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A systematic review of the nutritional adequacy of the diet in the Central Andes

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ABSTRACT

Objective. *To examine dietary adequacy in the Andean area, including macro- and micronutrient intakes, with a particular focus on rural communities; to highlight nutrition priorities in the Andes; and to identify opportunities for improvement.*

Methods. *A comprehensive literature search was conducted, identifying published and grey literature in English and Spanish related to diet in the central Andean countries of Bolivia, Colombia, Ecuador, and Peru. Articles reporting data from dietary surveys or nutrition interventions were included. Thirty-four papers or reports published in 1969–2011 were included in the final review. The mean and variation in intakes by sex and age group of all presented nutrients were collated and the mean of means were calculated.*

Results. *Thiamin, niacin, and vitamin C intakes were usually adequate. Intakes of most other micronutrients, including iron, zinc, vitamin A, riboflavin, vitamin B12, folate, and zinc were low, likely resulting in high levels of inadequacy. Energy intakes were lower than requirements, but it is unlikely to be a common problem, rather, this result was probably due to the known tendency of most dietary survey tools to underreport intake. However, energy from fat intakes was very low, usually less than 20% of the total, and in some settings, less than 10%.*

Conclusions. *The inadequate intake of some micronutrients is common in many developing countries, but the extremely low intake of dietary fat found in the central Andes is not. Increased consumption of animal-source foods would increase fat intakes, while addressing micronutrient deficiencies; however, the impact on the fragile ecosystem of the Andes needs considering. Indigenous crops, such as lupine bean, quinoa, and amaranth are also rich in fat or micronutrients.*

Key words Diet; nutrition, public health; macronutrients; Andean ecosystem; Bolivia; Colombia; Ecuador; Peru.

The Andes mountain range extends along the western coast of South America, beginning in Venezuela and running south through Colombia, Ecuador, Peru, Bolivia, to the farthest most reaches of Chile and Argentina. The central Andes comprises four countries—Colombia, Ecuador, Peru, Bolivia—that share a common culture and history (1), are relatively poor (ranked 85th–123rd for per-capita gross domestic product) (2), and subsist on a diet reliant on the potato and other tubers.

There have been many dietary studies and surveys on nutrition in the Central Andes over the last 40 years. An earlier review assessed intrahousehold distribution of food in low- and middle-income countries; it included four studies from the Andes (3). While limited in scope, it suggested that food is approximately equally-distributed in Andean households, consistent with the relative gender parity of the area (4). A great deal has been written about the role of the potato and other tubers in the Andean diet (5, 6), about indigenous crops and diversity of the Andean diet (7, 8), and seasonality in the Andes (9), but there has been no comprehensive review of the adequacy of the diet. A review of the nutritional status of Andean people will

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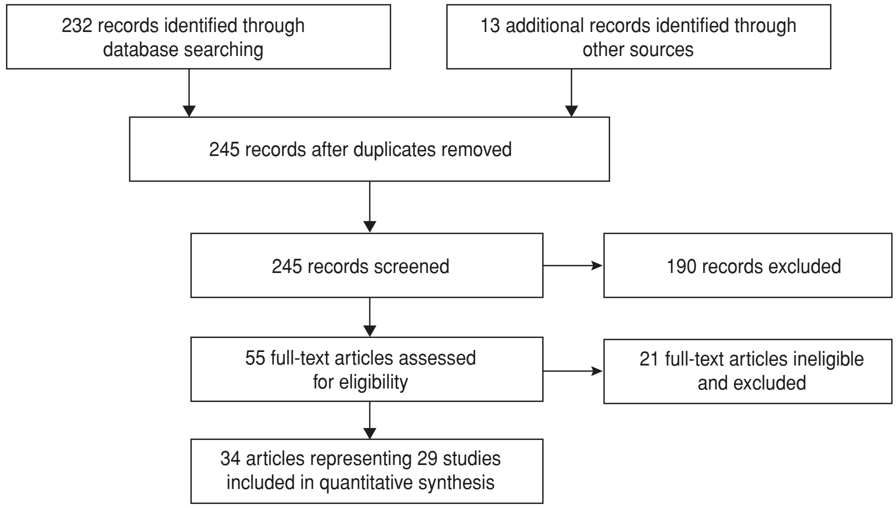
demonstrate the diet's various positive aspects and inadequacies, allowing for a better understanding of past work and for more informed planning of future nutrition programs.

The objectives of this literature review, therefore, were to examine the dietary adequacy across the Andean area, including macro- and micronutrient intakes, with a particular focus on rural communities; to highlight nutrition priorities in the Andes; and to identify opportunities for improvement.

FIGURE 1. Flow diagram of the search process for literature on the nutritional adequacy of the Andean diet, 1969–2011



MATERIALS AND METHODS

A comprehensive literature search was undertaken in January 2012–February 2013, following the guidelines of the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement (PRISMA) (10). Peer-reviewed and gray literature published since 1969, beginning with Gursky (11), were included in this review. Searches for relevant published literature were conducted in Medline, Embase, Scopus, and CINAHL using the following terms: (Peru OR Bolivia OR Ecuador OR Columbia OR Quechua OR Aymara OR Mestizo) AND (highland OR Andes OR altiplano) AND (food OR nutrition OR nutrient OR diet OR micronutrient). Google Scholar and Web of Science were also used to search for relevant articles using the same search criteria. Spanish equivalents of the search strategy were used to search the Spanish language literature. The World Health Organization (WHO), the World Bank, and global health websites were searched for relevant gray literature. Finally, articles and reviews were retrieved through backward searches (that is, search of the references in retrieved articles). Articles were scanned for relevance and those published in English or Spanish were included, as well as those that contained dietary data on populations identified as "Andean" or "highland."

Of these selected articles, those containing data from dietary surveys, nutrition interventions, or other studies that included dietary data were retained. Data were excluded if they were of lowland populations, published prior to 1969, or were of institutionalized subjects. Fifty-two papers or reports met the inclusion criteria; of these, 34 presented data suitable for inclusion (11–44). Some, however, were papers reporting from the same survey, and so in all, 29 original research projects or surveys carried out between 1969 and 2011 composed the literature review. The selection process is shown in Figure 1.

From the included papers and reports, data on the mean daily intakes of energy, macronutrients (carbohydrates, protein, and fat), micronutrients (vitamin A, thiamin, riboflavin, niacin, folate, vitamin B12, vitamin C, calcium, iron, iodine, and zinc), and study site locations were extracted. These data were recorded by age and gender groupings as presented in the papers. The dietary data tool used was also recorded (dietary recall, weighed record, or food frequency questionnaire [FFQ]), number of subjects, and number of observations per subject. In some cases, data were presented by sub-groups (e.g., pre- and post-harvest; high-, mid-, and low-socioeconomic status). In these cases each sub-group was recorded separately.

For the presentation of the nutrient intakes by age, an average and a standard deviation (SD) for each nutrient was calculated at 1-year intervals from birth to 19 years of age, and then another for adults. For reports that crossed multiple years, the mean was counted multiple times (e.g., if the average iron intake of children 2–4 years of age was 5 mg, then 5 mg was used in the calculation of average intakes for those 2, 3, and 4 years of age). The standard deviation was calculated as the SD of the means, not a pooled SD from all reports. There were few reports on pregnant or lactating women, so all women were grouped together.

Energy adequacy

Energy requirements vary with body size. Average body weight in Andean children tracks ~2 kg below the WHO international reference growth standards (45) from birth to approximately 10 years of age. At 10 years, the body weight of Andean children begins to fall farther behind WHO reference growth levels (e.g., 14, 23, 27, 31, 44), so that by adulthood, they weigh about ~10 kg less than their reference populations. Therefore, for estimates of energy requirements, the body weight of boys and girls, 1–10 years of age, was estimated as 2 kg less than the WHO reference population; at age 11 years, 3 kg less; at 12 years, 4 kg less, and so on; until at 19 years, both sexes were estimated 10 kg less, or 50 kg (females) and 60 kg (males). Body weight, along with gender and age, can be used to predict basal metabolic rate (BMR).

Energy requirements also vary with physical activity level (PAL), which is commonly expressed as a multiple of BMR. PAL varies from 1.4 for sedentary lifestyles, to 2.2 for highly vigorous lifestyles. It was hypothesized that the average, rural Andean (most of the reviewed data was from rural populations) has a PAL of 2.05, consistent with the Food and Agriculture Organization of the United Nations' (FAO) description of "populations with vigorous lifestyles," examples of which include:

> ". . . children and adolescents who every day walk long distances . . . engage in high energy-demanding occupations, or perform high energy-demanding chores for several hours each day; [Adults who] engage regularly in strenuous work or in strenuous leisure activities for several hours. Examples are . . . non-mechanized agricultural laborers who work with a machete, hoe or axe for several hours daily . . ." (46)

This definition is consistent with studies of Andean populations that have measured energy expenditure using doubly-labelled water, or heart-rate monitoring. In a Bolivian Aymara herding population, PAL were measured at approximately 1.8 in adult males and 2.0 in adult females (26), and later in the same communities, there was no difference between men (2.18 ± 0.23) and women (2.26 ± 0.25). Among Ecuadorian farmers, PAL was 2.39 ± 0.50 in adult males and 1.97 ± 0.57 in adult females (47). In urban Colombian women, PAL were 1.83 ± 0.43 for women at home and 1.90 ± 0.46 for women working outside the home (48).

Thus, this study integrated the physical activity (PAL of 1.4 or 2.05) and body weight estimates with the kcal per-kg body weight per-day estimates of energy requirements (46) to generate age- and sex-specific requirements, to which average energy intakes from these reports were compared.

Nutrient adequacy

Estimated nutrient requirements for evaluating diet adequacy were compiled from various sources (46, 49–53). In most cases, comparison was made to the Estimated Average Requirement (EAR), the level of intake necessary to meet the needs of 50% of the population. Calculation of the prevalence of nutrient inadequacy requires application of the cut-point method (54), which requires the individuals' intakes and is not feasible with summary data. Therefore, the assessment of adequacy carried out was approximate: when the average of a given nutrient was equal to the EAR, approximately 50% of the population would have inadequate intakes; when > the EAR, inadequacy would be < 50%; and when < the EAR, inadequacy would be > 50%.

RESULTS

Availability of data

Data sources are summarized in Table 1. Thirty-four different reports were available, including some national studies and multisite studies, but mostly single local/village level studies. When data from a single research site were presented in multiple papers (e.g., 13–15), it was considered a single "report." Of the 29 total reports, 7 were from Bolivia, 5 from Colombia, 6 from Ecuador, and 11 from Peru. Energy intake data were presented in 26 of these reports, whereas some nutrients were presented only once (iodine). Macronutrients were presented frequently: protein in 18 reports; fat, 12; and carbohydrates, 12. Some minerals were presented more often than others: iron in 12 reports; calcium, 11; zinc, 6; selenium, 1; and iodine, 1. There was also variation in the frequency of vitamin reporting: vitamin A in 12 reports; vitamin C, 11; riboflavin, 9; niacin, 9; thiamin, 8; folate, 6; and vitamin B12, 4. One report had data for energy and 15 macro- and micronutrients (42), but most presented data on fewer nutrients. The median presented data on three nutrients, 5 reports presented data on only energy, and 1 paper presented only folate intakes (39).

The dietary tool used most often was the 24-hour dietary recall (20 studies) and weighed records were used in 5 studies. FFQ were used alone in 1 study, and in combination with 24-hour recalls in 1 other study.

The representativeness of the data varied among studies. Most studies were from a single community or geographic area, with a small sample not drawn randomly from the study population; a couple of studies were nationally representative (31, 43). Even though approximately two-thirds of the populations of the countries reviewed live in urban areas, more data came from rural residents (Table 1). Overall, the reviewed data are not statistically representative of the Andean people. The data may be biased towards poorer households with oversampling of the diets of the rural poor, as a number of the studies intentionally targeted more vulnerable populations or more isolated and traditional populations.

Energy and nutrient intake

Average energy intakes from all the included observations are plotted in Figure 2, along with FAO recommendations for energy intakes by gender, age, and light and heavy activity levels (46). Intakes increase with age throughout childhood, but are usually less than the recommended amount.

In adults (data not shown) most reports present intakes less than 20% energy from fat, and in children (Figure 3), three-quarters of the reports show percent energy from fat less than the minimum of the recommended range.

Across age groups, iron intakes were relatively high; zinc intakes were moderate; and calcium intakes were low relative to requirements. Average intakes and their SDs are presented in Figure 4.

The average intakes of most vitamins were low for most age groups. For vitamin A, riboflavin, and folate, average intakes and their SDs from the reviewed literature are presented in Figure 5.

DISCUSSION

This is the first comprehensive review of the literature on dietary intakes in the Andean countries of Bolivia, Colombia, Ecuador, and Peru. The data represents a range of ethnic groups, age groups, genders, and socioeconomic levels, and includes urban and rural populations. So while there were 34 different reports, from 29 unique studies, there were so many different subpopulations (and most using non-representative sampling methods) that only crude statistics could be applied to the summary statistics from each paper—namely, the mean of the means and the standard deviation of the means, and these summary statistics are only approximations of the underlying real nutrient intakes in the Andes. Nonetheless, there are important implications from the data.

Energy intake

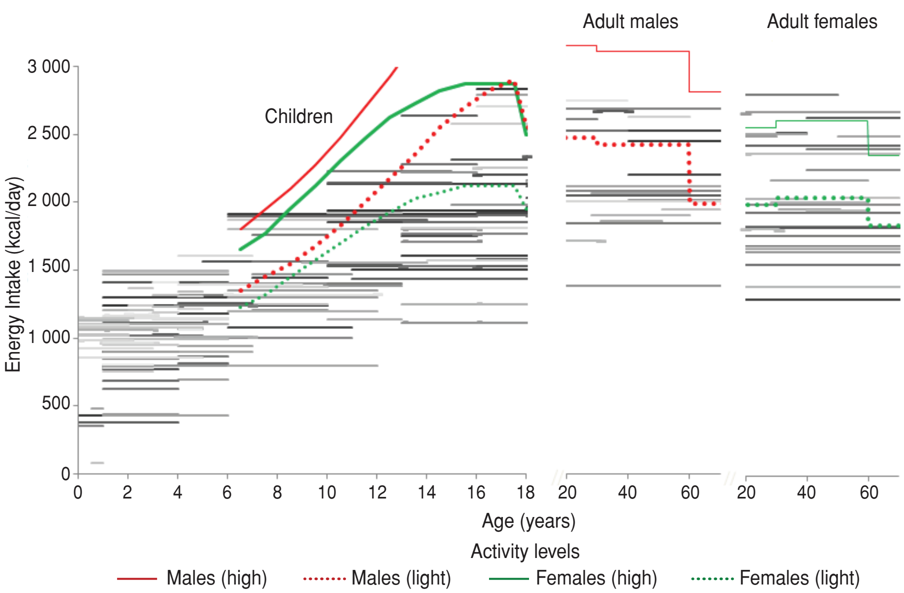
The reported energy intakes are low throughout the lifespan (Figure 2). For children less than 2 years of age, this may be in part because breast milk intake is underestimated. In children 2–10 years of age, the average intakes

TABLE 1. Summary of the literature included in a systematic review of literature on dietary intakes in the Andean countries of Bolivia, Colombia, Ecuador, and Peru, 1969–2011

Reference	Country	Survey year[a]	Location[b]	Altitude[c]	Dietary tool[d]	Days /person[e]	*n*	Age groups[f]	Energy[g]	Macro[h]	Vitamins[i]	Minerals[j]
12	Bolivia	2006, 2007	Potosi	2 800–4 100	24-hr	1	2 178	All ages	E	C,P,F	A, T, R, N, C, F	F, C
16	Bolivia	1978, 1979	La Paz	3 793	24-hr	1–3	70	18+ y	E	P		
26	Bolivia	1988	La Paz	4 000–4 100	Weighed	7	91	All ages	E	C,P,F	A, T, R, N, C	F, C
30	Bolivia	1988	La Paz	4 000–4 100	Weighed	7	91	All ages				S
33	Bolivia	<1982	La Paz	3 660	24-hr	1	117	7–11 y, M	E	C,P,F	A, R, N	F,C
34	Bolivia	2001	El Alto	4 080	24-hr	1	85	0–2 y	E	C,P,F	A, C	F,C
44	Bolivia	1978	Chuquisaca & Tarija	1 000–3 500	24-hr	1	224	1–5 y	E	P		
35	Colombia	<2011	Bogotá	2 600	24-hr	1	406	1–12 y	E	C,P,F	A, C	F, C, Z
36	Colombia	<2011	Bogotá	2 600	24-hr +FFQ	1	154	18–53 y	E	C,P,F		
37	Colombia	2009	Antioquia	1 000–4 080	24-hr	1–2	353	All ages	E	C		
38	Colombia	2005	urban	1 000–3 000	24-hr	1	2 400[k]	1–5 y	E		A, C	F, C, Z
39	Colombia	2009	Sante Fé	2 630	FFQ +24-hr	1	120				F	
13–15	Ecuador	1994	Salcedo	3 300–3 600	24-hr	1–6	183	All ages	E	C,P,F	A, T, R, N, 12, C, F	F, C, Z
27	Ecuador	1995,1996	Chimborazo	2 400–4 000	24-hr	4	91	20+ y, F	E	P	A, T, R, N, 12, C	F, C, Z
28	Ecuador	1995,1996	Chimborazo	2 400–4 000	24-hr	4	91	20+ y, F	E	C,P,F	A, T, R, N, 12, C, F	F, C, Z
31	Ecuador	1986	Sierra		24-hr	1	1 696	0–5 y	E	P,F	A,R,N,T,C	F,C
32	Ecuador	1992,1993	Salcedo	3 000–3 500	24-hr		61	0–5 y	E	P		
42	Ecuador	1999, 2000	Carchi	2 800–3 400	24-hr	2–3	276	All ages	E	C,P,F	A, T, R, N, 12, C, F	F, C, I, Z
18–19	Peru	1986–7	Puno	3 400	Weighed	1	124	All ages	E			
17	Peru	1995–7	Puno	3 400	Weighed	1	208	All ages	E			
11	Peru	1967	Nuñoa	4 000	na	1	36	All ages	E			
21	Peru	1968	Nuñoa	4 000	na	1	37	All ages	E			
22	Peru	<1976	Cuzco	3 430–3 822	3 day recall	3	30	18 yr+, M	E	C,P,F		
25	Peru	<1996	Huarez	3 300	24-hr	1	151	9–13	E	P		F
29	Peru	<1985	Pacobamba	2 700	24hr	3	29	0–3 y	E	P	A, T, R, N, C	C
40	Peru	2003	*National*		24-hr	1	120	12–35 m, 15–49 y, F			T, R, N, C, F	
41	Peru	1990–5	Multiple	~3 442	24-hr	1	680	1–3 y	E			
20,23,24	Peru	1985	Nuñoa	4 000	Weighed	1 to 2	146	All ages	E	C		
43	Peru	1997–2001	Sierra		24-hr	1	579	0–5 y	E	C,P,F	A	F

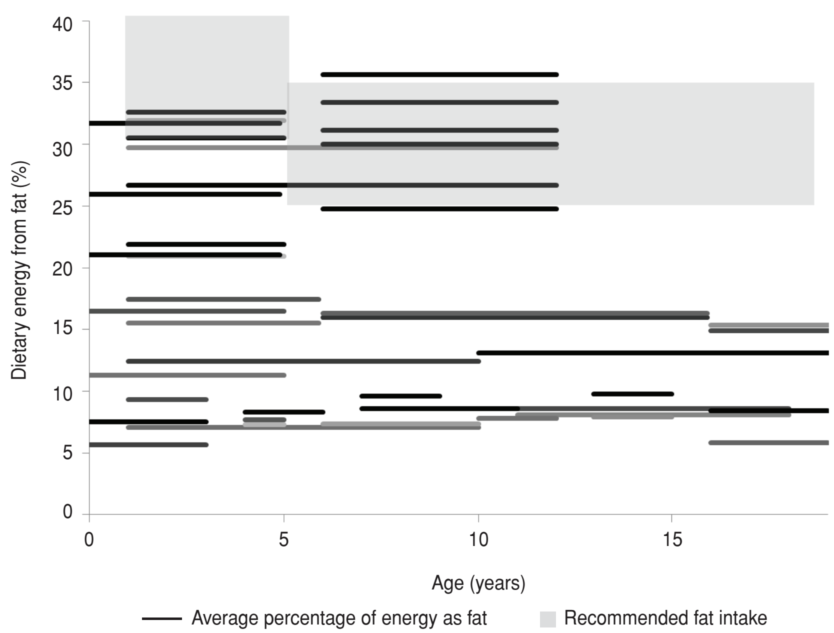
[a] The year in which the data were collected. If not specified in paper, then "<" is entered in front of the publication year.
[b] When the survey population was primarily urban, the location name is bolded.
[c] Meters above sea level
[d] Dietary tool used to collect data: 24 hr = 24 hour dietary recall; weighed = weighed food record; FFQ = Food Frequency Questionnaire; blank = unspecified
[e] The number of days observed per person
[f] Age groups: m = months, y = years, M = Males, F = Females
[g] If energy was measured indicated with e
[h] C = Carbohydrates, P = Protein, F = Fat
[i] A = Vitamin A, T = Thiamin, R = Riboflavin, N = Niacin, 12 = Vitamin B12, C = Vitamin C, F = Folate
[j] F = Iron, C = Calcium, I = Iodine, S = Selenium, Z = Zinc
[k] 2400 is the number of households in the survey, drawn from 30 municipalities. The number of individuals was not stated.

FIGURE 2. Average energy intakes from the reviewed literature on dietary intakes in the Andean countries of Bolivia, Colombia, Ecuador, and Peru, 1969–2011



Source: Food and Agriculture Organization of the United Nations, World Health Organization, United Nations University, 2004 (46).
Note: Each horizontal line represents an averge intake from the reviewed literature.

FIGURE 3. Contribution of fat to energy intake from the literature on dietary intakes in the Andean countries of Bolivia, Colombia, Ecuador, and Peru, 1969–2011



Note: Horizontal lines are average percentage of energy as fat in reviewed literature. Gray boxes represent recommended fat intake.
Source: National Research Council. Dietary reference intakes for energy, carbohydrate, fiber, fat, fatty acids, cholesterol, protein and amino acids (macronutrients). Washington, DC: National Academy Press; 2005.

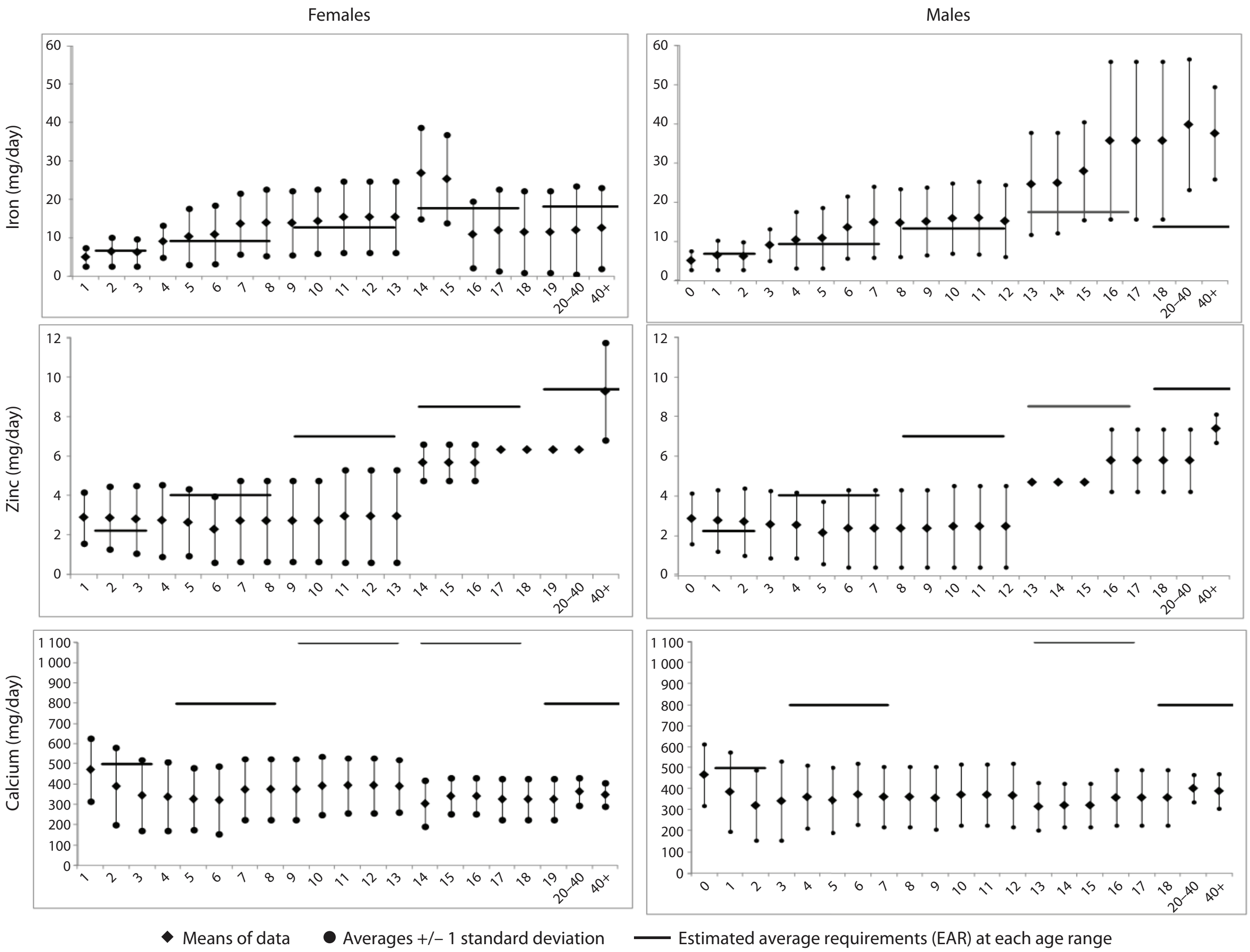
fall near the boundary of energy requirements for a light activity level. In the teen years and into adulthood, many of the average energy intakes are much less than estimated requirements, even for a light activity level. Such low intakes almost surely reflect underreporting. While an individual may have energy intakes less than requirements for a day or a short period, and preharvest shortages have been observed in the Andes (9), it is not possible that an entire population has lower-than-required intakes over a period of years. Not only are the reported intakes less than required for heavy activity (the level of typical rural populations), they often fall short of requirements for light activity, and in the long-term, would not suffice to sustain life. We conclude, therefore, that most of these reports underreport real food intakes—a common problem with dietary recall surveys (55).

Underreporting is an impediment to interpreting the reviewed literature, but it does not negate the usefulness of the reviewed nutrient intakes; rather, interpretation needs to consider the average intake and understand that the real, but unknown, intake may be 10%–50% greater. Also, it is not known if underreporting occurs evenly across all foods (e.g., all portion sizes are systematically underestimated by 10%), or if there is selective underreporting of certain food types (e.g., perceived unhealthy foods). If the underreporting is across all foods, then the underreporting of micronutrients is likely proportional to the underreporting of energy. If the underreporting is selective, then there might be only minimal underreporting of micronutrients. Therefore, it can be assumed that intakes that appear adequate, despite the underreporting, would be adequate if accurate data were available. However, intakes that are inadequate may be truly inadequate, or simply appear to be inadequate due to underreporting. This limitation colors the rest of the discussion.

Fat intake

Fat intakes in the reviewed reports are remarkably low (Figure 3), with numerous observations where energy from fat is less than 10%. Fat intakes appear to be higher in urban areas and wealthier countries, i.e., Colombia (35) and Ecuador (31), and lower in rural areas and poorer countries, i.e., Peru (43) and Bolivia (12). The consequences of insufficient fat intake are broad and deep, leading to poor child growth (56–58), impairing neurobehavioral development (58), and immune system function (59). Some of the impacts are due to insufficient total fat intake, and others are due to insufficient intake of specific essential fatty acids (57). Site-specific recommen-

FIGURE 4. Average intakes of iron, zinc, and calcium from the literature on dietary intakes in the Andean countries of Bolivia, Colombia, Ecuador, and Peru, 1969–2011



dations regarding fat are required. While it is important to increase the fat in the diet of the poor and rural areas, it should not be by increasing consumption of obesogenic, high-fat, "ultra-processed" foods, which would contribute to poor health (60).

Mineral intakes

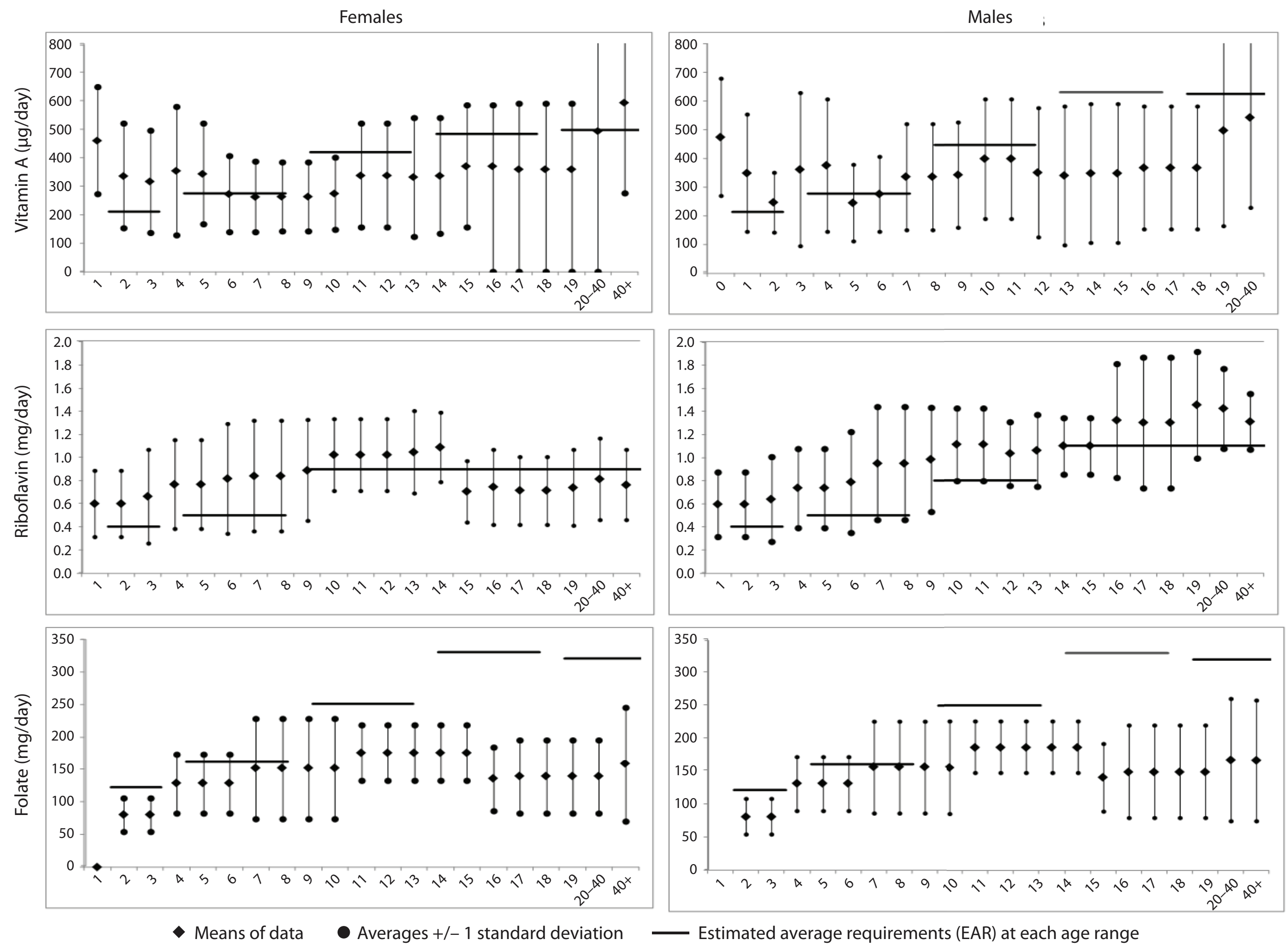
As with energy, widespread underreporting of mineral intakes was likely, and real intakes were likely higher by some unknown amount, but we speculate 10%–50%. Nonetheless, a few general observations can be made about each mineral.

Average iron intakes were higher than the EAR. However, iron requirements are highly dependent on the bioavailability of the iron in the diet. We have assumed bioavailability of dietary iron to be 8%, but it would vary markedly among geographic areas. In some parts of the Andes, it may be as low as 5%, and in populations with high meat intakes, as high as 18%, but probably 8%–12% (61). The most recent national surveys, which include areas outside of the Andes, observe anemia levels in non-pregnant women and children of: 33% for both in Colombia; 15% and 25% in Ecuador; 40% and 36% in Peru; and 61% and 35% in Bolivia (62, 63). While these include non-iron deficiency anemia, they are consistent with the intakes presented in Figure 4.

Average zinc intakes were far below the EARs, especially in late childhood and in adults. This is likely due in part to underreporting, and in part, to a less complete food composition database for zinc. For example, the Bolivian food composition table has data for 1 178 foods with entries for iron, but only 180 for zinc (64). However, for zinc inadequacy to *not* be a public health problem, the real intakes would need to be 2–3 times higher than in the reviewed literature. Two- to three-fold underreporting is unlikely, and inadequate intakes of zinc are probably common in the Andes, which could lead to impaired linear growth in children, impaired immune system function, and cognitive impairment (65).

Average calcium intakes are relatively constant across the age groups, fluctuating from 300 mg–400 mg—far below the EARs, which range from 500 mg at 1 year of age to 1 100 mg in adults. Despite the low average intakes of calcium, poor bone health is not a major contributor to burden of disease in the Andean countries (66).

FIGURE 5. Average intakes of vitamin A, riboflavin, and folate from the literature on dietary intakes in the Andean countries of Bolivia, Colombia, Ecuador, and Peru, 1969–2011



Dietary iodine intakes were presented in only one study, so the data were insufficient to estimate its adequacy. Until about 40 years ago when universal salt iodization was implemented, iodine deficiency was a serious public health problem throughout the Andes. Now over 90% of households use iodized salt in Colombia, Ecuador, and Peru, and 89% in Bolivia (67); therefore, iodine intakes are probably adequate in most households.

Vitamin intakes

As with the minerals, there was probably underreporting of vitamin intakes of 10%–50%. In childhood through adolescence, vitamin A intakes are relatively constant–approximately equal to the EAR in early childhood, but not increasing with the EAR as it should in later childhood. Average intakes in adults were usually much lower than the EARs. However, available biochemical indicators of vitamin A status show low levels of deficiency: in Ecuador, low serum retinol of 17% in children in 2013 (63); in highland Peru, in 12% of children and 5% of women in 2001; and in highland Bolivia, 14% of children in 1991 (68). Vitamin A deficiency may be less of a public health problem than would be expected from the dietary data.

Average riboflavin intakes were higher than the EAR in children and adult men, but lower in adult women. The lower intake in women was shown by one report (40) that contributed multiple observations of low riboflavin intake for women from various sites in Peru, and thus contributed to a low average intake in women. This likely does not reflect a real Andes-wide difference in riboflavin intake between men and women, and riboflavin inadequacy is likely not common. Similarly, women had lower intakes of folate (and thiamin, niacin, and vitamin C, not shown) than men, according to one report (40). Other sources (3, 14) do not suggest large differences between the diets of Andean men and women. Thiamin, niacin and vitamin C intakes appear to be generally adequate.

Vitamin B12 intakes were presented in only two reports, and in both were approximately equal to the EAR, suggesting high levels of dietary inadequacy. As vitamin B12 comes from animal source foods (meat, eggs, milk; ASF) and the Andean rural poor have low intakes of these, low B12 is not unexpected.

Study limitations

All available literature in English and Spanish was drawn upon to carry out this review, however, the analysis was hampered by three important limitations. First, the available literature is not statistically representative of the Central Andes. Rural areas are studied more often than urban ones, and poor areas more often than wealthier, and changes in national diets that have certainly taken place over the last 40 years have been lost in the averages presented here, even though our review draws on data collected by four studies in the 1960–1970s, eight in the 1980s, seven in the 1990s, and 10 in 2000–2010. Furthermore, few of the studies were based on statistically representative samples.

The second limitation is that two-thirds of the reviewed studies used 24-hour dietary recalls, which are known to often under-estimate intakes, but nonetheless are the most common dietary assessment method. Only two of the studies used FFQs, which sometimes over-estimate, and about one-quarter of the studies used directly weighed records, for which accuracy varies (55). Few of the studies had multiple observations in different seasons, and so seasonal variations were not reflected in the observations. Also, the bioavailability of some nutrients, most notably iron and zinc, are affected by the presence of enhancers and inhibitors in the meal. Failing to account for the whole meal leads to errors in interpretation of dietary intakes (55).

The third limitation is that simple mathematical averages were calculated, not weighted for sample size or representativeness of the region. Applying weighting or pooling did not seem warranted given the data quality and its heterogeneity. Thus, these mathematical averages should not be seen as precise estimates, but rather, rough approximations, and are susceptible to the outlier values of single reports. Therefore, this review does not provide an accurate diagnosis, but does provide a description of dietary strengths and limitations in the Andes.

Conclusions

The available dietary data from the highlands of Bolivia, Colombia, Ecuador and Peru revealed low average intakes of dietary fat, iron, zinc, calcium, vitamin A, folate, and vitamin B12. Clearly low intake of dietary fat is an important issue–at least in rural populations. And although contemporary urban populations may not have low fat intakes, they likely consume poor quality dietary fats. Food-based approaches may be useful for improving dietary fat and micronutrient intakes. A number of indigenous crops, such as lupine bean (*Lupinus mutabilis*, [69, 70]), quinoa (*Chenopodium quinoa* [69]), and amaranth (*Amaranthus* [69]) are rich in fat or micronutrients. ASF can be an excellent source of most nutrients, as well as fat. ASF-based interventions have been effective at improving diet (71–73), and suggestions to increase its consumption would likely be well received by Andean populations. However, it remains to be seen if ASF production can be increased to a level that improves diet, yet in a manner sustainable in the fragile ecosystem of the Andes and at a cost affordable to the poor.

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Conflict of interest. None.

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RESUMEN

Revisión sistemática de la adecuación nutricional del régimen alimentario en los Andes centrales

Objetivo. Analizar la adecuación del régimen alimentario en la zona andina, incluidas las ingestas de macro y micronutrientes, prestando especial atención a las comunidades rurales; señalar las prioridades nutricionales en los Andes; y establecer las oportunidades de mejora.

Métodos. Se llevó a cabo una exhaustiva búsqueda bibliográfica, en la que se seleccionaron documentos publicados y procedentes de la literatura gris, en inglés y español, relacionados con el régimen alimentario en los países andinos centrales de Bolivia, Colombia, Ecuador y Perú. Se incluyeron artículos que aportaran datos de encuestas alimentarias o intervenciones nutricionales. En el análisis final, se incluyeron 34 artículos o informes publicados desde 1969 a 2011. Se recopilaron las medias y las variaciones de las ingestas de todos los nutrientes presentados según el sexo y el grupo de edad, y se calculó la correspondiente media de las medias.

Resultados. Las ingestas de tiamina, niacina y vitamina C eran generalmente adecuadas. Las ingestas de la mayor parte de los restantes micronutrientes, incluidos el hierro, el cinc, la vitamina A, la riboflavina, la vitamina B12 y el folato, eran bajas, lo que probablemente ocasionaba altos niveles de inadecuación. Los aportes energéticos eran inferiores a los requeridos, aunque es poco probable que ello constituya un problema frecuente; más bien, este resultado podría deberse a la tendencia conocida de notificar insuficientemente la ingesta en la mayor parte de las encuestas alimentarias. Sin embargo, el aporte energético procedente del consumo de grasas era muy reducido, generalmente por debajo del 20% del total, y en algunos lugares, por debajo del 10%.

Conclusiones. La ingesta inadecuada de algunos micronutrientes es frecuente en muchos países en desarrollo, aunque no es tan frecuente la ingesta extremadamente baja de grasa alimentaria observada en los Andes centrales. Un mayor consumo de alimentos de origen animal aumentaría la ingesta de grasas, al tiempo que abordaría las carencias en micronutrientes; sin embargo, debe tenerse en cuenta su posible repercusión sobre el frágil ecosistema de los Andes. Los cultivos autóctonos, como el frijol de altramuz, la quinoa y el amaranto, son también ricos en grasas o micronutrientes.

Palabras clave Dieta; nutrición en salud pública; macronutrientes; ecosistema andino; Bolivia; Colombia; Ecuador; Perú.