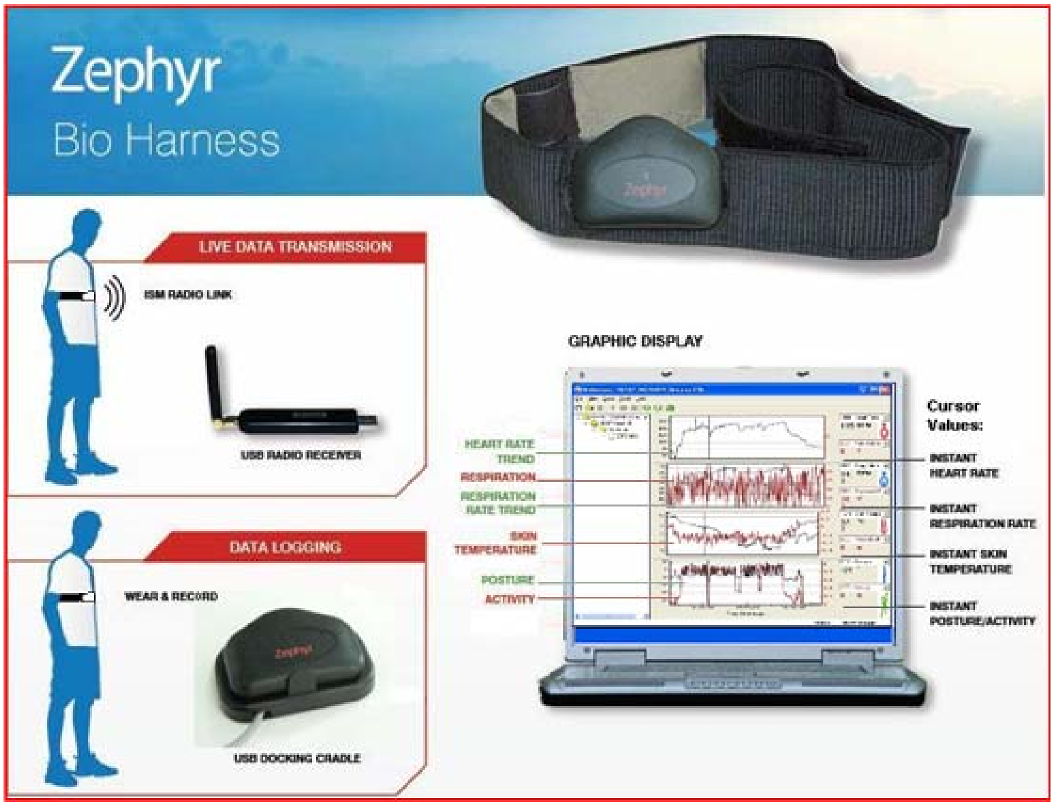

BioHarness™ User Guide

Contacts

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Phone: +64 9 574 6523
Fax: +64 9 574 6527

Your BioHarness™ System comprises :

- BioHarness™ Garment incorporating Zephyr Smart Fabric sensors
- BioHarness™ Device
- 1 docking/charging cradle
- 1 USB lead
- 1 USB radio receiver dongle
- 1 Installation CD comprising
  - Application software
  - .NET installation software
  - USB driver folder
  - User Guide
  - Adobe PDF Reader Installer
  - Sample BioHarness™ projects Folder
- 1 User Guide (black & white)
- 1 Software & Hardware Installation Guide

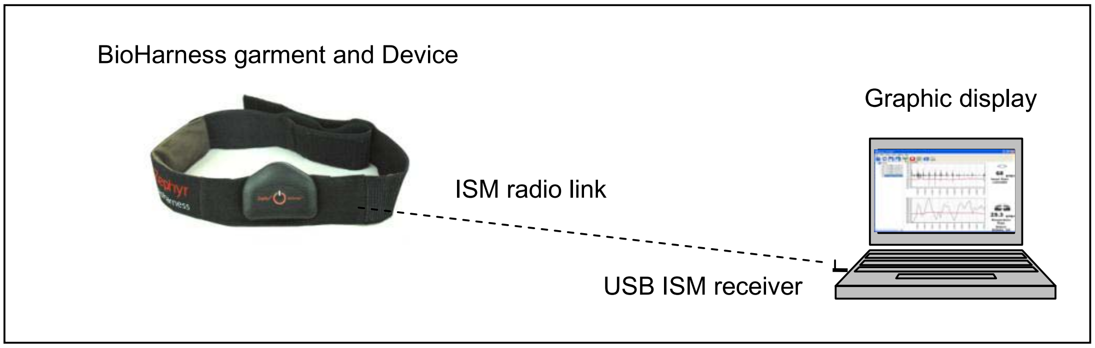
Contents

1 System Overview

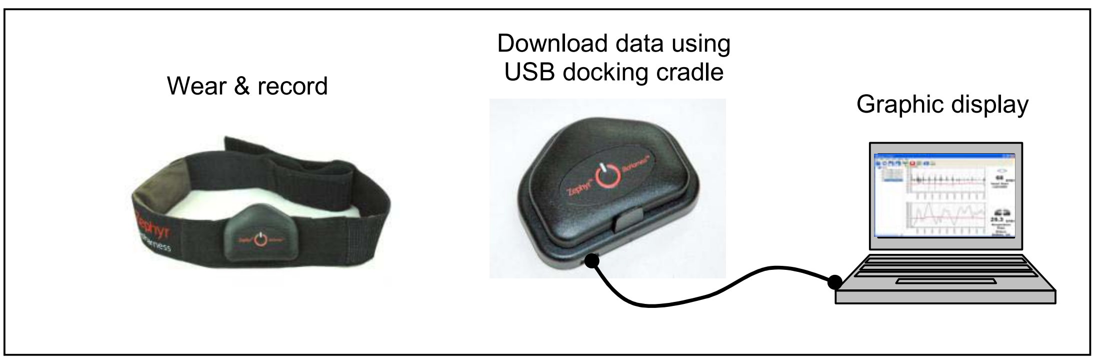
1.1 BioHarness™ System

The Zephyr BioHarness is a state-of-the-art lightweight portable biological data collection and analysis system. It monitors, analyses and records a variety of physiological parameters.
The system can operate in two modes:

RF *(Radio Frequency)* Transmitting mode for live viewing of data



Logging mode for remote monitoring of data



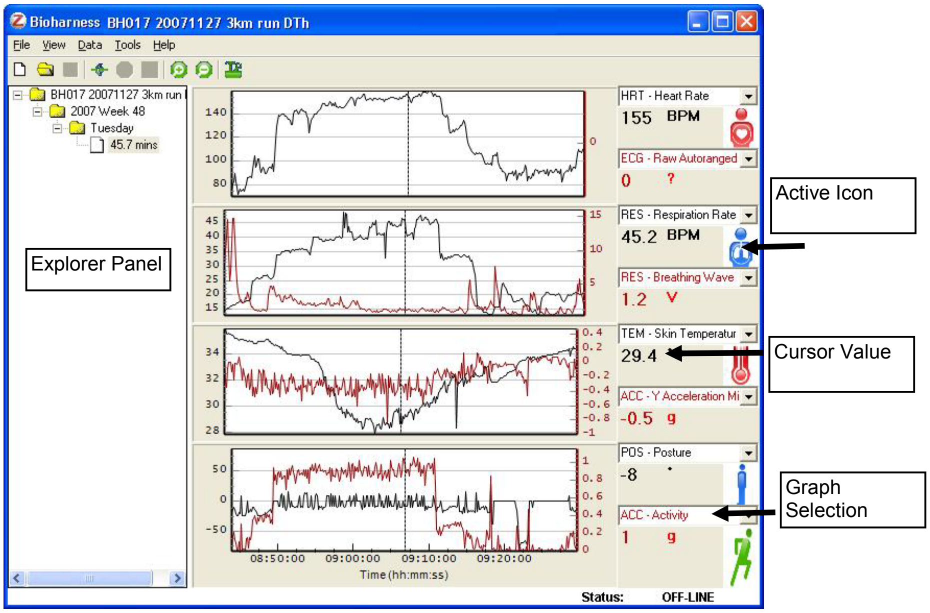
Live data viewing features include

- A variety of selectable waveforms and trend data including
  - 250 Hz indicative ECG
  - 18 Hz respiration and Heart Rate RR data
  - 1 Hz for all trend, activity and 3-axis acceleration-based parameters
- Real time pulse and breath detection indicator icons
- Activity level in VMU
- Posture – attitude of device – in degrees from vertical
- Recording of data

Historical and Logged data can be displayed. Exact data values can be determined by cursor position, with zoom and pan facilities on graphs.

All data can be exported to an external csv file with real-time timestamps for more detailed analysis.

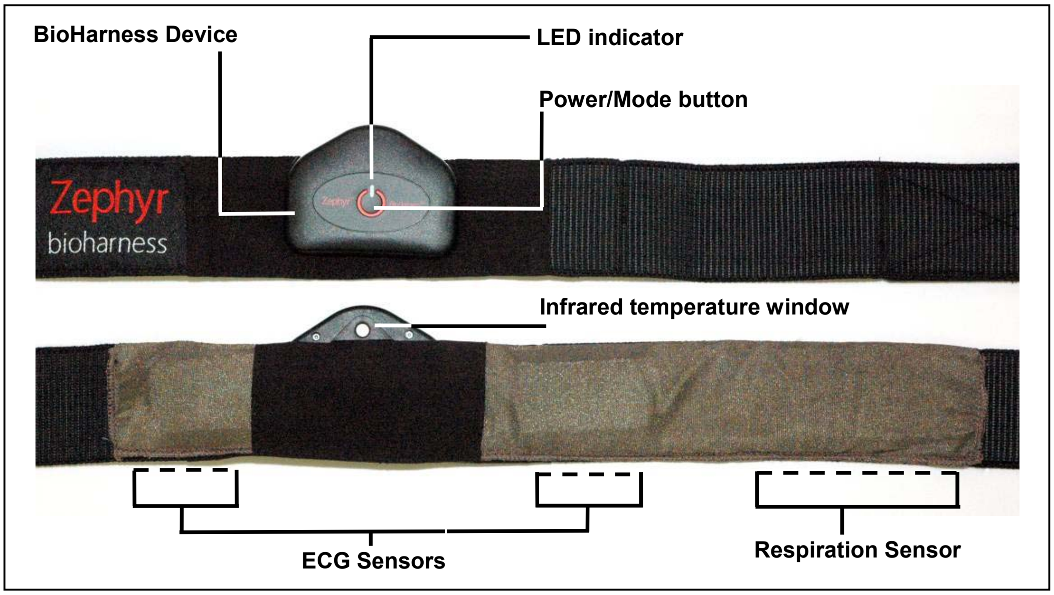
1.2 BioHarness Application Software



Toolbar Options

Open New Project	Play current project
Browse for existing Project	Record current RF data
Save current project	Stop current recording
Connect (RF mode)	Tools
Zoom In around graph Cursor	Zoom out

1.3 BioHarness Garment and Device



1.4 Button/LED Modes

Button (from off)	LED	Mode	LED Mode
Press & Hold		RF Transmit	Fast
Press again		Logging	Slow
Press & Hold 3 sec		Off	Off

1.4 Care and Maintenance

BioHarness Device:

- O-ring sealed and water resistant.
- Wipe with a soft damp cloth and towel-dry
- Clean the Temperature window with a cotton bud
- Do not leave in direct sunlight for long periods (such as in a vehicle)

BioHarness Garment:

- Rinse the garment in fresh water after use
- Hand wash, or to machine wash the garment, detach the BioHarness Device and wash on a Cold, Delicate setting
- Firmly attach the Velcro ® fastenings together and do not wash with other delicate garments which may be damaged by the fastenings. Use a washing pouch if possible.
- Do not spin or tumble dry
- Hang to dry, out of direct sunlight
- Do not use bleach, or iron

2. Technical Specifications

Minimum PC Requirements

Operating System:	Windows ® XP/SP2 with Microsoft ® .NET 1.1 Environment
Processor & Speed:	32 bit x86 2 GHz
Memory:	512 RAM
Connectors:	USB

Smart Fabric Garment

Material:	Elasticised webbing incorporating Zephyr Smart Fabric sensors
Width:	50mm
Weight:	50 grams
Length:	S/M/L Adjustable, Velcro® fastening

BioHarness Device (Transmitter/Recorder)

Weight	35 grams
Dimensions	80 x 40 x 15 mm
Frequency	ISM radio band (868 - 929MHz) Frequency is software configurable for Country-specific bands
Sample Rate	250 Hz Max.
Memory Capacity	~480 hours
Transmit Range	Up to 100m, environment and antenna dependent
Battery Life	~ 10 hours logging ~ 5 hours transmit

This device complies with Part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) this device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Part Numbers

Description	Zephyr Part No.
BioHarness™ transmitter/recorder device	9800.0049
USB RF receiver dongle	9800.0018
Smart Fabric Garment - Small	9800.0056
- Medium	9800.0040
- Large	9800.0057
Docking Cradle	9800.0047
USB/mini connector lead	0015.0003
Software Installation CD	9700.0011
User Guide	9700.0012

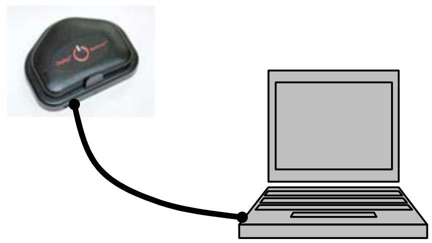
3. Get Started

Insert the Installation CD into your CD reader drive, and follow the instructions in the Software and Hardware Installation Guide to carry out the following:

1. Install the software and hardware

See Installation Guide

2. Charge the Batteries



See section 5
Full charge – 3hrs
90% charge – 1 hour
(Devices cannot be overcharged)

3.1 Precautions

- Do not use the unit if you are fitted with a heart pacemaker
- Do not attempt to operate the receiver dongle in wet conditions as it is not water resistant (the transmitter unit is water resistant and can be used in logging mode)
- Do not use in explosive atmospheres (such as gas stations)
- Do not use near blasting areas such as quarries

NOTE: THE MANUFACTURER IS NOT RESPONSIBLE FOR ANY RADIO OR TV INTERFERENCE CAUSED BY UNAUTHORIZED MODIFICATIONS TO THIS EQUIPMENT. SUCH MODIFICATIONS COULD VOID THE USER'S AUTHORITY TO OPERATE THE EQUIPMENT.

4. User Notes and Advice

4.1 ECG Performance

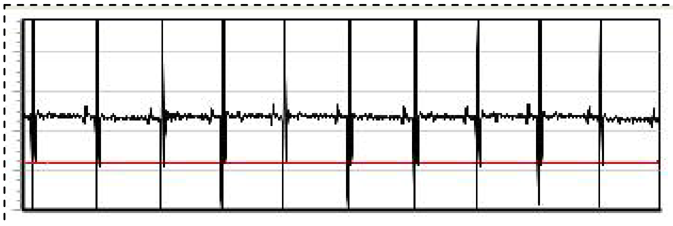


Fig 4.1.1 A good low-noise ECG signal from a static subject with a dry garment

Factors which can affect ECG performance are:

- Skin moisture – or lack of it. While the BioHarness system will perform well with non-moistened sensor surfaces, ECG data will be more susceptible to movement artefact noise as seen in the diagram below. Pre-moisten the sensor surfaces for best performance – see section 6.

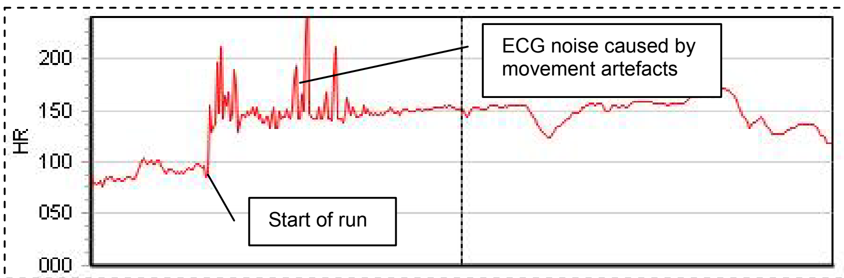


Fig 4.1.2 The subject has started a 3km run with a dry garment. The clean heart rate signal prior to the run is immediately noisy due to movement artefacts generated by the running action, and EMG noise. As the subject's skin moistens with perspiration, the noise clears.

- EMG – Electromyographic noise. As muscles on the torso contract and relax, they generate EMG signals which can be comparable in magnitude with the ECG signals. Excessive use of these muscles, such as vigorous arm-flapping can affect ECG detection.

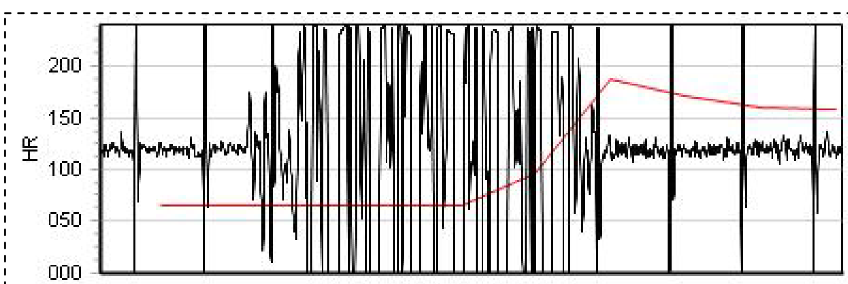


Fig 4.1.3 EMG noise/movement artefacts generated by vigorous arm movement

- A subject's own ECG amplitude. There is a large variation in the actual ECG signal strength within the human population. Users who have exceptionally weak ECG signals may observe reduced ECG performance with the system.

4.2 Respiration Performance

A breath is one inhalation/exhalation cycle. Respiration rate is the number of these cycles occurring in one minute.

The BioHarness detects and analyses expansion and contraction of the thorax (rib cage) in order to determine respiration rate. Zephyr's proprietary breathing detection algorithms need to 'learn' an individual's breathing action. Respiration rate takes 30 – 45 seconds to stabilise when the system is initially activated.

Factors which can affect Respiration Rate performance are:

- Physical activity – especially repetitive activity, which causes regular expansion and contraction of the rib cage, such as chopping with an axe or striking a punch bag repeatedly
- A subject's physique, and natural breathing rhythm.
- Breathing action. Breathing is a combination of apical and diaphragmatic actions. Apical breathing is driven by expansion of the rib cage, the mechanism a BioHarness analyses. Inhalation is also driven by contraction of the diaphragm in a downward direction. This does not greatly contribute to expansion of the rib cage. If a wearer has a predominantly diaphragmatic breathing action, then the BioHarness will be less effective in detecting breath cycles.

4.3 Skin Temperature Performance

The infrared sensor in the BioHarness device is fast-responding and accurate. The sensor window should be cleaned regularly with a cotton bud or similar. Skin temperature can vary locally by several degrees depending on the location of blood vessels and sweat glands.

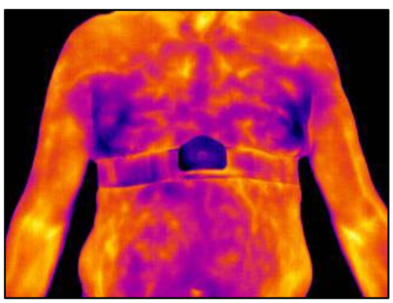


Fig. 4.3.1 A high definition Infrared camera image. Colour variation shows local variations in skin temperature in a subject who has been running on a treadmill.

Factors which can affect skin temperature are:

- Perspiration, which is the body's response to an increase in core temperature. Evaporative cooling of perspiration is part of a body's natural temperature regulation mechanism.
- Moisture condensation on the sensor window
- Environmental factors such as ambient temperature, humidity, wind and the sun's radiated heat.
- Any physical factor (such as clothing) which insulates the skin from the environment
- Local blood circulation
- Local perspiration
- Response to drugs, or medical conditions
- Physiological conditions (including shock and hypo- or hyperthermia)

These should all be taken into account when analysing temperature data.

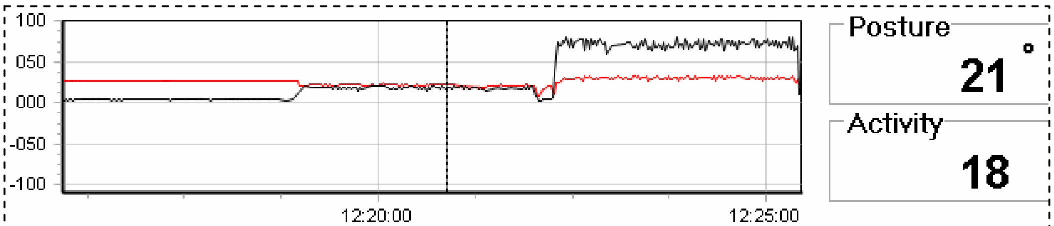
4.4 Activity and Posture Performance

4.4.1 Activity

The default activity data on the graph is shown in VMU. This is an average gravity-compensated value calculated over the previous 1.008 second epoch. It is an integration of all three axial values.

Activity data is also available as individual XYZ components in units of g (gravity) The minimum and maximum values of each 1.008 second epoch are available, as well as maximum acceleration magnitude and activity levels.

The cursor value below should be read as 0.18 VMU. The trace shows 3 min of inactivity, 3 min @ 5kph and 3 min @ 10 kph treadmill running.

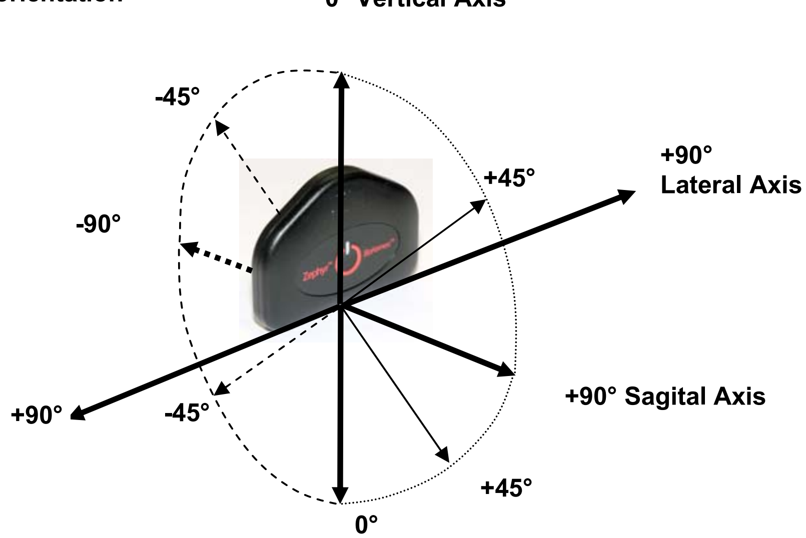


4.4.2 Posture

Posture data is affected by movement. High levels of activity will prevent the posture from being acquired reliably – and the posture will also be highly variable. Posture data is most accurate when the subject is static.

The actual posture value for a subject who wearing the device in a sitting or standing position will depend on the shape of their torso immediately underneath the garment – a stomach which protrudes is likely to result in a negative value for posture. As the subject leans forward the posture value will increase.

Posture orientation



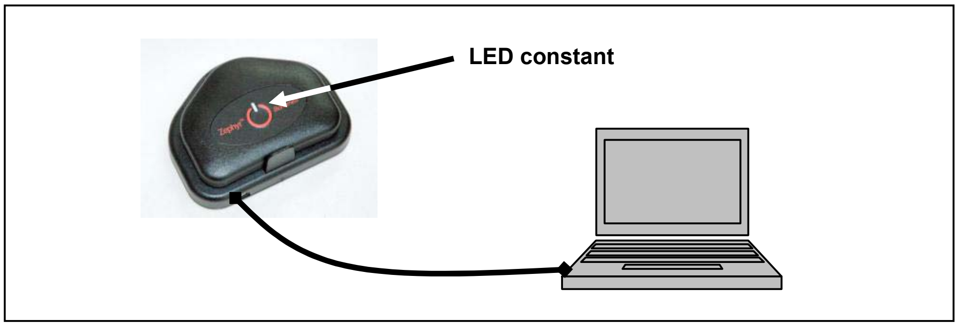
With fixed base point, tilt the apex of the device to any arrow head for the indicated posture value

5. Charge the Batteries & Set the Clock

When first delivered, the BioHarness is totally powered off. It will have some battery charge, but the time on the internal clock will be set to a default value of Jan 1 2000. The internal clock is used to assign timestamps to data logged on the device. In live RF mode, data is time stamped by the host PC at time of reception.

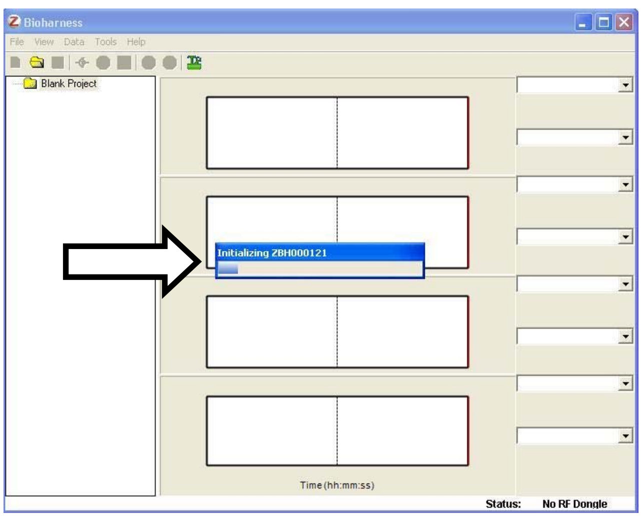
5.1 To charge the battery and reset the internal clock:

1. Install the Application Software, Driver files and hardware as described in the Software and Hardware Installation Guide.
2. Connect the BioHarness device in its cradle to the PC



When the LED is illuminated, the battery is charging.

3. Start the BioHarness software using the desktop shortcut 



An '*Initialising*' dialogue will display – when it is completed then the Clock is set to current PC time.

BioHarness status when placed in a cradle

- No application open – batteries charge, clock not initialised
- Application open – batteries charge, clock initialised
- Application Open, View Live Data via a 2nd device – batteries charge, clock not initialised until 2nd transmitting device disconnected

5.2 Charge Time

Full charge (100%): 3 hours from fully discharged
Quick Charge (90%): 1 hour from fully discharged

Charging is intelligent – the device cannot be overcharged

5.3 Charge Duration

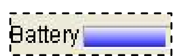
Time to full discharge of a fully charged Li-ion cell

Mode	Quick Charge	Full Charge
Power Off	~28 days	~ 30 days
RF transmitting mode	4 hours	5 hours
Logging Mode	7 hours	8 hours

In power off mode, the cell is discharged by the internal clock.

5.4 Charge Level

There is a charge level indicator on the Application software which is active when the BioHarness Device is transmitting live data. The colour of the indicator bar reflects the battery level:



Battery Level	
Blue	20 -100% capacity
Red	< 20% capacity

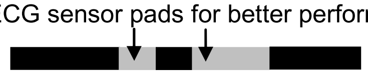
5.5 Battery Life

Expected life ~500 cycles

As with all rechargeable cells, such as mobile phone batteries, charge duration will shorten as the battery reaches the end of its life expectancy. The battery is not user replaceable. Contact your supplier for battery replacement information.

6. Put on the Garment

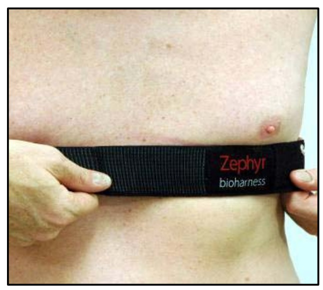
- Wet your fingers and lightly moisten the silver ECG sensor pads for better performance



The ECG will work when dry, but be more susceptible to signal noise when the wearer is very active

- Put the garment on backwards first, for easier adjustment of tension and alignment of the Velcro ® fastening
- Adjust the tension so that the garment is snug but comfortable and will not move under expected activity

- Position the garment so that is just below the chest muscles



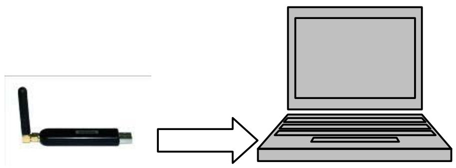
- Rotate the garment to that the fasteners are centred on the torso, with middle snap above the sternum

- Attach the BioHarness device, set to transmit or recording mode as necessary (see sections 7 & 11)

7. View Live Data

A BioHarness device with a fully-charged Li-ion cell should be able to transmit live data for approximately 5 hrs

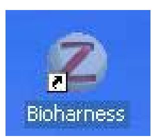
1. Connect the USB receiver dongle



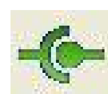
2. Switch the device on

Press and hold the button until the LED flashes in Fast mode (Section 1.4)

3. Start the Application Software

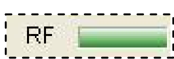


4. Click the Connect button on the Application Software toolbar



The graphs will populate with live data in a few seconds

5. Check Signal Quality



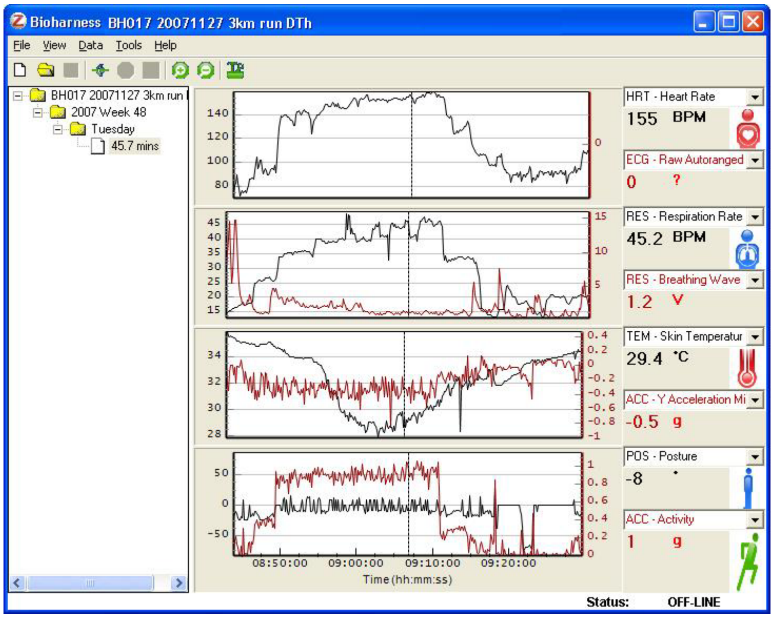
Colour	Signal Quality
Green	100%
Yellow	50 – 99%
Red	< 50%

Note that a yellow signal strength indication may only mean a 1% loss of quality – this is acceptable signal quality

6. Factors which *may* affect signal quality

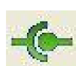
- Transmitter/receiver distance
- Orientation of subject
- Mobile phones
- Electrical equipment nearby
- Metallic obstructions
- Vehicle electrics
- Overhead lines

8. Record and Save Files



Viewing real-time data

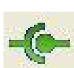

Open New Project (optional)

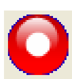

Connect

View Data


Disconnect when finished

Recording real-time data


Connect

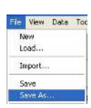

Record


Stop

New file created automatically

Saving a Project

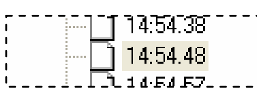

Save Project


…or Save As (rename in dialogue)

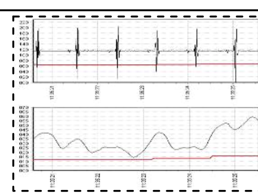
New Project created

Review of Saved files


Browse for Project if needed, or drag & drop into Project Explorer



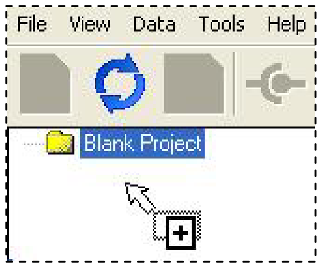
Select recording


Entire file displayed

9. View Saved Files

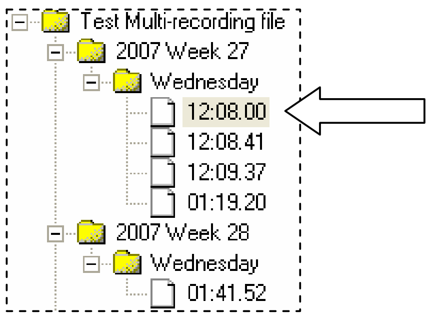
To view a saved file:

- Use the Browse button 
- …or use the menu option File>Open. The application will open the directory in which a Project was last saved
- Select a Project from the dialogue and click open
- The file will load into the application
- …or drag and drop a Bio Harness File into the Project Explorer pane:



.

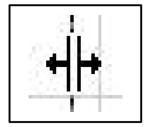
- Click on an individual session in the Project Explorer to load it



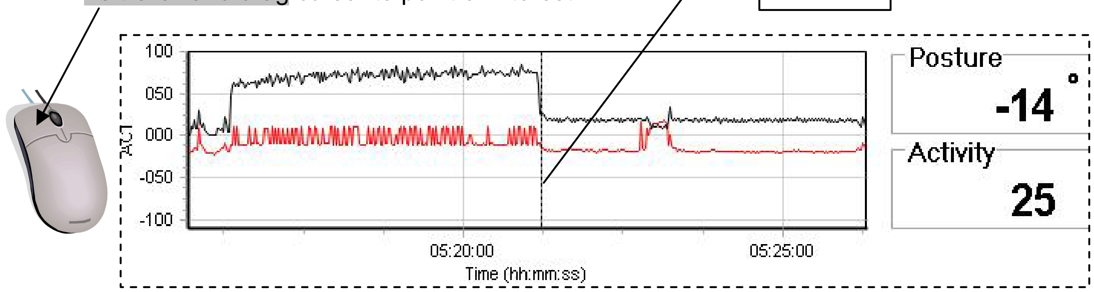
Note: a 5 hour BioHarness session recorded while in RF mode:

- is ~15MB in size
- will take ~ 30 seconds for the session to load into the application.

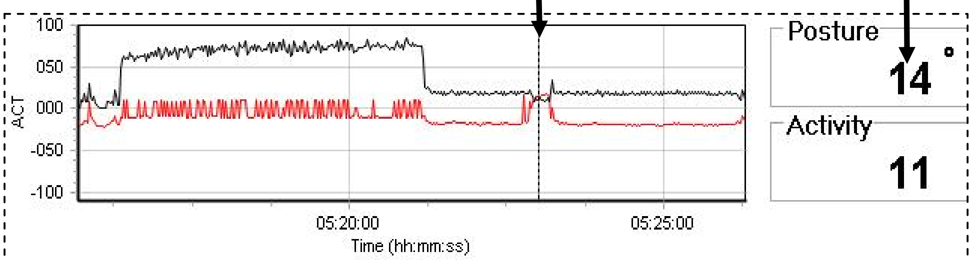
10. Read the Graphs



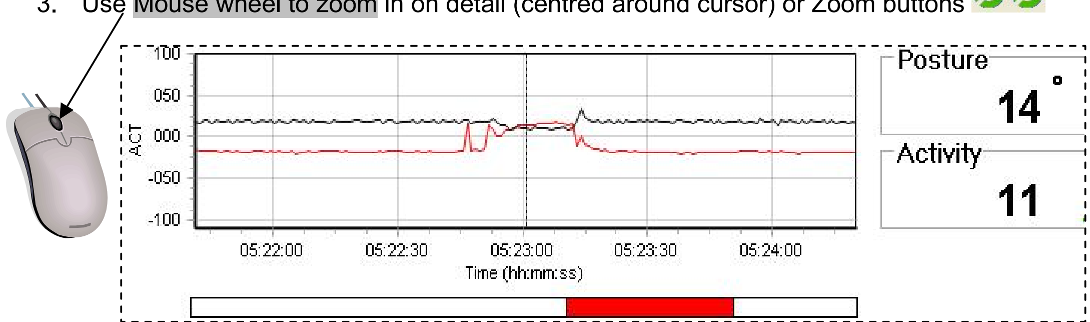
1. Left-click and drag cursor to point of interest



2. Values are shown for cursor position

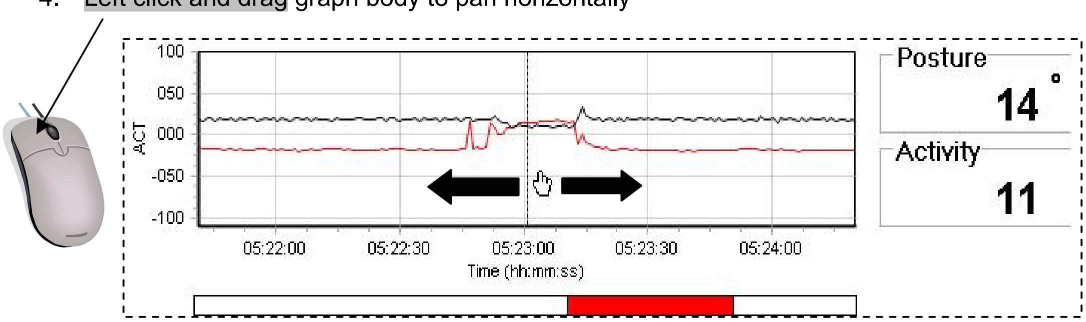


3. Use Mouse wheel to zoom in on detail (centred around cursor) or Zoom buttons 



Section of file on display shown

4. Left click and drag graph body to pan horizontally



11. Log on the Device

Data which is logged on the device is time stamped using the device's own internal clock. This clock should be reset to current time (initialised)

- After initial delivery
- Each time the battery has become completely discharged

If the clock is not initialised, then subsequent data will be time stamped starting at 12:00:00 on 1/1/2000. It is strongly advised that the clock is initialised before the device is used in Logging mode.

Section 5 explains how to initialise the clock.

1. To make a single Log:

Switch on the device

See section 1.4 for button modes:

- Press once for RF Transmit/ Fast LED mode
- Press again for Logging/Slow LED mode
- Press & Hold 3 sec for Off

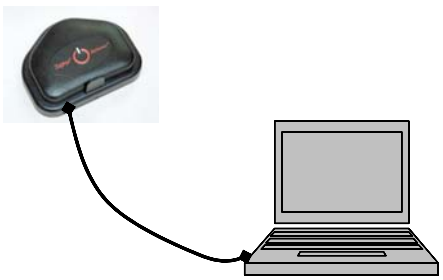
2. Repeat the above instructions to make a subsequent log.

12. Import Logs from the BioHarness Device

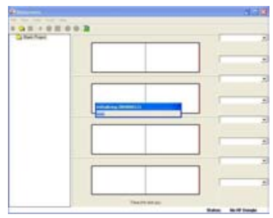
The BioHarness contains enough internal memory to hold the equivalent of 480 hours worth of data. Logs are copied, not moved, from device memory, so they can be imported multiple times. (Use the *Erase All* button in the import dialogue to permanently delete all recordings) When the memory is full, the oldest files will be overwritten.

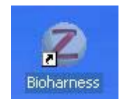
To import data:

1. Connect the Device



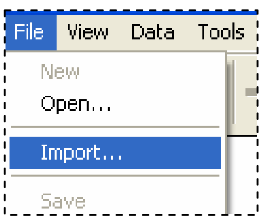
2. Start the Application



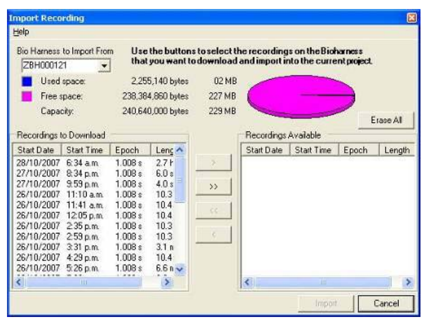


The Device will initialise

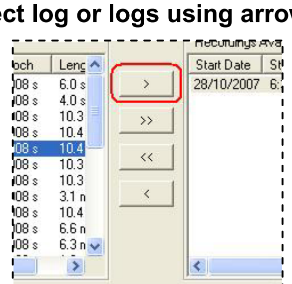
3. Select File>Import



4. Import Dialogue

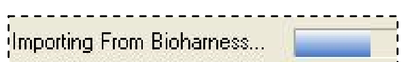


5. Select log or logs using arrows



Double-clicking a recording also works

6. Click Import



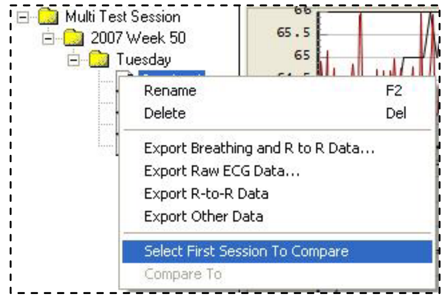
30 min of data will take ~1 min to Import

Data can be imported into a new Project, or any Project already opened in the application.

13. Compare Two Sessions

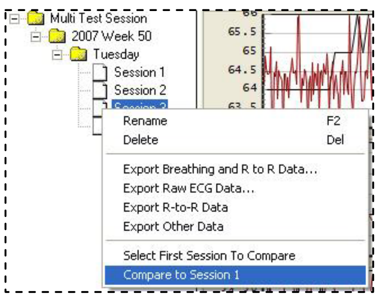
1. Load the Project or Projects containing sessions for comparison

2. Right Click 1st Session



Select *First Session to Compare*

3. Right Click 2nd Session

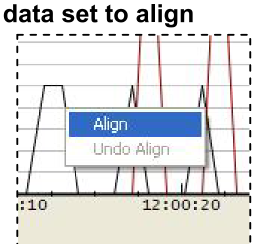


Select *Compare to Session 1*

4. Both sessions are loaded

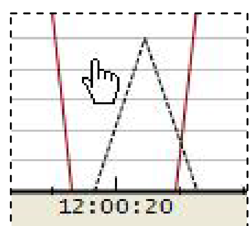
- 1st Session data in black
- 2nd Session data in Red
- Only one parameter per graph (Select using list)
- Cursor value of each is displayed

5. Select data set to align



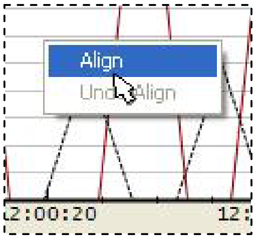
Place cursor over data set (red or black) on the BOTTOM graph and Left Click. This data set becomes dotted.

6. Realign data set



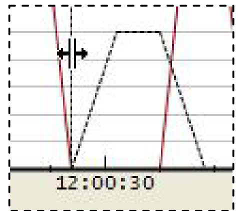
Pan the dotted data set to realign

7. Fix new alignment



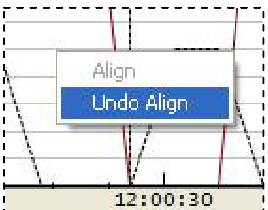
Right Click and select *Align* to set new alignment

8. Compare Data



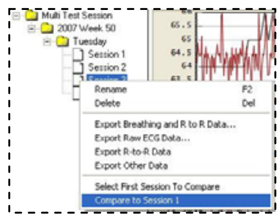
Use Cursor, Zoom and Pan on both data sets as necessary

9. Undo Align



Right click and select *Undo Align* to return to original state

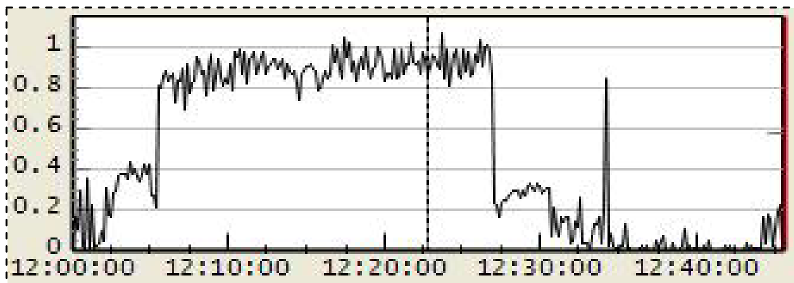
10. Select another data set



Select another data set – the <u>last session selected</u> is always available for comparison

14. Understand Data Options

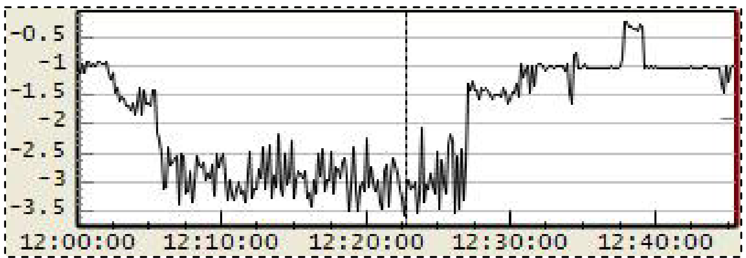
14.1 ACC – Activity

Data Frequency	1 Hz (1.008 seconds)
Units	Vector Magnitude Units (VMU) measured in ms^{-2}
Minimum Value	0
Maximum Value	5.7
Description	Scalar index of activity. (ACC X 10 and ACC X 100 are available as options to scale the graph display to suit activity level).
Sample	 Activity level during walk/3km run/walk/static. The Y axis has autoscaled to fit the data range.
CSV Export	Yes (x10 and x100 Activity levels are not available for export)

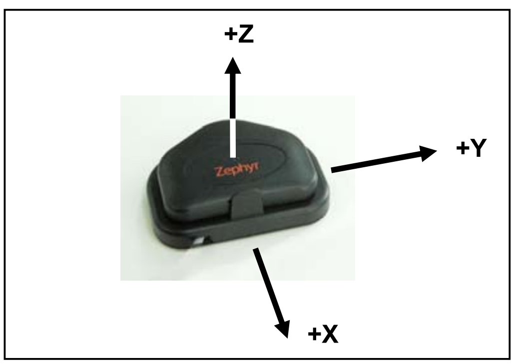
14.2 ACC – Peak Acceleration

Data Frequency	1 Hz (1.008 seconds)
Units	g (gravitational force)
Minimum Value	0
Maximum Value	5.7
Description	Maximum magnitude in any direction (X, Y or Z) during 1 second epoch. The maximum in any one axial direction is 3.3g, but an acceleration at 45° to all 3 axes simultaneously can have a net maximum of 5.7g
Sample	BUG – peak acceleration values in 100s???
CSV Export	Yes

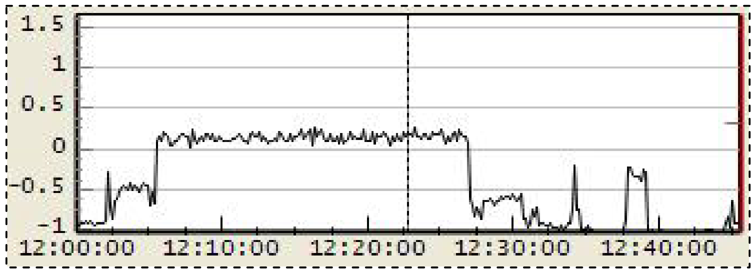
14.3 ACC – X/Y/Z Acceleration Minimum

Data Frequency	1 Hz (1.008 seconds)
Units	g
Minimum Value	– 3.3 in each axis
Maximum Value	+ 3.3 in each axis
Description	The minimum is the smallest acceleration value recorded during the previous 1 second epoch. This could be a negative value if there is an acceleration is a negative direction, or positive if *all* accelerations during that period are positive.
Sample	 Vertical (X) Acceleration Minimum during a walk/3km run/walk session. Note that accelerations are negative
CSV Export	Yes

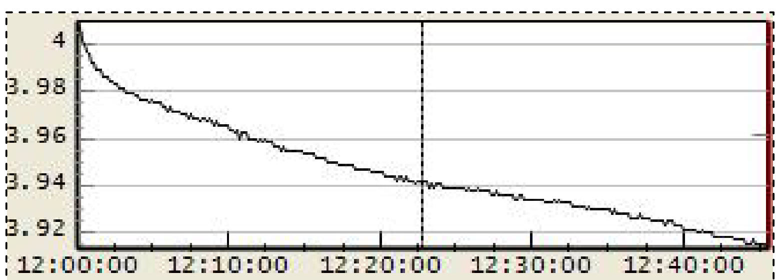
Orientation of XYZ axes for acceleration data:



14.4 ACC – X/Y/Z Acceleration Peak

Data Frequency	1 Hz (1.008 Seconds)
Units	g
Minimum Value	– 3.3 in each axis
Maximum Value	+ 3.3 in each axis
Description	The peak is the largest acceleration value recorded during the previous 1 second epoch. This could be a negative value if *all* accelerations are a negative direction, or the largest positive value
Sample	 Vertical acceleration during walk/3km run/walk. Note that peak acceleration during some epochs is a negative (towards the ground) value.
CSV Export	Yes

14.5 BAT – Battery Voltage

Data Frequency	1 Hz (1.008 Seconds)
Units	Volts
Minimum Value	~ 3.6
Maximum Value	~ 4.2
Description	Voltage level of the battery. The specified charging tolerances are slightly above and below the stated limits. The cell cannot be overcharged.
Sample	 Battery voltage level during a 45 min log recording. The Y axis has autoscaled to fit the discharge curve. Comparison of discharge curves over a time period could be used to determine the health of the battery.
CSV Export	Yes

14.6 ECG – Amplitude

Data Frequency	1 Hz (1.008 Seconds)
Units	Volts (indicative)
Minimum Value	0
Maximum Value	~ 0.0001 V
Description	This value is indicative – it is extracted during algorithmic processing of the ECG sensor output data. It is not a measurement of a subject's ECG voltage level, and should be used for debugging purposes only.
Sample	BUG – Y-axis doesn't include enough DPs to make sense of data
CSV Export	Yes

14.7 ECG – Noise

Data Frequency	1 Hz (1.008 Seconds)
Units	Volts (indicative)
Minimum Value	0
Maximum Value	~ 0.0001 V
Description	As for ECG amplitude – extracted during algorithmic processing of ECG sensor data.
Sample	BUG – Y-axis doesn't include enough DPs to make sense of data
CSV Export	Yes

14.8 ECG – Processed Autoranged

Data Frequency	250 Hz
Units	n/a
Minimum Value	To fit graph scale
Maximum Value	To fit graph scale
Description	The ECG waveform is autoscaled to fit the fixed Y axis of the graph in which it is displayed. The processed waveform should show reduced noise levels compared to the raw data.
Sample	BUG – all ECG waveforms not working – autoranging/refresh rate issue?
CSV Export	No

14.9 ECG – Raw Data

Data Frequency	250 Hz
Units	Bits
Minimum Value	0
Maximum Value	+ 4096
Description	*Indicative* ECG only. Amplification, filtering and processing is applied to the output from the ECG sensor. This parameter is only available from data transmitted by RF. A strong ECG signal will maximise the sensor output.
Sample	Will there be a difference between Raw & Autoranged in new graphs??? BUG – all ECG waveforms not working – autoranging/refresh rate issue?
CSV Export	Yes, but only from original data transmitted by RF

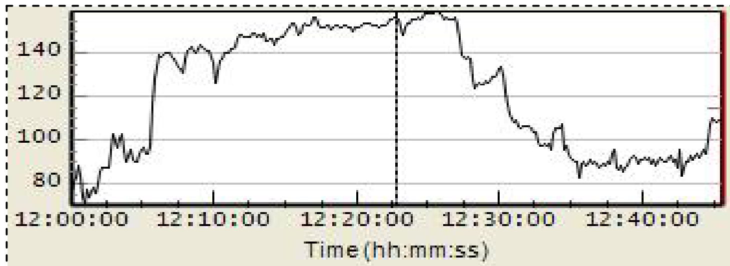
14.10 ECG – Raw Autoranged

Data Frequency	250 Hz
Units	n/a
Minimum Value	To fit graph scale
Maximum Value	To fit graph scale
Description	
Sample	BUG – all ECG waveforms not working – autoranging/refresh rate issue?
CSV Export	No

14.11HRT – Calculated Heart Rate

Data Frequency	250 Hz
Units	BPM (beats per minute)
Minimum Value	0
Maximum Value	240
Description	This value is calculated from the RF-transmitted ECG data and used to drive the flashing Heart icon on the application interface
Sample	
CSV Export	No

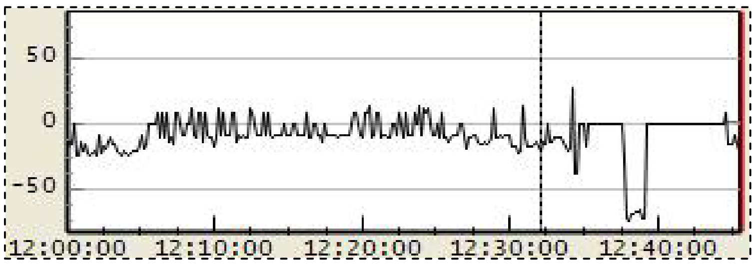
14.12 HRT – Heart Rate

Data Frequency	1 Hz (1.008 Seconds)
Units	BPM (Beats per minute)
Minimum Value	0
Maximum Value	240
Description	ECG data is filtered and processed to produce this value
Sample	 Heart Rate before, during and after a 3km run (logged data). The Y axis has auto-scaled to fit the data range of the entire session.
CSV Export	Yes

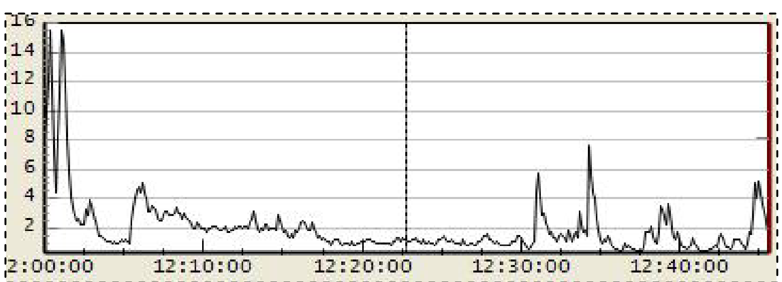
14.13 HRT – RR

Data Frequency	18 Hz (0.056 seconds)
Units	Milliseconds (ms)
Minimum Value	250 ms (=240 BPM) *reducing* HR in BPM *increases* RR interval
Maximum Value	1000 ms (=60 BPM)
Description	Time interval between successive heart contractions. Calculated from ECG data. Divide 60000 by the RR ms value to obtain instantaneous HR in beats per minute.
Sample	BUG – RR data still has alternating sings so graph is a sawtooth
CSV Export	Yes. Data is reported at 18 Hz, sign of values alternates positive and negative. A change of sign indicates that a new pulse has been detected.

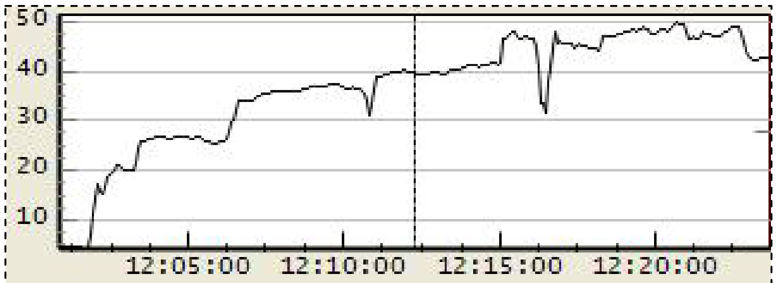
14.14 POS – Posture

Data Frequency	1 Hz (1.008 Seconds)
Units	Degrees from vertical
Minimum Value	– 90
Maximum Value	+ 90
Description	Degrees off vertical in any orientation. A positive value indicates an anterior (subject lean forward) component, negative a posterior component. See Section 4.4.2 A subject's natural posture may mean an 'upright' position does not generate a value of 0°
Sample	 A section of posture of a subject walking and then reclining in a chair (trough near end of recprding).
CSV Export	

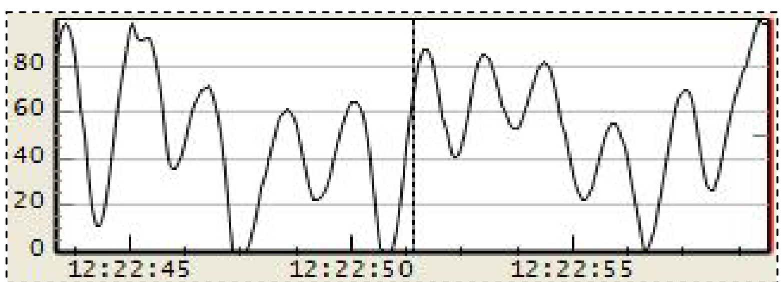
14.15 RES – Breathing Wave Amplitude

Data Frequency	1 Hz (1.008 Seconds)
Units	Volts (indicated)
Minimum Value	0
Maximum Value	TBD
Description	Average indicated breathing sensor output over previous second
Sample	 Breathing amplitude over a 3km run. This is an indicative measure of breathing depth.
CSV Export	Yes

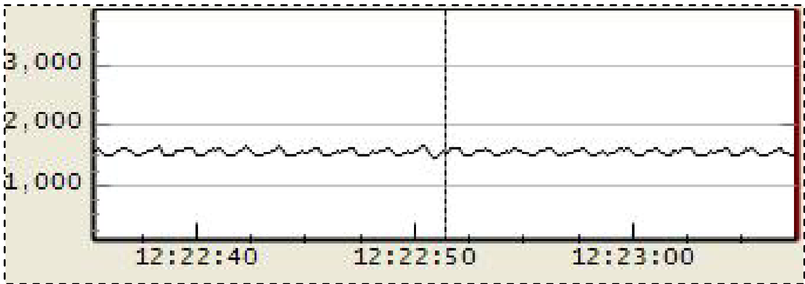
14.16 RES – Calculated Respiration Rate

Data Frequency	18 Hz (0.056 seconds)
Units	BPM (breaths per minute)
Minimum Value	0
Maximum Value	70
Description	Parameter calculated from raw RF-transmitted breathing data to drive the Breath detection icon on the application interface
Sample	 Section of data from a subject commencing a run. Note that isolated troughs and peaks in the data are likely to be artefacts.
CSV Export	No

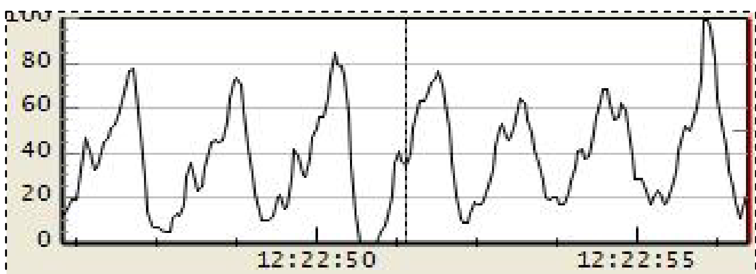
14.17 RES – Processed Breathing Wave Autoranged

Data Frequency	1 Hz (1.008 Seconds)
Units	n/a
Minimum Value	To fit graph scale
Maximum Value	To fit graph scale
Description	An indicative value only, due to autoranging process. Filtered and processed data – smooth waveform.
Sample	 Section of processed waveform. This should give an indication of the regularity of breathing action. The auto-range feature prevents any other inference being made from this data.
CSV Export	No

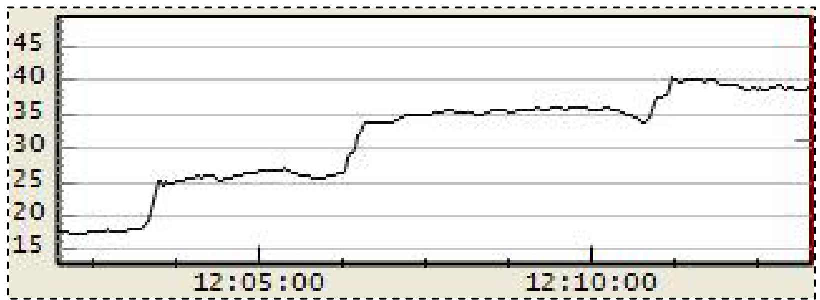
14.18 RES – Raw Breathing Wave

Data Frequency	18 Hz (0.056 seconds)
Units	Bits
Minimum Value	0
Maximum Value	4095
Description	Raw bit output of breathing sensor. Unfiltered, unprocessed.
Sample	 Raw breathing sensor output in bits. The variation in bits during breathing action compared to the absolute value is small.
CSV Export	Yes

14.19 Raw Breathing Wave Autoranged

Data Frequency	1 Hz (1.008 Seconds)
Units	n/a
Minimum Value	To fit graph scale
Maximum Value	To fit graph scale
Description	Unfiltered or processed data. A highly variable waveform
Sample	 Compare raw autoranged data with processed autoranged data (14.17), which is a much smoother curve.
CSV Export	No

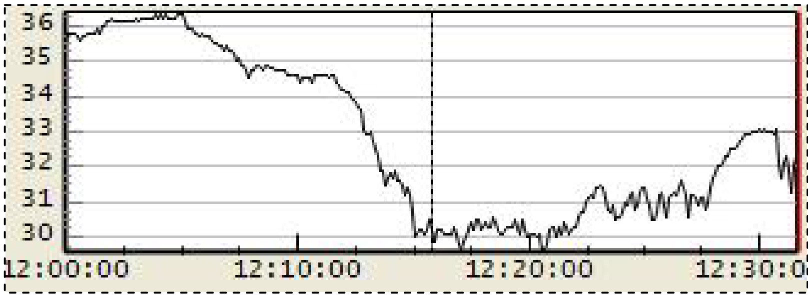
14.20 RES – Respiration Rate

Data Frequency	1 Hz (1.008 Seconds)
Units	BPM (breaths per minute)
Minimum Value	0
Maximum Value	70
Description	Respiration rate. It will take 30 – 45 seconds from start of data processing to stabilise
Sample	 Respiration rate showing step increases in rate as a subject starts a 3km run.
CSV Export	Yes

14.21 Respiration Rate Detector x 50

Data Frequency	1 Hz (1.008 Seconds)
Units	n/a
Minimum Value	0
Maximum Value	1
Description	A transition from 0 to 1 indicates a breath detection
Sample	This graph to be removed/reserved for developer version?
CSV Export	No

14.22 TEM – Skin Temperature

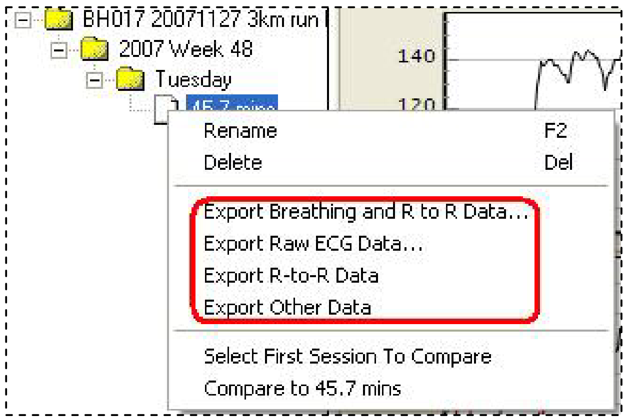
Data Frequency	1 Hz (1.008 Seconds)
Units	°C
Minimum Value	10
Maximum Value	60
Description	Skin temperature as measured by IR (infrared) sensor in apex of device. See section 1.3
Sample	 The degree of skin cooling of a subject during a 3km run – due to evaporative cooling of perspiration – is clearly evident.
CSV Export	Yes

15. Export data to an external .csv file

Any activity session which has been saved into the BioHarness application can be exported as a csv (comma separated values) file.

Note: Data which has been logged on the device does not include ECG Raw Data. This is only available from data which was transmitted over RF and recorded by the application. Including ECG Raw data in the Device log files would severely reduce total memory capacity

Right-click a record in the explorer panel and select data to export – csv column specifications are on the next page.



Notes

1. RF recorded data is time-stamped at time of reception on the host computer.
2. Logged data is time stamped with the time of the internal clock in the Device. This may be on a time after Jan 1 2000 12:00:00 if the batteries in the device have been recharged without setting the clock.
3. It may not be possible to see all data by opening the csv file as a standard Excel ® Spreadsheet, which has a limit of 65535 lines (2,000,000 in Excel ® 2007). This equates to around 61 minutes of logged data, or 4 minutes of RF raw ECG data. Open as a text file, or with an application designed to process large amounts of data.
4. 8 hours of data logged on the device itself will produce ~ 50MB of Breathing and R to R data, and ~12MB of Other data, in .csv format.
5. Posture - a positive value indicates the subject is inclined forward from vertical. A subject's natural posture, together with the contour of their torso, may indicate either a positive or negative value when they are in a standing or sitting position. Inclination to the subject's left or right does not affect the sign of the posture value.
6. Respiration Rate – in *Other Data* Export, data will not be populated in the Respiration Rate columns when exporting from some earlier version of BioHarness Projects. This data was used for development purposes. Users should use the Calculated Respiration Rate available by exporting *Breathing Rate and R to R* data.
7. R-to-R data. These values alternate in sign. Take an absolute value to graph variations in magnitude.

16. Understand External Data Files

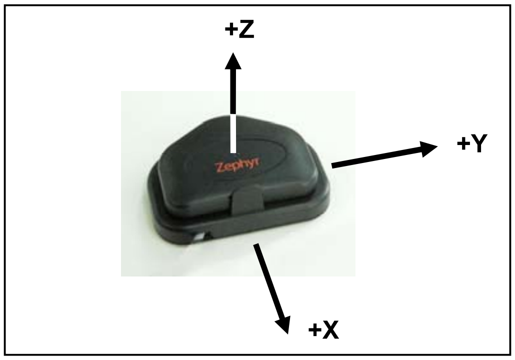
Export Breathing and R to R Data	Data Frequency: 0.056 seconds (18 Hz)			
	Log	RF	Typical Range	Units
(All timestamps)				yyyy/mm/dd hh:mm:ss.000
HRT - R to R	Y	Y	300 – 1500	Milliseconds (alternating ±)
RES - Calculated Respiration Rate	Y	Y	5-50	Breaths per Minute (BPM)
RES - Raw Breathing Wave	Y	Y	± 100 variation	Bits

Export Raw ECG Data	Data Frequency: 0.004 seconds (250 Hz)			
	Log	RF	Typical Range	Units
ECG - Raw Data	N	Y	1500-2400	Bits

Export R-to-R Data	Data Frequency: per pulse detection			
	Log	RF	Typical Range	Units
HRT – R to R Data	Y	Y	300 – 1500	Milliseconds (alternating ±)

Export Other Data	Data Frequency: 1.008 seconds			
	Log	RF	Typical Range	Units
HRT - Heart Rate	Y	Y	50 – 150	Beats per Minute
ECG - Amplitude	Y	Y	0.0004 – 0.0005	Volts
ECG - Noise	Y	Y	0.00005 – 0.0001	Volts
RES -Breathing Wave Amplitude	Y	Y	1 – 4	Volts
RES - Respiration Rate	Y	Y	5 – 50	Breaths per Minute
TEM - Skin Temperature	Y	Y	30 – 37	°C
BAT - Battery Voltage	Y	Y	4.0 – 4.2	Volts
POS - Posture	Y	Y	–90 – +90	Degrees from vertical
ACC - Activity	Y	Y	0 – 5.7	g
ACC - Peak Acceleration	Y	Y	–3.3 – +3.3	g
ACC - X Acceleration Minimum	Y	Y	–3.3 – +3.3	g
ACC - X Acceleration Peak	Y	Y	–3.3 – +3.3	g
ACC - Y Acceleration Minimum	Y	Y	–3.3 – +3.3	g
ACC - Y Acceleration Peak	Y	Y	–3.3 – +3.3	g
ACC - Z Acceleration Minimum	Y	Y	–3.3 – +3.3	g
ACC - Z Acceleration Peak	Y	Y	–3.3 – +3.3	g

Orientation of XYZ axes for acceleration data:



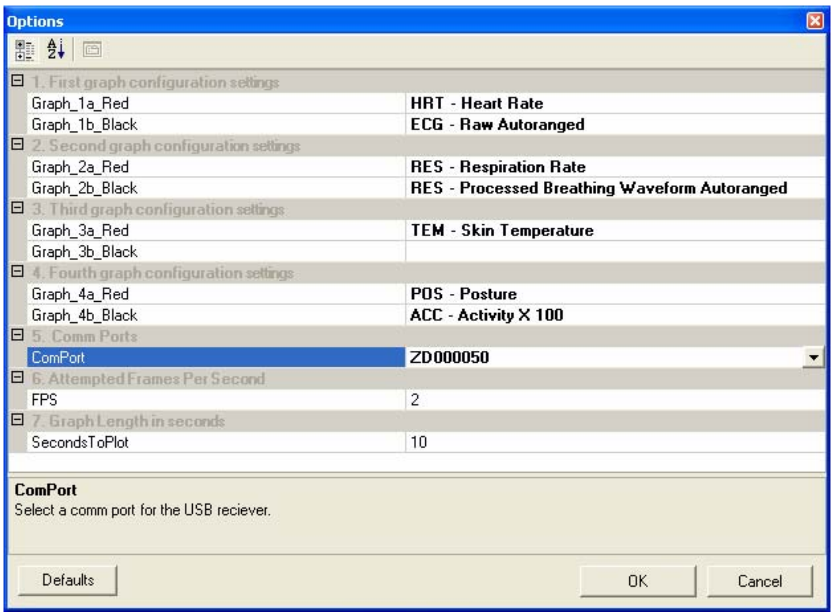
17. Change Settings

17.1 COM Port Selection

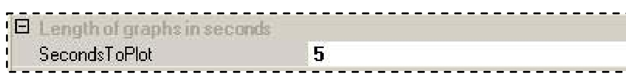
The COM port will auto-select and display the serial number of the Zephyr RF dongle connected when used in Transmit mode. A ‘Too Many Dongles’ message appears in the Status field on the application if more than one dongle is connected.

17.2 Display Settings

The default display settings (shown below) can be changed by selecting from the appropriate pull down lists. Return to Default settings using the button provided. The application remembers the last display settings selected.



17.3 Adjust Timescale Range



- Select Tools>Options
- Adjust Seconds to Plot if default 10 seconds displays too much or too little data
- Lower values cause graph to scroll faster, high values use more computer resource
- Available Range 2 – 100 seconds

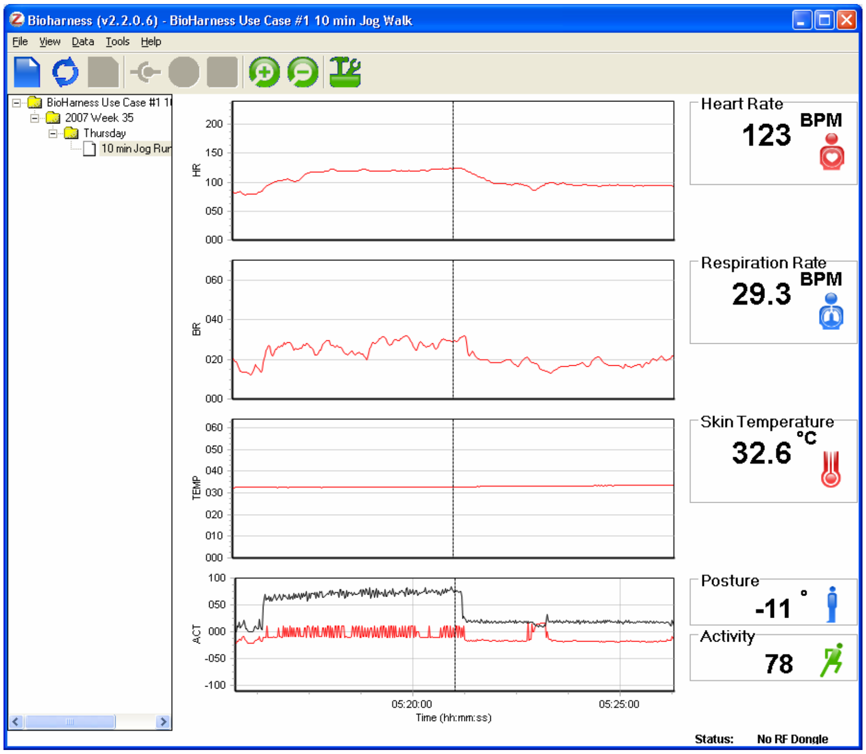
17.4 Adjust Frame Refresh Rate for Graphs (Refreshes per Second)

- Range is 1 – 100. Default is 2. Increasing the rate improves graph refresh performance but will require more PC resource – a faster processor and more RAM. Adjust if necessary for the best performance for your particular PC.

18. Sample BioHarness Projects

(These Projects are available on the installation CD – copy them to your PC before opening)

18.1 Use Case Example #1: Treadmill 7kph Jog / 4 kph walk Time: 10 min

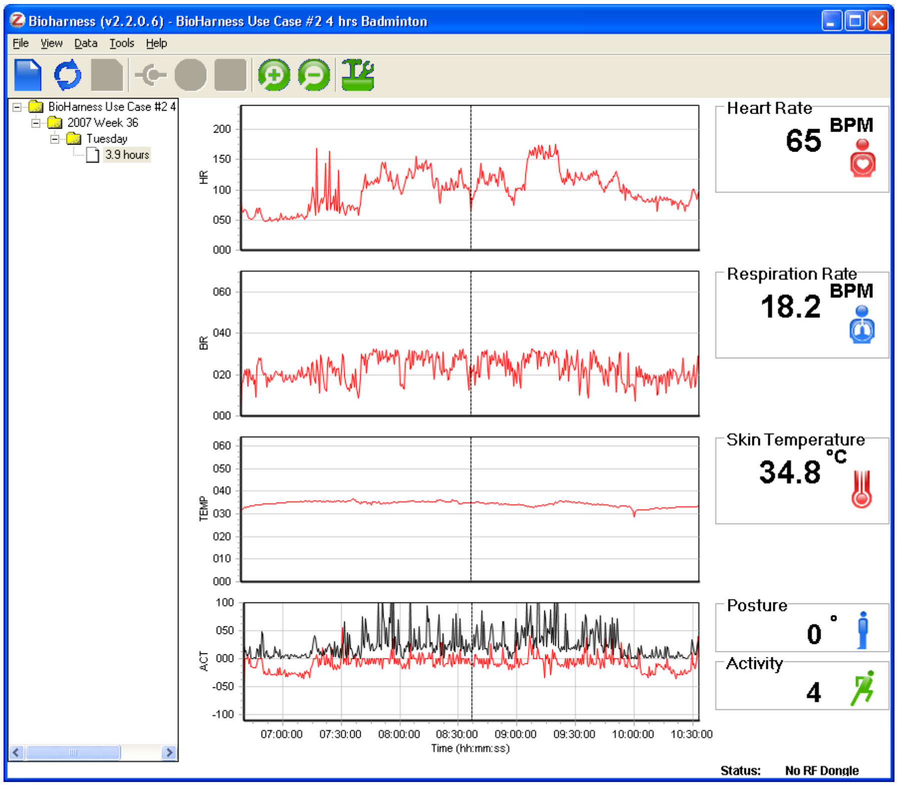


This project has been made in RF recording mode. Raw ECG data is available for export to a csv file. The ECG Raw data and Processed Breathing Waveform have been removed using Graph Settings so as not to obscure the trend data.

1. Heart Rate – shows rise from rest value of ~ 80 bpm to peak of 123 bpm at end of jogging section
2. Respiration Rate – the subject's breathing rate of 28 bpm while jogging eased to 18 bpm when walking, to the immediate right of the cursor position.
3. Skin temperature – the readings are relatively stable during this 5 minute activity.
4. Posture – the actual posture reading depends on the exact attitude of the device. It may not be 0° when the subject is standing or sitting upright. High levels of activity may result in offsets in the posture reading. A negative Posture value indicates the device is inclined rearwards
5. Activity – activity levels are measured in Vector Magnitude Units, which are determined using the acceleration values sampled in all three axes over the 1 second epoch. The change from stationary to jogging to walking is clearly evident.

   Use the *Activity x 10* or *Activity x 100* graph options to display activity data against the Y axis scale. The actual unscaled value is shown at the end of the graph.

18.2 Use Case Example #2: Badminton — Time: 3.9 hrs



This project has been made in logging mode. Raw ECG data is not available for export to a csv file.

1. Heart Rate – there is an initially noisy section. At this point the subject was helping to set up the nets and other equipment.
2. Respiration Rate – breathing rate is inherently more variable during racket games. Reductions in breathing rate between games are evident.
3. Skin temperature – the subject's temperature climbs from 32° to 36° during the activity. The dip in skin temperature occurred when the subject left the court and stopped to talk outside.
4. Posture – the actual posture reading depends on the exact attitude of the device. It may not be 0° when the subject is standing or sitting upright. High levels of activity – as seen here - may result in offsets in the posture reading. A negative Posture value indicates the device is inclined rearwards
5. Activity – activity levels are measured in Vector Magnitude Units, which are determined using the acceleration values sampled in all three axes over the 1 second epoch.
6. Use the *Activity x 10* or *Activity x 100* graph options to display activity data against the Y axis scale. The actual unscaled value is shown at the end of the graph. Closer study can identify the periods when the subject drove to and from the site

19. Troubleshooting

Issue	Cause	Action/Solution
Functionality		
Poor HR performance	Poor conductive path between skin and sensor pads	Moisten pads, adjust position of garment, adjust garment tension
	Movement artefacts	Adjust the garment tension
	Weak ECG signal	Compare ECG amplitude when subject stationary, with other subjects. Subjects with exceptionally weak ECG signals may not be good candidates for the system
	EMG noise caused by vigorous arm/torso movements	Reduce movements - EMG can't be eliminated
Poor Breathing performance	Regular or rhythmic activity which causes expansion of rib cage	Cease or be aware of activity. This doesn't appear to be a factor during normal running activity, but thoracic twisting, Arm lifts and chopping action all compromise breath detection
	Sudden changes in breathing patterns	
Rapid changes in skin temperature	Perspiration droplets on skin within field of IR sensor window; same on sensor window itself	Avoid excessive perspiration accumulation in sensor field (if this is practical)
Inaccurate skin temperature	Dirty sensor window	Check and clean sensor window
Straight lines in ECG trace	Dropped RF data packets	Check RF signal quality indicator, see list of factors affecting RF performance in Section 7. Move closer to receiver antenna. Raise the receiver antenna.
Electronic		
USB Device not recognised	Faulty lead	Check with replacement
	USB Hub Com Port issues	Connect direct to PC, not through hub
	Driver issue	Uninstall and reinstall driver - see Section 4.2 Install Guide
GUI		
Poor graph response	Low specification PC	Change to higher spec PC if possible
		Change graph refresh rate - see Section 17.4
	Too many applications running concurrently	Close other applications
Timeout Error on Import from device		Retry
Data		
Single data line anomaly in Imported log	File corruption during Import	Re-import

20. Glossary

Application Software: Program designed for a specific use, often with a graphical user interface (GUI)

BioHarness Device: Transmitter/recorder device which attaches by snaps to BioHarness garment

BPM: Beats per minute (ECG), Breaths per minute (Respiration)

CSV: Comma Separated Values - a common data file format where the data values are separated by commas. Can be opened as a text file or a spreadsheet.

Data Packet: A discrete collection of data sent by radio transmission

Dongle: Communications device designed to be plugged into a computer

Drivers: Software program files which facilitate communication between a computer's operating system, a hardware device, and application interface

ECG: Electrocardiogram (also EKG) - a test which records the electrical activity of the heart

EMG Noise: An electromyelogram is a measurement of electrical signals generated during the course of muscular contractions. EMG noise is generated by skeletal muscle tissue (other than the heart) during activity

GUI: Graphical User Interface - interactive graphical computer interface

Initialise: In BioHarness context, a process whereby the internal clock of a BioHarness device is set to a host PC's clock time when the BioHarness is connected to the computer in its USB cradle

IR: Infrared - measurement of temperature using an infrared-sensitive sensor.

ISM: Industrial, Scientific & Medical - a radio frequency band allocated internationally for short-range radio applications

LED: Light Emitting Diode - low current illumination source

Li-ion: Lithium Ion - a type of rechargeable power source

Logging Mode: A BioHarness Device state where the device records data to its internal memory, and timestamps data according to its internal clock

R to R / RR: The time interval between the R peaks in the QRS pattern on an ECG trace which represents contraction of the heart ventricles

RF: Radio Frequency

Timestamp: Data field time component describing time of recording

USB: Universal Serial Bus - common computer communications protocol

VMU: Vector Magnitude Units - a measurement of activity which is an integration of XYZ acceleration magnitudes over a time interval

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Warranty

Limited Warranty for the Zephyr BioHarness™ physiological monitoring system

Zephyr Technology Ltd warrants to the original end purchaser that the BioHarness™ hardware shall be free from material defects in material and workmanship for a period of one (1) year from the original date of purchase (the "Hardware Warranty Period"), the BioHarness Chest Strap shall be free from material defects in material and workmanship for a period of three (3) months or 50 hand washes, whichever comes first, from the date of purchase (the “Chest Strap Warranty Period”) and the software shall be free from material defects or errors for a period of one (1) year from the original date of purchase (the “Software warranty period”). If the product is determined to be materially defective during the Warranty Period, your sole remedy and Zephyr’s sole and exclusive liability shall be limited to the repair or replacement of this product with a new or refurbished product at Zephyr’s or its licensed distributor’s option. For purpose of this Limited Hardware Warranty and Liability, "refurbished" means a product that has been returned to its original specifications. Visit www.zephyr-technology.com for instructions on how to deliver the product to an authorized service facility.

This warranty shall not apply if this product
(a) is used with products that are not compatible with this product
(b) is modified, or tampered with
(c) is damaged by acts of God, misuse, abuse, negligence, accident, wear and tear, unreasonable use, or by other causes unrelated to defective materials or workmanship
(d) has had the serial number altered, defaced or removed; or
(e) has, in the reasonable opinion of zephyr or it’s licensed distributors, been opened, altered, or defaced. This warranty shall also be voidable by zephyr or its licensed distributors

If (1) Zephyr reasonably believes that the BioHarness™ system has been used in a manner that would violate the terms and conditions of a separate end user license agreement for system software; or (2) the product is used with products not sold or licensed by Zephyr. You assume all risks and liabilities associated with use of third party products.

This warranty is provided to you in lieu of all other express or implied warranties including warranties of merchantability and fitness for a particular purpose for the BioHarness™ system, which are disclaimed hereunder. However, if such warranties are required as a matter of law, then they are limited in duration to the warranty period.

Our sole and exclusive recourse in the event of any dissatisfaction with or damage arising from the use of the BioHarness™ system and Zephyr's maximum liability shall be limited to repair or replacement of the BioHarness™ system. Except as expressly stated above, Zephyr excludes all liability for any loss of data, loss of profit, or any other loss or damage suffered by you or any third party, whether such damages are direct, indirect, consequential, special, or incidental and however arising under any theory of law, as a result of using your BioHarness™ system. Some countries, states or provinces do not allow limitation on how long an implied warranty lasts and some countries, states and provinces do not allow the exclusion or limitations of consequential or incidental damages, so the limitations or exclusions may not apply to you.

This warranty gives you specific legal rights, and you may also have other rights which vary from country to country, state to state or province to province. This warranty is in all countries where Zephyr has an office or a licensed distributor. The warranty offered by Zephyr Technology Limited on your BioHarness™ hardware is the same whether or not you register your product. Failure to register within one (1) week of receipt voids the warranty for the BioHarness Chest Strap.