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Estimation of Total Body Fat from Potassium-40 Content

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ABSTRACT

This paper concerns on estimation of total body fat from potassium 40 content using total body counting technique. The work performed using fast scan whole body counter. Calibration of that system for K-40 was carried out under assumption that uniformity distribution of radioactivity of potassium was distributed in 10 polyethylene bottles phantom. Different body sizes were represented by 2, 4, 6, 8 and 10 polyethylene bottles; each bottle has a volume of 0.04 m^3 . The counting efficiency for each body size was determined. Lean body weight (LBW) was calculated for ten males and ten females using appropriate mathematical equation. Total Body Potassium ,TBK for the same selected group was measured using whole body counter. A mathematical relationship between lean body weight and potassium content was deduced.Fat content for some individuals was calculated and weight/height ratio was indicated for fatness.

Key words: Total body fat , K-40 content, Lean Body Weigh (LBW), whole body counter.

INTRODUCTION

The determination of fat content of the human body has physiological and medical importance. It may affect the ability to withstand exposure to cold and starvation. On the assumption that the potassium content of the lean body mass is constant, it should be possible to estimate fat content in living man from a measurement of potassium-40 activity in the whole-body. Natural K is a mixture of three nuclides ^{39}K, ^{40}K, and ^{41}K in the percentages of 93.08, 0.0118 and 6.91 respectively). In a human body of 70 kg mass contains about 140g of potassium (ICRP 1997) [(1)] that equivalent to about 4,400 nuclei of ^{40}K decay per second. Some authors such as M.S.Abdel wahab, 1992[(2)] and T.M.Taha (1997)[(3)] and M.A.Gomaa [(4.)] Used to determine total body potassium burden using whole body counter. In the other hands other authors used mathematical models for calculation of total body fat such as J. J. Kehayias et.al[(5)] generated mathematical method for assessment body fat and lean in the elderly by measuring body carbon and oxygen. E. I. Mohamed et .al [(6)] whom used mathematical models based on formalizing the knowledge on living systems obtained in clinical physiology and theoretical biophysics. Mona et.al[(7)] was written a computer program using quick basic language to compute the equivalent fat content as a percentage of body-weight, for a range of values for the sum of the four skinfolds, of Egyptian males and females of different ages.

This paper concerned on estimation of total body fat from potassium 40 content via determination of lean body weight from generated relationship between TBK and lean body weight . Body Fat (BF) was calculated as body weight minus lean body mass.

MATERIALS AND METHODS

The whole body counter used for measurements consists of two large NaI(TI) detectors (10 cm x 10 cm x 40 cm) configured in a linear array on a common vertical axis. (Gomaa et.al,2008)[4] . ASTSCAN is a linear geometry counter, designed to accurately measure inhaled or ingested radioactivity in subjects covering 99% of the size range of the working population (both male and female). Its sensitivity is such that a typical MDL is less than 5 nCi of Cs-137 or Co-60 in a one-minute count. There are no moving parts to break or slow down the subject's entrance and exit.

The software performs complete nuclide identification and quantification. It uses peak searching and detection techniques to allow for the identification and calculation of unexpected nuclides and to allow the user to quickly perform his own efficiency calibrations.

The operator interacts with a menu-driven program, which is easy to understand by a technician, but flexible enough to allow a wide variety of special procedures by the sophisticated user. The program is also designed to allow it to be easily modified for customer-specific data collection formats and report generation formats.

Uniformity distribution of radioactivity of potassium was distributed in 10 polyethylene bottles phantom containing of KCL containing different known concentrations. Different body sizes were represented by 2, 4, 6, 8 and 10 polyethylene bottles, each bottle has a volume of 0.04 m^3 . Are stacked close to each other to form the configuration shape of the committed reference man assembly phantom. A correction was also made for changing of the phantom size. The calibration sensitivity of the whole body counter can be predicted using the following sample formula

$$E = C/A \times B$$

Where C is the net full energy peak counting rate estimating from the summed spectrum after subtraction from background of empty wooden stand in count per second ,

A is the. Quantity of dissolved potassium in the phantom, in gram .

B: B is a correction factor for the deviation of the body size from the fitted standard reference Man. size (30000 cc).

Lean body weight was calculated using model of Mosteller [5] as presented in equation (1) and (2) for men and women respectively.

$$LBW_{men} = 1.10 \text{ X Weight (Kg) } -128 [(Weight^2 /(100 \text{ x Height(m)})^2] \quad (1)$$

$$LBW_{Women} = 1.07 \text{ X Weight (Kg) } -148 [(Weight^2 /(100 \text{ x Height(m)})^2] \quad (2)$$

RESULTS AND DISCUSSION

Counting efficiency for potassium was studied with different potassium concentrations as shown in figure 1 . Figure 2 shows the variation of the relative geometry correction factors with the deviation of the body size.

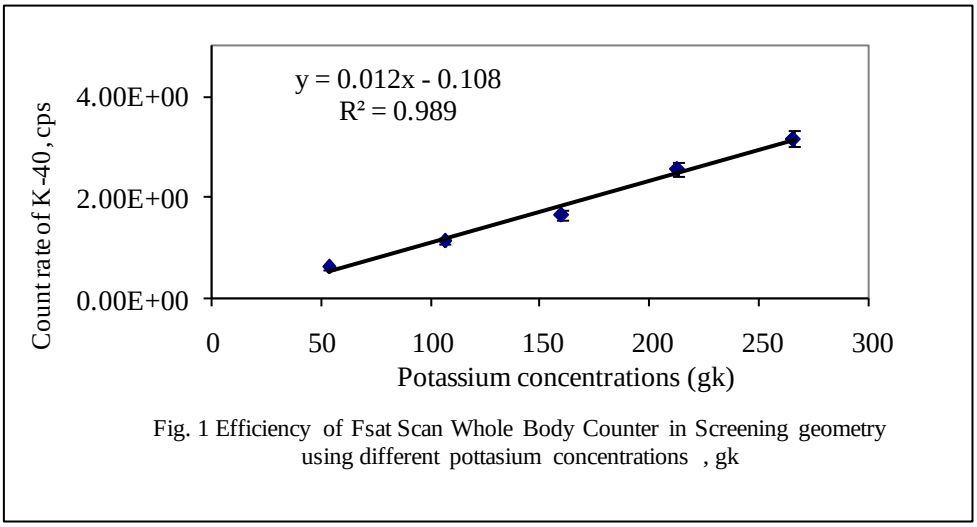

Fig. 1 Efficiency of Fsat Scan Whole Body Counter in Screening geometry using different pottasium concentrations , gk

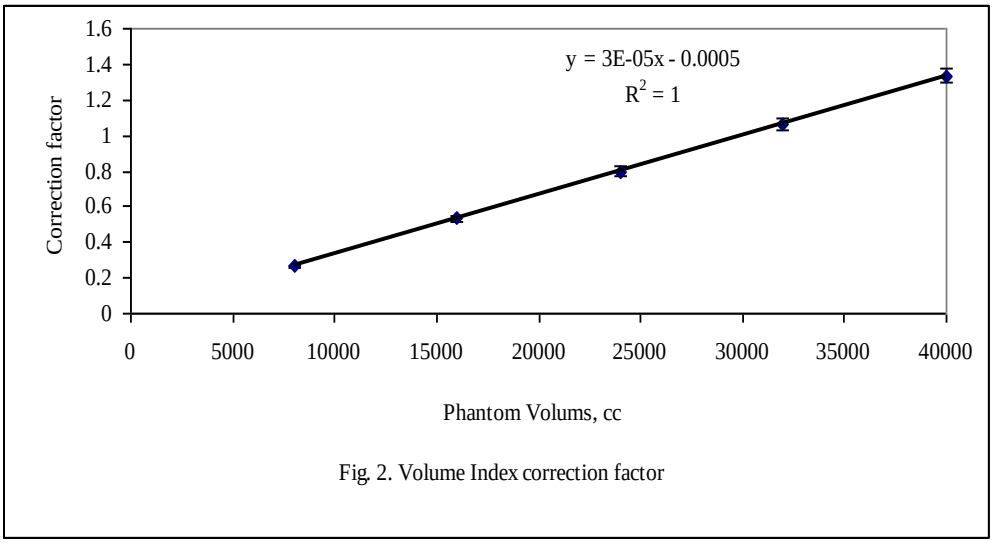

Fig. 2. Volume Index correction factor

Fig.2 Correction factor of body size

The relationship between the measurement of total body potassium and lean body weight was generated as shown in table 1.

Table. 1 Total Body Potassium, TBP, Kg and Lean Body Weight, LBW(kg)

Code	*Name*	*W//H/C*	*Calculated LBW , Kg*	*W/H Ratio*	*Measured TBK,gm*	*Age*	*Sex*
51302177	*TMT*	*95/172/3.2*	*65.45*	*0.552*	*187 ± 35*	*42*	♂
51302167	*TAA*	*97/185/3.1*	*71.51*	*0.524*	*182 ± 35*	*42*	♂
51302177	*SSA*	*98/185/3.2*	*71.88*	*0.530*	*186 ± 25*	*45*	♂
51333021	*A.H*	*90/167/3.1*	*42.25*	*0.54*	*182 ± 36*	*53*	♂
51220218	*TMT*	*95/172/3.2*	*65.45*	*0.552*	*122± 25*	*42*	♂
51102199	*AHY*	*93/186/2.7*	*55.75*	*0.50*	*157 ± 14*	*55*	♂
51302205	*NA*	*91/179/3.1*	*67.02*	*0.497*	*189 ± 11*	*36*	♂
51302206	*MA*	*84/173/2.8*	*51.61*	*0.486*	*171 ± 11*	*39*	♂
51302207	*EF*	*93/181*	*54.51*	*0.514*	*225 ± 11*	*40*	♂
51102222	*AMA*	*100/173*	*67.23*	*0.578*	*288 ± 32*	*29*	♂
51102220	*AME*	*70/170*	*55.3*	*0.411*	*163 ± 34*	*29*	♂
51102219	*MAT*	*90/171*	*51.63*	*0.526*	*168 ± 34*	*29*	♂
51102216	*AMA*	*74/171*	*57.43*	*0.433*	*217 ± 30*	*29*	♂
51302224	*AAM*	*67/165.5*	*50.52*	*0.41*	*126± 15*	*33*	♂
51302193	*HA*	*65/157*	*44.18*	*0.412*	*120 ± 11*	*32*	♀
51302195	*SA*	*85/165/3*	*51.67*	*0.516*	*195 ± 18*	*30*	♀
51302210	*MM*	*67/149/*	*41.79*	*0.4496*	*96 ± 16*	*38*	♀
51302211	*AF*	*94/157/*	*47.53*	*0.599*	*104 ± 21*	*31*	♀
51302225	*AS*	*73/162*	*48.06*	*0.45*	*105 ± 13*	*31*	♀
5130227	*AI*	*94/163*	*21.21*	*0.58*	*101 ± 17*	*39*	♀
51302228	*HO*	*79/159*	*47.99*	*0.50*	*72 ± 12*	*36*	♀
51302229	*SS*	*75/162*	*48.55*	*0.463*	*74 ± 13*	*34*	♀
51302230	*SY*	*91/166*	*50.04*	*0.55*	*75.2 ± 15*	*48*	♀

Where W: weight in Kg
H: Height in cm
C: Chest Circumference, cm

The relationship between fat content (kg) and total body fat (kg) for males and females were demonstrated as shown in figure 3 and figure 4.

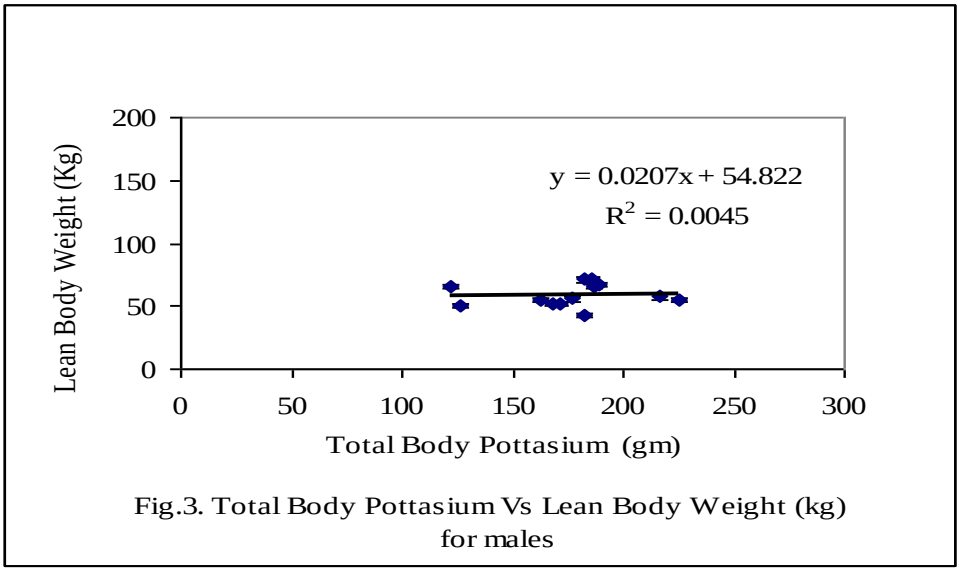

Fig.3. Total Body Pottasium Vs Lean Body Weight (kg) for males

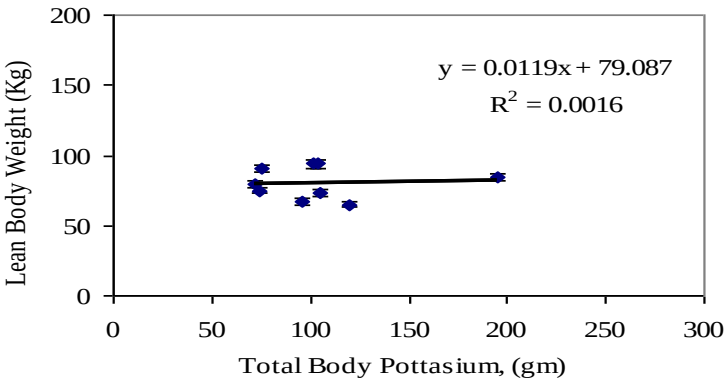

Fig.4. Total Body Pottasium Vs Lean Body Weight (kg) for Females

The Fat contents for the current study were presented in table 2. Fat contents for some individuals were assessed for males and females. It were ranged from 21% to 53% for males and from 32% to 77 % for females which were higher tan values obtained by . J. Kehayias et.al [5]

Table. 2 Total Body Potassium,TBP, Kg and Lean Body Weight, LBW (kg)

Code	*Name*	*Fat%*	*Age*	*Sex*
71302177	*AC*	*32.20*	*42*	♂
71302187	*AB*	*26.28*	*42*	♂
71302177	*SAS*	*26.65*	*45*	♂
71333021	*HA*	*53.05*	*53*	♂
71220218	*AMT*	*31.11*	*42*	♂
71102199	*YAH*	*39.73*	*55*	♂
71302205	*AN*	*26.35*	*36*	♂
71302206	*AM*	*38.6*	*39*	♂
71302207	*FE*	*41.3*	*40*	♂
71102222	*AEA*	*32.8*	*29*	♂
71102220	*EMA*	*21*	*29*	♂
71102219	*TAM*	*42.63*	*29*	♂
71102216	*AME*	*22.57*	*29*	♂
71302224	*MAA*	*24.60*	*33*	♂
71302193	*AH*	*32.03*	*32*	♀
71302195	*SA*	*39.21*	*30*	♀
71302210	*M.A*	*37.63*	*38*	♀
71302211	*FA*	*49.44*	*31*	♀
71302225	*SA*	*34.16*	*31*	♀
71302227	*LA*	*77.43*	*39*	♀
71302228	*DA*	*39.25*	*36*	♀
71302229	*AS*	*54.48*	*34*	♀
71302230	*YS*	*45.01*	*48*	♀

CONCLUSION

Fat contents for the individuals were calculated based on potassium 40 body content of a human body by using whole body counter method. A mathematical relationship between lean body weight and potassium content for males and females were generated . Fat contents for individuals under study were assessed for males and females which ranged from 14% to 37% for males and from 14% to 50% for females respectively.

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