Original article

Effect of disease duration on somatotype in a Mexican population with type 2 diabetes mellitus using structural equation modeling

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Summary

Background: Diabetes mellitus (DM) is a well-known health problem. Nevertheless, its etiology, natural history, and epidemiology are still incomplete. Its prevalence has increased, cases of DM have doubled and its association with body mass index and obesity is high. The objective was to determine the effect of disease duration on somatotype of patients with type 2 DM using structural equation modeling (SEM).

Methods: Two hundred participants underwent anthropometry following the restricted profile of the International Society for the Advancement of Kinanthropometry (ISAK). A database was made using age, height, weight, the other anthropometry measures, the three components of somatotype, and disease duration of DM.

Results: Mean age for men was 58,7 ± 11,1 and for women 56,4 ± 10,7 years; mean body weight for men was 80,0 ± 14,2 and for women 74,8 ± 8,0 kg; mean height for men was 168,3 ± 7,4 and women 154,9 ± 6,0 cm. The median and interquartile interval for the non-parametrical variables in men were endomorphy 4.86 (4.04 to 6.00), mesomorphy 5.82 (4.59 to 7.20), ectomorphy 0.49 (.10 to 1.22) and disease duration 9.00 (4.00 to 17.00); for women, endomorphy 7.52 (6.30 to 8.27), mesomorphy 6.28 (5.05 to 8.15), ectomorphy 0.100 (.10 to.500) and disease duration 9.00 (4.00 to 15.00). A correlation between disease duration and somatotype was found.

Conclusions: Longer disease duration is associated with an increase in endomorphy and mesomorphy; however, ectomorphy decreases. SEM showed that DM disease duration impacts somatotype but this relationship is different in men and women. More research is necessary to understand this relationship. SEM is a feasible technique for modeling disease duration and somatotype.

Key words:
Somatotype. Endomorph. Ectomorph. Mesomorph. Diabetes mellitus. Structural equation model.

Efecto del tiempo de evolución de la enfermedad en el somatotipo de una población Mexicana con diabetes mellitus tipo 2 usando modelamiento de ecuaciones estructurales

Resumen

Introducción: La diabetes mellitus (DM) es un problema de salud bien conocido. Sin embargo, su etiología, historia natural y epidemiología sigue incompleto. Su prevalencia ha aumentado, los casos de DM se han duplicado y su asociación con índice de masa corporal y obesidad es alta. El objetivo fue determinar los efectos de la duración de la enfermedad en el somatotipo de pacientes con DM tipo 2 utilizando modelamiento de ecuaciones estructurales (SEM).

Métodos: Se sometieron a antropometría doscientos participantes siguiendo el perfil restringido de la Sociedad Internacional para el Avance de la Kinanthropometry (ISAK). Se elaboró una base de datos utilizando edad, talla, peso, las medidas antropométricas restantes, los tres componentes del somatotipo y el tiempo de evolución de DM.

Resultados: Edad promedio para hombres fue 58,7 ± 11,1 y para mujeres 56,4 ± 10,7 años; peso promedio de hombres fue 80 ± 14.2 y de mujeres 74,8 ± 18.0 kg. Estatura promedio de hombres fue 168.3 ± 7.4 y de mujeres 154.9 ± 6.0 cm. La mediana y el intervalo intercuartil para las variables no paramétricas en hombres fueron endomorfia 4.86 (4.04 a 6.00), mesomorfia 5.82 (4.59 a 7.20), ectomorfia 0.49 (.10 a 1.22) y duración de la enfermedad 9.00 (4.00 a 17.00) y para mujeres endomorfia 7.52 (6.30 a 8.27), mesomorfia 6.28 (5.05 a 8.15), ectomorfia 0.100 (.10 a.500) y duración de la enfermedad 9.00 (4.00 a 15.00). Se encontró una correlación entre evolución de la enfermedad y somatotipo.

Conclusiones: Mayor tiempo de evolución se asocia con aumento de la endomorfia y la mesomorfia; sin embargo, la ectomorfia disminuye. SEM mostró que la evolución de DM afecta somatotipo, pero esta relación es diferente en hombres y mujeres. Se necesita más investigación para entender esta relación. SEM es una técnica factible para modelar duración de la enfermedad y somatotipo.

Palabras clave:
Somatotipo. Endomorfia. Ectomorfia. Mesomorfia. Diabetes mellitus. Modelo de ecuaciones estructurales.

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Introduction

Diabetes mellitus (DM) is a widespread health problem and a common health disorder known for centuries. Nevertheless, knowledge of its etiology, natural history, and epidemiology is still incomplete[1]. The global prevalence of diabetes mellitus is rapidly increasing. Over the past three decades, the number of people with diabetes has doubled[2].

An increase in the diagnosis of DM in young people in recent years has been observed, even though the disease has been related to older adults. Type 2 diabetes (T2DM) has a strong genetic component and is associated with obesity and low levels of physical activity[3,4].

People in Mexico have suffered a rapid shift in dietary and physical activity patterns and this has lead to an important increase in obesity and diabetes mellitus with diabetes causing almost 14% of all deaths. Also, the growing prevalence of obesity and metabolic syndrome in children and adults suggests that this situation will worsen in the future[4].

The National Survey on Health and Nutrition 2012 estimated that 9.2% of adults had a previous diagnosis of diabetes mellitus. This was an important increase in contrast to the results observed in 2000, where the proportion was 5.8%, and in 2006, 7%[5].

Somatotyping is a method used to evaluate, study, and appraise body shape and composition in terms of bone dimensions, muscle, and adipose tissue. It is a unique method that was first described by Sheldon *et al.* in 1940[6], and modified by Heath and Carter in 1967[7]. The somatotype is a description of the actual morphological constitution. It is comprised of three numerical variables, consisting of three sequential numbers representing endomorphy, mesomorphy and ectomorphy, respectively[8].

Endomorphy refers to relative fatness and relative leanness, mesomorphy, to relative musculoskeletal development according to height, and ectomorphy, to relative body linearity. It is based largely, but not entirely, on height/cubed root of weight ratio. Ectomorphy evaluates the form and degree of longitudinal distribution of the first and second component[9,10].

The relationship between somatotype and disease was first researched by Sheldon *et al* in 1940[6]. In 2002, Koleva *et al*[11] examined the association between somatotype and its three components, and the prevalence of several chronic diseases. In five disease groups, prevalence was significantly related to a somatotype. Other studies have shown an association between somatotype and other pathologies, such as polycystic ovary syndrome[12].

T2DM is a metabolic disorder that affects and is affected by body composition. It induces changes in body size and shape that adversely affect the prognosis of the disease[13]. Obesity, represented by endomorphy, has a positive correlation with the onset of diabetes and it is a well-known risk factor for cardiovascular disease[14,15]. However, the association between somatotype and diabetes is limited and poorly documented. The aim of this study was to determine the somatotype of T2DM patients in a Mexican population and the effects of disease duration on somatotype.

Material and method

Participants

This was a prospective, quantitative, observational and analytical, multiple correlation study previously approved by the Ethics Committee of the Institution with registration number MD13-001. Patients provided verbal informed consent after being informed about the study procedure and asked if they wanted to participate. All procedures in this study were carried out according to the guidelines of the Declaration of Helsinki. The study group consisted of 200 patients with a previous diagnosis of T2DM who attended the outpatient clinics of the departments of internal medicine, general medicine, and endocrinology. Individuals with complications that could alter their body composition such as lower extremity edema, amputations, hiatal hernia or other situations that limited their ability to stand up, such as fractures or recent surgery, were excluded. A good sample size for SEM is more than 200 considering an estimation of 20 participants for every variable in the model. In this case, there were four variables; therefore, a minimum sample size of 80 was adequate[16,17].

Structural Equation Modeling

Structural equation modeling (SEM) is a set of statistical techniques that systematically analyze multivariate data to measure latent variables and their interrelationships. Latent variables are variables that are observed indirectly or through the effects on observed variables; in this case, somatotype through endomorphy, mesomorphy and ectomorphy.

Anthropometrics

To measure the independent variable, somatotype, measures of weight, height and skinfolds were obtained using the restricted profile of anthropometric measures in accordance with the recommendations of the International Society for the Avancement of Kinanthropometry (ISAK)[18]. The measurements obtained directly were height; body weight; skin folds: triceps, subscapular, biceps, iliac crest, supraspinale, abdominal, front thigh, medial calf; girths of relaxed upper arm and flexed and tensed upper arm; waist (minimum); gluteal (hip); and calf (maximum); biepicondylar breadth of the humerus; biepicondylar breadth of the femur. Two measurements were taken at each site with the mean value being used. All measurements were made by the same measurer. The measurer was a level I ISAK-certified sports medicine physician. The variable disease duration was obtained by direct questioning.

Data Analysis

A database was made using Microsoft Excel 2010. This database was imported to SPSS AMOS version 21.0. Before conducting the statistical analysis, data were evaluated for implausible or error values, abnormalities indexes, and normality. We conducted a descriptive statistical analysis for quantitative variables. Measures of central tendency and dispersion are presented as means ± standard deviation. In the case of

qualitative variables, frequencies and percentages were obtained. The validity of several models that explain the relationship between disease duration and somatotype was tested using the following: multivariate normality, and maximum likelihood estimation (MLE) using confirmatory factor analysis.

Results

After eliminating cases with incomplete and missing data, the final sample consisted of 196 patients. The study group was 42.3% male and 57.7% female. The age interval was 27.1 to 85.0 years with a mean of 57.3 ± 10.8. Weight interval from 37.6 to 119 kg with a mean of 76.9 ± 16.6. Height interval from 136.5 to 191 cm with a mean of 160.5 ± 9.3 cm. The characteristics of the general population and gender are shown in Table 1.

The median and interquartile interval (IQI) for the non-parametrical variables in men were endomorphy 4.86 (4.04 to 6.00), mesomorphy 5.82 (4.59 to 7.20), ectomorphy 0.49 (.10 to 1.22) and disease duration 9.00 (4.00 to 17.00) (Table 2); for women, endomorphy 7.52 (6.30 to 8.27), mesomorphy 6.28 (5.05 to 8.15), ectomorphy 0.100 (.10 to.500) and disease duration 9.00 (4.00 to 15.00) (Table 3).

A measurement model was tested to predict the somatotype, based on disease duration by path analysis. This considers disease duration as an independent variable with the dependent variable being somatotype with its endomorphy, mesomorphy and ectomorphy factors (Figure 1). The final estimated model is depicted in Figure 2. The coefficient above each path is AMOS's maximum likelihood estimate of the effect size.

After evaluating the structural model disease duration—somatotype with its indicators, significant parameters were found. As shown in Table 4 in the column critical ratio (CR), all factors are considered loaded and have a significance of 0.05, since all CR values are greater than 1.96. Values greater than 2.58 have a confidence level of 0.01[19]. This means that the structural model between the endogenous variable somatotype and the exogenous variable disease duration is valid. Regarding standardized regression weights (Table 5), disease duration negatively impacts somatotype with a regression of −0.21. In relation to somatotype, endomorphy, with a weighted regression of 0.78, has a positive correlation and high weight. Mesomorphy in relation to somatotype has a weighted regression of 0.76. Ectomorphy in relation to somatotype has a negative weighted regression of −0.80, and a proportion of explained variance of 5.8% for the relationship between somatotype and disease duration. This result is statistically significant.

Table 1. Characteristics of the study group.

Gender	Age (yrs)			Weight (kg)			Height (cm)		
	n	mean	SD	n	mean	SD	n	mean	SD
Female	113	56.38	10.66	113	74.78	17.96	113	154.90	6.01
Male	83	58.71	11.08	83	80.03	14.20	83	168.28	7.37
Total	196	57.37	10.88	196	77.00	16.63	196	160.56	9.36

SD, standard deviation.

Table 2. Endomorphy, mesomorphy and ectomorphy factors in relation to disease duration in female population.

Variable		Endo	Meso	Ecto	Disease duration
N	Valid	111	111	111	111
	Missing	0	0	0	0
Percentiles	25	6.30	5.05	.100	4.00
	50	7.52	6.28	.100	9.00
	75	8.27	8.15	.500	15.00

Endo: endomorphy; Meso: mesomorphy; Ecto: ectomorphy.

Table 3. Endomorphy, mesomorphy and ectomorphy factors in relation to disease duration in male population.

Variable		Endo	Meso	Ecto	Disease duration
N	Valid	85	85	85	85
	Missing	0	0	0	0
Percentiles	25	4.04	4.59	.10	4.00
	50	4.86	5.82	.49	9.00
	75	6.00	7.20	1.22	17.00

Endo: endomorphy; Meso: mesomorphy; Ecto: ectomorphy.

Figure 1. Proposed model to estimate somatotype represented by endomorphy, mesomorphy and ectomorphy (endogenous variable) and disease duration (exogenous variable).
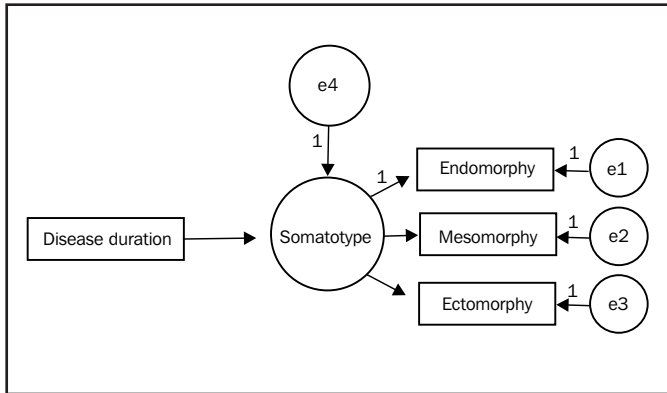

Figure 2. Standardized regression weights of the study group. The coefficient above each path is AMOS's maximum likelihood estimate of the effect size.
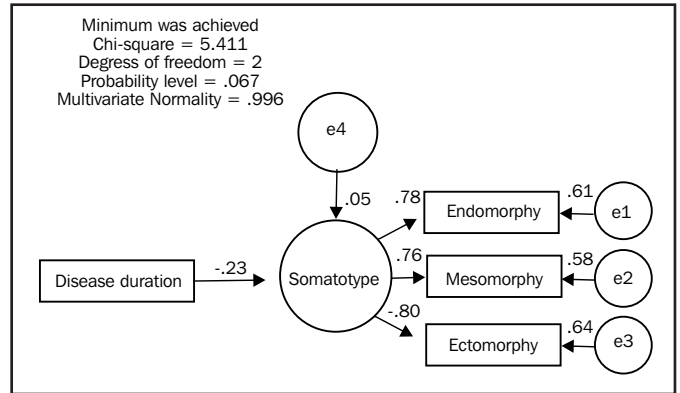

Table 4. Regression Weights (Group number 1 - Default model).

Variable			Estimate	SE	CR	P	Label
Somatotype	<---	Disease Duration	−0.040	.015	−2.67	.008	par_3
Endomorphy	<---	Somatotype	1.000				
Mesomorphy	<---	Somatotype	1.087	.115	9.42	***	par_1
Ectomorphy	<---	Somatotype	−0.386	.040	−9.56	***	par_2

SE: standard error; CR: critical ratio; P: bilateral asymptotic significance.

Table 5. Standardized Regression Weights (Group number 1 - Default model).

Variable		Variable	Estimate
Somatotype	<---	Disease duration	−0.21
Endomorphy	<---	Somatotype	0.78
Mesomorphy	<---	Somatotype	0.76
Ectomorphy	<---	Somatotype	−0.80

Table 6 shows a basic understanding of fit indexes cutoff levels for determining model fit. In general, if the vast majority of the indexes indicate a good fit, a good fit is accepted.

Discussion

The structural model estimated by Maximum Likelihood showed that somatotype (formed by endomorphy, mesomorphy, and ectomorphy) and disease duration were consistent as a construct to explain the effect of disease duration on somatotype. It demonstrated a negative impact on the somatotype of individuals with T2DM when diabetes mellitus duration increases. This means that an increase in disease duration increases the levels of endomorphy and mesomorphy, while ectomorphy decreases. A decrease in ectomorphy is expected since in this population it is known that[20]. What is not expected is an increase in mesomorphy. The changes observed in endomorphy are changes

Table 6. Cutoff Criteria for Several Fit Indexes.

Quality adjustment	Cutting criteria	Model results	Interpretation
Absolute fit			
X^2	Al .05 to 9.49	5.4	Good
X^2/DF	2 to 3.2	2.7	Good
AIC	Close to 0	21.4	Rejected
Comparative fit			
NFI	≥ .95	.97	Good
IFI	≥ .95	.98	Good
TLI	≥ .95	.95	Good
CFI	≥ .95	.98	Good
Parsimonious fit			
PNFI	Between .50 and .90	.32	Rejected
PCFI	Between .50 and .90	.32	Rejected
PGFI	Close to 1	.2	Rejected
Other			
GFI	≥ .95	.99	Good
AGFI	≥ .95	.92	Good
RMR	Close to 0	.39	Acceptable
RMSEA	< .08	.09	Good
HOELTER. 05	> 200	193	Good
HOELTER.01	> 200	296	Good

AIC: Akaike information criterion; NFI: normed fit index; IFI: Incremental fix index; TLI: Tucker-Lewis index; CFI: Comparative fit index; PNFI: Parsimony adjusted NFI; PCFI: Parsimony adjusted CFI; PGFI: Parsimony adjusted GFI; GFI: goodness of fit index; AGFI: adjusted GFI; RMR: root mean square residual; RMSEA: root mean square error of approximation; Hoelter 0.05, Hoelter 0.05 index.

Adapted from Schreiber *et al.* Reporting structural equation modeling and confirmatory factor analysis results: a review. Journal of Educational Research. 2006; 99: 323-337.

in body composition related to age. This combination of a decrease in muscle mass and muscle strength has been recently defined as sarcopenic obesity, a change that may cause an additive effect on insulin resistance in patients with diabetes[21,22]. The changes in ectomorphy can be explained as previously mentioned but not the changes in mesomorphy since we expect a loss of muscle mass not an increase[23,24].

In the study by Baltadjiev[13] mean somatotypes in men in both age groups, 40-60 years and 61-80 years, were endomorph mesomorph: endo, 5.03; meso, 6.57; ecto, 2.01, and endo, 4.14; meso, 5.88, and ecto, 1.64, respectively. In a second study by Baltadjiev[25] of mean woman somatotypes in the 40 to 60-year age group, the dominant somatotype component was endomorphy, while mesomorphy in the 61-80 years age group was mesomorph-endomorph: mean somatotypes were endo, 6.59; meso, 6.09; and ecto, 1.57, while in women 61 to 80 years it was an endomorph-mesomorph somatotype: endo, 5.39; meso, 9.41; ecto, 1.55. In contrast to our study, these results were not compared with disease duration.

Likewise, the results of Yadav et al.[14] showed a mesomorph-endomorph somatotype. Values in men in the 49.1–60-year age group were endo, 7.44 ± 1.27; meso, 4.97 ± 1.25; and ecto, 0.62 ± 0.51, while in women they were endo 8.11 ± 0.96; meso, 5.06 ± 1.57; ecto, 0.45 ± 0.48. In both groups, the mesomorph and endomorph components were elevated. These findings are similar to ours with regard to endomorphy but our values of mesomorphy were slightly higher.

Unlike other reports of somatotype in patients with T2DM, our patients, similar to Baltadjiev´s[13,25] over time show a tendency to have high endomorphy and mesomorphy components. As stated by Perna el al.[26] these individuals can benefit from this so-called "obesity paradox.". In the study by Mesquita el at.[27] obese patients had a lower prevalence of sarcopenia than those who were thin.

Fat and muscle mass are increased in individuals with T2DM. This is important because, in theory, this would represent a favorable somatotype. An increased muscle mass would facilitate control and/or management of diabetes mellitus with regard to exercise programs and also a lower sarcopenia index. However, this increase in mesomorphy may not be entirely associated with disease duration since some authors have mentioned an overestimation of mesomorphy caused by the accumulation of soft tissue which produces an erroneous measurement of the biepicondylar breadth of the humerus and the femur[28]. Herrera et al.[29,30] attribute this overestimation of mesomorphy to a centripetal redistribution of subcutaneous fat in the elderly. It is important to take this into consideration when mesomorphy is being interpreted. Maybe more exact methods, such as Dual-Energy-X-ray-Absorptiometry (DEXA), can help discriminate if this overestimation of mesomorphy exists.

Conclusions

This study shows that somatotype changes according to disease duration with a tendency towards increasing muscle mass and not only fat mass. With the findings in this study, we can say that somatotype can be effectively applied to the study of T2DM.

Conflict of interest

The authors do not declare a conflict of interest.

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