

Stride Analyzer Manual

Model SA-V

Software Version 5.10

B & L Engineering

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Chapter 1 Introduction

General Overview

The Stride Analyzer is a microprocessor / PC system designed to record foot-floor contact data from footswitches and calculate all the gait parameters obtainable from this data. Patient tests may be performed in any convenient walking area. Permanent records of the gait parameters and foot-floor contact patterns can be printed immediately following each test or later at the user's convenience.

The Stride Analyzer is designed to analyze the following walking parameters:

| | |
|----------------------------|-------------------------|
| Velocity | Swing |
| Cadence | Stance |
| Stride Length | |
| Gait Cycle | Initial Double Support |
| | Terminal Double Support |
| Single Limb Support | Total Double Support |
| Normal Single Limb Support | |

Data Acquisition Steps

InfraRed (IR) Light Sources should be mounted on the wall (using Velcro strips) at the beginning and end of a measured walkway at the same height as the Recorder on the patient. Please refer to page 2-1 Start / Stop Trigger (3) for important operating instructions.

Place Footswitches on subject/patient.

Place the belt on the subject with the Recorder attached on the subject's lower back - and connect the Footswitches to the Recorder. The Left Footswitch goes into the left side of the Recorder when viewing the LCD Display and keypad.

Make sure you have a properly initialized B&L CompactFlash Memory Card in the Recorder. Be sure to turn OFF the Recorder before inserting or removing the CompactFlash Memory Card.

Turn ON the Recorder. The LCD (Liquid Crystal Display) should show "READY TO OPERATE". If not, then the battery might be dead, or there is no CompactFlash card in the Recorder, or it isn't a valid B&L CompactFlash card.

Check the Footswitches using the Recorder Footswitch Tester Mode, then push the "READY—TRIALS" button.

Instruct the subject to walk the length of the measured walkway. As the subject passes the first light source or the therapist uses the hand-held trigger, the Recorder will "BEEP" and the GREEN LED should blink ON and OFF. The LCD displays T:NNN which increments once per second during data acquisition. Below that is the number of Footswitch changes and current Footswitch pattern in hexadecimal form. If the GREEN LED remains OFF, then the IR light beam did not trigger the Recorder and the test will have to be restarted. The IR detectors in the Recorder worn by the subject should be in view of the IR Light Sources in order to Start / Stop data acquisition in the Recorder.


As the patient passes the second light beam, the Recorder will "BEEP", the GREEN LED should stop blinking (it should turn OFF), and the trial count will increase by 1 on the Recorder. The maximum number of trials that the Recorder can store on one CompactFlash Memory Card is 80. The length (time duration) of each trial can be very long. When the Compact Flash Card is inserted into the

Reader and scanned by the Stride Analyzer Software, there must not be more than 80 trials on the Card. After trials are transferred to the PC, they should be deleted from the Card.

To acquire more trials, go to Step 7, otherwise continue.


First turn OFF the Recorder, then remove the CompactFlash Memory Card and put it into the Reader that is connected to a USB port in the PC. Run the Stride Analyzer program on the PC.

Select **File | Add New Patient...**  and enter the subject's information.

Select **View | Transfer FSW Data...**  and look at the message in the box at the lower right. If it says "CompactFlash Memory Card Not Found" or "Cannot Access CompactFlash", put the appropriate CompactFlash Memory Card in the Recorder which should be plugged into a USB port and try again. If it says "Invalid CompactFlash Memory Card", it needs to be initialized before use. If it says "Found B&L CompactFlash Memory Card", you may proceed.

For each Trial in the list at the left, Left Click on each entry that you want to Remove from the CompactFlash, then click on the Delete Button. Then Left Click on each entry that you want to transfer to the PC in the form of .SA files (or click on CheckAll). Next, if necessary, Right Click on each entry and change the default Distance and Conditions, then Click on OK. Then Click on the Transfer Button. The footswitch data (Footswitch pattern, time in milliseconds times two [500 = 1 second]) will be displayed in the lower right window.

After the data has been transferred, click on the OK Button.

To view all the gait parameters on the screen, select **View | Select Trial...**  Then Double-Click on the desired Trial Name, or Single-Click and then OK. You may view the gait parameters of other trials and print the desired screens.

WARNING: When disconnecting the footswitch cables from the Recorder, grasp the connector on both sides of the knurled section, pinch, and pull straight out. These connectors are "spring loaded" and are designed to come out only when pressure is applied to the opposite sides of the knurled section.

WARNING: Be sure to turn OFF the Recorder before inserting or removing the CompactFlash Memory Card.

Chapter 2 How to...

Set Up Hardware

List of Components

Recorder

Footswitches (5 pairs)

Standard Adult Sizes M-7, M-9, M-11, W-5, W-7

Children's Sizes C-1, C-6, C-11 available

Start / Stop Trigger (3)

InfraRed (IR) Light Source (2)

InfraRed (IR) Hand-Held Trigger (1)

CompactFlash Memory Card Reader with USB Cable

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PC compatible computer, any Microsoft Windows Operating System, and a mouse (Normally provided by the user but required for a complete system).

Recorder

The Recorder uses a 9-Volt **Alkaline** Battery for power. In order to acquire Footswitch Data, a B&L CompactFlash Memory Card must be inserted into the slot at the top of the Recorder. When the Recorder is turned ON, and the LCD will show "READY TO OPERATE".

Recorder Keypads: START and STOP Footswitch data acquisition, Footswitch Tester Mode, Version, Ready / Trials, Beeper, Delete Trial with "Are you sure?" Yes and No.

CompactFlash Memory Card

A CompactFlash Memory Card that has been initialized by B&L Engineering can be inserted into the slot at the top of the Recorder only when the Recorder is turned OFF. When the Recorder is turned ON, the LCD will show "READY TO OPERATE".

The maximum number of trials that the Recorder can store on one CompactFlash Memory Card is 80. The length (time duration) of each trial can be very long. When the Compact Flash Card is inserted into the Reader and scanned by the Stride Analyzer Software, there must not be more than 80 trials on the Card. After trials are transferred to the PC, they should be deleted from the Compact Flash Memory Card.

Footswitches (5 pairs)

The Footswitches are worn as insoles in the subject's shoes or taped to the bottom of bare feet, and indicate the total time each foot is and is not bearing weight. Contacts are provided in the Heel, 5th Metatarsal, 1st Metatarsal, and Great Toe areas to indicate when these areas of the foot are bearing weight. The heel section is separated from the forefoot section so that one pair of switches can accommodate a range of shoe sizes. Each Footswitch is connected to the Recorder by a thin cable.

Start / Stop Trigger (3)

All three of the Start / Stop Triggers are the same, but they can be used in two ways. They can be used as an InfraRed Light Source (mounted on a wall at the beginning and end of measured walkway) or as a Hand-Held Remote Control Trigger.

InfraRed Light Source (2)

The InfraRed (IR) Light Source is a small box that directs a beam of IR light that triggers the Recorder to Start or Stop Footswitch Data acquisition. They should be mounted on the wall at the beginning and end of the measured walkway at the height of the Recorder on the patient. The InfraRed Light Source requires a 9-Volt battery for power.

The RED button is pressed to turn on the IR light – the one that is nearest the RED LED. It will stay ON until it is pressed again to turn it OFF. The RED LED will go ON too. Only leave the InfraRed Light Source ON during a session of data collection. A new 9-Volt battery will last for a few days of continuous use. It is recommended that you turn OFF the Triggers when they are not in use.

As the subject walks past each InfraRed Light Source, the Recorder will BEEP and START or STOP data acquisition. The Recorder is mounted on the belt at the subject's lower back and should be within 5 feet of each Trigger.

Hand-Held Remote Control Trigger (1)

An alternative method of starting and stopping the Recorder is provided in the form of a Hand-Held Remote Control. Hold the Trigger within 6 feet of the Recorder pointing the IR emitter on the end of the Trigger at the IR detector on the Recorder (the small square near the ON-OFF button). Momentarily depressing the WHITE button while the Recorder LCD shows "READY TO OPERATE" or "Trial Count", will START Footswitch Data acquisition. You will hear a "BEEP" when you successfully START and STOP data acquisition. Another momentary push on the WHITE button - which must be at least two seconds after the first signal - will STOP the data acquisition. The purpose of this triggering method is to allow the STRIDE ANALYZER to be used in places other than a designated walkway - i.e. stairs, ramps, out of doors, in households, etc. The Hand-held trigger requires a 9-Volt battery for power.

The WHITE button is pressed momentarily by the operator while pointing the IR diode (the one that is coming out of the end of the trigger) at the Recorder on the subject's back to Start / Stop data acquisition. It is used like the remote control of a television. The RED LED will go ON when the WHITE button is pressed and the 9-Volt battery is good.

CompactFlash Memory Card Reader – USB (Cable is Optional)

The CompactFlash Reader is used to transfer Footswitch Data from the CompactFlash to the PC in the form of .SA files. Plug in the USB Connector into a USB port on the PC and insert the appropriate CompactFlash Memory Card into the Reader.

Set Up Walkway and InfraRed (IR) Light Sources

*The actual distance traveled by the patient during the test must be entered in **View | Transfer FSW Data** dialog box before the data is transferred to the PC.*

Select a convenient walking area at least 10 meters long. For running tests the walkway should be at least 20 meters long. A distance of 2 meters (about 6 feet) for walking tests, or 4 meters for running tests should be available before and after the measured walkway. This distance is necessary to enable the subject to accelerate and decelerate outside the measured test area.

1. For automatic start/stop control, the Light Sources should be placed at the beginning and end of the measured walkway. They should be placed at the height of the Recorder on the patient, perpendicular to the walkway and pointing at the Recorder as the patient walks by. The distance between the Light Sources should be approximately 6 meters for walking and 12 meters for running.


2. For manual start/stop control, measure a walking distance (as above) over which the subject will be asked to walk or run. Clearly mark the beginning and end of this distance. As above, a pre and post walking area must be provided to enable the subject to accelerate and decelerate outside the measured test area.

Install Software


The Stride Analyzer program runs under Microsoft Windows 95, 98, XP, NT, and 2000:

Install Software -- Insert the Stride Analyzer CD in the CD-ROM drive, select **Start | Run**, and browse for the file **SetupSA** on the CD, execute that file, then follow the instructions.

Set Up Patient Information

Before footswitch data can be transferred from the CompactFlash to the Computer, patient information must be added to the database by selecting **File | Add New Patient** . Enter patient information in a dialog box. Three fields are required: Patient I.D., Last Name, and Birth Date. After clicking the OK button, the patient's name will appear in the program title bar near the top of the window.

Set Up Patient with Footswitches and Recorder

Footswitches are the "sensors" of the Stride Analyzer System. The contact areas of each Footswitch must be positioned under the appropriate weight-bearing areas of the foot. When the Footswitch data has been analyzed, it is a good practice to look at the Footswitch Graphics screen (**File | Activities | Footswitch Graphics** ) to verify that the Footswitches are working properly.

Place the proper sized insole Footswitches in the patient's shoes or tape them to the bare foot. Five pairs of Footswitches are provided with the system. Each size can accommodate more than one shoe size because the heel section is separated from the forefoot section, allowing the two sections to be placed closer or further apart.

Anchor each Footswitch into position in its respective shoe with a small piece of tape. The heel section should correspond to the subject's heel and the forefoot section should correspond to the subject's metatarsal heads and great toe. The Footswitches can also be taped to the bare feet, or sweat socks.

The Footswitches are designed to be placed with the cable coming from the outside (lateral side) of the foot. The cable is then routed parallel to the leg up to the waist. Small pieces of tape should be used to anchor the cable to the leg so that it does not hang away from the leg and catch on protruding objects as the subject walks.

Attach the Recorder to the belt around the subject's waist. The Recorder should be placed on the back of the subject with the CompactFlash Memory Card on top. The two Footswitch cables are plugged in to each side.

Plug the right Footswitch into the connector labeled "RIGHT FOOT SWITCH" and the left Footswitch into the connector labeled "LEFT FOOT SWITCH". Care should be taken to align the RED dots on the connectors. **DO NOT FORCE THEM INTO PLACE.** The connectors are "Spring Loaded". To remove them, grasp the connector close to the Recorder and pull straight back. **DO NOT ATTEMPT TO ROTATE THE CONNECTORS.**

Test each Footswitch to verify that each switch is functioning properly. The Recorder's Footswitch Tester Mode is used only to insure that the Footswitches are functioning properly, and is not used during the actual test sequence. The method of using the Footswitch Tester Mode is to rock the foot from heel to 5th to 1st metatarsal to great toe and observe the Recorder's LCD to see that each switch on each foot is functioning properly.

For automatic Start/Stop Control: Turn on the Light Sources at the beginning and end of the walkway.
For manual Start/Stop Control: Use the Hand-Held trigger to Start and Stop Footswitch data acquisition.

Operate the Recorder

Push the Recorder "ON-OFF" button near the lower right corner of the Liquid Crystal Display (LCD) to turn "ON" the Recorder. First you might see "Testing System" on the LCD. If the LCD display shows "READY TO OPERATE", you may acquire FSW data. If the LCD display shows "CF Card ERROR!!", then you must turn OFF the Recorder, then insert a B&L CompactFlash Memory Card, and turn it ON again. If the LCD display shows "BAD Card ERROR! !", the CF Card is not a B&L CF Card. You must turn OFF the Recorder, insert a B&L CompactFlash Memory Card, and turn it ON again. The RED LED indicates an Error Condition.

Start the patient walking approximately 2 meters (4 meters for running) before the beginning of the measured walkway. The patient should pass close enough to the Light Sources so that the Recorder IR Detectors will "see" them as it passes. For manual start/stop control, push the button on the Hand-Held Trigger as the patient passes the first walkway mark and then again as he passes the second mark.

When the first Trigger occurs, the GREEN LED blinks ON and OFF to indicate that Footswitch data is being acquired. The Recorder samples the Footswitches 500 times per second looking for a change. When a change occurs, the Footswitch pattern (8-bits) and the time of the change is stored on the CompactFlash Memory Card. At the second Trigger, the trial counter will increase by 1 on the LCD. When the end of walkway trigger occurs, the GREEN LED turns OFF. The Footswitch data has been taken and the next step is to acquire another trial or transfer data to the computer.

Whenever the Recorder is "ON", the LCD will show some information. If the RED LED goes ON while you are using the Recorder, then the Recorder has encountered an Error Condition or battery voltage is too low and should be replaced. If the LCD does not show any information when the Recorder is turned ON, then the Recorder battery is totally dead and should be replaced. Use a 9-Volt **Alkaline** Battery! A

new 9-Volt Alkaline battery will last for about 3 to 4 hours of continuous use. To increase battery life, turn off the Recorder when not in use.

The maximum number of trials that the Recorder can store on one CompactFlash Memory Card is 80. The length (time duration) of each trial can be very long. When the Compact Flash Card is inserted into the Reader and scanned by the Stride Analyzer Software, there must not be more than 80 trials on the Card. After trials are transferred to the PC, they should be deleted from the Compact Flash Memory Card.

Liquid Crystal Display – Recorder Modes

Version

V011606A

Start – Stop

Start and Stop Footswitch Data acquisition

Footswitch Tester

| <u>DISPLAY</u> | <u>DEFINITION</u> |
|----------------|---|
| TESTER | test each footswitch on each side |
| 5H1T T1H5 | 5 – 5 th Metatarsal H – Heel |
| LEFT RIGHT | 1 – 1 st Metatarsal T – Great Toe |

Ready to Operate – Trial and Memory

TRIALS:
NNN

The maximum number of trials that the Recorder can store on one CompactFlash Memory Card is 80. The length (time duration) of each trial can be very long. When the Compact Flash Card is inserted into the Reader and scanned by the Stride Analyzer Software, there must not be more than 80 trials on the Card. After trials are transferred to the PC, they should be deleted from the Compact Flash Memory Card.

Beeper




Toggle that turns the Beeper ON or turns it OFF.

Delete Last Trial – YES or NO

Delete
Trial: nn

Transfer Footswitch data from CompactFlash to PC – Create .SA files

After Footswitch data has been stored in the Recorder on the CompactFlash Memory Card, the data can be transferred to the PC where .SA files are created (one per trial). With the Recorder turned OFF, remove the CompactFlash Memory Card and insert it into the Reader that is plugged into a USB port on the PC.

Run the Stride Analyzer program. Either select an existing subject in **File | Patient...**  or enter the subject information in **File | Add New Patient...**  Then select **View | Transfer FSW Data...**  The trials found on the CompactFlash will be listed in the window at the upper left. Select (click in the small box) the trials that are to be deleted, then click on the Delete Button. Select (click in the small box) the trials that are to be transferred. **The default Distance in meters and default trial Conditions are copied to all trials listed. Right Click on each trial to change the Distance and/or Conditions.** The Trial Conditions field is used to describe the run, such as, "Free Walk", "Fast Walk", "With AFO", "With Walker", etc. Then click on the Transfer Button.

The Trial Number will be added to the Trial Name Prefix (default is Patient ID) to create the trial filename. The filename should be a unique name such as the patient's initials and sequence number (JS01).

If the Trial Name already exists in the currently selected directory, then a message box will appear asking whether to Overwrite the existing data file. If you click on NO, then you should change the Trial Name Prefix and then click on the Transfer Button again.


Then click on the OK Button.

Analyze Data

When an .SA File is selected in the menu item **View | Select Trial...** , the Footswitch Statistics are displayed on the screen.

Stride Characteristics (text evaluation)  - Refer to Appendix B Sample Printouts page B-2.

There are two graphic screens that display the results in different ways.

Footswitch Graphics  - Refer to Appendix B Sample Printouts page B-3 and B-4.

Compare to Normal  - Refer to Appendix B Sample Printouts page B-5 and B-6.

The Patient Report lists the important gait parameters from all patient tests.

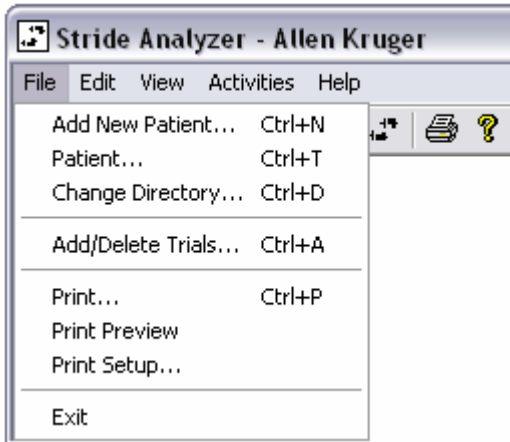
Patient Report **PR** - Refer to Appendix B Sample Printouts page B-7.


The Facility Report lists the patient information in the currently selected patient database.

Facility Report **FR** - Refer to Appendix B Sample Printouts page B-8.

Chapter 3 Menus and Commands

File Menu



Add New Patient -- to the Database. 

A dialog box titled 'Add Patient Information' with a close button (X) in the top right corner. It contains several input fields and a button. The fields are: 'Patient I.D.' (text box), 'Last Name' (text box), 'First Name' (text box), 'Date of Birth' (dropdown menu showing '6/19/78' and 'MM/DD/YY' format), and 'Diagnosis' (text box). To the right of the 'Last Name' field is a 'Gender' section with two radio buttons: 'Male' (selected) and 'Female'. Above the 'Date of Birth' field is a 'Load From SA File' button. At the bottom are 'OK' and 'Cancel' buttons.

Enter patient information in the dialog box shown above. Use the TAB key to advance to the next field. Three fields are required: Patient I.D., Last Name, and Birth Date. After clicking the OK button, the patient's name will appear in the program title bar near the top of the window.

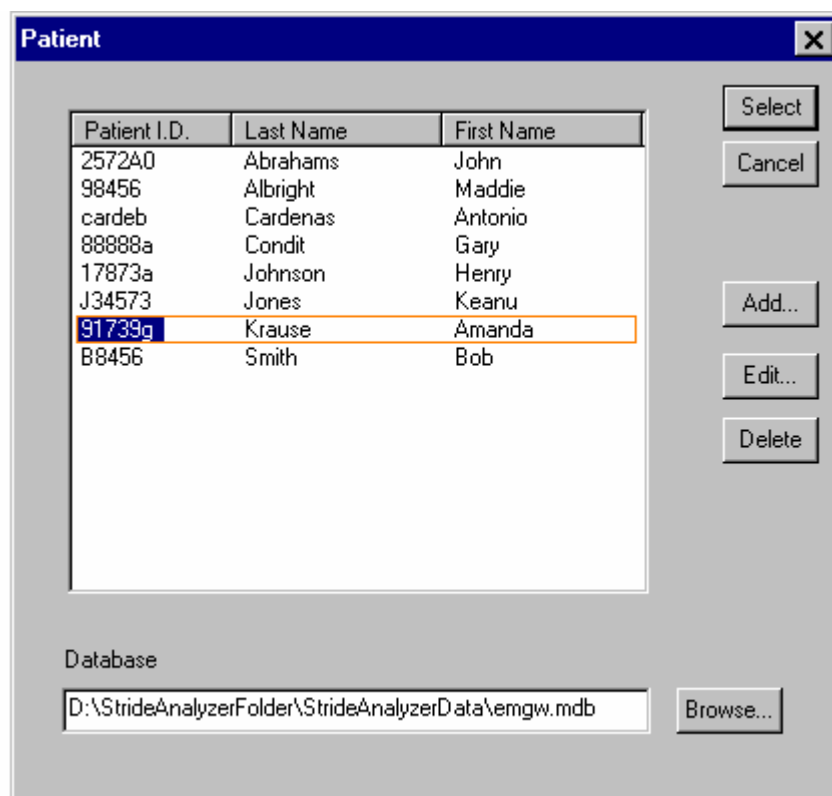
Patient -- select from the Database. 

Choose a patient from the list by double-clicking the desired one or highlighting the desired one and click the OK button. If the desired patient is not found, select Add from the same menu. After clicking the OK button, the patient's name will appear in the program title bar near the top of the window.

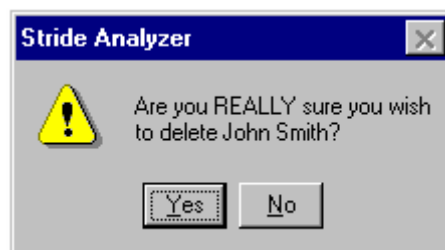
Edit Patient -- information in the Database.

Change patient information in the dialog box shown above. Three fields are required: Patient I.D., Last Name, and Birth Date. After clicking the OK button, the patient's name will appear in the program title bar near the top of the window.

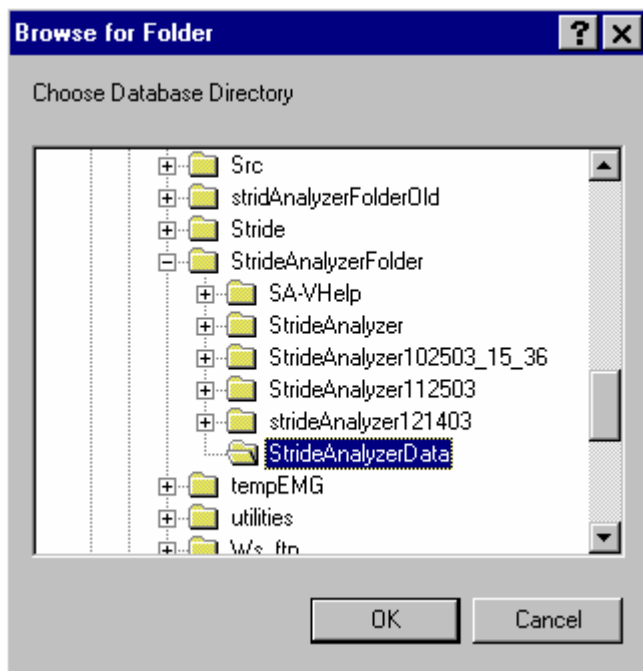
Delete Patient -- from the Database.



To remove a patient from the Database, select the patient to delete and click the OK button. You will be asked to confirm the decision to permanently remove this patient from the database.



Change Directory



Select the desired directory containing the patient database and .sa files to be processed.

When the Stride Analyzer software is installed, two directories are created that contain patient Databases. If the Stride Analyzer directory is C:\StrideAnalyzer, then the two directories are:

C:\StrideAnalyzer\EmptyDatabase and C:\StrideAnalyzer\Samples

The user can change the working directory to either of these by selecting one.

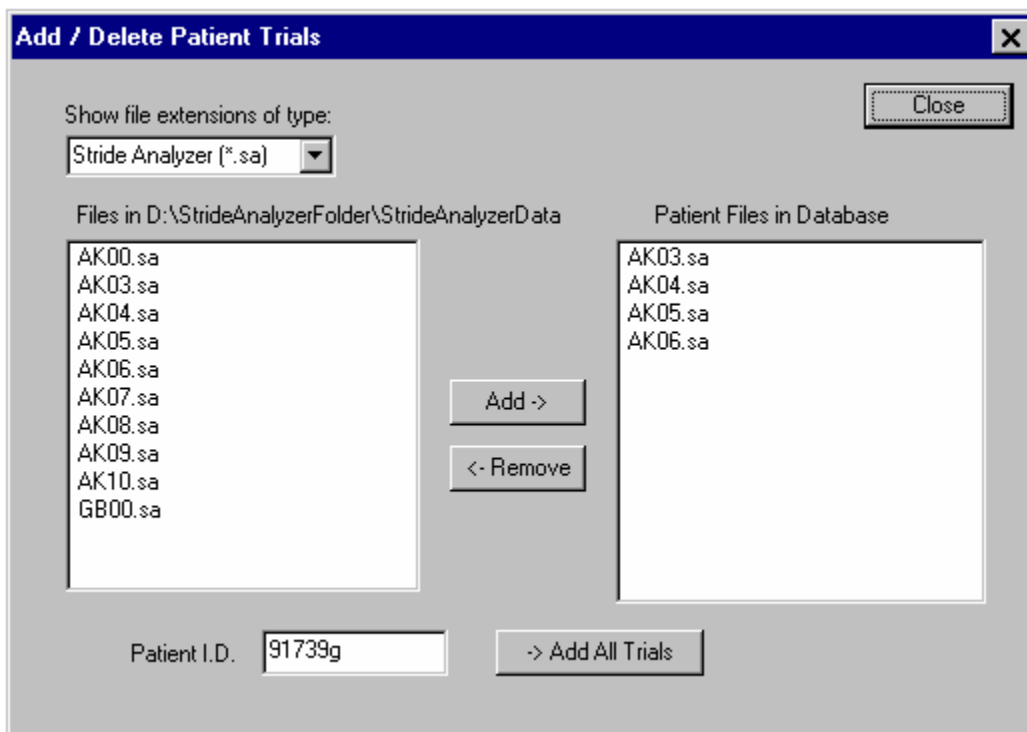
The EmptyDatabase directory contains only one file: SA.MDB (an empty database).

The Samples directory contains the following files:


SA.MDB
JS01.SA
JS03.SA
JS06.SA
MJ01.SA
MJ03.SA

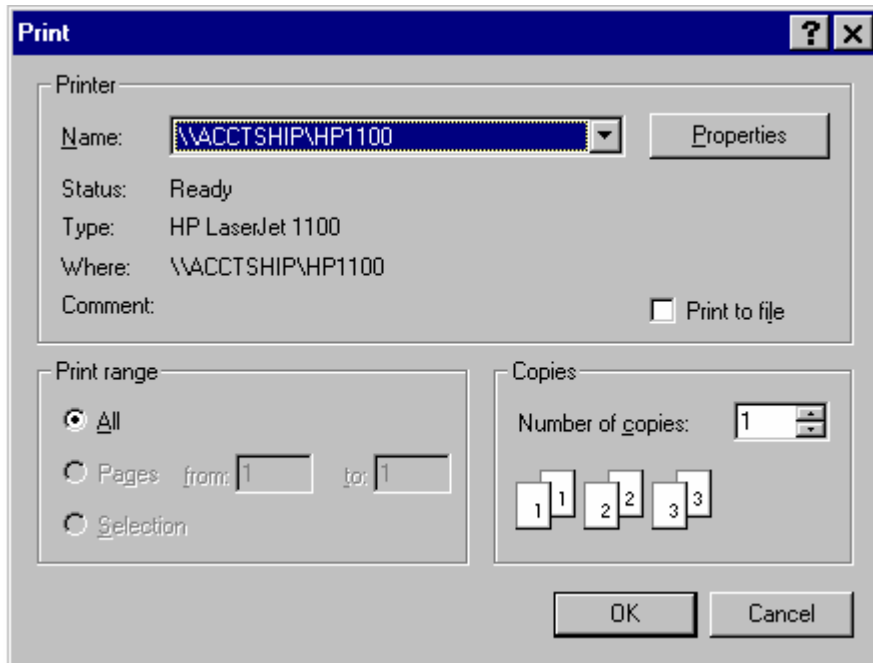
If the selected directory doesn't contain a Patient Database (SA.MDB), then a message box will appear indicating that there is no Patient Database in the selected directory. When this happens, the user can optionally copy an empty Patient Database to that directory.

Add/Delete Runs -- to/from the Database. 



One or more Trials in the left listbox can be selected and added to the Patient Trials in the database. Click on the Add All Trials button to add all the Trials with filenames that start with the Patient I.D.

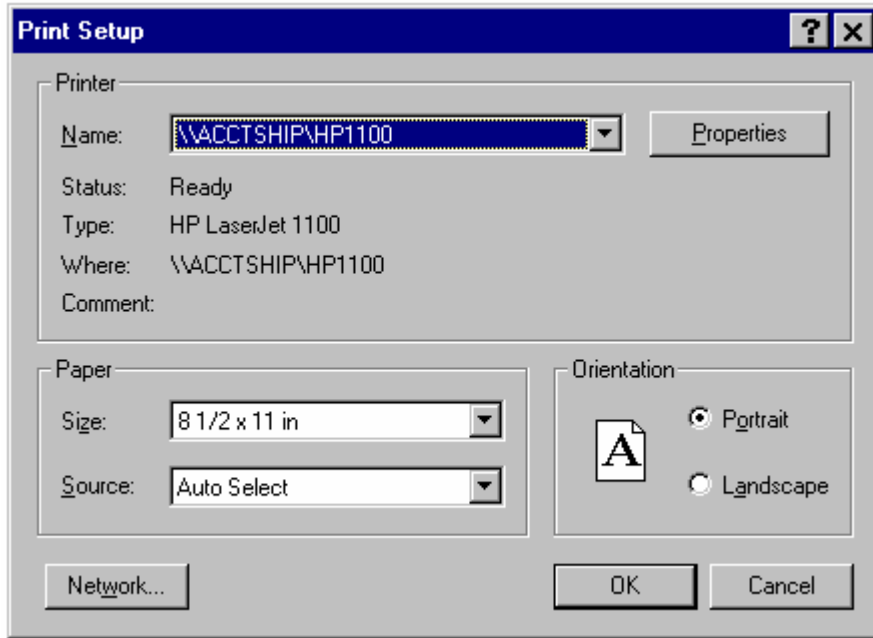
Print (Refer to Appendix B Sample Printouts) 



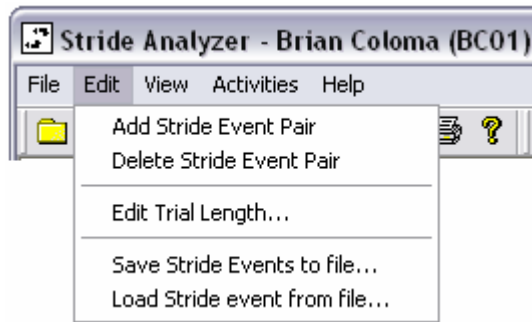
Any of the following screens can be printed by first displaying the screen, then select **File | Print**.

- Footswitch Statistics - Stride Characteristics (text evaluation)
- Footswitch Graphics
- Compared to Normal
- Patient Report
- Facility Report

Print Setup



Edit Menu




Add Stride Event Pair Add a stride to the raw Footswitch Data screen.

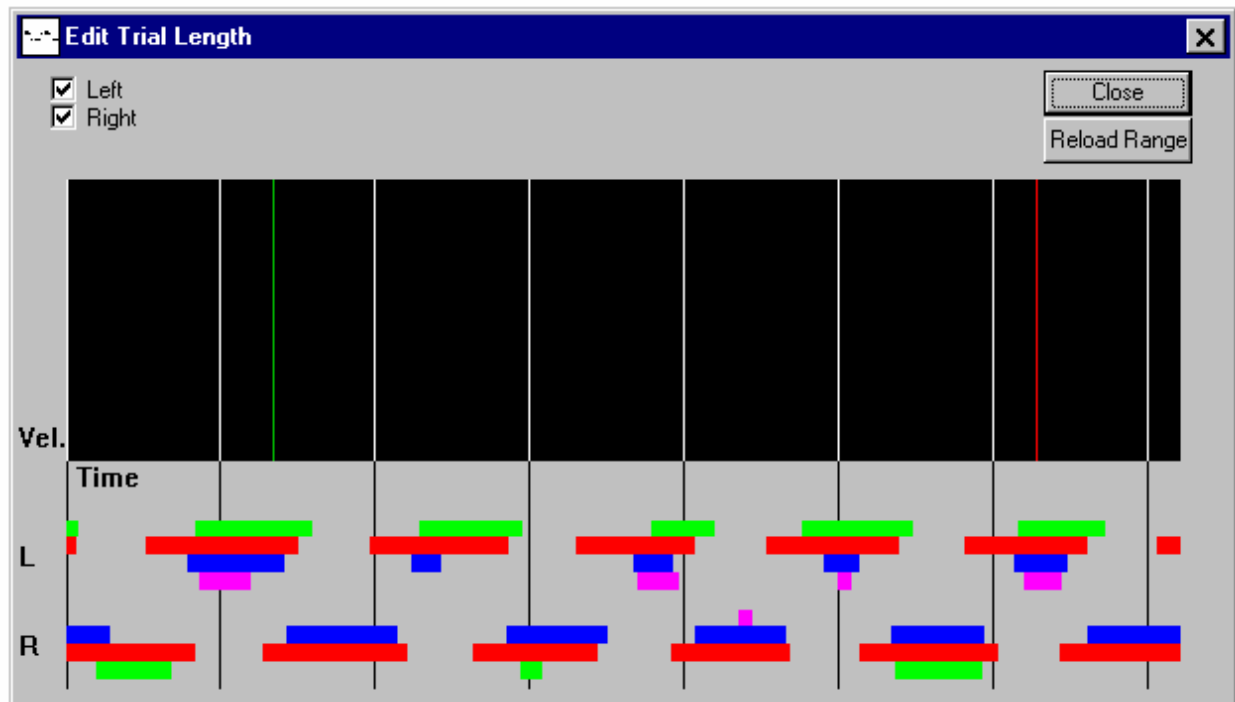
First select **Activities | Edit Initial Final Contacts** screen **E**, then click on **Edit | Add Stride Event Pair**. The cursor will change to a "+". Position the "+" just above the raw Footswitch data at the time you want to add an Initial Contact and click the left mouse button.

Delete Stride Event Pair Delete a stride on the raw Footswitch Data screen.

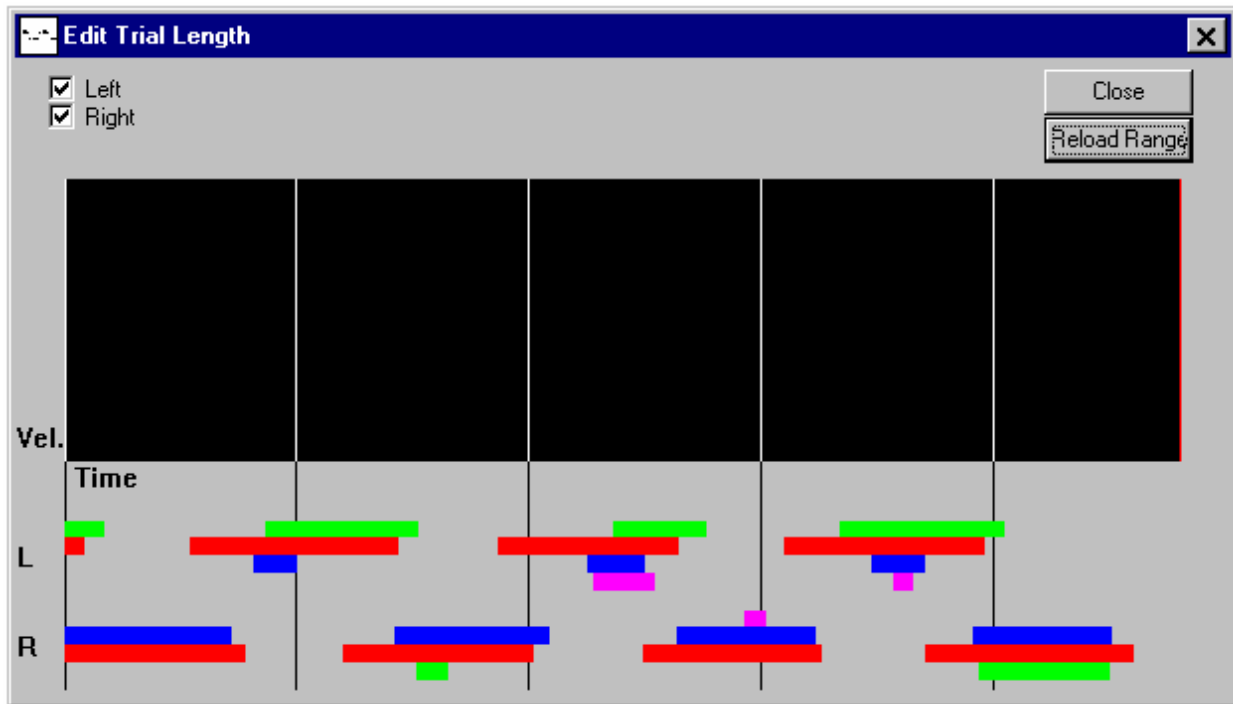
First select **Activities | Edit Initial Final Contacts** screen, then click on the Initial or Final Contact of the stride to be deleted. Then click on **Edit | Delete Stride Event Pair**.

Edit Trial Length  Select a portion of a run for computing stride characteristics.

This dialog box allows the user to analyze a subset of the Trial. Drag a vertical GREEN line from the left edge of the window to the right – just to the point at which data analysis is to start. Then drag a vertical RED line to the left from the right edge of the window to the end of data analysis.



Select a section of the Trial for processing. The Trial on the previous page has been marked at 1.3 seconds and 6.25 seconds. By clicking on the Reload Range button, the Trial will become that sub-section of 4.95 seconds. The vertical BLACK lines are one second time markers.



By clicking on the Reload Range button, the Trial will become that sub-section within the measurement volume.

Save Stride Events to file...

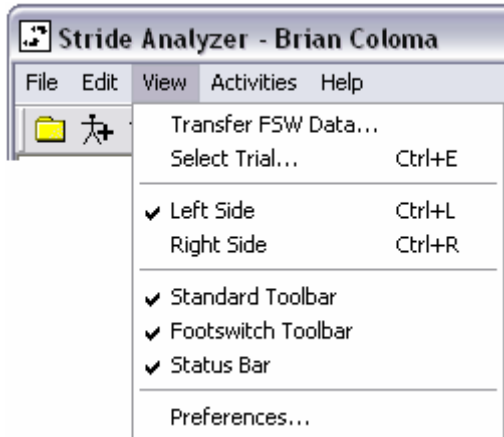
All of the current Stride Events (Initial and Final Contacts for both Left and Right sides) can be saved to a file in the current data directory. The default file name and extension is "trial name.sef".

Load Stride Events from file...

All of the previously saved Stride Events (Initial and Final Contacts for both Left and Right sides) can be loaded from a file in the current data directory.

Then click on **Activities | Footswitch Statistics**  to display the Stride Characteristics using those Stride Events.

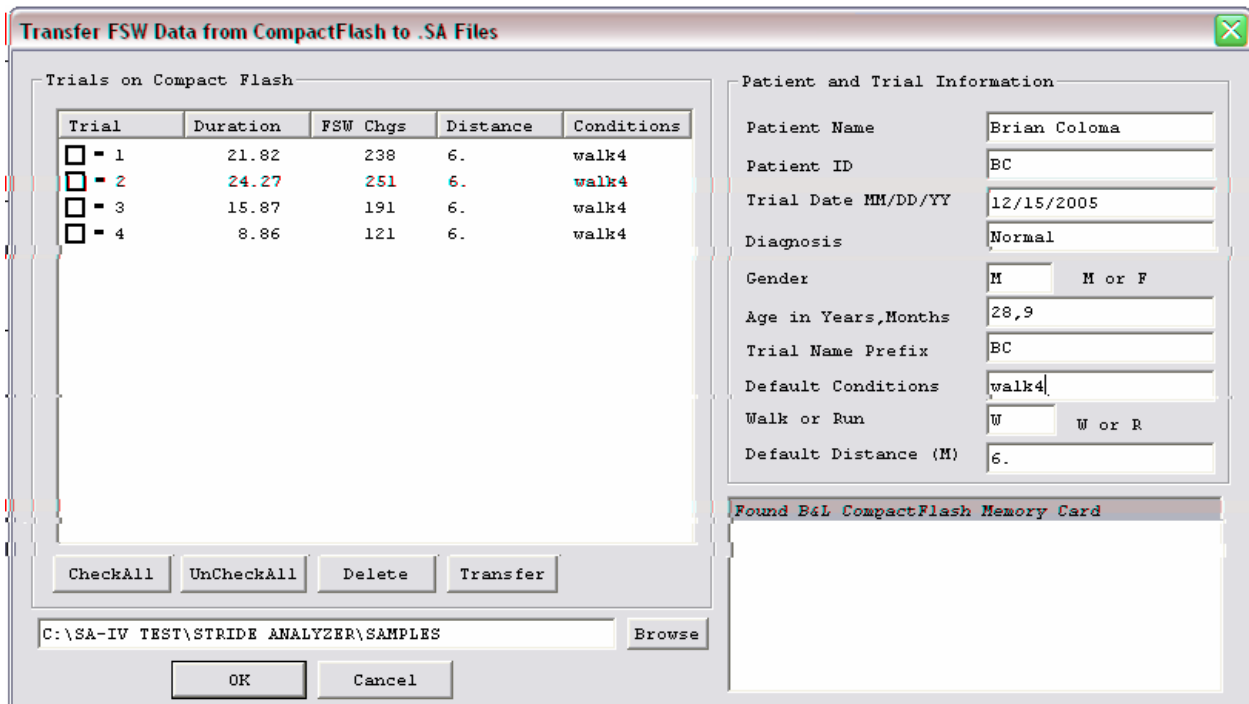
View Menu



Transfer FSW Data...






(Transfer data from Recorder to computer)



After Footswitch data has been taken in the Recorder, the operator can transfer the data to the PC.

The operator must first turn OFF the Recorder. Then remove the CompactFlash Memory Card from the top of the Recorder. If it is not already plugged in, plug in the USB Connector into a USB port on the PC and insert the CompactFlash Memory Card into the Reader.

Run the Stride Analyzer program. Either select an existing subject in **File | Patient...**  or enter the subject information in **File | Add New Patient...**  Then select **View | Transfer FSW Data...**  The trials found on the CompactFlash will be listed in the window at the upper left. The default Distance

in meters and default trial Conditions are copied to all trials listed. Select (click in the small box) the trials that are to be deleted, then click on the Delete Button. Select (click in the small box) the trials that are to be transferred. **To change the Distance and/or Conditions on the selected trials, change the default Distance and/or Conditions on the right side of the dialog box. To change the Distance and/or Conditions on one trial, right click on that trial to change them.** The Trial Conditions field is used to describe the run, such as, "Free Walk", "Fast Walk", "With AFO", "With Walker", etc. Then click on the Transfer Button.

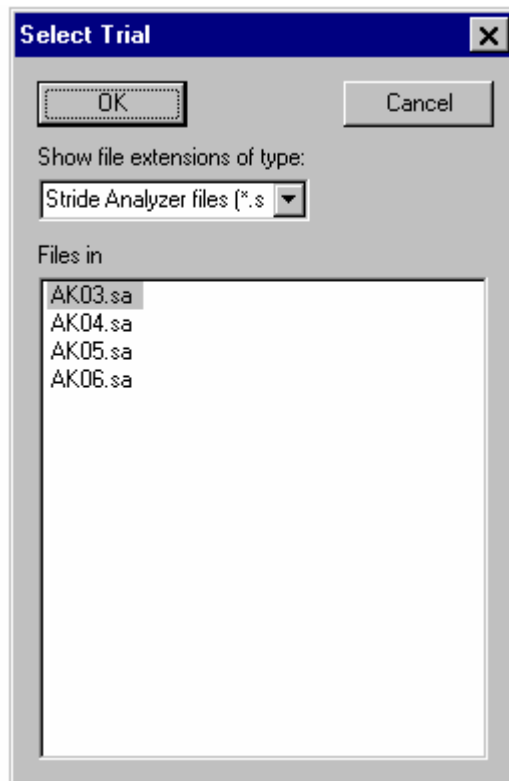
The Trial Number will be added to the Trial Name Prefix (default is Patient ID) to create the trial filename. The filename should be a unique name such as the patient's initials and sequence number (JS01).

When all desired trials to be transferred have check marks, click on the Transfer Button. The trial names (.sa files) will automatically be added to the database for the selected patient. There must not be more than 80 trials on the Card. After trials are transferred to the PC, they should be deleted from the Compact Flash Memory Card.

If the Trial Name already exists in the currently selected directory, then a message box will appear asking whether to Overwrite the existing data file. If you click on YES, the .sa file will be overwritten. If you click on YES to ALL, all of the existing trials will be overwritten. If you click on NO, then you should change the Trial Name Prefix and then click on the Transfer Button again.


Then click on the OK Button.

Select Trial



Previously acquired trials can be re-analyzed by selecting a Trial Name from the list box.


Select an existing Trial Name. Then click on the OK button or double click on the Trial Name.

If there are no Trial Names listed, then the selected patient has no trials in the database. If trials for this patient have been copied to the currently selected directory, then you can add them to the database by selecting **File | Add/Delete Trials** .

Left Side  Select the Left Side Footswitch Data in the Edit Footswitch screen


Right Side  Select the Right Side Footswitch Data in the Edit Footswitch screen

Standard Toolbar



Change Directory
Add New Patient
Select Patient
Add/Delete Trials
Select Trial
Edit Trial Length
Preferences
Transfer FSW Data
Print
Help

Footswitch Toolbar



Left Side
Right Side
Edit Gait Events
Footswitch Statistics
Footswitch Graphics
Compare to Normal
Patient Report
Facility Report

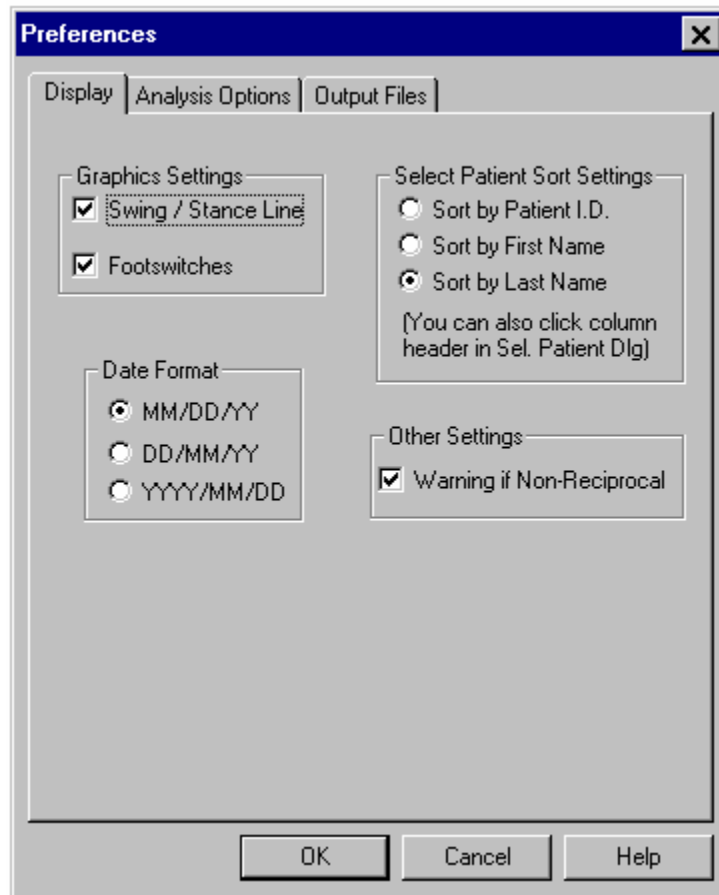
Status Bar



Messages displayed at the bottom of the window.

Preferences **P**

Display Tab



Swing / Stance Line

A solid vertical line shows the transition from Stance to Swing.

Footswitches

Individual stride or mean stride Footswitches are displayed in color or hatched patterns on Black and White devices.

Date Format

MM/DD/YY
DD/MM/YY
YYYY/MM/DD

Select Patient Sort Settings

Sort by Patient I.D.

The lines of data in the **File | Patient** - List Box will be sorted by Patient I.D.

Sort by First Name

The lines of data in the **File | Patient** - List Box will be sorted by First Name.

Sort by Last Name

The lines of data in the **File | Patient** - List Box will be sorted by Last Name.

Warning if Non-Reciprocal - not a valid walking sequence of gait events

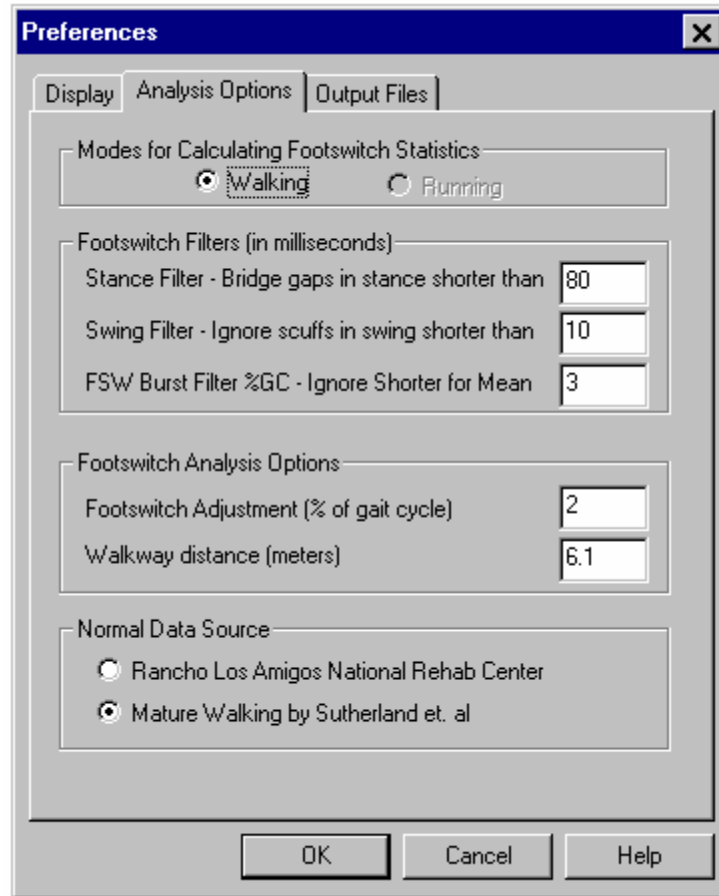
Reciprocal Gait is:

... LIC RTO RIC LTO LIC RTO RIC LTO LIC ...

where:

LIC = Left Initial Contact
RTO = Right Toe Off
RIC = Right Initial Contact
LTO = Left Toe Off

Analysis Options Tab



Modes for Calculating Footswitch Statistics

Walking -- Double Support

Running -- No Contact **(NOT YET IMPLEMENTED)**

Footswitch Filters

Stance Filter in milliseconds -- default is 80 milliseconds

Swing Filter in milliseconds -- default is 60 milliseconds

FSW Burst Filter in milliseconds -- default is 3 milliseconds

The Stance and Swing Footswitch Data Filters (in milliseconds) are used by the program to bridge small gaps in the stance phase and short duration stance periods during swing. The default for each value is 80 milliseconds.

By setting the Stance Footswitch Data Filter to a value such as 160 milliseconds, larger gaps in stance will be bridged. If the value is set to a smaller value such as 40 milliseconds, then only gaps shorter than 40 milliseconds will be bridged. By setting the Swing Footswitch Data Filter to a value such as 160 milliseconds, scuffs less than 160 milliseconds will be ignored. If the value is set to a smaller value such as 40 milliseconds, smaller scuffs during swing will be ignored.

Burst Filter

The FSW Burst Filter is used in the creation of the Mean Footswitch pattern. Very short duration switch on times (less than the Burst Filter in milliseconds) are ignored. The default value is 3.

Footswitch Analysis Options

Footswitch Adjustment (in percent of gait cycle) -- default is 2%. Recommended values: 0, 1, or 2.

This adjustment (2% of the gait cycle correction) is made because of the built-in bias of force required to activate the footswitch. Without this bias, the footswitches would close too easily and stay closed.

Each stride's Stance Phase is "stretched" 4% of that stride's gait cycle duration. The actual foot contact is 2% earlier and the cessation of contact is 2% later than the times from the footswitch data.

Footswitch / Force Plate studies were done to determine this correction factor.

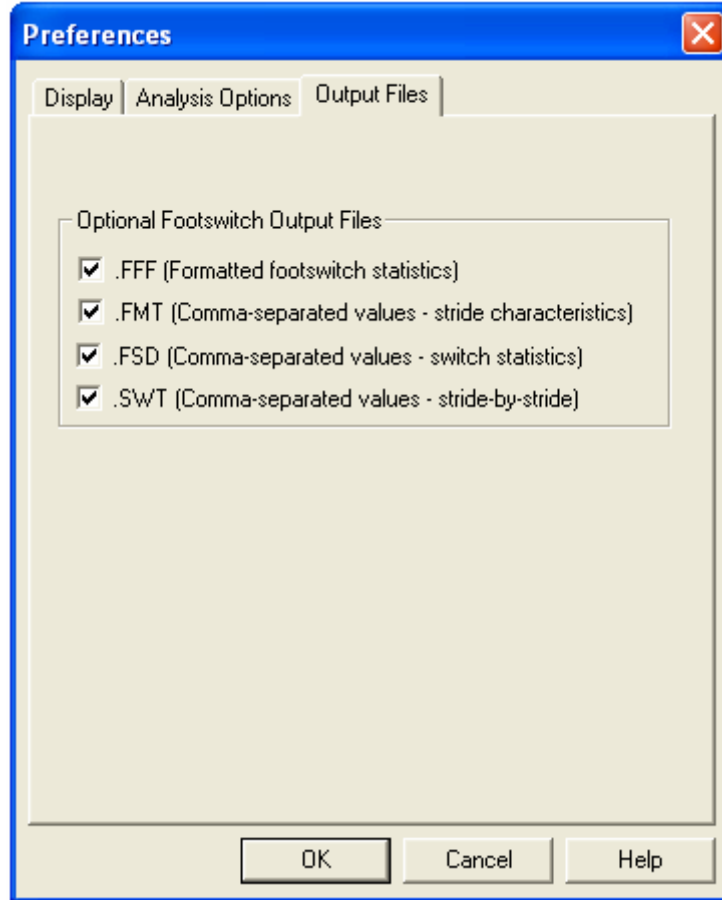
Walkway Distance (meters) -- default is 6 meters -- *The distance in meters traversed by the patient must be entered before the Trial is acquired (transferred from the Recorder to the PC)!*


Normal Data Source

- | | |
|--|---|
| (1) Rancho Los Amigos National Rehabilitation Center Pathokinesiology Service 800 Bldg., Room 33 7601 E. Imperial Hwy. Downey, CA 90242 | Abbreviation: Rancho Adult Footswitch data |
| (2) <u>The Development of Mature Walking</u> David H. Sutherland, M.D. Richard A. Olshen, Ph.D. Edmund N. Biden, Ph.D. Marilynn Wyatt, MA, PT <i>MacKieth Press, 1988</i> <i>Oxford Blackwell Scientific Publishing Limited</i> <i>Philadelphia, J. B. Lippincott Company</i> | Abbreviation: Sutherland Child Footswitch data Motion Analysis Laboratory San Diego Children's Hospital 3020 Children's Way San Diego, CA 92123 |

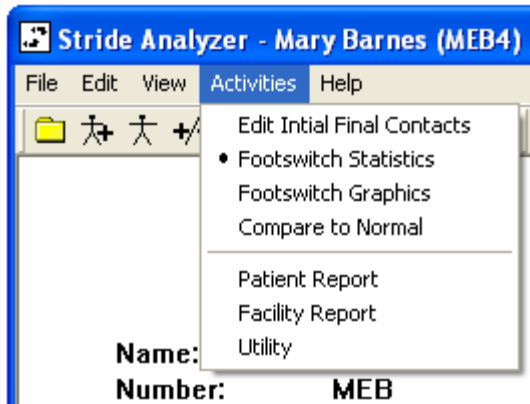
For a more complete description of the Normal Gait Data used, please refer to page 4-2.

Output Files Tab



Select the desired Output Files to be created by clicking the appropriate boxes with the mouse in **View | Preferences | Output Files**. Only Output Files marked with a check will be created. The Output File name will contain the Trial Name and the file extension shown in the dialog box below (for example JS01.FFF). The selected files are written to the Data Directory. All of the selected output files are created automatically after selecting a trial in **View | Select Trial** . Refer to Chapter 4 Technical Information for sample output files.

Activities Menu



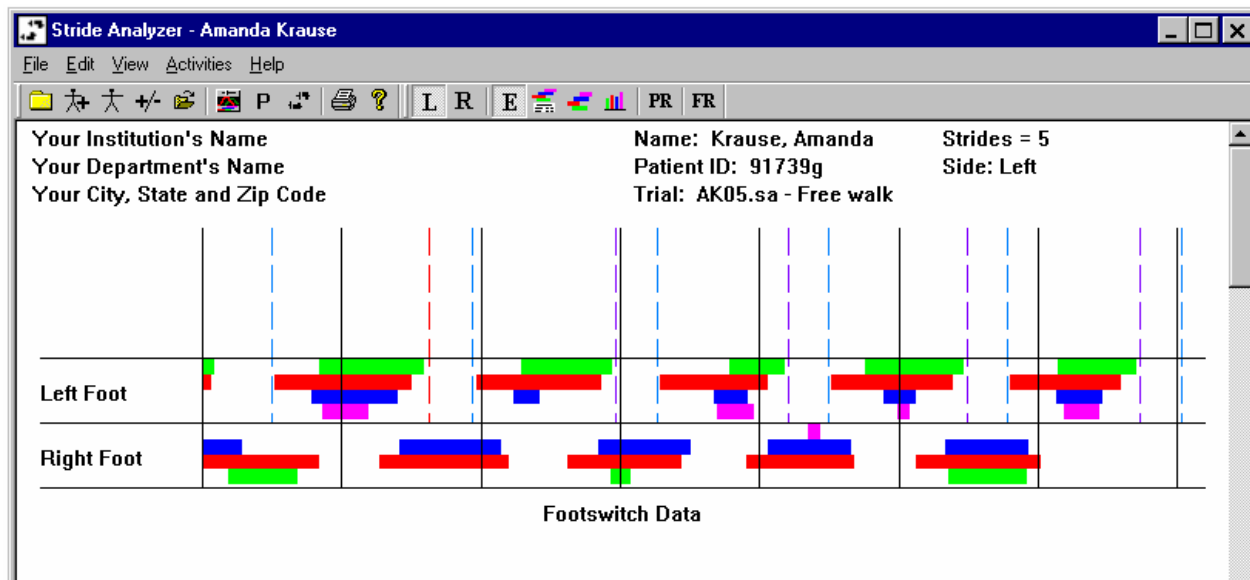
A subset of the trial can be processed by created a new starting and /or ending point by selecting **Edit | Edit Trial Length**.

Edit Initial Final Contacts

E

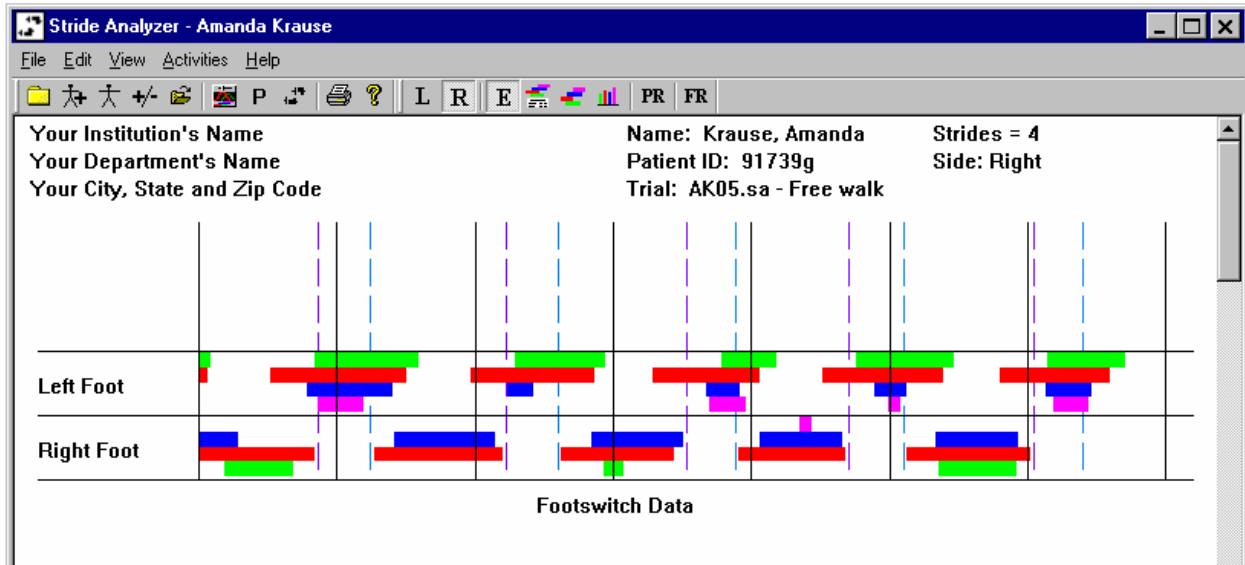
The raw Footswitch Data is drawn for the entire length of the trial. The solid vertical lines are one second time markers, and the dashed vertical lines mark the adjusted swing / stance changes on the selected side. The operator can Edit Gait Events with the mouse on this screen.

Edit Gait Events (Initial Contact and Final Contact) with Mouse



Any Initial Contact or Final Contact can be moved by clicking and dragging the dashed vertical line just above the Footswitch Channels. To delete a stride (Initial Contact / Final Contact pair), click on the desired side within the Footswitch Channel of the stride to be removed. It will turn Red. Then select **Edit | Delete Stride Event Pair**. To add a stride (Initial Contact / Final Contact pair), select **Edit | Add Stride Event Pair**. The cursor will change to a "+". Position the plus cursor just above the Footswitch Channels where you want the Stride Event Pair to be. An Initial Contact and Final Contact pair will

appear at that position on the screen. Each event can be moved with the mouse or an exact time can be entered for an event. Use the Right mouse button and click on the desired Initial or Final Contact vertical dashed line. A dialog box will appear with the lower and upper limits of where that event can be moved. The value for time is in milliseconds times 2, or in other words 500 = 1 second.



Save Gait Events to file - after adjusting the gait events, they can be stored in an .sef file

Load Gait Events from file - previously saved gait events can be re-loaded

Footswitch Statistics

Refer to Appendix B Sample Printouts page B-1 and B-2.


Footswitch Graphics

Refer to Appendix B Sample Printouts page B-3 and B-4.

Compare to Normal

Refer to Appendix B Sample Printouts page B-5 and B-6.

Patient Report

After first selecting a patient by accessing **File | Patient** , a patient report can be created. It contains all the patient information and a table of the most important gait characteristics from all the gait tests on the patient. Refer to Appendix B Sample Printouts page B-7.

Facility Report

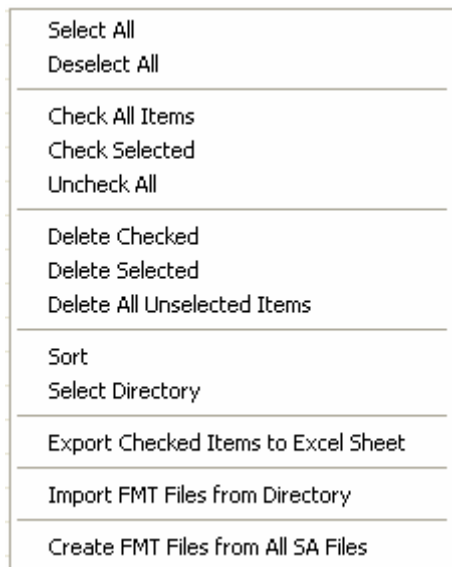
A list of all patient records in the database will be displayed. Refer to Appendix B Sample Printouts page B-8.

Utility

To access the "Utility" features select **Activities | Utility**. A blank window will appear.



Right Click anywhere in the window. A drop-down list will appear.



"Select All", "Deselect All", "Check All Items", "Check Selected", "Uncheck All", "Delete Checked", "Delete Selected", "Delete All Unselected Items", and "Select Directory" are all obvious.

"Sort" -- Left Click on sort, then click on the column heading in the drop-down list. That column will be moved to Column #1 and all rows will be sorted on that Column. NOT VERY USEFUL -- sorting can be done in EXCEL.

"Select Directory" – Must be done first!

"Export All Checked Items to Excel Sheet" -- both an .xls and .csv file will be created. When you load the .xls file in EXCEL, all the numbers are "literals", that is, strings of characters. You can't operate on them!!! Instead, load the .csv file (comma separated values) into EXCEL.

"Import FMT Files from Directory" -- All FMT files in the Selected Directory will be loaded into this window.

"Create FMT Files from All SA Files" means "Process All Trials".

Help Menu



About Stride Analyzer - Version, Date, B&L Engineering information

Help - Stride Analyzer Help Facility

Run Installation Diagnostics

Chapter 4 Technical Information

Footswitch Data Filters for Stance and Swing

In order to determine the exact times of the swing/stance changes, filters are used to bridge short duration swing events and ignore short duration stance events.

If there are short duration swing events in stance (gaps) that are smaller than the filter, then they will be bridged by the Stance Filter. Similarly, if there are short duration stance events in swing that are smaller than the filter, they will be ignored by the Swing Filter.

Under certain circumstances, it may be necessary to change these value to a higher or lower amount, in order for the program to correctly determine the swing/stance times. Accessing View | Preferences | Analysis Options can change the filter values. The adjusted swing/stance times are shown on the Footswitch Graphics screen in the patient's footswitch pattern by vertical black lines.

Edit Gait Events E

The Gait Events (Initial and Final Contacts) can be edited when viewing the raw Footswitch data screen. Select Activities | Edit Initial Final Contacts, then use the mouse to click and drag to the left or right any vertical dashed line just above the Footswitch patterns. To set an event to an exact time, right click on an initial contact or final contact. Then enter the desired time in terms of milliseconds times 2 (500 = 1 second).

Correction Factor -- Footswitch Adjustment (in percent of gait cycle)

This adjustment (2% of the gait cycle correction) is made because of the built-in bias of force required to activate the footswitch. Without this bias, the footswitches would close too easily and stay closed.

Each stride's Stance Phase is "stretched" 4% of that stride's gait cycle duration. The actual foot contact is 2% earlier and the cessation of contact is 2% later than the times from the footswitch data.

Footswitch / Force Plate studies were done to determine this correction factor.

Reciprocal Gait

The normal walking sequence consists of single support on each side separated by a period of double support. The normal walking sequence is the following:

... LIC RTO RIC LTO LIC RTO RIC LTO LIC ...

where:

LIC = Left Initial Contact
RTO = Right Toe Off
RIC = Right Initial Contact
LTO = Left Toe Off

Normal Gait Data (2 choices)

1. Source (Rancho):

Pathokinesiology Service
Rancho Los Amigos National Rehabilitation Center
Bldg. 800, Room 33
7601 E Imperial Hwy.
Downey, CA 90242

The gait characteristics of 423 normal subjects were compiled into a database. A breakdown of these subjects by age and sex follows:

| Group | Age | Females | Males |
|-------|-------|---------|-------|
| Child | 6-12 | 27 | 34 |
| Teen | 13-19 | 31 | 25 |
| Adult | 20-29 | 41 | 36 |
| ... | 30-39 | 10 | 11 |
| ... | 40-49 | 21 | 20 |
| ... | 50-59 | 12 | 8 |
| ... | 60-69 | 45 | 32 |
| ... | 70-79 | 27 | 26 |
| ... | 80-87 | 15 | 2 |
| Total | | 229 | 194 |

+ = 423

Regression analysis has provided normal curves for Velocity, Cadence, Stride Length, and Gait Cycle. These curves have been incorporated into the Stride Analyzer software in order to calculate percent of normal (% Normal) values.

2. Source (Sutherland):

The gait characteristics of normal children were obtained from the book "The Development of Mature Walking" by:

| | |
|--|-------------------------------------|
| David Sutherland, M.D. | Motion Analysis Laboratory |
| Richard A. Olshen, Ph.D. | Children's Hospital & Health Center |
| Edmund N. Biden, Ph.D. | 3020 Children's Way |
| Marilynn Wyatt, MA, PT | San Diego, CA 92123 |
| <i>MacKieth Press, 1988, Oxford Blackwell Scientific Pub. Ltd.</i> | |

Normal Switch Data (MALES and FEMALES -- 100 subjects, 1260 strides)

| SWITCH | % GC (standard deviation) |
|--------------------|---------------------------|
| Heel ON | 0.0 |
| 5th Metatarsal ON | 9.6 (4.64) |
| 1st Metatarsal ON | 19.2 (7.05) |
| Heel OFF | 29.9 (6.06) |
| Toe ON | 33.0 (8.22) |
| 5th Metatarsal OFF | 56.4 (2.59) |
| 1st Metatarsal OFF | 57.7 (1.91) |
| Toe OFF | 59.1 (2.06) |

Normal Single Limb Support

Many research studies of human gait have been done at the Pathokinesiology Service of Rancho Los Amigos Medical Center. One of them found a high correlation between velocity and single limb support for normal subjects. By testing many normal subjects at different velocities, a curve or formula was found for males and another for females. In the following formulas, SSN is Single Stance Normal.

MALES

$$SSN = 1.0 / (.23 * \text{SQRT}((\text{velocity} / .6) + 5.61) - .53) - \text{gait cycle} * .04$$

FEMALES

$$SSN = 1.0 / (.23 * \text{SQRT}((\text{velocity} / .6) + 4.81) - .5) - \text{gait cycle} * .04$$

Given the VELOCITY and GAIT CYCLE duration of the subject, the normal single limb stance is computed. Then the subject's single limb stance %NORMAL can be calculated.

The 4% of GAIT CYCLE reduction in SSN is to correct for the 2% delay in the footswitch closure at initial contact and going off at final contact. There is a bias built into the footswitches that prevents the switches from being activated by the slight force present when the footswitches are placed into the shoe or taped to the bottom of the shoe or foot. The bias varies with the footswitch size.

Description of Files Created for Each Trial

JS01.FFF -- contains one line of the most useful stride characteristics (used to create patient report)
[.FFF --> **F**ootswitches]

JS01.FMT -- contains all stride characteristics in comma separated format (Optional Import/Export file).
[.FMT --> **F**or**M**a**T**ted data]

JS01.SWT -- contains two sections of comma separated values – Left and Right Swing, Stance, and Double Support times in seconds for each stride (Optional Import/Export file).
[.SWT --> **S**Wing / **S**Tance data]

JS01.FSD -- contains average left and right switch ON and OFF events in percent of gait cycle in comma separated format (Optional Import/Export file). [.FSD --> **F**oot**S**witch **D**ata]

JS01.SA -- contains data acquired from the Recorder. [.SA --> **S**tride **A**nalyzer]

Example: JS01.FFF

| Run | Date | Velocity (M/MIN) | Cadence (STEPS/MIN) | Stride Length (M) | Gait Cycle (SEC) | Right S L S (SEC) | Left S L S (SEC) | Strides |
|------|------------|---------------------|------------------------|-------------------------|------------------------|-------------------------|------------------------|---------|
| J001 | 05/13/1993 | 60.3 | 100.4 | 1.201 | 1.20 | 0.429 | 0.418 | 4 |

Example: JS01.FMT

"JOHN SMITH", "1234", "05/13/1993", "Sprained Right Ankle", 29, "M", "JS01", 4, 6.00, "WALK", "W", 60.3, 74.0, 100.7, 93.0, 1.197, 79.6, 1.19, 106.4, 0.1, 5.9, 1.4, 99.5, 0.411, 82.9, 34.7, 33.5, 66.5, 3.4, 15.2, 0.8, 16.5, 2.5, 31.7, 0.400, 80.6, 33.4, 34.5, 65.5, 0.7, 15.4, 0.2, 15.2, 1.5, 30.6

The data names for the above are:

PATIENT NAME, PATIENT ID, TEST DATE, MEDICAL HISTORY, AGE, SEX, RUN NAME, STRIDES, DISTANCE, CONDITIONS, WALK OR RUN MODE, VELOCITY, VELOCITY %NORMAL, CADENCE, CADENCE %NORMAL, STRIDE LENGTH, STRIDE LENGTH %NORMAL, GAIT CYCLE, GAIT CYCLE %NORMAL, **GC-SD**, **GC-CV**, **GAI**, **SPS**, R SLS, R SLS %NORMAL, R SLS %GC, R SWING, R STANCE, **RST-SD**, R DS INITIAL, **RDSI-SD**, R DS TERMINAL, **RDST-SD**, RDS TOTAL, L SLS, L SLS %NORMAL, L SLS %GC, L SWING, L STANCE, **LST-SD**, L DS INITIAL, **LDSI-SD**, L DS TERMINAL, **LDST-SD**, L DS TOTAL

Example: JS01.SWT

L Stance, L Swing, R Stance, R Swing
0.520, 0.420, 0.534, 0.396
0.512, 0.418, 0.518, 0.420
0.508, 0.402, 0.496, 0.396
0.502, 0.416, 0.516, 0.420
0.524, 0.420, 0.528, 0.412
0.518, 0.416, 0.516, 0.420
L Init DbISup, L Term DbISup, R Init DbISup, R Term DbISup
0.034, 0.074, 0.074, 0.000
0.040, 0.076, 0.076, 0.040
0.024, 0.064, 0.064, 0.024
0.030, 0.076, 0.076, 0.030
0.024, 0.080, 0.080, 0.024
0.028, 0.078, 0.078, 0.028

There are two sections of comma separated values with descriptive headings. There is one line per stride. Values are in seconds, and a 0.000 value means "No Data Available".

Example: JS01.FSD

"John Smith", "12345", "05/13/1993", "Sprained Right Ankle", 29, "M", "JS01", 4, 6.00, "Free Walk", "W", 0.0, 50.6, 3.8, 63.3, 22.4, 63.9, 33.7, 65.5, 0.0, 50.8, 4.0, 64.8, 19.6, 63.8, 38.1, 65.2

The data names for the above are:

NAME, PATIENT ID, TEST DATE, MEDICAL HISTORY, AGE, SEX, RUN NAME, STRIDES, DISTANCE, CONDITIONS, WALK OR RUN MODE, L HEEL ON, L HEEL OFF, L 5TH ON, L 5TH OFF, L 1ST ON, L 1ST OFF, L TOE ON, L TOE OFF, R HEEL ON, R HEEL OFF, R 5TH ON, R 5TH OFF, R 1ST ON, R 1ST OFF, R TOE ON, R TOE OFF

Example: JS01.SA

JOHN SMITH
1234
00/13/1993
Sprained Right Ankle
M
29
JS01
WALK
W
6
92,2986
131,6
3,15
15,161
45,219
61,239
60,264
56,284
48,289
112,308
240,435
208,463
...

Patient Name
Patient I.D. Number
Date of test
Medical History
Sex (M or F)
Age
Run Name
Run Conditions
Walking or Running (W or R)
Distance in meters
Number of Footswitch changes, Run duration
Footswitch pattern, Time
Footswitch pattern, Time
etc.



Note: Run duration and Time are expressed in a count of milliseconds times 2.
(e.g. 500 = 1 second and a count of 219 = 219/500 = .438 seconds)

Each footswitch pattern is shown in decimal, such as 45.
Convert 45 to a binary number --> 0010 1101.
Left Right
T1H5 T1H5
0010 1101 --> Left Heel, Right Toe, 1st, and 5th Metatarsal

Appendix A Glossary of Terms

Cadence

To compute the number of steps per minute, since there are 2 steps per stride and 60 seconds in a minute, the formula is:

$$\text{CADENCE(STEPS/MIN)} = 2 * 60 / \text{GAIT CYCLE(SEC)}$$

Coefficient of Variation of Stride Time – Gait Cycle Duration (GC CV)

The coefficient of variation of the stride time (gait cycle duration) is calculated using a method that quantifies the dynamics of steady-state walking and filters “outliers”, such as turns. The CV assesses the stride-to-stride variability or (dys) rhythmicity of gait. Stride time variability is highly associated with the risk of falls.

$$\text{GC CV} = 100 * (\text{GC SD} / \text{MEAN GC})$$

CompactFlash Memory Card Reader with USB Cable

The CompactFlash Memory Card Reader allows the Stride Analyzer Software running on a PC to list the Trials acquired by the Recorder and stored on the CompactFlash Card. Those Trials can be transferred to the PC's hard disk in the form of .SA files or deleted. The opposite end of the cable is a USB connector.

The maximum number of trials that the Recorder can store on one CompactFlash Memory Card is 80. The length (time duration) of each trial can be very long. When the Compact Flash Card is inserted into the Reader and scanned by the Stride Analyzer Software, there must not be more than 80 trials on the Card. After trials are transferred to the PC, they should be deleted from the Compact Flash Memory Card.

Footswitches

The Footswitches are worn as insoles in the subject's shoes or taped to the bottom of bare feet, and indicate the total time each foot is and is not bearing weight. Contacts are provided in the Heel, 5th Metatarsal, 1st Metatarsal, and Great Toe areas to indicate when these areas of the foot are bearing weight. The heel section is separated from the forefoot section so that one pair of switches can accommodate a range of shoe sizes. Each Footswitch is connected to the Recorder by a thin cable.

Gait Cycle

On the side with the first initial contact after the start of data collection compute the time in seconds from the first initial contact to last initial contact before the end of the run on the same side. On the other side, compute the time in seconds from the first toe off to the last toe off. Divide each by the number of strides and average them. The result is gait cycle.

Gait Asymmetry Index (GAI)

The Gait Asymmetry index is measured and calculated as a marker of inter-limb coordination. It is determined as follows:

$$\text{GAI} = 100 * ((\text{swing paretic} - \text{swing non-paretic}) / (\text{swing paretic} + \text{swing non-paretic}))$$

where: swing paretic > swing non-paretic

Initial Double Support

Double Support is when BOTH feet are in contact with the floor. There are two periods of double support in each gait cycle. Initial Double Support starts at initial contact and ends when the opposite foot leaves the floor. These periods are converted to percent of gait cycle and the average across strides is computed.

Recorder

The Recorder is powered by a nine-volt battery and is worn on a belt at the patient's waist. The condition of the footswitches is sampled every two milliseconds (500 Hz). It records changes in footswitch patterns and the times of those changes. Whenever a switch changes, four bytes are stored in the memory of the Recorder; one byte for the footswitch pattern and three bytes for time. The memory capacity to store the footswitch data in the CompactFlash Memory Card in the Recorder is many, many hours. See **Data Acquisition Steps** and **Operate the Recorder** for more information.

Recorder Keypads: START and STOP Footswitch data acquisition, Footswitch Tester Mode, Version, Ready / Trials, Beeper, Delete Trial with "Are you sure?" Yes and No.

Start / Stop Trigger (3)

InfraRed Light Source (2)

The InfraRed (IR) Light Source is a small box that directs a beam of IR light that triggers the Recorder to Start or Stop Footswitch Data acquisition. They should be mounted on the wall at the beginning and end of the measured walkway at waist height. Press the WHITE button to turn ON the IR light – the ORANGE light should go ON. After patient trials have been acquired, turn OFF the IR light by pressing the WHITE button – the ORANGE light should go OFF. The InfraRed Light Source requires a 9-Volt battery for power.

Hand-Held InfraRed Trigger (1)

An alternative method of starting and stopping the Recorder is provided in the form of a Hand-Held IR Remote Control. Momentarily depressing the RED button while the Recorder LCD shows "READY TO OPERATE" or "Trials NNN", will start Footswitch Data acquisition. Another momentary push on the RED button - which must be at least two seconds after the first signal - will stop the data acquisition. The purpose of this triggering method is to allow the STRIDE ANALYZER to be used in places other than a designated walkway - i.e. stairs, ramps, out of doors, in households, etc. The Hand-held trigger requires a 9-Volt battery for power.

Single Limb Support

Average time in seconds when the foot is in contact with the floor and the other foot is NOT in contact with the floor.

Stance

Average percent of the gait cycle when the foot is in contact with the floor.

Stance Phase Symmetry

A clinically better measure gait symmetry – time spent in stance (more important for persons with stroke).

If Stance L > Stance R

$$\text{SPS} = 100 * (\text{Stance R} / \text{Stance L})$$

Else

$$\text{SPS} = 100 * (\text{Stance L} / \text{Stance R})$$

Stride Length

The average distance in meters from one heel strike to the next heel strike on the same side. The formula is:

$$\text{STRIDE LENGTH(M)} = \text{VELOCITY(M/MIN)} * \text{GAIT CYCLE(SEC)} / 60$$

Swing

Average percent of the gait cycle when the foot is NOT in contact with the floor.

Terminal Double Support

Double Support is when BOTH feet are in contact with the floor. There are two periods of double support in each gait cycle. Terminal Double Support starts at initial contact on the opposite foot and continues until the end of the gait cycle (the next initial contact). These periods are converted to percent of gait cycle and the average across strides is computed.

Total Double Support

The sum of Initial and Terminal Double Support.

Velocity

Average speed expressed in meters per minute. The formula is:

VELOCITY(M/MIN) = DISTANCE in meters / RUN DURATION in seconds * 60

Appendix B

Sample Printouts

Printer used:

Laser Printer