

Original

Nutritional status of intellectual disabled persons with Down syndrome

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Abstract

Background: To evaluate the nutritional status in young adults with Down syndrome (DS).

Methods: 38 persons, 15 (39.5%) women and 23 (60.5%) men (age range 16-38 years) with DS. Body composition was analyzed from anthropometric parameters according to standard protocols, levels of physical activity and nutrient intake was determined using validated questionnaires: a 72 h recall and consumption food frequency questionnaire (recorded by the tutors of the participants). The following biochemical parameters were estimated: blood lipids profile (total cholesterol, HDL-cholesterol, LDL-cholesterol and triglycerides), glucose, uric acid, proteins (ferritin and transferrin), minerals (Fe, Zn, Cu, Mg and Se) and vitamins (B12, B9, E, C and β -carotene). The data were statistically analysed with Student t tests.

Results: From the 38 participants, 36.8% were overweight (BMI: 25-29.9 kg/m²) and 36.8% were obese (BMI \geq 30 kg/m²). The BMI differed from women to men ($P < 0.001$) (29.1 \pm 4.3 and 27.9 \pm 4.6 kg/m², respectively). The average values of the biochemical parameters, except for uric acid, both in women and men were within normal ranges. The average energy intake was 1,909 \pm 337 and 2,260 \pm 284 kcal/day for women and men, respectively. The contribution of proteins to total caloric intake was 18.8 and 16.3% for women and men, respectively, while carbohydrates contributed 43.3 and 45.6%, and lipids 37.9 and 38.1%. All participants were sedentary.

Conclusion: In this group presented a high prevalence of overweight and obesity. Further research is required in the development and evaluation of appropriate intervention programs to improve their nutritional status and quality of life.

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Key words: Down syndrome. Intellectual disability. Obesity. Nutritional status. Body composition.

ESTADO NUTRICIONAL DE PERSONAS DISCAPACITADAS INTELECTUALES CON SÍNDROME DE DOWN

Resumen

Objetivo: Evaluar el estado nutricional en adultos jóvenes con síndrome de Down (SD).

Métodos: 38 personas con SD, 15 (39.5%) mujeres y 23 (60.5%) hombres (rango de edad 16-38 años) formaban la muestra que procedían de dos centros ocupacionales de discapacitados intelectuales. La composición corporal se analizó a partir de parámetros antropométricos de acuerdo a los protocolos estándar, los niveles de actividad física y consumo de nutrientes por medio de cuestionarios validados: recordatorio de 72 h y frecuencia de consumo alimentaria (realizados por los tutores de los participantes). Los parámetros bioquímicos determinados fueron los siguientes: perfil lipídico en plasma (colesterol total, HDL-colesterol, LDL-colesterol y triglicéridos), glucosa, ácido úrico, proteínas (ferritina y transferrina), minerales (Fe, Zn, Cu, Mg y Se) y vitaminas (B12, B9, E, C y beta-caroteno). Los datos fueron analizados estadísticamente con las pruebas de la t de Student.

Resultados: De los 38 participantes, el 36,8% presentó sobrepeso (IMC: 25-29,9 kg/m²) y 36,8% eran obesos (IMC \geq 30 kg/m²). El IMC difieren entre mujeres y hombres ($P < 0,001$) (29,1 \pm 4,6 y 27,9 \pm 4,3 kg/m², respectivamente). Los valores medios de los parámetros bioquímicos, excepto para el ácido úrico, tanto en mujeres y hombres estaban dentro de rangos normales. La ingesta energética media fue de 1.909 \pm 284 y 2.260 \pm 337 kcal/día para mujeres y hombres, respectivamente. La contribución de las proteínas a la ingesta calórica total fue de 18,8 y 16,3% para las mujeres y hombres, los carbohidratos 43,3 y el 45,6%, y los lípidos 37,9 y el 38,1%, respectivamente. Todos los participantes fueron clasificados como sedentarios.

Conclusión: En este colectivo se presentó una elevada prevalencia de sobrepeso y obesidad. Se requieren investigaciones adicionales en el desarrollo y evaluación de programas de intervención adecuados para mejorar su estado nutricional y calidad de vida.

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Palabras clave: Síndrome de Down. Discapacidad intelectual. Obesidad. Estado nutricional. Composición corporal.

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Introduction

Recent concerns about the impact of obesity upon health,¹ are based on increasing evidence that obesity has a negative impact upon mortality and morbidity.^{2,3,4} Meanwhile the negative impact of obesity on the health of individuals with intellectual disabilities (ID) has been highlighted as a priority by the *International Association for the Scientific Study of Intellectual Disabilities*.⁵ Down syndrome (DS) is a common chromosomal disorder, affecting 1 per 700-1,000 live births. Life expectancy has increased in the recent decades, due to the improvement in our scientific knowledge of the syndrome and its complications, and also due to the easier access to diagnostic and therapeutic measures and the multiprofessional health teams that accompany them.⁶

Obesity is associated with significant health problems, including cardiovascular disease (CVD), for which persons with DS are already at greater risk. People with DS also have higher than average levels of serum lipids^{7,8,9} and a greater than average prevalence of diabetes,¹⁰ which may result from excess adiposity. Finally but not least, obesity is associated with substantial social stigma, for which persons with DS are already at greater risk.^{11,12}

Children and adults with DS have greater adiposity than those without DS.^{13,14,15} Studies looking specifically at individuals with DS have found an even higher prevalence of obesity.^{16,17,18,19,20} Taken together, these studies suggest that overweight and obesity are more prevalent in DS adults than in non-DS adults. Relatively little is known about the reasons for the increased prevalence of obesity in individuals with DS. The cause of the greater prevalence of obesity appears to be somewhat specific to DS, since persons with ID in general are not fatter than persons without ID.^{21,22} The precise nature of the cause is unknown, but a decreased metabolic rate has been suggested,²³ perhaps resulting from the hypothyroidism frequently observed in persons with DS.^{24,25} However, the importance of social and environmental factors, such as the opportunity for physical activity, must also be considered. In fact, somewhat surprisingly, Fujiura et al.¹⁸ did not find the expected association between BMI and diet or physical activity in adults with DS. As the authors rightly point out, the health of individuals must always be considered within a wider social context.

In addition to medical risks, a study by Gortmaker et al.²⁶ documented significantly increased discrimination directed at obese women in the workplace and in social situations. Also, psychosocial dysfunction resulting from perceived or actual discrimination tends to make the obese state self-perpetuating.^{26,27} In persons with DS, where the syndrome itself may stigmatize the person, obesity can further limit the capacity to participate in the social, recreational and athletic activities that are important for physical and emotional development.^{14,28} Rimmer et al.²⁹ made recommendations about potentially

useful interventions and highlighted the importance of education and the involvement of carers and support workers. The effect of obesity upon the health of this group deserves further study, while the development and evaluation of appropriate interventions for use with individuals with DS will have positive effects on their quality of life. Despite the above, no research has simultaneously evaluated anthropometric, biochemical and dietary risk factors for obesity-related diseases in persons with DS. The objective of the present study was to make an evaluation of the nutritional status, based on the biochemical and anthropometric measurements and dietary intake of young adults with DS.

Subjects and methods

Subjects

In the evaluation of nutritional status, 38 people with DS participated. Their ages ranged from 16 to 38 years (15 women and 23 men) and all attended two occupational centres in the province of Murcia (Spain).

Ethical aspects and confidentiality of the data

The study were performed according to the *Principles of the Helsinki Declaration 1961* (rev. Edimburg 2000). The informed consent of voluntary participation was signed by the parents of the subjects. The study was evaluated and approved by the Ethical Committee of the San Antonio Catholic University, Murcia (Spain). The information was considered confidential, and only the participants, family and tutors knew the data provided.

Level of intellectual disabilities and familiarization of the subjects

The classification of the degree of ID (low, moderate, severe and profound) of the participants was based on the intelligence coefficient and other variables such as motor control, physical inactivity, psychiatric problems, behaviour and sociability, as described in an inventory for planning of services and individual programming (ICAP).³⁰

Familiarization is one of the most important problems facing researchers working with a population suffering ID and is an aspect that must be taken into account before gathering any experimental data. Special care is required and the confidence of individuals must be gained to ensure total collaboration the success or failure of such studies frequently depending on this stage.^{31,32} All the subjects took part in practice sessions to familiarise them with instrumentation, laboratory personnel and testing protocols. Participants were allowed to touch and to try any testing instruments.

Anthropometric measurements and body composition

All patients participating in the study were submitted to anthropometric measurements to evaluate the degree and class of obesity. The protocol used in each survey followed the recommendations of the *Spanish Society for the Study of Obesity* (SEEDO 2007 Consensus).³³ The methodology used for each of the anthropometric measurements is described below. Body weight was measured with an accuracy of 0.1 kg, with an electronic balance (Seca 840, Hamburg, Germany). The subjects were weighed barefoot, in underclothes and before eating. Height was measured with an accuracy of 0.1 cm by precision stadiometer (Seca 221, Hamburg, Germany). Skinfold thickness was measured with a skinfold caliper (Harpenden, CA, USA) (range, 0-80 mm) with a precision of 0.2 mm and constant pressure of 10 g/mm², in the following anatomical locations of the individual: triceps, biceps, subscapular, iliac crest, abdominal, front thigh and medial calf skinfold. Body perimeters were measured by means of a flexible non-stretch tape measure (Holtain Ltd. London, UK) (range, 0-150 cm) with a width of less than 7 mm, with easy to read scale. The circumferences were obtained in the following anatomical locations, wrist, relaxed arm, waist, hip, thigh (medial), leg (medial). All the anthropometric measurements were made by the same trained anthropometrist in one session and using the same instruments. From the measurements the following anthropometric index and body composition were calculated: BMI, waist-hip ratio (WHR), body density and total BF (%). The BMI is the relation between the weight in kilograms and the height in metres (squared) and is used to evaluate excess weight for the identification of obese subjects.^{33,34,35,36} The classification criteria were those established by *SEEDO 2007 Consensus*.³³ overweight degree I, a BMI of between 25 and 26.9 kg/m²; overweight degree II, a BMI of between 27 and 29.9 kg/m²; obesity class I, between 30 and 34.9 kg/m²; and obesity class II, between 35 and 39.9 kg/m². The subjects were classified as being of normal weight when the BMI was between 18.5 and 24.9 kg/m². The WHR is the relation between the waist and hip circumferences in centimetres, and is used to describe the distribution, of both subcutaneous and intraabdominal fat. Total body fat BF (%) was calculated using the equation given by Brozek et al.³⁷ Body density was determined using the equation of Durnin and Womersley³⁸ for men and the equation of Jackson and Pollock³⁹ for women. Both equations have been used and validated in adult populations with ID by Rimmer et al.⁴⁰

Biochemical index

Blood was extracted first thing in the morning before eating, at a local medical centre, puncturing the antecubital

vein of one arm. The samples were obtained by vacuum extraction (Vacutainer[®]), and a total of 3 tubes (3 ml sample) per subject were used. The biochemical parameters used to evaluate the nutritional state were the following: proteins (ferritin, transferrin), lipids (total cholesterol, HDL-cholesterol, LDL-cholesterol and triglycerides), vitamins (vitamin B₁₂, folic acid, vitamin E, vitamin C and β -carotene), minerals (Mg, Fe, Zn, Cu and Se), others (glucose, uric acid). All samples were processed within two hours of sampling and divided into aliquots for immediate analysis or longterm storage at -80 °C until their analysis. Triglycerides, cholesterol, glucose, uric acid, Fe were determined by colorimetric enzymatic methods using kits sold by Roche-Boehringer and adapted to a Hitachi Autoanalyser (Roche-Hitachi Modular PyD Autoanalyser, Roche Laboratory Systems, Mannheim, Germany). The high-density lipoprotein cholesterol (HDL-c) was determined after selective precipitation according to the method described and validated by Gutiérrez et al.⁴¹ The low-density lipoprotein cholesterol (LDL-c) was determined indirectly or directly after selective precipitation according to the methodology described by Gonzalvo et al.⁴² Ferritin and transferrin were determined by immune-fluorescence using a Beckman Array 306 protein analyses. The levels of vitamin B₁₂ and folic acid were determined by means of enzyme-immune-analyser using the system AIA-600. The instrumental techniques used for the determination of minerals Mg, Cu, Zn and Se was atomic absorption spectrophotometry (EAA). High performance liquid chromatography (HPLC) was used to determine vitamins (vitamin C, vitamin E and β -carotene). All the determinations were subjected to controls of internal and external quality according to the norm established by the Clinical Laboratory of the Hospital Virgen de la Arrixaca and Labomur Laboratory S.L. of Murcia (Spain).

Dietary intake survey

Due to the subjects intellectual disabilities, the dietary intake surveys were completed by a relative or tutor (previously instructed), normally the mothers of the subjects in the occupational centres or at the homes of the participants, throughout the period of collection of data of dietary intake. Codification of the surveys was carried out by a nutritionist.

For the present study four types of dietary intake surveys were made, with the purpose of limiting error sources: 72-hour dietary recall, dietary registers of three consecutive days, food frequency questionnaire and dietetic history. The amount of food consumed was measured using household measures (cup, glass, ladle and dish). The energy and nutrient content of the recorded food intake was calculated by a computer application Dietsource version 3.0 (Novartis-Nutrition, 2004) that uses the composition tables for Spanish

foods.⁴³ The results obtained were compared with the recommended intake of energy and nutrients for a Spanish population.⁴⁴ Diets were evaluated by calculating the caloric profiles of macronutrients, lipids, dietary fibre and cholesterol.

Physical activity

To determine the degree of physical activity of the subjects, a trained professional helped the relative to complete a validated questionnaire of physical activity for two days. This provided information concerning the time dedicated to daily activities such as sleeping, cleaning up, getting dressed, sitting, walking, eating, working, playing, relaxing, going up and down stairs, practising physical exercise, sports and other activities.⁴⁵

Definition and classification of the levels of physical activity and activity factors

Very low (1.2): spends most of the day sitting in a chair or lying in bed or on the couch. It does not include people who are involved in sports activities every day. *Low* (1.3): spends most of the day standing or sitting, using their arms. This would be similar to someone who works on an assembly line or in a repetitive type of job staying at one work station most of the day. *Moderate* (1.4): spends most of the day walking or standing, uses brisk arm movements, and walks at a good speed rather than sauntering. At home, moderate activity would include being active by walking around the neighborhood and helping around the house with tasks. *High* (1.5): includes many sports, walking uphill and other activities. It is unlikely that these activities will be pursued throughout the day.

Statistical analysis

The biochemical and anthropometric data and dietary intake were summarized by means of frequency tables and the mean and standard deviation (SD). If a variable presented noticeable asymmetry, the mean was used in the case of negative asymmetry and the geometric mean in the case of positive asymmetry.⁴⁶ When the number of samples is small ($n_0 < 30$ and $n_1 < 30$), it is necessary that the distribution of the variable in the population follow a normal law. This assumption was analyzed by means of the Shapiro-Wilk test. In order to analyse the existing differences between sexes for each of the variables an analysis of variance (ANOVA) was made if the data followed a normal distribution, and a non parametric Wilcoxon signed rank test if the data did not fulfil the normality assumption. A level of $P < 0.05$ was considered significant. The statistical analyses were made by means of

Table I
Age and anthropometric characteristics of the studied population

Variables	Women (n = 15) Mean(SD)	Men (n = 23) Mean(SD)	P
Age (years)	23.4(4.2)	23.5 (5.2)	NS
Height (cm)	144.1 (4.7)	155.8 (5.9)	<0.001
Weight (kg)	60.5 (9.4)	68.1 (13.7)	
BMI (kg/m ²)	29.1 (4.3)	27.9 (4.6)	
WC (cm)	85.6 (7.7)	92.8 (13.0)	<0.01
HC (cm)	103.3 (8.4)	96.7 (9.9)	<0.001
WHR	0.82 (0.06)	0.95 (0.05)	<0.01
Body fat (%)	33.2 (5.1)	24.2 (5.6)	<0.001

Data are expressed as means and standard deviation (SD). Comparisons of anthropometric variables between women and men, were assessed with general linear models of variance.

P: Significant differences between sexes. BMI: body mass index; WC: waist circumference; HC: hip circumference; WHR: waist/hip ratio.

computer science program SPSS for Windows, version 15.0.⁴⁷

Results

Anthropometric data

A summary of the age and anthropometric characteristics of the studied population is shown in table I. The mean BMI differed from men to women ($P < 0.001$) (27.9 ± 4.6 and 29.1 ± 4.3 kg/m², respectively), although both values are classified as overweight class II (SEEDO 2007).³³ The study points to a high prevalence of excess weight and obesity in the studied population: 65.7 % of the subjects showed a BMI above 27 kg/m², of which 36.8 % were classified as obesity class I and class II (IBM: 30 to 39.9 kg/m²), which would imply a high risk for the state of health of the studied group. Table II classifies the sample into SEEDO 2007 categories for weight status based on BMI. The sex-differentiated average values of age, height, weight and BMI of the group were very close to those obtained by Guerra⁴⁸ and Melville et al.³⁹

The higher BMI of the participants in the present study may partially be explained by the general increase in overweight (BMI ≥ 25 kg/m²) and obesity (BMI ≥ 30 kg/m²) that has occurred in the general population. Women showed higher values than the men in BMI and %BF. Table I demonstrates that there were significant differences in mean height, weight, BMI, HC, WC, WHR and %BF between men and women with DS. The %BF was $24.2 \pm 5.6\%$ and $33.2 \pm 5.1\%$ ($P < 0.001$) in men and women, respectively. The WHR was 0.95 ± 0.05 and 0.82 ± 0.06 in men and women, respectively ($P < 0.01$), both outside the values

Classification*	Values BMI (kg/m ²)	Total (n = 38) %	Women (n = 15) %	Men (n = 23) %
Insufficient weight	< 18.5	2.6	0	4.3
Normal-weight	18.5-24.9	23.7	20.0	26.1
Overweight degree I	25-26.9	7.9	6.7	8.7
Overweight degree II	27-29.9	28.9	40.0	21.7
Obesity class I	30-34.9	28.9	20.0	34.8
Obesity class II	34.9-39.9	7.9	13.3	4.3

*SEEDO 2007: Spanish Society for the Study of Obesity 2007 Consensus.

Variables	Mean (SD)	Normal limits	P
Glucose (mg/dL)	82.4 (8.6)	76-110	
Uric acid (mg/dL)			
women (n = 15)	5.2 (0.6)	2.4-5.7	<0.05
men (n = 23)	7.2 (0.9)	3.4-7	
Transferrin (mg/dL)			
women (n = 15)	236.3 (33.6)	185-405	NS
men (n = 23)	238.1 (21.9)	200-380	
Ferritin (ng/mL)			
women (n = 15)	64.0 (7.5)	10-160	<0.05
men (n = 23)	144.4 (6.9)	30-400	
Fe (µg/dL)			
women (n = 15)	84.0 (6.2)	50-150	<0.05
men (n = 23)	93.5 (10.8)		
Total cholesterol (mg/dL)			
women (n = 15)	158.8 (11.9)	50-230	<0.05
men (n = 23)	171.7 (16.6)		
HDL-cholesterol (mg/dL)			
women (n = 15)	53.9 (4.5)	45-75	NS
men (n = 23)	48.0 (5.8)		
LDL-cholesterol (mg/dL)			
women (n = 15)	92.7 (7.4)	<130	<0.05
men (n = 23)	104.4 (10.8)		
Triglycerides (mg/dL)			
women (n = 15)	61.3 (6.0)	50-200	<0.05
men (n = 23)	96.3 (8.1)		

Data are expressed as means and standard deviation (SD). Comparisons of blood biochemical variables between women and men, were assessed with general lineal models of variance. P: Significant differences between sexes. HDL-c: high-density-lipoprotein cholesterol; LDL-c: low-density-lipoprotein cholesterol.

considered to represent risk delimiters, although 13.3% of the women and 17.4% of the men showed values considered to represent a risk of CVD. The average values of WC in men and women were on the borderline of metabolic complications associated with obesity, 40 % of the women and a 21.7 % of the men being classified as at risk, and 26.7 % of women and a 30.4 % of men at high risk.

Biochemical data

The average values obtained for biochemical parameters (table III) in men and women of the studied group were within range considered normal, except the uric acid levels, which were above normal in men (7.2 ± 0.9 mg/dL) and very close to the upper limit of analytical normality in women. Elevated plasma uric acid levels are associated with obesity and could be an expression of insulin-resistant state and metabolic syndrome. Mean levels for LDL-c, HDL-c, triglycerides and total cholesterol were all within the recommended ranges for health. The statistical results of the lipid parameters (table III) showed levels within normality for the group as a whole. The total cholesterol levels, triglycerides and LDL-c, were higher in men, than in women. The numbers of HDL-c were close to the lower limit of analytical normality, both in the group as a whole and when differentiated by sex. Table IV shows that the mean levels recorded for vitamins and minerals were all within the recommended ranges for good health.

Dietary intake data

The macronutrient, lipid and caloric profile of the diets studied is shown in table V. The average energy intake was $1,909 \pm 337$ and $2,260 \pm 284$ kcal/day for women and men, respectively. Protein represented the 18.8 and 16.3% of total the caloric value, carbohydrates 45.3 and 48.6% and lipids 35.9 and 35.1% in women and men, respectively. The dietary intake of the population studied was unbalanced: protein intake was far higher than recommended and carbohydrate intake far lower (table V), findings that are repeated constantly in nutritional evaluations of obese populations.⁵⁴

The contribution of saturated fatty acids and monounsaturated fatty acids showed values near the nutritional objectives recommended for the Spanish population,⁵⁵ although polyunsaturated fatty acids intake was below the recommended value (5% of total

Table IV Average values of vitamins and minerals in blood/plasma				
Variables	Women (n = 15) Mean (SD)	Men (n = 23) Mean (SD)	Normal limits	P
β-carotene (µg/L)	232.7 (32.7)	341.1 (23.9)	50-740	<0.05
Vitamin C (µmol/L)	31.6 (3.5)	28.1 (3.9)	20-80	NS
Vitamin E (µg/mL)	10.8 (1.1)	11.1 (1.9)	5.0-20	NS
Folic acid (ng/mL)	8.2 (0.7)	7.0 (0.7)	3.0-24	NS
Vitamin B ₁₂ (pg/mL)	522.4 (30.6)	463.5 (17.4)	200-950	<0.05
Mg (mg/dL)	1.9 (0.1)	1.9 (0.2)	1.7-2.8	NS
Zn (µg/dL)	85.5 (7.0)	85.6 (8.3)	70-150	NS
Cu (µg/dL)	91.5 (10.9)	95.2 (6.1)	80-155	<0.05
Se (µg/mL)	99.7 (6.5)	91.2 (8.7)	50-150	NS

Data are expressed as means and standard deviation (SD). Comparisons of blood vitamins and minerals between women and men, were assessed with general lineal models of variance. P: Significant differences between sexes.

Table V Dietary variables of subject by sex: energy, macronutrient, dietary fibre and cholesterol intake				
Variables	Women (n = 15) Mean (SD)	Men (n = 23) Mean (SD)	Recommended intake*	P
Energy (kcal/day)	1,909 (337)	2,260 (284)		<0.05
Protein (g/day)	88.1 (10.9)	90.7 (10.2)		NS
Protein (%)	18.8 (2.5)	16.3 (2.1)	10-15	NS
Carbohydrates (%)	45.3 (2.7)	48.6 (3.9)	50-60	NS
Fat (%)	35.9 (3.6)	35.1 (3.1)	30-35	NS
Saturated (%)	10.9 (2.0)	11.1 (1.7)	<10	NS
Monounsaturated (%)	14.8 (2.2)	14.4 (1.8)	15-20	NS
Polyunsaturated (%)	4.2 (0.5)	4.0 (0.8)	5	NS
Cholesterol (mg/day)	298.2 (102)	345.8 (180)	<300	<0.05
Dietary fibre (g/day)	17.0 (2.7)	20.4 (3.7)	>25	0.06

Data are expressed as means and standard deviation (SD). Comparison of nutrient's intake between women and men, were assessed with general lineal models of variance. P: Significant differences between sexes. (%) Percentage of total energy intake. *Recommended intake of the Spanish Society of Community Nutrition (SENC, 2001).

energy intake), both for women and men. Cholesterol intake was above the recommended level of 300 mg/day in men (345.8 ± 180.8 mg/day) and very close to the limit in women (298.2 ± 102 mg/day). The contribution of dietary fibre in men (20.4 ± 3.7 g/day) and in women (17.0 ± 2.7 g/day) was below the recommended value⁵⁶ (≥ 30 g/day).

Physical activity

The physical activity undertaken by the group was low, the average applied physical activity factor being of 1.3 in men and women alike. A physically active lifestyle is not common in individuals with ID, with or without DS,³¹ and the sedentary lifestyle of this population is often associated with obesity and low levels of physical fitness. Since the physical activity of the

group was very light, it would be recommendable to promote physical exercise to increase total energy consumption and to maintain or to diminish the dietary intakes of the subjects accordingly.

Discussion

Anthropometric data

Persons with DS have higher BMI and %BF than age and sex matched persons without DS. Although the BMI does not reflect the difference between excess fat and muscle, it is closely associated with body fat and predicts the development of health problems related to excess weight in the general population. Due to the shorter stature of individuals with DS, it is not clear whether the cut-off points for obesity and overweight

developed for the general population are applicable to subjects with DS. Body composition of this population during adolescence is almost unknown.

The WHR has been used as an indicator of BF distribution in the population by other investigators.³⁴ Increased central adiposity is closely linked with different metabolic diseases.

Despite the extremely high values for overweight and obesity in most of the participants, traditional risk factors for type 2 diabetes and CVD were within the desirable ranges. These findings corroborate and reinforce the results of several previous investigations.^{52,53}

Biochemical data

Uric acid arises from purine metabolism and can increase with a higher intake of nucleic acid-rich food, which also has high protein content. Nevertheless, the high uric acid levels in these persons with DS are more likely to result from a combination of high BMI and metabolic disorders, i.e., hyperinsulinemia, insulin-resistance, dyslipidemia and metabolic syndrome as indicated by the present finding of a positive association of BMI and a negative association of HDL-c with uric acid.⁵⁷

Uric acid is an efficient hydrophilic plasma antioxidant that may be associated with the increased resistance of serum lipids to oxidation which is thought to play an important role in the atherogenic process, but the origin of this biochemical anomaly is unclear. Some authors attribute this increase to alterations in glomerular filtration⁵⁸, but the formation of uric acid can also occur through the xanthine oxidase with concomitant production of superoxide. An excess of oxygen-derived free radicals could result in an extra demand for antioxidant nutrients like vitamins C, E, beta-carotene, minerals Se and Zn (cofactor for GSH-Px). Thus even normal serum concentrations of these nutrients could be functionally deficient in the face of excess demand. This opens the possibility that antioxidant nutrient supplementation might help to ameliorate the pathology of DS.

Dietary intake data

Hypothyroidism is common in individuals with DS,⁴⁹ and resting energy expenditure is reportedly lower in prepubescent children with DS than in control subjects matched for age, weight and % BF.^{50,51} The cause of obesity in an imbalance between dietary intake and energy expenditure⁵⁹. Low fibre intake may be a contributing factor to the constipation often reported in persons with DS.⁶⁰ An increase of fibre was recommended for almost all of the subjects during individual nutrition counseling. We suggest that any weight management program tailored to persons with DS should include —an individually prescribed bal-

anced diet— that incorporates nutrient-rich and natural food sources.

Conclusions

To conclude, obesity in adults with DS is a prevalent and under-researched phenomenon. Our results show that a worrying percentage of people with DS can be classified as being overweight or obese. Studies are needed in which more direct assessments of body composition, are compared with BMI measurements for this population. The associated health risks, combined with the vulnerability and specific needs of adults with DS, require the provision of effective interventions and accessible services. In short, nutritional intervention (dietary intake, physical activity, nutritional education) is desirable for this group to improve individuals nutritional status and quality of life.

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