

Magnesium Status and Ca/Mg ratios in a Series of Children and Adolescents with Chronic Diseases

Marlene Fabiola Escobedo-Monge ^{1,*}, Enrique Barrado ², Joaquín Parodi-Román ³, María Antonieta Escobedo-Monge ⁴ and José Manuel Marugán-Miguelsanz ⁵

Table S1. Regression analysis between serum magnesium, dietary magnesium intake and nutritional parameters in the groups by body mass index ($n = 78$).

Obesity ($n = 24$)		Undernutrition ($n = 30$)		Eutrophic ($n = 24$)	
Serum magnesium Magnesium intake		Serum magnesium Magnesium intake		Serum magnesium Magnesium intake	
Linear	regression	analyses			
	$r = 0.347, p = 0.002$ Height-for-age	$r = 0.137, p = 0.048$ Height-for-age	$r = 0.236, p = 0.007$ Weight-for-height Z-score	$r = 0.281, p = 0.011$ Height-for-age Z-score	
	$r = 0.342, p = 0.005$ kilograms muscular mass by A.	$r = 0.263, p = 0.021$ BMI Z-score		$r = 0.225, p = 0.030$ Weight-for-age Z- score	
	$r = 0.308, p = 0.009$ Waist circumference	$r = 0.354, p = 0.002$ Waist/height ratio		$r = 0.298, p = 0.009$ Head circumference	$r = 0.187, p = 0.035$ Waist/hip ratio
$r = 0.177, p = 0.046$ Polyunsaturated fat intake	$r = 0.368, p = 0.004$ BCS absolute value				
	$r = 0.350, p = 0.003$ Serum vitamin B12		$r = 0.243, p = 0.014$ Serum vitamin B12	$r = 0.274, p = 0.026$ Serum vitamin D	
$r = 0.193, p = 0.036$ Serum zinc	$r = 0.279, p = 0.010$ Serum phosphorus	$r = 0.186, p = 0.020$ Serum phosphorus	$r = 0.292, p = 0.014$ BUN		$r = 0.165, p = 0.049$ Leucocytes
$r = 0.498, p = 0.000$ MCH	$r = 0.309, p = 0.006$ IGF-1	$r = 0.176, p = 0.026$ CV risk index			$r = 0.210, p = 0.032$ CV risk index
Multilinear	regression	analyses			
			$r = 0.438, p = 0.007$ Sum of skinfolds Z-score, waist/hip ratio		$r = 0.471, p = 0.002$ Bicipital skinfold and waist/hip ratio
	$r = 0.824, p = 0.000$ Calcium, monosaturated fats, protein, folic acid, and cholesterol intakes		$r = 0.759, p = 0.000$ Vitamin B12, and zinc intakes	$r = 0.407, p = 0.006$ cholesterol, carbohydrates, and vitamin B1 intake	$r = 0.696, p = 0.000$ energy and iodine intakes
		$r = 0.631, p = 0.000$ AST and glucose			
$r = 0.814, p = 0.001$ T-lymphocytes CD4 and Ig A	$r = 0.942, p = 0.000$ Ig A, complement C3 and Ig G2	$r = 0.335, p = 0.014$ Basophiles and leucocytes	$r = 0.563, p = 0.000$ Complement C3 and CD4/CD8 ratio		

Legend: A: Anthropometry. BMI: Body mass index. BCS: Bone conduction speed. BUN: Blood urea nitrogen. MCH: Mean corpuscular hemoglobin. IGF-1: Insulin-like growth factor-1. CV: Cardiovascular. AST: Aspartate aminotransferase. Ig: Immunoglobulin.

Table S2. Regression analysis between serum calcium, dietary calcium intake and nutritional parameters in the groups by body mass index ($n = 78$).

Obesity ($n = 24$)		Undernutrition ($n = 30$)		Eutrophic ($n = 24$)	
Serum calcium	Calcium intake	Serum calcium	Calcium intake	Serum calcium	Calcium intake
Linear	regression	analyses			
$r = 0.328, p = 0.010$ Subscapular skinfold Z-score	$r = 0.375, p = 0.003$ Fat mass by BIA		$r = 0.145, p = 0.041$ BMI Z-score $r = 0.213, p = 0.014$ FA/MA index $r = 0.418, p = 0.000$ Iron intake	$r = 0.182, p = 0.042$ Head circumference	$r = 0.173, p = 0.043$ Hip circumference $r = 0.440, p = 0.000$ Saturated fat intake
$r = 0.220, p = 0.032$ BCS absolute value					
$r = 0.201, p = 0.032$ Beta-carotene	$r = 0.271, p = 0.011$ Serum vitamin B12		$r = 0.185, p = 0.036$ Serum vitamin B12	$r = 0.225, p = 0.040$ Serum vitamin B12	
	$r = 0.211, p = 0.027$ Serum phosphorus	$r = 0.417, p = 0.000$ Serum phosphorus	$r = 0.154, p = 0.039$ Serum phosphorus	$r = 0.199, p = 0.037$ Serum zinc	
$r = 0.233, p = 0.046$ Creatinine	$r = 0.357, p = 0.024$ AST				$r = 0.318, p = 0.012$ T-lymphocytes CD16+56
$r = 0.400, p = 0.002$ Lymphocytes	$r = 0.191, p = 0.042$ Lymphocytes		$r = 0.06, p = 0.005$ Lymphocytes		$r = 0.178, p = 0.040$ MCHC
Multilinear	regression	analyses			
	$r = 0.391, p = 0.006$ Height-for-age, bicipital skinfold		$r = 0.705, p = 0.000$ Sum of skinfold, BMI Z-score, height- for-age Z-score, head circumference		
	$r = 0.734, p = 0.000$ Magnesium, vitamin B2, iron and vitamin B6		$r = 0.460, p = 0.005$ BUN, and HDL- cholesterol	$r = 0.979, p = 0.000$ Glucose, CRP, creatinine, albumin, transferrin, GGT, triglycerides, and ferritin	
$r = 0.615, p = 0.014$ T-lymphocytes CD8, and CD19	$r = 0.673, p = 0.007$ IgA, and complement C3	$r = 0.523, p = 0.001$ CD4/CD8 ratio, T-lymphocytes CD4			

Legend: A: BMI: Body mass index. BCS: Bone conduction speed. BIA: bioelectrical impedance analysis. FA/MA: Fat area/muscle area. AST: Aspartate amino transferase. MCHC: Mean corpuscular hemoglobin concentration. Ig: Immunoglobulin.

Table S3. Regression analysis between serum calcium/magnesium and calcium/magnesium intake ratios and nutritional parameters in the groups by body mass index ($n = 78$).

Obesity ($n = 24$)		Undernutrition ($n = 30$)		Eutrophic ($n = 24$)	
Serum Ca/Mg ratio	Ca/Mg intake ratio	Serum Ca/Mg ratio	Ca/Mg intake ratio	Serum Ca/Mg ratio	Ca/Mg intake ratio
Linear	regression	analyses			
$r = 0.191, p = 0.042$			$r = 0.406, p = 0.000$		$r = 0.182, p = 0.038$
Height-for-age			Weight-for-height		Waist circumference
Z-score			Z-score		Z-score
$r = 0.237, p = 0.035$	$r = 0.270, p = 0.011$	$r = 0.277, p = 0.017$	$r = 0.242, p = 0.012$		$r = 0.151, p = 0.038$
Head circumference	IGFBP3	BMI Z-score	Waist/height ratio		Waist circumference
$r = 0.190, p = 0.049$		$r = 0.165, p = 0.032$			
BCS absolute value		Monosaturated fat intake			
$r = 0.529, p = 0.000$	$r = 0.255, p = 0.017$			$r = 0.243, p = 0.020$	
MCH	MCV			Basophiles	
Multilinear	regression	analyses			
			$r = 0.736, p = 0.000$		
		$r = 0.374, p = 0.006$	Height-for-age Z-score, suprailiac skinfold Z-score, BMI Z-score		
		Waist/height and waist circumference			
	$r = 0.445, p = 0.002$		$r = 0.529, p = 0.000$	$r = 0.477, p = 0.002$	$r = 0.664, p = 0.000$
	Magnesium and vitamin B2 intake		Magnesium and iron intake	Cholesterol and carbohydrates intake	Saturated fat, and niacin intake
$r = 0.993, p = 0.000$		$r = 0.991, p = 0.000$	Serum Mg, Ca, and phosphorus	$r = 0.987, p = 0.000$	$r = 0.537, p = 0.001$
				Serum Mg and Ca	Serum vitamin B12 and C
	$r = 0.576, p = 0.009$	$r = 0.694, p = 0.000$	$r = 0.632, p = 0.001$	$r = 0.778, p = 0.000$	
	Cholesterol and prealbumin	HDL-cholesterol, GGT, and creatinine	ESR, transferrin, and GGT	LDL-cholesterol, total bilirubin, cholesterol, and alkaline phosphatase	
		$r = 0.405, p = 0.004$	$r = 0.673, p = 0.000$		
		MCH, and monocytes	MCHC, monocytes, MCV, and eosinophiles		
$r = 0.860, p = 0.000$		$r = 0.820, p = 0.000$	$r = 0.720, p = 0.000$	$r = 0.651, p = 0.000$	$r = 0.528, p = 0.002$
IgA, T-lymphocytes		IgG2, IgG4, complement C3, and IgG1	Complement C3, T-lymphocytes CD16+56 and CD3	Complement C4, IgG3, and complement C3	T-lymphocytes CD19 and IgG2
CD3, complement C4					
		$r = 0.200, p = 0.017$		$r = 0.261, p = 0.015$	
		CV risk index		CV risk index	

Legend: IGFBP3: insulin-like growth factor-binding protein 3. BMI: Body mass index BCS: Bone conduction speed. MCV: Mean corpuscular volume. GGT: Gamma glutamyl transpeptidase. ESR: Erythrocyte sedimentation rate. MCH: Mean corpuscular hemoglobin. MCHC: Mean corpuscular hemoglobin concentration. Ig: Immunoglobulin. CV: Cardiovascular.

Table S4. Regression analysis between serum and dietary calcium and magnesium levels and calcium/magnesium ratios and nutritional parameters in children ($n = 42$).

Dietary calcium	Dietary magnesium	Ca/Mg intake ratio	Serum calcium	Serum magnesium	Serum Ca/Mg ratio
	$r = 0.297$, $p = 0.001$ Waist/hip ratio			$r = 0.155$, $p = 0.001$ Waist/hip ratio	$r = 0.234$, $p = 0.004$ Kilograms muscle mass by A.
$r = 0.345$, $p = 0.000$ Vitamin A and B1 intake	$r = 0.318$, $p = 0.000$ Niacin, folic acid intake	$r = 0.709$, $p = 0.000$ Niacin, calcium, folic acid intake	$r = 0.197$, $p = 0.017$ Protein, vitamin E intake	$r = 0.289$, $p = 0.003$ Vitamin B1 and E intake	$r = 0.280$, $p = 0.003$ Vitamin B1, saturated fat intake
			$r = 0.445$, $p = 0.001$ Total protein, AST, ferritin	$r = 0.397$, $p = 0.001$ HDL-cholesterol total bilirubin	$r = 0.529$, $p = 0.000$ HDL-cholesterol, total protein, and bilirubin
$r = 0.237$, $p = 0.004$ Serum vitamin B12		$r = 0.233$, $p = 0.004$ Serum vitamin B12	$r = 0.145$, $p = 0.026$ Serum magnesium	$r = 0.450$, $p = 0.000$ Beta-carotene, serum vitamin D, calcium	$r = 0.905$, $p = 0.000$ Serum magnesium, calcium, beta-carotene
				$r = 0.503$, $p = 0.002$ IGF-1	$r = 0.270$, $p = 0.001$ IGFBP3
$r = 0.133$, $p = 0.026$ Eosinophils	$r = 0.112$, $p = 0.043$ Leucocytes				
$r = 0.327$, $p = 0.005$ T-lymphocytes CD 4, CD16+56			$r = 0.298$, $p = 0.002$ T-lymphocytes CD8	$r = 0.593$, $p = 0.000$ T-lymphocytes CD8, CD19, IgG2, IgM,	$r = 0.214$, $p = 0.013$ IgG2
				$r = 0.182$, $p = 0.000$ CV risk	$r = 0.322$, $p = 0.001$ CV risk, transferrin saturation

Legend: A: Anthropometry. AST: Aspartate aminotransferase. IGF-1: Insulin-like growth factor-1. IGFBP3: insulin-like growth factor-binding protein 3. Ig: Immunoglobulin. CV: Cardiovascular.

Table S5. Regression analysis between serum and dietary calcium and magnesium levels and calcium/magnesium ratios and nutritional parameters in adolescents ($n = 36$).

Dietary calcium	Dietary magnesium	Ca/Mg intake ratio	Serum calcium	Serum magnesium	Serum Ca/Mg ratio
$r = 0.409$, $p = 0.000$ Height-for-age and Waterloo II	$r = 0.297$, $p = 0.001$ Waist/hip ratio				
$r = 0.448$, $p = 0.000$ Magnesium, cholesterol intake	$r = 0.448$, $p = 0.000$ Calcium, vitamin D intake	$r = 0.768$, $p = 0.000$ Calcium, vitamin D, saturated fat folic acid intake -		$r = 0.184$, $p = 0.010$ Magnesium intake	$r = 0.130$, $p = 0.033$ Magnesium intake
$r = 0.165$, $p = 0.032$ Ferritin	$r = 0.163$, $p = 0.033$ Ferritin		$r = 0.232$, $p = 0.011$ Albumin		
	$r = 0.427$, $p = 0.000$ Serum vitamin D, zinc/copper ratio			$r = 0.183$, $p = 0.016$ Serum iron	$r = 0.991$, $p = 0.000$ Serum magnesium, calcium,
		$r = 0.211$, $p = 0.007$ Basophiles	$r = 0.320$, $p = 0.001$ Lymphocytes	$r = 0.267$, $p = 0.002$ HbCM	$r = 0.361$, $p = 0.004$ HbCM, Leucocytes
			$r = 0.570$, $p = 0.000$ T-lymphocytes CD8, CD19, complement C4	$r = 0.329$, $p = 0.004$ Complement C4	$r = 0.406$, $p = 0.001$ Complement C4

Legend: MCH: Mean corpuscular hemoglobin.

Table S6. Basic characteristic of patients with low bone conduction speed.

Cases No	1st	2nd	3rd	4th	5th
Age (years)	2	4	10	12	19
Gender	Male	Male	Female	Female	Female
Nutritional status by body mass index	normal	undernutrition	obesity	undernutrition	obesity
BCS Z-score	-2.31	-3.35	-2.29	-2.32	-2.24
Height Z-score	normal	normal	normal	Low	normal
Vitamin D (%DRI)	61*	15*	109	56*	17*
Calcium (%DRI)	143**	103	155**	89	109
Magnesium (%DRI)	111	92	199**	58*	116
Calcium/magnesium intake ratio	1.29*	1.11*	0.78*	1.28*	1.02*
Zinc (%DRI)	24*	96	93	45*	83
Serum vitamin D (ng/mL)	53	85**	19*	28*	10*
Serum calcium (mg/dL)	10.20	9.70	9.90	9.60	9.40
Serum magnesium (mg/dL)	2.2	2.2	1.9*	2.5**	2.1
Serum calcium/magnesium ratio	4.6	4.41	5.21**	3.84*	4.48
Serum phosphorus (mg/dL)	4.5	5.2	5.4	4.7	3.7*
Serum zinc (µg/dL)	85	76	85	85	92
Serum copper (µg/dL)	163**	143**	114	104	113
Copper/zinc ratio	1.92**	1.88**	1.34**	1.22**	1.23**
Zinc/copper ratio	0.52*	0.53*	0.75	0.82	0.81
C-reactive protein U/L	10.7**	3.75	6.3**	3.75	8.5**
Erythrocyte sedimentation rate mm/h	22**	30**	13	8	13

Legend: % DRI: percentage of dietary reference intake (normal values 80-120%DRI). Serum Ca 8.8-10.8 mg/dL [55] and hypercalcemia >11 mg/dL [56]. Symptomatic hypomagnesemia <1.22 mg/dL, asymptomatic hypomagnesemia 1.22-1.82 mg/dL, chronic latent Mg deficiency 1.82-2.07 mg/dL, interval for health 2.07-2.32 mg/dL, asymptomatic hypermagnesemia 2.32-4.86 mg/dL, symptomatic hypermagnesemia >4.86 mg/dL [57]. Deficiency vitamin D < 20 ng/mL, insufficiency vitamin D 20-30 mg/mL [61]. Serum phosphorus in children 4.5-6.5 mg/dL [55]. Hypozincemia levels <70 µg/dL in children under 10 years of age in both sexes and in females >10 years and <74 µg/dL in males older than 10 years [62]. Hypocupremia <70 µg/dL and hypercupremia >140 µg/dL [63]. The Copper/zinc ratio 0.7 to 1.0 [64]. The /copper ratio < 4.0 [65]. *Low level. **High level.

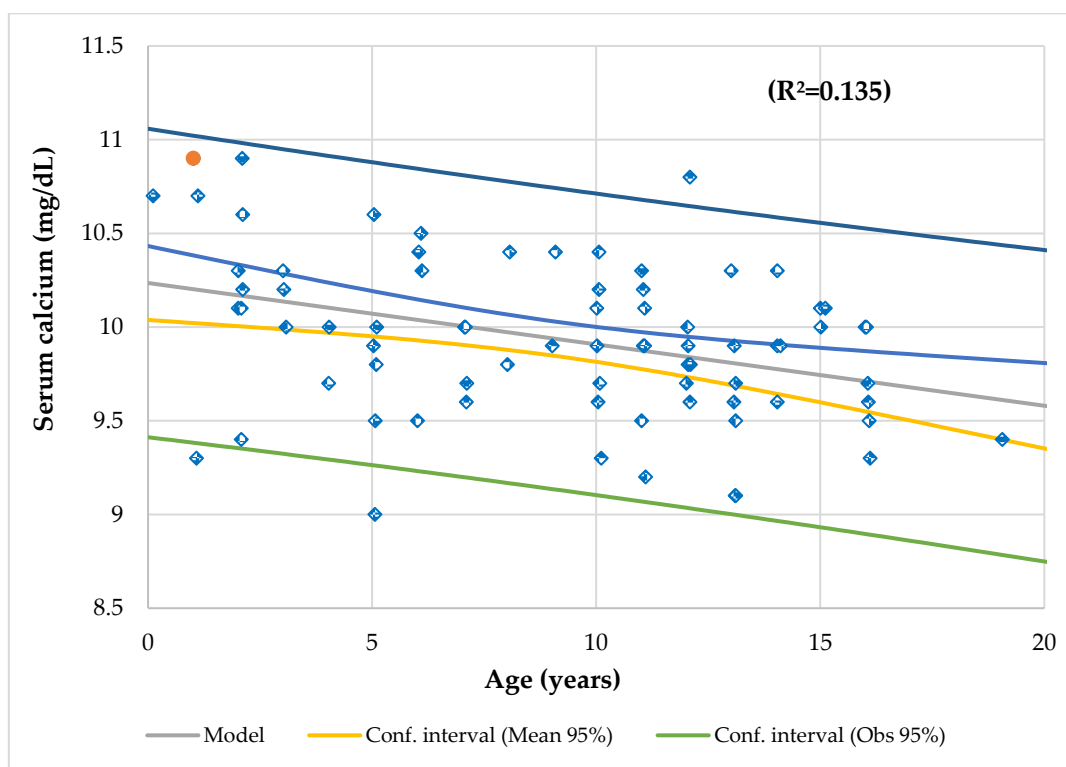


Figure S1. Regression serum calcium (mg/dL) by age (years).

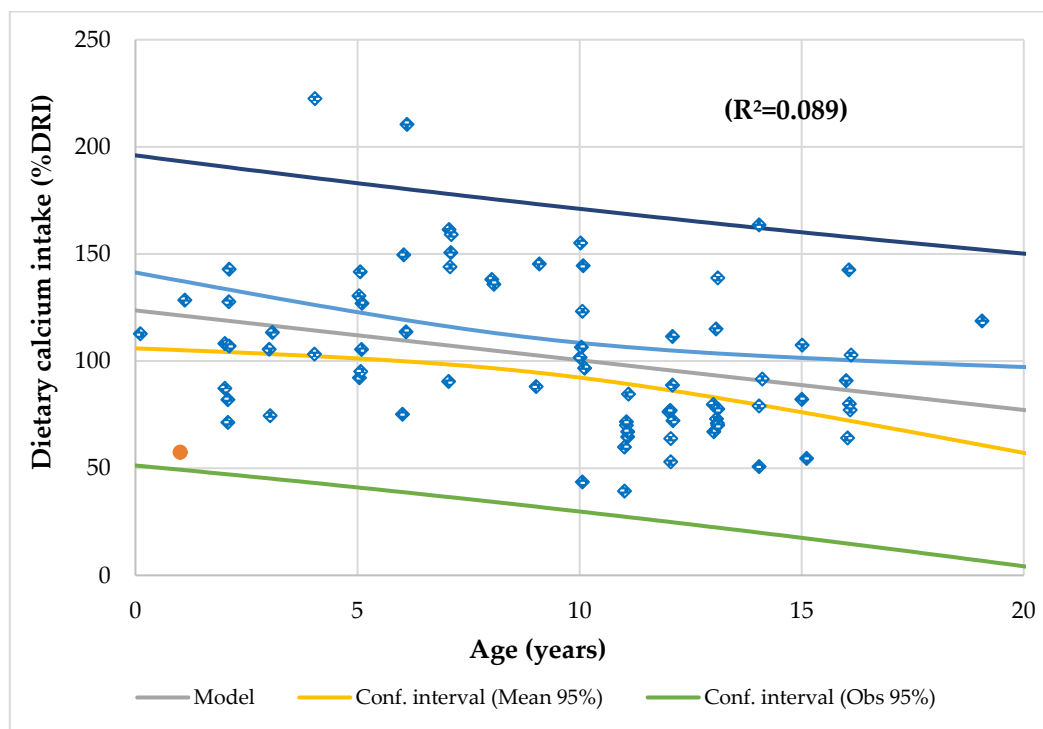


Figure S2. Regression dietary calcium intake (%Dietary Reference Intake) by age (years).