# Processing Breath-by-Breath Data From Indirect Calorimetry

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Nutrition, Exercise and Sports Information Services (NEXSIS); www.NEXSIS.org

## Overview

The program you purchased and are about to use was written with LabVIEW, a data flow programming language from National Instruments (Austin, Texas). A LabVIEW program is referred to as a virtual instrument (VI). This program has one main control program, and within this are several other sub-programs, or subVIs.

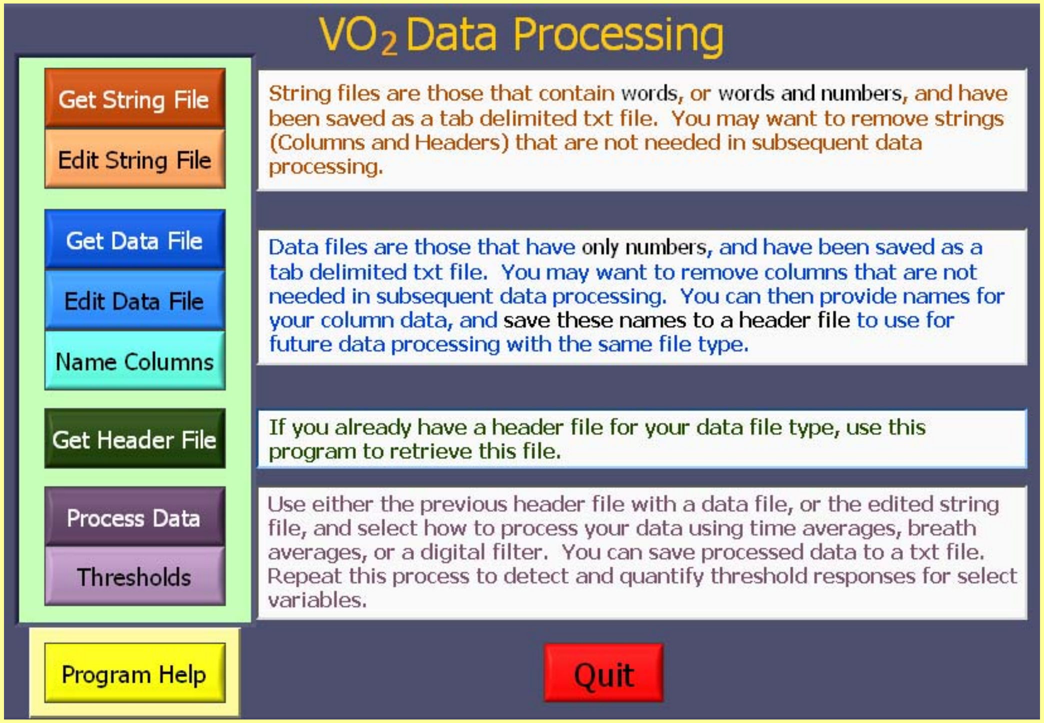
With this program you will be able to process breath-by-breath data using either of user-selected time or breath averages, as well as a low frequency digital filter at user-selected low frequency (Hz) cut-off values. Figure 0 presents a photograph of a subject performing an incremental exercise test using breath-by-breath technology. The program also supports the selection of regions within the data set to apply segmental linear regression to more objectively identify threshold changes, such as for the ventilation or lactate threshold. Data sets from within the imported text file can be saved after processing a text file.

LabVIEW programming is based on what are called the Front Panel and the Block Diagram. The Block Diagram is for the programmer for developing the program. The Front Panel is essentially the user interface.

**Figure 0. A female endurance trained subject completing a test of $VO_2$max in the Exercise Physiology Laboratories of the University of New Mexico.**

Figure 1 provides an image of the Front Panel for this program.

Note that there are 8 options, and since you are reading this, you have managed to successfully migrate to this Program Help window. Alternatively, you may have gone straight to the pdf file that is called by the “Program Help” button after you installed the software. Note that the options are grouped into String File, Data File, Header File, Process Data and Thresholds sections, and all are color coded. The Program Help icon is separate. When you click on an option, you will start a subVI with a specific and different Front Panel to this “Home” window. These features are explained below.



String files are those that contain words, or words and numbers, and have been saved as a tab delimited txt file. You may want to remove strings (Columns and Headers) that are not needed in subsequent data processing.

Data files are those that have only numbers, and have been saved as a tab delimited txt file. You may want to remove columns that are not needed in subsequent data processing. You can then provide names for your column data, and save these names to a header file to use for future data processing with the same file type.

If you already have a header file for your data file type, use this program to retrieve this file.

Use either the previous header file with a data file, or the edited string file, and select how to process your data using time averages, breath averages, or a digital filter. You can save processed data to a txt file. Repeat this process to detect and quantify threshold responses for select variables.

**Figure 1. An image of the Front Panel window of the Program and the initial program selection features.**

## Program Instructions

As you now know, the Program Instructions selection takes you to a window that displays an Acrobat Reader display containing a pdf file of this instruction document. Scroll down and up through the pdf document with this Acrobat Reader display and learn how to use and get the most from this program. If you do not see this pdf when you run this program, you do not have the correct version of Adobe Acrobat Reader. My experience with this program and different versions of Adobe Acrobat Reader has revealed that this program works best with Adobe Acrobat Reader version 7.

## String Files

A string file is a text file that contains words, or both words and numbers. For LabVIEW to read a file with words in it, additional programming needs to occur in order to access numbers vs. word text. Hence the distinction between string and data files within this program. Most often the data file you import that contains words will have header names, with additional information. As you will see, you need to edit this raw file so that it contains only 1 row of header words (1 header per column) and the remaining content being all numbers.

## Get String File

Figure 2 reveals the Front Diagram of the “Get String File” subVI, along with the file selection window that appears when the sub-VI is first called.

After a string file is selected, the text and data appear in the array as shown in Figure 3. This data is from a typical text file generated by a commercial system for indirect calorimetry. It is recommended that you check all the columns and rows of this data file by scrolling through the row and column scroll bars to the top left of the data array. This will reveal what columns and rows that you need to delete in the next subVI.

In the data file of Figure 3, the initial text and data of columns 0 to 8 need deleting, as do the contents of row 1 and 2. Remember number counting starts at 0 in LabVIEW and all programming. When this is done, as shown in Figure 4, the Time data column is the 0 column, with the header “t” at row 0, column 0.

Click “Continue” to go back to the control VI so you can select the “Edit String File” subVI and complete the necessary editing.

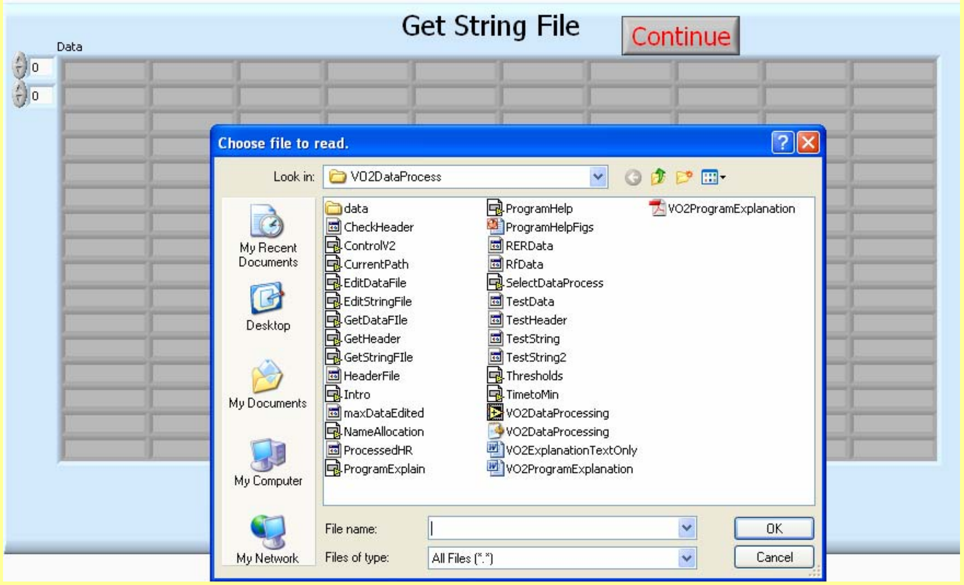
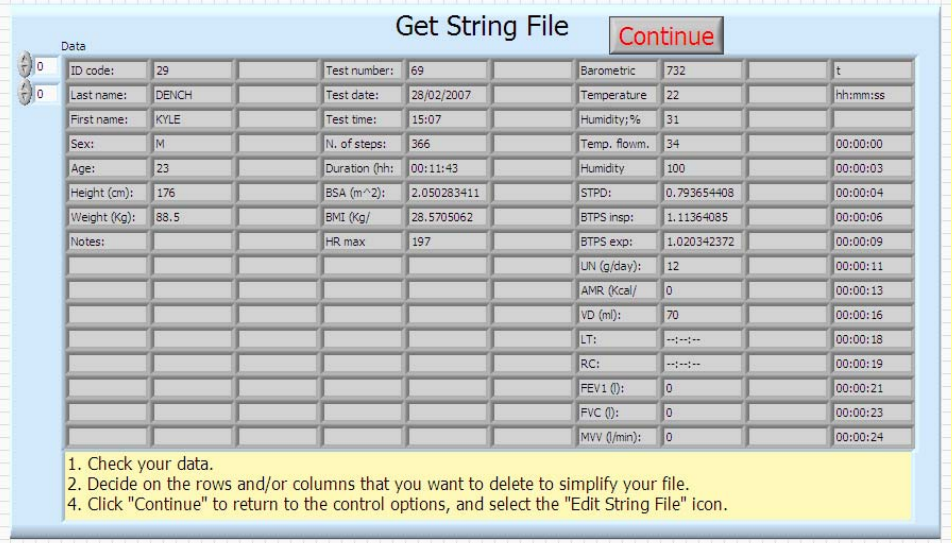


Figure 2. An image of the Front Panel of the “Get String File” subVI.



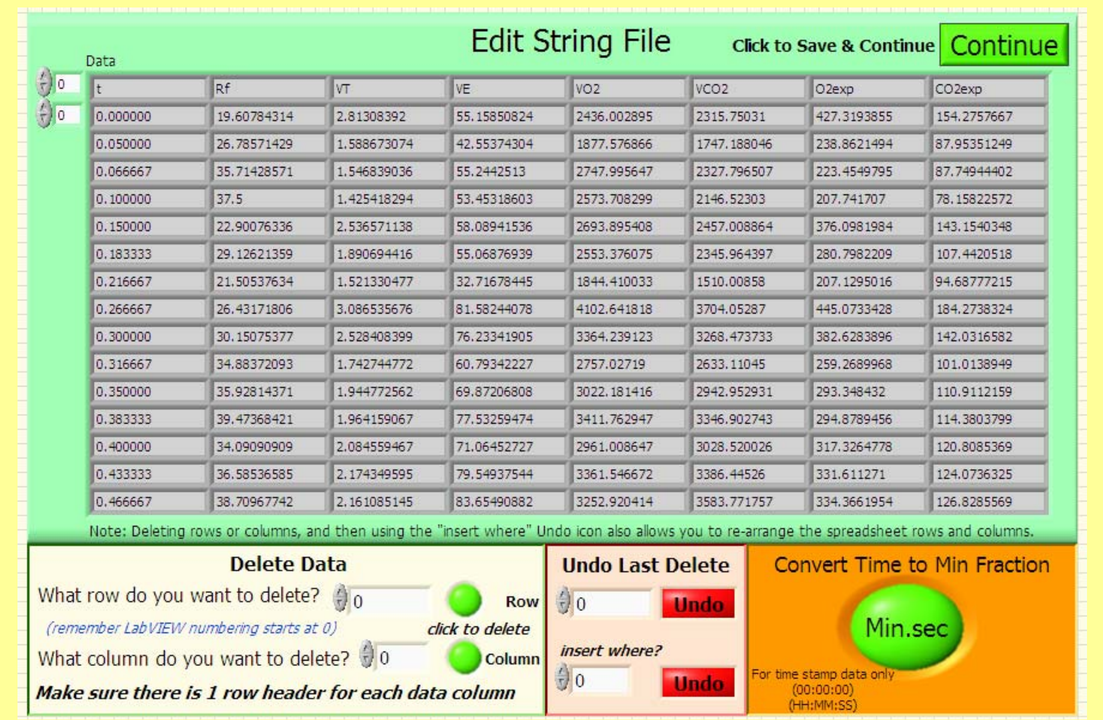
| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| ID code: | 29 | | Test number: | 69 | | Barometric | 732 | | t |
| Last name: | DENCH | | Test date: | 28/02/2007 | | Temperature | 22 | | hh:mm:ss |
| First name: | KYLE | | Test time: | 15:07 | | Humidity;% | 31 | | |
| Sex: | M | | N. of steps: | 366 | | Temp. flowm. | 34 | | 00:00:00 |
| Age: | 23 | | Duration (hh: | 00:11:43 | | Humidity | 100 | | 00:00:03 |
| Height (cm): | 176 | | BSA (m^2): | 2.050283411 | | STPD: | 0.793654408 | | 00:00:04 |
| Weight (Kg): | 88.5 | | BMI (Kg/ | 28.5705062 | | BTPS insp: | 1.11364085 | | 00:00:06 |
| Notes: | | | HR max | 197 | | BTPS exp: | 1.020342372 | | 00:00:09 |
| | | | | | | UN (g/day): | 12 | | 00:00:11 |
| | | | | | | AMR (Kcal/ | 0 | | 00:00:13 |
| | | | | | | VD (ml): | 70 | | 00:00:16 |
| | | | | | | LT: | --:--:-- | | 00:00:18 |
| | | | | | | RC: | --:--:-- | | 00:00:19 |
| | | | | | | FEV1 (l): | 0 | | 00:00:21 |
| | | | | | | FVC (l): | 0 | | 00:00:23 |
| | | | | | | MVV (l/min): | 0 | | 00:00:24 |

1. Check your data.
2. Decide on the rows and/or columns that you want to delete to simplify your file.
4. Click "Continue" to return to the control options, and select the "Edit String File" icon.

Figure 3. Typical string data imported into the program.

## Edit String File

Figure 4 reveals the Front Diagram of the “Edit String File” subVI. The text and data of Figure 4 reveal the single header per column of selected, as explained above. Note that the scroll bars for rows and columns are still on “0”. As there are no additional rows that need deleting at the top of the file, clicking on the row scroll bar would increment rows one at a time until you get to the bottom/end of the data file. Alternatively, highlighting the row number of the scroll bar and typing a given row number and clicking off the scroll bar would immediately increment the top row to this row number. The same is true for the column scroll bar.



Edit String File

Click to Save & Continue

Data

0

0

| t | Rf | VT | VE | VO2 | VCO2 | O2exp | CO2exp |
|---|---|---|---|---|---|---|---|
| 0.000000 | 19.60784314 | 2.81308392 | 55.15850824 | 2436.002895 | 2315.75031 | 427.3193855 | 154.2757667 |
| 0.050000 | 26.78571429 | 1.588673074 | 42.55374304 | 1877.576866 | 1747.188046 | 238.8621494 | 87.95351249 |
| 0.066667 | 35.71428571 | 1.546839036 | 55.2442513 | 2747.995647 | 2327.796507 | 223.4549795 | 87.74944402 |
| 0.100000 | 37.5 | 1.425418294 | 53.45318603 | 2573.708299 | 2146.52303 | 207.741707 | 78.15822572 |
| 0.150000 | 22.90076336 | 2.536571138 | 58.08941536 | 2693.895408 | 2457.008864 | 376.0981984 | 143.1540348 |
| 0.183333 | 29.12621359 | 1.890694416 | 55.06876939 | 2553.376075 | 2345.964397 | 280.7982209 | 107.4420518 |
| 0.216667 | 21.50537634 | 1.521330477 | 32.71678445 | 1844.410033 | 1510.00858 | 207.1295016 | 94.68777215 |
| 0.266667 | 26.43171806 | 3.086535676 | 81.58244078 | 4102.641818 | 3704.05287 | 445.0733428 | 184.2738324 |
| 0.300000 | 30.15075377 | 2.528408399 | 76.23341905 | 3364.239123 | 3268.473733 | 382.6283896 | 142.0316582 |
| 0.316667 | 34.88372093 | 1.742744772 | 60.79342227 | 2757.02719 | 2633.11045 | 259.2689968 | 101.0138949 |
| 0.350000 | 35.92814371 | 1.944772562 | 69.87206808 | 3022.181416 | 2942.952931 | 293.348432 | 110.9112159 |
| 0.383333 | 39.47368421 | 1.964159067 | 77.53259474 | 3411.762947 | 3346.902743 | 294.8789456 | 114.3803799 |
| 0.400000 | 34.09090909 | 2.084559467 | 71.06452727 | 2961.008647 | 3028.520026 | 317.3264778 | 120.8085369 |
| 0.433333 | 36.58536585 | 2.174349595 | 79.54937544 | 3361.546672 | 3386.44526 | 331.611271 | 124.0736325 |
| 0.466667 | 38.70967742 | 2.161085145 | 83.65490882 | 3252.920414 | 3583.771757 | 334.3661954 | 126.8285569 |

Note: Deleting rows or columns, and then using the "insert where" Undo icon also allows you to re-arrange the spreadsheet rows and columns.

Delete Data

What row do you want to delete? 0 Row

*(remember LabVIEW numbering starts at 0)* *click to delete*

What column do you want to delete? 0 Column

***Make sure there is 1 row header for each data column***

Undo Last Delete

0

*insert where?*

0

Convert Time to Min Fraction

For time stamp data only (00:00:00) (HH:MM:SS)

**Figure 4. Data of Figure 3 that has been edited to show column headers in row 0 and data in all remaining rows.**

### *Delete Data*

The “Delete Data” window can then be used to select a row or column to delete. Clicking either of the green circular icons causes the deletion. It is important to note that the selected row or column number does not change after each deletion. This way, you can select the first row or column of a block of data that needs deleting, and simply continue to click on the green circular icon until all rows or columns have been deleted.

### *Undo Last Delete*

The “Undo Last Delete” can only do what is says, undo the LAST deletion. You can then insert this column or row where you want by selecting a given row or column. This feature also lets you rearrange the data set, by row or column. The bottom line though is to not delete more than one row or column at a time before you realize that you have made a mistake. If you do this, you will have to start the program again to re-edit your data file, as you will not be able to retrieve rows or columns deleted prior to the last delete. Sorry!!!

### *Convert Time to Minute Fraction*

The “Convert Time to Minute Fraction” option is for data files that have time stamp data for the time column. Look back to the time (t) data of Figure 3 (last column on right). This is time stamp data. This option will convert time stamp to minute fraction data, as you see in the first column (column 0) of Figure 3. ***For time data that is not already in a minute fraction, or a second fraction, or time stamp, you will need to convert this time data column to a time (minute or second) fraction in Excel prior to using the text file in this program.***

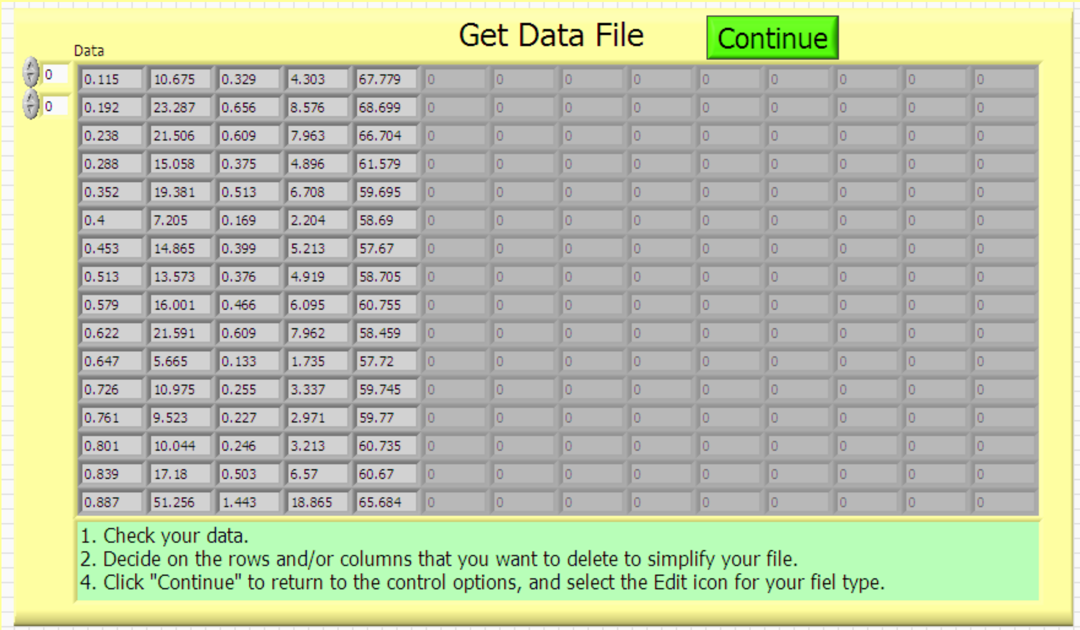
Clicking the “Continue” icon first launches a prompt to name and save the edited string file a destination path. Once this occurs, the program returns to the control front panel.

### Data Files

Some $VO_2$ systems save only data to a text file. Here you simply import this data file and then after editing it, you make your own headers for each column.

### <u>Get Data File</u>

Figure 5 reveals the Front Diagram of the “Get Data File” subVI. This subVI is similar to the “Get String File” subVI, as revealed in Figures 2 and 3, only it is for data text files only. In this example, only 5 columns are shown (0-4) in the data set, and these are time, expired ventilation, $VO_2$ (L/min), $VO_2$ (mL/kg/min) and heart rate.



| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.115 | 10.675 | 0.329 | 4.303 | 67.779 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.192 | 23.287 | 0.656 | 8.576 | 68.699 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.238 | 21.506 | 0.609 | 7.963 | 66.704 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.288 | 15.058 | 0.375 | 4.896 | 61.579 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.352 | 19.381 | 0.513 | 6.708 | 59.695 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.4 | 7.205 | 0.169 | 2.204 | 58.69 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.453 | 14.865 | 0.399 | 5.213 | 57.67 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.513 | 13.573 | 0.376 | 4.919 | 58.705 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.579 | 16.001 | 0.466 | 6.095 | 60.755 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.622 | 21.591 | 0.609 | 7.962 | 58.459 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.647 | 5.665 | 0.133 | 1.735 | 57.72 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.726 | 10.975 | 0.255 | 3.337 | 59.745 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.761 | 9.523 | 0.227 | 2.971 | 59.77 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.801 | 10.044 | 0.246 | 3.213 | 60.735 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.839 | 17.18 | 0.503 | 6.57 | 60.67 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 0.887 | 51.256 | 1.443 | 18.865 | 65.684 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |

1. Check your data.
2. Decide on the rows and/or columns that you want to delete to simplify your file.
4. Click "Continue" to return to the control options, and select the Edit icon for your fiel type.

**Figure 5. The data retrieved from a text file containing 5 columns of data.**

### <u>Edit Data File</u>

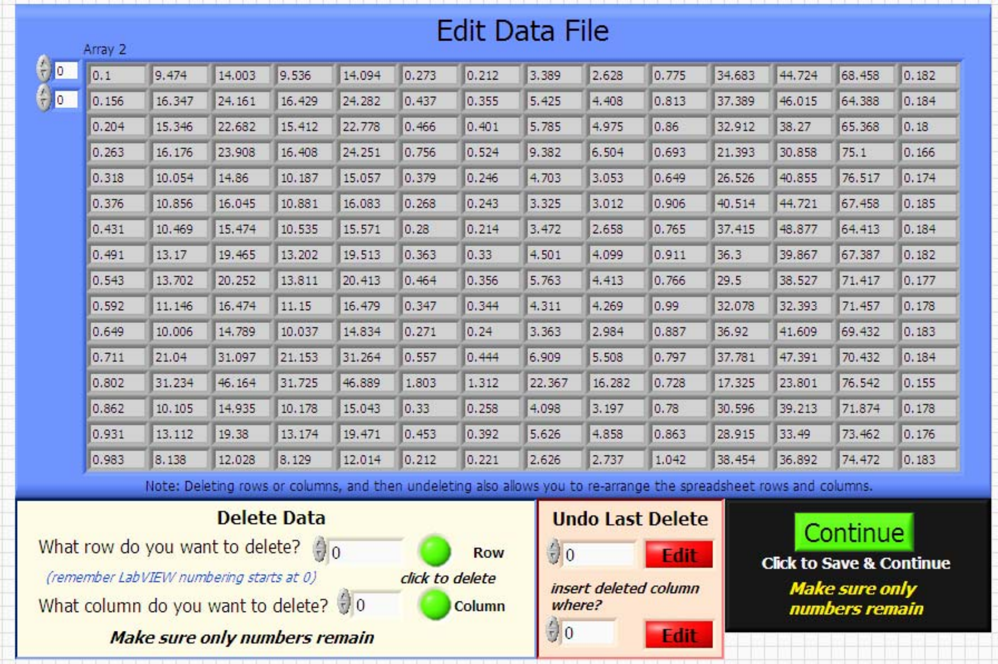
Figure 6 reveals the Front Panel of the “Edit Data File” subVI. This is similar to the “Edit String File” of Figure 4.

The only difference with this “Edit Data File” subVI is that the Continue button also saves a data text file of the edited data just in case you need this edited file for other reasons, such as for importing into a graphics program. Once you click on this button icon you will be prompted to name this text file and select the path where you want to save it to.  As indicated, you should only be working with numbers, and as such, you can only save this data to a file if it contains only numbers.

## Name Columns

The “Name Columns” subVI is for work with data files only.  As string files have their own text headers, and these are saved in the programming when editing the string file, ***you do not need to use this subVI if you worked with a string file***.

When using data files, you need to create headers, or column names, to be able to use the data processing subVI.  You do this with this subVI, as shown in Figure 7.  Note that there are “Enter” and “Edit” selections.  To name a column, select a column number and type the name in the Column Name entry box.  When you click the “Enter” icon, you will see the column number and name in the Header 2D array.  In Figure 7 you will see that I named the first three columns (0-2), and then edited the time header to show the units of time.  As the column number does not increment after each entry, make sure you remember to change the column with each new column header.



Edit Data File

Array 2

0
0

| | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0.1 | 9.474 | 14.003 | 9.536 | 14.094 | 0.273 | 0.212 | 3.389 | 2.628 | 0.775 | 34.683 | 44.724 | 68.458 | 0.182 |
| 0.156 | 16.347 | 24.161 | 16.429 | 24.282 | 0.437 | 0.355 | 5.425 | 4.408 | 0.813 | 37.389 | 46.015 | 64.388 | 0.184 |
| 0.204 | 15.346 | 22.682 | 15.412 | 22.778 | 0.466 | 0.401 | 5.785 | 4.975 | 0.86 | 32.912 | 38.27 | 65.368 | 0.18 |
| 0.263 | 16.176 | 23.908 | 16.408 | 24.251 | 0.756 | 0.524 | 9.382 | 6.504 | 0.693 | 21.393 | 30.858 | 75.1 | 0.166 |
| 0.318 | 10.054 | 14.86 | 10.187 | 15.057 | 0.379 | 0.246 | 4.703 | 3.053 | 0.649 | 26.526 | 40.855 | 76.517 | 0.174 |
| 0.376 | 10.856 | 16.045 | 10.881 | 16.083 | 0.268 | 0.243 | 3.325 | 3.012 | 0.906 | 40.514 | 44.721 | 67.458 | 0.185 |
| 0.431 | 10.469 | 15.474 | 10.535 | 15.571 | 0.28 | 0.214 | 3.472 | 2.658 | 0.765 | 37.415 | 48.877 | 64.413 | 0.184 |
| 0.491 | 13.17 | 19.465 | 13.202 | 19.513 | 0.363 | 0.33 | 4.501 | 4.099 | 0.911 | 36.3 | 39.867 | 67.387 | 0.182 |
| 0.543 | 13.702 | 20.252 | 13.811 | 20.413 | 0.464 | 0.356 | 5.763 | 4.413 | 0.766 | 29.5 | 38.527 | 71.417 | 0.177 |
| 0.592 | 11.146 | 16.474 | 11.15 | 16.479 | 0.347 | 0.344 | 4.311 | 4.269 | 0.99 | 32.078 | 32.393 | 71.457 | 0.178 |
| 0.649 | 10.006 | 14.789 | 10.037 | 14.834 | 0.271 | 0.24 | 3.363 | 2.984 | 0.887 | 36.92 | 41.609 | 69.432 | 0.183 |
| 0.711 | 21.04 | 31.097 | 21.153 | 31.264 | 0.557 | 0.444 | 6.909 | 5.508 | 0.797 | 37.781 | 47.391 | 70.432 | 0.184 |
| 0.802 | 31.234 | 46.164 | 31.725 | 46.889 | 1.803 | 1.312 | 22.367 | 16.282 | 0.728 | 17.325 | 23.801 | 76.542 | 0.155 |
| 0.862 | 10.105 | 14.935 | 10.178 | 15.043 | 0.33 | 0.258 | 4.098 | 3.197 | 0.78 | 30.596 | 39.213 | 71.874 | 0.178 |
| 0.931 | 13.112 | 19.38 | 13.174 | 19.471 | 0.453 | 0.392 | 5.626 | 4.858 | 0.863 | 28.915 | 33.49 | 73.462 | 0.176 |
| 0.983 | 8.138 | 12.028 | 8.129 | 12.014 | 0.212 | 0.221 | 2.626 | 2.737 | 1.042 | 38.454 | 36.892 | 74.472 | 0.183 |

Note: Deleting rows or columns, and then undeleting also allows you to re-arrange the spreadsheet rows and columns.

**Delete Data**

What row do you want to delete? 0 ● **Row**

*(remember LabVIEW numbering starts at 0)* ***click to delete***

What column do you want to delete? 0 ● **Column**

***Make sure only numbers remain***

**Undo Last Delete**

0 **Edit**

***insert deleted column where?***

0 **Edit**

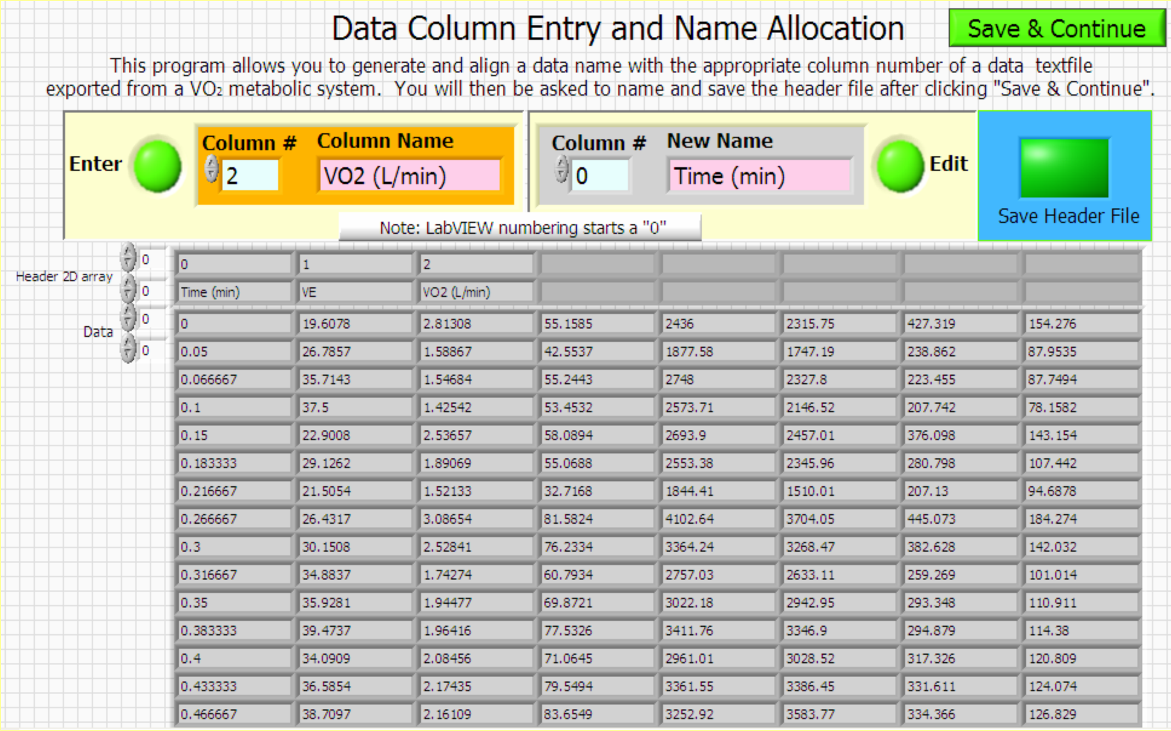
**Continue**

**Click to Save & Continue**

***Make sure only numbers remain***

**Figure 6. The data retrieved from a large text file prior to any editing.  As explained in the text, editing could consist of deleting columns, or rearranging the columns.**

To save the column names (headers) to a file for latter use in this program when working with a different data set from the same system and final data column features, click on the “Save Header File” button.  This will prompt you to enter a name and select the path where you want this file saved.  If you edit your $VO_2$ data the same, then I would use this saved header file rather than use the “Name Columns” subVI each time I processed data.  This will save you time when processing multiple data files.



Data Column Entry and Name Allocation

This program allows you to generate and align a data name with the appropriate column number of a data textfile exported from a VO₂ metabolic system. You will then be asked to name and save the header file after clicking "Save & Continue".

Column # 2 Column Name VO2 (L/min)

Column # 0 New Name Time (min)

Note: LabVIEW numbering starts a "0"

Header 2D array 0 0

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 1 | 2 | | | | | |
| Time (min) | VE | VO2 (L/min) | | | | | |

Data 0 0

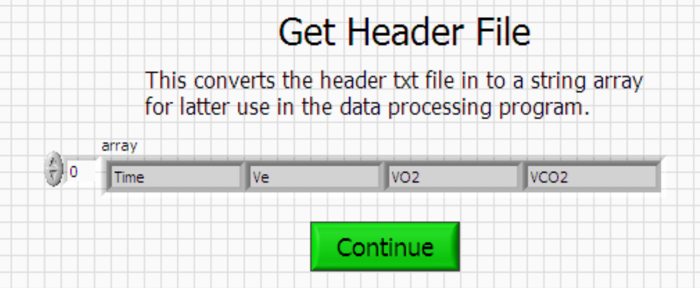
| | | | | | | | |
|---|---|---|---|---|---|---|---|
| 0 | 19.6078 | 2.81308 | 55.1585 | 2436 | 2315.75 | 427.319 | 154.276 |
| 0.05 | 26.7857 | 1.58867 | 42.5537 | 1877.58 | 1747.19 | 238.862 | 87.9535 |
| 0.066667 | 35.7143 | 1.54684 | 55.2443 | 2748 | 2327.8 | 223.455 | 87.7494 |
| 0.1 | 37.5 | 1.42542 | 53.4532 | 2573.71 | 2146.52 | 207.742 | 78.1582 |
| 0.15 | 22.9008 | 2.53657 | 58.0894 | 2693.9 | 2457.01 | 376.098 | 143.154 |
| 0.183333 | 29.1262 | 1.89069 | 55.0688 | 2553.38 | 2345.96 | 280.798 | 107.442 |
| 0.216667 | 21.5054 | 1.52133 | 32.7168 | 1844.41 | 1510.01 | 207.13 | 94.6878 |
| 0.266667 | 26.4317 | 3.08654 | 81.5824 | 4102.64 | 3704.05 | 445.073 | 184.274 |
| 0.3 | 30.1508 | 2.52841 | 76.2334 | 3364.24 | 3268.47 | 382.628 | 142.032 |
| 0.316667 | 34.8837 | 1.74274 | 60.7934 | 2757.03 | 2633.11 | 259.269 | 101.014 |
| 0.35 | 35.9281 | 1.94477 | 69.8721 | 3022.18 | 2942.95 | 293.348 | 110.911 |
| 0.383333 | 39.4737 | 1.96416 | 77.5326 | 3411.76 | 3346.9 | 294.879 | 114.38 |
| 0.4 | 34.0909 | 2.08456 | 71.0645 | 2961.01 | 3028.52 | 317.326 | 120.809 |
| 0.433333 | 36.5854 | 2.17435 | 79.5494 | 3361.55 | 3386.45 | 331.611 | 124.074 |
| 0.466667 | 38.7097 | 2.16109 | 83.6549 | 3252.92 | 3583.77 | 334.366 | 126.829 |

**Figure 7. An image of the Front Panel of the "Name Columns" subVI.**

## Get Header File

Figure 8 reveals the Front Panel of the "Get Header File" subVI.

When working with data files, and when using a header file from a previous data processing, this allows you to import this file and converts it to a suitable format to use in the "Process Data" subVI.



Get Header File

This converts the header txt file in to a string array for latter use in the data processing program.

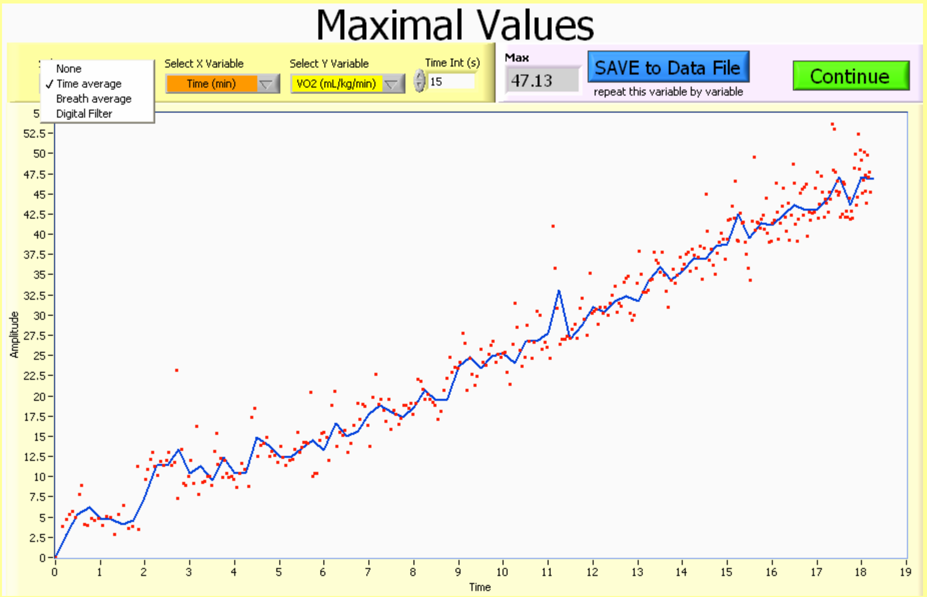
array 0

| | | | |
|---|---|---|---|
| Time | Ve | VO2 | VCO2 |

**Figure 8. An image of the Front Panel of the "Get Header File" subVI.**

## Process Data

Figure 9 reveals the Front Panel for the “Process Data” subVI, which also functions to assist in detecting maximal values.



Maximal Values

Select X Variable: Time (min)

Select Y Variable: VO2 (mL/kg/min)

Time Int (s): 15

Max: 47.13

**Figure 9. An image of the Front Panel of the “Process Data” subVI.**

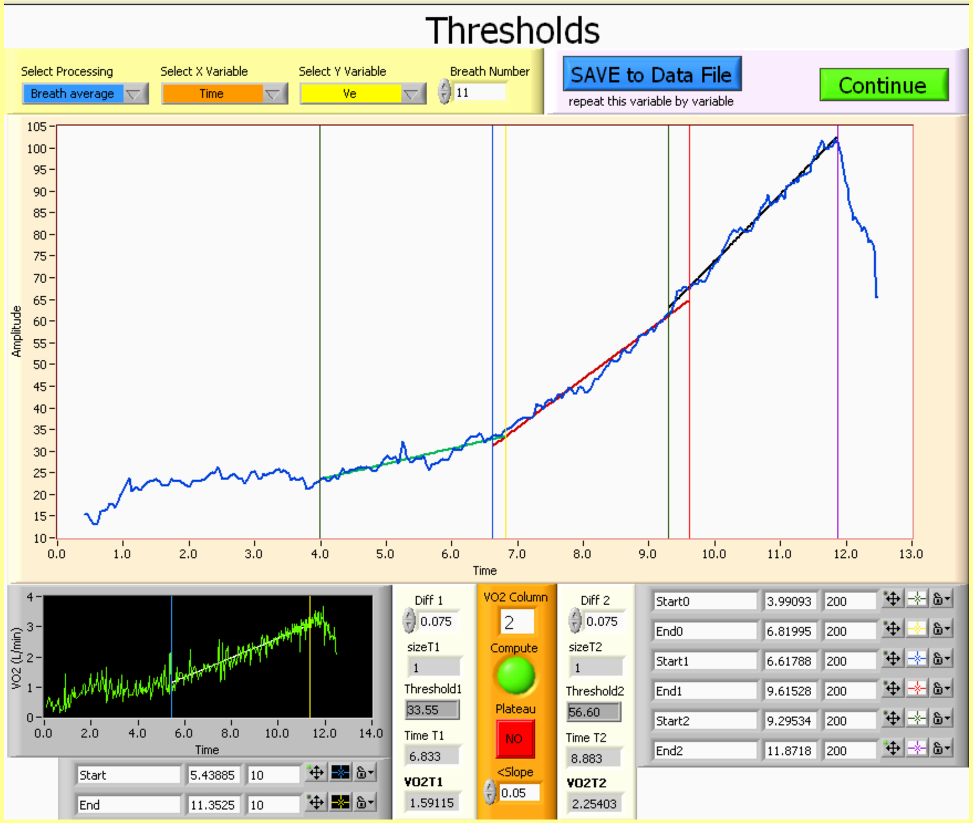
This data is from an incremental exercise test to $VO_2$max. Note the four user interactive controls in the top left for Select Processing, Select X Variable, Select Y Variable, and Breath Number. Actually, the Breath Number control changes depending on what processing is selected. In this example, a Breath average is selected, and so a control for Breath Number appears. If the selection was for a time average, a control for the time of the average appears. If a Digital filter is selected for processing, then a control for the lower Hz cut-off appears. As previously explained, the headers for the data columns are used in the Select X or Y Variable controls. If “Nothing” is selected for the processing, no data appears on the graphs. A breath average of 1 breath would be the raw data when using breath-by-breath data.

The “Max” number above the right graph reveals the highest data point in the data set after processing. My argument is that the highest data point after your selected processing would be the peak data point, or either $VO_2$ peak or $VO_2$max when processing $VO_2$ data. However, you can use whatever method you want for detecting peak values. Just be aware that when using time averages, even a 30 s time average severely over-processes the data and falsely lowers maximal values. This will be self evident when you play with the program. You will see that a 0.08 Hz digital filter, a 7 breath average and a 15 s average give similar processing.

The “Save to Data File” icon can be used to save each time and Y variable data set to a text file after it is processed.

## Thresholds

Figure 10 presents the front panel image of the “Thresholds” option. Note the top figure for first processing the data, which is identical to the options of Figure 9. However, in this graph, there are also 6 cursor bars, with a cursor legends bar underneath the graph on the right side. The 6 cursors actually represent 3 pairs of cursors, as revealed by the cursor names, each one having a start and end reference (e.g. start0 and end0). To remove the cursors from the graph, simply enter data values for X and Y coordinates that are not on the visible region of the X and Y axes of the graph. For example, as all cursors have Y values set to 200, which is off the Y scale of the graph, no horizontal lines are visible on the graph.



Thresholds

Select Processing: Breath average
Select X Variable: Time
Select Y Variable: Ve
Breath Number: 11
repeat this variable by variable

| | | |
|---|---|---|
| Start | 5.43885 | 10 |
| End | 11.3525 | 10 |

Diff 1: 0.075
sizeT1: 1
Threshold1: 33.55
Time T1: 6.833
VO2T1: 1.59115

VO2 Column: 2
Plateau
<Slope: 0.05

Diff 2: 0.075
sizeT2: 1
Threshold2: 56.60
Time T2: 8.883
VO2T2: 2.25403

| | | |
|---|---|---|
| Start0 | 3.99093 | 200 |
| End0 | 6.81995 | 200 |
| Start1 | 6.61788 | 200 |
| End1 | 9.61528 | 200 |
| Start2 | 9.29534 | 200 |
| End2 | 11.8718 | 200 |

**Figure 10. An image of the Front Panel of the “Thresholds” subVI for expired ventilation data from a test to $VO_2$max.**

In the data example of Figure 10 I have used the cursors to assess any slope change in $VCO_2$. I prefer to use $VEVO_2$ and $VEVCO_2$ to detect the ventilation threshold. I start with the 3rd cursor pair and position these at the end of the data set for the last segment of data. I then position the 2nd cursor pair over the prior segment, and the initial cursor pair across what is the next segment. The order of the cursors is important, and always order from left to right.

The graph on the bottom left is the raw $VO_2$ data, and it used to generate a linear regression between the region bordered by the blue and yellow cursor. Note that you select the column that contains the VO2 data, and remember that the first column is column 0. When the “Compute” circular icon is clicked, the segments generated on the top main graph by the cursors are used to detect two thresholds where the three lines intersect. These are “Threshold 1” and ‘Threshold 2”, respectively. The $VO_2$ at these threshold times are computed from the $VO_2$-time linear regression and presented in their respective indicators.  Diff1 and Diff2 represent the differences in processing math used to detect the thresholds.  They represent minimal differences between $VO_2$ predictions based on time to show where two linear segments are close enough to being equal, and hence intersect.  I have found that the default of 0.075 s works well for most $VO_2$ breath-by-breath data sets.

Be careful when using this application for $VO_2$ data sets where the $VO_2$ slope of the test is not consistent across the times of the thresholds.  When this happens, select a segment of the $VO_2$ curve that only spans single thresholds, which will require you to repeat the processing of the $VO_2$ region for each threshold time.

The red plateau box changes to green when the $VO_2$ data changes by less than 50 ml/min over the last 30 s of the data set.  You need to make sure the data set ends at the end of the test (contains no recovery data) for this to be valid.