BIOSWAY PORTABLE BALANCE SYSTEM

OPERATION MANUAL

950-460
950-461

Biodex eLearning

As a valued Biodex customer, we invite you to learn how to use your Portable BioSway with a series of online tutorials.

www.biodex.com/elearning
This manual covers installation and operation procedures for the following products:

950-460       BioSway Portable Balance System w/Case
950-461       BioSway Portable Balance System w/o Case

⚠️ **CAUTION:** Federal law restricts this device to sale of or on the order of a medical practitioner. When prescribed for therapeutic purpose, a physician should clearly define the parameters of use (i.e., total work, maximum heart rate, etc.) to reduce the risk of patient injury.
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The Biodex BioSway is compact, lightweight and easily portable.

The BioSway is a versatile Balance Assessment and Training Device. Lightweight and relatively small, it is easily portable. Set-up only takes minutes to provide the clinician with a choice of six interactive training modes or three standardized testing protocols including the Clinical Test of Sensory Integration and Balance protocol.

The easy-to-follow touch screen format makes BioSway simple to learn and operate. All test results and training sessions can be stored and printed. Comparison to normative data helps to communicate need, progress and outcome.

An optional hard shell “wheelie board” case provides convenience and protection when using the BioSway outside the clinic.

WHAT DOES THE BIOSWAY DO?
1. Provides valid, reliable, and repeatable objectives measures of a patient’s neuromuscular control and ability to balance on a firm and/or unstable surface.
2. Documents balance rehabilitation and assessment.
3. During rehabilitation provides visual feedback of a patient’s ability to control their center of gravity (COG).

The Biodex BioSway can be the cornerstone for the following programs:
- Fall Risk Assessment and Conditioning Programs
- Movement Disorders associated with neuromuscular control
- Amputee prosthetic rehabilitation
- Orthopedic rehabilitation associated with ligament sprains and poor neuromuscular control
- Sports Medicine and Conditioning Programs
- Core and Lumbar Stabilization Strategies
- Pre- and post-head injury screening
- Concussion Management Program with Play It S.A.F.E.®

For more specific applications, please refer to the Fall Risk Screening protocol and Compendium of Balance Application protocols.
eLEARNING

We invite you to learn how to use your new Portable BioSway with a series of online tutorials.

www.biodex.com/elearning

The content of the BioSway Essentials eLearning course is based largely on this manual. It is a comprehensive collection of short product demonstrations and try-it-yourself interactive sessions. We believe you will find this to be a valuable educational resource if you are a new customer or if you have new employees who will need to be trained on the BioSway.

The course is accessible on most internet browsers and mobile devices.
2. SYSTEM SPECIFICATIONS

Includes:
Balance Platform, Color Touch Screen LCD display, Indexed Foam Pad, Blindfold, Power supply and cables, Data collection software, Serial Cable and USB adapter

Power:
115V / 230VAC, 50/60 HZ, 15 amp line
This system uses APS (Advanced Power Solutions) Power Supply
Part #: APS22ES-150160/KOB Order #:1101-00396

Line Voltage:
AC Voltage 100 to 240 VAC, auto selectable by the power supply 0.6 – 0.3 amps

Output Voltage:
15VDC, 1.6A

Line Frequency:
50/60 Hz
Detachable line cord.
Built-in EMI filter and transient suppression.

Patient weight capacity:
500 lb (227 kg)

Platform Dimension:
21.25” w x 19.00” l x 2.56” h

Weight:
19 lb

Display Specifications:
Display Size and Type: 12.1” (30.7 cm); color touch screen.
Display resolution: 800 x 600
Operating System: Windows CE 6.0 R3
Printing: PCL printing via USB port (see list of compatible printers)
Memory: 256 MB
Audio:
Audio out with standard stereo line jack
Video Out Display: supports simultaneous analog up to 800 x 600 resolution

User Interface and Device Capabilities:
USB ports: Four 1.1 host ports to support
Mass Storage Device: USB Thumb drive
Mouse wired and wireless to allow for remote control operation, plus:
Remote CRT connector
Serial communication port
Weight:
5 lb

Hard Case Dimension:
23.75” w x 22.75” l x 10.75” h

Total weight in case:
44 lb

Environmental Operating Conditions:
Temperature:
0 to 40°C
Humidity:
0 to 90% rh, non-condensing

For optimum performance, the BioSway should be operated in a normal environment where the temperature and humidity are maintained for normal human comfort.

Certification:
ETL and cETL listed to UL 60601-1, CAN/CSA C22.2 No.:601-1-M90 and EN60601-1
EMC Certified to: EN 60601-1-2
Class: Type (B) equipment
CE Conformity to MDD 93/42/EEC

Authorized European Community Representative:

Emergo Europe
Molenstraat 15
2513 BH, The Hague
The Netherlands
3. CONNECTIONS AND ADJUSTMENTS

The BioSway is quick and easy to assemble. Simply remove the shipping knob and store it in the handle, connect the components as described on the connection instruction placard, and level the platform as needed. The entire process should take only a few minutes.

Figure 3.1. Shipping Knob in shipping position.

Figure 3.2. Shipping Knob in storage position.

Figures 3.1 and 3.2. Remove the shipping knob and insert it into the handle for storage. Be sure to replace the knob if transporting the system.

Figure 3.3. BioSway components shown in the optional hard case.
1. Foam pad
2. Cables
3. AC power adapter
4. Blindfold
5. Connection instruction placard
6. Base unit
7. Display unit (NOTE: Store this upside down in the optional hard case.)
8. Table Top Stand (included)
Base To Display Connections  
(See Figure 3.4.)

Connect the cable with the 15 pin Female D connector to the display. Connect the 15-pin Male D connector at the opposite end of the cable to the base.

![Figure 3.4. Base to display connections.](image)

AC Power Connections  
(See Figure 3.5.)

Plug the power supply into wall current. Plug the opposite end of the power supply into the base unit. Insert plug and twist ? turn to lock.

![Figure 3.5. AC power connections.](image)
Printer Connection
(See Figure 3.6.)

The USB port and cable are used to connect the printer.

NOTE: The printer is sold separately. Check Appendix 10 for list of compatible printers, or contact Biodex customer service.

![Figure 3.6. Printer connections.](image)

Serial Connection To Laptop or PC
(See Figure 3.7.)

The serial connection is used to connect the BioSway to a laptop or PC.

NOTE: See Chapter 9, System Utilities, for more information on patient data collection software.

![Figure 3.7. Serial connection to a laptop or PC.](image)
Platform Setup
(See Figures 3.8 and 3.9.)

This routine ensures the platform is level. The platform is level when all four markers on the display are green.

Figures 3.8 and 3.9. Use the Adjustment Knob to compensate for floor irregularities when leveling the platform. When all four boxes on the display are green, the platform is level.
CHOICE OF DISPLAY STANDS
The BioSway Display connects to either the Table Top Stand (included) or Telescoping Stand with a universal quick-connect mount. Both stands fold for compact transport.

950-463 BioSway Display Stand, Table Top (included)
950-465 BioSway Display Stand, Telescoping

Table Top Stand for BioSway Display (included)
The Table Top Stand fits into the BioSway case for portability and can also be wall mounted.

BioSway Display on Telescoping Stand (sold separately)
The Telescoping Stand adjusts vertically: 39” to 69” (99 to 175 cm) – measuring from the top of the display. The stand folds at the base to fit into its own travel case.
Connecting the Display to the Telescoping Stand:

![](image1)
![](image2)
![](image3)

*Figure 1.*  
*Figure 2.*  
*Figure 3. - Release Tab shown.*

Connecting and Disconnecting to/from the Telescoping Stand
- Position so it clicks in place (See Figure 1 and 2)
- Press the release tab to remove. (See Figure 3)

Connecting the Display to the Table Top Stand:

![](image4)
![](image5)

Use the Table Top Stand for a Wall Mounted Display

![](image6)
![](image7)
![](image8)
Mount the Display to VESA MIS-D
The BioSway Display mount even allows for direct attachment to other 100 mm VESA MIS-D compatible display mounts. It is best to leave the black mounting plate in place. VESA MIS-D is a common interface for a wide variety of monitor products.

Designed for Portability with Compact Storage

Compact for travel from place to place.
Loosen knob and fold up for travel.

Tilt and travel for short trips. Power supply and cables stow in base channel.

A travel bag is provided to protect the Telescoping Stand. The travel bag can easily fit on top of case or be carried separately.

BioSway tilts to roll with stand.
Prior to using the BioSway with patients, make certain to read and comprehend this entire manual. Ensure that you are completely familiar with all aspects of training and testing, as well as patient history. Be sure to adhere to the following clinical guidelines at all times when using this system. All users should have a verbal understanding of the BioSway prior to stepping on the device. Never allow a patient to use the BioSway while unsupervised.

1. A walker can be used as needed for patient’s that require or feel more comfortable with something to hold onto if needed.
2. When patients are working with their eyes closed, ensure that a clinician is ready to assist in case of loss of balance.
3. For optimal operation, ensure the patient is standing in the center of the platform.
4. Position the display so that the patient can look straight at it. This will help ensure good posture during the test or exercise session.
5. There is a learning curve that must be considered when testing with this device. Clinical research suggests practice trials be performed prior to testing.
6. It is highly recommended that the clinician remain with the patient during testing or training. An outstretched arm, not touching is reassuring for the patient.

**Figure 4.1.**

**Figure 4.2.**

Figures 4.1 and 4.2. Ensure all users have a verbal understanding of the BioSway before using the device. Never allow a patient to use the BioSway without supervision.

**BALANCE OVERVIEW**

Maintaining postural balance involves complex coordination and integration of multiple sensory, motor, and biomechanical components as graphically represented below. Balance is a motor skill most people take for granted. An individual senses body position in relation to gravity and environmental surroundings by combining vestibular, visual, and proprioceptive (somatosensory) inputs (1). Body position and smooth functional movement patterns result from these coordinated actions along with integration of graded ankle, knee and hip movements along the kinetic chain (2).

A person’s ability to maintain Balance becomes compromised when one action does not function accordingly and or equilibrium becomes altered. A variety of consequences can occur due to poor balance therefore clinicians need to address each component in order to prevent injury, re-injury or further trauma. The Biodex BioSway provides valuable objective assessment of neuromuscular control and somatosensory input important to balance.
Components of Balance  
*(See Figure 4.3.)*

Postural balance involves special sensory receptors that provide information in regards to various environmental and physiological conditions that may affect a person’s ability to maintain equilibrium. They are as follows:

![Figure 4.3. Components of balance.](image)

**Vestibular Apparatus**

The vestibular apparatus (VA) consists of three semicircular canals, and provides sensory information in regards to head position and gravitational changes. This information is used in three distinct ways.

1. Assists with maintaining upright posture, these organs are referred to as “sense organs of balance.” As they provide a sense of space via gravitational stimuli. This is apparent when the eyes are closed and the subject must rely on VA input.

2. Controlling the movement of the eye muscles via the vestibular-ocular reflex (VOR), which allows the eyes to remain fixed during movement or perturbation. The VOR is important for maintaining a frame of reference and providing spatial information regarding the environment around the person. When the VA is disturbed, the eyes will exhibit nystagmus in order to fix a reference point, otherwise, the movement of the eyes is equal and in the opposite direction of head movement.

3. Provides conscious awareness in regards to the body’s position and acceleration. This information is provided after stimuli have been relayed by the thalamus to the cerebral cortex (3).

**Visual Input**

Visual input is important to integrate the stimuli of the VA with the subject’s physical environment. The eyes function to detect a focal point on an object long enough for them to gain a clear image of that point. When the head is moved, the endolymph in the semicircular canals specific to that plane of movement bends the tiny hairs located in the semicircular canals and sends messages to the 8th cranial nerve, assisting to elicit a vestibular-ocular reflex, in turn rotating the eyes in an equal and opposite direction of the head. This movement allows for a fixed reference point.
Proprioception and Kinesthetic Input
The proprioceptive component of balance involves mechanoreceptors located within the skin, muscle tendons, and ligaments surrounding a joint. These structures play an important role in providing sensory information relating to touch, body position and rate of movement from external cues or conscious movement patterns associated with daily living. They also assist with providing adequate response to perturbations or noxious stimuli via reflex loops within the spinal cord to protect the body from injury.

Two such mechanoreceptors of importance to postural balance are: Muscle Spindle Fibers (MSF) and Golgi Tendon Organs (GTO). They consist of afferent nerve fibers and provide the nervous system with continual impulses regarding the status of a muscle at rest and during movement, they are crucial to maintaining postural balance.

Muscle Spindle Fibers:
1. Provide information in regards to muscle length, and the rate of change of a muscle’s length
2. Myotatic Reflex.
   • This is possible due to efferent branches which complete a loop through the spinal cord with the afferent tracts
   • Causes a muscular contraction to protect the muscle during rapid stretching
     - Example: during force inversion of the ankle during walking

Golgi Tendon Organs:
1. Located in the tendon near the musculotendinous junction
2. Serve as the protective mechanism to relax an overstretched muscle
3. Senses tension within the prospective muscle and transmits the information to the CNS, and through polysynaptic reflexes
   • Inhibits the motor neurons of the contracting muscle.
   • Muscle tension is monitored throughout the range of motion by the GTO; this is crucial to preventing muscle strains and tears.

Limits of Stability
The Limits of Stability (LOS) for standing balance is defined as the maximum angle a person’s body can achieve from vertical without losing balance. Basically, how well can a person control their Center of Gravity (COG) once it comes outside their Base of Support (BOS). Maintaining LOS is the result of integration of the sensory and motor control aspects of balance and plays an important role in activities of daily living. Once the LOS is exceeded a corrective strategy must take place in order to prevent a fall or stumble. LOS for bilateral stance in normal adults is 8° anterior, 4° posterior, and 8° laterally to the right and 8°.

The Limits of Stability (LOS) Test
This test challenges patients to move and control their center of gravity within their base of support. During each test trial, patients must shift their weight to move the cursor from the center target to a blinking target and back as quickly and with as little deviation as possible. The same process is repeated for each of nine targets. Targets on the screen blink in random order. Three skill levels allow the targets to be grouped closer together or spread further apart. If desired, single leg LOS test may be performed but no bilateral comparison is provided.

This test is a good indicator of control within a normalized sway envelope. Poor control, inconsistencies or increased times suggests further assessment for lower extremity strength, proprioception, vestibular or visual deficiencies may be indicated. The default setting for the LOS test is 75% LOS (moderate skill level).

A static force plate is typically used to record a patient’s movement of their COG over their BOS as an average amount of angular displacement. This is then further defined as a percentage of the patient’s LOS. For example, at 100% LOS, a patient will fall if they do not respond accordingly, (ankle, knee, hip strategy, or take a step to correct the BOS).
Figure 4.4. The Limits of Stability Test is a good indicator of control within a normalized sway envelope.

CLINICAL TEST OF SENSORY INTEGRATION AND BALANCE – CTSIB OR MCTSIB (MODIFIED CTSIB)

The Clinical Test of Sensory Interaction and Balance CTSIB is an accepted test protocol for Balance assessment on a static surface. The CTSIB test protocol was selected for Fall Risk assessment as it is well documented in the literature as an effective test in identifying individuals with mild to severe balance problems. The CTSIB consists of six conditions. This test provides a generalized assessment of how well a patient can integrate various senses with respect to balance and compensate when one or more of those senses are compromised.

- Condition 1 – Eyes open firm surface: Baseline: Incorporates visual, vestibular and somatosensory inputs
- Condition 2 – Eyes closed firm surface: Eliminate visual input to evaluate vestibular and somatosensory inputs.
- Condition 3 – Visual conflict on firm surface: Some vision present but information conflicts with vestibular information. This condition brings in more vestibular and somatosensory inputs.
- Condition 4 – Eyes open on a dynamic surface used to evaluate somatosensory interaction with visually input.
- Condition 5 – Eyes closed on dynamic surface: used to evaluate somatosensory interaction with vestibular input
- Condition 6 – Visual conflict on dynamic surface: Used to evaluate the mediation of visual with and vestibular and somatosensory inputs.

Another version of this test called the modified CTSIB is often used. The m-CTSIB eliminates conditions 3 and 6. The BioSway uses the M-CTSIB format of 4 conditions as the default with the ability to include the other 2 if desired.

The CTSIB was selected as the primary test for Fall Screening for these reasons:

1. The breadth of the existing studies supporting and accepting the CTSIB as a valid clinical assessment of balance
2. Well documented definitive correlations for fall risk assessment
3. Clinician familiarity with the test
4. The comprehensiveness of the test to address each of the systems that contributes to balance: Visual, vestibular and somatosensory.

What is being measured during the CTSIB test?
• Stability Index
• Sway Index

Stability Index And Sway Index
The BioSway tracks the subjects sway angle and direction from center. This measure is called the Stability Index. The Stability index is the average position from center. Specific information on how the Stability index is calculated can be found in the appendix. The Stability index does not indicate how much the patient swayed only their position. To quantify how much the person swayed we use the standard deviation of the Stability index. This value we have called the Sway Index.

For example:

If a patient is positioned in a manner that biases their placement from the center, the stability index will be a large value. However, if the patient swayed very little the standard deviation would be low. This is evident in the COG plots. A patient could have a score of equal 6.5, yet standard deviation would only be .8 and the printout tracing would show they did not sway very much. However, if they were positioned off-center, or even on-center – and swayed a lot - the standard deviation would be higher. Thus the standard deviation is indicative of sway.

The Sway Index is a subjective quantification of what commonly is done with a time-based pass/fail for completing the CTSIB stage in 30 seconds without falling, or assigning a value of 1 to 4 to characterize the sway. 1= minimal sway, 4 = a fall.

The Sway Index is really the Standard deviation of the Sway Angle. The higher the Sway Index. The move unsteady the person was during the test.

BioSway CTSIB Normative data ranges for each condition.
Reliability and normative data are described in more detail in Appendix B.

<table>
<thead>
<tr>
<th>Condition</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Condition 1: Eyes Open firm surface</td>
<td>.21-.48</td>
</tr>
<tr>
<td>Condition 2: Eyes closed firm surface</td>
<td>.48-.99</td>
</tr>
<tr>
<td>Condition 3: Visual conflict firm surface</td>
<td>.46-.88</td>
</tr>
<tr>
<td>Condition 4: Eyes Open foam surface</td>
<td>.38-.71</td>
</tr>
<tr>
<td>Condition 5: Eyes Closed foam surface</td>
<td>1.07-2.22</td>
</tr>
<tr>
<td>Condition 6: Visual conflict foam surface</td>
<td>.84-1.47</td>
</tr>
</tbody>
</table>

If a patient cannot complete a condition, it is noted as “Fell” on results screen and report.

NOTE: Visual Conflict Eye Glasses: Clinicians that want to do the Visual conflict conditions will require some type of glasses that provide a distorted yet transparent image. Commercially available Prism type glasses are commonly used. Other improvised glasses are: 3D glasses, or clear safety glasses in which the lenses have been marred or covered with Scotch™ type tape.
References

6. Marcia Hall, PT, Eric Miller, MSPA. Balance Function Testing.: 7/16/2001 Neurocom publication

NOTE: Additional information on Movement Strategies for Balance, Sensory Organization, Age-related changes in balance and CTSIB test result interpretation can be found in the Appendix C.
5. GETTING STARTED

The BioSway software program is easy to master. Simply follow the screen prompts as they lead you step-by-step through testing and training protocols or software utility options.

THE MAIN MENU
(See Figure 5.1.)
To access the BioSway System Main Menu:

1. Press the <ON/STANDBY> button on the display to turn the BioSway ON.
2. There will be brief BIODEX splash screen prior to seeing the Main Menu screen.
3. The Main Menu allows the user to select the Training, Testing or Utilities menus.
4. If security code was enable – enter 781. (See Chapter 9, System Utilities, Configuration, for more information on security code access.)

![Figure 5.1. The Main menu.]

DISPLAY PANEL BUTTONS
There are only three buttons located on the Display Panel. These buttons operate as follows:

1. <On/Standby> – <Power Off>: The only way to fully depower the BioSway is to disconnect the AC adapter. When plugged in, the display still has power to it, even if it appears off. You can bring up or “awaken” the display by simply touching the screen. The <On/Standby> button will turn ON the display as well as turn it OFF.
2. The <Start> button is used to begin the selected training or testing protocol selected.
3. The <Stop> button is used to end the selected training or testing protocol selected.

SCREEN KEYS
The following on-screen touch keys are consistent whenever they appear throughout the entire BioSway program.
• <HOME>: Touch this key to return to the Main Menu.
• <NEXT>: Touch this key to advance to the next logical screen.
• <BACK>: Touch this key to return to the previous screen.
• <OK>: Touch this key to confirm selections or entries and advance to the next screen.
6. THE TRAINING MODES

The training modes provide a simple means of setting up Balance training sessions. Six interactive game-like training modes are provided. These allow for fast patient setups and less formal protocols than the testing. All training modes can be customized to provide specific rehab goals with the on-screen grid and score-keeping functions used to both help motivate users and keep them focused on the task at hand. In addition, custom training protocols that were previously created through the Utilities option can be selected. Typically a custom protocol is one that a clinician has developed and would like to use with various patients without having to recreate it each time.

In training mode, only the most basic parameters are addressed. If desired, a pre-existing patient can be recalled from the Test/Rehab Results option in Patient Maintenance menu to allow for quick and easy repeat of a training or test session. The print screen function will allow the user to generate a printout of training results.

Training results can also be saved and recalled for later use by touching the <Save> icon on the results screen following any training session. A patient name is required to save the results. If no pre-existing name is available, the name entry screen will be displayed. Fill out the patient information and touch <Save> to record the training result numeric values, along with patient foot position on the platform.

To recall a patient and repeat an exercise session, select the desired patient from the Patient Management screen (see Chapter 9, System Utilities) and touch <Repeat>. The Position Patient screen with previous values is presented so the patient can be easily repositioned exactly as in the previous training session.

Training mode formats include: postural stability, limits of stability, weight shift, maze control, random control and percent weight bearing training as described in the following sections.

Figure 6.1. The Training screen.
The Postural Stability Training mode is designed to emphasize specific movement patterns or strategies by placing markers anywhere on the screen grid. The patient’s score is a tally of how many times the patient can touch targets with the on-screen cursor during any session. Time counts up or down as set.

**Postural Stability Training Access**

To Access The Postural Stability Mode:
1. At the Main Menu, touch <Training>. The Training Menu screen should now be displayed.
2. Touch <Postural Stability>. The User Setup Information screen should now be displayed. If this is a new patient and you want to save this training session after its completion, you must enter the patient’s name, height and weight. If you do not need to save the training session, touch <Next> and skip to step 8.

**NOTE:** Patient Height is entered so that the patient’s Center of gravity can be estimated. 55% of the patient’s height is used to calculate where the COG is. Based on the COG height, the BioSway takes into account that the theoretical angular excursion of the COG is different for different height people. Taller people will find it easier than shorter people to move their COG out to the extremes of the platform. Height is used to scale or compensate for this difference. What is described is also accommodated for with a cursor sensitivity selection. The cursor sensitivity can either be normal or more sensitive which allows the excursion to be a little easier. This is helpful with patient’s that have difficult time reaching the outermost targets.

3. Touch the <Keypad> icon for “Name” and enter the patient’s name. Touch <OK> to return to the User Information screen.
4. Touch the <Keypad> icon for “Age” and enter the patient’s age. Touch <OK> to return to the User Information screen.
5. Touch the <Keypad> icon for “Height” and enter the patient’s height. Touch <Next> to advance to the Postural Stability Training screen.
6. At the Postural Stability Training screen, touch <Place Target> and then touch the screen location where you would like a target to be placed. Repeat this process to place up to nine targets on the screen.

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**THE TRAINING MODES**
7. To clear any misplaced or unwanted targets, touch <Clear Target>. Each time this key is pressed, the most recent target added to the screen will be removed.

8. Touch <More Options> to advance to the Postural Stability Training Options screen if desired. Here you can set the total time for the exercise, enter initial and ending platform stability settings, turn tracing ON/OFF and Scoring Tone ON/OFF. Touch <OK> to confirm your selections and return to the Postural Stability Training Options screen, or <Cancel> to return to the Postural Stability Training Options screen without making changes.

   - Use the <▲> or <▼> keys to set the total time in 10-second increments (during the routine the software will count down from the time setting selected).
   - To turn tracing ON/OFF, touch <Tracing> to toggle between choices. Same for Scoring Tone.

9. Explain the training protocol to the patient and then press <Start> on the display to begin the training session. The Stability Training grid on the screen charts the patient’s stability performance through the course of the training session (touch the <Magnifying Glass> to enlarge the screen if desired).

   **NOTE:** If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes.

10. At any time during the training session, the “tracing” can be erased by pressing <Clear Tracing>.

11. To stop the training session at any time, press <Stop> on the display.

12. On all training screens tracing will automatically be drawn when the exercise is complete. When you are finished reviewing the training screen, touch <Print> to print the screen (if connected to a printer), or <Save Results> to save the training session (numeric data only).

13. After printing or reviewing the screen, press <Start> to immediately begin another training session using the same parameters, or press <Back> to return to the Training Setup screen.
LIMITS OF STABILITY (LOS) TRAINING ROUTINE
(See Figure 6.3.)

![Figure 6.3. The Limits of Stability (LOS) Training screen.]

The Limits of Stability Training screen is designed to challenge the user to move through a movement pattern consistent with the sway envelope. The sway envelope is that area a person can move their COG within their base of support. It is approximated from vertical as 8 degrees to one side, 8 degrees to the other (total of 16 degrees of sway,) and 8 degrees forward and 4 degrees back (12 degrees total). Limits of Stability training and testing are based on challenging the patient within this sway envelope. Testing is usually done at 75% LOS, which is the moderate skill level. Easy skill level is 50% and hard skill level is 100% of the sway envelope. Scoring percentage-based and reflects the directional accuracy of the movement to the blinking targets (see Appendix B-1) Time counts up during the LOS training.

LOS Training Access and Differences From Other Training Modes
Access to the Limits of Stability Training mode is similar to Postural Stability Training with the following differences:

1. Touch <Skill Level> to tighten or widen the spread between targets. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target configuration is displayed.
2. If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.
3. Touch <More Options> to advance to the Limits of Stability Training Options screen if desired. Here you can set the Limits of Stability Hold Time for the exercise, Scoring Tone On/OFF and turn Tracing ON/OFF. Touch <OK> to confirm your selections and return to the Limits of Stability screen, or <Cancel> to return to the Limits of Stability screen without making changes.
   • To set a Limits of Stability Hold Time, use the <▲> or <▼> keys to scroll to the desired setting. Hold times range from .025 to 5 seconds.
   • To turn tracing ON/OFF, touch <Tracing> to toggle between choices.
4. Explain the training protocol to the patient, then press <Start> to begin the LOS training session. The LOS Training screen reflects the patient’s stability performance through the course of the LOS training session. The Elapsed Time from the start of the training session is shown at the top right of the display while the stability level is illustrated by a bar graph. A running patient score is also provided in the upper right corner.

NOTE: If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes. At any time during the training session, the “tracing” can be erased by pressing <Clear Tracing>. To stop the training session at any time, press <Stop> on the display. The system will stop gathering data.

Figure 6.4. Touch the <Magnifying Glass> to enlarge the The Limits of Stability (LOS) Training screen.
WEIGHT SHIFT TRAINING
(See Figure 6.5.)

Figure 6.5 The Weight Shift Training screen.

This training mode allows for exercise in the most basic of activities; weight shifting. The patient has the ability to shift weight in medial/lateral, anterior/posterior and diagonal planes. During this training routine the target zone, defined by two parallel lines, can be rotated to any of three positions while the amount of excursion within the target area can be modified to allow for the most limited to most difficult degree of weight shifting. To reposition the target zone hit lines at any time, simply touch the desired line and re-touch the screen where you want the line to be relocated.

Scoring is percentage-based and equals net good hits/total target hits. If you cross the boundary, that counts against the good hit total. All outside boundary hits are subtracted from the total amount of target hits. This value equals the net good hits. For example: Enter 10 as the # of target hits. There were 4 times when the cursor went outside the boundary:

10-4 = 6 good hits. Score = 6/10 or 60%.

NOTE: For weight shift training the time value always counts up.

Weight Shift Training Access and Differences From Other Training Modes
Access to Weight Shift Training Mode is similar to other training modes with the following differences:

1. At the Weight Shift Training screen, touch <Rotate Target> to toggle through the three patient target positions until the desired rotation is displayed on the grid.
2. Touch <Skill Level> to enlarge or decrease the target box size. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target configuration is displayed.

If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.
3. Touch <More Options> to advance to the Weight Shift Training Options screen if desired. Here you can set the total hits for the exercise (default = 60), turn tracing ON/OFF and set Scoring Tone ON/OFF. Touch <OK> to confirm your selections and return to the Weight Shift Training Options screen, or <Cancel> to return to the Weight Shift Training Options screen without making changes.

- Use the <▲> or <▼> keys to set the total hits.
- To turn tracing ON/OFF, touch <Tracing> to toggle between choices.
MAZE CONTROL TRAINING
(See Figures 6.6 and 6.7.)

This mode allows the patient to follow a reproducible pattern of movement throughout a maze in both static and dynamic environments. Three skill levels allow the maze to be modified to create a simple or more difficult environment for the patient to navigate through. Time counts up or down as set. Scoring is percentage-based on the net good hits/total target hits. If the cursor hits the boundary that hit is subtracted from the total possible amount of good hits.

- Easiest maze has 28 total targets, 14 in each direction
- Moderate has 36 targets, 18 in each direction
- Most difficult has 72 targets, 36 in each direction

In the case of the easiest maze, if the wall is hit 6 times the resulting score will be 22/28 = 78%

Maze Control Training Access and Differences From Other Modes
To Access the Maze Control Mode is similar to other training modes with the following differences:

1. Cursor sensitivity can be either more sensitive or Normal. The cursor sensitivity can either be normal or more sensitive which allows the excursion to be a little easier. This is helpful with patient’s that have difficult time reaching the outermost targets.
2. Touch <Skill Level> to increase or decrease the number of targets displayed on the graph. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target configuration is displayed.

If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.

Figure 6.6. Change Cursor Sensitivity screen.
3. Touch <More Options> to advance to the Maze Control Training Options screen if desired. Here you can set the total time for the exercise, and turn tracing ON/OFF. Touch <OK> to confirm your selections and return to the Maze Control Training Options screen, or <Cancel> to return to the Maze Control Training Options screen without making changes.

- Use the <▲> or <▼> keys to set the total hits.

Again please note: If you have selected to enlarge the screen by touching the <Magnifying Glass>, you must return to the normal viewing screen format to make any changes. And at any time during the training session, the “tracing” can be erased by pressing <Clear Tracing>.

![Maze Control Training screen](image)

Figure 6.7. The Maze Control Training screen.
RANDOM CONTROL TRAINING
(See Figures 6.8 and 6.9.)

The Random Control training mode allows the patient to perform neuromuscular control activities in random patterns generated by the display and is ideal for motor control and vestibular training. The size and speed of the target can be modified for progressions ranging from easy to difficult. Scoring is percentage-based and equals the total time inside the circle/total time in and outside of the circle. Time counts up or down as set.

Random Control Training Access and Differences From Other Modes
Access to Random Control Training Mode is similar to other training modes with the following differences:

1. Cursor sensitivity can be either more sensitive or Normal. The cursor sensitivity can either be normal or more sensitive which allows the excursion to be a little easier. This is helpful with patient’s that have difficult time reaching the outermost targets.

2. At the Random Control Training screen, the target circle should be flashing in the center of the stability grid. Touch <Circle Speed > to toggle though the three target circle speeds until the target circle flashes at the desired speed.

3. Touch <Skill Level> to enlarge or decrease the target circle size. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target size is displayed.

Figure 6.8. The Random Control Training Start screen.

If desired, touch <Clear Tracing> to remove any tracing that remains on the screen from a previous exercise session.

Touch <More Options> to advance to the Random Control Training Options screen if desired. Here you can set the total time for the exercise, enter initial and ending platform stability settings, turn tracing ON/OFF and scoring tone ON/OFF. Touch <OK> to confirm your selections and return to the Random Control Training Options screen, or <Cancel> to return to the Random Control Training Options screen without making changes.

- Use the <▲> or <▼> keys to set the total time in 10-second increments (during the routine the system will count down from the time setting selected).
PERCENT WEIGHT-BEARING TRAINING
(See Figures 6.10 and 6.11.)

Percent Weight-Bearing Training provides real-time feedback of the percentage of weight-bearing on the patient’s foot, ankle, knee, hip, body side, etc. In this mode targets can be set that encourage patients to focus on Percent weight-bearing goals in anterior, posterior, medial and lateral movements. Therapists and patients should find Percent weight-bearing training to be an effective mode for communicating what, where and how a patient’s body weight is located or feels. Movement feedback can be limited to Medial Lateral or Anterior Posterior or combined.

NOTE: Scoring is this mode is the percent time spent within the target range. The axis will show green when weight bearing is within target settings.
Figure 6.11. The Percent Weight Bearing Training screen. Scoring is the percent of time spent within the target range.

Figure 6.12. The position patient screen is used to adjust and record the patient’s foot position prior to beginning the training exercise.
Percent Weight Bearing Training Access and Differences From Other Modes

Access to Percent Weight-Bearing Training Mode is similar to other modes with the following differences:

1. This is the one training mode where positioning the patient is required. Position the patient’s feet as noted. If patient cannot be positioned as suggested, center patient and enter new foot position. The foot angle is determined by the line that is parallel with the inside of the foot.

Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient’s left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Percent Weight Bearing Training screen.

The Percent Weight Bearing Training screen displays a Medial Lateral/Anterior Posterior grid. If you would prefer a Medial Lateral only grid, touch <More Options>. The More Options screen also allows the clinician to set an end by time value. Touch <OK> after making changes to return to the Percent Weight Bearing Training screen.

If desired, shift the red Percent Weight Bearing target zone by touching and dragging the appropriate red line to the desired Percent Weight Bearing target.
Static testing measures the angular excursion of the patient’s center of gravity. Body height must come into play for static measures. A person’s Center of Gravity (COG) is approximately 55% of their height. Based on the selected height an appropriate static measure scaling is applied.

Testing provides a baseline for rehabilitation programs as well as balance screening. Good static testing scores can lead to a progression into more dynamic testing and training. Test formats include Postural Stability, Limits of Stability, m-CTSIB and the ability to select previously constructed custom protocols.

Figure 7.1. The Testing screen.
THE POSTURAL STABILITY TEST
(See Figure 7.2.)

The Postural Stability Test emphasizes a patient’s ability to maintain center of balance. The patient’s score on this test assesses deviations from center, thus a lower score is more desirable than a higher score.

![User Setup Information](image)

Figure 7.2. The User Setup Information screen.

Performing A Postural Stability Test

1. At the Main Menu, touch <Testing>. The Testing Menu screen should now be displayed.
2. Touch <Postural Stability>. The User Setup Information screen should now be displayed.
3. Touch the <Keypad> icon for “Name” and enter the patient’s name. Touch <OK> to return to the User Setup Information screen.
4. Touch the <Keypad> icon for “Age” and then enter the patient’s age. Touch <OK> to return to the User Setup Information screen.
5. Touch the appropriate <Height> key to highlight the patient height range setting desired. Touch <Next> to advance to the Patient Position screen.
6. Position the patient on the system and explain the test protocol. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid.
7. Touch <Record> to bring up the Position Patient Entry screen. Again, suggested standardized foot positions are provided. (reference McIlroy WE) Position the patient’s feet as noted. If patient cannot be positioned as suggested, center patient and enter new foot position.
8. Press <Start> on the display to activate the cursor and have the patient move the cursor to the center point on the grid. Touch <Record> to bring up the Position Patient Entry screen. Using the keypads, enter the patient’s left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Using the keypads, enter the patient’s left foot, left heel, right foot and right heel positions using the midline of the foot and the platform grid as reference points. Touch <Next> to advance to the Postural Stability Testing screen.
9. At the Postural Stability Testing screen, touch <Stance> to scroll through the three stance positions provided: left, right or both.
10. Touch <Tracing> to toggle tracing ON or OFF as desired.
11. Touch <Clear Tracing> to clear any tracing that remains from previous tests.
12. Touch <More Options> to advance to the Postural Stability Test Options screen if desired. Here you can set the Test Trial Time, enter initial and ending platform stability settings, enter the number of trials, enter the Rest Countdown, or toggle bilateral comparison to “Yes” or “No” and enter the Rest Countdown. You can also toggle the cursor ON / OFF and set Scoring Tone. Touch <OK> to confirm your selections and return to the Postural Stability Testing screen.

- Use the <▲> or <▼> keys to set the total time in five-second increments (during the routine the system will count down from the time setting selected).
- To set the number of trials or rest countdown, touch the appropriate key and then enter the setting from the keypad displayed.
- To turn the cursor ON / OFF, touch <Cursor> to toggle between choices. Same for Scoring Tone.
- To toggle bilateral comparison “Yes” or “No,” touch <Bilateral Comparison>.

13. With the patient ready to begin the test, touch <Collect Data>. The screen will provide a three-second countdown before beginning the first of three test trials. The display screen will show Total Trial Time, and Stance to the left of the grid. Trial Number and score are displayed to the right of the grid. If desired, at this point you can touch the <Magnifying Glass> to select the zoom feature. You must, however, leave the zoom feature to make any changes.

NOTE: A Practice rep is suggested and is available prior to each test rep. Simple press Practice Rep and a trial rep will be presented just like the test rep. The Practice rep can be stopped at anytime to proceed to the test rep.

14. After completing the test, a “Test Complete” message is displayed. Touch <Results> to advance to the Postural Stability Test Results screen.

NOTE: If you have selected Bilateral Test, the system will begin by testing the initial side as set up above. After the third trial on the initial side is finished, touch <Test Other Leg> to continue. The system automatically selects the opposite side and then allows the user to proceed from the Position Patient screen. Repeat steps 8 – 17 to test the opposite side.

15. At the Postural Stability Test Results screen, touch <Print> to automatically generate a printed report if desired. If you have performed a Bilateral Test, the Test Results screen and report will provide a bilateral comparison.

16. To save the test data, touch <Save Results> and then touch <OK> in response to the “Save Results for later reporting or export?” prompt. The system will display “Save Results Completed after the results are saved.

17. Another test for the same patient can be perform simply by touching <ANOTHER TEST SAME PATIENT>. You can also return to the Opening Menu by touching <HOME> or from Stability Test Results screen.
PERFORMING A LIMITS OF STABILITY TEST
(See Figure 7.3.)

Testing is usually done at 75% LOS, which is the moderate skill level. Easy skill level is 50% and hard skill level is 100% of the sway envelop. Scoring percentage-based and reflects the directional accuracy of the movement to the blinking targets (see Appendix for details on scoring). Time counts up during the LOS testing.

<table>
<thead>
<tr>
<th>Limits of Stability Test Results</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time to Complete Test 00:28</td>
</tr>
<tr>
<td>Direction Control   Actual    Goal</td>
</tr>
<tr>
<td>Overall             80        65</td>
</tr>
<tr>
<td>Forward/Right       95        65</td>
</tr>
<tr>
<td>Forward/Left        87        65</td>
</tr>
<tr>
<td>Backward/Right      90        65</td>
</tr>
<tr>
<td>Backward/Left       87        65</td>
</tr>
</tbody>
</table>

Figure 7.3. The Limits of Stability (LOS) Test Results screen.

Accessing The Limits Of Stability Test and Differences From Other Test Modes

To Access The LOS Test, simply follow screen prompts as for Postural Stability testing with the following differences:

1. Touch <Skill Level> to tighten or widen the spread between targets. Three skill levels are available from which to choose. Touch <Skill Level> until the desired target configuration is displayed.

2. Touch <More Options> to advance to the Limits of Stability Training Options screen if desired. Here you can set the Limits of Stability Hold Time for the exercise, turn Tracing ON/OFF or Scoring Tone ON/OFF. Touch <OK> to confirm your selections and return to the Limits of Stability screen, or <Cancel> to return to the Limits of Stability screen without making changes.

• To set a Limits of Stability Hold Time, use the <▲> or <▼> keys to scroll to the desired setting. Hold times range from .025 to 5 seconds.
PERFORMING A CTSIB TEST
(See Figures 7.4 – 7.7.)

To perform the CTSIB test, simply follow screen prompts.

Other points of interest:

1. Touch <More Options> to advance to the CTSIB Test Options screen if desired. Here you can set the Test Trial Time, enter the number of trials and enter the Rest Countdown, and change which conditions you want to test by simply touching to highlight the conditions you want to do. You can also toggle the cursor ON/OFF. The Cursor should be OFF during the actual test. Touch <OK> to confirm your selections and return to the CTSIB Testing screen.

   • Use the <▲> or <▼> keys to set the Test Trial time in five-second increments (during the routine the system will count down from the time setting selected).
   • To set the number of trials or rest countdown, touch the appropriate key and then enter the setting from the keypad displayed.

Press <OK> to continue to do the test. The Press <START> to beginning the testing sequence for each condition.

Figure 7.4. The m-CTSIB Testing Options screen.
2. Again as with the other tests you will have the option to perform a trial rep prior to each test condition rep. The practice rep can be stopped at anytime to proceed to the test rep.

3. After completing the condition the next test condition will follow until all conditions have been completed. When the last condition is completed a “Test Complete” message is displayed. Touch <Results> to advance to the CTSIB Test Results screen.
4. At the Results screen, touch <Print> to automatically generate a printed report if desired.

5. To save the test data, touch <Save Results> and then touch <OK> in response to the “Save Results for later reporting or export?” prompt. The system will display “Save Results Completed” after the results are saved.

6. Another test for the same patient can be performed.

7. To return to the Opening Menu from the CTSIB screen, touch <Home>.

8. If a patient could not complete a stage, the stage is noted as “Fell”.

---

**Figure 7.7. The m-CTSIB Test Results screen.**
The BioSway offers reports for each of the test modes. These can be used to objectively measure and record the patient’s balance ability. Progress reports that graph overall stability scores from each test date are also available.

Sample reports for each testing mode are provided later in this chapter.

REPORT PARAMETERS
The following parameters appear on various reports:

Stability Index
Stability index is the average position from center. The Stability index does not indicate how much the patient swayed. For this we use the standard deviation of the Stability index. This value we have called the Sway Index.

Sway Index
The Sway Index is really the Standard deviation of the Sway Angle. The higher the Sway Index the more unsteady the person was during the test.

(Refer to Appendix C for additional information)

The Stability Index is represented in the following formats:

1. The Overall Stability Index takes into account COG displacement in the following directions
2. Anterior/Posterior (A/P)-Sagital Plane
3. Medial/Lateral (M/L)-Frontal Plane

Overall Stability Index
The following equation is used to calculate the Overall Stability Index.

\[
(DI)^2 = \sum (0 - X)^2 + \sum (0 - Y)^2 \\
DI = \frac{(DI)^2}{\text{# of samples}}
\]

Anterior/Posterior (A/P)
The Anterior/Posterior Stability Index represents platform displacement in a sagital plane. A high score in this direction may indicate poor neuromuscular control of:

1. The quadriceps and/or hamstring muscles
2. The anterior/posterior compartment muscles of the lower leg.

The following equation is used to calculate the Anterior/Posterior Stability Index:

\[
DI_y = \sqrt{\sum (0 - Y)^2} \\
\text{# of samples}
\]

Medial/Lateral (M/L)
The Medial/Lateral Stability Index represents platform displacement in the frontal plane. A high score in this direction may be indicative of:

1. Bilaterally- Poor neuromuscular control of the abductor and adductor muscles of the lower leg.
2. Unilaterally — Poor neuromuscular control of the inversion or eversion muscles of the lower leg, especially following an ankle sprain.

The following equation is used to calculate the Medial/Lateral Stability Index:

\[
DI_x = \sqrt{\sum (0 - X)^2} \\
\text{# of samples}
\]
Standard Deviation (SD)

This is the amount of variability in the statistical measure between data points. A low standard deviation demonstrates that the range of values from which the mean was calculated were close together. Standard Deviation should be relatively low.

\[ \frac{\sum \sqrt{(X_n - X)^2}}{n} \]

\( n = \# \) of samples
\( X_n = n \text{ th sample} \)
\( X = \text{mean deflection} \)

DATA INTERPRETATION FOR THE LIMITS OF STABILITY

Since the BioSway measures COG angular displacement from center it can be used to assess a patient’s LOS in two ways.

Method 1

Using the Stability Index (SI) gained from a Dynamic Balance Report it can be determined how well a patient controls their balance within their LOS in both an Anterior/Posterior (A/P) direction and a Medial/Lateral direction (M/L). For example, an A/P SI of 6.8 would mean that a patient remains within 57% of their A/P LOS:

\[
\hspace{1cm} \begin{align*}
\text{A/P LOS} &= 12 \\
\text{A/P SI} &= 6.8 \\
\therefore \text{6.8/12} &= 0.566 \text{ or } 0.57 \times 100 = 57\%
\end{align*}
\]

The same method can be used to determine the M/L LOS control. They are both important for determining a patient’s potential risk for falling. Rehabilitation exercises can be properly prescribed from these results to effectively assist the patient to better control their LOS.

Method 2

By using the Limits of Stability Test protocol it can be determined exactly in which direction a patient may have more trouble controlling their LOS. The test results are based on 100, with 100 being a perfect score. The patient’s score is based on their ability to accurately move the display cursor to a target 10 º from a level platform position and back to level again. The more direct the path to the target and back to center the higher their score will be. Lower Scores may be indicative of poor neuromuscular control.

Parameters for this Assessment can be found on the report for the Comprehensive LOS. Test report. The formula found below is used to calculate the final score which is represented both numerically and graphically. From the results it can be determined how well the subject was able to control their COG over their BOS. Higher numbers represent better control, with lower numbers representing a poor control. The report also gives the total time it took the patient to complete the test which can also be compared between sessions.
DYNAMIC LIMITS OF STABILITY SCORE CALCULATION

DLOS SCORE % = \( \frac{\text{Straight Line Distance to Target}}{\text{Actual Distance Traveled}} \times 100 \)

WHERE:

Actual Distance Traveled (trace)

\[ \sum_{I=1}^{I=8} \text{(DLOS Scores)} \]

Or the Average of all 8 Targets
SAMPLE BALANCE REPORTS
(See Figures 8.1 – 8.4.)

Postural Stability Test Results

<table>
<thead>
<tr>
<th>Foot Placement</th>
<th>Left</th>
<th>Right</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foot Angle</td>
<td>5</td>
<td>5</td>
</tr>
<tr>
<td>Heel Position</td>
<td>d7</td>
<td>d16</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Protocol</th>
<th>Platform Setting: STATIC</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Test Trial Time: 29</td>
</tr>
<tr>
<td></td>
<td>Test Trials: 1</td>
</tr>
<tr>
<td></td>
<td>Stance: Both</td>
</tr>
<tr>
<td></td>
<td>Cursor: ON</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Actual</th>
<th>STD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Score</td>
<td>Dev.</td>
</tr>
<tr>
<td>Overall</td>
<td>2.2</td>
</tr>
<tr>
<td>Anterior/Posterior index</td>
<td>1.6</td>
</tr>
<tr>
<td>Medial Lateral Index</td>
<td>1.2</td>
</tr>
</tbody>
</table>

% Time in Zone: A 97 B 2 C 0 D 0
% Time in Quadrant: I 7 II 6 III 33 IV 54

Comments:

Clinician:

Figure 8.1. The Postural Stability Test Report.
Figure 8.2. A Limits of Stability Test Report.
**Clinical Test of Sensory Integration of Balance**

<table>
<thead>
<tr>
<th>Condition</th>
<th>Stability Index</th>
<th>Sway Index</th>
<th>Sway Index</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eyes Open Firm Surface</td>
<td>2.0</td>
<td>0.90</td>
<td>Better 1.5</td>
</tr>
<tr>
<td>Eyes Closed Firm Surface</td>
<td>2.2</td>
<td>0.93</td>
<td>Better 1.5</td>
</tr>
<tr>
<td>Visual Conflict Firm Surface</td>
<td>1.8</td>
<td>0.91</td>
<td>Better 1.5</td>
</tr>
<tr>
<td>Eyes Open Foam Surface</td>
<td>1.1</td>
<td>1.23</td>
<td>Better 1.5</td>
</tr>
<tr>
<td>Eyes Closed Foam Surface</td>
<td>1.8</td>
<td>2.29</td>
<td>Better 1.5</td>
</tr>
<tr>
<td>Visual Conflict Foam Surface</td>
<td>2.6</td>
<td>2.41</td>
<td>Better 1.5</td>
</tr>
</tbody>
</table>

**Comments:**

**Clinician:**

Figure 8.3. CTSIB Sample report, 6 conditions. Note that if the patient failed to complete a condition, it would be denoted as “FELL.”
PROGRESS REPORTS
(See Figure 8.4.)

Progress Reports graph overall stability scores for each Postural Stability Test date selected. The tests are selected from Patient Maintenance on the Utilities Menu. The patient selected must have multiple tests, with resultant Stability Index scores, to generate a report.

To Print A Progress Report:
1. Touch <Utilities> on the Main Menu. The System Utilities screen should now be displayed.
2. Touch <Patient Management> and enter code 781 to advance to the Patient Management screen.
3. Touch the desired POS Postural Stability Test and then touch <Progress Report>. Note that the report will be limited to the specific test type selected.
4. Up to ten test records can be displayed on the screen. Scroll right or left to see additional tests.
5. Touch <Print> to print the Progress Report.

![Figure 8.4. A sample Progress Report.](image-url)
9. SYSTEM UTILITIES

The System Utilities allow users to access the System Configuration and Patient Management screens.

To access the System Utilities, touch <Utilities> on the Main Menu. The System Utilities screen should now be displayed. From here you can select Configuration or Patient Management by touching the desired icon.

**Figure 9.1. The Utilities screen.**

**SYSTEM UTILITIES**

**CONFIGURATION**
**PATIENT MANAGEMENT**
**CUSTOM PROTOCOL LIST**
**PATIENT DATA STORAGE USAGE**
**SOFTWARE AND HARDWARE INFORMATION**
**HOURS OF USE**

**Patient Data Storage Usage:** A bar graph that shows how much of the storage capacity has been used. It is suggested that once 85% is reached, that measures be taken to free up storage space. See Patient management for more information.
CONFIGURATION
Touch <Configuration> and then enter 781 in response to the “Enter Access Code” prompt. Touch <OK>. The Configuration screen should now be displayed. At this screen users can set values for Screen Time Out, Date/Time and Default Settings. You can also turn Tone ON/OFF, adjust LCD brightness or Tone volume, and select Measurement Units, Printer Resolution or CTSIB Defaults. When you have finished making all of your selections and adjustments, touch <OK> to return to the Main Menu.

![Configuration Screen Diagram]

Figure 9.2. The Configuration screen.

Set Screen Time Out
The Screen Time Out setting determines how long the display screen remains ON when the system is not in use of the test/exercise is completed. Once the selected time expires, the screen fades to black even if the system remains ON.

1. At the Configuration Screen, touch <Set Screen Time Out>. The Set Test/Exercise Complete Screen Time Out screen should now be displayed.
2. Use the <▲> or <▼> arrows to increase or decrease the value displayed in 30-second increments. Time Out range is from 00:00 to 30:00.
3. Touch <OK> to confirm your changes and return to the Configuration screen. Touch <Cancel> to return to the Configuration screen without making any changes.

Set Date/Time
Time and Date are system-wide parameters that show on all printed reports.

1. At the Configuration Screen, touch <Set Date/Time>. The Set System Date/Time screen should now be displayed.
2. Touch the parameter to set so that the selected field is highlighted.
3. Use the <▲> or <▼> arrows to increase or decrease the value displayed for the highlighted parameter.
4. Repeat steps 2 and 3 until you have adjusted all the parameters you wish to correct.
5. Touch <OK> to confirm your changes and return to the Configuration screen. Touch <Cancel> to return to the Configuration screen without making any changes.
Turn Tone ON/OFF: This setting enables or disables an audible tone which is used throughout the BioSway for scoring tones, test or exercise start signals, and completion or countdown between trials. At the Configuration screen, simply touch the ON or OFF icon to select the desired setting.

Adjust Tone Volume: This setting raises or lowers the volume of the audible tone described above. between trials.

Adjust LCD Brightness: This setting brightens or darkens the display screen for all applications.

At the Configuration screen, simply touch along the LCD Brightness Bar Scale until the desired display brightness is achieved. The left end of the scale is darkest; the right end of the scale is lightest.

At the Configuration screen, simply touch along the Tone Volume Bar Scale until the desired level is achieved. The left end of the scale is least loud; the right end of the scale is most loud.

Select Measure Units or Printer Resolution These setting are simple toggle choices. Simply touch the desired parameter to view the choices, and then touch the setting you want to select.

• Measure Units: Metric or US
• Printer Resolution: normal or high

m-CTSIB Default Settings
(See Figure 9.3.)

![m-CTSIB Defaults](image)

Figure 9.3. The m-CTSIB Defaults screen.
At the Default Settings screen, users can set which conditions of the CTSIB they want as defaults for testing as well as the ability to enter in or change Sway Index Goals. Default settings can be restored to the “factory” defaults by pressing Restore Defaults.

**Changing The CTSIB Default Conditions**
1. At the Configuration Screen, touch <Default Settings>. The Default Settings screen should now be displayed.
2. Touch the conditions you want as defaults. The selection will be highlighted.
3. Touch <Ok> to save and return the Configuration screen.

**Adjusting The Sway Index Goals**
1. At the Configuration Screen, touch <Default Settings>. The Default Settings screen should now be displayed.
2. Touch the goal value to you wish to adjust.
3. Use the <▲> or <▼> arrows to increase or decrease the value displayed.
An Entry Access Code provides a level of security to all default settings.

Secure Code: Enabling this would require the 781 code to be entered each time the device is turned on. This provides some level of security.

PATIENT MANAGEMENT
(See Figure 9.5.)

At the System Utilities screen, touch <Patient Management > and then enter 781 in response to the “Enter Access Code” prompt. Touch <OK>. The Patient Management screen should now be displayed. This screen shows a listing of patient and associated saved test and training sessions along with the date performed. Use the <▲> or <▼> arrows to scroll through the list of patient tests.

NOTE: Patient data storage is close to 2 MB. That should be enough storage for 200 patient tests.
Figure 9.6. The Patient Management screen.

View Test Results

To view the results of any test displayed simply touch the desired entry on the Patient Management screen to produce an on-screen report.

Repeat (recalls a patient for a test or exercise session)

To repeat any saved test or exercise session, touch <Repeat> on the on-screen report. The system will return to the appropriate test or training Position Patient screen with the position values for foot and heel reflecting the selected session. The selected name, age and height of the selected patient will also be recorded with the new test or training session if you save at completion.

Figure 9.7. Limits of Stability test results.
Print Test Results
To print test results for any patient, touch the desired test to generate an on-screen report then touch <Print> to print the test results.

Single Patient Export
To export the results of any saved test, touch <Export Data>. The data will immediately be sent to the export program.

Single Patient Delete
Although the BioSway can store hundreds of CTSIB patient tests, more patients if you do less CTSIB conditions, you may want to decrease the number of stored records from time to time. To delete any full page display of saved reports, touch <Delete>. Respond <OK> to the delete prompt. The page displayed will be deleted from the display memory. The delete function only works with pages; you cannot select a specific test or patient to delete without deleting every test and patient displayed on the screen.

Multiple Patient Export
(See Figure 9.8.)

NOTE: This process requires Patient Data Export Software. Install the software as per instructions and connect the serial interface cable from the BioSway display to the target computer. The program allows both multiple and single patient export. In addition to exporting any single patient record, multiple patient records can be exported.

1. At the Patient Management screen touch <Multiple Export> to export multiple patient records. The Multiple Patient Data Export screen should now be displayed.
2. Four options are available for multiple export: all (export all patient records); prior-to (export all patient records prior to selected date); from (delete all patient records after a selected date); and from-to (export all records between selected dates.) Touch <Options> until the desired option is displayed.

• For prior-to and from-to, touch the date displayed to advance to the date screen. Touch the date section to change and use the arrows to adjust.

3. Touch <Export Now> to export the selected patient files.

Figure 9.8. The Multiple Patient Data Export screen.
Multiple Patient Delete
In addition to deleting any single patient record, multiple patient records can be deleted.

1. At the Patient Management screen touch <Multiple Delete> to delete multiple patient records. The Multiple Patient Data Delete screen should now be displayed.
2. Three options are available for multiple delete: all (delete all patient records); prior-to (delete all patient records prior to selected date); and from-to (delete all records between selected dates). Touch <Options> until the desired option is displayed.
   • For prior-to and from-to, touch the date displayed to advance to the date screen. Touch the date section to change or use the arrows to adjust.
3. Touch <Delete Now> to delete the selected patient files.

CUSTOM PROTOCOL LIST AND CREATING CUSTOM PROTOCOLS
(See Figures 9.9 – 9.12.)

Custom protocols are organized as those for Training and those for Testing. Creating protocols are the same for either case.

1. Select <Create Protocol>.
2. Select from screen either Training or Testing.
3. However you create this protocol, whether testing or training by setting the various options or placing targets, it will be saved under whatever name you provide. The protocol can then be recalled exactly as stored for reuse as a custom protocol.

![Custom Protocol List](image)

**Figure 9.9.** Protocols will be organized as Custom Training Protocols and Custom Testing Protocols. They will be listed under the name that was assigned.
Figure 9.10. Custom protocols can be organized under Training or Testing.

Figure 9.11. The Training Custom Protocols list. Note that all target placements and goal settings are saved and recalled for custom protocols.
Figure 9.12. The Postural Stability Training Protocol Set-Up.

NOTE: All target placements and goal settings are saved and recalled for custom protocols.
## 10. COMPATIBLE PRINTERS AND COMPONENT PART LIST

### COMPATIBLE PRINTERS*
PCL printers specifically
- HP H470
- HP 6000
- HP6940
- HP6940dt
- HP6988
- HP9800
- HP5400
- HPD5360
- HP5650
- HP5550

### COMPATIBLE POINTING DEVICES*

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<td>Seal Shield</td>
<td>SSMKV5</td>
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<td>Targus</td>
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<td>Dell</td>
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### COMPATIBLE KEYBOARDS*

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<td>Keyboard</td>
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<td>Adesso</td>
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<td>Adesso</td>
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<td>Adesso</td>
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</table>

* Printers and other devices are subject to market availability. Please check with Biodex customer service if questions arise.
BALANCE SYSTEM CLINICAL TEST OF SENSORY INTEGRATION AND BALANCE (CTSIB) SWAY INDEX EQUATION

TEST DESCRIPTION
The objective of this test is to quantitatively determine a score defining a patient’s ability to maintain a stable vertical posture while positioned on a stationary platform. The patient is positioned on a stable platform and instructed to try to maintain a stable vertical posture under a variety of sensatory conditions, eyes open, eyes closed, and vision partially obscured.

EQUIPMENT DESCRIPTION
Sway information is collected by positioning the patient on a static force plate and then sampling and recording patient movement. The system employs a series of strain gauges to determine variation in the subject’s resultant center of pressure (COP). The center of pressure is the patient’s center of gravity projection on the platform resulting from sway angle and the patient height. Data is sampled at the rate of 20Hz. Each recorded sample consists of a (X, Y) coordinate. What is displayed is the sway angle derived from the position of the COG from zero and the height of the patients COG taken as .55 times the patient height.

This data is recorded for later analysis and also displayed, in real time on, an LCD display observable by the patient. The resultant movement results in a “spaghetti plot” as shown below. This plot indicates patient movement from one sample to the next.

Essentially, the database consists of an array of (X, Y) coordinates defining the calculated COP. The data can be interpreted as an ordered series of sequential vectors from point to point.

For example:  \[(X_0, Y_0)\]  
\[(X_1, Y_1)\]  
\[(X_2, Y_2)\]  
...........  
...........  
\[(X_n, Y_n)\]

The “Score” is defined as the standard deviation of position over the length of the test. The Standard deviation is interpreted to be the absolute vector length deviation from the mean vector end point. Basically, all vectors (X,Y) coordinates are summed and divided by the number of samples, to obtain a vector sum which represents the position of the mean.

\[
\sigma_x = \frac{1}{N} \sum_{n=0}^{N-1} X_n
\]

\[
\sigma_y = \frac{1}{N} \sum_{n=0}^{N-1} Y_n
\]

and

\[
\phi = \sqrt{\frac{1}{N} \sum_{n=0}^{N-1} ((X_n-\sigma_x)+(Y_n-\sigma_y))^2}
\]
BIOSWAY RELIABILITY AND CTSIB NORMATIVE DATA

BioSway Reliability and CTSIB data were collected from 100 randomly recruited people. All test subjects were healthy, active, working people. Medical history was recorded via a confidential questionnaire. The testing and protocol followed IRB approval and was performed on site.

In addition to the CTSIB, all 100 recruits participated in a Timed Get up and Go (TUG) and Gait Speed assessment. The TUG and Gait Speed tests are accepted tests for Balance assessment. The reason for doing the additional tests with the CTSIB was to strengthen the results when a positive correlation is made between the three accepted standardized assessments. Subjects were tested initially then again 2 weeks later. A third follow test was administered 3 months later on 27 of the original 100 subjects. This third test was to negate any learning effect in the initial test-retest (given they were done consecutively with less than 2 weeks between trials).

Descriptive Statistics

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<th></th>
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<th>Minimum</th>
<th>Maximum</th>
<th>Mean</th>
<th>Std. Deviation</th>
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<tr>
<td>Height (meters)</td>
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<tr>
<td>Weight (KG)</td>
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<td>12.50</td>
<td>44.60</td>
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<tr>
<td>Valid N (listwise)</td>
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<td></td>
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</table>

Reliability: The resultant ICC is .81, which is considered acceptable.

Intraclass Correlation Coefficient

<table>
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<th>95% Confidence Interval</th>
<th>F Test with True Value 0</th>
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<td>Upper Bound</td>
<td>Value</td>
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<tr>
<td>Single Measures</td>
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<td>.573</td>
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<tr>
<td>Average Measures</td>
<td>.801</td>
<td>.729</td>
</tr>
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</table>

Two-way mixed effects model where people effects are random and measures effects are fixed.

- Type C intraclass correlation coefficients using a consistency definition-the between-measure variance is excluded from the denominator variance.
- The estimator is the same, whether the interaction effect is present or not.
- This estimate is computed assuming the interaction effect is absent, because it is not estimable otherwise.

CTSIB Normative Sway Index ranges are:

- Condition 1: Eyes Open firm surface: .21-.48
- Condition 2: Eyes closed firm surface: .48-.99
- Condition 3: Visual conflict firm surface: .46-.88
- Condition 4: Eyes Open foam surface: .38-.71
- Condition 5: Eyes Closed foam surface: 1.07-2.22
- Condition 6: Visual conflict foam surface: .84-1.47
MOVEMENT STRATEGIES FOR BALANCE, SENSORY ORGANIZATION, AGE-RELATED CHANGES IN BALANCE AND CTSIB TEST RESULT INTERPRETATION.

MOVEMENT STRATEGIES FOR BALANCE (Robertson)
According to the Systems Approach to motor control, the nervous system uses preprogrammed strategies or synergies to simplify movement. The central nervous system (CNS) takes advantage of pathways that link together groups of muscles in a flexible and repeatable sequence. This linking or packaging of muscle groups allows the brain to respond to an infinite variety of circumstances by drawing on muscle responses that have been successful in the past. This linking or packaging of muscles in a repeatable sequence is called a movement strategy.

Utilizing a movement strategy simplifies the way the nervous system accesses a motor reaction in response to sensory input. Strategies are automatic reactions that have evolved over time, taking into account biomechanical and environmental constraints. Strategies that are successful for maintaining balance are stored so that the CNS is not forced to start from scratch each time a loss of balance occurs. Strategies are automatic reactions, slower than reflexes but much faster than voluntary movements. Three anterior-posterior movement strategies have been identified: the ankle, hip and stepping strategies.

Ankle Strategy
The nervous system employs the ankle strategy in response to small losses of balance and to adjust balance in quiet standing. The ankle strategy is also called ankle sway and uses the length of the foot as a lever to correct for minor losses of balance. In the ankle strategy, activation of the leg muscles is from the floor up or distal to proximal. A small loss of balance in the forward direction causes contraction of the gastrocnemius, hamstrings, and lower-back muscles, in that order, to bring the body back into balance.

A small loss of balance in the backward direction causes contraction of the anterior tibialis, quadriceps, and lower abdominal muscles, in that order, to bring the body back into balance. Our bodies are constantly using this strategy to adjust for minor losses of balance. For example, you would use the ankle strategy to maintain balance when standing on a bus, to correct for losses of balance and to prevent yourself from falling as the bus changes speed. You might also use the ankle strategy to maintain your balance on a very soft surface such as thick grass or a piece of foam.
Hip Strategy
The hip strategy describes movement about the hip in response to larger losses of balance or when the support surface does not allow the use of the ankle lever, such as on an icy surface or when the surface is shorter than the length of the foot. In the hip strategy, activation of muscles is from the trunk down, or proximal to distal. A loss of balance in the forward direction causes contraction of the lower-back and hamstring muscles, in that order, to regain balance.

When the hip strategy is used, the muscles of the lower leg (anterior tibialis and gastrocnemius) are almost silent. Studies have shown that when a walker is used, the body largely abandons the ankle strategy and relies heavily on the hip strategy for balance. This dependence on the hip strategy for balance paradoxically may lead to a decrease in ankle sway and contribute to further decline in balance arising from loss of ankle strength and flexibility. For this reason the pros and cons of walker use must be carefully considered before a walker is recommended for fulltime use.

Stepping Strategy
The third strategy employed by the nervous system for balance is the stepping strategy. This strategy is used when the loss of balance exceeds the area of stability and the person is forced to step or fall.

SENSORY ORGANIZATION FOR BALANCE
Perhaps the most confusing part of a balance evaluation is the part that examines the sensory system and its contribution to balance. The sensory system includes the eyes, ears, vestibular apparatus (inner ear), somatosensory system (touch and proprioception), taste, and smell. The parts of the sensory system that contribute directly to balance are the visual, vestibular, and somatosensory (touch and proprioception) systems. The use of multiple systems in balance allows us to learn new movements quickly and to fine-tune and easily repeat familiar movements.

The sensory system receives input from the environment through specialized receptors located in the sensory end-organs in the eyes, vestibular apparatus of the inner ear, muscle spindles, Golgi tendon organs, and touch receptors in the skin. Sensory input is transmitted to the spinal cord via afferent nerve fibers and then to the brain via spinal nerve tracts such as the spinothalamic tract (pain and temperature) and the dorsal column medial lemniscal tract (fine touch, muscle and tendon position sense).

Sensory input provides a continuous flow of information to the CNS, which in turn utilizes this incoming information to make decisions about movement. The CNS sifts, compares, weighs, stores, and processes sensory input and uses this information to alter the force, speed, and range of a movement.

Vision
Vision is a critical part of our balance system. It allows us to identify objects and determine their movement and tells us where we are in relation to other objects (object-to-object orientation). When we use vision to gather information about the position of our body in the environment or to determine the position of one body part vis à vis another, then vision is providing proprioceptive information to the CNS as well (visual proprioception).

Vision works in conjunction with the vestibular system, comparing information about velocity and rotation from the vestibular system with actual visual information. The visual system is a combination of both central and peripheral vision, although some research has suggested that peripheral vision is more important for postural control and balance than central vision (Shumway-Cook & Woollacott, 2001).
The visual system may provide inaccurate information to the nervous system. For example, a person sitting at a stoplight in a car may think she has started to move when the car next to her starts to move. The visual system “goes along” with the movement of the neighboring car and tells the brain that both cars are moving. The CNS mediates this sensory conflict by instructing the leg to slam on the brake to stop the car from moving forward. As soon as the foot touches the brake the somatosensory and vestibular systems realize that the car is, in fact, not moving. For a split second, input from the visual system was given preference by the brain, even though the information turned out to be inaccurate.

Visual input may also be inaccurate due to diseases or disorders that affect the visual system, such as diabetic retinopathy, cataracts, macular degeneration, injuries, or stroke.

**Vestibular Input**
The vestibular system is responsible for processing information about movement with respect to gravity — specifically, rotation, acceleration/deceleration, and head stabilization during gait. The vestibular system works in conjunction with the visual system to stabilize the eyes and maintain posture during walking (vestibular-ocular reflex). Vestibular disorders cause a feeling of dizziness and unsteadiness. Vestibular dysfunction also affects the ability of the CNS to mediate intersensory conflicts such as that in the example given above.

**Somatosensory Input**
Somatosensory input consists of touch and proprioception. Input from these two sensory sources provides critical feedback to the CNS regarding positioning in space, body sway, and changes in terrain. The sensory input from touch and proprioception allows the muscles to make constant, automatic adjustments to maintain balance and avoid falls.

In the example where the person in the stationary car slams on the brake, only to realize through somatosensory input that her car has not moved, the feeling that the car is moving when it is not is an example of a visual intersensory conflict; the conflict is resolved quickly by pressing on the brake and feeling that the car has not moved.

**Sensory Disorganization**
The loss or disruption of sensory input in the visual, vestibular, and/or somatosensory systems can affect balance in a number of ways. How balance is affected depends on several factors, including the extent of the nervous system damage, the number and extent of sensory losses, and the availability of the other senses for compensation. In many instances, more than one sensory system is impaired, as in the case of a person with a peripheral neuropathy and visual impairment (common with diabetes and stroke). But, just as an individual with impaired vision develops a keener sense of hearing, a person with any sensory loss will attempt to compensate by using the unaffected or less-affected senses to improve balance.

**Sensory Loss**
The way balance is affected by loss of sensory input depends on the extent and nature of the sensory loss. Recall that the senses most associated with balance are somatosensory (touch and proprioception), visual, and vestibular. Of these, the somatosensory system plays the biggest role in balance, so losses associated with peripheral neuropathies, stroke, and other neurologic disorders can have a profound effect on balance.

A person with sensory loss (eg, bilateral lower-leg peripheral neuropathy) who does not receive normal sensory input from the sensory receptors in the feet and ankles will attempt to compensate by depending more on visual and vestibular input for balance. If there is significant sensory loss in the feet, a person will be unable to adjust easily to changes in the support surface during tasks such as walking on grass or uneven surfaces, or even walking in shoes with soft soles.
A person with impaired vision from a stroke or cataracts will depend less on vision and more on touch and vestibular feedback for balance. In this case, choice of assistive device, hand railings for touch, and proper lighting are important. A person with a visual impairment may perform well in a clinical setting but have difficulty with balance in more complex visual situations that demand rapid visual interpretation of multiple visual cues. For example, a person may be safe walking in a quiet, well-lit hallway but be unable to negotiate a busy, noisy hallway filled with people and equipment.

Vestibular damage or loss can also have a profound effect on balance and postural control. Vestibular impairment can cause problems with gaze stabilization, including blurred vision, problems with balance and posture, and vertigo (Shumway-Cook & Woollacott, 2001).

**Improper Sensory Selection**

Sensory loss may lead to inflexible or improper sensory weighting. A person may depend on one particular sense for postural control even if that sense leads to further instability (Shumway-Cook & Woollacott, 2001). You may notice a person walking with head down, carefully watching every step. In this case, vision is the dominant sense being used for balance. Retraining would involve improving the use of somatosensory and vestibular input to reduce dependence on visual input.

**Abnormal Internal Representations**

Individuals’ perceptions of their limits of stability are difficult to assess and understand. Illness and injury, including stroke, clearly affect confidence and may alter perceived stability limits. A person’s stability may be affected by fear of falling, even when the physical ability exists to perform a task safely. Conversely, individuals may not have an accurate idea of the limits of their stability and thus have little warning when loss of stability is occurring, leading to falls.

**Sensorimotor Adaptation**

The nervous system has a powerful ability to compensate for actual or perceived disabilities. Once an injury has occurred, the nervous system immediately goes to work attempting to compensate for neurologic changes, weakness, and loss of function. But the brain doesn’t always choose the best (or even a good) compensation; it chooses the fastest and most efficient in an attempt to continue functioning. One of the immediate goals of therapy is to help the nervous system develop strategies and compensations that minimize musculoskeletal damage and maximize function.

**AGE-RELATED CHANGES IN BALANCE**

Many changes in balance relate to normal aging. Some changes (i.e., slowed gait, decrease in lower-extremity strength, decreased ROM) can be easily addressed with a daily exercise program. Other changes (i.e., declining visual ability, including loss of visual acuity, declining visual fields, light-dark adaptation, increased sensitivity to glare, loss of peripheral vision and depth perception) are more complex and may require assessment by another healthcare professional such as an optometrist or ophthalmologist.

Age-related changes in balance are the result of changes in every system in our bodies. Neurologic changes include slowed response to losses of balance, decreased righting responses, and abnormal sensory selection or weighting (i.e., overuse of vision or underuse of proprioception). Orthopedic changes include loss of ankle sway, leading to an increase in the use of the hip and stepping strategies and lower-foot swing height. Psychomotor changes include loss of confidence (changes in the perceived limits of stability) and a propensity to fall in new or novel situations, perhaps due to impaired anticipatory mechanisms. Sensory changes include abnormal sensation (i.e., peripheral neuropathies, abnormal tone, effects of drugs, visual disturbance such as hemianopsia) and a reduction in the function of the vestibular system of the inner ear (Shumway-Cook and Woollacott, 2001).
CTSIB TEST RESULT INTERPRETATION (Neurocom)
The CTSIB is the Clinical Test for Sensory Integration and Balance. The CTSIB is the standard
test for differentiating balance problems as a result of visual, vestibular or somatosensory

The CTSIB uses 4 conditions to test contribution of visual, vestibular and somatosensory inputs:

1. Eyes Open, firm surface: This is the baseline condition. Accurate information is available to all
   three sensory systems: visual, vestibular and somatosensory. Normal individuals are very stable in
   this condition.

2. Eyes Closed, Firm surface: No visual input is available. The Patient must rely on somatosen-
   sory and vestibular inputs. Somatosensory is the primary sensory input. Vestibular inputs are
   secondary. High sway scores are indicative of problems with somatosensory. In normal indi-
   viduals there is no significant difference in sway with eyes open or closed on a firm surface.

3. Eyes Open, Unstable (foam) surface. The unstable surface confounds the somatosensory
   information as it imposes additional challenges to the musculoskeletal system. Primary inputs
   are visual with vestibular as secondary. Normal individuals will sway more on the unstable sur-
   face, but will not fall.

4. Eyes Closed, Unstable (foam) surface: This condition focuses on the vestibular sensory input as
   visual is not available and somatosensory is challenged by the unstable surface. Again nor-
   mal individuals will sway more on the unstable surface, but will not fall.

To interpret or apply the test results consider under what condition was sway the greatest?

Normal balance includes the ability to hold still in various situations depending on the activity
or circumstance demands. The COG sway scores indicate how well the patient accomplished
this. Lower scores reflect little movement which are consider better than higher scores which
reflect more movement.

Firm Surface: Eyes Open vs. Eyes Closed
Normal individuals standing on a firm surface have similar amounts of sway with eyes open or
closed. On a firm surface, when significantly more sway is present with eyes closed then the
patient maybe having difficulty using somatosensory inputs (this is the input up from the feet). An ankle strategy should be used for primary balance control on a firm surface.

Unstable (Foam) Surface: Eyes Open vs Eyes Closed
With Eyes open on an unstable surface, normal individuals have significantly more sway then
when standing on a firm surface. And even more sway on the unstable surface with their eyes
closed. However – they do not become overly unstable or fall. Patients that do become unstable
or fall when standing on foam with eyes open may have difficulty using visual information for
balance control and/or may have lower extremity musculoskeletal problems. A hip strategy
should be used on unstable surfaces.

NOTE: These tests are targeting sensory integration deficits. Standing on an unstable surface presents
biomechanical and musculoskeletal challenges. Patient with ankle or foot problems, joint weakness or pain
will have high scores. As such in these patients it can not be assumed that sensory abnormalities are the
underlying cause, as they can not be distinguished from motor (musculoskeletal) issues. Ideally patient
should be screen for motor problems prior to the CTSIB test. Only patients without motor problems
should be tested with the CTSIB. The LOS test is an effective test to tease out this question.
References


Foot Placement Reference
ADDITIONAL NOTES ABOUT CTSIB REPORT INTERPRETATION

The CTSIB result presentation is easy to understand and communicate if you keep the following points in mind:

1. A description of the relationship of the test condition to the sensory system is provided when the m-CTSIB protocol format of 4 conditions is used. Space limitations preclude the description for 6 conditions. The 4 condition m-CTSIB test is the preferred test protocol.
2. The results are presented relative to the upper limit of the “normal” reference data. Patient results will either be better, equal to or worse than normal. The higher the Sway Index score, the more unstable the patient was for the condition. Total instability, where a patient must hold onto something or stop, is considered a fall and is noted as “Fell” in the test results.
3. The number at the midpoint of the scale is the upper limit of the normal score, rounded to the nearest .25. For example:
   - Eyes open firm high value is .48. The noted value is .50
   - Eyes closed firm high value is .99. The noted value is 1.0
   - Eyes open foam high value is .71. The noted value is .75
   - Eyes closed foam high value is 2.22. The noted value is 2.25
4. The end point for the RED zone is three times the mid point or, basically, three standard deviations from the mid point.

![m-CTSIB Test Results](Figure D1: The m-CTSIB Test Results screen.)
Figure D.2: These results indicate the patient was very unstable in the conditions with Eyes closed. They could not complete the test and as such the condition is noted as “Fell.”

Figure D.3: This is the screen from the Configuration area that allows for the Sway Index Goal to be entered. The values noted as defaults are the factory defaults from our existing normative data.

**NOTE:** Values entered or shown as goals will be rounded to nearest .25, as the goal shown in the midpoint of the report scale.
A NOTE ABOUT CTSIB REPORT INTERPRETATION.
Normal individuals have significantly more sway when standing on a foam surface versus a firm surface with eyes open, and even more sway on foam with eyes closed. However they do not become unstable or fall. Patients who become unstable or fall when standing on foam with eyes open may have difficulty using visual information for balance control and or they may have lower extremity musculoskeletal problems, which make it difficult to stand on the foam or compensate for the unstable surface.

NOTE: Caution should be used when interpreting the CTSIB test results. The test is assumed to reflect sensory integration deficits. However, standing on the foam surface provides a biomechanical challenge as well as a sensory one. Patients with ankle or foot weakness, joint restrictions, or pain will have difficulty standing steadily on the foam and will produce high sway scores. In these patients it is not valid to assume sensory abnormalities are the sole cause of abnormally increased sway. Sensory problems may be present, but cannot be distinguished from the motor problems. Ideally patients should be screened for motor problems (central and musculoskeletal) prior to administration of the CTSIB. Only in patients without motor involvement can increased sway clearly be assumed to indicate sensory system deficits. One effective way to screen for motor deficits is to administer the LOS test prior to the CTSIB test, as the LOS test measures voluntary movement.

CONFORMANCE TO STANDARDS

This equipment conforms to the following safety standards:

<table>
<thead>
<tr>
<th>Standard</th>
<th>Edition and/or date</th>
</tr>
</thead>
</table>

*Table 1.1 Safety standards*

Accompanying EMC Documents

This medical electrical equipment needs special precautions regarding EMC and needs to be installed and put into service according to the EMC information provided in this manual.

- Portable and mobile RF communications equipment can affect medical electrical equipment.
- Use of accessories, transducers and cables other than those specified, with the exception of accessories, transducers and cables sold by the manufacturer of this equipment, as replacement parts for internal and external components, may result in increased emissions or decreased immunity of the equipment.
- The BioSway Balance system should not be used adjacent to or stacked with other equipment. If the BioSway Balance system is used while positioned adjacent to other equipment, it should be observed to verify normal operation in the configuration in which it will be used.

List of Cable Accessories

The list in Table 1.2 includes all accessory cables supplied with the BioSway Balance system for which the manufacturer of this equipment claims compliance to EN 60601-1-2 when used with the BioSway Balance system.

<table>
<thead>
<tr>
<th>Cable Description</th>
<th>Part No.</th>
<th>Cable Length</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power cable</td>
<td>Biodex # C13154</td>
<td>6ft</td>
</tr>
<tr>
<td>Data cable</td>
<td>Biodex # C13141</td>
<td>10ft</td>
</tr>
</tbody>
</table>

*Table 1.2 BioSway Balance cables*
DECLARATION OF CONFORMITY

Emissions

Manufacturer's declaration electromagnetic emissions

The BioSway Balance is intended for use in the electromagnetic environment specified below. The customer or the user of the BioSway Balance system should assure that it is used in such an environment.

<table>
<thead>
<tr>
<th>Emission test</th>
<th>Compliance</th>
<th>Electromagnetic environment</th>
</tr>
</thead>
<tbody>
<tr>
<td>RF emissions</td>
<td>Group 1</td>
<td>The BioSway Balance system generates RF energy only for its internal functions. Therefore, its RF emission is very low and is not likely to cause any interference in nearby electronic equipment.</td>
</tr>
<tr>
<td>CISPR 11</td>
<td>Class A</td>
<td>The BioSway Balance system is suitable for use in all establishments other than domestic and those directly connected to the public low-voltage power supply network supplying buildings used for domestic purposes.</td>
</tr>
<tr>
<td>Harmonic distortion</td>
<td>Class A</td>
<td></td>
</tr>
<tr>
<td>EN 61000-3-2</td>
<td>Complies</td>
<td></td>
</tr>
<tr>
<td>Voltage fluctuations and flicker</td>
<td></td>
<td></td>
</tr>
<tr>
<td>EN 61000-3-3</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Immunity

Manufacturer's declaration electromagnetic immunity

The BioSway Balance is intended for use in the electromagnetic environment specified below. The customer or the user of the BioSway Balance system should assure that it is used in such an environment.

<table>
<thead>
<tr>
<th>Immunity test</th>
<th>IEC 60601-1-2 Test level</th>
<th>IEC 60601-1-2 Compliance level</th>
<th>Electromagnetic environment – guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electrostatic discharge (ESD)</td>
<td>± 6 kV contact</td>
<td>Contact ± 6 kV</td>
<td>Floor should be wood, concrete or ceramic tiles. If floor is covered with synthetic material, the relative humidity should be at least 30%</td>
</tr>
<tr>
<td>IEC 61000-4-2</td>
<td>± 8 kV air</td>
<td>Air ± 8 kV *</td>
<td></td>
</tr>
<tr>
<td>Electrical fast transients/burst</td>
<td>± 2 kV for power lines</td>
<td>Power ± 2 kV</td>
<td>Mains power quality should be that of a typical commercial or hospital environment</td>
</tr>
<tr>
<td>IEC 61000-4-4</td>
<td>± 1 kV for input/output lines</td>
<td>Signal ± 1 kV</td>
<td></td>
</tr>
<tr>
<td>Surge</td>
<td>± 1 kV differential mode</td>
<td>± 1 kV diff. mode</td>
<td></td>
</tr>
<tr>
<td>IEC 61000-4-5</td>
<td>± 2 kV common mode</td>
<td>± 2 kV com. mode</td>
<td></td>
</tr>
</tbody>
</table>

* Reference test results for details
<table>
<thead>
<tr>
<th>Immunity test</th>
<th>IEC 60601-1-2 Test level</th>
<th>IEC 60601-1-2 Compliance level</th>
<th>Electromagnetic environment – guidance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Voltage dips, short interruptions and voltage variations on power supply input lines</td>
<td>&lt;5% UT (&lt; 95% of dip in UT) for 1/2 cycle 40% UT (60% of dip in UT) for 5 cycle 70% UT (30% of dip in UT) for 25 cycle &lt;5% UT (&gt; 95% of dip in UT) for 5 sec</td>
<td>&lt;5% UT (&lt; 95% of dip in UT) for 1/2 cycle 40% UT (60% of dip in UT) for 5 cycle 70% UT (30% of dip in UT) for 25 cycle &lt;5% UT (&gt; 95% of dip in UT) for 5 sec</td>
<td>Mains power quality should be that of a typical commercial or hospital environment. If a better mains power quality is required, it is recommended that the BioSway Balance is powered from an uninterruptible power supply</td>
</tr>
<tr>
<td>Power frequency (50/60 Hz) magnetic field</td>
<td>3 A/m</td>
<td>3 A/m</td>
<td>If image distortion occurs, it may be necessary to position the BioSway display further from sources of power frequency magnetic fields or to install magnetic shielding. The power frequency magnetic field should be measured in the intended installation location to assure that it is sufficiently low</td>
</tr>
<tr>
<td>Conducted RF IEC 61000-4-6</td>
<td>3 Vrms, 150 KHz to 80 MHz</td>
<td>3 Vrms, 150 KHz to 80 MHz</td>
<td>Portable and mobile RF communications equipment should be used no closer to any part of the BioSway Balance, including cables, than the recommended separation distance calculated from the equation applicable to the frequency of the transmitter. Recommended separation distance: [ d = 1.2\sqrt{P} \text{ m} ] where ( P ) is the maximum output power rating of the transmitter in watt (W) according to the transmitter manufacturer, and ( d ) is the recommended separation distance in meters (m). Field strengths from fixed RF transmitters, as determined by an electromagnetic site survey, should be less than the compliance level in each frequency range. Interference may occur in the vicinity of equipment marked with the following symbol:</td>
</tr>
<tr>
<td>Radiated RF IEC 61000-4-3</td>
<td>3 V/m, 80 MHz to 2.5 GHz</td>
<td>3 V/m, 80 MHz to 2.5 GHz</td>
<td>See Risk Analysis Report *</td>
</tr>
</tbody>
</table>

Note 1. UT is the a.c. mains voltage prior to application of the test level.
Note 2. At 80 MHz and 800 MHz, the higher frequency range applies.
Note 3. These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflections from structures, objects and people

* Field strength from mixed transmitters, such as base stations for radio telephones and land mobile radios, amateur radio, AM or FM broadcast and TV broadcast cannot be predicted theoretically with accuracy. To assess the electromagnetic environment due to fixed RF transmitters, an electromagnetic site survey should be considered. If the measured field strength in the location in which the BioSway Balance is used exceeds the applicable RF compliance levels above, the BioSway Balance should be observed to verify normal operation. If abnormal performance is observed, additional measures may be necessary, such as reorienting or relocating the BioSway Balance system.

* Over the frequency range 150 KHz to 80 MHz, field strengths should be less than 3 V/m.

*Reference test results for details
RECOMMENDED SEPARATION DISTANCES

<table>
<thead>
<tr>
<th>Rated maximum output power of transmitter [W]</th>
<th>Separation distance according to frequency of transmitter [m]</th>
<th>150 kHz to 80 MHz</th>
<th>80 MHz to 800 MHz</th>
<th>800 MHz to 2.5 GHz</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.01</td>
<td>d = 1.2√P</td>
<td>0.12</td>
<td>0.12</td>
<td>0.23</td>
</tr>
<tr>
<td>0.1</td>
<td></td>
<td>0.38</td>
<td>0.38</td>
<td>0.73</td>
</tr>
<tr>
<td>1</td>
<td></td>
<td>1.2</td>
<td>1.2</td>
<td>2.3</td>
</tr>
<tr>
<td>10</td>
<td></td>
<td>3.8</td>
<td>3.8</td>
<td>7.3</td>
</tr>
<tr>
<td>100</td>
<td></td>
<td>12</td>
<td>12</td>
<td>23</td>
</tr>
</tbody>
</table>

For transmitters rated at a maximum output power not listed above, the recommended separation distance d in meters (m) can be estimated using the equation applicable to the frequency of the transmitter, where P is the maximum output power rating of the transmitter in watts (W) according to the transmitter manufacturer.

Note 1. At 80 MHz and 800 MHz, the separation distance for the higher frequency range applies.

Note 2. These guidelines may not apply in all situations. Electromagnetic propagation is affected by absorption and reflection from structures, objects and people.

Operating Temperature
Do not expose the equipment to a temperature change of more than 5° F (3° C) per hour. Limits of low and high operating temperature ranges are 59° to 86° F (15° C to 30° C).
CLEANING AND MAINTENANCE

GENERAL MAINTENANCE
The Biodex BioSway requires only the most basic general maintenance, performed on an as-needed basis at least every three to four months.

CLEANING INSTRUCTIONS
With the system turned OFF, wipe down all surfaces with a damp cloth. Mild soap and water can be used to remove stains and scuff marks. As needed, inspect all locking and adjustment mechanisms for signs of wear or damage.

If you have any questions or need further assistance, contact the Biodex Customer Service Department.

⚠️ CAUTION: Some steps of these procedures require the BioSway to be turned ON. When this is the case, use extreme caution working on the system.

⚠️ ATTENTION: Certaines étapes de la présente marche à suivre nécessitent que le système d’équilibre soit mis SOUS TENSION. En pareille circonstance, user de précautions extrêmes dans la manipulation du système.