instrumented and active way. Medications, if appropriate, can be prescribed by the

physician. When the examination is performed by a non-prescribing professional, the patient must be referred.[28]

Evaluations by teleconsultation have substantial limitations; however, they may be an efficient alternative in specific situations. If, after completion, the conclusion is unrevealing, the examiner may still suggest in-person instrumented vestibular testing in the office. However, it is important to highlight that the previous evaluation by teleconsultation would reduce the length of stay and the number of patients in the clinic, since most of the examinations would have already been performed.

If the internet connection is poor

To perform step 3, it is important that both the patient and the examiner have good internet connection, in order to provide sufficient spatial and temporal resolution for video observation. In this regard, several complications may arise: i) internet failures can occur; ii) lack of ability to perform some commands live; or iii) maybe the patient initially had an adequate internet connection, but it subsequently degrades, interfering with video and audio transmission. In these situations, it may be possible for the examiner to guide the patient with his or her companion, record videos of the necessary tests, and send them for a subsequent "off-line" analysis. These guidelines can be provided by the examiner during the live transmission, or by sending instruction materials (such as links to web pages or prerecorded instructional videos). This asynchronous ("store and forward") technique is still a viable approach to teleconsultation, as was made clear in a study[27] demonstrating its usefulness in the differential diagnosis of Ménière disease, and in findings of central and peripheral deficits. Furthermore, the practice of recording oculomotor and other physical examination findings by smartphone was even described in the emergency department setting, where, with the use of the device, the eye movements of patients were recorded, which were evaluated at another time by specialists.[25]

Limitations imposed by the inability to eliminate the suppression of the visual fixation

Removal of the suppression of the visual fixation is a very important factor during certain parts of the neurotological assessment, as this can "unmask" certain forms of nystagmus.[44–52] Routinely, clinicians use instruments such as Frenzel glasses and infrared Frenzel video goggles to achieve this effect. However, other resources can be used during the exam, such as the ophthalmoscope.[53] For otoneurological teleconsultations, a reasonable adaptation is for the patient to occlude one eye manually, or, if possible, with adhesive occlusive material (such as an eye patch), and the companion should shine a flashlight on the other (unoccluded) eye during the perfomance of the tests guided by the examiner. While imperfect, this is still a reasonable method to decrease visual fixation in order to bring out any latent oculomotor abnormalities.

Otoneurology is a growing field, and its diagnostic capabilities have been enhanced by technology, but the importance of the bedside clinical assessment should not be overlooked, and is still highly recommended when feasible.[54] While the number of vestibular clinicians is growing, the availability of clinicians of this subspecialty is still greatly exceeded by the demand for care, because vestibular disease is extraordinarily common. While technology has been helpful, much of this specialized equipment may be unaffordable or simply unavailable, even though the need for care continues to grow.

Teleconsultation relies on the same clinical skills that one would use during an in-person evaluation. The limitations imposed by the COVID-19 pandemic should spur us all to reflect on the need to be prepared for adverse circumstances, to be nimble and adapt the practice with new resources, as each situation may require (►**Fig. 2**).

Conclusion

This teleconsultation strategy to diagnose VH is expected to be a relevant and useful method for neurotology professionals during the COVID-19 pandemic. In addition, it is believed that this approach can be applied in situations in which access to in-person care is limited, either due to long distance or other geographical barriers.

Studies are needed to assess the validity, reliability and sensitivity of this method. We suspect that this method is also economical, though a formal cost-benefit analysis should be conducted.

Conflict of Interests
The authors have no conflict of interests to declare.

References

1 Bogoch II, Watts A, Thomas-Bachli A, Huber C, Kraemer MUG, Khan K. Potential for global spread of a novel coronavirus from China. J Travel Med 2020;27(02):taaa011. Doi: 10.1093/jtm/taaa011
2 Lu R, Zhao X, Li J, et al. Genomic characterisation and epidemiology of 2019 novel coronavirus: implications for virus origins and receptor binding. Lancet 2020;395(10224):565–574. Doi: 10.1016/s0140-6736(20)30251-8
3 World Health Organization. WHO Director – Ge;neral's remarks at the media briefing on 2019-nCoV on 11 February 2020[EB/OL]. 2020. Accessed May 02, 2020 at https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-media-briefing-on-2019-ncov-on-11-february-2020
4 International Committee on Taxonomy of Viruses. Naming the 2019 Coronavirus. Accessed May 15, 2020 at: https://talk.ictvonline.org/
5 Wilder-Smith A, Freedman DO. Isolation, quarantine, social distancing and community containment: pivotal role for old-style public health measures in the novel coronavirus (2019-nCoV) outbreak. J Travel Med 2020;27(02):taaa020. Doi: 10.1093/jtm/taaa020
6 World Health Organization. Considerations for quarantine of individuals in the context of containment for coronavirus disease (COVID-19): interim guidance, 19 march 2020. Geneva; 2020 Mar 19. 4 f. Accessed May 20, 2020 at: https://apps.who.int/iris/handle/10665/331497
7 Diário Oficial da União Law n°. 13979, of February 6, 2020. Provides for measures to deal with the public health emergency of international importance resulting from the coronavirus responsible for the 2019 outbreak. Diário Oficial da União, Brasília,

DF, ed. 27, section 1, p. 1, 7 Feb 2020. 2020. Accessed April 17, 2020 at: http://www.in.gov.br/en/web/dou/-/lei-n-13.979-de-6-de-fevereiro-de-2020-242078735
8 Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD. How will country-based mitigation measures influence the course of the COVID-19 epidemic? Lancet 2020;395(10228):931–934
9 Qualls N, Levitt A, Kanade N, et al. Community mitigation guidelines to prevent pandemic influenza - United States, 2017. Recommendations and Reports / April 21, 2017 / 66(1);1–34. 2020: Accessed May 05, 2020 at: https://www.cdc.gov/mmwr/volumes/66/rr/rr6601a1.htm#contribAff
10 Ferreira MJ Jr, Irigoyen MC, Consolim-Colombo F, Saraiva JFK, Angelis K. Physically Active Lifestyle as an Approach to Confronting COVID-19. Arq Bras Cardiol 2020;114(04):601–602. https://doi.org/10.36660/abc.20200235
11 Baloh RW, Honrubia V, Kerber KA. Bedside Examination of the Vestibular System. In: Baloh and Honrubia's Clinical Neurophysiology of the Vestibular System. 4 ed. ed. Oxford,. UK: Oxford University Press; 2011https://oxfordmedicine.com/view/10.1093/med/9780195387834.001.0001/med-9780195387834-chapter-006. Accessed June 23, 2020
12 Odriozola-González P, Planchuelo-Gómez Á, Irurtia MJ, de Luis-García R. Efeitos psicológicos do surto e bloqueio do COVID-19 entre estudantes e trabalhadores de uma universidade espanhola. [publicado online antes da impressão, 2020 em 19 de maio de 2020] Psiquiatria Res 2020;290(1–8):113108. Doi: 10.1016/j.psychres.2020.113108
13 Hall CD, Herdman SJ, Whitney SL, et al. Vestibular Rehabilitation for Peripheral Vestibular Hypofunction: An Evidence-Based Clinical Practice Guideline: FROM THE AMERICAN PHYSICAL THERAPY ASSOCIATION NEUROLOGY SECTION. J Neurol Phys Ther 2016; 40(02):124–155. Doi: 10.1097/NPT.0000000000000120
14 Hain TC, Cherchi M, Yacovino DA. Bilateral Vestibular Weakness. 2018;9344(1–14). Published 2018 May 31. Doi: 10.3389/fneur.2018.00344
15 Chau AT, Menant JC, Hübner PP, Lord SR, Migliaccio AA. Prevalence of Vestibular Disorder in Older People Who Experience Dizziness. ORL J Otorhinolaryngol Relat Spec 2015;77(1–22):197–218. Published 2015 Dec 24. Doi: 10.3389/fneur.2015.00268
16 van de Berg R, van Tilburg M, Kingma H. Bilateral Vestibular Hypofunction: Challenges in Establishing the Diagnosis in Adults. ORL J Otorhinolaryngol Relat Spec 2015;77(04):197–218. Doi: 10.1159/000433549
17 Moffat M, Bohmert JA, Hulme JB. Neuromuscular essentials: Applying the preferred physical therapist practice patterns. Thorofare, NJ: SLACK; 2008
18 Agrawal Y, Carey JP, Della Santina CC, Schubert MC, Minor LB. Disorders of balance and vestibular function in US adults: data from the National Health and Nutrition Examination Survey, 2001-2004. [published correction appears in Arch Intern Med. 2009 Aug 10;169(15):1419] Arch Intern Med 2009;169(10): 938–944 Doi: 10.1001/archinternmed.2009.66
19 Jahn K. The Aging Vestibular System: Dizziness and Imbalance in the Elderly. Adv Otorhinolaryngol 2019;82:143–149. Doi: 10.1159/000490283
20 Givens GD, Elangovan S. Internet application to tele-audiology–" nothin' but net". Am J Audiol 2003;12(02):59–65. Doi: 10.1044/1059-0889(2003/011)
21 Lancaster P, Krumm M, Ribera J, Klich R. Remote hearing screenings via telehealth in a rural elementary school. Am J Audiol 2008; 17(02):114–122. Doi: 10.1044/1059-0889(2008/07-0008)
22 Conselho Federal de Fisioterapia e Terapia Ocupacional (COFFITO) RESOLUTION n°. 516, od march 20, 2020–Teleconsultation, Telemonitoring and Teleconsulting. Accessed May 18, 2020 at: https://www.coffito.gov.br/nsite/?p=15825
23 Arriaga MA, Nuss D, Scrantz K, et al. Telemedicine-assisted neurotology in post-Katrina Southeast Louisiana. Otol Neurotol 2010;31(03):524–527. Doi: 10.1097/MAO.0b013e3181cdd69d
24 Viirre E, Warner D, Balch D, Nelson JR. Remote medical consultation for vestibular disorders: technological solutions and case report. Telemed J 1997;3(01):53–58. Doi: 10.1089/tmj.1.1997.3.53
25 Shah MU, Lotterman S, Roberts D, Eisen M. Smartphone telemedical emergency department consults for screening of non-acute dizziness. Laryngoscope 2019;129(02):466–469. Doi: 10.1002/lary.27424
26 Seim NB, Philips RHW, Matrka LA, et al. Developing a synchronous otolaryngology telemedicine Clinic: Prospective study to assess fidelity and diagnostic concordance. Laryngoscope 2018;128(05): 1068–1074. Doi: 10.1002/lary.26929
27 Kıroğlu M, Dağkıran M. The Role of Mobile Phone Camera Recordings in the Diagnosis of Meniere's Disease and Pathophysiological Implications. J Int Adv Otol 2020;16(01):18–23. Doi: 10.5152/iao.2019.6605
28 van Vugt VA, van der Wouden JC, Essery R, et al. Internet based vestibular rehabilitation with and without physiotherapy support for adults aged 50 and older with a chronic vestibular syndrome in general practice: three armed randomised controlled trial. BMJ 2019;367(1–11):l5922. Doi: 10.1136/bmj.l5922
29 Barreto RG, Yacovino DA, Teixeira LJ, Freitas MM. Teleconsultation and Teletreatment Protocol to Diagnose and Manage Patients with Benign Paroxysmal Positional Vertigo (BPPV) during the COVID-19 Pandemic. Int Arch Otorhinolaryngol 2021;25(01): e141–e149. Doi: 10.1055/s-0040-1722252
30 Bertholon P, Thai-Van H, Bouccara D, Esteve-Fraysse MJ, Wiener-Vacher SR, Ionescu E. Guidelines of the French Society of Otorhinolaryngology (SFORL) for teleconsultation in patients with vertigo during the COVID-19 pandemic[published online ahead of print, 2020 Dec 14]. Eur Ann Otorhinolaryngol Head Neck Dis 2020:S1879–7296(20)30280–5. Doi: 10.1016/j.anorl.2020.11.011
31 Shaikh AG, Bronstein A, Carmona S, et al. Consensus on Virtual Management of Vestibular Disorders: Urgent Versus Expedited Care. Cerebellum 2021;20(01):4–8. Doi: 10.1007/s12311-020-01178-8
32 Conselho Regional de Fisioterapia e Terapia Ocupacional 2 (CREFITO 2). Telehealth: online consultation. Accessed May 12, 2020 at: http://www.crefito2.gov.br/clientes/crefito2/fotos//CartilhaTELESSAUDE.pdf
33 Giordano V, Koch H, Godoy-Santos A, Dias Belangero W, Esteves Santos Pires R, Labronici P. WhatsApp Messenger as an Adjunctive Tool for Telemedicine: An Overview. Interact J Med Res 2017; 6(1–8):e11 . Doi: 10.2196/ijmr.6214
34 U.S. Department of Health & Human Services. Notification of Enforcement Discretion for Telehealth Remote Communications During the COVID-19 Nationwide Public Health Emergency. Accessed May 12, 2020 at: https://www.hhs.gov/hipaa/for-professionals/special-topics/emergency-preparedness/notification-enforcement-discretion-telehealth/index.html
35 Mat Q, Noël A, Loiselet L, et al. Vestibular Neuritis as Clinical Presentation of COVID-19. Ear Nose Throat J 2021 (1–4); 145561321995021:145561321995021. Doi: 10.1177/0145561321995021
36 Newman-Toker DE, Edlow JA. TiTrATE: A Novel, Evidence-Based Approach to Diagnosing Acute Dizziness and Vertigo. Neurol Clin 2015;33(03):577–599, viii. Doi: 10.1016/j.ncl.2015.04.011
37 Maia FCZE, Albernaz PLM, Carmona S. Otoneurologia Atual. 1st ed. Rio de JANEIRO: REVINTER; 2014
38 American Academy of Neurology. Telemedicine and COVID-19. Accessed may 17, 2020 at: https://www.aan.com/siteassets/home-page/tools-and-resources/practicing-neurologist–administrators/telemedicine-and-remote-care/20200326-Telemedicine-and-covid-19-final.pdf
39 American Academy of Neurology. NeuroBytes: The Neurologic Exam Via Telemedicine. Accessed May 18, 2020 at: https://learning.aan.com/diweb/catalog/item?id=5033281
40 Halmagyi GM, Black RA, Thurtell MJ, Curthoys IS. The human horizontal vestibulo-ocular reflex in response to active and passive

head impulses after unilateral vestibular deafferentation. Ann N Y Acad Sci 2003;1004:325–336. Doi: 10.1196/annals.1303.030

41 Daye PM, Roberts DC, Zee DS, Optican LM. Vestibulo-ocular reflex suppression during head-fixed saccades reveals gaze feedback control. J Neurosci 2015;35(03):1192–1198. Doi: 10.1523/JNEUROSCI.3875-14.2015

42 Brodsky JR, Cusick BA, Kawai K, Kenna M, Zhou G. Peripheral vestibular loss detected in pediatric patients using a smartphone-based test of the subjective visual vertical. Int J Pediatr Otorhinolaryngol 2015;79(12):2094–2098. Doi: 10.1016/j.ijporl.2015.09.020

43 Kessler P, Tomlinson D, Blakeman A, Rutka J, Ranalli P, Wong A. The high-frequency/acceleration head heave test in detecting otolith diseases. Otol Neurotol 2007;28(07):896–904

44 Gauthier GM, Vercher JL. Visual vestibular interaction: vestibulo-ocular reflex suppression with head-fixed target fixation. Exp Brain Res 1990;81(01):150–160. Doi: 10.1007/BF00230111

45 West PD, Sheppard ZA, King EV. Comparison of techniques for identification of peripheral vestibular nystagmus. J Laryngol Otol 2012;126(12):1209–1215. Doi: 10.1017/S0022215112002368

46 Hirvonen TP, Juhola M, Aalto H. Suppression of spontaneous nystagmus during different visual fixation conditions. Eur Arch Otorhinolaryngol 2012;269(07):1759–1762. Doi: 10.1007/s00405-011-1824-3

47 Tschang HH, Harrison MS. Note on the value of Frenzel's glasses for the recognition and qualitative evaluation of spontaneous nystagmus. J Neurol Neurosurg Psychiatry 1971;34(03):362–366. Doi: 10.1136/jnnp.34.3.362

48 Reker U. Peripheral-vastibular spontaneous nystagmus. Analysis of reproducibility and methoidolgies. Arch Otorhinolaryngol 1980;226(04):225–237. Doi: 10.1007/BF00455584

49 Mulch G, Bonner C. The effect of eye closure upon the pathological vestibular spontaneous nystagmus. Acta Otolaryngol 1976; 81(5-6):376–385. Doi: 10.3109/00016487609107491

50 Gizzi MS, Harper HW. Suppression of the human vestibulo-ocular reflex by visual fixation or forced convergence in the dark, with a model interpretation. Curr Eye Res 2003;26(05):281–290. Doi: 10.1076/ceyr.26.4.281.15426

51 Van Nechel C. Visual suppression of vestibular nystagmus. Acta Otorhinolaryngol Belg 1998;52(01):1–8

52 Karlsen EA, Goetzinger CP, Hassanein R. Effects of six conditions of ocular fixation on caloric nystagmus. Arch Otolaryngol 1980; 106(08):474–476. Doi: 10.1001/archotol.1980.00790320026007

53 Hain TC, Cherchi M. Vestibular Testing. Continuum (Minneap Minn) 2021;27(2 Neuro-otology):330–347

54 Tarnutzer AA, Dieterich M. Bedside examination of the vestibular and ocular motor system in patients with acute vertigo or dizziness. Clinical and Translational Neuroscience 2019;3(02):. Doi: 10.1177/2514183X19886158

