

ABSORMETRIA RADIOLÓGICA DE DUPLA ENERGIA CONTRA EQUAÇÕES FEMININAS DE COMPOSIÇÃO CORPORAL EM DIABÉTICAS TIPO 1: ESTUDO DE CASO

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Resumo: Diabetes tipo (DT1) é uma doença metabólica modulada por fatores de risco como composição corporal (CC), que pode ser analisada pela mensuração de compartimentos corporais, percentual de gordura corporal (%GC), massa gorda (MG) e massa magra (MM). O Objetivo foi analisar fórmulas para mulheres com DT1 usando absorimetria radiológica de dupla energia (DEXA) como padrão ouro. 3 mulheres diabéticas tipo 1 participaram de um estudo experimental. Foram submetidas a medidas antropométricas (peso, altura, perímetros, e dobras cutâneas) e DEXA. Cinco fórmulas foram utilizadas para comparar os resultados utilizando índice de massa corporal (IMC), dobras cutâneas (DC) e perímetros (P) como valores principais. Teste de Friedman foi aplicado comparando valores de %GC, MG e MM. Como resultados sete equações apresentaram diferenças com valores do DEXA ($p=0.002$; $F=14.05$). Conclui-se que apesar de diferenças visuais, métodos usando IMC, DC e P podem ser uma forma de avaliação prática, de baixa custo para mulheres com DT1, em relação a variáveis de composição corporal obtidos pelo DEXA.

Palavras-chave: Antropometria; Diabetes mellitus; Massa gorda; Massa magra.

Afiliação

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DUAL-ENERGY X-RAY ABSORPTIOMETRY AGAINST FEMALE BODY COMPOSITION EQUATION IN DIABETES TYPE 1: CASE STUDY

Abstract: Diabetes type 1 (T1D) is a metabolic disease modulated by risks factors such as body composition (BC), which can be analyzed by the measurement of body components, body fat percentage (BF%), fat mass (FM) and Lean Mass (LM). The aim was to analyze CC formulas for women with T1D using the Dual-energy X-ray absorptiometry gold standard technique (DXA). 3 female T1D participated in an experimental study. Participants underwent basic anthropometric measurements (weight, height, perimeters, and skinfolds) and DXA. Five formulas were used to compare results using body mass index, skin folds, and perimeters as principal values. Friedman's test was applied to compare BF%, FM and LM. As results seven skinfolds equations presented difference to DXA ($p=0.002$; $F=14.05$). the conclusion is that although visual differences, methods using BMI, skin folds and perimeters could be a practical and low-cost body evaluation method to female T1D in relation to the body composition variables obtained by DXA.

Key words: anthropometry. Diabetes mellitus. Fat mass. Lean mass.

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Introduction

Diabetes mellitus type 1 (DM1) is a chronic disease characterized by hyperglycemia, due to lack of insulin production in pancreas beta cells^{1,2,3}. DM1 correspond to 10% of the total diabetic diagnosis, occur because of an auto immune response where the beta cells are destroyed, and thus, no hormone is produced, resulting in exogenous dependence of lifelong insulin therapy for control of hyperglycemia^{4,5,2}. Other Forms of disease control are through balanced diet and exercise⁵. Regular exercise helps the disease prognosis improving insulin sensitivity and increasing muscle glucose uptake, beyond improving body composition (fat mass and fat free mass)^{6,7,4}.

For ensure safety and better results of exercise is important undergo a physical evaluation with anthropometric measures and body composition. For these, can be used measures such as weight, height, perimeters, skinfolds, which in turn are subject to variations, since they depend on human factors, as it requires specific technical skill of the evaluator⁸. In addition to these, dual energy X-ray absorptiometry (DXA) is considered a gold standard to be used as comparative^{9,10}.

In professional practice, many times only equipment such as measuring tape and plicometers are available, and there are no specific formulas created for DM1 from dissection^{11,12}. Thus, the aim of this study is to analyze anthropometry and body composition formulas for women with T1DM using the DXA gold standard technique.

Material and methods

Population and inclusion criteria of the study sample

Sample was 3 woman T1DM diabetes recruited by social media in a Health University Campus between august 2017 to July 2018. Age 18 to 35 years who agreed and voluntarily participated in the research and signed the Informed Consent Term. Inclusion criteria in this study were female and male subjects; who exercise regularly, use insulin and have no osteoarticular issues or any complication caused by T1DM which do not allow any data collection. Volunteer were excluded if do not underwent at all measures.

Ethical aspects

The research was approved by the Ethics and Research Committee (Nº: 029770/2016; CAEE: 55081916.9.0000.5192), according to Resolution 466/12 of the National Health Council.

Research design

Participants were asked to abstain from alcohol, smoking, vigorous physical activity in the previous 24 hours and to carry out their normal eating and insulin plan habits. All body composition evaluation were performed with appropriate clothing in a Human Performance Evaluation Laboratory with temperature (24 ± 2 °c), air humidity (40-60%) and an atmospheric pressure of (approximately 760 mmHg) controlled by an environmental station.

Day 1

After anamneses reaching the inclusion criteria, participants underwent to basic anthropometric measurements (weight, height, perimeters and skin folds) and DXA. BMI, perimeters and skinfold measurements were used to calculated % body fat (%BF), fat mass (FM) and lean mass (LM).

Day 2

Baseline biochemical measures were made (lipid profile and glycated hemoglobin) in a Laboratory with ISO 9002 certification.

Anthropometry, body composition formulas and DXA

Anthropometry and Skinfolds

Body mass was analyzed in kilograms by means of a digital scale (Filizola, Brazil), with an accuracy of 0.1 kg and height in centimeters, by means of a wooden stadiometer mounted with scale in LM. The body mass index (BMI) was calculated by the formula: $\text{Body mass (kg)} / \text{Height (m)}^2$. Measurement of perimeters and skinfolds followed internationally standardized techniques for female sample¹³.

“BMI formula”

Subsequently, the measurements were used in different equations. First, in the equation of Deurenberg, Weststrate and Seidell¹⁴ (BMI formula), for the estimation of body fat uses anthropometric measures such as BMI calculated by weight and height. The formula used was: $\%BF = 1,2 \times BMI + 0,23 \times \text{age} - 10,8 \times \text{sex} - 5,4$, being the value 0 for male sex and 1 for female sex.

“Skin Folds (SF) formulas”

In skin folds formula (SF1) for female with 18 to 55 years, Jackson, Pollock and Ward (1980)¹⁵ was used: $BD = 1,097 - 0,00046971 (SSF) + 0,00000056 (SSF^2) - 0,00012828 (Age)$, while SSF was the sum of the skin folds and age in years.

In SF2, Katch & McArdle (1973)¹⁶ formula which uses 3 skin folds, to female $BD = 1.09665 - 0.00103*(T) - 0.00056*(SB) - 0.00054*(AB)$, while T is tricipital skin fold, SB is subscapular skin fold and AB is abdominal skin fold.

In SF3, Durnin & Womerley (1974)¹⁷ the formula for female between 16 to 68 years was $BD = 1.1567 - 0.0717 \log_{10} (B+T+SB+SI)$ while B is bicipital fold, T is tricipital fold, SB is subscapular fold and SI is supra iliac fold. Finally, the body density values obtained by skin folds techniques was used to calculate body fat by the following Siri (1961)¹⁸ formula $\%BF = ((4,95/\text{body density}) - 4,5) \times 100$. In perimeters formula, Katch and McArdle equation (1984)¹⁹ for female between 27 to 50 years was used $BF\% = (AB \times 0.467493) + (TH \times 0.486803) - (C \times 0.569296) - 18.4$, while AB is abdominal fold, TH is thigh and C is calf.

After using all formula to find the BF%, the value found was used to calculate the FM using: $FM (kg) = (\%BF \times \text{body mass})/100$. Then, the FM was used to calculate the LM, according to $LM (kg) = \text{body mass} - FM$.

Ultimately, the DXA method was performed. The manufacturer's guidelines were used, with the following protocol: First, the calibration of the equipment before each data collection. Next, the subject's history was filled out with the insertion of data such as weight, stature and, ethnicity. To perform the test, the volunteer was remembered to wear light clothing and without any metal, lie down in the supine position, with his head still and looking at the ceiling. The volunteer was positioned with a straight body on the table and centered with the lines on the tabletop. With arms positioned at the side of the body, the hands are pronated and away from the body, the hip and feet turned inward (hip in inversion) around 25°, pointing upwards. The volunteer remained motionless, attempting to maintain normal breathing also, without sleeping during the scan. Total scan lasts 6 to 8 minutes⁹.

Statistical analysis

Shapiro-Wilk Normality test was made to confirm data normality distribution. To analyze method differences in % body fat, fat mass and lean mass was used ANOVA of Friedman with Dunn's Post Hoc (female) to each body composition compartment. All statistical

analyses were made considering $p < 0.05$ by Graph Pad 3.0 version.

Results

The initial results were: a) The equations used in DM1 women can be used in practice, however, with caution with SF1. b) In women with DM1, perimetry and skin fold can be used. These simple and less costly tools of body composition assessment are affordable choices for this analysis in type 1 diabetic women.

Table 1 presents the description of the sample (socio-demographic aspects, cardiovascular, lipid profile and anthropometric and skin folds).

Table 1. Basic characteristics of the sample (n=3)

		M (SD)	
Age (years)		31 (2)	
Diagnostic time (years)		15.9 (6.8)	
Weight (kg)		59.6 (4.1)	
Stature (cm)		160 (5)	
BMI (kg/m ²)		23.3 (0.2)	
Glycated Hemoglobin (%)		9.5 (1.1)	
HDL cholesterol (mg/dL)		82 (13)	
LDL cholesterol (mg/dL)		99 (17)	
Total cholesterol (mg/dL)		197 (13)	
Triglycerides (mg/dL)		76 (16)	
Anthropometric parameters			
Skinfolds*		Perimeters*	
Biceps	12 (8)	Waist	80 (7)
Triceps	32 (3)	Abdominl	80 (3)
Subscapular	20 (5)	Hip	97 (3)
Chest	20 (6)	Right Arm	28 (2)
Axillar	16 (8)	Left Arm	29 (1)
Supraspinale	22 (3)	Right forearm	24 (1)
Front Thigh	36 (5)	Left foream	24 (1)
Medial calf	25 (16)	Right thigh	55 (3)

Abdominal	31 (5)	Left thigh	54 (3)
		Right calf	36 (1)
		Left calf	36 (2)

BMI – Body mass index; HDL - High Density Lipoproteins; LDL - Low Density Lipoproteins;
*the median values of each measurement to each volunteer were used.

There were statistical differences in SF1 formula in relation to DXA in %BF, FM and LM ($p=0.002$; $F=14.05$). Figure 1 presents these statistical values.

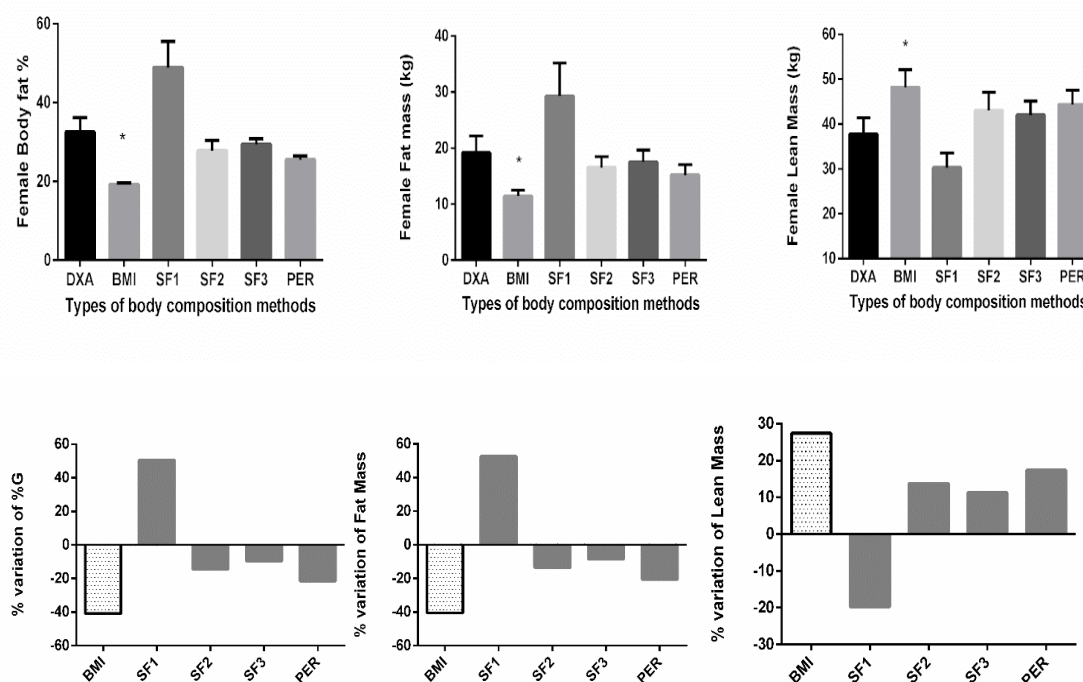


Figure 1. Absolute and relative differences of body composition in type 1 diabetics (general) (n=3)

SF1- Skin fold 1; SF2 - Skin fold 2 - SF3: Skin fold 3; PER - Perimeter.

Discussion

Despite the small sample amount, it represents the portion of the Brazilian population carrier of DM1. The first formula (BM1), when compared with DXA presented $19.2 \pm 0.4\%$ fat vs $32.5 \pm 3.0\%$ fat in DXA. The fat mass presented 11.4 ± 0.9 kg vs 19.2 ± 2.5 kg in DXA. In lean body mass it presented 48.2 ± 3.2 kg vs 37.8 ± 3.0 kg in DXA. In the study by Park *et*

*al.*²⁰ in type 1 diabetic adolescents, $23.9 \pm 8.9\%$, $4.5 \pm 2.4\text{kg} / \text{m}^2$ and $13.7 \pm 1.6\text{kg} / \text{m}^2$ were found for % fat, fat mass and lean mass respectively for each of these compartments. Little similarity between studies.

The second formula (SF1), when compared with DXA presented $48.9 \pm 5.4\%$ fat vs $32.5 \pm 3.0\%$ fat in DXA. The fat mass presented $29.3 \pm 4.8\text{kg}$ vs $19.2 \pm 2.5\text{kg}$ in DXA. In the lean mass presented $30.3 \pm 2.7\text{kg}$ vs $37.8 \pm 3.0\text{kg}$ in DXA. In the study by Nunes *et al.*²¹, in men and women with DM1, was found $24.9 \pm 9.85\%$ fat, to find the fat mass and the fat free mass was calculated with the mean mass of the sample that was equal at $65.5 \pm 11.36\text{kg}$ giving an approximate value for fat mass of 16.31kg and lean mass 49.2kg. Little similar values since the study contained 45 women and 39 men.

The third formula (SF2), when compared with DXA presented $27.9 \pm 2.1\%$ fat vs $32.5 \pm 3.0\%$ fat in DXA. The fat mass presented $16.6 \pm 1.6\text{kg}$ vs $19.2 \pm 2.5\text{kg}$ in DXA. In the lean mass it presented $43.0 \pm 3.4\text{kg}$ vs $37.8 \pm 3.0\text{kg}$ in DXA. The fourth formula (SF3), when compared with DXA presented $29.4 \pm 1.2\%$ fat vs $32.5 \pm 3.0\%$ fat in DXA. The fat mass presented $17.6 \pm 1.8\text{kg}$ vs $19.2 \pm 2.5\text{kg}$ in DXA. In the lean mass presented $42.1 \pm 2.5\text{kg}$ vs $37.8 \pm 3.0\text{kg}$ in DXA. In the study by Braulio *et al.*²² values were found for overweight and obese women of $42.3 \pm 3.6\%$ fat, $33.7 \pm 5.4\text{kg}$ of FM and $45.9 \pm 6.6\text{kg}$ of FFM.

The fifth formula (PER), when compared with DXA presented $25.5 \pm 0.8\%$ fat vs $32.5 \pm 3.0\%$ fat in DXA. The fat mass presented $15.2 \pm 1.5\text{kg}$ vs $19.2 \pm 2.5\text{kg}$ in DXA. In lean body mass it presented $44.4 \pm 2.6\text{kg}$ vs $37.8 \pm 3.0\text{kg}$ in DXA.

When comparing the groups without DM and disease, there is an increase in % fat in the second group Sarnbland *et al.*²³, this is also associated with poor glycemic control beyond the age group investigated. It realizes the significant increase in the upper limb skinfolds^{12,24} and these rates change according to the ethnic groups, being important to draw references for these different populations^{17,25,26}. In addition, the sample were different from those surveyed in the present study, either because they contained men or because they were in another age group²⁷. As well as no studies with the formulas SF2 and PER were found, attesting the lack of studies with this specific population¹².

Although BMI is useful for detecting obesity, it cannot be considered as the best index for determining body fat, as well as the equation by Jackson, Pollock and Ward (1980)¹⁵ (SF1) Sarnbland *et al.*¹²; Nunes *et al.*¹⁹. The others when compared to DXA presented values very close to the standard, thus validating the found values and making the measurements viable.

Conclusion

Jackson, Pollock and Ward (1980)¹⁵ was not a good equation to evaluate female type 1 diabetics. Also, although visual differences, the other methods which using BMI, skin folds and perimeters such as Deurenberg, Weststrate and Seidell (1991)¹⁴, Katch & McArdle (1973)¹⁶, Durnin & Womerley (1974)¹⁷ and Katch & McArdle (1984)¹⁹ could be a practical and low-cost body composition method to type 1 diabetic in relation to the body composition variables obtained by DXA. Future studies should investigate body composition in male and female type 1 diabetics in order to create a specific formula.

References

- 1 Monnier VM, Bautista O, Kenny D, Sell DR, Fogarty J, Dahms W, et al. Skin collagen glycation, glycoxidation, and crosslinking are lower in subjects with long-term intensive versus conventional therapy of type 1 diabetes: relevance of glycated collagen products versus HbA1c as markers of diabetic complications. *Diabetes*. 1999;48(4):870-880.
- 2 Chiang JL, Kirkman MS, Laffel LMB, Peters AL. Type 1 Diabetes Through the Life Span : A Position Statement of the American Diabetes Association. *Diabetes Care*. 2014;37:2034-2054.
- 3 Mosso C, Halabi V, Ortiz T, Hodgson MI. Dietary intake , body composition , and physical activity among young patients with type 1 diabetes mellitus. *J Pediatr Endocrinol Metab*. 2015;28(8):895-902.
- 4 SBD. Atualização Brasileira sobre Diabetes. *Soc Bras Diabetes*. 2016.
- 5 Leal PM, Souto DL, Lima ES, Miranda MP De, Rosado EL. Influence of fat intake on body composition , lipemia and glycemia of type 1 diabetics. *Nutr Hosp*. 2011;26(5):1110-1114.
- 6 Schweiger B, Klingensmith G, Snell-bergeon JK. Physical Activity in Adolescent Females with Type 1 Diabetes. *Int J Pediatr*. 2010;2010.
- 7 Araujo LM, Britto MM; Cruz TR. Tratamento do Diabetes Mellitus do Tipo 2: Novas opções. 2000. 10 f. *Mono Araujo LM, Britto MM; Cruz TR. Tratamento do Diabetes Mellitus do Tipo 2: Novas opções. 2000. 10 f. Monografia (Especialização) - Curso de Medicina, Endocrinologia, Universidade Federal da Bahia, Salvador. grafia (Especialização) - Curso de Medicina, Endocrinologia, Universidade Federal da Bahia, Salvador.*

- 8 Fonseca PH, Carlos J, Marins B. Validação de equações antropométricas que estimam a densidade corporal em atletas profissionais de futebol. *Rev Bras Med do Esporte*. 2007;13:153-156.
- 9 Heymsfield, S. B. et al. Assessing skeletal muscle mass : historical overview and state of the art. *Journal Cachexia Sarcopenia Muscle*, v. 5, p. 9–18, 2014.
- 10 Salamone LM, Fuerst T, Visser M, Kern M, Lang T, Dockrell M, et al Measurement of fat mass using DXA: a validation study in elderly adults. *J Appl Physiol*. 2000; 89(1):345-52.
- 11 Guedes DP. Procedimentos clínicos utilizados para análise da composição corporal. *Rev Bras cineantropometria e desempenho Hum*. 2013;15(1):113-129. doi:10.5016/1980-6574.2010v16n4p1006.
- 12 Sarnblad S, Magnuson A, Ekelund U, Aman J. Body fat measurement in adolescent girls with type 1 diabetes : a comparison of skinfold equations against dual-energy X-ray absorptiometry. *Acta Paediatr*. 2016;105(10):1211-1215.
- 13 Stewart A, Marfell-Jones M, Olds T, Ridder de H. International Society for the Advancement of Kinanthropometry. International Standards for Anthropometric Assessment. Australia. 2011.
- 14 Deurenberg P, Weststrate J, Seidell J. Body mass index as a measure of body fatness : age- and sex- specific prediction formulas. *Br J Nutr*. 1991:105-114.
- 15 Jackson AS, Pollock ML, Ward A. Generalized equations for predicting body density of women. *Med Sci Sports Exerc* 1980;12:175-82.
- 16 Katch FI, McArdle WD. Prediction of body density from simple anthropometric measurements in college-age men and women. *Humam Biol*. 1973;45(3):445-455.
- 17 Durnin J, Womersley J. Body fat assessed from total body density and its estimation from skinfold thickness : measurements on 481 men and women aged from 16 to 72 Years. *Br J Nutr*. 1974;32:77-97.
- 18 Siri, WE. Body composition from fluid spaces and density: analysis of methods. In J. Brozek & A. Henschel (Eds.). *Techniques for measuring body composition*. Washington, DC: National Academy of Science. 1961 p. 233-244.
- 19 Katch, Frank I., McArdle WD. Nutrição, controle de peso e exercício. *Medsa*. 1984.

20 Park HW, Kim YH, Cho M, Kwak BO. Adolescent Build Plotting on Body Composition Chart and the Type of Diabetes Mellitus. *J Korean Med Sci*. 2012;(9):1385-1390.

21 Nunes, Raquel Ramalho et al. Reliability of the classification of nutritional status obtained through the BMI and three different methods of body fat percentage in patients with type 1 diabetes mellitus. *Arquivos Brasileiros de Endocrinologia & Metabologia*. V. 53, n. 3, p. 360-367, 2009.

22 Braulio VB; Furtado VC; Silveira MG; Fonseca MH; Oliveira JE. Comparison of body composition methods in overweight and obese Brazilian women. *Arq Bras Endocrinol Metab* vol.54 no.4 São Paulo June 2010.

23 Särnblad, Stefan et al. Body composition in young female adults with Type 1 diabetes mellitus. A prospective case-control study. *Diabetic medicine*, v. 24, n. 7, p. 728-734, 2007.

24 Tillmann V, Adojaan B, Shor R, Price DA TT. Physical development in Estonian children with type 1 diabetes. *Diabetes Med*. 1996;1(July 1995):97-101.

25 Costa RF, Gomes RV, Maria S, Ribeiro L, Veibig RF, Aoki MS. Equações Preditivas de Gordura Corporal: Saber Escolher é Fundamental Resposta. *Rev Bras Med do Esporte*. 2009;15(6):2009-2010.

26 Costa KB, Pessoa DCN de P, Perrier-Melo RJ, Brito-Gomes JL De, Guimarães FJ de SP, Costa M da C. Composição corporal da fita métrica à pesagem hidrostática: Uma análise de dois componentes An analysis of two components. *Rev Ciência e Movimento*. 2015;23(3):105-112.

27 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.