PHYSICAL SCIENCES

ISSN (Print): 24490954
ISSN (Online): 26364972

NUMERICAL ESTIMATES OF DAILY ENERGY REQUIREMENT AND DAILY CALORIES EXPENDED BY AKUNZA COMMUNITY SCHOOL CHILDREN

Olagunju A. S, Akeremale O. C, Enoch B. T, Lawal G. U. and Eze E. H.

Department of Mathematics, Federal University Lafia
**Corresponding Email: olagunjuas@gmail.com*

Manuscript Received: 22/02/2017 Accepted: 12/04/2018 Published March: 2018

ABSTRACT

A research study was carried out using numerical techniques to establish the pattern of daily Estimated Energy Requirement (EER) and Calories Expended (CE) by school children in Akunza community of Lafia in Nasarawa State, Nigeria. Using factors such as age, height, weight, activity level and genetic make-up, the EER and CE per day vary from person to person. In this study, these two variables are estimated for each selected pupil with the use of equations developed by Institute of Medical Equation. The resulting numerical values are thereafter interpolated with the use of Lagrange interpolation technique which yielded a set of equations governing the pattern of flow of these variables among the school children in Akunza community. A total of 60 pupils were randomly selected for this study and factors that affect their daily energy expended were measured with specialized instruments (meter rule, digital weighing scale and activity level scale). For the purpose of fast and cost effective assessment of EER and calories burned by each pupil, the set of equations arrived at are inculcated into a computing template. This in essence can be used in estimating energy requirement and calories burned by any member of this population, without subjecting such to any test.

Key words: *Age, weight, height, activity factor, calorie, EER, Lagrange interpolation.*

INTRODUCTION

A few decades ago the problem of overweight and obesity was rare in early childhood, but with the caloric makeup of present day food substance and current disposition to feeding, this assertion has changed dramatically (de Onis, Blossner, and Borghi, 2010). According to the data from the National Health and Nutrition Examination Survey (NHANES), childhood overweight and obesity has risen substantially over the past thirty years (Ebbeling *et al.,* 2012). A good example is the scenario in the United States where for children aged 2-5 years, the prevalence of overweight increased from 5.0% to 13.9% within the past 5 years. For developing countries, the reverse is however the case especially among the rural community dwellers, where malnutrition is prevalent owing to economic status of the people (Laurencia *et al.,*). The problem of underweight and stunted growth are therefore of a massive dominance among this population. However, according to Mozaffrarian *et al.,* (2011), achieving and sustaining appropriate body weight across lifespan is not just for the sake of it, but much more benefit from it is the maintenance of good health and quality of life. Therefore knowing the estimate of energy requirement and calories expenditure is of significant importance in the fight to stay healthy and to be in shape.

When a person expends more calories than heconsumes, he will lose weight. On the other hand the person that consumes more calories than he burns will stand the risk of being overweight or obese. Many behavioural, environmental and genetic factors have been shown to affect a person's body weight, however maintaining calorie balance over time is the key to weight management. For the poor masses in rural community, it is established that the caloric value of their food is minimal to the point that the energy expended in many activities such as farming, hunting, trekking, dancing and doing sport outweighs the consumed energy. The resultant effect of this is energy imbalance and subsequently loss of weight.

In addition to this, the knowledge of number of calories in food substance can help to balance the energy put into the body with the amount used, in supporting optimal growth and metabolic processes. For instance, children require a variety of nutrient-dense foods and adequate calories in order to grow and develop properly. And also, teaching them good nutrition habits from young age can decrease the likelihood of the becoming overweight or underweight (Stare and Mcwilliams1977).

MATERIALS AND METHODS

Interpolation, a fundamental technique in numerical analysis, is the problem of constructing a function which goes through a given set of data points. In some applications, these data points are obtained by sampling a function or process; subsequently, the values of the function can be used to construct an interpolant, which agrees with the interpolated function at the data points. Lagrange interpolation technique, is in this work, deployed as a tool for estimating the energy requirement and calorie status of individual pupil just by supplying necessary variables into the governing polynomial fit. This technique was initially developed for univariate data set but has been extended to data sets (Steffenson, 2006).

Estimated Energy Requirement (EER) is the average dietary energy intake that is predicted to maintain energy balance in healthy, normal weight individuals of a definite age, gender, weight, height and level of physical activity consistent with good health. According to the institute of medical equation,

EER is given by:

$$EER\,(kcal/day) = Total\ energy\ \mathrm{exp}enditure + Energy\ deposition.$$

Mathematical expressions for EER for each gender across different age range are therefore given as follows:

Boys:

Ages 3-8 yrs:

$$EER\,(kcal/d) = 88.5 \times A\,(yrs) + PA \times (26.7 \times W\,(kg) + 903 \times H\,(m)) + 20 \quad (1)$$

Ages 9-18 yrs:

$$EER\,(kcal/d) = 88.5 \times A\,(yrs) + PA \times (26.7 \times W\,(kg) + 903 \times H\,(m))\ 25 \quad (2)$$

Girls:

Ages 3-8 yrs:

$$EER\,(kcal/d) = 135.3 - (30.8 \times A\,(yrs)) + PA \times (10.0 \times W\,(kg) + 934 \times H\,(m)) - 20 \quad (3)$$

Ages 9-18 yrs:

$$EER\,(kcal/d) = 135.3 - (30.8 \times A\,(yrs)) + PA \times (10.0 \times W\,(kg) + 934 \times H\,(m)) - 25 \quad (4)$$

Daily Calorie Expenditure

Nutritionally, Calorie is the unit used in measuring the energy-producing value of food, it is equally the unit for measuring the rate at which the energy is used up via physical exercise and metabolic activities. Technically, a calorie is defined as the amount of heat necessary to raise the temperature of one gram of water one degree centigrade.There are four major sources of energy in food, these are carbohydrate, protein, fat and alcohol. When burned (metabolised) these provide different amount of energy.

RESULTS AND DISCUSSION

TABLE 1: Caloric content of food substance

Food component	Energy density (kcal/gram)
Carbohydrate	4 Cal
Protein	4 Cal
Fats and oil	9 Cal
Ethanol (drinking alcohol)	7 Cal
Fiber	2 Cal
Sugar alcohols and sweeteners	2.4 Cal

Formulas given below provide an estimate of total daily caloric expenditure by multiplying the Harris-Benedict equations for Basal metabolic rate (BMR) by an "Activity Level Factor" that accounts for daily physical activity levels and the thermic effect of food. The equations are as follow:

- $Male(metric): DCE = ALF \times ((13.75 \times WKG) - (5 \times HC) - (6.76 \times age) + 66)$ (5)
- $Male(imperial): DCE = ALF \times ((6.25 \times WP) - (12.7 \times HI) - (6.75 \times age) + 66)$ (6)
- $Female(metric): DCE = ALF \times ((9.56 \times WKG) - (1.85 \times HC) - (4.68 \times age) + 665)$ (7)
- $Female(imperial): DCE = ALF \times ((94.35 \times WP) - (4.7 \times HI) - (4.68 \times age) - 665)$ (8)

Where

ALC = Activity level factor
DCE = Daily caloric expenditure
HC = Height in centimetre
HI = Height in inches
WKG = Weight in kilograms

Accurate determination of the calories burned can only be accomplished by individual physiological testing. However, this equations provide a reasonable estimate, and can be used to quickly compare the effects of different exercises on total energy expenditure. Also these mathematical expressionsuse the most recent set of metabolic equations and physical activity coefficients developed by Food and Nutrition Board, Institute of Medicine (IOM).

For each of the sample (60 pupils), variables contained in equations outlined in sections 3 and 4 are measured with the use of bathroom scale (for weight), Metre rule (height), activities scale (activities level). These are thereafter substituted into these equations to arrive at EER and CE. Tables depicting these variables for the 60 pupils selected at random are as follows:

TABLE 2: TABLE OF CB and EER FOR MALE

Age	Height	Weight	Calories Burned	EER
6.0833	76	13.1	1028.022	1182.414
7.5	122.5	26	1731.312	2164.775
7.6667	135	33.6	2022.568	1692.225
7.6667	109	18.2	1422.443	2596.571
7.75	107	16.9	1355.622	1613.191
7.75	120	20.5	1573.704	1912.105
8.0833	116.5	19.3	1509.981	1807.370
8.25	122.5	19.8	1572.842	1891.593
8.5	106.5	16.6	1351.891	1554.231
8.5833	115.5	18.8	1483.141	1745.089
8.5833	131	28.5	1853.427	2303.625
8.75	100	15.1	1255.531	1400.513
8.75	132	26.2	1804.774	2219.320
9.25	124.5	26.5	1740.024	2044.818
9.3333	115.6	20.6	1518.446	1767.211
9.4167	103.8	15.1	1280.992	1407.284
9.5667	113.7	20.1	1486.877	1710.056
9.5833	109	13.2	1278.946	1391.688
9.5833	101	15.3	1259.181	1639.050
9.5833	132	28.9	1859.904	2269.320
9.6667	119	23.3	1609.479	1728.048
9.75	146	33.3	2087.202	2607.938
10.4167	116.5	19.8	1494.111	1681.623

TABLE 3: TABLE OF CB and EER FOR FEMALE

Age	Height	Weight	Calories Burned	EER
5.5833	80	11.8	1559.428	1194.615
6.4167	90	16	1655.177	1358.506
6.9167	118	18.9	1788.744	1749.833
7	112.5	17	1738.528	1648.750
7.25	111	17	1731.708	1621.438
7.25	109	19.8	1772.681	1634.484
7.75	115.5	19.5	1784.068	1699.878
8	109.5	16	1709.856	1564.722
8.1667	115.5	22.7	1834.688	1734.842
8.25	115	21.1	1932.102	1705.340
8.3333	107.5	15.6	1688.005	1527.704
8.3333	104	16	1683.675	1487.539
8.3333	119.5	20.7	1812.19	1756.016
8.4167	111	16.2	1708.54	1579.302
8.4167	150	40	2234.217	2422.467
8.5	106	13.2	1641.323	1469.357
8.5	114	17.7	1742.699	1636.964
8.5	110.5	18.8	1750.197	1606.598
8.5	127	30.2	1995.083	1981.952
8.5833	115	21.8	1814.452	1704.875
8.6667	112	16.8	1719.778	1593.077
8.8333	100	14.1	1634.765	1393.235
8.8333	123	24.2	1878.278	1838.029
9.3333	118.5	22.3	1827.784	1737.340
9.3333	121.5	26	1899.803	1825.568
9.4167	111	18.1	1732.371	1575.102
9.4167	140	31.4	2048.96	2140.506
9.5	102.5	15.1	1654.066	1419.389
9.5	112	16.5	1707.816	1563.211
9.5345	109.5	16.8	1704.679	1533.660
9.5833	113.5	19.5	1762.567	1622.261
9.5833	116.5	19.9	1778.829	1667.088
9.6667	114.5	20.2	1776.872	1642.568
9.6667	142	20.6	1870.751	2007.758
9.6667	131	29.3	1982.898	1992.722
9.9163	107	17.9	1712.187	1485.944
9.9167	106	17.5	1702.257	1504.611

Lagrange Polynomial Interpolation

Let $y_0, y_1 \ . \ . \ . \ y_n$ be the values of $y = f(x)$ corresponding to the argument $x_0, x_1, . . . x_n$ not necessarily equally spaced, the Lagrange interpolation polynomial $p(X)$ of degree n given at $n+1$ points $(x_i, y_i)_{i=1}^{n+1} \in \mathbb{R}^2$ where $x_i \neq x_j$ is given by:

$$y = p(X) = \sum_{i=1}^{n+1} y_i L_i(X) \qquad (9)$$

Where $L_i(X)$ are the Lagrange Basis Polynomials defined by:

$$L_i(X) = \prod_{j=1, j \neq i}^{n+1} \frac{X - x_j}{x_i - x_j} \qquad (10)$$

Lagrange Interpolation polynomial fit for Calories burned and EER

For the purpose of efficient handling of data in table 2 and 3, we hereby grouped the data according to their ages as follows:

Table 4 Grouped data for male

Age Grp	Average age	Weight (kg)	Height (cm)	Average Cal	Average EER
6.1-7.0	6.0833	13.1	0.76	1028	1203
7.1-8.0	7.6667	23.04	1.187	1621	2029
8.1-9.0	8.5	20.6143	1.1771	1547	1878
9.1-10.0	9.5259	21.8333	1.1807	1569	1865
10.1-11.0	10.4167	19.8	1.165	1494	1713

Table 5 Grouped data for female

Age Grp	Average age	Weight (kg)	Height (cm)	Average Cal	Average EER
5.1-6.0	5.5833	11.8	0.8	1559	1203
6.1-7.0	6.7778	17.3	1.0683	1727	2029
7.1-8.0	7.5625	18.075	1.1125	1749	1878
8.1-9.0	8.4778	20.6067	1.5333	1804	1865
9.1-10.0	9.5739	20.4829	1.1754	1797	1713

Both Calorie burned and EERon tables4 and 5 are thereafter approximated as function of age only while other variables are held constant. With the use of equations (9) and (10), the relationship between these dependent variables (CE and EER) and age are correspondingly interpolated in relation to age variable. The resulting equations are the interpolation polynomials each valid only for the respective interval.

$EER_{Boys} \rightarrow f(x) = -40.7925x^4 + 1407.4625x^3 - 18082.7143x^2 + 102431.0138x - 213725$ ....(11)

$EER_{Girls} \rightarrow f(x) = -30.7684x^4 + 954.7888x^3 - 11015.9964x^2 + 56082.8673x - 104086.9253$ ....(12)

$CE_{Boys} \rightarrow f(x) = -25.9799x^4 + 896.8115x^3 - 11529.5944x^2 + 65394.0248x - 136423.8596$ ....(13)

$CE_{Girls} \rightarrow f(x) = -14.2231x^4 + 430.2703x^3 - 4853.5424x^2 + 24233.2467x - 43507.6525$ ....(14)

These are therefore the governing equations for predicting what the EER or CE will be for any school pupil picked from Akunza community.It is to be noted that each of these equations is only valid for corresponding age range, i. e.each will predict correctly either the EER or CB only when the substituted age (x) is within the age range of the pupils considered in the group.

CONCLUSION

In conclusion, by this work we arrived at equations that govern daily calories expended and estimated energy requirement by Akunza Community school children.

These serve as veritable tools in knowing the pattern of how these pupils use energy, such that without subjecting anyone to the series of measurements and medical examination, daily energy used and estimated energy requirement can be arrived at, in no time.

From this work, it is also observed that the activities level of these pupils is quite encouraging as most of them burn calories in accordance with the stipulated average calories burn for their age bracket. But a lot needs to be done as in all cases and for all pupils, the estimated energy requirement is greater than the calorie burned, this in essence signifies that these pupils need to eat more of food that are high in calories so as to matchup with the corresponding level of activities.

REFERENCES

Fleck, H. (1976). Introduction to nutrition. 3rd edition, New York, MacMillan Publishing Co. 14-19.

Gann, Carrie. (2013). For Calories, It's all about quality over quantity, Harvard study says"ABC News.

Grant, E.W. (1966). Some cultural factors that influence food habits in part of Africa. a talk presented at the foods and nutrition agents of North Carolina training conference. Betsy Jeff Penn training center, Reidsville, N.C., USA.

Hill, M.M. (1970). Food guides - their development and use *Nutrition Program News* .US department of agriculture. Washington, D.C. 1-5.

Hunt, C,L.(1923). Good proportions in the diet. US department of agriculture,Washington D,C.*Farmers Bulletin, no, 1313*

Mahan, K. L. (2000). Krause's food, nutrition and diet therapy. 10th ED. Philadelphia: W.B. Saunders Co.

Müller, B., Merk, S., Bürgi, U. and Diem, P (2001). Calculating the basal metabolic rate and severe and morbid obesity. Praxis (Bern 1994) 90 (45): 1955–63.

Olver, P. J. On multivariate interpolation. Studies in Applied Mathematics, 116(4): 201-240; 2006.

Roza, A. M. &Shizgal, H. M. (1984): The Harris Benedict equation reevaluated: resting energy requirements and the body cell mass. *The American Journal of Clinical Nutrition 40*:168–182.

Stare, F.J. and M. McWilliams (1977). Living Nutrition, 2nd edition. New York, John Wiley. 6-18.

Steffenson J. F., Interpolation. Dover Publications, inc., New York, second edition, 2006.

WHO. (1985). Energy and protein requirements: Report of a jointFAO/WHO/UNUexpert consultation. Geneva, WHO Tech.

Laurencia G, Kirthee P, Muthulisi S, Albert M and Tafadzwanashe M (2017): Food and nutrition insecurity in selected rural communities of KwaZulu-Natal, South Africa – linking human nutrition and agriculture. *Int J. Environ Res Public Health. 14*(1):17