Nutrition in relation to puberty in girls and age at menarche

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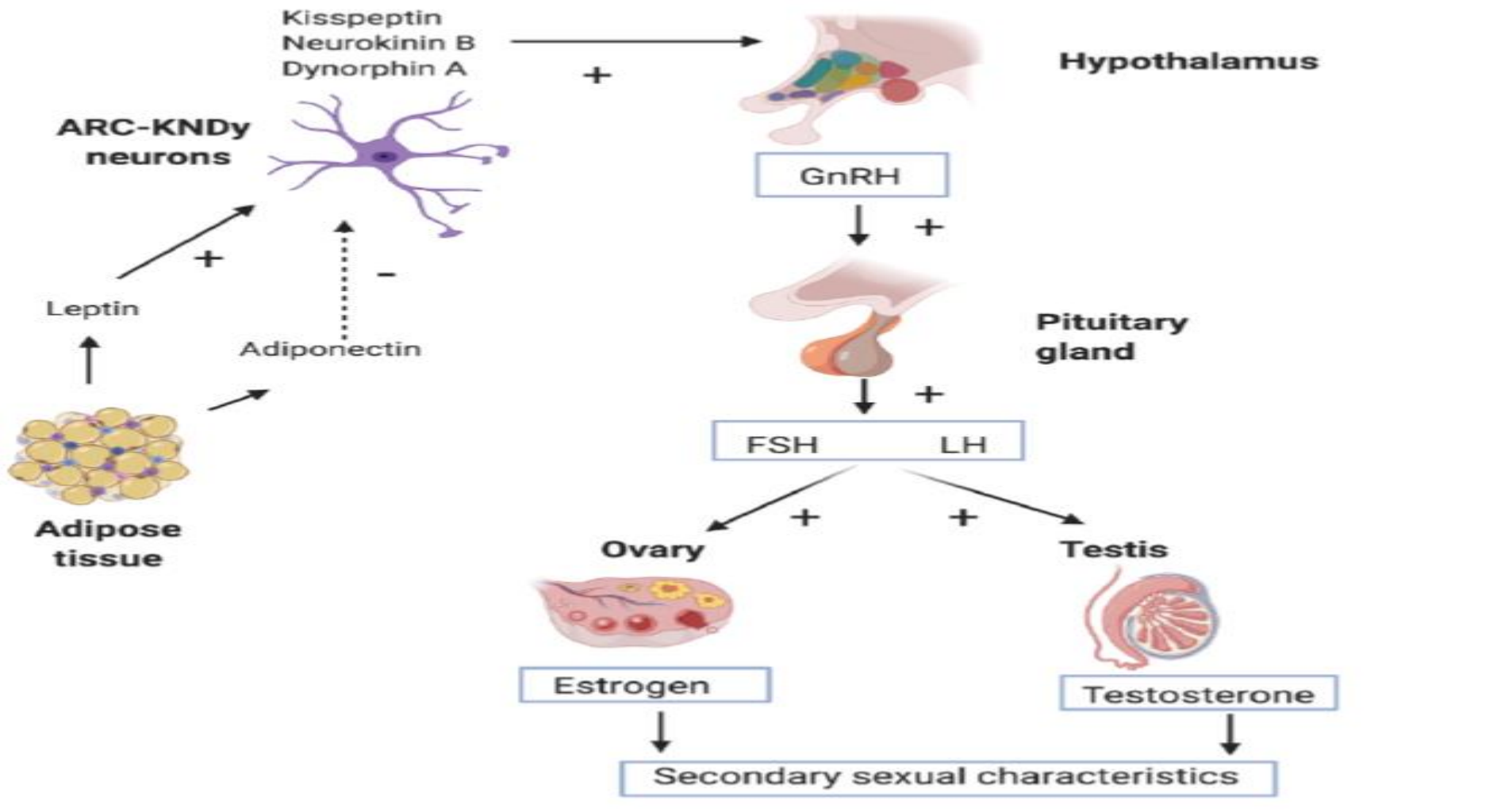
Puberty

- Puberty is a biological process that represents the development of secondary sexual characteristics and attainment of reproductive capacity.
- During the puberty, people experience the transformation from children to adults
- Two physiological processes, **gonadarche** and **adrenarche**, govern pubertal transition
- Later in infancy, HPG axis becomes inactive during the first five years of life, until its successive activation in adolescence

Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000–. PMID: 25905253.
Endocrinol Metab Clin North Am. 2024;53(2):183-194.

Gonadarche


Kisspeptin
Neurokinin B
Dynorphin A
+
Hypothalamus
ARC-KNDy neurons
GnRH
+
+
-
Leptin
Adiponectin
Pituitary gland
+
FSH
LH
+
+
Ovary
Testis
Estrogen
Testosterone
Secondary sexual characteristics
Adipose tissue

Adrenarche

- Adrenarche signifying adrenal pubertal maturation
- Adrenarche typically begins prior to the first visible physical manifestation of gonadarche, breast development, or testicular enlargement
- Adrenarche results in Pubarche (development of pubic hair, axillary hair, apocrine odor)
- Tanner staging is used to describe breast and pubic hair development (5 stages)
- For girls, breast growth, pubic hair development, and menarche are the main secondary sexual characteristics in puberty.

Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000–. PMID: 25905253.
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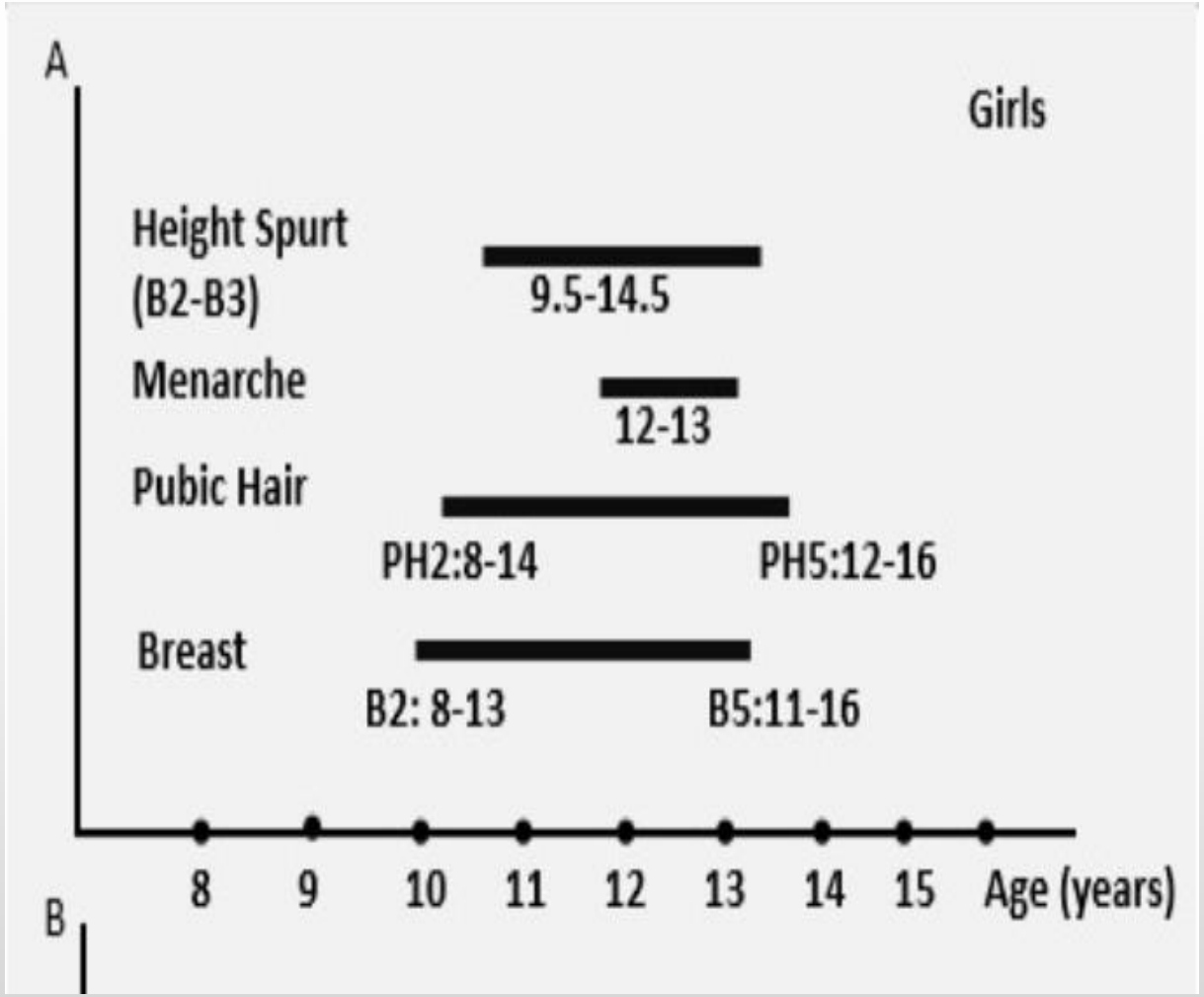
Puberty in girls

- The typical first clinical sign of puberty in girls is the appearance of breast tissue
- Breast development is evident before pubic hair development
- The pubertal growth spurt in girls occurs concurrently with the onset of breast development
- Menarche occurs, on average, 2 to 2.5 years after the onset of breast development



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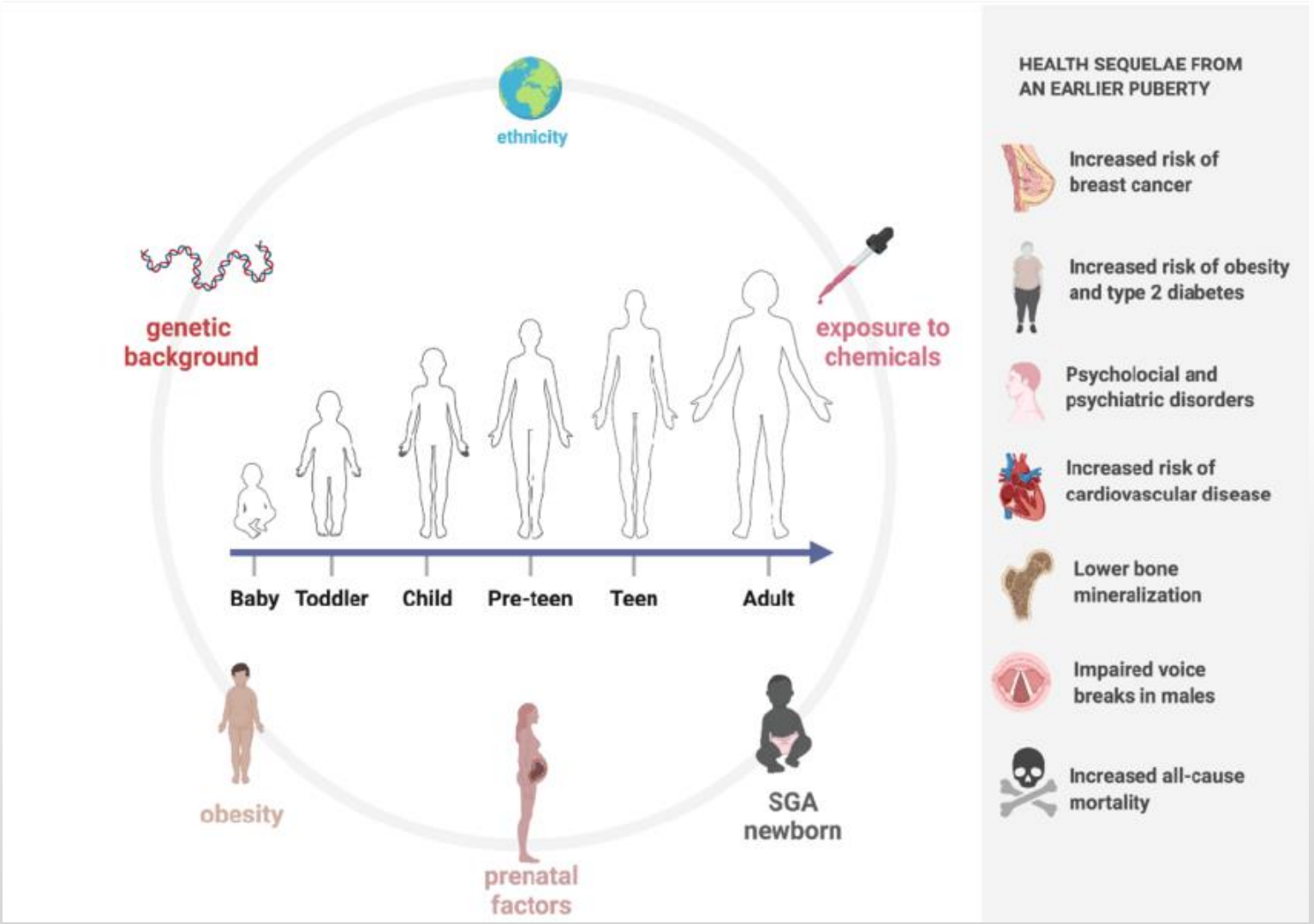
Precocious Puberty

- There are variations in age at onset and tempo of pubertal development.
- Precocious Puberty is defined as the beginning of pubertal development before eight years of life in girls and nine years of life in boys.
- There is a trend that the prevalence of early puberty is increasing worldwide, particularly in girls.

Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000–. PMID: 25905253.
JAMA Pediatr. **2020**, 174, e195881.

Factors for earlier puberty & health consequences



Determinants :

- ✓ Genetic background (50-80%)
- ✓ Ethnicity (earlier onset of puberty in African American and Hispanic)
- ✓ Exposure to endocrine-disrupting chemicals
- ✓ Fetal growth (SGA, IUGR)
- ✓ Prenatal factors
- ✓ Early-life and childhood nutrition (25%)

Life (Basel). 2021;11(12):1353.

Diet and time of puberty

- Maternal nutrition (prenatal factors)
- Neonatal and early infancy nutrition
- Childhood nutrition

Maternal nutrition

- Some authors reported an inverse linear association between the maternal BMI and the daughter's age at menarche, while others did not find any associations.
- A high **prepregnancy BMI** and a greater **gestational weight gain** are associated with earlier puberty in daughters.
- Excessive calorie intake and high-fat diet during preganancy increase risk of obesity and early puberty in the offspring.
- It is unclear whether dietary intakes of phytoestrogens during pregnancy affect puberty in offspring.

Life.2021;11(12):1353.
Am. J. Epidemiol. 2018, 187, 677–686.

Neonatal and early infancy nutrition

Dietary source	Mechanism of action	BMI dependent and/or independent action	Effect on puberty
Breastfeeding	- Overweight prevention - Microbiome balance - Positive psychosocial influence	Both	Precocious puberty prevention
Formula feeding	- Overweight development	BMI dependent	Increased risk of precocious puberty
Complementary feeding	- Overweight development in case of age-inappropriate feeding and high protein consumption	BMI dependent	Increased risk for precocious puberty
Soy-based foods	Weak estrogenic effect of soy isoflavones	BMI independent	Uncertain increased risk for precocious puberty

Childhood nutrition & puberty

Childhood Overweight/Obesity and Early Puberty in girls

Groups	No. of studies	Odds ratio (95% confidence interval)	I2 (%)
Early puberty			
Overweight	3	4.67 (1.60, 13.63)	81
Obese	9	2.22 (1.65, 2.99)	94
Early menarche	5	2.28 (1.03, 5.04)	95

Front Pediatr. 2022;10:795596.

Childhood nutrition & puberty

Dietary source	Mechanism of action	BMI denpendet and /or independent	Effect on puberty
High-energy diet	Higher levels of leptin, IGF-1 activation, adrenal androgen overproduction	BMI dependent	Increased risk of precocious puberty
High protein intake	Adiposity rebound, IGF-1 secretion	Both	Increased risk of precocious puberty
High fat intake	- Direct effect on steroidogenesis and mammary gland - Indirect effect though induction of low-grade hypothalamic inflammation	BMI independent	Increased risk of precocious puberty (PUFA) Uncertain increased risk of precocious puberty (MUFA)

Nutrients. 2020;12(9):2544.
Life. 2021;11(12):1353.

Childhood Nutrient Intake & Early Menarche

Nutrient	Risk ratio (95% CI)	I2 (%)
Increased risk of early menarche		
Higher energy	3.32 (1.74-6.34)	97
Higher protein	3.15 (2.87-3.44)	0
Higher PUFA	1.25 (1.05-1.49)	44
Decreased risk of early menarche		
Higher intake of fiber	0.83 (0.69, 1.00)	31
Higher intake of MUFA	0.66 (0.50, 0.86)	0

Nutrients. 2020;12(9):2544

Protein intake and menarche in Iranian girls

- Higher intake of milk was associated with higher risk of early menarche
- No association was observed between yogurt intake and early menarche
- Girls in the middle tertile of cheese intakes had a lower risk of early menarche
- It seems that dairy products including milk, cheese and yoghurt may have different effects on puberty
- Higher intake of plant protein was assocaited with lower risk of early menarche

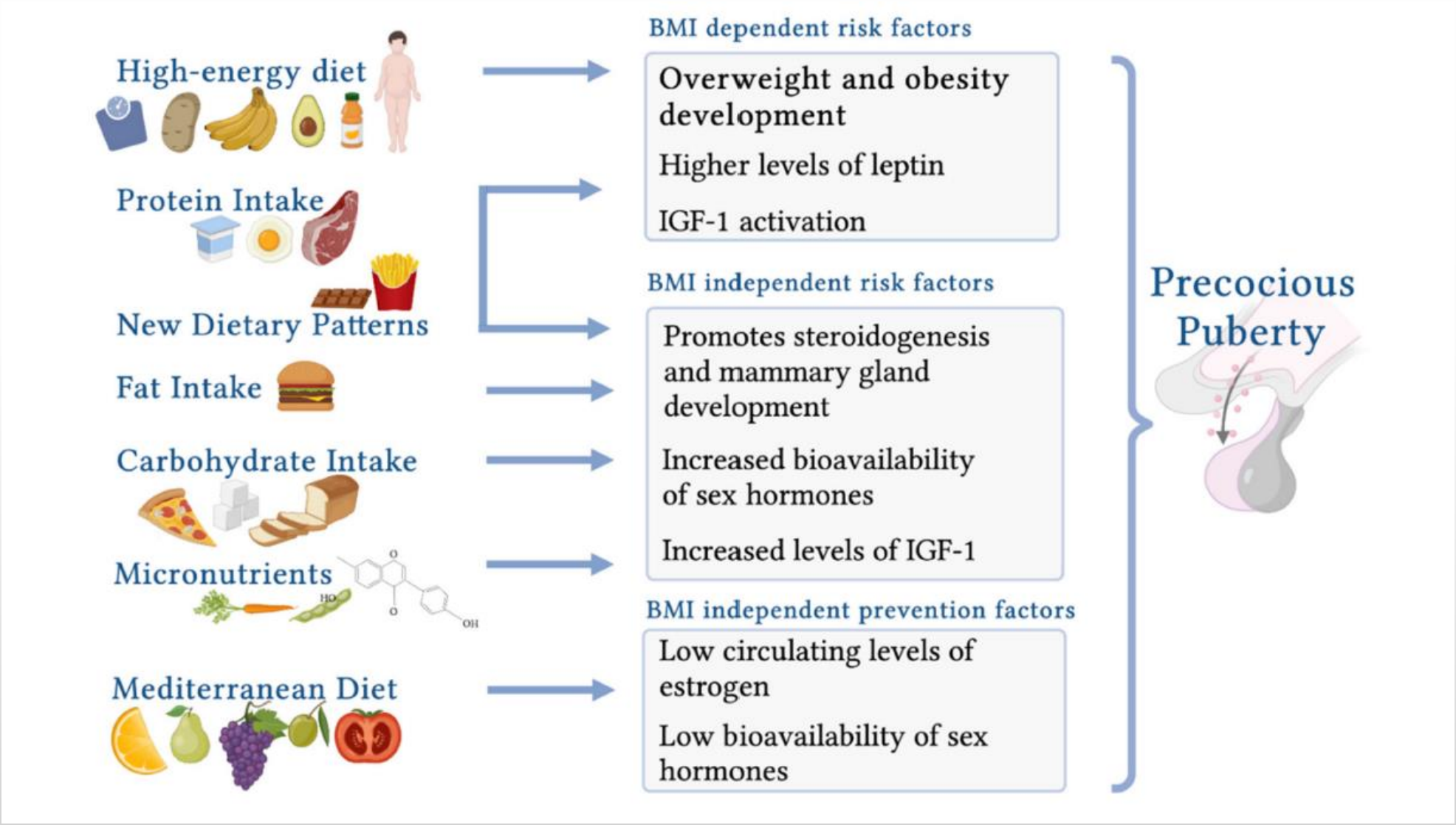
PLoS One. 2013;8(2):e57696.
BMC Pediatr. 2021;21(1):206.

High carbohydrate intake & puberty

- The association between carbohydrate intake during childhood and precocious puberty is uncertain.
- It seems that quality of the carbohydrate is important.
- One study demonstrates that a high-glycemic-index diet causes early Puberty
- Sugary drinks predicted an earlier menarche onset in the US girls but not related to the age of menarche among Chinese girls.
- Higher intake of fiber, legumes, and fruits may be associated with lower risk of early menarche.

Public Health Nutr. 2002;5(2):353-60.
Hum Reprod. 2015;30(3):675-83.
Nutrients. 2020;12(9):2544.
Wei Sheng Yan Jiu. 2023;52(1):85-89.

Childhood nutrition and puberty



Conclusions

- ✓ Nutritional status in early life and childhood may explain over 20% of pubertal timing variation.
- ✓ Early nutritional surveillance and pubertal growth monitoring are essential for all children, especially those at risk (SGA and/or IUGR).
- ✓ Breastfeeding is an important protective factor against early menarche.
- ✓ A diet with high energy, high protein, and high fat during childhood may increase the risk of early puberty.
- ✓ More research is needed to determine how macronutrients (different sources), micronutrients, and the Mediterranean diet associate puberty.