



Adolescent nutrition: what do pediatricians do?

Eell Ryoo, MD

Department of Pediatrics, Gachon University Gil Hospital, Gachon University of Medicine and Science, Incheon, Korea

Received: 16 May 2011, Accepted: 30 May 2011
Corresponding author: Eell Ryoo, MD
Department of Pediatrics, Gachon University Gil Hospital, Gachon University of Medicine and Science, 1198 Geweoldong, Namdong-gu, Incheon 405-760, Korea
Tel: +82-32-460-3959, Fax: +82-32-460-3224
E-mail: ryoo518@gilhospital.com

Multiple psychosocial problems and many chronic diseases of adulthood can be influenced by adolescent nutritional problems. In Korea, adolescent obesity and obesity related health risks have been increased and insufficient intakes of nutrients, such as calcium, iron and potassium, and distorted thinking about obesity are also common. However there are no comprehensive countermeasure because of the excessive burden of studies and the lack of community interest. And the nutrition guidelines that is suitable for Korean adolescent leaves something to be desired, and the pediatrician's concern is lacking yet. In the Korean dietary reference intakes 2010 that was revised according to the 2007 Korean National Growth Chart and 2007 Korean National Health and Nutrition Examination Survey, the range for adolescents is changed to the age 12-18 and dietary reference intakes of some nutrients mainly with vitamin D is changed. Recently several researches, about how school nutrition policies and media effect on eating habits and the weight concerns, and influences of public nutrition policies and fast food commercials have been actively studied to improve adolescent nutritive conditions. In this review, I summarize the dietary reference intakes for Korean adolescents that were revised in 2010, and current studies about the adolescent nutrition.

Copyright © 2011 by The Korean Pediatric Society

Key words: Adolescent, Nutrition, Koreans

This is an open-access article distributed under the terms of the Creative Commons Attribution Non-Commercial License (<http://creativecommons.org/licenses/by-nc/3.0/>) which permits unrestricted non-commercial use, distribution, and reproduction in any medium, provided the original work is properly cited.

Introduction

Although adolescent period is different between studies, but is usually defined as age 10 to 20, and the second rapid growth spurt is developed at this period. And they experience many changes on body structure and physiologic, psychologic, and social functioning¹⁾. Because of rapid growth and development on self-awareness at this age, many adolescents die prematurely due to accidents, suicide, violence, pregnancy related complications and other illnesses that are either preventable or treatable²⁾. Adolescents are usually influenced by peers rather than parents, and can be at risk for dietary excesses

such as excess of total fat, saturated fat, cholesterol, sodium and sugar and deficiencies caused by insufficient intake of fruits, vegetables and calcium rich foods. As a result, deficiencies of iron, vitamins, minerals and calcium, obesity and obesity-related health risks-diabetes and liver diseases and cardiovascular disease and can be developed in these stages. Also poor nutrition can have lasting consequences on adolescents' cognitive development, resulting in decreased learning ability, poor concentration, and impaired school performance³⁾. In Korean adolescents, there are insufficient intakes of nutrients such as calcium, iron and potassium, and distorted thinking about obesity is also common⁴⁾.

In this review I will discuss the nutritional needs in adolescent according to the guidelines of the 2010 Korean Dietary Reference Intakes (KDRI), and encountered nutritional problems in Korean

adolescents, and what to do as a pediatrician to improve the adolescent nutritional status.

Nutrition requirements for adolescents

Table 1. Dietary Reference Intakes for Korean Adolescents (15-18 year of age) by Korean Nutrition Society, 2010

Age (yr)	Male		Female		DRI
	12-14	15-18	12-14	15-18	
Energy (kcal/day)	2,400	2,700	2,000	2,000	EER
Protein (g/day)	50	55	45	45	RNI
Total Fiber (g/day)	25	25	20	20	AI
Water (mL/day)	2,300	2,600	2,000	2,100	AI
Fat-soluble vitamins					
Vitamin A ($\mu\text{g RE/day}$) [*]	700	850	650	600	RNI
Vitamin D ($\mu\text{g/day}$)	5	5	5	5	AI
Vitamin E (mg $\alpha\text{-TE/day}$) [†]	10	12	9	10	AI
Vitamin K ($\mu\text{g/day}$)	70	80	65	65	AI
Water-soluble vitamins					
Vitamin C (mg/day)	100	110	100	100	RNI
Thiamine (mg/day)	1.1	1.3	1.1	1.0	RNI
Riboflavin (mg/day)	1.5	1.7	1.2	1.2	RNI
Niacin (mg NE/day) [‡]	15	17	14	14	RNI
Vitamin B ₆ (mg/day)	1.5	1.5	1.4	1.4	RNI
Folate ($\mu\text{g/day}$)	400	400	400	400	RNI
Vitamin B ₁₂ ($\mu\text{g/day}$)	2.3	2.7	2.4	2.4	RNI
Pantothenic acid (mg/day)	5	6	5	6	AI
Biotin ($\mu\text{g/day}$)	25	30	25	30	AI
Macrominerals					
Calcium (mg/day)	1,000	90	900	800	RNI
Phosphorus (mg/day)	1,000	1,000	900	800	RNI
Sodium (g/day)	1.5	1.5	1.5	1.5	AI
Chloride (g/day)	2.3	2.3	2.3	2.3	AI
Potassium (g/day)	3.5	3.5	3.5	3.5	AI
Magnesium (mg/day)	300	400	290	340	RNI
Microminerals					
Iron (mg/day)	14	15	13	17	RNI
Zinc (mg/day)	8	10	7	9	RNI
Copper ($\mu\text{g/day}$)	740	870	740	870	RNI
Fluoride (mg/day)	2.5	3.0	2.5	2.5	AI
Manganese (mg/day)	4.0	4.0	3.5	3.5	AI
Iodine ($\mu\text{g/day}$)	130	130	130	130	RNI
Selenium ($\mu\text{g/day}$)	50	60	50	60	RNI
Molybdenum ($\mu\text{g/day}$)	400	500	400	500	Tolerable upper intake level

DRI, dietary reference intakes; RE, retinol equivalent; TE, tocopherol equivalents; NE, niacin equivalent; EER, estimated energy requirements; RNI, recommended nutrient intake; AI, adequate intake.

^{*}RE=1 μg retinol or 6 μg $\beta\text{-carotene}$. [†] $\alpha\text{-TE}$ =1 mg D- α tocopherol. [‡]NE=1 mg niacin or 60 mg dietary tryptophan.

The range for adolescents was changed to 12-18 years in 2010 KDRI that was revised according to the 2007 Korean National Growth Chart compared to 2005 KDRI. Also the Dietary Reference Intakes (DRI) with Recommended Nutrient intake (RNI) and Adequate Intake (AI) as its center of each nutrient have changed with the contents below (Table 1).

1. Energy and macronutrients

The proportion of three nutrients - carbohydrates, protein and fat - and RDI of macronutrients is not changed, but Estimated Average Requirement (EAR) of protein is increased with 5 g/day than EAR of 2005 KDRI in female adolescent because of increased weight. The Estimated Energy Requirements (EER) is increased due to increased height and weight standards in adolescents, but the calculated value is rounded down considering the increasing obesity. Because of the insufficient evidences, the KDRIs for lipids are not established in children and adolescents. The AI of dietary fiber was decreased with 4-7 g/day in both sexes, and the AI of water is also decreased with 100 mL/day⁶. The past AI of dietary fiber and water were based on the adult standards, so these were revised by the KNHANES⁸.

2. Vitamins

The dietary intakes of lipid-soluble vitamins have no differences compared to the value of 2005 KDRIs except vitamin D. The AI of vitamin D was 10 $\mu\text{g/day}$ in 2005 that was based on the lower levels of 25-hydroxy (OH) vitamin D than adults because of less exposure to the sunlight, but that was changed to 5 $\mu\text{g/day}$ because mean of adolescents' vitamin D intake was 4.4-4.9 $\mu\text{g/day}$ on the Korean Health Behavior Online Survey⁴.

The RNI of water-soluble vitamin such as thiamine, riboflavin, niacin and vitamin B₆ are lowered slightly in older adolescent because of decreased weight, and the upper intake level of folic acid is also lowered because the larger population intakes relatively excessive amount of it and the toxic effects can be developed indirectly. But the RNI of vitamin B₁₂ and Biotin is increased little bit than the past according to the adult standards.

3. Macrominerals

The RNI of calcium in older adolescent is decreased than the past that was based on the mean of Canadian adolescents' the total body bone mineral content and the report of Food and Agriculture

Organization/World Health Organization (WHO) about calcium loss, and compared with the weight and the height of Korean adolescent⁶. The AI of potassium is revised lower than the past according to the 2005 Korean National Health and Nutrition Examination Survey (KNHANES).

4. Microminerals

For the result of the calculation according to the body surface, the RNI of iron is changed for boys with age, and increased for girls. There were no research results about the EAR of manganese, but the AI of manganese is increased due to the calculated result that was based on the KNHANES⁹. At the estimated result based on the report of WHO/United Nations Children's Fund/International Council for Control of Iodine Deficiency Disorders 2007, the RNI of iodine is decreased¹⁰.

Common nutritional problems in adolescents

About nutritional problems on the adolescents, large portion of the size, lower fruit and vegetable intake, higher consumption of sweetened beverages, frequent consumption of fast food long hours of television viewing and skipping breakfast, etc were known as the risk factors of excessive weight gain and nutritional imbalance¹¹⁻¹³.

Neumark-Sztainer D et al.¹¹ has been reported that less than one third of adolescents eat five or more servings of fruits and vegetables on a daily basis and these trends tend to decline as adolescents get older¹¹. American national survey in 2000 shows that 25% of the adolescents were overweight, and 45% of the girls and 20% of boys had at some point been on a diet, and eating disorder was reported by 13% of the girls and 7% of the boys¹⁴. Girls reported more frequent consumption of beverages than boys in the group of adolescents who watched television for 2 hours per day in recent European study¹⁵. Because of costs, easy accessibility and exposure to television advertisement, many adolescents choose the fast foods. Regardless of genders, races, ethnics and regions, 30.3% of the adolescents consumed fast food which contains more total energy, fat, carbohydrate with added sugar and sugar sweetened beverage, and less fiber, milk, fruit, and non-starchy vegetables¹⁶. The ratio of skipping breakfast was 31.5% in American adolescents, and breakfast skippers had higher body mass index than others¹⁷.

According to the online survey of Korean children and adolescents⁴ major sources of energy supply for different age groups says rice and cereal is the first and second most common foods at all groups of age. However the third common food is milk on age between 1 to and instant noodles on ages 50 to 75%; it means that instant foods has been increased with the major source of the excessive

energy intake. Major sources of lipid intake are pork, instant noodles and milk for adolescence in order, and especially instant noodles is increased as age increases. Rice, cereals and pork are investigated in order as major sources of carbohydrate. As a result of estimation of each nutrient, each mean of intake ratio of calcium and iron is 58.1% and 89.9% which is below the RNI, and the ratio of the insufficient calcium intake is 96.9% in adolescent age between 13 and 19. Forty six percent of female adolescent age between 13 and 19 think they are obese, but among them only 63.1% of them are not obese in fact. The obese adolescents consumed larger portion sizes and less fruits and vegetables compared to the non-obese adolescents. It is similar to other western studies that as many as 50 to 75% of adolescent girls are dissatisfied with their weight and body image because of the implication of mass media.

Among adolescent dietary intake and eating patterns are influenced by multiple factors such as individual factors, social environmental factors, physical environmental factors and societal factors. Individual factors contain psychosocial and biological influences and life styles¹⁸.

Food preferences, taste and sensory perceptions of food, health and nutrition, meanings of food, self-efficacy and knowledge are influenced as psychosocial aspect¹⁹. For example, the symbolic meanings of the attaching to junk food in adolescents is important to understand the eating behaviors because eating and liking this food is seen as normal behavior for them. Persistent use of unhealthful weight control behaviors is reported by approximately 45% of females and 17% of males, and healthful weight control behaviors are only 10% of females and 15% of males in American study²⁰.

Interpersonal relations influence on adolescents' eating behavior. In spite of social changes of the family structure and diet, parental influence is still critical during adolescence. The role of peers in influencing food choices was not important, in other words, peers exert on eating behaviors may be indirect rather than direct¹⁹.

Community settings such as schools, fast-food restaurants, vending machines, and convenient stores and societal factors, such as media and food advertisings also affect adolescents' eating behaviors. Adolescents consume a large proportion of their total daily energy intake at school, therefore schools should be an environment where healthful eating behavior is normative, modeled, and reinforced¹⁹. Recently, as a result of strategy of advertising on the increased portion of the beverage, total energy intake is overall increased²¹. Mass media effects on eating habit are also considered as important factors especially in female adolescents.

Recent advances in adolescent nutrition

A recent report of the protection against obesity found the

high protein/low glycemic index combination, the prebiotic supplementation and the avoidance of a low calcium intake are effective for children and adolescent^{22,23}.

Estimation of the dietary requirement for vitamin D was unclear for many past decades, because of different sunlight exposure on the subject and difficult estimation methods²⁴. Therefore, there are many studies about the RNI of vitamin D, but there are no studies about Korean adolescent until now. During adolescence, one of the major factors of Ca absorption is the serum level of 25-(OH) vitamin D, and IGF-1 is also known as another factor in recent study²⁵. The calcium homeostasis and bone metabolism are known as the major roles of vitamin D, but this can influence to the muscle functions on recent study^{23,26}.

Gastrointestinal dysfunction is selected as the critical endpoint among several harmful effects of excessive iron intake; this setting was supported by recent report that iron fortification can produce a potentially more pathogenic gut microbiota profile and increase gut inflammation^{6,27}.

Because number of family members has been decreasing, lack of time with their parents and the increasing role of the peer group, there are many difficulties on the modification of adolescent eating behavior. Recent studies report that the strategy focused at the age-appropriate curriculum intervention and the role of school is important^{19,28}. One of the interesting recent study reported that misperceptions of peer sugar-sweetened beverage consumption norms are pervasive and associated with unhealthy sugar-sweetened beverage consumption behaviors; this result partially explains the complexity of adolescents' psychosocial influences and their own particular teen culture^{19,29}.

Conclusion

Because of the expression of the secondary sex characteristics and rapid growth and development during the adolescent period, many chronic diseases of adulthood and variable physical and psychosocial problems can be influenced by the adolescent nutrition. Therefore, it is important that the pediatrician should understand the adolescent nutritional guidelines and the appropriate strategies to correct the nutritional imbalance. Also, in order to improve adolescents' nutritive condition not only do the studies for the nutritional requirements that are suitable for Korean adolescents are needed but also do the understanding of the adolescent periods and the awareness as a pediatrician on the social environments is needed.

References

1. Kliegman R, Nelson WE. *Nelson textbook of pediatrics*. 18th ed. Philadelphia: Saunders, 2007.
2. Adolescent health [Internet]. Geneva: World Health Organization; c2011 [cited 2010 Mar 5]. Available from: http://www.who.int/topics/adolescent_health/en.
3. Nutrition and physical activity guidelines for adolescents [Internet]. Sacramento: California Department of Public Health; c2010 [updated 2011 Jul 15; cited 2010 Apr 27]. Available from: <http://www.cdph.ca.gov/HealthInfo/healthyliving/childfamily/Documents/MO-NutritionAndPhysicalActivityGuidelines.pdf>.
4. The 5th (2009) Adolescent health behavior online survey [Internet]. Seoul: Korean Ministry of Education, Science and Technology; c2011 [cited 2011 Mar 22]. Available from: <http://yhs.cdc.go.kr/>.
5. Moon JS, Lee SY, Nam CM, Choi JM, Choe BK, Seo JW, et al. 2007 Korean National Growth Charts: review of developmental process and an outlook. *Korean J Pediatr* 2008;51:1-25.
6. Korean Nutrition Society. *Dietary reference intakes for Koreans*. Seoul: Korean Nutrition Society, 2010.
7. Korean Nutrition Society. *Dietary reference intakes for Koreans*. Seoul: Korean Nutrition Society, 2005.
8. Korea Centers of Disease Control and Prevention. *The 3rd Korea National Health and Nutrition Examination Survey (KNHANES III)*. Seoul: Korea Centers of Disease Control and Prevention, 2005.
9. Korea Centers of Disease Control and Prevention. *The 3rd Korea National Health and Nutrition Examination Survey (KNHANES IV)*. Seoul: Korea Centers of Disease Control and Prevention, 2010.
10. World Health Organization, United Nations Children's Fund, International Council for Control of Iodine Deficiency Disorders. *Assessment of iodine deficiency disorders and monitoring their elimination: a guide for programme managers*. 3rd ed. Geneva: World Health Organization, 2007.
11. Neumark-Sztainer D, Flattum CF, Story M, Feldman S, Petrich CA. Dietary approaches to healthy weight management for adolescents: the New Moves model. *Adolesc Med State Art Rev* 2008;19:421-30, viii.
12. Park SH. Adolescent nutrition. *J Korean Pediatr Soc* 2001;44:857-66.
13. Park S. Adolescent nutrition and growth. *Korean J Pediatr* 2006;49:1263-6.
14. Neumark-Sztainer D, Hannan PJ. Weight-related behaviors among adolescent girls and boys: results from a national survey. *Arch Pediatr Adolesc Med* 2000;154:569-77.
15. Rey-López JP, Vicente-Rodríguez G, Répásy J, Mesana MI, Ruiz JR, Ortega FB, et al. Food and drink intake during television viewing in adolescents: the Healthy Lifestyle in Europe by Nutrition in Adolescence (HELENA) study. *Public Health Nutr* 14:1563-9.
16. Bowman SA, Gortmaker SL, Ebbeling CB, Pereira MA, Ludwig DS. Effects of fast-food consumption on energy intake and diet quality among children in a national household survey. *Pediatrics* 2004;113(1 Pt 1):112-8.
17. Deshmukh-Taskar PR, Nicklas TA, O'Neil CE, Keast DR, Radcliffe JD, Cho S. The relationship of breakfast skipping and type of breakfast consumption with nutrient intake and weight status in children and adolescents: the National Health and Nutrition Examination Survey 1999-2006. *J Am Diet Assoc* 2010;110:869-78.
18. French SA, Perry CL, Leon GR, Fulkerson JA. Dieting behaviors and

- weight change history in female adolescents. *Health Psychol* 1995;14:548-55.
19. Story M, Neumark-Sztainer D, French S. Individual and environmental influences on adolescent eating behaviors. *J Am Diet Assoc* 2002;102(3 Suppl):S40-51.
20. Larson NI, Neumark-Sztainer D, Story M. Weight control behaviors and dietary intake among adolescents and young adults: longitudinal findings from Project EAT. *J Am Diet Assoc* 2009;109:1869-77.
21. Flood JE, Roe LS, Rolls BJ. The effect of increased beverage portion size on energy intake at a meal. *J Am Diet Assoc* 2006;106:1984-90.
22. Papadaki A, Linardakis M, Larsen TM, van Baak MA, Lindroos AK, Pfeiffer AF, et al. The effect of protein and glycemic index on children's body composition: the DiOGenes randomized study. *Pediatrics* 2010;126:e1143-52.
23. Abrams SA, Griffin IJ, Hawthorne KM, Ellis KJ. Effect of probiotic supplementation and calcium intake on body mass index. *J Pediatr* 2007; 151:293-8.
24. Yang HR, Seo JW, Kim YJ, Kim JY, Ryoo E, Sim JG, et al. Recent concepts on vitamin D in children and adolescents. *Korean J Pediatr* 2009;52:1082-9.
25. Hill KM, Braun M, Kern M, Martin BR, Navalta JW, Sedlock DA, et al. Predictors of calcium retention in adolescent boys. *J Clin Endocrinol Metab* 2008;93:4743-8.
26. Ward KA, Das G, Roberts SA, Berry JL, Adams JE, Rawer R, et al. A randomized, controlled trial of vitamin D supplementation upon musculoskeletal health in postmenarchal females. *J Clin Endocrinol Metab* 2010;95:4643-51.
27. Zimmermann MB, Chassard C, Rohner F, N'goran EK, Nindjin C, Dostal A, et al. The effects of iron fortification on the gut microbiota in African children: a randomized controlled trial in Cote d'Ivoire. *Am J Clin Nutr* 2010;92:1406-15.
28. Bravender T, Russell A, Chung RJ, Armstrong SC. A "novel" intervention: a pilot study of children's literature and healthy lifestyles. *Pediatrics* 2010;125:e513-7.
29. Perkins JM, Perkins HW, Craig DW. Misperceptions of peer norms as a risk factor for sugar-sweetened beverage consumption among secondary school students. *J Am Diet Assoc* 2010;110:1916-21.