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NUTRITION IN ADOLESCENT GIRLS: NUTRIENT INTAKE, DIETARY PATTERNS AND IMPLICATIONS FOR BONE AND CARDIOMETABOLIC HEALTH — A CRITICAL NARRATIVE REVIEW

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review paper

Summary

Adolescence is a period of rapid growth, pubertal maturation and development of dietary habits. This critical narrative review examines nutrient intake, dietary patterns and their associations with bone and cardiometabolic health in adolescent girls. PubMed was searched iteratively up to 9 October 2026 using combinations of terms for adolescent girls, dietary intake, iron, folate, calcium, vitamin D, bone health and dietary patterns, including studies from the European Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) project. Studies were selected purposively, prioritising sex-stratified observational data, European and Croatian studies, systematic reviews and randomised trials. In the European nutrient-intake analysis (n = 1,590; 859 girls), median intakes among girls aged 13–15 and 15–17.5 years were approximately 9.6 and 9.8 mg/day for iron, 722 and 661 mg/day for calcium, 187 and 195 µg/day for folate, and 1.8 µg/day for vitamin D in both groups. These estimates must not be interpreted as the prevalence of biochemical deficiency. Other analyses from the same project associated greater recreational screen exposure with less favourable dietary patterns, while a Croatian cross-sectional study linked selected dietary habits with elevated blood pressure. Systematic reviews of calcium and vitamin D trials showed limited and outcome-specific skeletal benefits in generally healthy young people. Taken together, the evidence favours dietary adequacy and whole-diet approaches rather than indiscriminate supplementation. Interpretation is constrained by cross-sectional designs, selection bias, heterogeneous outcomes and older European datasets. Further representative, sex-specific longitudinal and intervention studies are needed.

Keywords: adolescent girls, nutrient intake, dietary patterns, bone health, micronutrients

Introduction

Adolescence is a biologically sensitive stage during which linear growth, changes in body composition, endocrine maturation and the development of independent eating behaviours occur simultaneously. In girls, the onset of menstruation adds an important source of iron loss, while substantial skeletal mineral accrual increases the relevance of adequate calcium intake, vitamin D status and weight-bearing activity. These changes do not imply that all girls have the same requirements: chronological age, pubertal stage, menstrual characteristics, activity and health status vary considerably.

A useful appraisal of adolescent nutrition must distinguish four constructs that are often conflated: reported food consumption, estimated usual nutrient intake, biochemical nutritional status and clinically meaningful outcomes. A low dietary intake does not establish deficiency; likewise, a statistically significant association between a dietary behaviour and an outcome does not establish causation. This distinction is especially important when evaluating large cross-sectional datasets and intervention trials with surrogate bone outcomes.

The aim of this review is to critically synthesise evidence on nutrient intake and dietary patterns in adolescent girls, with particular attention to iron, folate, calcium and vitamin D; examine observational associations with lifestyle and cardiometabolic markers; compare these findings with intervention evidence on bone health; and identify implications for research and nutrition education.

Materials and methods

Review design and literature identification

A critical narrative review was undertaken. PubMed was searched iteratively using topic-specific search strategies conducted during manuscript development and completed on 9 October 2026. Search concepts included “adolescent girls”, “female adolescents”, “nutrition”, “diet quality”, “dietary patterns”, “iron deficiency”, “folate”, “calcium”, “vitamin D”, “bone mineral density”, “HELENA study”, “Europe” and “Croatia”, combined with Boolean operators. One

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documented HELENA query was: ("HELENA study"[Title/Abstract] OR "HELENA study"[All Fields]) AND ("diet quality"[Title/Abstract] OR "dietary patterns"[Title/Abstract] OR "food consumption"[Title/Abstract] OR "dietary intake"[Title/Abstract]); this returned 54 records at the time of searching. Additional targeted searches identified reviews and randomised trials of supplementation. Relevant full-text sections and sex-specific tables were examined where accessible.

Selection, extraction and interpretation

Priority was given to studies reporting findings separately for girls, studies of European and Croatian populations, systematic reviews and randomised controlled trials. Older landmark studies were retained where they addressed a question not adequately answered by newer sources. Extracted information included design, sample size, age, sex distribution, dietary assessment, outcome definition, major findings and limitations. The evidence was organised thematically; no pooled effect estimate was calculated. Studies from the same HELENA research programme were considered potentially overlapping populations rather than independent prevalence estimates. This was not a systematic review: there was no registered protocol, exhaustive dual screening, complete Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) flow diagram or formal risk-of-bias assessment of every retrieved record. Consequently, the evidence base is selective and findings should not be interpreted as an exhaustive synthesis.

Results and discussion

1. Dietary intake and nutritional quality in European adolescent girls

The HELENA project provides a large comparative European dataset. Diethelm et al. (2014) assessed nutrient intake in 1,590 adolescents from eight European cities, including 859 girls and 731 boys, using two non-consecutive 24-hour recalls. The initial sample comprised 3,528 adolescents. In the analysed sample, the intake of many nutrients was broadly aligned with the German, Austrian and Swiss (D-A-CH) reference values used by the investigators, whereas saturated fat and salt intake were high and polyunsaturated fatty acid intake was low. Dietary vitamin D, folate and iodine were among the nutrients falling substantially short of the reference framework; the median Nutritional Quality Index (NQI) was 71 out of 100.

Sex-stratified results are particularly relevant. Among girls aged 13–15 years (n = 451), the reported median daily intakes were approximately 9.6 mg iron, 722 mg calcium, 187 µg folate and 1.8 µg vitamin D. Among girls aged 15–17.5 years (n = 357), corresponding medians were 9.8 mg, 661 mg, 195 µg and 1.8 µg. The youngest category in the original table included an additional 51 girls and is not combined with these two groups. Table 1 presents the principal values. The figures are population medians, not estimates of the percentage of individuals below an estimated average requirement.

Interpretation of these estimates depends on the reference system and assessment method. A recommended intake is not interchangeable with an estimated average requirement, and the prevalence of inadequacy cannot be inferred by comparing a group median with a recommended allowance. Moreover, two recall days may not characterise long-term individual intake without appropriate modelling. Dietary vitamin D is particularly difficult to translate into serum 25-hydroxyvitamin D status because sunlight exposure and other determinants also contribute.

Selection is another substantive concern. In the HELENA nutrient analysis, the adolescents retained for analysis had lower body mass index standard-deviation scores, lower adiposity and a lower prevalence of overweight than those excluded because of missing or implausible dietary information. This limits generalisability and could bias estimates if dietary reporting differs by weight status (Diethelm et al., 2014).

Table 1. Median estimated dietary intakes in adolescent girls from the HELENA study (Diethelm et al., 2014). Values are medians of reported intakes; they are not deficiency prevalence estimates

Nutrient	Girls aged 13–15 y (n = 451)	Girls aged 15–17.5 y (n = 357)
Iron (mg/day)	9.6	9.8
Calcium (mg/day)	722	661
Folate (µg/day)	187	195
Vitamin D (µg/day)	1.8	1.8

2. Iron and folate: growth, menstruation and nutritional vulnerability

Iron supports haemoglobin synthesis, oxygen transport and numerous enzymatic pathways. In adolescent girls, requirements reflect growth and, following menarche, menstrual blood losses. Diet composition also matters: haem iron is more readily absorbed than non-haem iron, while enhancers and inhibitors of absorption influence bioavailability. Consequently, dietary counselling should consider food combinations, menstrual history and the possibility of restrictive eating rather than treating iron intake as an isolated number.

The HELENA medians of approximately 9–10 mg/day in older girls raise concerns about adequacy relative to the reference values used by the investigators (Diethelm et al., 2014). However, dietary data cannot diagnose iron deficiency or iron-deficiency anaemia. In clinical settings, interpretation of a full blood count and ferritin may be appropriate when symptoms or risk factors are present, with inflammatory status considered when relevant. Iron supplementation is not equivalent to general dietary improvement and should be tailored to clinical indications and local recommendations.

Folate contributes to DNA synthesis, cell division and haematopoiesis. The HELENA medians of 187–195 µg/day among girls aged 13–17.5 years were below the study's reference values. This finding supports attention to folate-rich foods, but does not establish biochemical folate deficiency. Adolescence also provides an opportunity to build nutritional literacy relevant to later reproductive life, without assuming that reproductive health concerns are identical across all adolescent girls.

3. Calcium, vitamin D and skeletal development

Bone mineral accrual accelerates during puberty and depends on genetics, sex hormones, maturation, mechanical loading and nutrient availability. In HELENA, median calcium intake declined from 722 mg/day in girls aged 13–15 years to 661 mg/day in the older group, while estimated dietary vitamin D intake remained around 1.8 µg/day (Diethelm et al., 2014). These findings justify attention to food sources of calcium and to overall vitamin D status where clinically indicated; they do not establish low bone density or a biochemical deficiency.

Evidence from supplementation trials is more directly relevant to causal questions but remains outcome-specific. Winzenberg et al. (2006) synthesised 19 randomised trials involving 2,859 children and adolescents. Calcium supplementation produced small improvements in some bone outcomes, including total-body bone mineral content and upper-limb bone mineral density, but no convincing improvements at the hip or lumbar spine. These surrogate changes should not be presented as proven fracture prevention. The review did not establish a robust sex-specific benefit.

In an individual-participant-data meta-analysis, Wu et al. (2023) included 11 randomised trials; nine supplied individual data on 1,439 participants, of whom 86% were female. Vitamin D supplementation produced a small effect on total hip areal bone mineral density after one year (mean difference 6.8 mg/cm²; 95% confidence interval 0.7–12.9), with no clear effects on the other assessed bone outcomes. There was no convincing interaction with baseline vitamin D concentration within the studied range. The authors emphasised that the evidence was largely applicable to White postpubertal girls and did not address symptomatic vitamin D deficiency or concentrations outside the investigated range.

Together, these reviews challenge the assumption that routine high-dose supplementation improves skeletal outcomes in all healthy adolescents. They do not negate the need to treat diagnosed deficiency or to ensure appropriate intake. Nutritional adequacy, physical activity and individual risk assessment are more defensible priorities than universal supplementation without indication.

4. Dietary patterns, breakfast and sedentary behaviour

Dietary-pattern analyses can capture co-occurring food choices that nutrient-by-nutrient approaches miss. In a HELENA cross-sectional analysis of 2,202 adolescents, Santaliestra-Pasías et al. (2014) identified five patterns among girls: confectionery and snacking, plant-based, breakfast, animal-protein and health-conscious patterns. Watching television or using the internet recreationally for more than four hours per day was associated with greater adherence to the confectionery-and-snacking pattern and lower adherence to the health-conscious pattern in girls. The "plant-based" label refers to a statistically derived dietary pattern and should not be equated with veganism or vegetarianism.

A later HELENA analysis of 1,804 adolescents found that adolescents who regularly consumed breakfast had higher diet-quality and Mediterranean diet scores than habitual breakfast skippers in both sexes after accounting for specified covariates (Giménez-Legarre et al., 2022). Nevertheless, breakfast consumption may also act as a marker of broader routines and family circumstances. Cross-sectional findings cannot establish that introducing breakfast alone will improve

health outcomes or that any particular breakfast composition is beneficial.

Aparicio-Ugarriza et al. (2019) evaluated adapted Mediterranean diet scores in 2,330 HELENA participants. Certain continuous indices were positively associated with fruit and vegetable consumption and selected nutritional biomarkers, supporting their construct validity as dietary-quality measures. Such validation studies do not demonstrate that a dietary score causally improves cardiometabolic or skeletal outcomes. Furthermore, these HELENA analyses overlap in source population and should not be counted as independent replications of a prevalence estimate.

5. Croatian findings and cardiometabolic indicators

Country-specific data can inform interpretation but should not be treated as nationally representative without an appropriate sampling frame. In a Croatian cross-sectional study, Martinis et al. (2020) analysed 246 girls and 111 boys with complete anthropometric information. Among girls, elevated blood pressure was associated with choices made for school breakfast ($p = 0.008$) and the reported frequency of white-fish ($p = 0.021$) and oily-fish consumption ($p = 0.026$). Among boys, an association was reported for meat-product consumption ($p = 0.015$). Adiposity-related indicators were also associated with elevated blood pressure.

These are associations within sex-stratified analyses, not evidence that any particular food causes elevated blood pressure. Multiple testing, self-reported diet, small subgroup sizes and unmeasured confounding limit interpretation. Importantly, a statistically significant association in girls but not boys is not evidence of a statistically significant sex interaction. The study is valuable as Croatian contextual evidence, but the findings should be regarded as hypothesis-generating rather than prescriptive.

6. Integrated critical appraisal and practical implications

The studies address complementary but distinct questions. Dietary recalls quantify reported intake; principal-component dietary patterns describe co-occurring food choices; observational models identify associations with behaviour or clinical markers; and randomised supplementation trials test particular interventions against defined outcomes. Conflating these levels of evidence risks overstating conclusions. Across the literature reviewed here, the most defensible synthesis is that dietary quality and micronutrient adequacy deserve attention in adolescent girls, while the benefits of routine supplementation for skeletal outcomes in otherwise healthy populations are limited and inconsistent. Table 2 summarises the principal studies and their methodological limitations.

The evidence base also has important temporal and geographical constraints. HELENA data were collected well before this review, and participating European cities are not a substitute for a contemporary representative Croatian sample. Different analyses within the same project may reuse participants and share measurement biases. In addition, the Croatian blood-pressure study was relatively small, and dietary assessment and confounder control varied across studies. The current review itself used purposive, iterative searches rather than a comprehensive systematic protocol; publication and selection biases therefore remain possible.

For nutrition education, a non-stigmatising, food-first approach is reasonable: promote regular, nutritionally balanced meals; varied sources of iron and folate; calcium-rich foods appropriate to dietary preferences; and overall dietary quality while addressing excessive intake of salt and saturated fats. Counselling should account for menstruation, food insecurity, cultural practices, disordered eating risk and physical activity. Laboratory assessment or supplementation should be individualised rather than inferred from population dietary medians. School and community programmes may address eating patterns and screen-related routines together, but their effectiveness requires direct intervention evaluation.

Future studies should use representative samples of adolescent girls, validated measures of usual intake, appropriate biochemical markers and longitudinal designs. Studies designed to test sex interactions, and trials reporting patient-important outcomes rather than surrogate markers alone, would improve clinical applicability. In Croatia, updated population-based estimates of diet quality, iron status, vitamin D status and menstrual-related nutritional risk are priorities.

Table 2. Evidence map and principal methodological limitations. RCT, randomised controlled trial; IPD, individual participant data; BMD, bone mineral density

Evidence	Study population / design	Main interpretation and limitations
Diethelm et al. (2014)	HELENA; n = 1,590, 859 girls; cross-sectional	Sex-specific intake estimates; exclusions may bias representativeness.
Santaliestra-Pasías et al. (2014)	HELENA; n = 2,202; cross-sectional	Screen exposure associated with dietary patterns; causality unproven.
Giménez-Legarre et al. (2022)	HELENA; n = 1,804; cross-sectional	Breakfast associated with higher diet-quality scores; confounding possible.
Martinis et al. (2020)	Croatia; 246 girls and 111 boys; cross-sectional	Selected diet–blood-pressure associations; small groups and multiple comparisons.
Winzenberg et al. (2006)	19 calcium RCTs; n = 2,859; systematic review	Small surrogate skeletal effects; fracture prevention not established.
Wu et al. (2023)	11 vitamin D RCTs; 9 with IPD, n = 1,439	Small hip BMD effect; limited generalisability and no other clear effects.

Conclusions

Adolescent girls face interacting nutritional demands related to growth, menstruation and skeletal maturation. European data suggest potentially inadequate intakes of iron, folate, calcium and dietary vitamin D in substantial adolescent samples, but do not quantify biochemical deficiency. Dietary patterns correlate with sedentary routines, and selected Croatian observations suggest associations with blood-pressure indicators, without establishing causality. Randomised evidence indicates only modest and site-specific skeletal effects of routine calcium or vitamin D supplementation in generally healthy young people. Nutrition strategies should therefore prioritise dietary adequacy, supportive environments and individual risk assessment. More recent, representative and sex-specific studies are needed to guide policy and clinical practice.

Ethical Considerations

No new data from human participants were collected for this narrative review.

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