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Neurologic Disorders

Assessment and Treatment of Balance

A PRACTICAL GUIDE FOR POSTUROGRAPHIC ANALYSIS WITHIN NEUROLOGICAL DISORDERS CONTEXT. HOW TO USE PHYSIOSENSING TO ASSESS AND TREAT BALANCE DYSFUNCTION.

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Meet Ana, a physiotherapist with a master's degree in human physiology, currently specializing in neurobiology.

Ana currently serves as the clinical specialist at PhysioSensing, a cutting-edge Balance Assessment and training device. Leveraging her strong foundation in scientific research and evidence-based practices, Ana creates customized assessment and training plans. Her approach is firmly rooted in the latest scientific findings, ensuring that PhysioSensing users receive the most effective and up-to-date care.

In addition to her role in designing tailored programs, Ana plays a pivotal role in guiding new clients through the learning process of using PhysioSensing. She also provides advanced training and support to existing customers seeking to further deepen their clinical practice knowledge and stay on top of the latest scientific advancements.

If you have some doubts about any information or need some advice about a Balance Sytem, feel free to book a quick meeting with me.

Click here to book with me

Contextualizing

Neurological disorders are one of the major causes of mortality and disability worldwide (GBD 2016 Neurology Collaborators, 2019) and are frequently associated with varying degrees of sensory, motor, coordination and central function problems. Balance control impairment is often present in patients suffering from these disorders, highly impacting daily life. Having an intact balance control is required for maintaining postural stability and for enabling safe mobility related daily activities, that include weight shifting and changing position while performing manual tasks, walking and climbing stairs, among others (Mancini & Horak, 2010). Patients with balance disorders present a higher fall risk leading to limited activity capacity and restrictions in participation in daily life situations, which result in social isolation and physical inactivity and its underlying consequences (Kwakkel et al., 2023; Nonnekes et al., 2018). For this reason, it is vital to recognize and assess neurological disorders of balance and posture in clinical settings.

Balance control system

Balance control is achieved by integration and coordination of different body systems, involving the vestibular and vision system for gaze stabilization, interconnected with the somatosensory system (proprioception) and motor systems for postural stabilization. Information (input) from all the sensory systems is processed and interpreted by the central nervous system so an adequate response (output) is given for the appropriated muscle activation and body movement (Mancini & Horak, 2010). This process of processing and integration of sensory cues of body motion produces an error signal between predicted and actual sensory cues of balance-related movements. Compensatory motor commands are generated by the central nervous system to respond to this error (Forbes et al., 2018). Meaning that our brain is making real-time posture adjustments while we walk on uneven surfaces, perform demanding motion tasks or even to "catch us" when we lose our balance. To do so, our balance system must have the ability to orient the body in relation to the gravitational vertical, using the vestibular system, and to be aware of our body position in space, using the somatosensory system. In order to maintain postural orientation, sensory inputs from the vestibular and somatosensory systems are used as compensatory mechanisms (Forbes et al., 2018). Imagining being in a dark room, naturally there will be diminished visual input, in order to maintain postural stability, the weight on the visual system has to decrease and the weight on the somatosensory and vestibular system have to increase. The same happens when a person is standing on top of a foam surface in a well-lit room, the weight on the somatosensory system decreases, and the weight on the vestibular and vision system have to increase (Horak, 2006; Hupfeld et al., 2022). In a situation where a healthy person is standing on a firm surface in a well-lit room, the percentage of sensory reliance for each system is 70% on the somatosensory inputs, 10% on visual inputs, and 20% on vestibular inputs (Peterka, 2002). When the ability to rapidly re-weight sensory inputs is lost it can lead to postural imbalance and a higher risk of falling (Forbes et al., 2018).

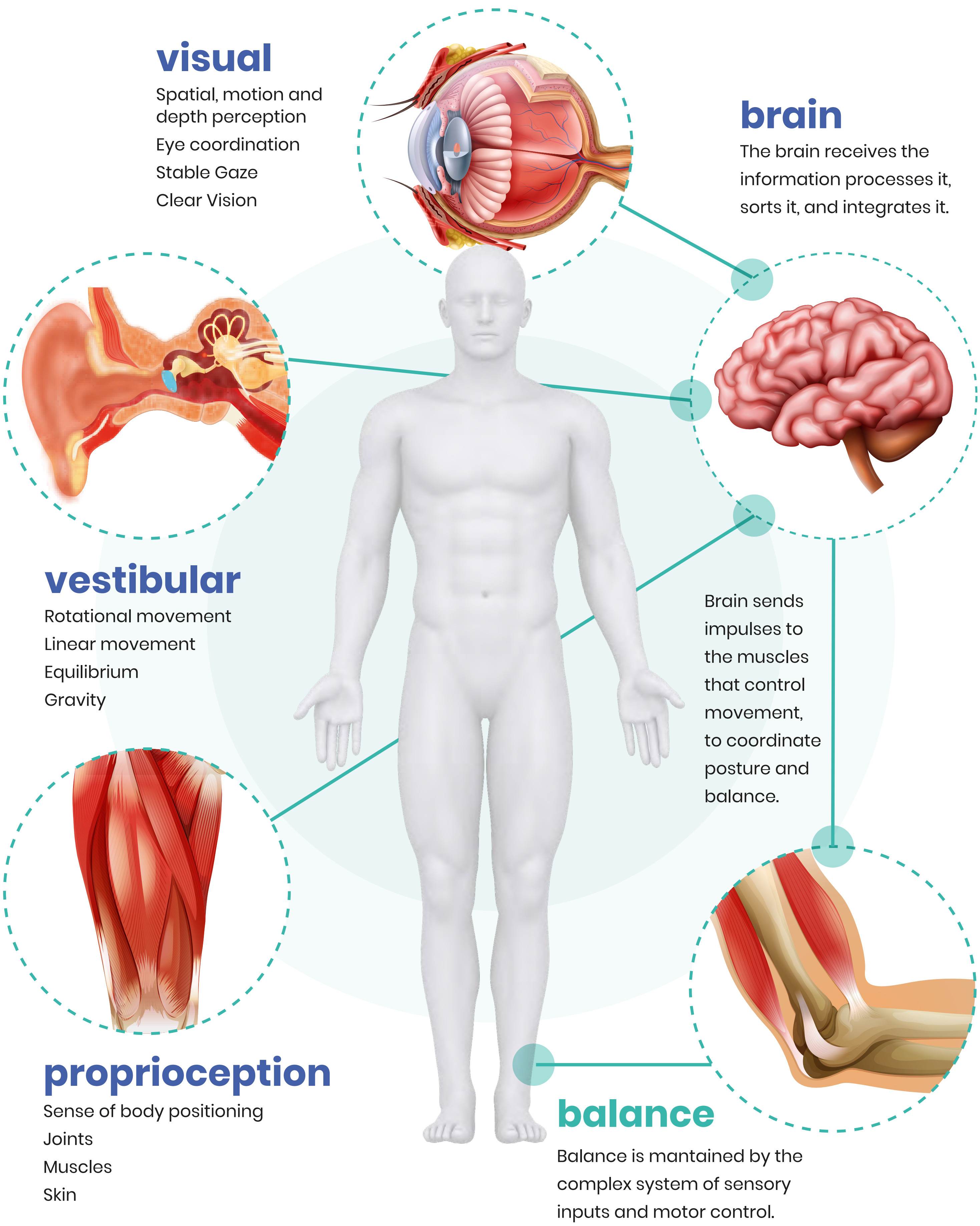

Figure 1: Balance Mechanisms

When balance gets tough

For healthy individuals, balancing is a simple task that requires little effort and energy. The innate difficulties associated with balance are not disclosed until a pathology or injury impairs its control (Forbes et al., 2018).

Within neurological disorders it is possible to observe serious alterations in matters of peripheral and central nervous system, such as somatosensory impairments, that include changes in proprioception resulting from slowed transmission of somatosensory impulses or changes in mechanoreceptors, alterations of integration of sensory inputs, changes in reflexes, muscle strength, neuromuscular function, and muscle tone, among others that have a serious impact on postural control.

COMMON NEUROLOGIC DISORDERS THAT AFFECT BALANCE

- post stroke
- traumatic brain injury
- parkinson's disease
- multiple sclerosis

Figure 2: Neurologic Disorders that affect Balance

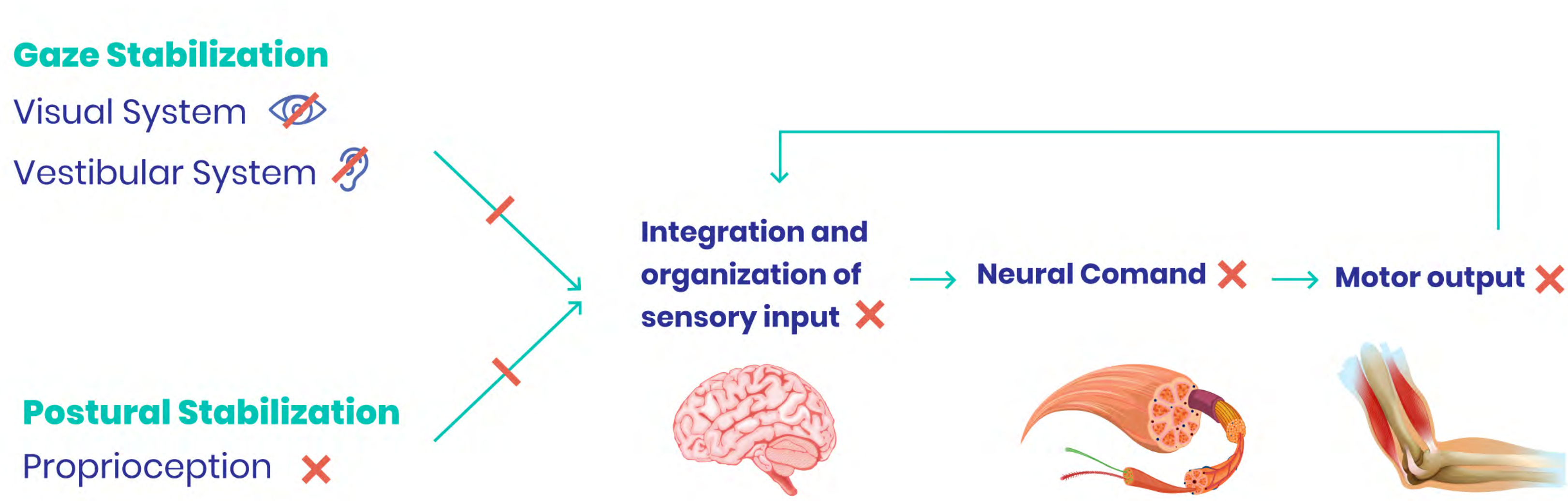

Figure 3: Balance Dysfunction

For instance, post-stroke patients who suffer from impaired balance and postural control, frequently show an increased sway during quiet stance, asymmetrical lower limb weight distribution, an excessive reliance on visual input, and an impairment of anticipatory postural adjustments and postural reactions after external perturbations , these alterations are believed to be resultant from muscle weakness, proprioception deficits, alteration in muscle tone and in reflexes, as from deficits in motor control (Bonan et al., 2004; De Nunzio et al., 2014; Hugues et al., 2017, 2017; Mansfield et al., 2013; Schröder et al., 2022).
Balance dysfunction is also very common in Parkinson's Disease, being highly disabling and resulting in an increased predisposition for falling. The loss of postural reflexes, impaired cognition, changes in visual stimuli perception and a narrowing of the base of support can lead to an increase in fall risk. Additionally, alterations in muscle tone and proprioception disrupt sense of position, which results in displacement of the body center of mass over the base of support, contributing to a higher velocity and frequency of body sway (Chen et al., 2018; Ferrazzoli et al., 2015; Mancini et al., 2012; Opara et al., 2017).

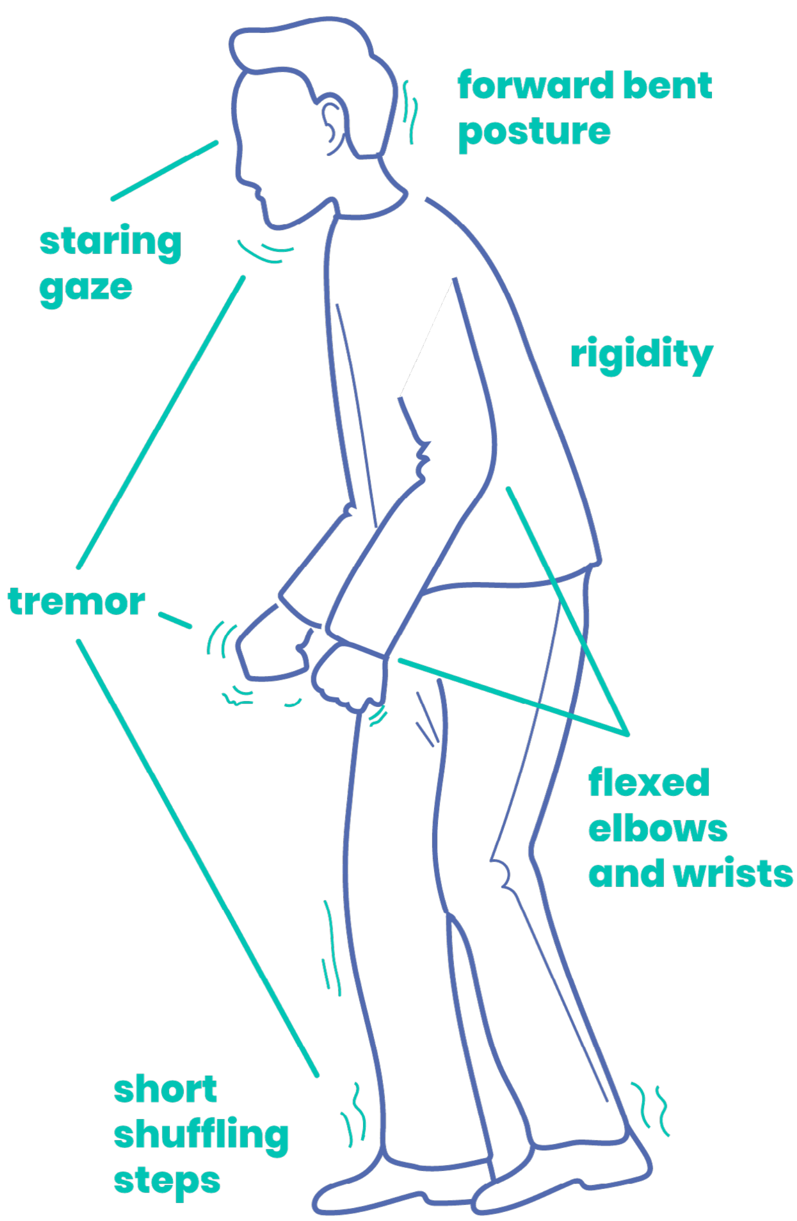

Figure 4: Parkinson's Disease Symptons

Traumatic brain injuries, which are acquired acute neurological disorders can also lead to balance dysfunction. It is believed that the areas of the brain disrupted from this type of injury are responsible for maintaining postural control, leading to difficulties in integration and organization of sensory information, involving the use of visual, proprioceptive and vestibular (Guskiewicz et al., 2001; Valovich McLeod & Hale, 2015). Furthermore, areas responsible for voluntary control of movements involved in dynamic balance tasks, such as the motor cortex and its projections, could also be compromised, resulting in a reduced cone of stability. Expectably, activities involving leaning, bending over or reaching can become more challenging, leading to a increased fall risk and some limitations in daily life activities (Row et al., 2019).

Figure 5: Parkinson's Disease Postural Imbalance

In multiple sclerosis, up to two thirds of patients show incapacitating balance problems. Multiple sclerosis is a disease of the central nervous system, it affects the brain, brainstem, spinal cord, and optic nerves. The main symptoms include weakness, spasticity, fatigue, changes in sensation including slowed transmission of somatic sensory inputs, alterations in coordination, vision, and cognition. Expectably, postural imbalance, gait dysfunction and a higher risk of falling are present in people suffering from this disease (Cameron & Nilsagard, 2018; Inojosa et al., 2020).

Interestingly, many patients are not fully aware of changes in balance and posture, which is frequently one of the earliest signs of a neurological disorder (Nonnekes et al., 2018). This emphasizes the importance of a rigorous and objective balance and posture assessment as part of clinical examination.

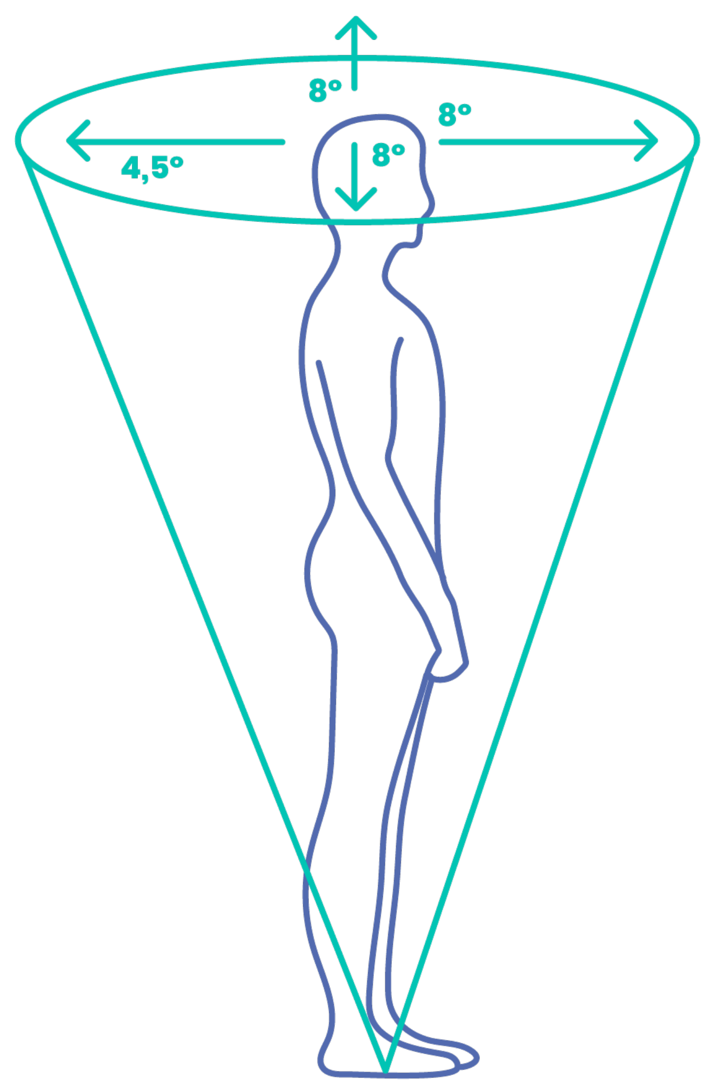

Figure 6: Stability Cone, Limits of stability

Balance Assessment Posturography

The aim of clinical balance and posture assessment is to, firstly, identify if there is in fact a balance problem, and finally to determine and differentiate the underlying cause, so the intervention is as effective as it can be. This means that balance and posture assessment should provide objective and quantitative measurements so it can be translated into simple, nonetheless vital, information for diagnosis and treatment planning (Mancini & Horak, 2010; Visser et al., 2008).
Posturography is seen as the gold standard for postural control assessment, capable of showing sensory and motor contributions for postural and balance control, deviations from center of gravity and changes in limits of stability. During an upright body position, it is possible to quantify the small corrections that are performed to oppose the destabilizing effect of gravity. This stabilization of the body is visible in the center of pressure (COP) trajectory, being the COP displacement the most common posturographic measurement in balance assessment. With instrumented solutions like force or pressure plates we can obtain sway displacement during a period of time in mediolateral and anteroposterior directions (Duarte & Freitas, 2010).

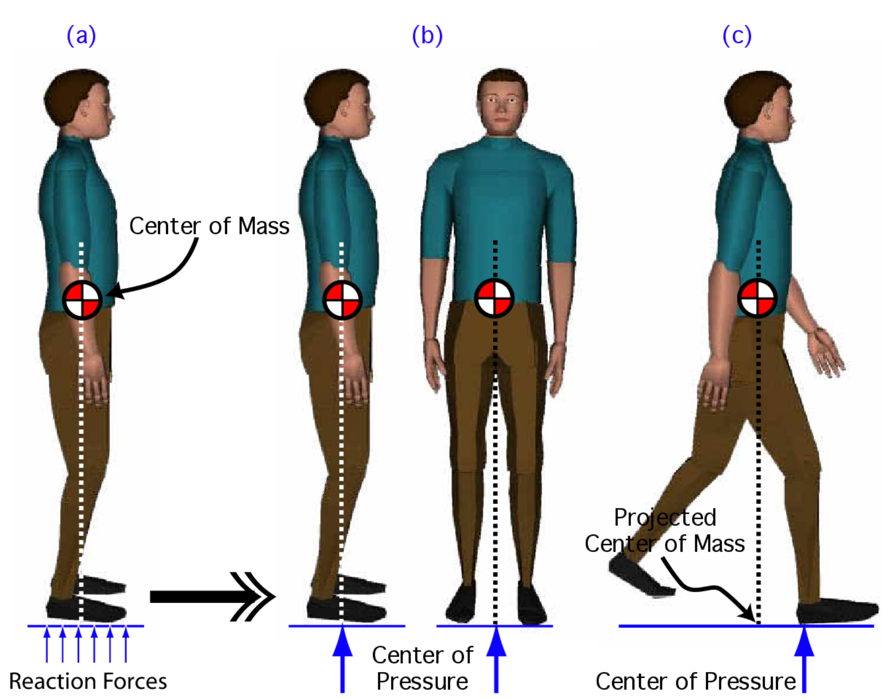

Figure 7: Center of Pressure illustration from (ref) Bryce Parkinson, M. (2004). BALANCE MAINTENANCE IN NORMAL SEATED REACH. University of Michigan.

Figure 8: PhysioSensing Pressure Plate

For instances, a study from Inojosa et al. in 2020 showed that balance alterations in multiple sclerosis patients could be detected with static posturography before being perceivable by the physician, both the ellipse area and the average sway speed could sense differences between healthy subjects and multiple sclerosis patients with normal cerebellar function and Romberg Test (Inojosa et al., 2020).

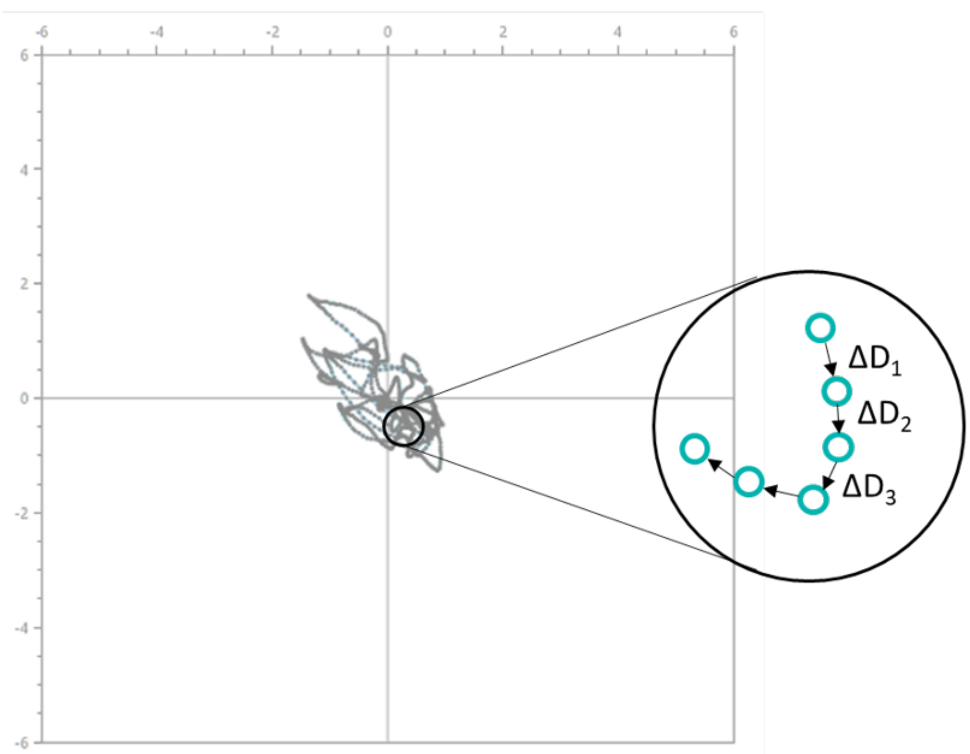

Figure 9: Statokinesiogram - Illustration of COP data in detail (in the middle), in which each COP displacement (D1, D2, D3) can be observed. COP Length is the sum of all those displacements

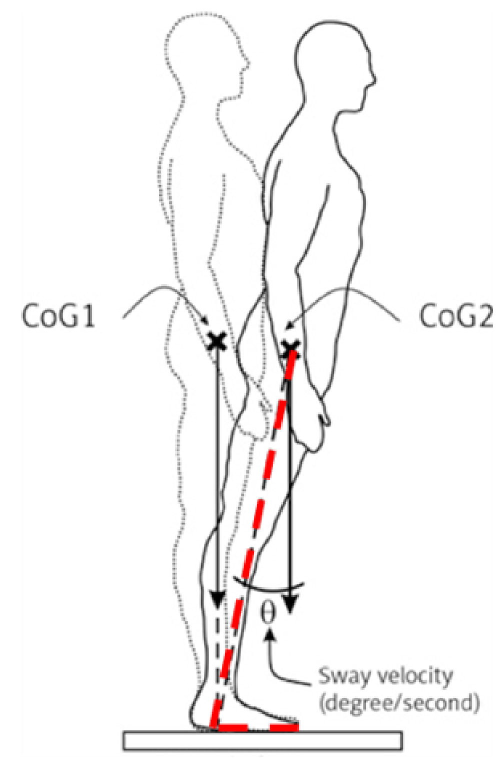

Figure 10: Sway velocity - Distance travelled by COP divided by test time (mm/s or °/s)

Ferrazzoli et al. came to a similar conclusion, where balance dysfunction in Parkinson's Disease patients could be detected before patients complain using posturography platforms (Ferrazzoli et al., 2015). In stroke patients, studies have shown greater ellipse area and a higher tendency to sway, specifically in the mediolateral plane (Hugues et al., 2017; Lee et al., 1997).

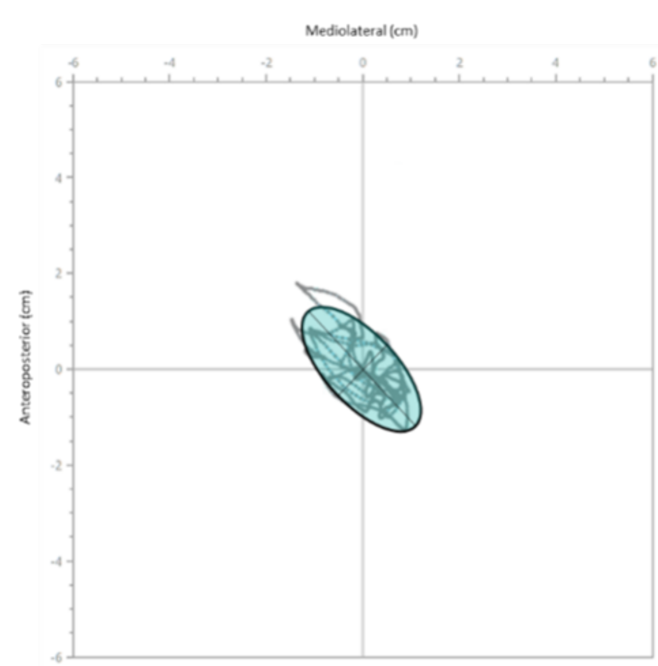

Figure 11: COP Ellipse Area: Area of the prediction ellipse with 95% of the COP values (mm^2). It can be calculated with the principal component analysis method.

Furthermore, De Nunzio et al. concluded that the COP index of asymmetry (a COP resulting parameter of COP displacement in the mediolateral plane) is a valid measure of paretic limb loading during stroke recovery (De Nunzio et al., 2014). Whereas in Parkinson´s Disease patients, posturography analysis shows smaller limits of stability and higher mediolateral sway, partially explained by the proprioceptive dysfunction and reducing perception of trunk and surface orientation (Ferrazzoli et al., 2015). Another interesting study was conducted by Silsby et al. showed that objective assessment of balance using posturography may work as a biomarker of Intravenous Immunoglobulin efficacy in patients with Chronic Inflammatory Demyelinating Polyradiculoneuropathy (Silsby et al., 2022).

Here we present just a small number of studies that use posturography for balance assessment, within neurologic dysfunction context. For instance, Parkinson's Disease is a very complex disease, with multiple systems being affected, posturography has been investigated in order to better understand it's role on the objective evaluation of deficits in balance and postural control as on the development of rehabilitation programs (Ferrazzoli et al., 2015; Terra et al., 2020).

Balance Assessment with Physiosensing

PhysioSensing has 14 assessment protocols that measure balance through COP displacement. Below, you can see our evidence-based recommendation of which PhysioSensing assessment protocols are adequate for each balance dimension within the neurologic disorder's context.

BALANCE DIMENSION	PHYSIOSENSING ASSESSMENT
Sensory Reception And Organization	mCTSIB, Romberg Test, Total Balance Pro
Proprioception	Limits Of Stability, Romberg Test, mCTSIB, Total Balance Pro
Motor Control	Limits Of Stability, Rhythmic Weight Shift, Total Balance Pro, Sit To Stand
Muscle Strength	Weight Bearing Squat, Sit To Stand, Limits Of Stability, Toral Balance Pro
Reflexes And Reaction Time	Limits Of Stability, Rhythmic Weight Shift, Sit To Stand, Total Balance Pro
Postural Control	Body Sway
Weight Distribution	Sit To Stand, Weight Bearing Squat
Function	Sit To Stand

Figure 12: Balance Assessment with PhysioSensing Protocols

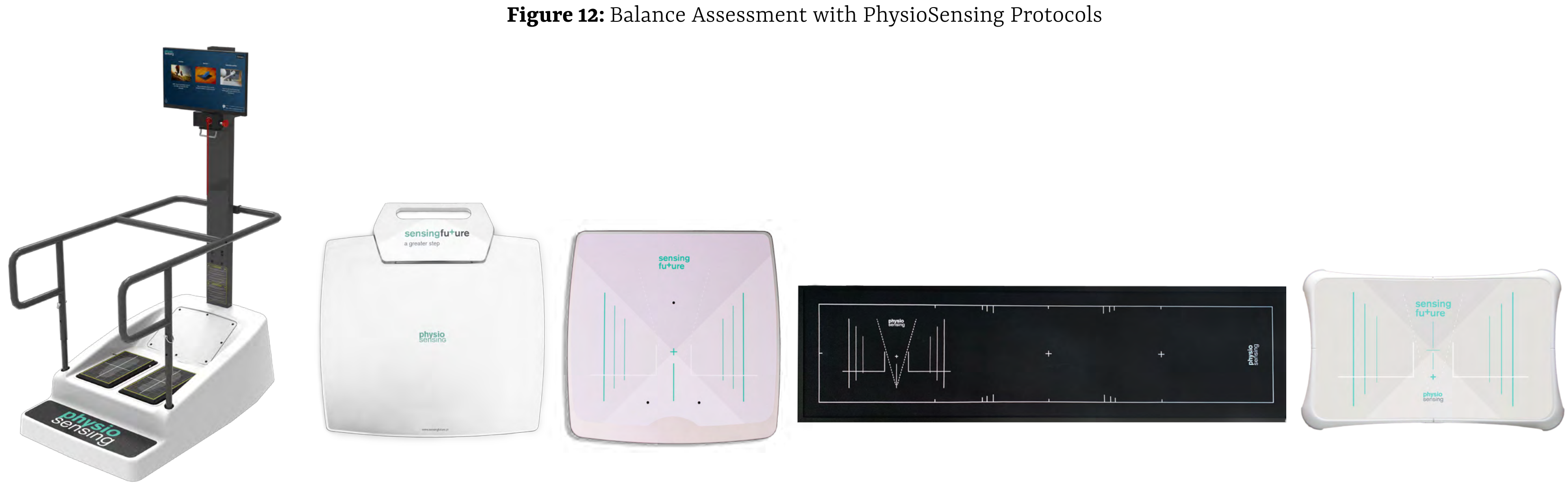

Figure 13: PhysioSensing Balance Plates

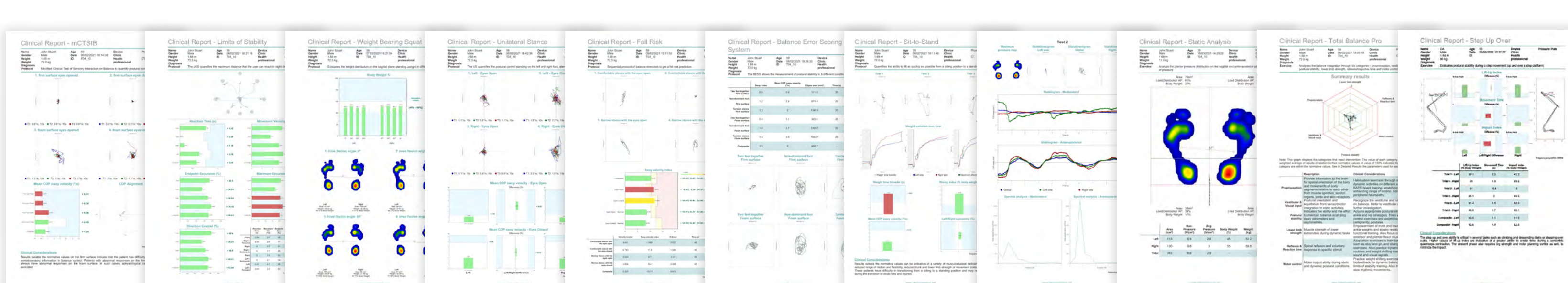

Figure 14: PhysioSensing Assessment Protocols

How to improve with PhysioSensing?

After selecting the adequate assessment protocol for your patient, you can collect a substantial amount of objective data that will inform you about your patient balance status.
Let us create a scenario where you want to assess motor control, proprioception and have a functional assessment to complement. We are going to choose the following protocols: Romberg test, Limits of Stability and Sit to Stand.

Results from Limits of Stability Protocol

Figure 15: Limits of Stability Protocol - COP displacement in eight directions

Limits of Stability Protocol can give us a lot of information about motor control, muscle strength and proprioception. What can we see in the results from our neurologic patient?

• **Reaction time:** The results show a high reaction time, being the composite value (average of 8 directions) higher than the normative value. This can mean an apprehension/fear of losing balance, needing more time to prepare for the movement, or a dysfunction at cortical level causing a prolonged reaction time (Paraskevopoulou et al., 2021). Additionally, muscle weaknesses and rigidity could also partially explain it. These alterations are common in Parkinson's Disease (Opara et al., 2017).

• **Movement Velocity:** The results show a reduced movement velocity, being below the normative values. We can think about different causes for this. One that might be relevant is a reduction in proprioception, meaning that the patient needs more time to sense alterations in body position and to adjust to it in matters of muscle activation (neuromuscular activity), this may be caused by alterations in the mechanoreceptors at the soles of the feet, slowed transmission of somatosensory impulses or changes in integration of sensory input (Melzer et al., 2008). Some of these alterations are common in polyneuropathy.

• **Endpoint Excursion and Maximum Excursion:** The results show values below the normative data for the two parameters, except for movement in back direction. Two possible reasons for these might be lack of muscle strength on the plantar flexors, they need to support the leaning of the body to the front, and lack of ankle mobility or rigidity (Melzer et al., 2008). Another interesting finding in these results is the asymmetry between right and left direction. We will analyze this finding in association with the results from the Sit to Stand protocol.

• **Direction Control:** The results show a decreased direction control, demonstrated by the composite (average) value. This means that an insufficient portion of the COP displacement happened in the wanted direction. The lack of direction control might signify problems in motor control, this can be due to alterations in afferent inputs, like proprioception, alterations in integration and organization of these inputs, and in the right muscle activation (neuromuscular control). Another explanation for lack of direction control could be the presence of alterations in extra-pyramidal paths, we would need to clarify the cause, if it really is a sensory dysfunction or a cerebellum dysfunction. To do that we need to do the Romberg Test, if the increased body sway does not differ much between eyes open condition and eyes closed condition it might be related to cerebellum dysfunction (D'Angelo, 2018; Inojosa et al., 2020). In common with Endpoint Excursion and Maximum Excursion parameters, we can see an asymmetry between right-left movement and back-front movement in matters of direction control.

	Reaction Time (s)	Movement Vel. (°/s)	Endpoint Exc. (%)	Maximum Exc. (%)	Dir. Control (%)
Front	0.07	2.7	45	57	16
Right / Forward	1.38	0.9	17	26	32
Right	2.44	1.2	27	29	66
Right / Backwards	0.31	0.6	10	31	35
Back	1.19	0.8	33	34	34
Left / Backwards	1.72	0.5	20	48	42
Left	2.27	1.5	48	48	75
Left / Forward	1.17	1.2	47	48	82

Figure 16: Limits of Stability Protocol resulting Parameters - Table

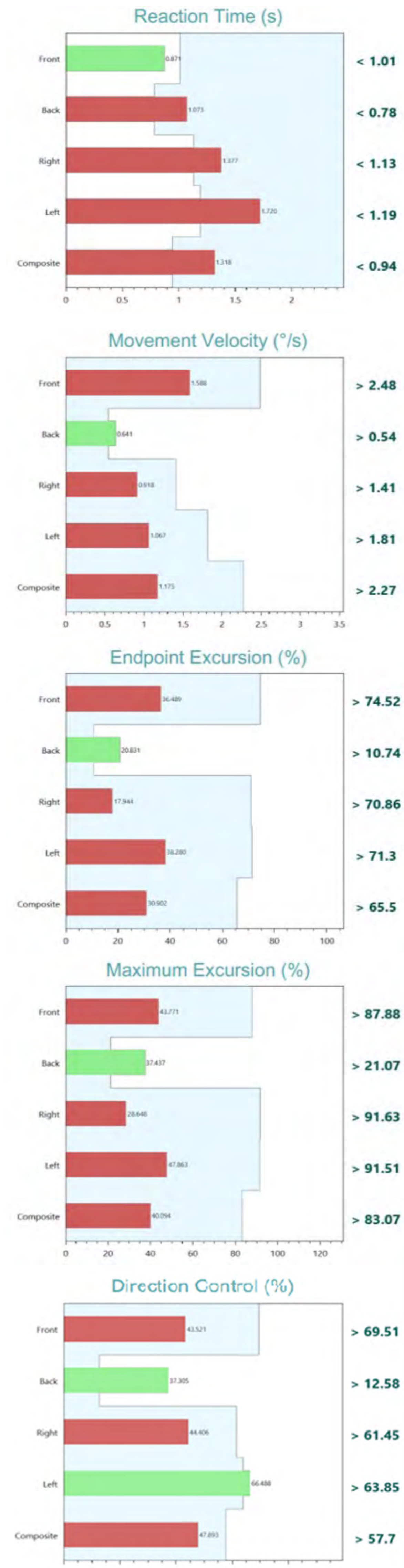

Figure 17: Limits of Stability Protocol resulting Parameters - Charts

Results from the Sit to Stand Protocol

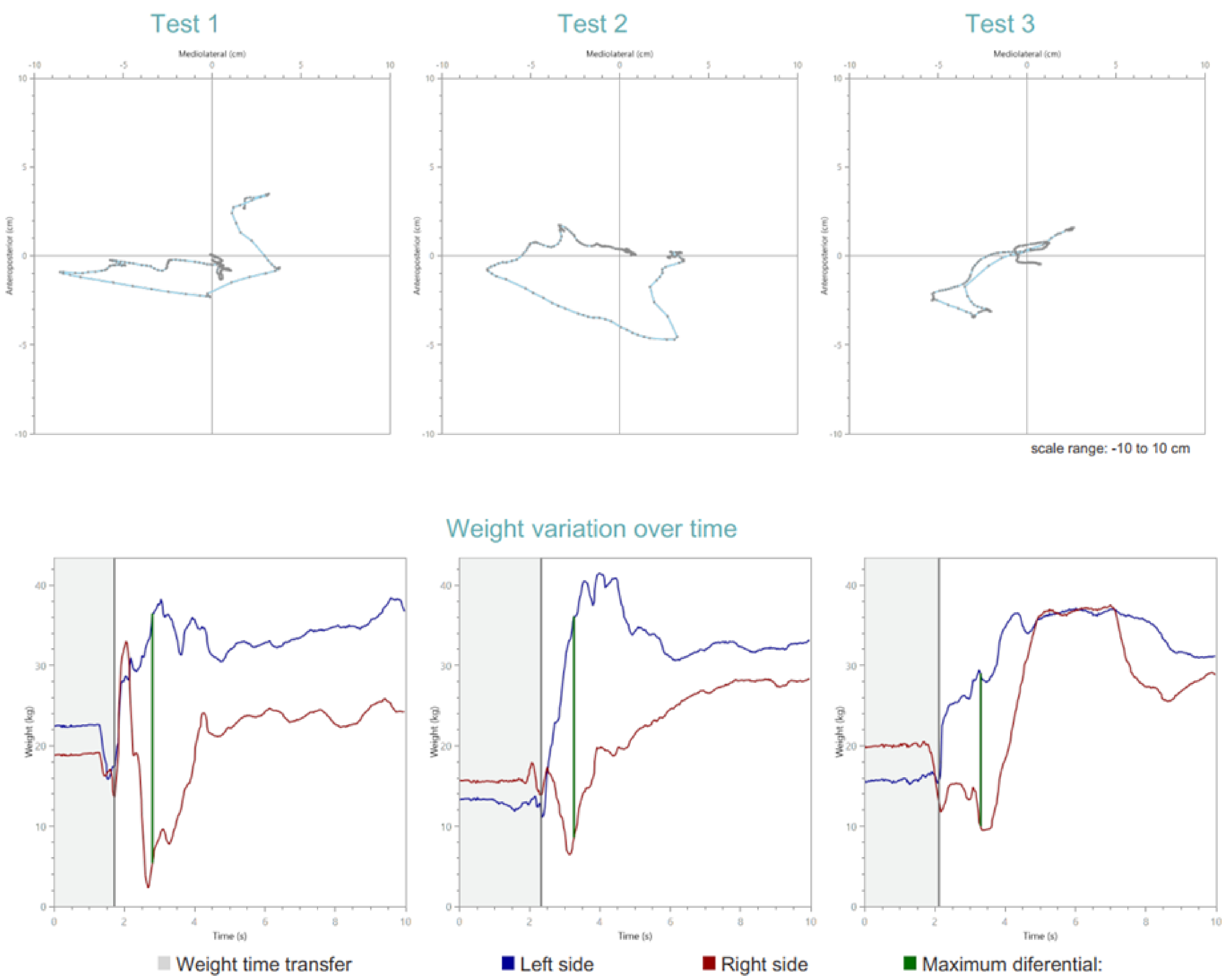

Figure 18: Sit to Stand Resulting Parameters - COP displacement and Weight variation over time.

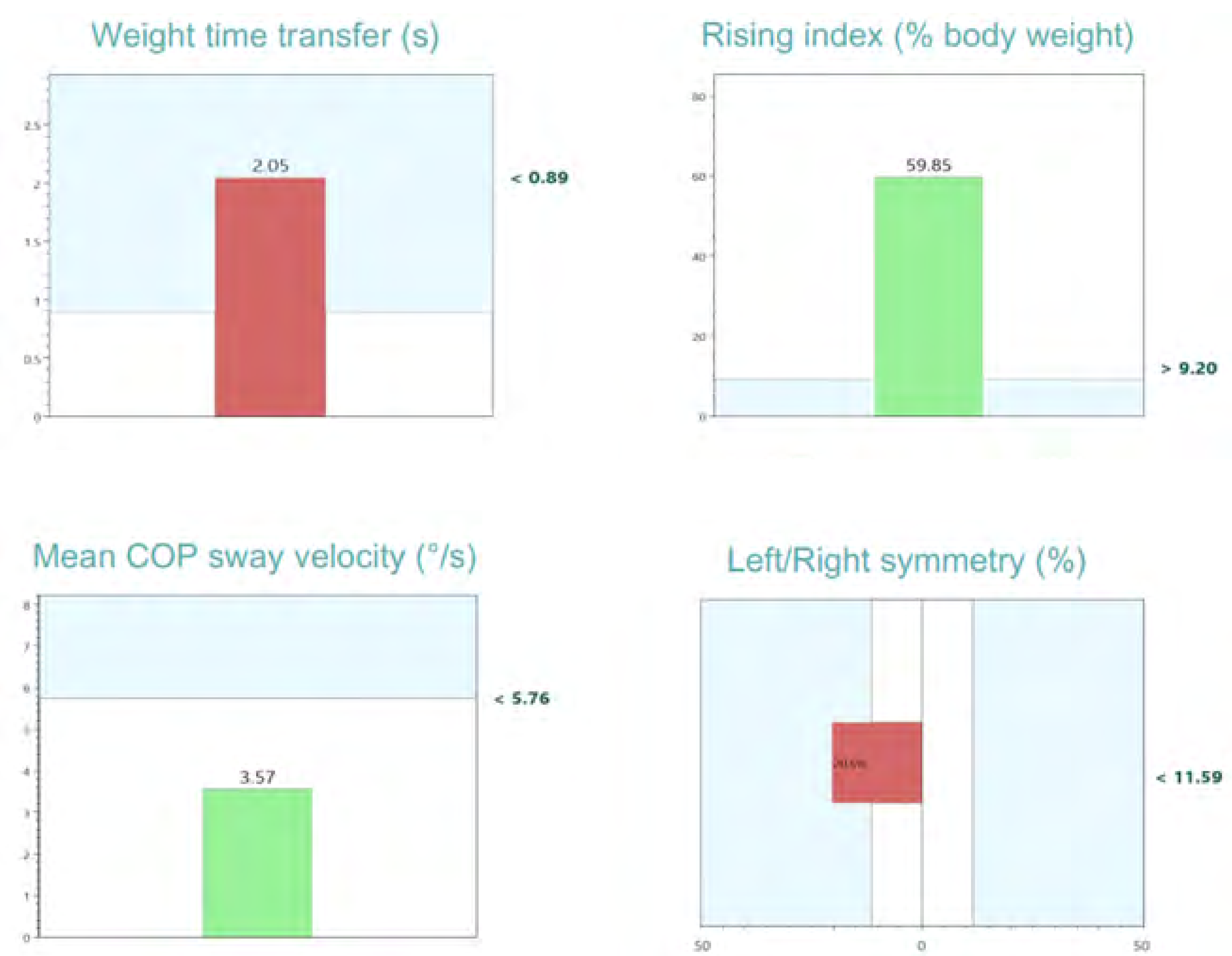

Figure 19: Sit to Stand Resulting Parameters (Weight time transfer, Rising index, Mean COP sway velocity, Left/Right symmetry) - Chart

While analyzing the results from the Sit to Stand Protocol we can see an asymmetry in COP displacement in the statokinesiograms, there is a tendency for mediolateral sway towards the left side, which is in accordance with the asymmetry seen during LOS assessment, additionally, the results also show a marked asymmetry between left and right weight distribution, this patient is clearly supporting more weight on the left leg. These are common findings in stroke and Parkinson´s patients, explained by lack of muscle strength and/or by a somatosensory deficit (De Nunzio et al., 2014; Frykberg & Häger, 2015). Moreover, an increase in weight time transfer has also been demonstrated in studies comparing stroke patients with healthy control subjects (Chou et al., 2003).

Results from the Romberg test Protocol

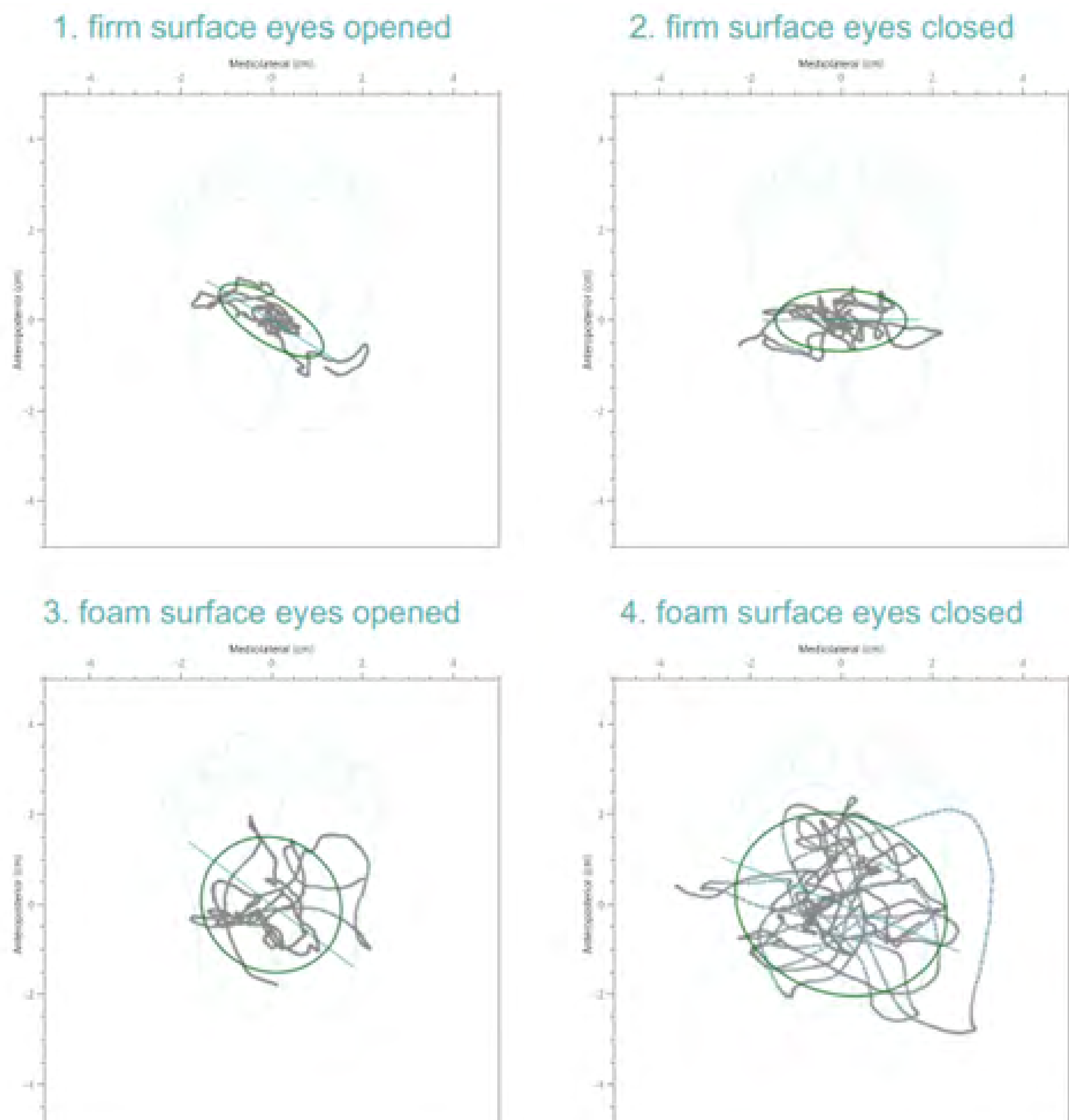

Figure 20: Statokinesiograms from each test condition

The Romberg test is commonly used for assessing balance, specifically the assessment of the dorsal column of the spinal cord that conducts proprioceptive sensory information. The test is positive if the patient loses balance with their eyes closed, this means increased body sway, placing one foot in the direction of the sway or falling. The foam surface will decrease the proprioceptive input, making the task more challenging. In the last condition, foam surface with eyes closed, the patient is relying mainly on the vestibular system input, so we can roughly assess the vestibular function (Inojosa et al., 2020). However, it is not a reliable indicator of vestibular function as we do need two systems input to maintain balance. There are specific tests for vestibular assessment on our Virtual Reality Software.

Looking into Romberg test results we can see an increase in COP displacement, in ellipse area, as well as in sway velocity during eyes closed condition. In addition, the Romberg Quotient also indicates a possible somatosensory deficit. The Romberg Quotient is calculated as the Ratio between closed and open eyes values.

	COP displacement (mm)	Elipse area (mm)	Elipse rotation angle (º)	Mean velocity (mm/s)	Standard deviation of velocity (mm/s)	Standard deviation of COPml (mm)	Standard deviation of COPap (mm)	Time (s)
Firm-Eyes Open	307.41	206.34	-31.83	10.25	8.7	5.88	4.16	30
Firm-Eyes Closed	388.16	305.19	0.21	12.94	11.42	7.33	3.45	30
Foam-Eyes Open	488.63	726.37	-37.56	16.29	13.91	7.84	7.69	30
Foam-Eyes Closed	1296.5	1468.8	-21.83	43.23	35.15	11.84	10.37	30
Composite	620.18	676.67	-22.75	20.68	17.3	8.22	6.42	-

Figure 21: Romberg Test Protocol Resulting Posturography Parameters and Romberg's Quotient Analysis- Table

In summary, these were the main findings of the 3 protocols used for the assessment of our neurological patient:

Romberg's Quotient Analysis

	Lenght RQ	Area RQ	Velocity RQ
Firm surface	1.26	1.48	1.26
Foam surface	2.65	2.02	2.65

Figure 22: Romberg Test Protocol Resulting Posturography Parameters and Romberg's Quotient Analysis- Table

- Probable proprioceptive deficit
- Reduced limits of stability
- Increased body sway in the medial lateral plane
- Asymmetric weight transfer during voluntary movement in the medial lateral plane, in favor of the left side
- Impaired directional control, possible deficit in motor control

Balance Dimension	LOS	Sit to Stand	Romberg Test
Proprioceptive deficit	Movement Velocity Direction Control		COP Displacement Ellipse Area
Reduced limits of stability	Endpoint Excursion Maximum Excursion		
Increased body sway in the medial lateral plane		Statokinesiogram analysis	Ellipse Rotation Angle
Asymmetric weight transfer during voluntary movement in the medial lateral plane, in favor of the left side		Weight variation over time Left/Right Symmetry	
Motor control deficit	Movement Velocity Direction Control Reaction Time		

Rehabilitation Program with PhysioSensing

1. Balance and Stability – Sagittal

Goal: To improve postural control, while trying to distribute body weight equally on both feet to reach a stable (balanced) position.

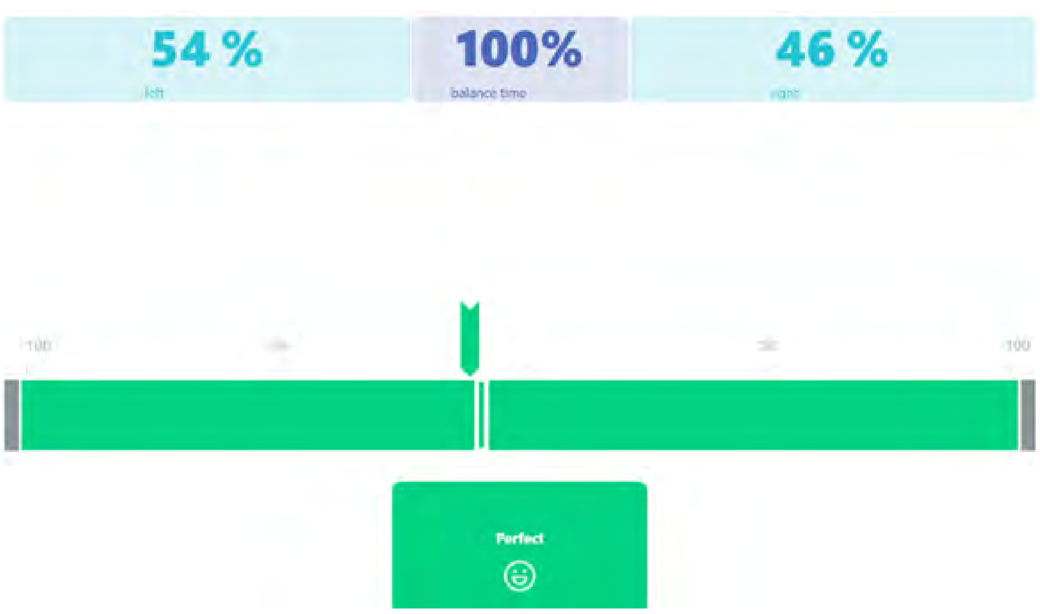

Figure 23: Balance and Stability - Sagittal Exercise Interface

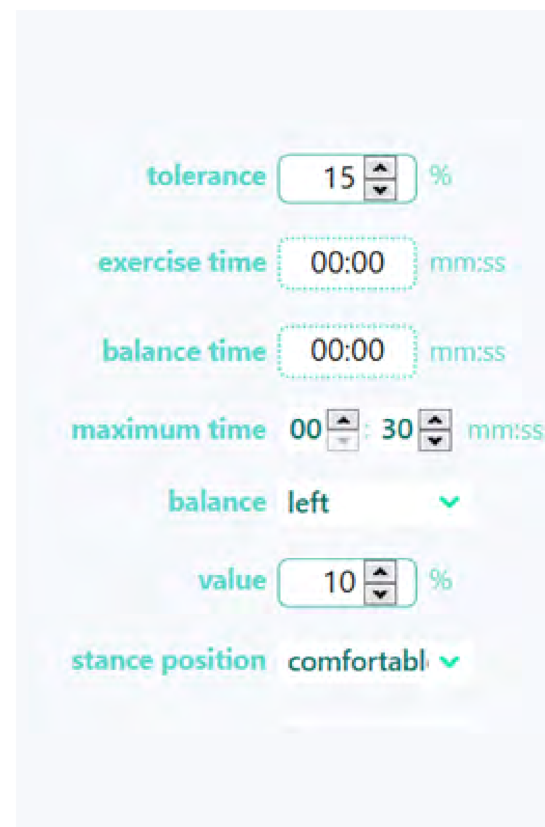

Figure 24: Balance and Stability - Sagittal Exercise Parameters

Definition of exercise's parameters:

- **Tolerance: 15%:** Tolerance is the weight percentage margin allowed so that the indicator remains green. To decrease exercise difficulty level, we can increase the tolerance value;
- **Maximum Time:** 30 seconds – In the beginning of treatment is better to start with a lower exercise time;
- **Balance: Left:** We understood that the patient has an asymmetric posture and movement in the medial lateral plane, showing a tendency towards the left side. In the beginning of treatment, we can adjust the central (balance) position to the left, considering the patient's characteristics. We can progressively return to the "real" reference central position during the following sessions. This is a way we have to adjust the difficulty level to each patient;
- **Value: 10%:** We adjust the central position of reference in 10% to the left;
- **Stance Position:** Comfortable;
- **Unstable surface:** No.

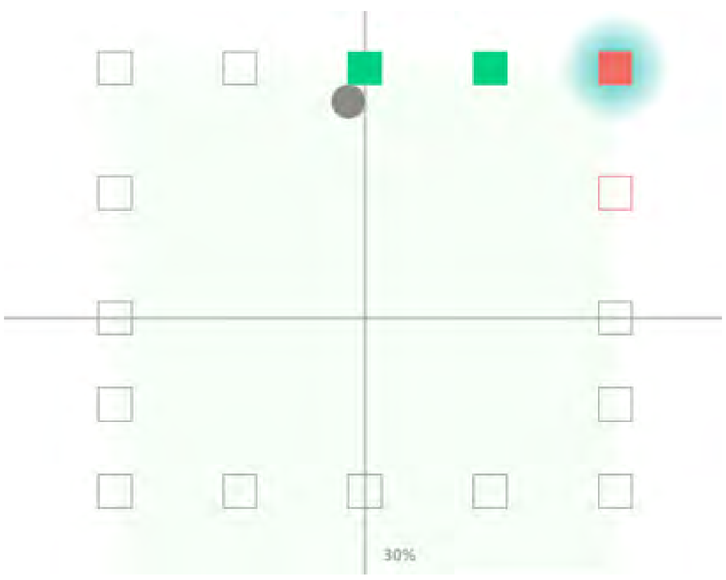

Figure 25: Figure and Paths - Square Exercise Interface

2. Figure and Paths - Square

Goal: Improve postural control during movement and weight transfer while trying to reach all points with the COP.

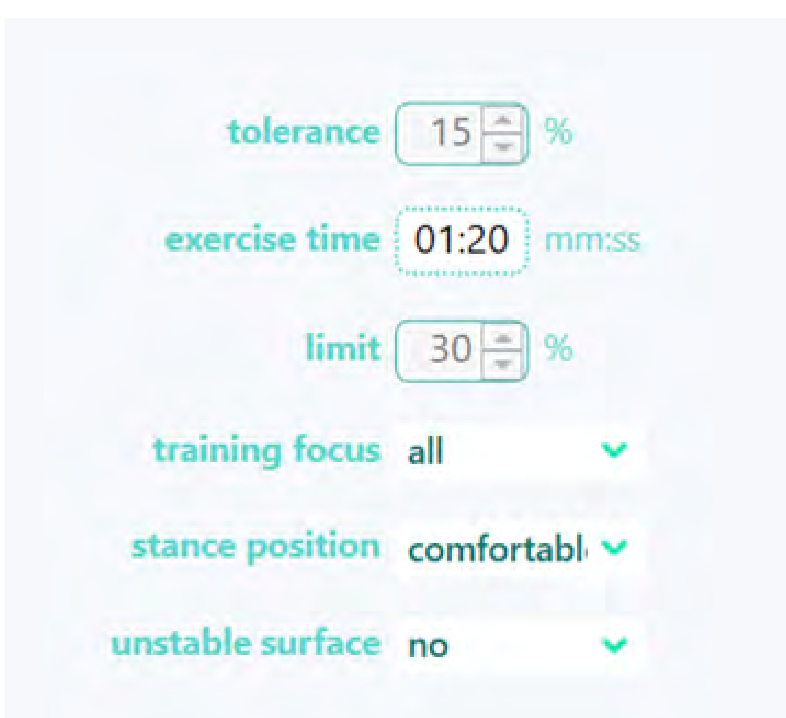

Figure 26: Figure and Paths - Square Exercise Parameters

Definition of exercise's parameters:

- **Tolerance:** 15%: Tolerance is the margin of weight percentage allowed for the patient to reach and validate the dot. To decrease exercise difficulty level, we can increase the tolerance value;
- **Limit:** 30%: Analyzing the results from LOS protocol, we can see the maximum excursion values referent to movement to the right barely reached 30%. Therefore, choosing 30% of the theoretical limit of stability for the exercise is a good starting point;
- **Training Focus:** All;
- **Stance Position:** Comfortable;
- **Unstable surface:** No.

3. Random Points - Follow Me

Goal: To improve dynamic postural control and motor control while moving the COP in different directions to reach aleatory points.

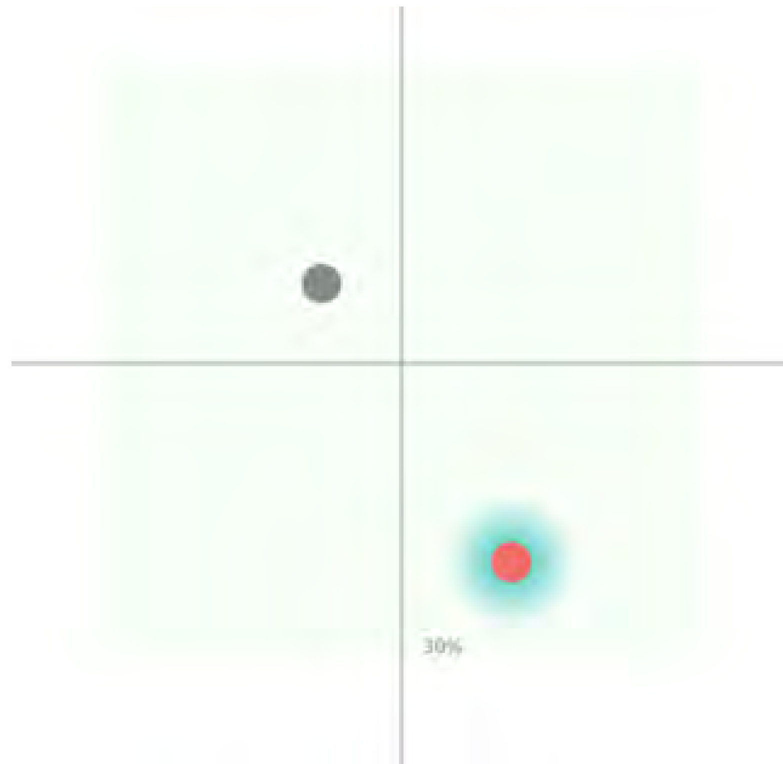

Figure 27: Random Points - Follow me Exercise Interface

Definition of exercise's parameters:

- **Tolerance:** 15% - Tolerance is the margin of weight percentage allowed for the patient to reach and validate the dot. To decrease exercise difficulty level, we can increase the tolerance value;
- **Limit:** 30% - Analyzing the results from LOS protocol, we can see the maximum excursion values referent to movement to the right quadrant barely reached 30%. Therefore, choosing 30% of the theoretical limit of stability for the exercise is a good starting point;
- **Time at the point:** 2 seconds – Try to maintain balance in each point reached for 2 seconds, for increasing difficulty the patient can stay at the point for a longer time;
- **Training focus:** Right - To stimulate weight transfer to the right we can set the training focus so the points will appear more on the right quadrants;
- **Stance Position:** Comfortable;
- **Unstable surface:** No.

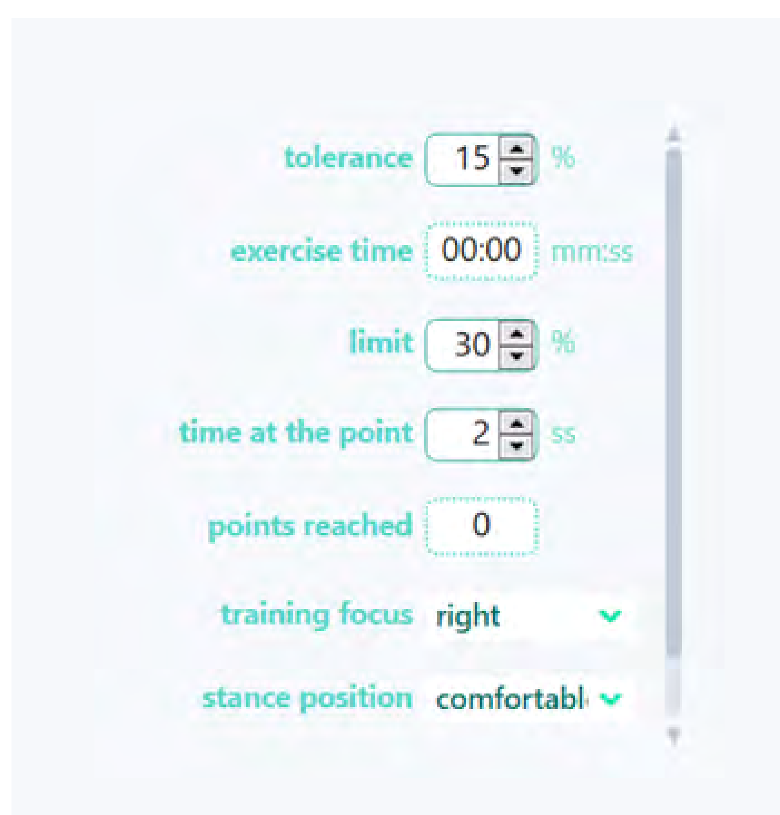

Figure 28: Random Points - Follow me Exercise Parameters

4. Protocols Training - Limits of Stability

Goal: To improve limits of stability (how far can a patient displace their COP in 8 directions, without losing balance), proprioception, motor control, reaction time, muscle strength of the posterior muscle chain and ankle mobility.

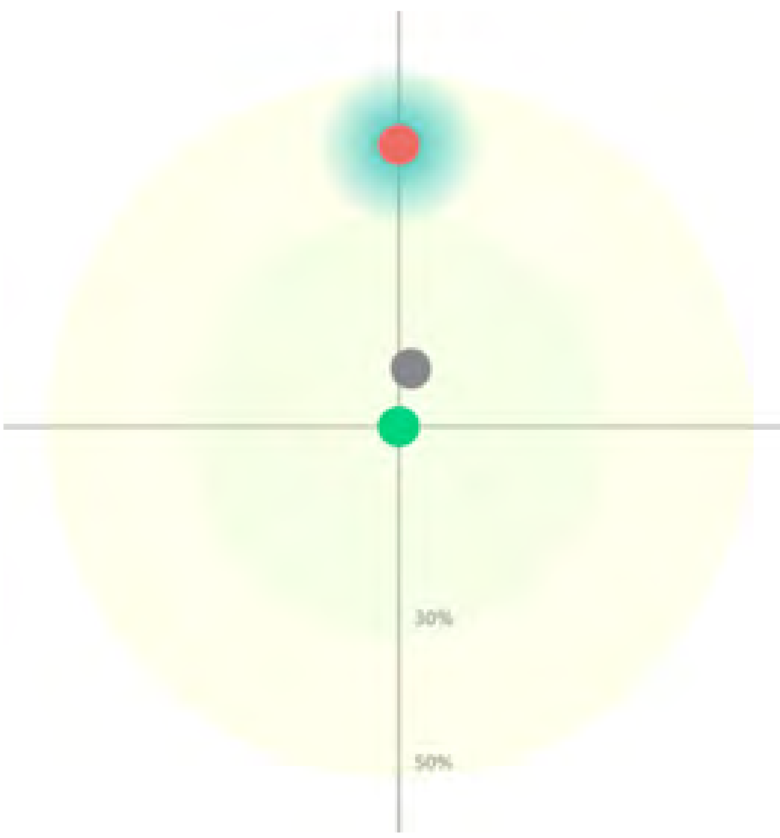

Figure 29: Protocols Training - Limits of Stability Exercise Interface

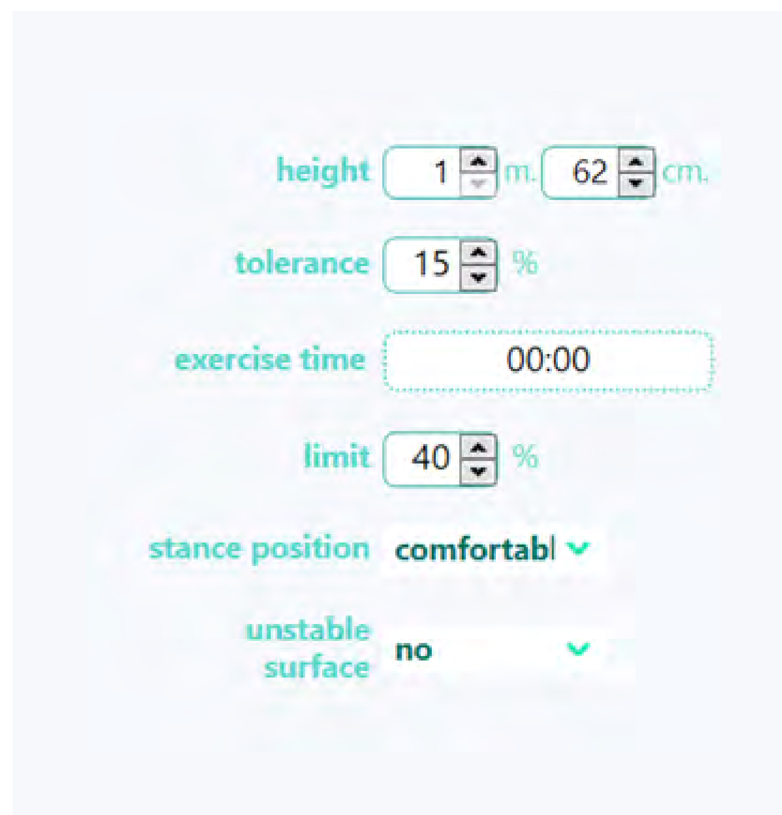

Figure 30: Protocols Training - Limits of Stability Exercise Parameters

Definition of exercise's parameters:

- **Tolerance: 15%:** Tolerance is the margin of weight percentage allowed for the patient to reach and validate the dot. To decrease exercise difficulty level, we can increase the tolerance value;
- **Limit: 40%:** Analyzing the results from LOS protocol, we can see the maximum excursion values referent to movement to the right quadrants barely reached 30%. For training the limits of stability we can choose 40% for every direction, to challenge and motivate the patient to improve;
- **Stance Position:** Comfortable;
- **Unstable surface:** No.

5. Load Charts – Load Distribution in Sagittal Plane while performing Sit to Stand

Goal: To train equal load distribution during sit to stand movement facilitated by the visual bio-feedback.

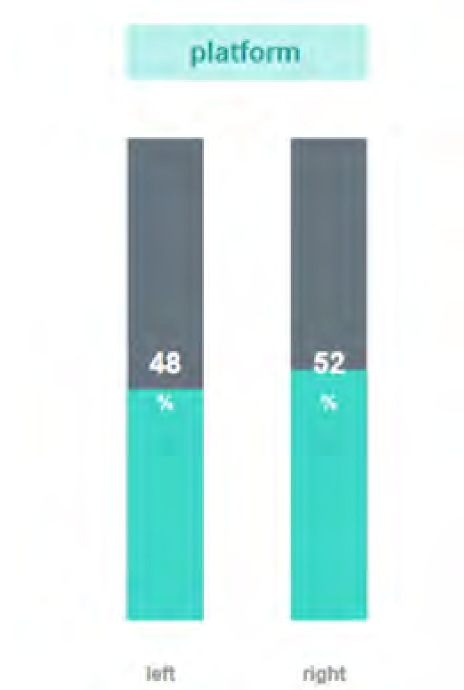

Figure 31: Load Charts - Load Distribution in Sagittal Plane Exercise Interface

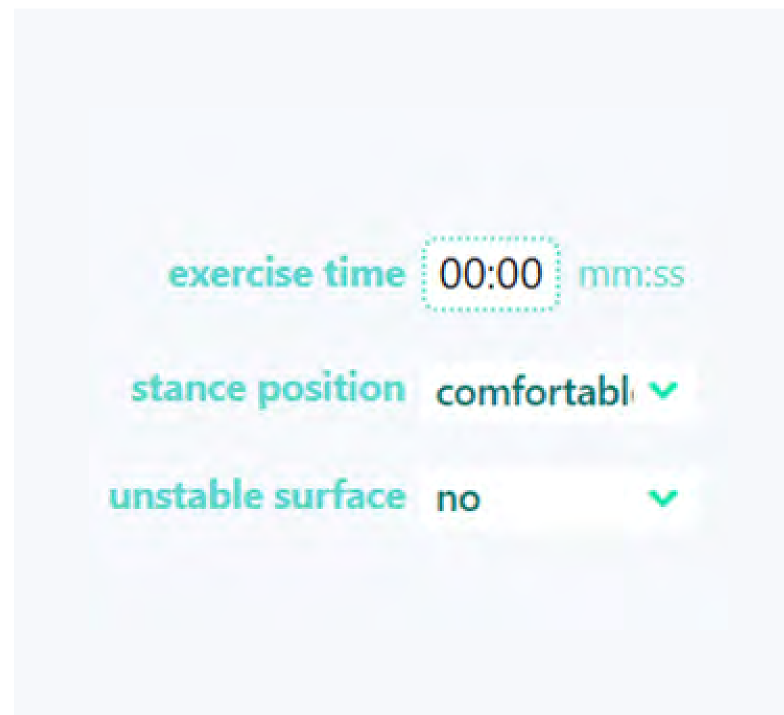

Figure 32: Load Charts - Load Distribution in Sagittal Plane Exercise Parameters

Definition of exercise's parameters:

• Stance Position: Comfortable;

• Unstable surface: No – We can progress to adding a foam to reduce proprioception input and increase difficulty level.

6. Load Distribution - Global while performing heel raises and toe raises

Goal: To improve balance in a more unstable stance, improve muscle strength on the plantar and dorsal flexors and to train equal load distribution in the mediolateral plane.

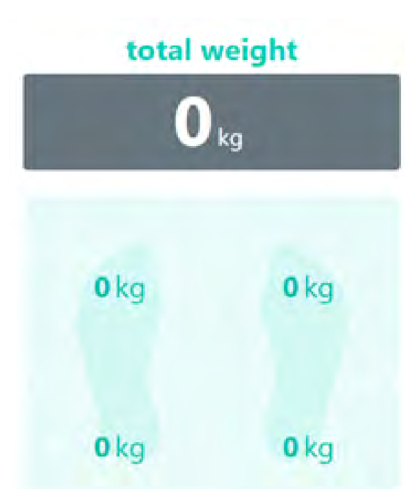

Figure 33: Load Distribution - Global Exercise Interface

7. Balance and stability – Sagittal while squatting

Goal: To train squatting, a functional movement used in daily activities, while trying to symmetrical distribute the weight on both legs.

Definition of exercise's parameters:

- **Tolerance: 15%:** Tolerance is the weight percentage margin allowed so that the indicator remains green. To decrease exercise difficulty level, we can increase the tolerance value;
- **Maximum Time:** 30 seconds – In the beginning of treatment is better to start with a lower exercise time, the goal is to try do the squatting repetitions correctly and not as many as the patient can do in 30 seconds;
- **Balance: Left:** We understood that the patient has an asymmetric posture and movement in the medial lateral plane, showing a tendency towards the left side. In the beginning of treatment, we can adjust the central (balance) position to the left, considering the patient's characteristics. We can progressively return to the "real" reference central position during the following sessions. This is a way we have to adjust the difficulty level to each patient;
- **Value: 10%:** We adjust the central position of reference in 10% to the left;
- **Stance Position:** Comfortable.

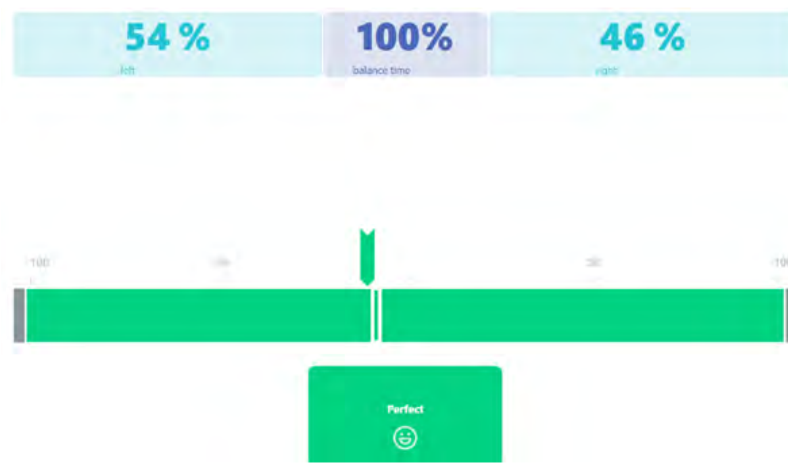

Figure 34: Balance and Stability - Sagittal While Squatting Exercise Interface

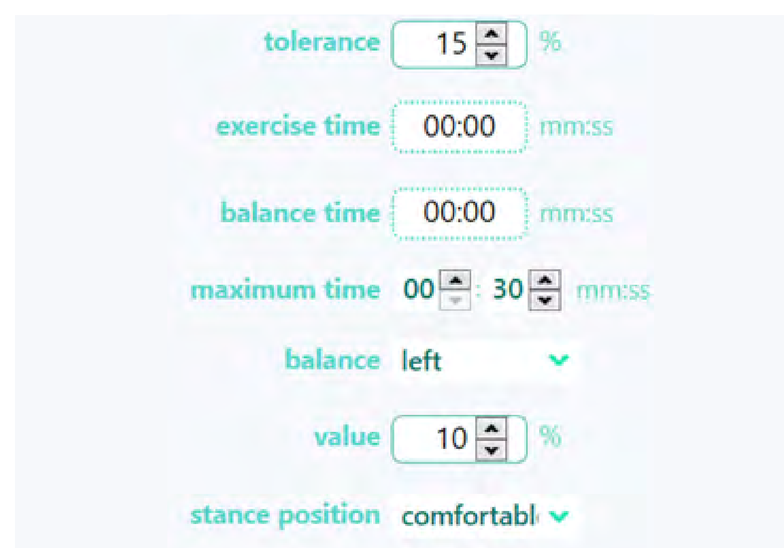

Figure 35: Balance and Stability - Sagittal While Squatting Exercise Parameters

8. Load Transfer – Sagittal while grasping and reaching towards the right side

Goal: To stimulate weight transfer to the right while maintaining balance.

Figure 36: Load Transfer - Sagittal Exercise Interface

Figure 37: Load Transfer - Sagittal Exercise Parameters

Definition of exercise's parameters:

- **Stance Position:** Comfortable;
- **Unstable surface:** No

We can progress to adding a foam to reduce proprioception input and increase difficulty level.

Summary

Every time a patient completes an exercise or an assessment protocol, all data gets stored. For a clinical setting the reports generated are useful for analyzing the results from one session or the progression of several sessions, or even to explain to the patient the goal and meaning of each protocol or exercise results. It is a valuable tool for the clinical assessment of balance disorders, mainly due to the objectivity and reliability of the parameters measured.

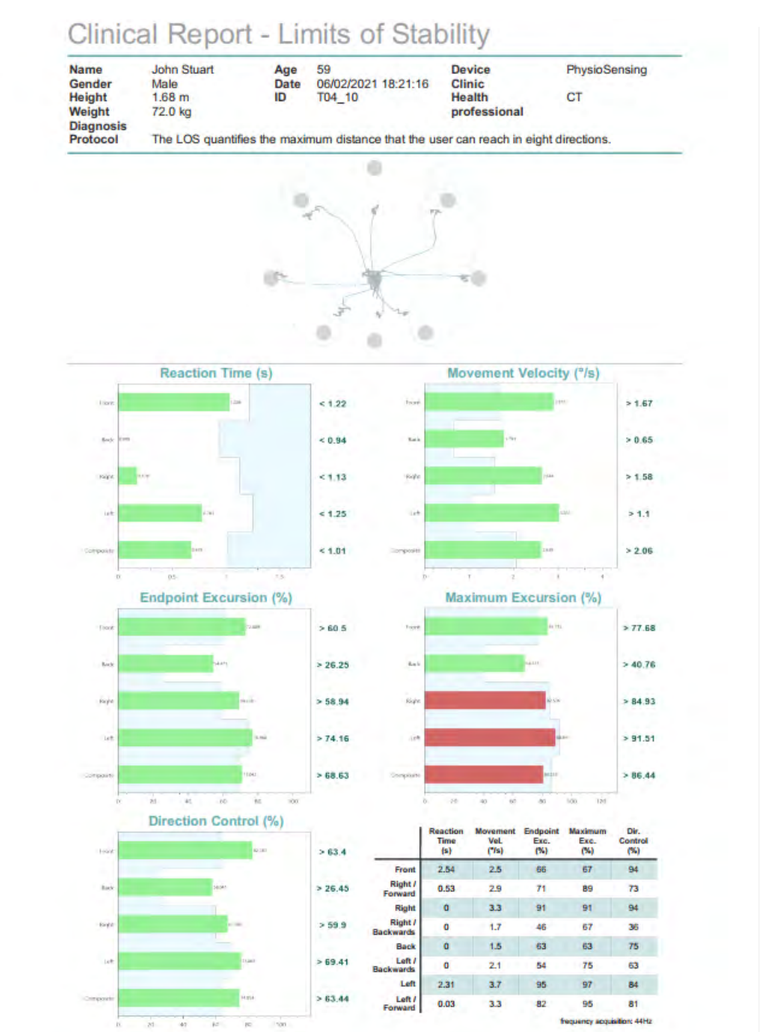

Figure 38: Clinical Report - Limits of Stability Assessment

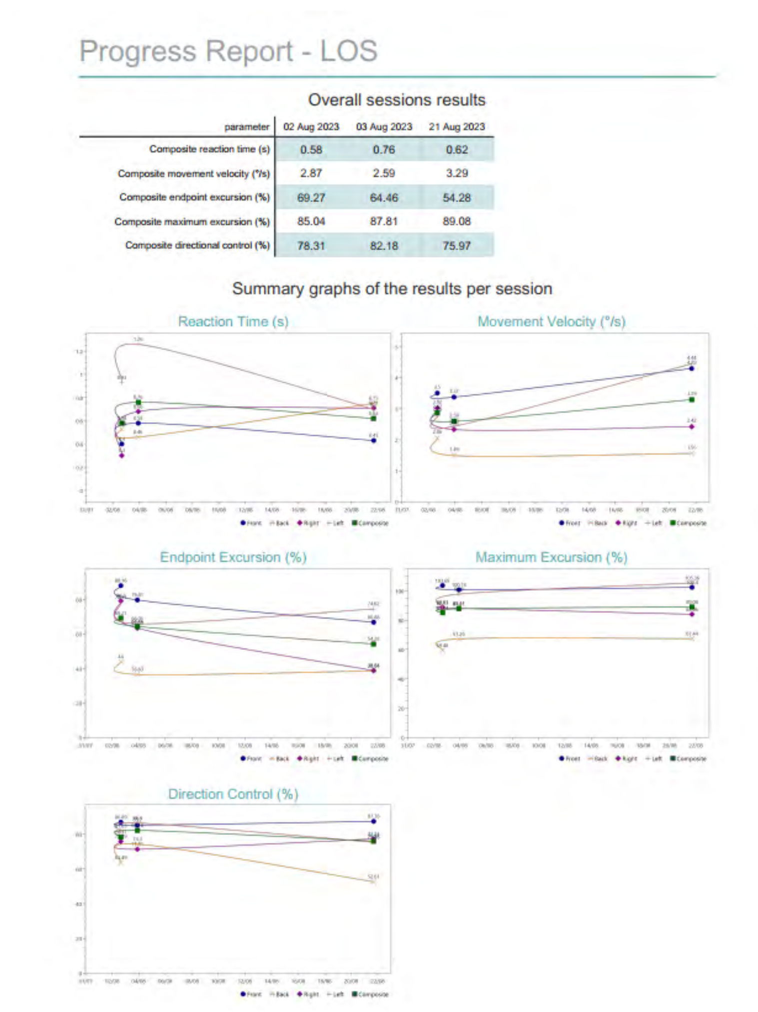

Figure 39: Progress Report - Limits of Stability Assessment

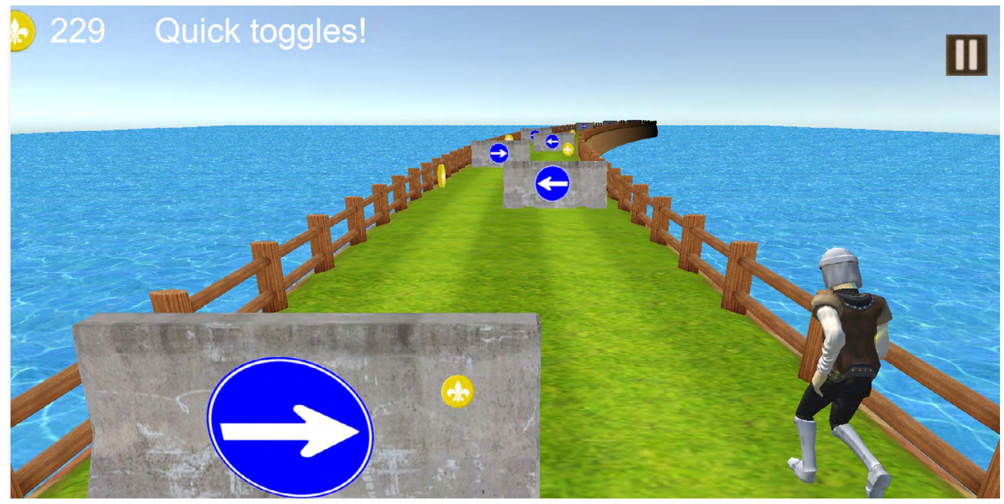

Figure 40: PhysioSensing Balance Software - Bart Game

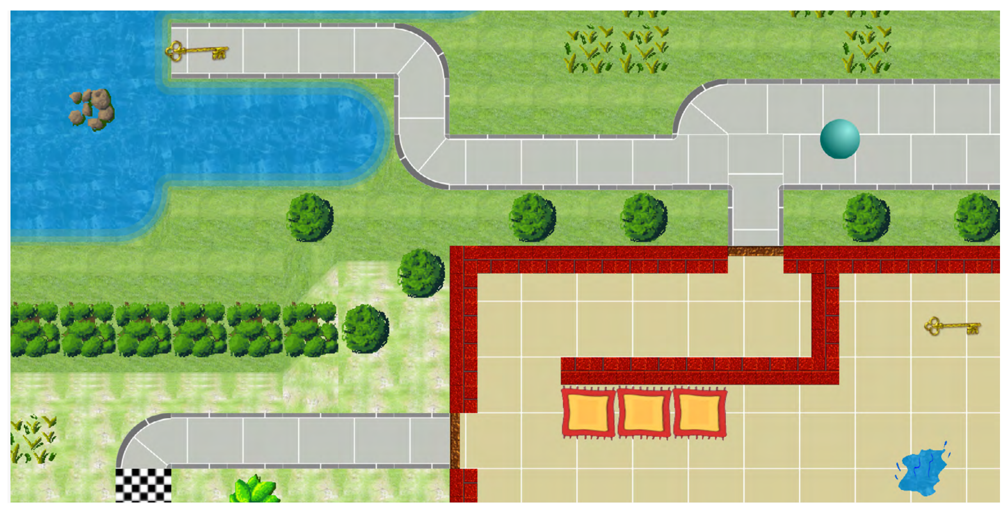

Figure 41: PhysioSensing Balance Software - 2D Games

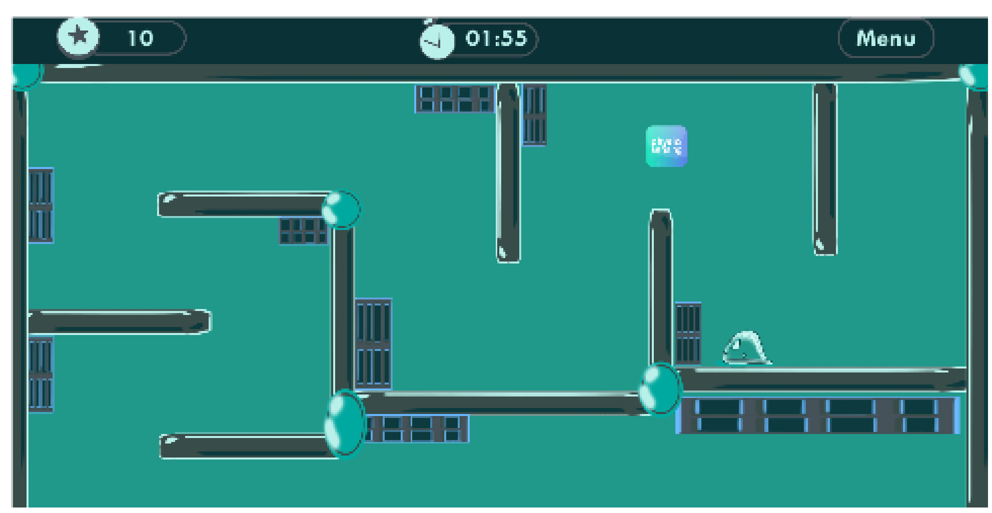

Figure 42: PhysioSensing Balance Software - Slime Run Game

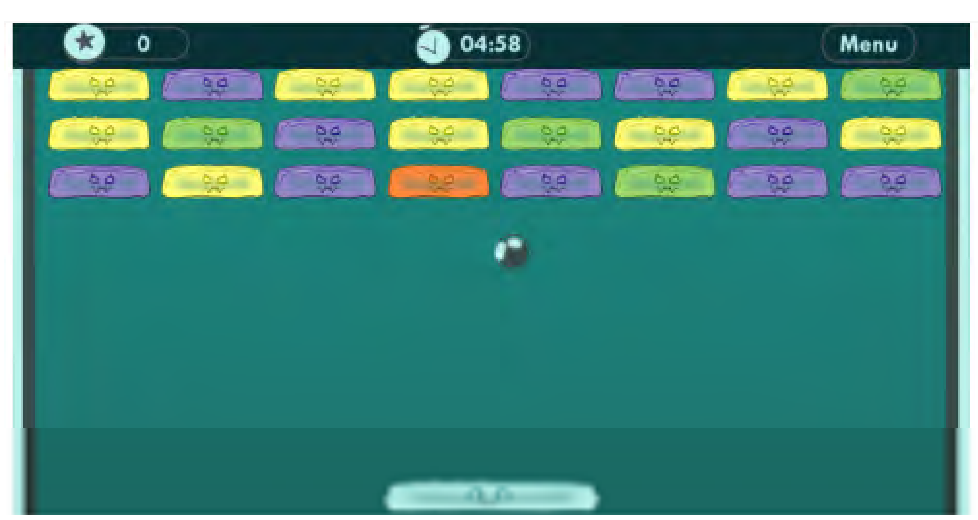

Figure 43: PhysioSensing Balance Software - Slime Pong Game

Another interesting feature of Balance Software is the 7 games available. Each game gathers a set of exercises that allow load transfer in several planes and balance training, appropriate for a high variety of therapeutic situations. Allied with physical stimulation, visual biofeedback has been considered a very efficient way to improve rehabilitation results. Additionally, associating a ludic component to a rehabilitation process has also shown to increase motivation and adherence to the process (Gil-Gómez et al., 2011).

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