

Thinness, overweight and obesity in indigenous youth in Oaxaca, 1970 and 2007

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Abstract

Objective. To evaluate change in body mass index (BMI) and weight status of indigenous youth in Oaxaca between the 1970s and 2007. **Materials and methods.** Heights and weights were measured in cross-sectional samples of school children 6-14 years in the 1970s (2 897) and 2007 (4 305); BMI was calculated. International Obesity Task Force cutoffs for weight status were used. BMI and prevalence of severe and moderate thinness, overweight and obesity were compared by year. **Results.** BMI increased significantly across time. Primary change in weight status occurred in overweight, 1970s, <2%; 2007, 7 to 12%. Little change occurred in thinness (<2%) and obesity (\leq 1%) in both surveys, except in children 6-9 years (obesity=4% in 2007). **Conclusion.** BMI and prevalence of overweight increased across all ages from the 1970s to 2007, but children 6-9 years appeared to be more at risk for obesity than youth 10-14 years. Prevalence of thinness was unchanged.

Key words: prevalence; growth; children; adolescents; Mexico

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Resumen

Objetivo. Evaluar el cambio en el índice de masa corporal (IMC) y el estatus de peso entre 1970 y 2007 en jóvenes indígenas de Oaxaca. **Material y métodos.** Se midieron estatura y peso de series transversales de escolares indígenas en edades de 6 a 14 años en 1970 (2 897) y en 2007 (4 305), se calculó el IMC y se emplearon los puntos de corte del International Obesity Task Force para el estatus de peso. El IMC y la prevalencia de delgadez, sobrepeso y obesidad en 1970 y 2007 fueron comparados. **Resultados.** El IMC aumentó de manera significativa entre 1970 y 2007. Los cambios más importantes fueron en sobrepeso, <2% en 1970 a 7-12% en 2007. Hubo poco cambio en la delgadez (<2%) y la obesidad (\leq 1%) en ambas investigaciones, excepto en niños de 6 a 9 años (4% en 2007). **Conclusión.** El IMC y la prevalencia de sobrepeso aumentaron a través de todas las edades de los años 1970 a 2007, pero los niños de 6 a 9 años parecen tener un mayor riesgo para la obesidad que los jóvenes de 10 a 14 años. La frecuencia de la delgadez fue igual.

Palabras clave: prevalencia; crecimiento; niños; adolescentes; México

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Increased prevalence of overweight and obesity among Mexican youth¹⁻⁶ is consistent with the global epidemic. Prevalence in Mexico was lowest among children 5-11 years in the southern region, which includes Oaxaca, and rural areas.³⁻⁵ Estimates for Oaxaca youth in 2006 were among the lowest in all Mexican states.⁷ Overweight and obesity were also less prevalent in households in which women <50 years spoke an indigenous language.⁴

Our previous studies in Oaxaca have considered change in overweight and obesity in a rural indigenous community in the central valley between 1968, 1978 and 2000⁸ and in a colonia of Oaxaca de Juárez between 1972 and 2000.⁹ Overweight and obesity were not common among youth in 1968-1978, but overweight and to a lesser extent obesity increased in 2000. This report extends our observations to indigenous youth in four regions of Oaxaca. It specifically evaluates change in the BMI and prevalence of thinness, overweight and obesity in indigenous school youth 6-14 years between the 1970s and 2007. Oaxaca has the largest indigenous population in Mexico and includes at least 15 different linguistic groups.¹⁰

Materials and methods

Surveys

The growth status of 2 897 (1 419 boys, 1 478 girls) school youth 6-14 years of age in 18 communities in four regions of Oaxaca (Central Valley, Sierra South, Sierra Northeast, Isthmus) was surveyed in 1971, 1972, 1977 and 1978.* Surveys were set in the context of nutritional anthropology and conducted in collaboration with ethnographic studies. Grant support for surveys in 1971, 1972 and 1978 implied approval by the University of Texas at Austin (see Acknowledgements); formal institutional review committees were not established at the time of the surveys.^{8,11} Officials (president and council, school principal) in each community also approved the surveys. Surveys in 1977 were done at the request of Instituto Nacional para el Desarrollo de la Comunidad y de la Vivienda Popular (INDECO). In-

stitute personnel obtained approval from community and school officials.

The 18 communities represented the Central Valley (10), Sierra South (5), Sierra Northeast (2) and Isthmus (1). All rural communities were indigenous. The two colonias were populated primarily by indigenous migrant families from rural areas of the state.

Permission for participation of the children was thus granted by the president and his council, and school principal in each community. Surveys were done at the schools. Children were free to choose to participate or not participate. The sample thus represented children in attendance on days of the surveys. Individual identities were blinded in all analyses.

The data for 2007 are for youth 6-14 years enrolled in bilingual schools, *albergues escolares*.¹²⁻¹⁴ The sample was based on a double cluster and stratified design. Criteria for attendance at *albergues* schools were membership in an indigenous community, speak/understand an indigenous language, registration at a public school, and unstable home conditions.¹³ The latter included children who did not live with their parents, children with a mother or father who had emigrated, and/or children from families with some degree of dysfunction. Height and weight were measured as part of the health and nutrition monitoring program. Data were provided by the *albergues* directorate, and are presently restricted for research or implementation of public policies. Individual identities of the children were blinded. The present analysis is limited to 4 305 youth (2 368 boys, 1 937 girls) from 58 municipios located in the same regions surveyed in the 1970s: Central Valley (6), Sierra South (24), Sierra Northeast (17) and Isthmus (11).¹⁵

Measurements

Height was measured with a field anthropometer to the nearest 0.1 cm in the 1970s, and weight with a portable scale to the nearest 0.5 pound (converted to kg). Children wore light clothing with shoes and accessories removed. Inter- and intra-observer technical errors of measurement for height were 0.20 to 0.54 cm and 0.33 to 0.38 cm, respectively.¹⁰ Replicate weights were not measured. Heights and weights in 2007 were measured by trained *albergues* staff following the U.S. Centers for Disease Control and Prevention protocol.¹⁵

The body mass index (BMI, kg/m²) was calculated. Ages were extracted from school records. Sex- and age-specific BMI criteria of the International Obesity Task Force (IOTF) were used to define overweight and obesity,¹⁶ and severe and moderate thinness.¹⁷ Comparative data for Mexico also used these criteria.⁷

* Malina RM, Peña-Reyes ME. Estatus de crecimiento en niños escolares del estado de Oaxaca: Resultados de encuestas realizadas en 18 comunidades en la década de 1970. México, DF. Instituto Nacional de Antropología e Historia: (in press).

⁸ Institutional review boards were not established until after the 1979 Belmont Report from the Department of Health, Education, and Welfare.¹¹

Analysis

Age- and sex-specific means and standard deviations for BMI were calculated for the 1970s and 2007. Sex-specific multiple analyses of covariante (MANCOVA), controlling for age, were used to compare BMIs across years in two age groups: 6-9 (childhood) and 10-14 (early- and mid-adolescence). Prevalence of severe and moderate thinness, overweight and obesity was calculated for

the two sex-specific age groups by year and compared with Chi square. The Statistical Package for the Social Sciences (SPSS version 14.0) was used. Significance was set at $p < 0.05$.

Results

Descriptive statistics for BMI by age and sex are summarized by year in Table I. Comparisons of sex-specific

Table I
SAMPLE SIZES AND DESCRIPTIVE STATISTICS FOR THE BMI (KG/M²) OF INDIGENOUS SCHOOL YOUTH BY SEX, AGE AND YEAR. OAXACA, MÉXICO, 1970 AND 2007

Age, yrs	Boys						Girls					
	1970s			2007			1970s			2007		
n	Mean	SD	n	Mean	SD	n	Mean	SD	n	Mean	SD	
6+	129	15.6	1.4	116	16.6	2.3	140	15.4	1.2	92	16.5	2.5
7+	176	15.6	1.6	163	16.7	1.8	172	15.4	1.2	135	16.7	2.5
8+	188	15.8	1.5	201	16.8	2.4	225	15.7	1.3	188	16.7	2.1
9+	200	15.9	1.2	241	17.1	2.0	214	15.8	1.3	221	17.0	2.1
10+	193	16.0	1.2	321	17.4	2.2	223	16.3	1.5	291	17.4	2.2
11+	189	16.4	1.3	300	17.7	2.2	193	16.5	1.5	288	18.2	2.3
12+	165	16.7	1.6	373	18.4	2.3	156	17.3	1.6	292	19.1	2.5
13+	114	17.6	1.9	364	19.0	2.1	100	18.8	2.3	239	20.3	3.0
14+	65	17.7	1.9	289	19.7	2.3	55	19.9	2.1	191	21.1	2.9

Table II
SAMPLE SIZES, MEANS AND STANDARD DEVIATIONS FOR AGE, RESULTS OF THE MANCOVAS AND ADJUSTED MEANS AND STANDARD ERRORS¹ FOR THE BMI BY AGE GROUP, SEX AND YEAR

Sex, Age Group	F (p)	1970s		2007		Difference between Years		
		Mean	SE	Mean	SE	Mean	SE	95% CI
6-9 yrs								
Boys, N:		693	721					
Age, yrs		8.2	1.1	8.3	1.1			
BMI, kg/m ²	130.27 (<.001)	15.7	0.07	16.8	0.07	1.10	0.10	0.91-1.29
Girls, N:		751	636					
Age, yrs		8.2	1.1	8.3	1.1			
BMI, kg/m ²	138.48 (<.001)	15.6	0.07	16.7	0.07	1.14	0.10	0.95-1.33
10-14 yrs								
Boys, N:		726	1647					
Age, yrs		12.0	1.3	12.5	1.4			
BMI, kg/m ²	276.61 (<.001)	16.9	0.08	18.4	0.05	1.53	0.09	1.35-1.71
Girls, N:		727	1301					
Age, yrs		11.9	1.3	12.3	1.4			
BMI, kg/m ²	192.39 (<.001)	17.4	0.09	18.9	0.06	1.49	0.11	1.28-1.70

¹ Adjusted for age and age squared

age groups across time are shown in table II. BMIs are significantly higher in 2007 compared to the 1970s. Secular increases are larger in older than younger children. Lack of overlap of 95% CIs suggests a significantly larger increase in older than younger boys, but 95% CIs overlap somewhat between age groups of girls. Estimated rates of secular gain in BMI over approximately 3.2 decades are 0.34 and 0.36 kg/m² per decade in boys and girls 6-9 years, respectively, and 0.48 and 0.47 kg/m² per decade in boys and girls 10-14 years, respectively.

Prevalence of severe and moderate thinness is low and does not differ between surveys (table III). Overweight is low in the 1970s but increases in both age groups and sexes in 2007 ($p < 0.001$). Obesity is largely absent in the 1970s, but increases to 3.7% and 3.9% in boys and girls 6-9 years, respectively, in 2007 ($p < 0.001$). Obesity among youth 10-14 years, though significantly higher in 2007 ($p < 0.05$), is <1%.

Discussion

BMIs of indigenous Oaxaca school children increased significantly between the 1970s and 2007. Compared to U.S. reference values¹⁸ mean BMIs of boys and girls in the 1970s were at the medians at 6-7 years and shifted toward the 25th percentiles (P 25) by 11 years; BMIs of boys remained at P 25 while those of girls reached the median at 13-14 years. In 2007, mean BMIs of boys and girls were at 75th percentiles (P 75) at 6-7 years, and shifted towards the reference medians between 8 and 11 years. At 12-14 years, BMIs of indigenous girls moved towards P 75 while those of boys remained

close to the medians. Both height and weight increased significantly in the indigenous children between the 1970s and 2007¹⁹ and contributed to the gains in BMI over the interval of about 32 years (assuming 1975 as the 1970s midpoint).

Rural communities surveyed in the 1970s depended on subsistence agriculture, but several also produced cheese, poultry and crafts and few had regional market activities.¹⁰ Colonia residents depended on occupational resources in the capital. Elevated infant and preschool mortality in Oaxaca in the 1970s suggested marginal health and nutritional conditions in the rural areas and colonias.^{10,20} Living and nutritional conditions in the respective communities have presumably improved over time in association with economic growth and land reform and in turn contributed to secular improvement in growth status of the indigenous children.¹⁹⁻²²

The major change in weight status of indigenous school youth between the 1970s and 2007 occurred in overweight which increased significantly from <2% to 12% in boys and girls 6-9 years and girls 10-14 years, and to 7% in boys 10-14 years (table III). Prevalence of severe and moderate thinness was low and did not change across time. Obesity was present in <1% of youth in the 1970s. It increased to ~4% in boys and girls 6-9 years in 2007 but remained <1% in boys and girls 10-14 years. Indigenous children 6-9 years thus appeared more at risk for obesity than older youth.

Prevalence of overweight and obesity among indigenous children 6-9 years in 2007 was reasonably similar to estimates for Oaxaca children 5-11 years (indigenous and non-indigenous) in the 2006 National Health and Nutrition Survey.⁷ On the other hand, overweight and

Table III
PREVALENCE OF THINNESS, OVERWEIGHT AND OBESITY BY AGE GROUP, SEX AND YEAR, AND SIGNIFICANCE OF THE DIFFERENCES BETWEEN YEARS (P VALUES). OAXACA, MÉXICO, 1970 AND 2007

Sex Age Group	Year	N	Severe Thinness		Moderate Thinness		Overweight		Obese	
			%	95% CI	%	95% CI	%	95% CI	%	95% CI
6-9 yrs										
Boys	1970s	693	0.1	0.0-0.9	1.0	0.4-2.2	1.4	0.8-2.6	0.9	0.4-2.0
	2007	721	0.4	0.1-1.3	0.8	0.3-1.9	12.1	9.8-14.7	3.7	2.5-5.5
	p		0.336		0.726		<0.001		<0.001	
Girls	1970s	751	0.4	0.1-1.3	1.3	0.7-2.5	1.5	0.8-2.7	0.1	0.0-0.9
	2007	636	1.1	0.5-2.4	1.3	0.6-2.6	12.1	9.7-15.0	3.9	2.6-5.8
	p		0.124		0.904		<0.001		<0.001	
10-14 yrs										
Boys	1970s	726	1.0	0.4-2.1	1.5	0.8-2.8	0.8	0.3-1.9	0	
	2007	1647	0.9	0.5-1.5	1.2	0.8-1.9	7.4	6.2-8.8	0.7	0.4-1.3
	p		0.784		0.552		<0.001		0.021	
Girls	1970s	727	0.4	0.1-1.3	1.7	0.9-2.9	1.2	0.6-2.4	0.1	0.0-0.9
	2007	1301	0.6	0.3-1.3	1.0	0.5-1.7	12.1	10.4-14.1	0.9	0.5-1.6
	p		0.552		0.202		<0.001		0.046	

obesity among indigenous youth 10-14 years in 2007 were less prevalent compared to Oaxaca youth 12-17 years in the 2006 survey.

The *albergues* schools provided meals daily and some provided rooms Monday to Friday. School meals followed the directive of the Ministry of Health for "*el plato de bien comer*" which included three food groups: green vegetables and fruits; cereals; and legumes and foods of animal origin. The diet aimed to normalize nutritional deficiencies (milk fortified with iron, zinc, folic acid and vitamins) and incorporate local vegetables and fruits.^{23,24} A regular and improved diet at the schools may have contributed to the secular gain in weight-for-height reflected in the BMI.

Detailed observations for a single rural Zapotec-speaking community indicated little dietary variety, limited sources of animal protein, and dependence upon corn in the form of tortillas and beans at the household level in 1968 and 1978²⁵ but greater variety and increased consumption of animal protein in 2000.²⁰ Soft drinks were noted in 5% of households in 1968, 26% in 1978 and 36% in 2000.^{20,25} Corresponding data for Oaxaca households were 21% in 1996 and 23% in 2006.²⁶

Reduction in habitual physical activity is often indicated as contributing to the current epidemic of obesity. Subsistence agriculture required regular moderate-to-vigorous and periodically vigorous physical activity in adult males and boys (when school was out). Women and girls were also involved at some times of the year, specifically harvest. Youth 9-17 years in a rural Zapotec community in 2000-2002 spent about 2 hours per day on household chores which were moderate-to-vigorous and vigorous in boys and moderate or moderate-to-vigorous in girls.²⁷ Children 6-8 years and youth 9-17 years also walked, respectively, an estimated $2\ 364 \pm 1\ 125$ (median $2\ 249$) and $2\ 605 \pm 1\ 176$ (median $2\ 650$) steps per day to and from school, and had one hour per week of required physical education.^{27,28} The majority of youth (~85%) also reported regular participation in sport, soccer (boys) and basketball (both sexes). Assuming reasonably similar conditions in other indigenous communities, lifestyles of rural youth probably involved regular physical activity. In contrast, only 35% and 24% of Mexican youth 10-19 years (sexes combined) in the 2006 National Health and Nutrition Survey were physically active (7 hrs/week in moderate or vigorous activity) and moderately active (4-6 hrs/week), respectively, while 40% were inactive.²⁹

Television viewing was a major sedentary leisure activity for Zapotec youth, 2.1 ± 1.5 hrs/day in our 2000-2002 field survey (only five boys and no girls reported playing video games),²⁷ which was about one-half of reported screen time (television, games, videos) in

Mexico City youth.^{30,31} Televisions increased from 31% to 58% in rural Oaxaca households between 1996 and 2005.²⁶ Increased availability of appliances and reduction in agriculture as the primary subsistence activity and in the percentage of households raising animals, fruits and vegetables declined between 1996 and 2005. Overall, changes at the household level enhanced the potential for reduction in physical activity in rural areas of Oaxaca.

Two concerns are inherent to comparisons across time, measurement protocols and population comparability. Height and weight are standard measurements in surveys of growth and nutritional status. The first author (RMM) trained technicians in anthropometry for the U.S. National Health Examination of youth 12-17 years in the 1960s; the same protocol was used in our surveys in the 1970s. Techniques used in the U.S. were also used in the indigenous schools. It is thus reasonable to assume measurement techniques in the 1970s and 2007 were similar.

The sample in the 1970s included all children in attendance at schools in 18 communities at the time of the surveys in 1971, 1972, 1977 and 1978. School children in 2007 represented a stratified random sample of children attending *albergues* schools in the state of Oaxaca, although only those attending schools in the same four regions as in the 1970s were used. The 2007 sample is perhaps more representative of indigenous school children than the 1970s sample, thus limiting comparisons of weight status across two time points to some extent. However, consistency of measurement protocols in the 1970s and 2007 and the relatively large samples should serve to offset potential sampling bias. Several other considerations also highlight comparability of the samples. All were from indigenous communities in the same regions of Oaxaca (except for two colonias). The majority were from Zapotec-, Mixtec- and Mixe-speaking communities, ~80% (1970s) and ~83% (2007). Although indigenous groups of Oaxaca are linguistically and to some extent culturally isolated, they are rather homogeneous genetically.³² The Zapotec, Mixtec and Mixe also form a closely related genetic cluster distinguished from other populations in Mexico and Central America.³³⁻³⁵ Other indigenous groups from Oaxaca were not represented in the latter analyses.

In summary, changes in the BMI over ~3 decades between the 1970s and 2007 were reflected in a significant increase in overweight in indigenous school youth 6-9 and 10-14 years. Prevalence of thinness in both age groups and obesity in youth 10-14 years was low and did not change. By inference, change in energy intake and/or physical activity (energy expenditure) was not sufficient to trigger a major increase in obesity. However,

~4% of indigenous children 6-9 years in 2007 were obese, which suggests that the signal for obesity may be incipient in younger children.

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References

- Peña-Reyes ME, Cardenas-Barahona EE, Cahuich MB, Barragan A, Malina RM. Growth status of children 6-12 years of age from two different geographic regions of Mexico. *Ann Hum Biol* 2002; 29:11-25.
- Sánchez-Castillo CP, Lara JJ, Villa AR, Aguirre J, Escobar M, Gutiérrez H, et al. Unusually high prevalence rates of obesity in four Mexican rural communities. *Eur J Clin Nutr* 2001; 56:833-840.
- Hernández-Prado B, Rivera-Dommarco J, Shamah-Levy T, Cuevas-Nasu L, Ramirez-Silva I, Camacho-Cisneros M, et al. Escolares. In: Rivera Dommarco J, Shamah-Levy T, Villalpando-Hernández S, Gonzalez de Cossio T, Hernández Prado B, Sepúlveda J (eds). Encuesta Nacional de Nutrición 1999: Estado Nutricio de Niños y Mujeres en México. Cuernavaca, México, Instituto Nacional de Salud Pública: 2001:69-101.
- Hernández B, Cuevas-Nasu L, Shamah-Levy T, Monterrubio EA, Ramirez-Silva CI, Garcia-Feregrino R, et al. Factors associated with overweight and obesity in Mexican school-age children: Results from the National Nutrition Survey 1999. *Salud Publica Mex* 2003; 45 (suppl):S551-S557.
- del Rio-Navarro BE, Velásquez-Monroy O, Sánchez-Castillo CP, Lara-Esqueda A, Berber A, Fanghänel G, et al. The high prevalence of overweight and obesity in Mexican children. *Obes Res* 2004; 12:215-223.
- Rivera-Dommarco J, Cuevas-Nasu L, Shamah-Levy T, Villalpando-Hernández S, Avila-Arcos MA, Jimenez-Aguilar A. Estado nutricional. In: Olaiz G, Rivera J, Shamah T, Rojas R, Villalpando S, Hernández M, et al. (eds). Encuesta Nacional de Salud y Nutrición 2006. Cuernavaca, México, Instituto Nacional de Salud Pública: 2006:85-103.
- Cuevas-Nasu L, Rivera-Dommarco JA, Shamah-Levy T, González de Cossío-Martínez TNJ, Moreno-Macias LB, Ávila-Arcos MA. Estado nutricional. In: Shamah Levy T, Villalpando Hernández S, Rivera Dommarco JA (eds). Resultados de Nutrición de la ENSANUT 2006. Cuernavaca, México, Instituto Nacional de Salud Pública: 2007:23-83.
- Malina RM, Peña-Reyes ME, Tan SK, Buschang PH, Little BB. Overweight and obesity in a rural Amerindian population in Oaxaca, southern Mexico, 1968-2000. *Am J Hum Biol* 2007; 19:711-721.
- Malina RM, Peña-Reyes ME, Little BB. Secular change in the growth status of urban and rural schoolchildren aged 6-13 years in Oaxaca, southern Mexico. *Ann Hum Biol* 2008; 35:475-489.
- Barabás AM, Bartolomé MA. Los protagonistas de las alternativas para las autonomías. In: Barabás AM, Bartolomé MA (eds). Configuraciones Étnicas en Oaxaca: Perspectivas Etnográficas para las Autonomías. Vol I. Introducción, Macroetnias. México, DF, Instituto Nacional de Antropología e Historia/Instituto Nacional Indigenista: 1999:15-56.
- Gunsalus CK, Bruner EM, Burbules NC, Dash L, Finkin M, Goldberg JP, et al. Mission creep in the IRB world. *Science* 2006; 312:1441.
- Comisión Nacional para el Desarrollo de los Pueblos Indígenas. Albergues Escolares Indígenas. Comisión Nacional para el Desarrollo de los Pueblos Indígenas: México, DF, 2006. [Accessed 3 october 2008]. Available at: www.e-mexico.gob.mx/wb2/eMex/eMex_Albergues_Escolares_Indigenas_elnd.
- Comisión Nacional para el Desarrollo de los Pueblos Indígenas. El Diario Oficial, Diciembre 29, 2008. Acuerdo de modificación a las reglas de operación de los siguientes programas: Albergues escolares indígenas. México, DF, Comisión Nacional para el Desarrollo de los Pueblos Indígenas: 2008.
- Peña-Reyes ME, Chávez GB, Little BB, Malina RM. Community well-being and growth status of indigenous school children in rural Oaxaca, southern Mexico. *Eco Hum Biol* 2010; 8:177-187.
- Comisión Nacional para el Desarrollo de los Pueblos Indígenas. Técnicas de Medición para la Toma Peso y Estatura. Comisión Nacional para el Desarrollo de los Pueblos Indígenas: México, DF, 2006. [Accessed 26 august 2008]. Available at: www.emexico.gob.mx/wb2/eMex/eMex_Albergues_Escolares_Indigenas_elnd.
- Cole TJ, Bellizzi MC, Flegal KM, Dietz WH. Establishing a standard definition for child overweight and obesity worldwide: International survey. *BMJ* 2000; 320:1240-1243.
- Cole TJ, Flegal KM, Nicholls D, Jackson AA. Body mass index cut offs to define thinness in children and adolescents: International survey. *BMJ* 2007; 335:194-201.
- Kuczmarski RJ, Ogden CL, Grummer-Strawn LM, Flegal KM, Guo SS, Wei R, et al. CDC growth charts: United States. *Advance Data from Vital and Health Statistics*, no 314. Hyattsville, MD, National Center for Health Statistics: 2000.
- Malina RM, Peña-Reyes ME, Chávez GB, Little BB. Secular change in height and weight of indigenous school children in Oaxaca, Mexico, between the 1970s and 2007. *Ann Hum Biol* 2011; 38:691-701.
- Malina RM, Peña-Reyes ME, Little BB. Epidemiologic transition in an isolated indigenous community in the Valley of Oaxaca, Mexico. *Am J Phys Anthropol* 2008; 137:69-81.
- Malina RM, Peña-Reyes ME, Little BB. Secular change in heights of indigenous adults from a Zapotec-speaking community in Oaxaca, southern Mexico. *Am J Phys Anthropol* 2010; 141:463-475.
- Malina RM, Peña-Reyes ME, Tan SK, Buschang PH, Little BB, Koziel S. Secular change in height, sitting height and leg length in rural Oaxaca, southern Mexico: 1968-2000. *Ann Hum Biol* 2004; 31:615-633.
- Comisión Nacional para el Desarrollo de los Pueblos Indígenas. Guía para el Buen Comer en los Albergues Escolares Indígenas. México, DF, Comisión Nacional para el Desarrollo de los Pueblos Indígenas: 2006. [Accessed 26 august 2008]. Available at: www.cdi.gob.mx.
- Comisión Nacional para el Desarrollo de los Pueblos Indígenas. Desarrollo social y humano, Acciones de Gobierno para el Desarrollo Integral de los Pueblos Indígenas. Informe 2009. Comisión Nacional para el Desarrollo de los Pueblos Indígenas: México, DF, 2010:87-88. [Accessed 15 october 2009]. Available at: www.cdi.gob.mx.
- Peña-Reyes ME, Malina RM, Little BB, Buschang PH. Consumo de alimentos en una comunidad rural Zapoteca en el valle de Oaxaca. In: Ramos-Rodríguez RM, López-Alonso S (eds). Estudios de Antropología Biológica 5. México, DF, Instituto Nacional de Antropología e Historia: 1995:407-414.
- Ávila-Curiel A, Galindo-Gómez C, Chávez-Villasana A. Encuesta Nacional de Alimentación y Nutrición en el Medio Rural ENAL 2005,

- Resultados Oaxaca. Cuernavaca, México, Instituto Nacional de Salud Pública: 2006. [Accessed 14 august 2008]. Available at: http://www.nutricionemexico.org.mx/encuestas/enal_2005_oax.pdf
27. Malina RM, Pena Reyes ME, Tan SK, Little BB. Physical activity in youth from a subsistence agriculture community in the Valley of Oaxaca, southern Mexico. *Appl Physiol Nutr Metab* 2008; 33:819-830.
28. Malina RM, Peña-Reyes ME, Tan SK, Little BB. Physical fitness of normal, stunted and overweight children 6-13 years in Oaxaca, Mexico. *Eur J Clin Nutr* 2011; 65:826-834.
29. Shamah-Levy T, Morales-Ruan C, Rivera-Dommarco J, Hernández-Prado B, Gómez-Acosta LM, López-ERM, et al. Actividad física en adolescentes. In: Olaiz G, Rivera J, Shamah T, Rojas R, Villalpando S, Hernández M, et al. (eds). Encuesta Nacional de Salud y Nutrición 2006. Cuernavaca, México, Instituto Nacional de Salud Pública: 2006:105-109.
30. Hernández B, Gortmaker SL, Colditz GA, Peterson KE, Laird NM, Parra-Cabrera S. Association of obesity with physical activity, television programs and other forms of video viewing among children in Mexico City. *Int J Obes* 1999; 23:845-854.
31. Siegel SR, Malina RM, Peña-Reyes ME, Cárdenas-Barahona EE, Cumming SP. Correlates of physical activity and inactivity in urban Mexican youth. *Am J Hum Biol* 2011; 23:685-692.
32. Quinto-Cortés CD, Arriola LA, García-Hughes G, García-López R, Molina DP, Flores M, et al. Genetic characterization of indigenous peoples from Oaxaca, Mexico, and its relation to linguistic and geographic isolation. *Hum Biol* 2010; 82:409-432.
33. Torroni A, Chen Y-S, Semino O, Santachiara-Beneceretti AS, Scott CR, Lott MT, et al. mtDNA and Y-chromosome polymorphisms in four Native American populations from southern Mexico. *Am J Hum Genet* 1994; 54:303-318.
34. Wang S, Lewsis CMS, Jakobsson M, Ramachandran S, Ray N, Bedoya G, et al. Genetic variation and population structure in Native Americans. *PLoS Genet* 2007; 3 (e185):2049-2067.
35. Hunley K, Healy M. The impact of founder effects, gene flow, and European admixture on Native American genetic diversity. *Am J Phys Anthropol* 2011; 146:530-538.