

PROPTRAK.EXE

REMITRAK.EXE

User Help Notes

Index

Page 2.

Lean body mass – the trouble with James. A brief analysis of the derivation of the James formula and the 'high BMI' problem

Page 3.

Alternative Lean Body Mass equations. LBM equations that do not have the 'high BMI' problem..

Page 4.

References to the above.

Page 5.

The software. [REMITRAK.EXE](#) and [PROPTRAK.EXE](#) screen dumps and descriptions.

Page 6.

Running the software. Advice on operating systems etc.

Using your data. . Advice on using the data output CSV file.

Page 7

This help file. Other information.

Lean body mass – the trouble with James

Lean body mass estimates have been used in the propofol model by Dr Schnider¹ and remifentanyl model by Dr Minto². The equations used were those attributed to James in the publication 'Research into Obesity'³. However these equations are known to have a major shortcoming in that they appear to underestimate lean body mass in the obese^{4,5}. As such commercial target controlled infusion (TCI) pumps are often patient weight limited.

As such I investigated the origin of the 'James' equation and compared this the other lean body mass equations, namely Hume(1966)¹¹, Hume & Weyers(1971)⁶ and Janmahasat(2005)¹⁰.

The 'James' formulae

The lean body mass formulae used by Drs Schnider¹ and Minto² for their TCI data sets were derived from equations attributed to T P Eddy in 'Research into Obesity'³ as a means of estimating the total body fat from the Body Mass Index (BMI) and are used therein to illustrate tables. There was no other discussion within the publication of lean body mass. Firstly for men: Both of the equations appear to have been derived from data in other publications, namely Hume & Weyers⁶ 1971 paper which measured the total body water via tritium dilution and thence the lean body mass could be calculated from an earlier animal study⁷ which found lean body mass to be 73% water. Of the other papers quoted, Boddy⁸ used the Hume and Weyers equation to estimate total body water. Wormesley⁹ also used the Hume and Weyers equation to compare with anthropometric methods (e.g. skinfold thickness).

The equations are:

$$\text{Men} \quad \text{Fat\%} = 1.281 * \text{BMI} - 10.13$$

$$\text{Women} \quad \text{Fat\%} = 1.48 * \text{BMI} - 7.0$$

Neither equation as such directly derives lean body mass but as

$$LBM = \text{weight} - (\text{weight of fat})$$

$$\text{Then } LBM = w - w * (\text{fat\%}) / 100$$

Substituting, we have the 'James' equations (weight as kg, height as cm):

$$LBM_m = 1.1 * w - 128 * w^2 / h^2$$

$$LBM_f = 1.07 * w - 148 * w^2 / h^2$$

To test the assumption that the lean body mass rises to a certain BMI and then falls with increasing weight requires some very simple calculus. As both equations are of the form:

$$l = a * w - b * w^2 / h^2$$

then the first differential will give the gradient, setting this to zero will give us the maximum:

$$dl/dw = a - 2 * b * w / h^2 = 0$$

Hence

$$a = 2 * b * w / h^2$$

Substituting back the constants we have the maximum BMIs of 42.97kg/m² (male) and 36.15kg/m² (female). This has confirmed the assumption that the equations peak. However the original Hume and Weyers equations showed that for any given height, lean body mass increases with

gross weight.

Alternative Lean Body Mass equations.

The Hume and Weyers equations are:-

$$\text{Male} \quad \mathbf{LBM}_m = \mathbf{0.2668h + 0.4066w - 19.19}$$
$$\mathbf{(r^2 = 0.908)}$$

$$\text{Female} \quad \mathbf{LBM}_f = \mathbf{0.4720h + 0.2518w - 48.32}$$
$$\mathbf{(r^2 = 0.916)}$$

As can be seen both equations have good correlation.

Dual energy xray absorptiometry (DEXA) has been used by Janmahasation¹⁰ in 2005 to produce his own formulae in an attempt to be more accurate than Hume & Weyers but in practice produced similar results. A more readable paper discussing the Janmahasation results was that of Han¹². A notable feature of the paper was the vast number of subjects (373) and range of BMI(17 – 70). The equations are:-

$$\text{Male} \quad \mathbf{LBM}_m = \frac{\mathbf{9270w}}{\mathbf{6680 + 216*BMI}}$$
$$\mathbf{(r^2 = 0.92)}$$

$$\text{Female} \quad \mathbf{LBM}_f = \frac{\mathbf{9270w}}{\mathbf{8780 + 244*BMI}}$$
$$\mathbf{(r^2 = 0.94)}$$

I have used the Hume and Wyeth and Janmahasation equations in both the remifentanil (Minto) and propofol (Schnider) models.

[Hume also published lean body mass equations in a 1966 paper¹¹ but these equations are less accurate compared to his later paper.]

References

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14. Non-linear mixed effects modelling. Available from <http://www.iconplc.com/technology/products/nonmem/>
15. STANPUMP. Available from <http://opentci.com>

All programs, a poster and several free downloadable papers (including this one) are available from my website: <http://muirheads.co.uk/richard>

The Software

REMITRAK.EXE

Remitrak
 Remifentanyl Tracker (c) Richard Muirhead 2013
 email : rmuirhead@compuserve.com
 Minto model with variable lean body mass algorithms.

Age (y) Height (m) Weight(kg)
 Confirm patient

LBM (James) = 58.26 LBM (Janmahasation/Han) = 57.6
 LBM (Hume) = 57.57 BMI (kg/m2) = 22.72

Set rate (mcg /kg/min)

Remifentanyl Current infusion rate = 0.6 mcg/kg/min.

<u>Predicted concentrations</u> (ng / ml)	Plasma	Effect
James	14.09	12.93
Hume	14.17	13.00
Janmahasation	14.17	13.00

Elapsed 00:09:08
 22/05/2013 16:07:22

PROPTRAK.EXE

PropTracker
 Propofol tracker (c) Richard Muirhead 2013
 Email: rmuirhead@compuserve.com
 Schnider model with variable lean body mass algorithms.

Age (y) Height (m) Weight(kg)
 Confirm patient

LBM (James) = 58.26 LBM (Janmahasation) = 57.6
 LBM (Hume) = 57.57 BMI (kg/m2) = 22.72

Set rate (mg/kg/hr)

Propofol current infusion rate = 10 mg/kg/hr.

<u>Predicted concentrations</u> (mcg / ml)	Plasma	Effect
James	3.75	3.61
Hume	3.69	3.56
Janmahasation	3.70	3.56

Elapsed 00:12:08
 22/05/2013 15:51:05

This software is written to estimate the remifentanyl and propofol compartment concentrations using alternative lean body mass equations in real time. The lean body mass equations used are those of James³ (as in the original algorithms), Hume & Wyeth⁶ and Janmahasatian¹⁰. All estimates are compiled simultaneously.

These program are intended for academic interest and, as such, will accept unlikely combinations of height and weight. This software may be used simultaneously with total intravenous anaesthesia but IT IS NOT A MEDICAL DEVICE and must not be used, directly or indirectly to control total intravenous anaesthesia.

This software was compiled using Delphi 2 and will run, to the best of my knowledge, on all 32-bit Windows systems including Windows 95. It was compiled and tested under Windows XP but has been tested on a Toshiba Libretto (Windows 95B / 32MB) and 64-bit Windows 7. Each screen will fit into a standard VGA (640x480) display. All inputs can be tabbed but a mouse or similar pointing device is recommended.

The software uses a 4th-order Runge-Kutta integration at 5 second intervals using a threaded timer which renders it rather more accurate than some similar programs and would permit other programs to be run simultaneously, though this cannot be recommended.

Running the software.

This program should run on all 32-bit versions of Windows. There is no need to install - this program makes no changes to start files or the registry. You can run this off a floppy disc (if you still have one), a memory card or USB drive. All boxes and buttons can be tabbed; also '**Enter**' can be used to move onto the next box or button.

As you will notice both programs are similar but differ in font colour. On opening you will be required to enter the patient details: age, height, weight and gender. When you are happy that these details are correct you must '**confirm patient**'. The program will then ask you whether to save the run into a CSV file. The data saved is anonymous though there are blank lines in the file to add identifiers as required. Derived lean body mass estimates and BMI are also presented. You will be unable to change the patient details within the run: pressing '**Abort**' will return the software to the starting state and close any open file.

You may start the program immediately with an infusion rate of zero or, alternatively, change the rate before starting. You may change the infusion rate at any time by entering a new rate into the box. You must confirm the change of rate before the program will use it: a prompt will appear after a few seconds if you do not. Obviously you cannot enter negative values but zero is accepted – obviously the pump can be turned off and on again! Confirming the rate can be by pressing the adjacent button or by pressing 'Enter'.

If you are using these programs on a small screen device then the tool bar icon can be used to maximise (left click) or minimise (right click) as appropriate.

Using your data.

I have included a CSV (otherwise known as comma delimited text file) as, until recently, it could be opened by virtually every spreadsheet and database. However, for reasons that escape me, Microsoft have recently removed the 'import CSV' facility from Access. As I do not use Microsoft Office I cannot offer any definitive method to load the data but there are several methods on the

internet which claim to facilitate this. I suggest an internet search using 'access read csv file'.

I understand that Microsoft Excel can read CSV files and then be linked to Access; this may, in practice, be the easiest method.

For Access 2010 try this link: <http://office.microsoft.com/en-gb/access-help/introduction-to-importing-and-exporting-data-HA101790599.aspx>

This help file.

Traditionally Windows programs would use help(.hlp) files. However as Microsoft stopped supporting .hlp files from Vista, users of later operating systems would not be able to read these without a download. Similarly HTML help files would be poor on early (slow) machines. This help file has been created as a PDF as virtually everyone has a reader and is fast in all environments. Please contact me if other formats are required.

This software was written using Borland's Delphi2, a version of Pascal for 32-bit Windows. I have not, and do not intend to, recompile this software for other platforms. It should, however, recompile using Lazarus/FreePascal under Linux for Android devices. Please email me if you want the source code:-

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