Balance testing in cardiac rehabilitation with a computerized portable foot pressure mat

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ABSTRACT

An age-related decline in balance increases fall risk in the elderly. Balance testing supported with therapeutic exercise may lower risk and improve tasks of daily living. The Rehabilitation Artificial Physical Intelligence Database (RAPID) Computerized Portable Foot Pressure Mat System is a novel technology that can provide meaningful objective performance metrics that cannot be measured with traditional pre-post cardiac rehabilitation (CR) program balance testing. In January 2021, Mayo Clinic-Arizona CR integrated this technology into clinical practice. Mayo Clinic CR Enterprise balance testing procedures continue as normal, with the added benefit of the RAPID System, and the option to conduct specialized balance tests such as the modified Clinical Test of Sensory Interaction in Balance (mCTSIB) and the 4-Stage Balance Test (4-SBT). A foot pressure mat connects to the computer via a USB cable, which ensures patient privacy. RAPID's secure cloud-based software program interprets the pressures on the mat to display graphical feedback on an exam room computer screen. The RAPID software decodes peak foot pressure, weight distribution and Center of Pressure (CoP) associated with lower extremity limitations and instability. RAPID's CoP Sway Index is an objective quantification of postural sway and indicates the standard deviation of the patient's average position from the center. A higher score measured in total sway centimeters indicates a limited ability to remain steady during testing. RAPID can also measure ground reaction force, body alignment, loading patterns and force-time relationships to better understand neuromuscular imbalances, performance deficits and instabilities. Results are securely stored in the RAPID Technology portal for viewing by the clinician. The software uses RAPID's artificial intelligence to recommend evidence-based therapeutic exercises based on test results. The clinician can use this feedback to customize an individualized exercise plan. The patient views video demonstrations and practices these exercises onsite with clinician supervision. The mat also has the versatility to be used for biofeedback training. Repeated measures balance testing provides both the clinician and patient feedback about progress. Another application includes the option to assign the video demonstrations to the patient via an institution approved Connected Health (CH) platform. Patients can access the videos on a mobile device at home. The CR staff have found these applications of technology to be user friendly and the objective metrics generated have the potential to improve the patient experience.

LEARNER OBJECTIVES

1. Understand the rationale for the balance testing in CR.
2. Describe testing procedures for the mCTSIB and 4-SBT.
3. Identify a process to evaluate balance with the RAPID System and prescribe therapeutic exercise.

BACKGROUND

With the increased aging population, cardiac and pulmonary rehabilitation is starting to recognize the importance of improved physical function (the ability to perform physical tasks necessary for activities of daily life) in older adults.[1-3] There are a variety of performance evaluations that can be used to assess physical function in different populations.[4-13] The quantification of balance is an important component of physical function in older and frail patients.[14] Balance testing with a foot pressure mat and associated software can provide objective performance metrics that cannot be measured with traditional methods. A clinician can use test results to customize an individualized therapeutic exercise plan.[15-21] Using a portable device to conduct a clinic-based performance evaluation has been well received at MCA cardiology in the past. [22]

PURPOSE

To describe the practical application of technology to help cardiopulmonary professionals determine the functional status of older and frail patients.

METHODS

Balance Testing Procedures

Examples of specialized static balance tests include the modified Clinical Test of Sensory Interaction in Balance (mCTSIB)[23] and the 4-Stage Balance Test (4-SBT).[24] These are validated and reliable tests that can be conducted without[25-26] or with technology support. [27-29]

METHODS

The modified Clinical Test of Sensory Interaction in Balance (mCTSIB)

The mCTSIB provides a generalized assessment of the patient's ability to integrate a combined contribution of input from the different senses within the body to control balance while making compensations when one or more of those senses are compromised. The patient is challenged to remain still in a balanced position for 20 seconds in 4 test conditions, which progressively increases the demand on the senses to remain balanced. The clinician can evaluate each of the senses through a process of elimination as described below.

Test Conditions

Eyes open, firm surface – Tests all three balance related sensory inputs: Visual, somatosensory and vestibular.

Eyes closed, firm surface - Visual is not available; consequently, somatosensory and vestibular are tested. Somatosensory input consists of proprioception and touch, which allows the muscles to make continuous automatic adjustments to maintain balance and avoid falls. If the patient performs poorly, the somatosensory or vestibular system may be compromised, which increases visual dependency.

Eyes open, unstable surface (foam) – Somatosensory is compromised; consequently, visual and vestibular are tested. If the patient performed poorly, visual or vestibular may be compromised, which increase somatosensory dependency.

Eyes closed, unstable surface (foam) - Visual is not available and somatosensory is compromised; consequently, only vestibular is tested. The vestibular system is responsible for processing information about movement with respect to gravity; more specifically rotation, acceleration/deceleration, head stabilization and works with the visual system to stabilize the eyes and maintain posture during exertion. Vestibular disorders cause a feeling of dizziness and unsteadiness. For the elderly this may be evident while performing activities of daily living. If performance is limited, the vestibular system may be disrupted.

Four Stage Balance Test

The 4-SBT is a component of the Stopping Elderly Accidents, Deaths & Injuries (STEADI) toolkit compiled by the Centers for Disease Control for the purpose of assisting healthcare professionals with the task of identifying patients at lower, moderate and higher risk for falls.[24] The test assesses an individual's ability to remain stable for 10 seconds with eyes open on a firm surface in 4 test conditions, which requires a progressive demand on neuromuscular control; Side-by-Side Stand, Semi-Tandem, Tandem and/or Single-Leg Balance (See Figure 1). The clinician records the time in seconds achieved before failure when conducting traditional test procedures. However, this testing procedure does not not capture objective metrics to quantify the quality of balance performance.

FIGURE 1

Rehabilitation Artificial Physical Intelligence Database (RAPID) Computerized Portable Foot Pressure Mat System

Computerized posturography involves balance testing with the assistance of technology. In January 2021, Mayo Clinic-Arizona CR integrated the Rehabilitation Artificial Physical Intelligence Database (RAPID) Computerized Portable Foot Pressure Mat System into clinical practice.

A RAPID foot pressure mat is connected to an exam room computer via a USB cable, which ensures patient privacy (See Figure 2). Balance testing conducted while standing on the mat gives the clinician objective performance metrics about the quality of performance (See Figures 3-4).

FIGURE 2

FIGURES 3 & 4

RAPID's secure cloud-based software program that interprets the pressures on the mat to display graphical feedback on an exam room computer screen. Results are securely stored in the RAPID Technology portal for viewing by the clinician
(See Figures 5-6).

The RAPID software decodes peak foot pressure, weight distribution and Center of Pressure (CoP) associated with and lower extremity limitations and instability. RAPID's CoP Sway Index is an objective quantification of postural sway and indicates the standard deviation of the patient's average position from the center. A higher Sway Index indicates a limited ability to remain steady during testing. RAPID also measures ground reaction force, body alignment, loading patterns and force-time relationships to better understand neuromuscular imbalances, performance deficits and instabilities.

FIGURES 5 & 6

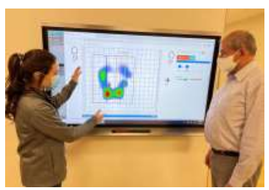

FIGURE 7

The software uses RAPID's artificial intelligence to recommend evidence-based therapeutic exercises based on test results. The clinician can use this feedback to customize an individualized home exercise plan. The patient views video demonstrations and practices these exercises onsite with clinician supervision (See Figure 7). The mat also has the versatility to be used for biofeedback training. Repeated measures balance testing provides both the clinician and patient feedback about progress.

FUTURE DIRECTIONS

Currently, Mayo Clinic Enterprise balance testing procedures continue as normal, with the added benefit of the RAPID System, and the option to conduct specialized testing such as the mCTSIB and the 4-SBT.

A future application of the RAPID System includes the option to assign patients video demonstrations of prescribed therapeutic exercises via an institution approved Connected Health platform. Patients could then access the videos on a mobile device at home.

The Mayo Clinic Enterprise CR Research Group are exploring the possibility of conducting a large-scale research investigation to evaluate the application of balance testing the RAPID System, which would provide objective performance metrics in a diverse CR early outpatient population. Normative data would improve fall risk stratification and help guide strategic rehabilitation efforts to enhance physical function.

CONCLUSION

The CR staff have found these applications of technology to be user friendly and the objective metrics generated have the potential to improve the patient experience.

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