Mini Review

Insulin dependent diabetes and anthropometric assessment: Understanding the rationale for body composition measurement

Jonathan Nsamba*, Elezebeth Mathews, Ronald Buyinza

Abstract

The purpose of the review is to explore the interlinkages between diabetes, insulin therapy, and body composition and discuss the need for body composition assessment as part of the routine nutrition and health assessment of children living with diabetes especially in resource limited contexts with a case study of Uganda. Changes in body composition have an intractable effect of Insulin Dependent Diabetes Mellitus and its management. The association between diabetes and body composition has the potential to lead to adverse health outcomes, especially in later years of life. Health practitioners shall devise strategies to efficiently monitor the body composition of young diabetics at an early stage to revert the life threatening complications among young diabetic patients.

Keywords: Diabetes; Body composition; Children; Uganda

Introduction

Cardiovascular diseases (CVDs) are one of the leading causes of mortality and a serious public health threat disproportionately affecting the less developed nations.[1,2] Diabetes Mellitus, one of the main risk factors for CVDs, refers to several metabolic disorders that result in an abnormally high concentration of glucose in the blood.[3] Insulin dependent diabetes Mellitus (IDDM) sometimes referred to as Type 1 diabetes, a subtype of diabetes, results when the pancreas is unable to produce enough insulin, usually owing to the autoimmune destruction of the beta cells of the islets of Langerhans.[4] Beta cells tend to be destroyed by the T-lymphocytes that enter the islets of Langerhans. IDDM is one of the global health emergencies of the 21st century whose prevalence has escalated on the African continent in recent times among children and adolescents.[5,6] Over 1 million children and adolescents are affected worldwide.[5] Sub Saharan African region is still grappling with diabetes and its associated complications. The International Diabetes Federation indicates that Africa is home to 50,600 children living with IDDM with an annual incidence of 18300 new cases. Correspondingly, 2725 children and adolescents are living with IDDM in Uganda.

Diabetes and its associated management is a huge financial impact on individuals especially in low developing countries in terms of catastrophic health expenditures. The impact is either direct or indirect with direct costs involving expenditures associated with medicines, insulin, and laboratory tests. Indirect costs are related to incomes spent towards diet, transport and any other need in seeking medical care. They also relate to absenteeism, and loss of working time. Poor households are disproportionately affected because they send a large portion of their income on diabetes care than the financially better households. The high costs associated are reported to increase with increasing increasing Body Mass Index which underscores the need for routine body composition assessments.[7] Patients with Type 1 Diabetes Mellitus patients have traditionally been described as leanhowever,[8-10] current trends show that they exhibit a higher preponderance for overweight and obesity with the greatest risk evident during the early years of life.[11] The medical management of T1DM involves the use of insulin as a hormonal therapy, however, due to its lipogenic and anti-catabolic effects on lipids and proteins, respectively, contributes to weight gain. The main goal of diabetes management is to maintain normo glycemia and reduce complications. The key principles of diabetes management involve insulin therapy, blood glucose monitoring, health and nutrition education. However, the diagnosis and initiation of anti-diabetic medications such as insulin therapy on patients tend to show considerable bodyweight changes, the composition of which remains unknown.[7] We are not sure whether these changes reflect increases in fat or fat free mass compartments of the body. The assessment of body composition is a key in the early identification of changes at a cellular level, making it a vital tool in the assessment of health and nutrition status.

The assessment of body composition has traditionally focused on the use of anthropometric approaches such as Body Mass Index because it is simple, cheap, and non-invasive, however, it has been deprecated as it lacks precision as far as the estimation of body compartments of fat and muscle is concerned since it does not rightfully disaggregate the surrogate body weight into its compo-

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nents of fat mass and fat free mass. Therefore, to manage IDDM effectively, there is a need to develop and advance valid, precise, and innovative low cost techniques to measure body composition especially in resource restrained contexts. This will facilitate early screening and identification of individuals having a host of cardio metabolic risk markers. Unless corrected, altered body composition can lead to early complications and adverse cardiovascular outcomes, which negatively impact children's health, productivity, and quality of life, which are all associated with increased mortality.

Results

The heavy burden of obesity the economics of prevention. Countries spend an average of USD 209 per capita annually in management of high body mass Index and obesity and their related complications. It is estimated that about 70% of health expenditure on diabetes is attributed to overweight. At macro-economic level, diabetes and its complications affect the GDP of a country. Diabetes has an impact on life expectancy of citizens, morbidity, mortality and health expenditure. Overweight reduces life expectancy by 2.7 years on average and countries spend USD PPP 209 per capita annually to treat obesity, overweight and their associated complications. Therefore it is critical to invest in prevention and treatment of overweight among diabetics. Given the long term progression of diabetes and its associated high costs, prevention aimed at altering its progression have shown effectiveness in cutting down related costs.

Current treatment regimen: Globally and in Uganda

The starting point of treatment is early diagnosis of diabetes especially among children and adolsecents. The longer someone lives with diabetes, the easier more complications develop. Diabetes is characterized by a trio of cardinal signs including polydysia, polyphagia and polyuria. The main goal of treatment is to maintain normal glysemia, prevent hyper glysemia and reduce the chances of developing complications. The principles of diabetes management involve physiologic insulin replacement therapy, monitoring of blood glucose, health education to the patient and a supportive clinical team inclusive of psycologists. In Uganda, there are majorly three insulin regimens commonly used for the treatment of IDDM. These include fixed insulin dose regimens, glucose and meal adjusted regimens, and insulin pump therapy. Insulins used in these regimens include short acting, long acting, and premixed insulin.[12] Specifically, most patients in Uganda receive Neutral Protamine Hagedorn and regular insulin.[13]

Treatment of IDDM requires the administration of subcutaneous insulin in doses calculated according to the patient's body weight, blood glucose concentration, carbohydrate consumption, and physical activity.[14] Insulin can be delivered by syringe, taken as Multiple Daily Injections or Continuous Subcutaneous Insulin Infusion injected over the abdomen, thigh, buttocks, and upper arm.[12,15]

Nutrition therapy

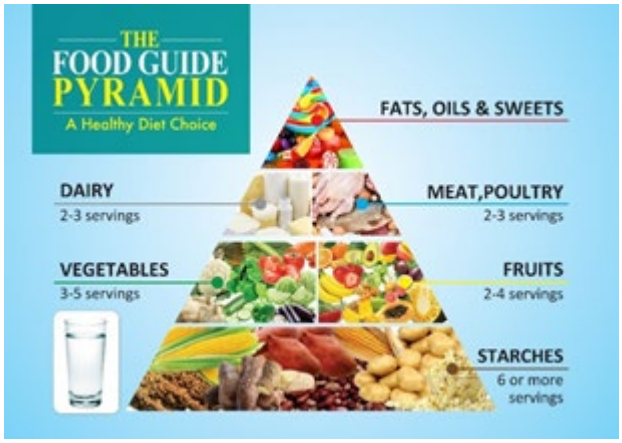
Nutritionally, there is no standerd universal meal plan for people with diabetes. However, it is important that there is individualized nutrition therapy that is based on individual goals, anthropometry, cultural and personal preferences. Current recommendations of care centred on the healthy plate and the food guide pyramid as shown in Figures 1 and 2. It is recommended that one continues to access healthy wholesome.

Association between Insulin and Body Composition

Following Insulin discovery by Fredrick Banting, J.J.R Macleod, Charles Best, and James Collip in 1921, it has saved millions of people worldwide who otherwise would have died as a result of poor glycaemic control.[16,17] While insulin therapy is vital in glucose metabolism, its use has been accompanied by some deleterious side effects. Insulin leads to weight gain due to efficient absorption of glucose from food; with excess beyond the metabolic need being converted into adipose tissue which manifests as weight gai.[18] Observed weight changes may be a result of insulin metabolism, low levels of physical activity, and poor dietary and nutrition habits.[19,20] The medical approach to IDDM management involves the use of insulin therapy, however, studies show that insulin contributes to weight gain as it inhibits protein catabolism, stimulates lipogenesis, and reduces basal metabolic rate.[21] A reduction in protein catabolism leads to an increase in fat free mass, while an increase in lipogenesis and a reduction in basal metabolic rate leads to an increased tendency for fat mass accumulation. An over increase in fat mass can lead to dyslipidaemia, insulin resistance, and cardio metabolic complications in type 1 diabetes.

Figure 1: *Showing the healthy plate*

Figure 2: Showing the food guide pyramid



Changes in body composition represent one of the mechanisms through which early metabolic exposures increase one's susceptibility to disease outcomes in later life, especially adverse cardiovascular outcomes.[22] Diabetes Mellitus is one of the metabolic disorders during childhood and adolescence that has a profound effect on disease outcomes later in adult life. Increased fat adiposity among IDDM patients contributes to a biological embodiment that relates to how factors that are experienced at different life stages alter the body's biological functioning, thus increasing the risk of later disease outcomes.[23] Scientific evidence shows that weight gain has short term benefits to most patients because they are usually lean.[8,10] Unfortunately, excess weight gain can lead to an increase in fat mass which is strongly associated with insulin resistance.[24] Weight gain among IDDM children is partly attributed to the intrinsic lipogenic effect of insulin, which results in a higher rate of fat storage. This metabolic pathway results in a reduction of catabolism and urinary caloric loss. The body cells then absorb more glucose and eventually convert it to body fat, which is one of the primary constituents of body weight.

Body Composition Assessment

The assessment of body composition is key in the early identification of changes at a cellular level, making it a vital tool in the assessment of health and nutrition status since changes in body compartments of fat and fat free mass have health risk implications. We are then able to harness insulin use in glycaemic control but optimise the resulting weight and body composition changes. The assessment of body composition is an important clinical procedure to provide clinically relevant information for the proper medical management of the disease. Body composition refers to the individual compartments that make up one's total body weight. The body is made up of water, protein, fats, carbohydrates, connective tissue, bones, among others. Conventionally, body composition is measured in a two component model. In this model, total body weight is regarded as a sum of fat mass and fat free mass. Fat mass consisting of the water free compartment with fat free mass consisting of muscles, body organs, and interstitial tissues.[25] Furthermore, Fat free mass comprises 7% bone mass content, 29% extracellular water, 44% intracellular water, and 20% visceral protein.[26] Once the fat mass is determined, the fat free mass becomes the difference between total body weights.

Overtime, inaccuracies have been discovered in the two component model due to differences in hydration status as regards to the estimation of total body water giving rise to a three component model.[27] The three component model divides the body into fat mass, fat free mass, and total body water. Total body water can be accurately estimated by impedance or doubly labelled water or isotope dilution (Fuller et al., 1992). In this model, fat free mass is divided further to represent its water content and the remaining solids consisting of protein and minerals.[26] The four component model further measures the protein and mineral content differently to give a more accurate breakdown of body composition. The four component model is an accurate but expensive model of body composition measurement. Dual energy X-ray absorptiometry (DXA) which is currently considered the reference method of body composition is used to measure bone mineral density to segregate the body into fat, water, minerals, and protein masses. Several methods can be used to assess body composition. Some of the methods include anthropometry (skinfold thickness), isotope dilution, densitometry, dual energy X-ray absorptiometry, air displacement plethysmography, and bioelectrical impedance analysis.[27] Imaging techniques such as nuclear magnetic resonance imaging and computed tomography can visualize and quantify tissues and adipose tissue.[25] All these methods vary in their precision, validity, accuracy, reliability, and applicability.

Discussion

Densitometry, deuterium dilution, Magnetic resonance imaging (MRI), and Dual energy X-ray absorptiometry (DXA) are the most accurate methods to measure body composition however their applicability in clinical and field settings is questionable especially in low resource settings contrary to Bioelectrical Impedance (BIA) that is relatively cheaper.[26] BIA is a non-invasive, relatively cheaper, reliable, and widely used method of body composition estimation. BIA is an indirect method and thus, its accuracy depends hugely on physical and biological assumptions.[28] Bio-electrical impedance uses a physical assumption of reactance and resistance to a low voltage electrical current. Fat free mass, which is an aqueous body tissue, is the major conductor of an electrical current, whereas fat mass causes resistance to the flow of the same current. Assessment of body composition by bio-electrical impedance among diabetic patients has been reported to have no contradictions.[29] Assessment of body composition reveals any changes in fat mass and fat free mass body compartments.[19] Body composition analysis is essential because it indicates the level of fat and muscle in the body. In metabolic conditions such as IDDM, this is a key in medical management since too much increase in fat mass

can exacerbate cardiovascular disease risk.[30-35]

Conclusion

Achieving tight glycaemic control without adverse weight changes is the goal of insulin therapy. However, we need re-assurance of the cardiovascular safety of IDDM patients. Whether weight gain is desirable or not, it remains unknown in contexts where nutrition assessments remain largely unsatisfactory. Integration of body composition in the routine nutrition assessment can therefore offer insights into the actual composition of the body through analysis of fat mass or fat free mass body compartments. The rationale for body composition assessment among diabetes children and adolescents is related to medical treatment costs that are higher in advanced stages of disease when complications develop. Given the long term progression of diabetes and its associated high costs, medical interventions aimed at altering this kind of evolution are fundamental if countries are to cut down on healthcare related costs.

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Conflict of Interest Statement

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References

1. Boden G, Shulman GI. Free fatty acids in obesity and type 2 diabetics: Defining their role in the development of insulin resistance and beta cell dysfunction. Eur J Clin Invest. 2002;32:14-23.[Cross Ref]
2. Krishnan S, Short KR. Prevalence and significance of cardiometabolic risk factors in children with type 1 diabetes. J Cardiometab Syndr. 2009;4(1):50-56.
3. Demaio AR, Nielsen KK, Tersbol PB, et al. Primary Health Care: A strategic framework for the prevention and control of chronic non-communicable disease. Glob Health Action. 2014 Aug 4;7:24504–24504.
4. American Diabetes Association. Diagnosis and classification of diabetes mellitus. Diabetes Care. 2009;32(Suppl 1):S62–S67.
5. Shu J, Matarese A, Santulli G. Diabetes, body fat, skeletal muscle, and hypertension: The ominous chiasmus? J Clin Hypertens. 2019;21(2):239-242.
6. International Diabetes Federation. IDF diabetes atlas, 8th edn [Internet]. 2017 [cited 2019 Oct 9].
7. Majaliwa ES, Elusiyan BEJ, Adesiyun OO, et al. Type 1 diabetes mellitus in the African population: Epidemiology and management challenges. Acta Biomed. 2008;79(3):255-259.
8. Russell-Jones D, Khan R. Insulin associated weight gain in diabetes causes, effects, and coping strategies. Diabetes Obes Metab. 2007;9(6):799-812.
9. Davis NL, Bursell JDH, Evans WD, et al. Body composition in children with type 1 diabetes in the first year after diagnosis: Relationship to glycaemic control and cardiovascular risk. Arch Dis Child. 2012;97(4):312-315.
10. Fellinger P, Fuchs D, Wolf P, et al. Overweight and obesity in type 1 diabetes equal those of the general population. Wien Klin Wochenschr. 2019;131(3):55-60.
11. Rigalleau V, Delafaye C, Baillet L, et al. Composition of insulin-induced body weight gain in diabetic patients: A bio-impedance study. (2008)
12. Szadkowska A, Madej A, Ziółkowska K, et al. Gender and Age - Dependent effect of type 1 diabetes on obesity and altered body composition in young adults. Ann Agric Environ Med. 2015;22(1):124-128. .
13. Bahendeka S, Ramaiya K, Andrew SB, et al. EADSG guidelines: Insulin therapy in diabetes. Diabetes Ther. 2018;9(2):449-492. .
14. Piloya-Were T, Sunni M, Ogle GD, et al. Childhood diabetes in Africa. Curr Opin Endocrinol Diabetes Obes. 2016;23(4):306-311.
15. Blair JC, McKay A, Ridyard C, et al. Continuous subcutaneous insulin infusion versus multiple daily injection regimens in children and young people at diagnosis of type 1 diabetes: Pragmatic randomised controlled trial and economic evaluation. BMJ. 2019;365:l1226.
16. Frid AH, Kreugel G, Grassi G, et al. New insulin delivery recommendations. Mayo Clin Proc. 2016;91(9):1231-1255.
17. Rosenfeld L. Insulin: Discovery and controversy. Clin

Chem. 2002;48(12):2270-2288.

18. Peterson CM. Symposium on optimal insulin delivery. Introduction: History and goals of insulin treatment. Diabetes Care. 1982 ;5 (Supp 1):1-5.
19. Wilcox G. Insulin and insulin resistance. Clin Biochem Rev. 2005;26(2):19-39.
20. Calella P, Gallè F, Fornelli G, et al. Type 1 diabetes and body composition in youth: A systematic review. Diabetes Metab Res Rev. 2019;e3211.
21. Liese AD, Ma X, Maahs DM, et al. Physical activity, sedentary behaviours, physical fitness, and their relation to health outcomes in youth with type 1 and type 2 diabetes: A review of the epidemiologic literature. J Sport Health Sci. 2013;2(1):21-38. .
22. Mottalib A, Kasetty M, Mar JY, et al. Weight management in patients with type 1 diabetes and obesity. Curr Diab Rep. 2017 2020;17(10).
23. Nsamba J, Lule SA, Namara B, et al. Effect of birth weight, exclusive breastfeeding and growth in infancy on fat mass and fat-free mass indices in early adolescence: An analysis of the Entebbe Mother and Baby Study (EMaBs) cohort. AAS Open Research. 2019;2:11.
24. Power C, Kuh D, Morton S. From developmental origins of adult disease to life course research on adult disease and aging: Insights from birth cohort studies. Annu Rev Public Health. 2013 Mar 18;34(1):7–28.
25. Momesso DP, Bussade I, Lima GAB, et al. Body composition, metabolic syndrome and insulin resistance in type 1 diabetes mellitus. Arq Bras Endocrinol Metabola. 2011;55(3):189-193.
26. Fuller NJ, Jebb SA, Laskey MA, et al. Four-component model for the assessment of body composition in humans: Comparison with alternative methods, and evaluation of the density and hydration of fat-free mass. Clin sci. 1992;82(6):687-693.
27. Marra M, Sammarco R, De Lorenzo A, et al. Assessment of body composition in health and disease using bioelectrical impedance analysis (BIA) and Dual Energy X-Ray Absorptiometry (DXA): A critical overview. Contrast Media Mol Imaging. 2019;2019:3548284.
28. Kuriyan R. Body composition techniques. Indian J Med Res. 2018;148(5):648-158.
29. Hills A, Byrne N. Bioelectrical impedance and body composition assessment. Malays J Nutr. 1998;4(1):107-112.
30. Leiter LA. Use of bioelectrical impedance analysis measurements in patients with diabetes. The diabetes control and complications trial research group. Am J Clin Nutr. 1996;64(3 Suppl):515S-518S.
31. Sinha A, Formica C, Tsalamandris C, et al. Effects of insulin on body composition in patients with insulin-dependent and non-insulin-dependent diabetes. Diabet Med. 1996;13(1):40-46.
32. Effertz T, Engel S, Verheyen F, et al. The costs and consequences of obesity in Germany: A new approach from a prevalence and life-cycle perspective. Eur J Health Econ 2016;17(9):1141-1158.
33. OECD. Heavy Burden of Obesity: The economics of prevention a quick guide for policy makers. 2019.
34. American Diabetes Association. 2. Classification and diagnosis of diabetes: Standards of medical care in diabetes-2021. Diabetes Care. 2020;44(Supp 1):S15-S33. .
35. Seguya W. The food carb counting guide.2020.