Metabolic Analysis with LabScribe

Introduction

Metabolic parameters are detected, and functions derived from those parameters are computed in *LabScribe's* **Metabolic Advanced Analysis Module**.

The **Metabolic Advanced Analysis Module** requires a separate license. The first time you select **Metabolic**, you will be asked for a username and a serial number. Your username and serial number can be found on the packing slip that is included with the metabolic kit.

The **Metabolic Advanced Analysis Module** can both analyze online data as they are being collected, and perform offline analysis of previously recorded data files.

This document includes a **Step by Step** tutorial for using most of the features of the **Metabolic Advanced Analysis Module**, as well as a more detailed **Reference** section that covers the material in the tutorial, and adds additional context and detail. To use the **Step by Step** guide, you will need a recording with metabolic data. In order to use the online analysis part of the module, you will need to be recording these parameters as you proceed through the tutorial. This file can then be saved and used in the offline analysis tutorial.

For users not familiar with how to use iWorx hardware and software to generate a file with metabolic data, a checklist for setting up the metabolic cart, and configuring *LabScribe* to record metabolic data, follows the **Step by Step** and **Reference** sections of this document. Detailed hardware and software instructions are also included in the individual **Human Exercise** lab exercises that utilize iWorx gas analyzers. There are also instructional videos available at iworx.com illustrating the process.

Metabolic Analysis: Step by Step

When **Metabolic** is chosen from the **Advanced** menu, a submenu opens, displaying three options: **Calibrate Flowhead**, **Online Calculations**, and **Offline Calculations**.
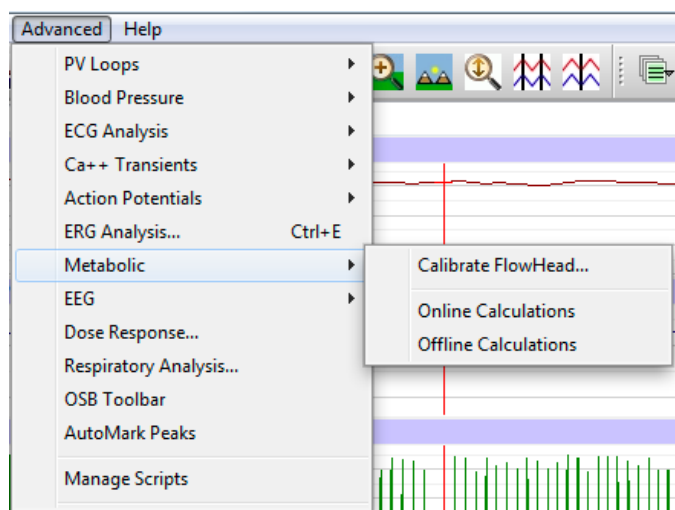
Metabolic submenu

Complete instructions for using the **Calibrate Flowhead** dialog can be found in the **Spirometer Calibration** exercise found in the **Human Exercise-GA200** and the **Human Exercise-GA300** folders of the complete *LabScribe* installer.

The **Online Calculations** and **Offline Calculations** options provide analysis of metabolic experiments that use a mixing chamber such as the experiments in the **Human Exercise-GA200** and **Human Exercise-GA300** folders of the complete *LabScribe* installer.

Online Calculations
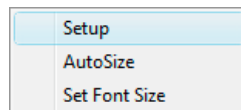
To use the **Online Calculations:**

To perform real-time analysis of mixing chamber metabolic data, *LabScribe* needs to be configured as in the experiments in the **Human Exercise-GA200** and **Human Exercise-GA300** folders. The procedure for setting up the iWorx hardware and software is also summarized after the **Reference** section of this manual. Using the **Online Calculations**, it is possible to generate metabolic calculations in real time.

1) Configure the hardware and *LabScribe* software to record mixing chamber metabolic data.
2) Record a sample, autoscaling all channels. Stop recording as you configure the online analysis.
3) Choose **Online Calculations** from the **Metabolic** submenu to display the **Metabolic Toolbar** above **Channel 1**.
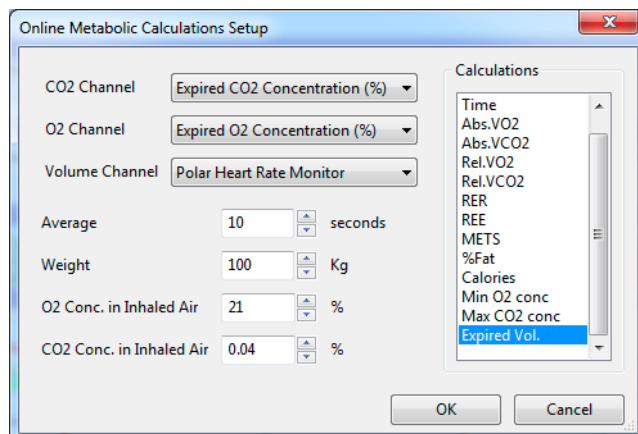

Online Metabolic Toolbar

4) Click on the down arrow on the left side of the **MetabolicToolbar** to display a submenu with three choices: **Setup**, **AutoSize**, and **Set Font Size**.


Metabolic Online Setup Menu

5) Choose **Setup** to open the **Online Calculation Setup** dialog.

Online Metabolic Calculations Setup dialog.

6) From the **CO2 Channel** menu, choose the % CO_2 channel from your recording.
7) From the **O2 Channel** menu, choose the % O_2 channel from your recording.
8) From the **Volume Channel** menu, choose the breath volume channel from your recording.
9) In order to compensate for variation from breath to breath, it is possible for *LabScribe* to average the data over a segment of time. In the text box to the right of **Average**, indicate the segment duration you would like to average for analysis. The ACSM recommends an averaging time of twenty seconds.
10) In the text box next to **Weight**, enter the weight of your subject in kilograms.
11) In the text box to the right of **O2 Conc. in Inhaled Air**, indicate the oxygen concentration of inhaled air, usually 20.9%.
12) In the text box to the right of **CO2 Conc. in Inhaled Air**, indicate the carbon dioxide concentration of inhaled air, usually 0.04%.
13) From the **Calculations** list, control-click on those variables you would like to record in the data boxes of the **Metabolic Toolbar**. To remove a variable after you have selected it, control-click on that variable. Definitions of all variables can be found in the **Metabolic Analysis: Reference** section.
14) Click **OK** to close the dialog.
15) Return to the **Metabolic Toolbar** menu (accessed by clicking the arrow) and choose **AutoSize**. The size of the data boxes and the titles will be adjusted to the number of variables you have chosen.
16) From the **Metabolic Toolbar** menu, choose **Set Font Size**. The font size of the data box values can be chosen from the dialog that opens.
17) Resume recording. The changing variables will be displayed in the data boxes of the toolbar.
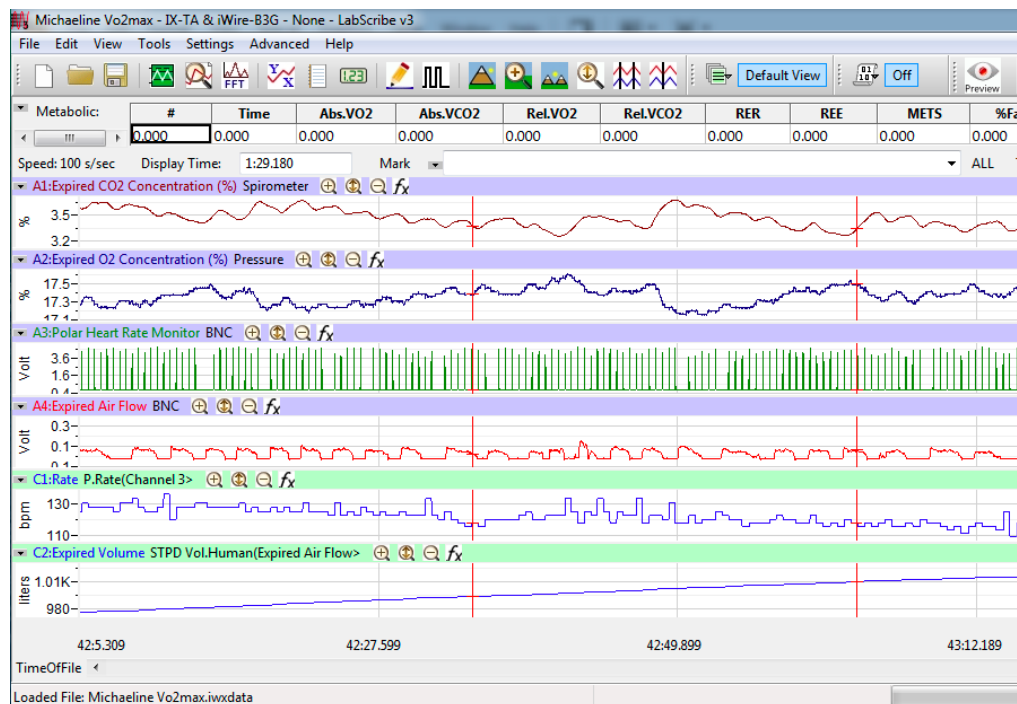

Online Metabolic main window display.

18) Save the recording for offline analysis.

Offline Calculations

The offline **Metabolic Calculations** dialog allows sophisticated offline analysis of previously recorded metabolic data.

To perform offline analysis:

1) Open the recording from the online analysis or another file with previously recorded metabolic data.

2) Choose **Offline Calculations** from the **Metabolic** submenu to open the **Offline Calculations** dialog. The panels of this dialog can be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.

3) Familiarize yourself with the **Offline Calculations** dialog, pictured below.
   - The tabbed configuration dialogs are on the upper left portion of the dialog.
   - An XY graph window on the right displays the **Metabolic Graph**, showing metabolic data from the selected segments in the **Segments Selected** list.
   - Between the configuration dialogs and the XY graph window is the **Segments Selected** list, an editable list of the segments that can be displayed and analyzed.
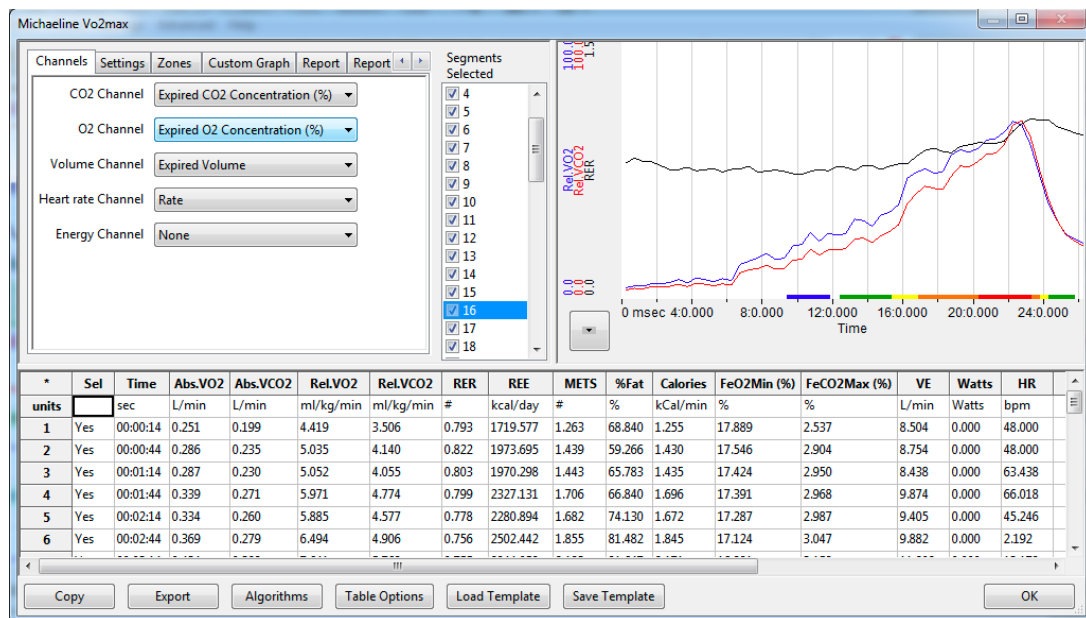
The Offline Calculations Dialog

4) The **Data Table** is located on the lower part of the dialog.

To configure the **Channels:**

1) Click on the **Channels** tab, opening the **Channels** configuration dialog.

The Channels configuration dialog.

2) From the **CO₂ Channel** menu, choose the % CO_2 channel from your recording.
3) From the **O₂ Channel** menu, choose the % O_2 channel from your recording.
4) From the **Volume Channel** menu, choose the breath volume channel from your recording.
5) From the **Heart rate Channel** menu, choose the calculated heart rate channel from your recording.
6) Optionally, choose an **Energy Channel** if there is one on the recording, typically a power output from an ergometer.

To configure the **Settings:**

1) Click on the **Settings** tab, opening the **Settings** configuration dialog.


The Settings configuration dialog.

2) Enter the subject's name and the protocol being used in the **Name** and **Protocol** text boxes.
3) Enter the subject's age and sex in the **Age** and **Sex** text boxes.

5

4) Select the amount of time to average per segment in the **Average (sec)** text box.
5) Enter the subject's height (in centimeters or inches) and weight (in kilograms or pounds) in the **Height** and **Weight** text boxes.
6) Enter the maximum experimental heart rate your subject may attain in the **Maximum Heart Rate** text box. This is typically calculated as: 220 - the subject's age.
7) Enter the concentrations of oxygen (usually 20.9%) and carbon dioxide (usually 0.04%) in inhaled air in the **Insp. O2 (%)** and **Insp. CO2 (%)** text boxes.
8) The subject's profile can be saved for future experiments by clicking the **Save Subject** button at the top of the dialog. This profile can later be retrieved and entered by clicking the **Load Subject** button.
9) By clicking **Calculate**, the **Metabolic Graph** will appear in the XY graph window, and the **Data Table** will be populated with the metabolic parameters. Click **Calculate** whenever settings are updated.
10) The subject's anaerobic threshold (**AT**) is calculated automatically, and is shown in the **VCO2 vs VO2** XY graph. This value can be recalculated manually as described in the **Metabolic Graph** section below. Click **Calculate AT** to display the recalculated anaerobic threshold.
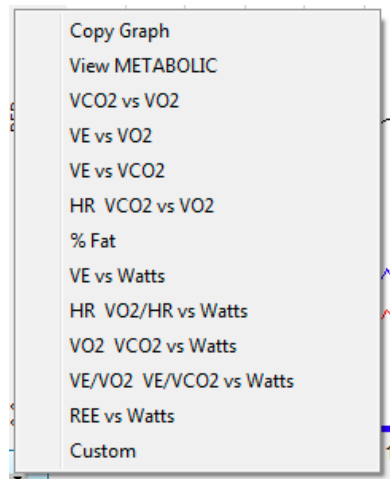
To display and analyze the **Metabolic Graph:**
1) Familiarize yourself with the **Metabolic Graph**, which will be displayed in the XY graph area for all the segments in the selection and is illustrated below.
   - By default, the graph displayed is of **VCO2**, **VO2**, and **RER** over time. All the segments are displayed.
   - Segments can be deselected (or selected) by clicking on the check box to the left of the segment number in the **Segments Selected** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles.
   - The specific parameters shown in the graph can be customized in the **Custom Graph** dialog.
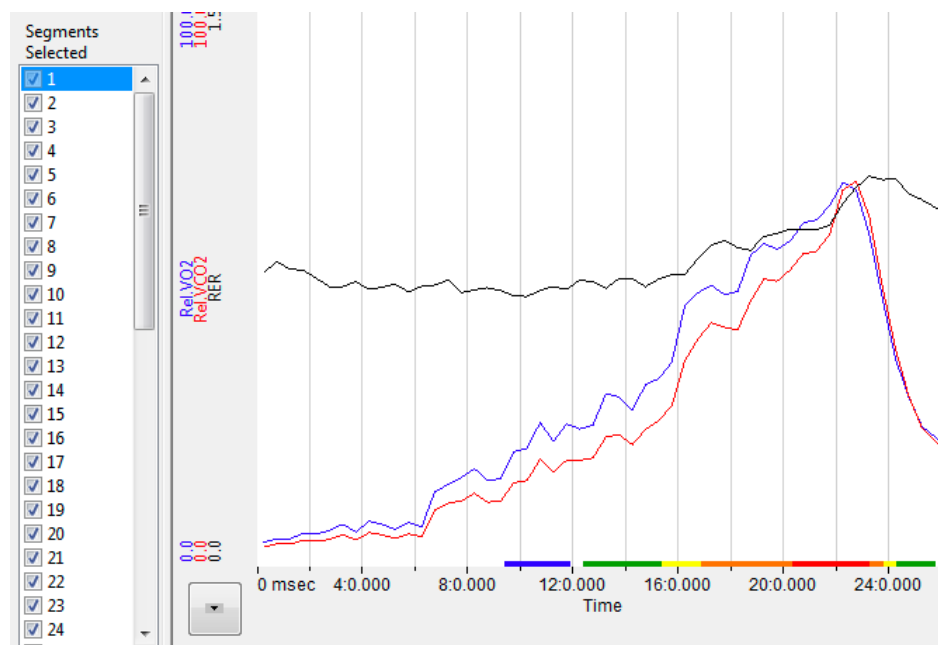

The Metabolic Graph.

2) Click the arrow to the lower left of the XY graph window to open a menu with options for the displayed XY graph.

| Copy Graph |
| View METABOLIC |
| VCO2 vs VO2 |
| VE vs VO2 |
| VE vs VCO2 |
| HR VCO2 vs VO2 |
| % Fat |
| VE vs Watts |
| HR VO2/HR vs Watts |
| VO2 VCO2 vs Watts |
| VE/VO2 VE/VCO2 vs Watts |
| REE vs Watts |
| Custom |

XY Graph menu.

3) Click **Copy Graph** to copy the current **Metabolic Graph** to the clipboard. It can then be pasted into the **Journal** or an external application.
4) **View Metabolic** displays the default graph.
5) **VCO$_2$ vs VO$_2$** displays VCO$_2$ as a function of VO$_2$. The subject's anaerobic threshold (**AT**) is calculated automatically and is indicated on this graph, as well as the intervals over which the slopes before and after the aerobic/anaerobic break were determined. These intervals (indicated by the markers labeled 1 - 2 and 3 - 4) can be adjusted by moving the markers on the graph. Click **Calculate AT** in the **Settings** dialog to recalculate the anaerobic threshold based on the revised intervals.
6) **VE vs VO$_2$** displays the minute ventilation as a function of VO$_2$.
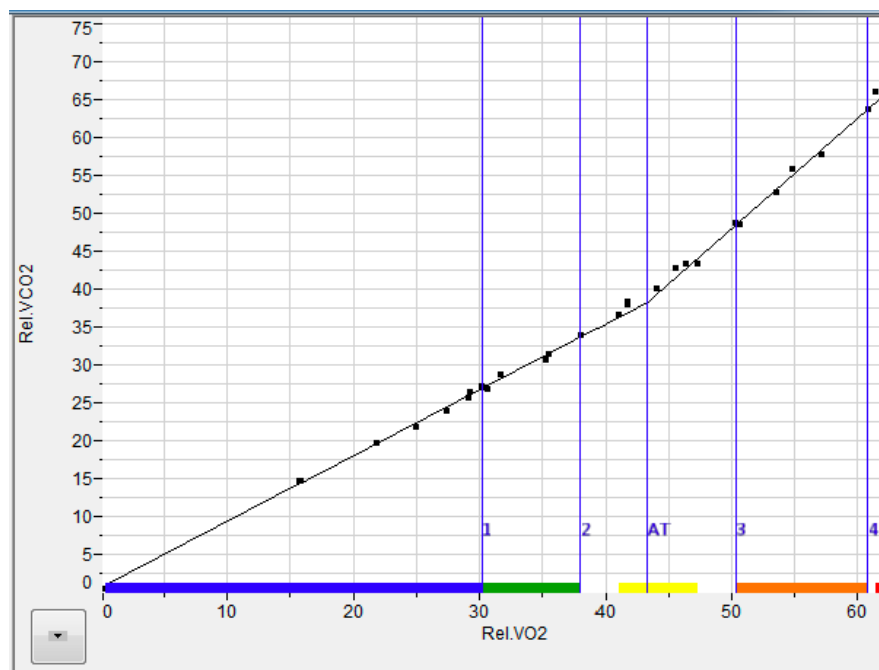
VCO$_2$ vs VO$_2$ XY graph with Anaerobic Threshold (AT) indicated.

7) **VE vs VCO₂** displays the minute ventilation as a function of VCO_2.
8) **HR VCO₂ vs VO₂** displays the Heart Rate and VCO_2 as a function of VO_2.
9) **% Fat** displays the calories from fat as a % of total calories burned over time.
10) **VE vs Watts** displays the minute ventilation as a function of Watts (requires an Energy channel).
11) **HR VO₂/HR vs Watts** displays the Heart Rate and VO_2/HR as a function of Watts (requires an Energy channel).
12) **VO₂ VCO₂ vs Watts** displays VO_2 and VCO_2 as a function of Watts (requires an Energy channel).
13) **VE/VO₂ VE/VCO₂ vs Watts** displays VE/VO_2 and VE/VCO_2 as a function of Watts (requires an Energy channel).
14) **REE vs Watts** displays REE as a function of Watts (requires an Energy channel).
15) **Custom** displays a custom graph as configured in the **Custom Graph** dialog.

To configure **Zones:**
1) Click on the **Zones** tab to open the **Zones** configuration dialog.

The

Zones configuration dialog.

2) Different heart rate zones are displayed in different colors on the X-axis of the default graph and the **VO₂ vs VCO₂** XY graph. The default zones are automatically calculated based on the subject's maximum heart rate and will typically not need to be changed. If, however, you would like to change the zones from the default settings, it is possible to change an individual subject's heart rate zones by changing the values in this dialog.

To configure the **Custom Graph:**
1) Click on the **Custom Graph** tab to open the **Custom Graph** dialog.
2) Choose the variable you would like displayed on the X-axis of the XY graph by choosing one of the variables in the menu next to **X-axis**.
3) Choose the variable(s) you would like displayed on the Y-axis by choosing them from the menus in the boxes of the left column next to **Y-axis.**
4) Choose the desired color for each Y variable, whether you would like the data displayed as dots or a line, and the Y-axis scale for each chosen variable.
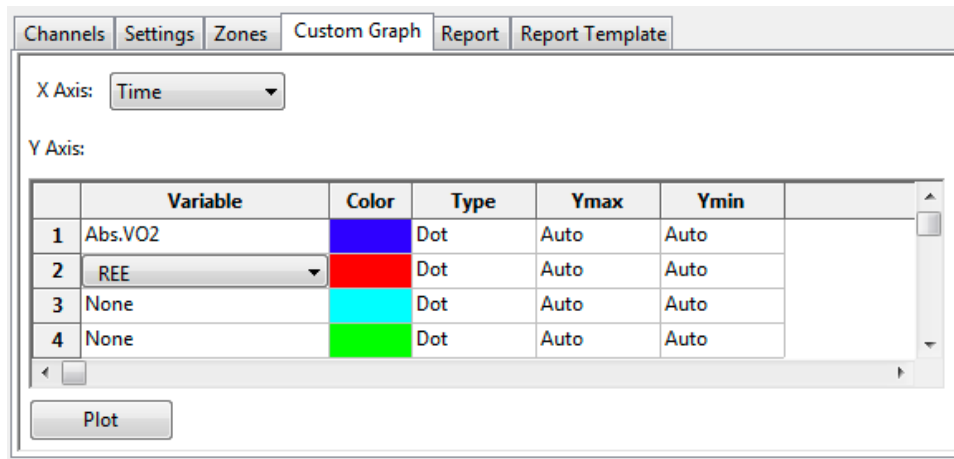
The Custom Graph configuration dialog.

5) Click **Plot** to display your custom graph. Choosing **Custom** from the XY graph menu will display the most recently configured custom graph.

To configure the **Report:**

1) Click on the **Report** tab to open the **Metabolic Report** configuration dialog.
2) By clicking **Create Report**, a dated report is generated. This report includes subject information, the metabolic data in table form, and the current set of XY graphs.
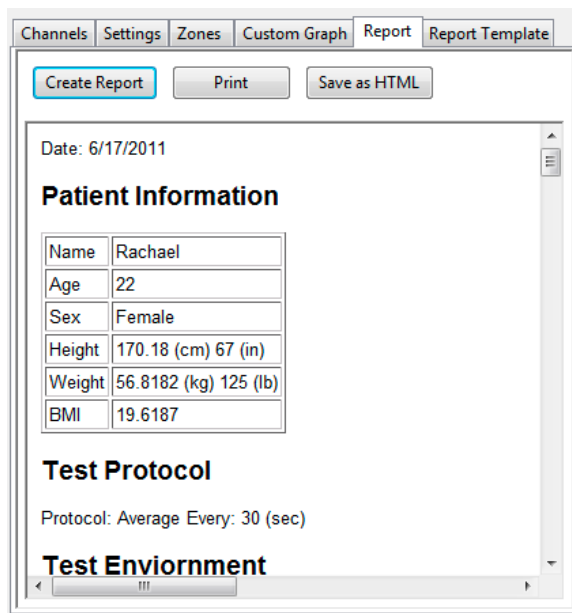
The Report Configuration Dialog

3) Included in the report are data from previously saved subject data. When **Save Subject** is clicked in the **Settings** configuration dialog, the averaged data from the current experiment are saved as part of the subject profile and when **Load Subject** is clicked in the **Settings** dialog of a future experiment, these data are entered into the Results summary that is part of the report, as indicated in the figure below.

Results

| Calculation	2012-05-22	2013-01-30	2013-06-13	Units
Maximum Heartrate	187	183	177	beats per min
Heartrate at Threshold	139	143	132	beats per min
Heartrate at aerobic base	111	118	110	beats per min
VO2 max	63.2	65.8	65.7	ml/kg/min
VO2 at Threshold	36.0	44.4	43.3	ml/kg/min
VO2 at aerobic base	19.1	20.4	30.7	ml/kg/min
VCO2 max	77.8	75.9	75.9	ml/kg/min
VCO2 at Threshold	32.0	39.2	38.3	ml/kg/min
VCO2 at aerobic base	19.1	20.5	26.8	ml/kg/min

Results summary in Report including data from this subject's prior experiments.

4) Click **Print** to print the report.
5) Click **Save as HTML** to save the HTML source code for the report.

To configure the **Report Template:**

1) Click on the **Report Template** tab to open the **Metabolic Report Template** configuration dialog. Here you can customize the HTML code for the report generated in the **Report** dialog.
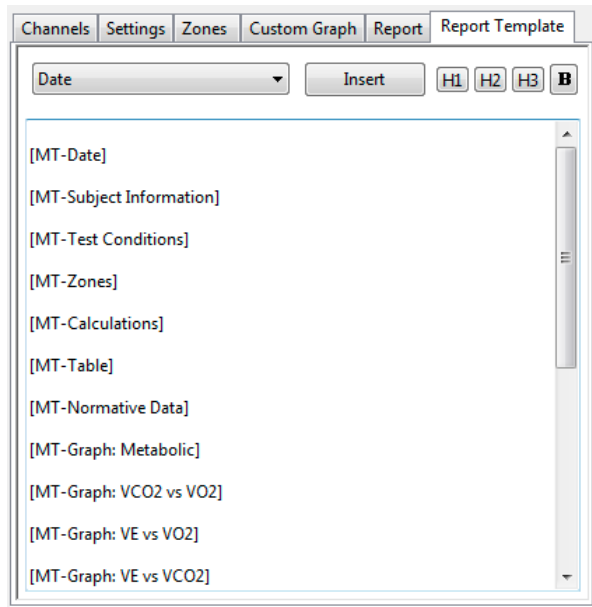
The Report Template configuration dialog.

2) Edit the elements to be included in the report by deleting elements not desired, changing the order of the elements, and adding elements from the **Insert** menu.
3) Add text directly to the report template and customize the appearance of added text with the HTML code provided.

4) Copy the template and save it in a text editor from which it can be copied and pasted into this dialog in future experiments.

To use the **Data Table:**

*	Sel	Time	Abs.VO2	Abs.VCO2	Rel.VO2	Rel.VCO2	RER	REE	METS	%Fat	Calories	FeO2Min (%)	FeCO2Max (%)	VE	Watts	HR	
47	Yes	00:23:14	3.400	3.581	59.846	63.028	1.053	24832.720	17.099	0.000	17.002	17.273	3.818	101.033	0.000	185.818	er
48	Yes	00:23:44	2.748	2.868	48.368	50.481	1.044	20024.412	13.819	0.000	13.741	17.225	3.841	80.427	0.000	179.068	
49	Yes	00:24:14	2.121	2.222	37.338	39.111	1.047	15472.123	10.668	0.000	10.607	17.389	3.681	65.042	0.000	164.471	
50	Yes	00:24:44	1.737	1.746	30.567	30.724	1.005	12537.678	8.733	0.000	8.684	17.221	3.734	50.370	0.000	147.507	
51	Yes	00:25:14	1.435	1.421	25.258	25.006	0.990	10322.146	7.217	3.327	7.176	17.315	3.597	42.577	0.000	135.545	
52	Yes	00:25:44	1.326	1.285	23.335	22.611	0.969	9487.320	6.667	10.344	6.629	17.332	3.520	39.345	0.000	125.386	
53	Yes	00:26:14	1.228	1.173	21.611	20.643	0.955	8756.923	6.175	14.924	6.139	17.378	3.436	36.807	0.000	120.682	
55																	
56	#		44	44	44	44	44	44	44	44	44	44	44	44	44	44	
57	Mean		1.975	1.729	34.756	30.437	0.841	13808.813	9.930	54.380	9.874	16.446	3.872	47.004	0.000	132.031	
58	SD		1.056	1.055	18.586	18.568	0.102	7592.239	5.310	31.703	5.280	0.606	0.387	28.146	0.000	36.145	
59	Max		3.928	3.940	69.130	69.336	1.053	28183.000	19.751	90.441	19.639	17.389	4.349	112.202	0.000	187.547	0.
60	Min		0.382	0.291	6.723	5.121	0.729	2594.836	1.921	0.000	1.910	15.544	2.865	10.571	0.000	68.868	0.

Metabolic Data Table.

1) Familiarize yourself with the **Data Table**.
   - The **Data Table** spans the lower part of the **Metabolic Calculations** dialog and displays the calculated values for each of the segments in the **Segments Selected** list.
   - The top line indicates the **units** for each of the chosen parameters.
   - The colors in the left-hand column correspond to the Heart Rate zones configured in the **Zones** dialog.
   - The bottom few rows show the sample size, the mean, the standard deviation, minimum and maximum values, and the range of each of the chosen parameters averaged over all the selected segments.
2) Click the asterisk at the upper left of the **Data Table** to display two options: **AutoSize** and **Copy Selection**. **AutoSize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.

There are six buttons beneath the **Data Table: Copy, Export, Algorithms, Table Options, Load Template,** and **Save Template.**

1) Click **Copy** to copy all the calculated data in the **Data Table** to the clipboard.
2) Click the **Export** button to export the data as a tab (*.txt) or comma (*.csv) separated text file. The currently displayed XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
3) Click **Algorithms** to display the mathematical definitions of the parameters included in the **Data Table**.
4) Click **Table Options** to open the **Offline Calculations Options Dialog**, which lists the functions from which the **Data Table** parameters can be chosen. All functions are described in the **Metabolic Analysis: Reference** section.
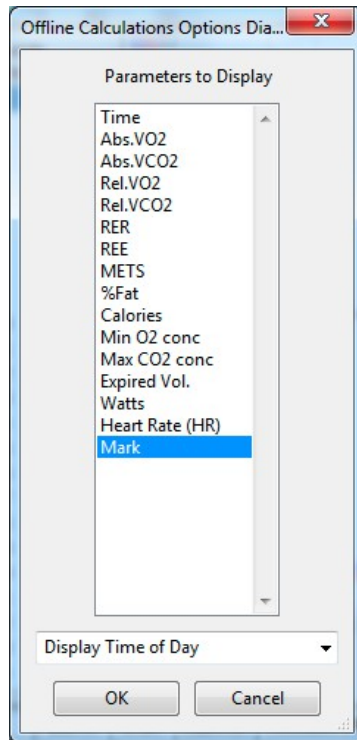
Complete list of Data Table parameters.

5) Click **Load Template** or **Save Template** to display a dialog allowing you to name and save a specific configuration for future use or to load a previously saved template.
6) Click **OK** to close the analysis.

Metabolic Analysis: Reference

When **Metabolic** is chosen from the **Advanced** menu, a submenu opens, displaying three options: **Calibrate Flowhead**, **Online Calculations**, and **Offline Calculations**.
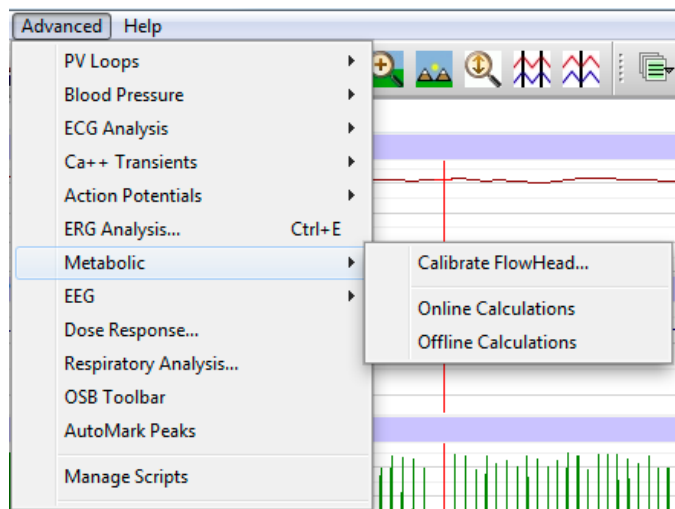
Metabolic submenu

Calibrate Flowhead

In order to use the mixing chamber calculations, the flowhead must be calibrated. Detailed instructions for flowhead calibration can be found in the **Spirometer Calibration** exercise found in the **Human Exercise-GA200** and **Human Exercise-GA300** folders of the complete *LabScribe* installer. Part of that procedure requires that the **Calibrate Flowhead** dialog be displayed and completed. A calibration file is generated that can be used in future experiments, which will then require only an abbreviated spirometer calibration process.

Online Metabolic Calculations

While recording data, many metabolic parameters can be calculated and displayed online using **Online Calculations**. Choosing **Online Calculations** from the **Metabolic** submenu opens the **Metabolic Toolbar** above the uppermost channel. The function titles and the corresponding data values are displayed in the toolbar's data boxes.

Metabolic:	Time	Abs.VO2	Abs.VCO2	Rel.VO2	Rel.VCO2	RER	REE	METS	%Fat	Calories	FeO2Min (%)	FeCO2Max (%)	VE

The Online Metabolic Toolbar

The online parameters are:
- **Time**: Time (in seconds) from the start of the recording.
- Absolute VO$_2$ (**Abs. VO$_2$**): Volume of oxygen consumed in liters per minute**.**
- Absolute VCO$_2$ (**Abs. VCO$_2$**): Volume of carbon dioxide produced in liters per minute.
- Relative VO$_2$ (**Rel. VO$_2$**): Volume of oxygen consumed in milliliters per minute per kilogram of body weight.
- Relative VCO$_2$ (**Rel. VCO$_2$**): Volume of carbon dioxide produced in milliliters per minute per kilogram of body weight.
- Respiratory Exchange Ratio (**RER**): VCO$_2$/VO$_2$.
- Resting Energy Expenditure (**REE**): 5.46 VO$_2$ + 1.75 VCO$_2$ (in kcal/24 hr).
- Metabolic Equivalents (**METS**): Units of energy expenditure; 3.5 ml VO$_2$/kg body weight.
- % Fat (**%Fat**): Estimate of energy expenditure that comes from fat as a percentage of total calories expended.
- Calories (**Calories**): The total number of calories expended.
- Minimum oxygen concentration (**FeO$_2$Min %**): Minimum percentage of oxygen in expired air.
- Maximum CO$_2$ concentration (**FeCO$_2$Max %**): Maximum percentage of carbon dioxide in expired air.
- Expired volume (**VE**): Expired air volume per minute at BTPS.
- Watts (**Watts**): Measure of power produced during exercise, or rate of energy use.
- Heart Rate **(HR)**: 60/period of each cycle.
- Mark (**Mark**): Phase of protocol as indicated by associated mark.

Clicking on the down arrow on the left side of the **Metabolic Toolbar** will display a submenu with three choices:
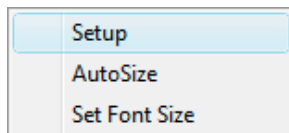
Metabolic Online Setup menu.

- **Setup**: Opens the **Online Metabolic Setup** dialog.
- **AutoSize**: Adjusts the size of the **Metabolic Toolbar** title and data boxes.
- **Set Font Size**: The user can change the size of the font in the **Metabolic Toolbar** data boxes.

The criteria for setting up the **Metabolic Online Calculations** are entered into the **Online Calculation Setup** dialog.
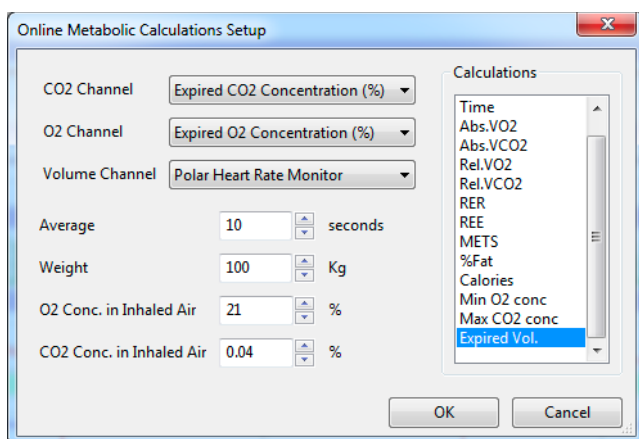
The Online Metabolic Calculations Setup dialog.

The **Online Metabolic Setup** dialog is configured by choosing the O_2, CO_2, and volume channels to be used, and the calculations to be performed in real time.

In order to compensate for variation from breath to breath, it is possible for *LabScribe* to average segments of a chosen duration. This duration should be entered in the **Average** text box. The ACSM recommends an average segment duration of twenty seconds.

The subject's weight (in kilograms) and the concentrations of oxygen (typically 20.9%) and carbon dioxide (typically 0.04%) in inhaled air should be entered in the appropriate text boxes.

The displayed variables can be chosen from the **Calculations** list, by control-clicking on those variables you would like to record in the data boxes of the **Metabolic Toolbar**. Selected variables can be removed from the list by control-clicking on that variable. Definitions of all variables can be found below.

Clicking **OK** will close the dialog and the selected calculations will be displayed in the data boxes of the **Metabolic Toolbar** as data are recorded.

Offline Metabolic Calculations

In addition to the online **Metabolic** calculations, *LabScribe* can perform additional offline **Metabolic** calculations on previously recorded metabolic data, and display a number of XY graphs based on the recorded data.

Choosing **Offline Calculations** from the **Metabolic** submenu opens the **Metabolic Calculations Dialog**. The panels of this dialog can all be resized by moving the mouse cursor over the boundaries until a double-headed arrow appears, and dragging the boundaries to resize the panels.
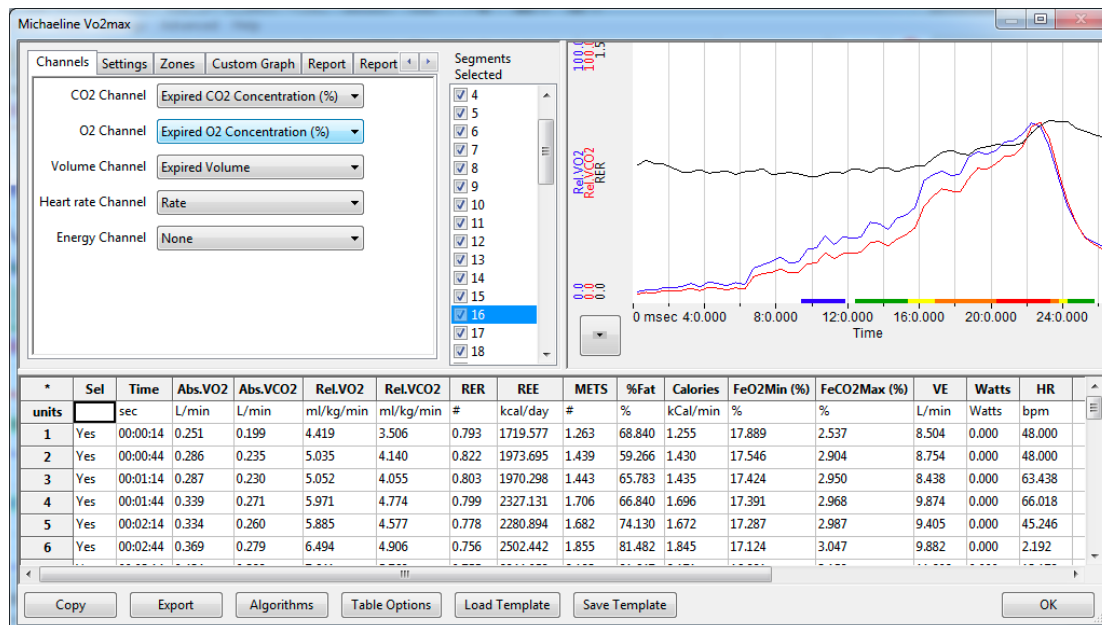
The Offline Metabolic Calculations dialog.

The sections of the **Offline Metabolic Calculations** dialog, each of which is described in more detail below:

- The tabbed configuration dialogs are on the upper left portion of the dialog.
- An XY graph window on the right displays a variety of metabolic graphs.
- Between the configuration dialogs and the XY graph window is the **Segments Selected** list, an editable list of the cycles that can be displayed and analyzed.
- The **Data Table** is located on the lower part of the dialog.

The Configuration Dialogs

There are six tabbed configuration dialogs: **Channels, Settings, Zones, Custom Graph, Report,** and **Report Template.**

The Channels Configuration Dialog

- The CO2, O2, and air volume channels are chosen from the respective menus.
- The calculated heart rate channel from your recording is chosen from the **Heart Rate Channel**.
- Optionally, an **Energy Channel** is chosen if there is one on the recording, typically a power output from an ergometer.

The Channels configuration dialog.

The Settings Configuration Dialog

The Settings configuration dialog.

Starting at the top of the **Settings** configuration dialog:

- The subject's name, age, and sex are entered in the respective text boxes.
- The amount of time to average per segment is entered in the **Average (sec)** text box.
- The subject's height (in centimeters or inches) and weight (in kilograms or pounds) are entered in the **Height** and **Weight** text boxes.
- The maximum experimental heart rate the subject may attain is entered in the **Maximum Heart Rate** text box.
- The concentrations of oxygen (usually 20.9%) and carbon dioxide (usually 0.04%) in inhaled air are entered in the **Insp. O2 (%)** and **Insp. CO2 (%)** text boxes.
- The subject's profile can be saved for future experiments by clicking the **Save Subject** button at the top of the dialog. This profile can later be retrieved and entered by clicking the **Load Subject** button.

- By clicking **Calcula**te, the **Metabolic Graph** will appear in the XY graph window, and the **Data Table** will be populated with the metabolic parameters. Click **Calculate** whenever settings are updated.
- The subject's anaerobic threshold (**AT**) is calculated automatically, and is shown in the **VCO2 vs VO2** XY graph. This value can be recalculated manually as described in the **Metabolic Graph** section below. By clicking **Calculate AT**, the recalculated anaerobic threshold is displayed.

The Zones Configuration Dialog

Different heart rate zones are displayed in different colors on the X-axis of the default graph and the **VO₂ vs VCO₂** XY graph. An individual subject's heart rate zones can be altered by changing the values in this dialog. The default zones are automatically calculated based on the subject's maximum heart rate and will typically not need to be changed.

| Channels | Settings | Zones | Custom Graph | Report | Report Template |

Zones	% of max Heart Rate		Subjects Range		Color
Zone 5	90	to	100	178	to 198	
Zone 4	80	to	90	158	to 178	
Zone 3	70	to	80	138	to 158	
Zone 2	60	to	70	118	to 138	
Zone 1	50	to	60	99	to 118	

The Zones configuration dialog.

The Custom Graph Configuration Dialog

It is possible to generate an XY graph displaying variables chosen by the user.

| Channels | Settings | Zones | Custom Graph | Report | Report Template |

X Axis: Time

Y Axis:

	Variable	Color	Type	Ymax	Ymin
1	Abs.VO2		Dot	Auto	Auto
2	REE		Dot	Auto	Auto
3	None		Dot	Auto	Auto
4	None		Dot	Auto	Auto

Plot

The Custom Graph configuration dialog.

- The desired X-axis and Y-axis variables are chosen from the menus in this dialog.
- The color for each Y variable, whether the data are displayed as dots or a line, and the Y-axis scale are also chosen here.
- Clicking **Plot** will display the custom graph. Choosing **Custom** from the XY graph menu will display the most recently configured custom graph.

The Report Configuration Dialog

By clicking **Create Report**, a dated report is generated. This report includes subject information, the metabolic data in table form, and the current set of XY graphs. The report can be printed or saved in HTML by clicking the respective buttons.
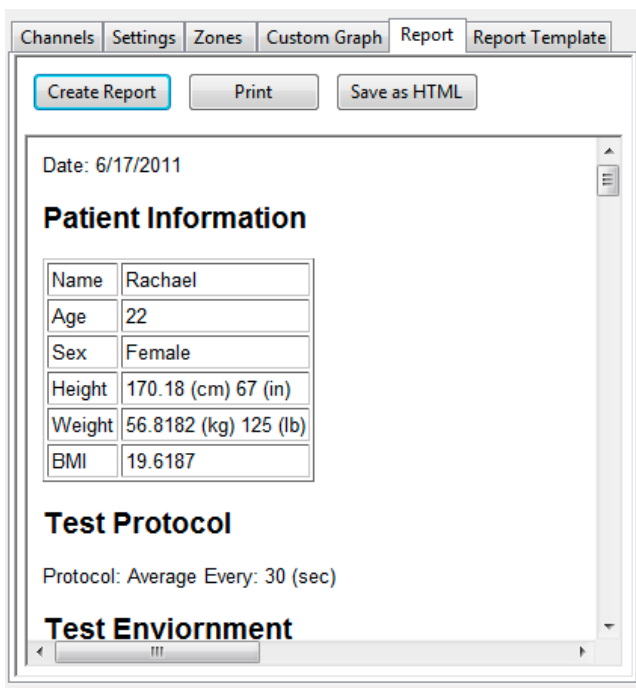
The Report configuration dialog.

- Included in the report are data from previously saved subject data. When **Save Subject** is clicked in the **Settings** configuration dialog, the averaged data from the current experiment are saved as part of the subject profile and when **Load Subject** is clicked in the **Settings** dialog of a future experiment, these data are entered into the Results summary that is part of the report, as indicated in the figure below.

Results

Calculation	2012-05-22	2013-01-30	2013-06-13	Units
Maximum Heartrate	187	183	177	beats per min
Heartrate at Threshold	139	143	132	beats per min
Heartrate at aerobic base	111	118	110	beats per min
VO2 max	63.2	65.8	65.7	ml/kg/min
VO2 at Threshold	36.0	44.4	43.3	ml/kg/min
VO2 at aerobic base	19.1	20.4	30.7	ml/kg/min
VCO2 max	77.8	75.9	75.9	ml/kg/min
VCO2 at Threshold	32.0	39.2	38.3	ml/kg/min
VCO2 at aerobic base	19.1	20.5	26.8	ml/kg/min

Results summary in Report including data from this subject's prior experiments.

The Report Template Configuration Dialog

A **Report Template** can be configured in HTML and saved for future use.
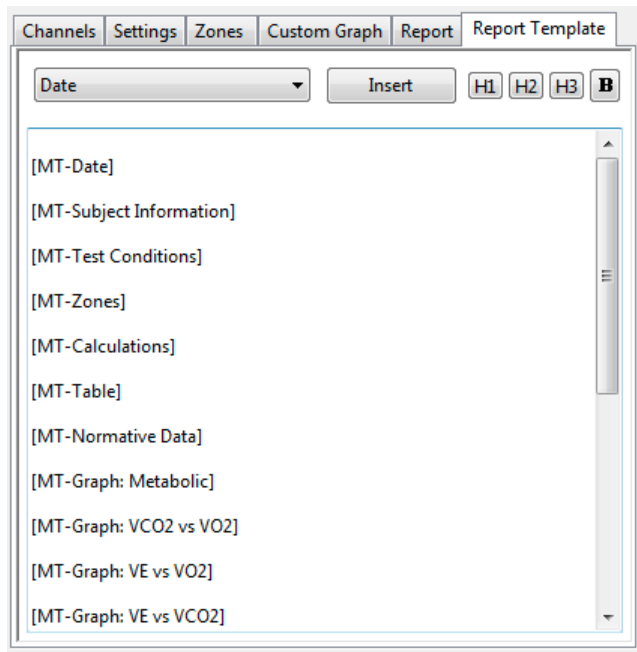
The Report Template configuration dialog.

- The elements to be included in the report are determined by deleting elements not desired, changing the order of the elements, and adding elements from the **Insert** menu.
- Text can be directly entered into the template and its appearance customized with the HTML code provided.
- The template can be copied and saved in a text editor from which it can be copied and pasted into this dialog in future experiments.

The Metabolic Graph

By default, the graph displayed is of VCO2, VO2, and RER over time. All the segments are displayed. Segments can be deselected (or selected) by clicking on the check box to the left of the segment number in the **Segments Selected** list to the left of the graph. The UP and DOWN arrows on the computer keyboard can be used to move quickly through the individual cycles. The specific parameters shown in the graph can be customized in the **Custom Graph** dialog.
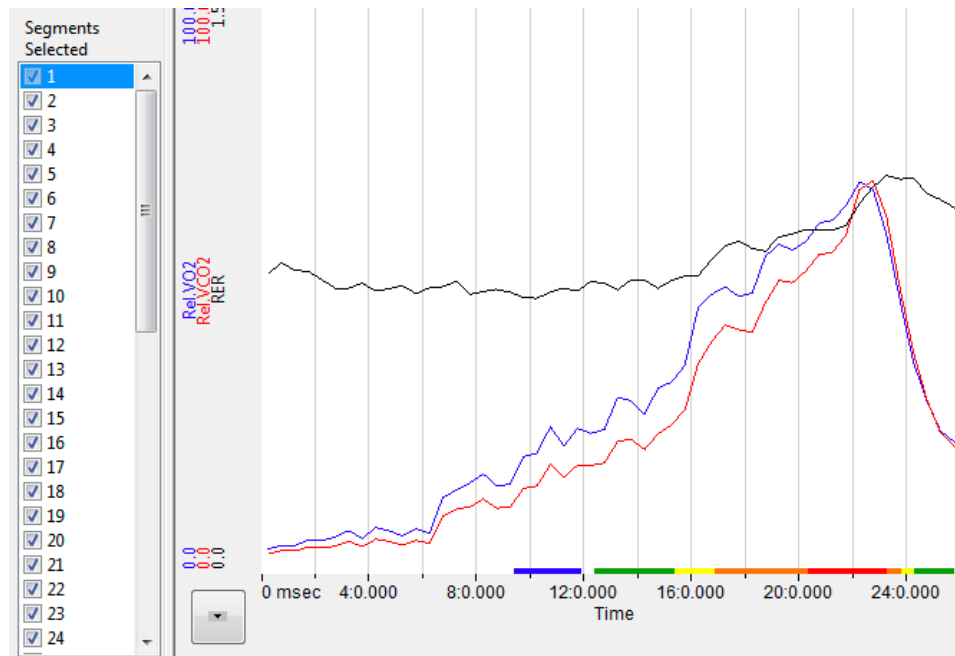
The Metabolic XY Graph.

The XY Graph Menu

Clicking on the arrow in the lower left corner of the XY graph pane opens a menu that offers options to display other graphs as well as an option to copy the graph to the clipboard.
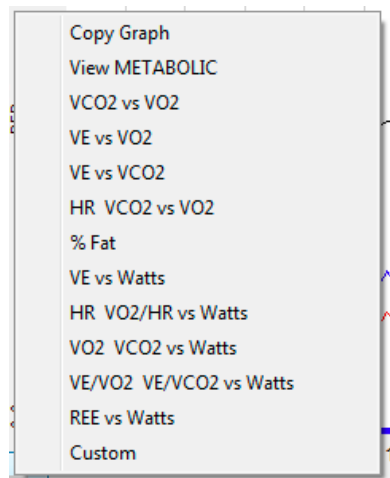

The XY Graph menu.

The menu items are:

- Clicking **Copy Graph** copies the current **Metabolic Graph** to the clipboard. It can then be pasted into the **Journal** or an external application.
- **View Metabolic** displays the default graph.

- **VCO₂ vs VO₂** displays VCO_2 as a function of VO_2. The subject's anaerobic threshold (**AT**) is calculated automatically and is indicated on this graph, as well as the intervals over which the slopes before and after the aerobic/anaerobic break were determined. These intervals (indicated by the markers labeled 1 - 2 and 3 - 4) can be adjusted by moving the markers on the graph. By clicking **Calculate AT** in the **Settings** dialog, the anaerobic threshold is recalculated based on the revised intervals.
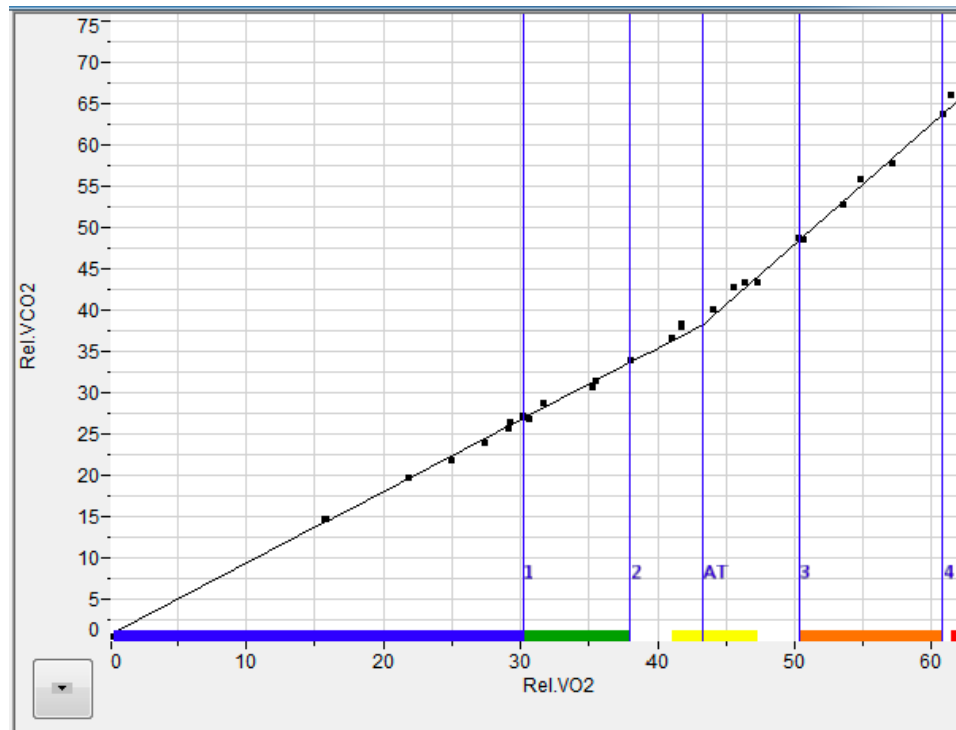
VCO_2 vs VO_2 XY graph with Anaerobic Threshold (AT) indicated.

- **VE vs VO2** displays minute ventilation as a function of VO2.
- **VE vs VCO2** displays minute ventilation as a function of VCO2.
- **HR VCO2 vs VO2** displays the Heart Rate and VCO2 as a function of VO2
- **% Fat** displays the calories from fat as a % of total calories burned over time.
- **VE vs Watts** displays minute ventilation as a function of Watts (requires an Energy channel).
- **HR VO2/HR vs Watts** displays Heart Rate and VO2/HR as a function of Watts (requires an Energy channel).
- **VO2 VCO2 vs Watts** displays VO2 and VCO2 as a function of Watts (requires an Energy channel).
- **VE/VO2 VE/VCO2 vs Watts** displays VE/VO2 and VE/VCO2 as a function of Watts (requires an Energy channel).
- **REE vs Watts** displays REE as a function of Watts (requires an Energy channel).
- **Custom** displays a custom graph as configured in the **Custom Graph** dialog.

The Data Table

The **Data Table** displays the chosen calculated values for each segment.

| *	Sel	Time	Abs.VO2	Abs.VCO2	Rel.VO2	Rel.VCO2	RER	REE	METS	%Fat	Calories	FeO2Min (%)	FeCO2Max (%)	VE	Watts	HR	
47	Yes	00:23:14	3.400	3.581	59.846	63.028	1.053	24832.720	17.099	0.000	17.002	17.273	3.818	101.033	0.000	185.818	er
48	Yes	00:23:44	2.748	2.868	48.368	50.481	1.044	20024.412	13.819	0.000	13.741	17.225	3.841	80.427	0.000	179.068	
49	Yes	00:24:14	2.121	2.222	37.338	39.111	1.047	15472.123	10.668	0.000	10.607	17.389	3.681	65.042	0.000	164.471	
50	Yes	00:24:44	1.737	1.746	30.567	30.724	1.005	12537.678	8.733	0.000	8.684	17.221	3.734	50.370	0.000	147.507	
51	Yes	00:25:14	1.435	1.421	25.258	25.006	0.990	10322.146	7.217	3.327	7.176	17.315	3.597	42.577	0.000	135.545	
52	Yes	00:25:44	1.326	1.285	23.335	22.611	0.969	9487.320	6.667	10.344	6.629	17.332	3.520	39.345	0.000	125.386	
53	Yes	00:26:14	1.228	1.173	21.611	20.643	0.955	8756.923	6.175	14.924	6.139	17.378	3.436	36.807	0.000	120.682	
55																	
56	#		44	44	44	44	44	44	44	44	44	44	44	44	44	44	
57	Mean		1.975	1.729	34.756	30.437	0.841	13808.813	9.930	54.380	9.874	16.446	3.872	47.004	0.000	132.031	
58	SD		1.056	1.055	18.586	18.568	0.102	7592.239	5.310	31.703	5.280	0.606	0.387	28.146	0.000	36.145	
59	Max		3.928	3.940	69.130	69.336	1.053	28183.000	19.751	90.441	19.639	17.389	4.349	112.202	0.000	187.547	0.
60	Min		0.382	0.291	6.723	5.121	0.729	2594.836	1.921	0.000	1.910	15.544	2.865	10.571	0.000	68.868	0.

The Metabolic Data Table.

Clicking the asterisk at the upper left of the **Data Table** displays two options: **AutoSize** and **Copy Selection**. **AutoSize** will optimize the size of the **Data Table** boxes, and **Copy Selection** copies any selected **Data Table** cells to the clipboard.

The **Data Table** displays the chosen calculated values for each of the segments in the **Segments Selected** window, as well as the mean, standard deviation, and range of each of the chosen parameters averaged over all the selected cycles.

There are six buttons across the bottom of the **Metabolic Calculations Dialog: Copy, Export, Algorithms, Table Options, Load Template,** and **Save Template.**

- All the calculated data in the **Data Table** can be copied to the clipboard by clicking the **Copy** button, or exported by clicking the **Export** button. The data are exported in a tab (*.txt) or comma (*.csv) separated text file, and the XY graph can be exported as a Portable Network Graphics (*.png) or JPEG (*.jpg) image.
- Clicking **Algorithms** opens an information window describing the mathematical equations used to compute a number of the offline parameters.
- Clicking **Save Template** will save the current configuration of the dialog as a template file. Clicking **Load Template** will load a previously saved template.
- *LabScribe* is able to calculate a large number of metabolic calculations for each segment. By clicking **Table Options** at the bottom of the **Metabolic Calculations Dialog**, the **Offline Calculations Options Dialog** opens, and calculations to be displayed in the dialog **Data Table** can be chosen from the list of all possible calculations.
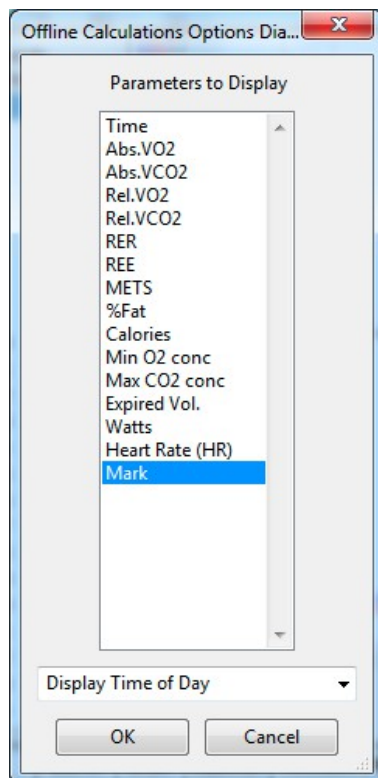
Offline Table Options dialog.

Offline Calculations:
- **Time**: Time (in seconds) from the start of the recording.
- Absolute VO2 (**Abs. VO2**): Volume of oxygen consumed in liters per minute**.**
- Absolute VCO2 (**Abs. VCO2**): Volume of carbon dioxide produced in liters per minute.
- Relative VO2 (**Rel. VO2**): Volume of oxygen consumed in milliliters per minute per kilogram of body weight.
- Relative VCO2 (**Rel. VCO2**): Volume of carbon dioxide produced in milliliters per minute per kilogram of body weight.
- Respiratory Exchange Ratio (**RER**): VCO2/VO2.
- Resting Energy Expenditure (**REE**): 5.46 VO2 + 1.75 VCO2 (in kcal/24 hr).
- Metabolic Equivalents (**METS**): Units of energy expenditure: 3.5 ml VO2/kg body weight.
- % Fat (**%Fat**): Estimate of energy expenditure that comes from fat as a percentage of total calories expended.
- Calories (**Calories**): The total number of calories expended.
- Minimum oxygen concentration (**Min O2 conc**): Minimum percentage of oxygen in expired air.
- Maximum CO2 concentration (**Max CO2 conc**): Maximum percentage of carbon dioxide in expired air.
- Expired volume (**Expired Vol.**): Expired air volume per minute at BTPS.
- Watts (**Watts**): Measure of power produced during exercise, or rate of energy use.
- Heart Rate **(HR)**: 60/period of each cycle.
- Mark (**Mark**): Phase of protocol as indicated by associated mark.

Configuring iWorx Hardware and LabScribe Software for Use with the Metabolic Advanced Analysis Module

To use the **Metabolic Advanced Analysis Module**, *LabScribe* needs to be configured as in the experiments in the **Human Exercise-GA200** and **Human Exercise-GA300** folders. The procedure for setting up the iWorx hardware and *LabScribe* software is also summarized here.

Metabolic Cart Setup

To prepare the metabolic cart for use with a human subject, complete the following procedure.

Equipment Setup: iWorx TA

1) Plug in and turn on the GA-200 or GA-300 Gas Analyzer and the iWorx TA control module to allow them to warm up for 30 minutes before doing any recording.
2) Using a BNC cable, the CO2 output of the gas analyzer should be plugged into the iWorx TA. From the GA-200, the CO2 output should be connected to A3. From the GA-300, the CO2 output should be connected to A4.
3) The O2 output of the gas analyzer should be connected to the iWorx TA. From the GA-200, the O2 output should be connected using a BNC cable to A4. From the GA-300, the O2 output should be connected with a DIN8 cable to A5.
4) Attach the Luer-Lock ends of the white airflow tubing directly to A1 on the TA. Attach the red side of the tubing to the red connector on the TA and the white side to the white connector.

Equipment Setup: iWorx 214

1) Plug in and turn on the GA-200 or GA-300 Gas Analyzer and the iWorx 214 data acquisition system to allow them to warm up for 30 minutes before doing any recording.
2) Using a BNC cable, the CO2 output of the gas analyzer should be plugged into the iWorx 214. From the GA-200, the CO2 output should be connected to Channel 1. From the GA-300, the CO2 output should be connected to Channel 2.
3) The O2 output of the gas analyzer should be connected to the iWorx 214. From the GA-200, the O2 output should be connected using a BNC cable to Channel 2. From the GA-300, the O2 output should be connected with a DIN8 cable to Channel 3.
4) Attach the SP-304 Spirometer to Channel 4 of the iWorx 214.
5) Attach the white tubing to the SP-304, ribbed side to red connector.

Assemble the Metabolic Components

1) Attach the Nafion gas sampling tubing to the filter on the inlet on the front of the GA-200 or the rear of the GA-300 so that the braided end attaches to the filter. *Note: The filter must be changed after 5 tests.*
2) Attach the clear end of the Nafion gas sampling tubing to the sampling port near the outlet of the mixing chamber.
3) Attach one end of the second gas sampling tubing to the sampling port near the inlet of the mixing chamber.
4) Attach the other end of the second gas sampling tube to the outlet port of the GA-200 or GA-300 Gas Analyzer.

5) Attach the large smooth interior vacuum hose to the inlet of the mixing chamber. After calibrating the flowhead, the other end will be connected to the subject's non-rebreathing mask.
6) Attach the other end of the white airflow tubing to the FH-1000 Flowhead. Attach the ribbed side of the tubing to the red connector on the flowhead.
7) Connect the FH-1000 Flowhead to the mixing chamber. The red port on the flowhead must be closest to the mixing chamber.

Spirometer Flowhead Calibration

Note: This procedure uses a previously saved flowhead calibration (.iwxfcd) file.

1) Click on the *LabScribe* shortcut on the computer desktop.
2) From the **Settings** menu choose **Human Exercise-GA200** or **Human Exercise-GA300** depending on which gas analyzer you are using, then on the experiment you would like to perform.
3) Attach the open end of the large vacuum tubing to the 3 liter calibration syringe. Pull the plunger of the syringe all the way out until it stops.
4) Click **Record** and wait at least 10 seconds so that there is no air flow through the syringe. This must be done or the test will not be accurate.
5) Push the plunger in all the way until it stops. Pull the plunger out all the way until it stops.
6) Repeat the procedure in Step 5 for 10 repetitions, varying the speed and force on the plunger. The plunger must go all the way in and come all the way out to be correctly calibrated. No wait time is needed between strokes.
7) After the last stroke the plunger should be left all the way out. Wait 5 seconds after the final stroke and click S**top**.
8) On the **Lung Volumes STPD** channel, click on **STPD Vol.MC(Air Flow)** and choose **setup function** in the displayed menu.
9) In the **Spirometer Calibration Dialog**, enter the following:
   • **Type of Flowhead:** choose **Calibrated** from the drop-down menu.
   • For the **Calibration Curve Data**, click **Load** and navigate to your .iwxfcd calibration file.
   • Enter the **Atmospheric Pressure.**
   • Enter the temperature of the mixing chamber.
   • To set the **Baseline: use first 10 seconds as zero**.
10) Set the **Calibrate difference between cursors** volume to **3L.**
11) Move the cursors on the recording in the dialog to the flat lines before and after the calibration procedure. It is important that the left-hand cursor be all the way at the beginning of the recording.
12) Click **Calibrate difference between cursors** button.
13) Click **OK.**
14) Name and save this data file.
15) Disconnect the vacuum tubing from the syringe and connect it to the clear side of the non-rebreathing valve on the mask.

Calibrate the O2 and CO2 Channels

1) Remove the clear end of the Nafion gas sampling tubing from the outlet side of the mixing chamber, place it on the table away from the cart, and minimize movement in the room.
2) Wait 10 seconds to allow for room air to be pumped to the gas analyzer sensor.
3) Click **Record**.
4) In the text box next to the **Mark** button, type **Room Air** and press Enter on the computer keyboard.
5) Record at least 15 seconds of **Room Air**.
6) Attach the clear plastic end of the A-CAL-150 Calibration Chamber to the hose from the **Known Gas** canister and the Nafion gas sampling tubing leading to the inlet of the gas analyzer to the other end (the white plastic with the holes).
7) In text box next to the **Mark** button, type **Known Gas** and press Enter on the computer keyboard.
8) Record at least 30 seconds of the **Known Gas** until both the CO2 and O2 recordings level out.
9) Click **Stop**.
10) Close the regulator and disconnect the A-CAL-150. Reconnect the Nafion gas sampling tubing to the mixing chamber.

Convert the Units on Gas Concentration Channels

Convert the voltages of the Expired CO2

1) Click on the arrow to the left of the CO2 channel to open the channel menu.
2) Select **Units** and then **Advanced**.
3) Make sure the **Apply all units** box is checked.
4) Move the first two cursors so they are in the collected room part of the recording and the second set of cursors so they are in the known gas part of the recording.
   - Room Concentration of CO2 = 0.04%
   - Known Concentration of CO2 as specified on the gas canister
5) Click **OK**.

Convert the voltages of the Expired O2

1) Click on the arrow to the left of the O2 channel to open the channel menu.
2) Select **Units** and then **Advanced**.
3) Make sure the **Apply all units** box is checked.
4) Move first two cursors so they are in the collected room part of the recording and the second set of cursors so they are in the known gas part of the recording.
   - Room Concentration of O2 = 20.9%
   - Known Concentration of O2 as specified on the gas canister.
5) Click **OK**.
6) **Save** the file.

Starting a Metabolic Test

Once you have completed the Metabolic Cart Setup Checklist, you are ready to take metabolic data from a human subject by following this procedure.

1) At this point, follow the **Metabolic Analysis: Step by Step** guide to configure all online calculations.
2) Have your subject get into position for the test and fit your subject with the mask.
3) Remove the large vacuum tubing from the mixing chamber and place away from the chamber.
4) Type the subject's name and the type of test in the text box to the right of the **Mark** button.
5) Click **Record**.
6) Wait at least 10 seconds to allow the **Expired Air c**hannel to return to zero.
7) Reconnect the large vacuum tubing to the mixing chamber.
8) Press the computer's Enter key to place the mark in the recording.
9) **AutoScale** all channels.
10) Check the **Expired Air** channel to be sure you are seeing an oscillating wave of airflow. You may need to click **AutoScale** after about 30 seconds to see good waves.
11) Perform your experiment.