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Improving literacy around energy-related issues: The need for a better understanding of the concepts behind energy intake and expenditure among adolescents and their parents

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Abstract

Despite the need for effective obesity prevention strategies, little research is currently available to assess adolescents' knowledge around basic concepts of energy intake, expenditure and balance. Using data from 349 adolescent-caregiver pairs (recruited from Minneapolis/St. Paul metro region, MN, 2006-2007), cross-sectional linear regression was used to assess adolescent and parental knowledge related to energy intake and expenditure as a predictor of adolescent weight-related behaviors and outcomes. Findings indicated that knowledge related to energy intake and expenditure was highly variable, with a substantial proportion of participants (particularly adolescents) lacking knowledge on a range of concepts. Adolescent knowledge was positively associated with moderate physical activity and negatively associated with television viewing ($P < 0.05$), but it was not associated with sweetened beverage consumption, fast food intake, weight status, and/or body composition. While overall parental knowledge was a significant predictor of adolescent knowledge ($p < 0.01$), parent-child agreement on individual items was poor. As adolescents age, low literacy in this area may set the stage for poor decision-making related to energy balance and healthy weight maintenance. However, in that knowledge was not a significant predictor of various weight-related outcomes, these and other findings suggest that purely education-based health promotion strategies are insufficient to initiate long-term healthy behavior change. Educational strategies may be effective when combined with those also targeting familial, social, and environmental influences. The examination of interactive effects between individual-level and environmental influences on health behavior is an important area for future obesity-related research.

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Keywords

adolescence; nutrition; obesity; health knowledge

INTRODUCTION

Obesity is a major public health concern.(1) Poor diet and inactivity are two of the greatest contributors to United States (US) deaths.(2,3) Current efforts to improve diet and physical activity have shown varying degrees of effectiveness, and to some extent rely upon the public's understanding of energy balance-related issues, including both appropriate energy intake and expenditure. To be effective, initiatives such as MyPyramid.gov,(4) Dietary Guidelines for Americans,(5) Nutrition Facts Panels,(6) and point-of-purchase restaurant labeling,(7) require that the public understands concepts such as (a) what a calorie is, (b) where calories are found and (c) how many calories a person needs. Such concepts are essential for understanding energy balance.

Previous research suggests an inconsistent relationship between nutrition knowledge and behavioral outcomes.(8,9) Education-based interventions have not shown great success for weight management.(10) Furthermore, much of the research assessing knowledge to date has examined specific kinds of knowledge, such as knowledge of relationships between specific health behaviors and outcomes (e.g., heart health and fat intake).

Adolescence is particularly an important transition period, marked by substantial declines in diet quality and physical activity,(11,12,13) and has become recognized as an important time for obesity prevention and treatment. While there have been a number of school-based primary obesity prevention trials for youth, successes have been infrequent and very modest.(14) In fact, we know very little about how youth understand basic issues related to energy balance, a concept that is necessary for individuals to understand in order to find a healthy balance between energy intake and expenditure and maintain a healthy weight. Energy balance, including both energy intake and expenditure, is a very complex concept that requires an individual to understand a variety of issues related to health, nutrition and physical activity, including: how many calories they need to ingest to simply fuel basic physiological needs; how many calories are needed for different levels of activity; food and beverage sources of calories, and nutrient quality of lower calorie products (for example, provision of adequate vitamins/minerals in skim milk versus whole milk); how modified foods (e.g., lower in fat, higher in carbohydrate) might affect what and how much they can eat; and how energy intake and expenditure balanced over time impacts weight.

To understand the utility of knowledge-based obesity prevention interventions, further research is needed to examine adolescent nutrition and activity knowledge related to energy intake and expenditure. This study's aim was to assess adolescents' knowledge related to energy intake and expenditure, and the extent to which this knowledge was associated with adolescent weight status, diet, and activity. In addition, to assess knowledge transmission through families, the relationship between parent and child knowledge, as well as associations between parent knowledge and adolescent health outcomes, was also assessed. Hypotheses prior to conducting this work included: (a) that adolescent and parental knowledge would yield a weak, yet significant, association with adolescent outcomes, and (b) that parent and adolescent knowledge would be significantly associated.

METHODS

Data were collected through the Identifying Determinants of Eating and Activity (IDEA) study, a three-year study following youth and one adult caregiver. From 2006–2007, 349 youth were recruited within the Minneapolis/St. Paul metropolitan area. The University of Minnesota Institutional Review Board approved study protocols.

Measures

Nutrition and Activity Knowledge Related to Energy Intake and Expenditure—

Adolescent and parent knowledge was assessed with 15 items. (Table 1.) Items were developed and selected for inclusion based on: (a) research indicating that the behavioral factor of interest contributes to excessive energy intake and/or insufficient energy output, (b) formative work with parents, collected as pilot data for the IDEA study, and (c) input from the research team suggesting that these energy-related concepts were commonly misunderstood by the public. To ensure clarity, these questions were pre-tested with adolescents by conducting one-on-one interviews where research staff reviewed and discussed all items with the adolescent as s/he completed the survey. Interviews were used to gain insight into adolescents' comprehension of individual survey items and any difficulty or misinterpretation that the teens may have had. Staff continued to complete pre-testing interviews until saturation (i.e., repetition in adolescents' responses) was achieved. The Cronbach's alpha for the final scale was 0.56 among adolescents and 0.67 among parents (possible range: 1–15).

Adolescent-level Characteristics—Adolescent-level characteristics were assessed via self-reported and objective measurements. Eating behaviors included fast food and sugar-sweetened beverage intake. *Fast food* was assessed by asking: "In the past month, how many times did you buy food at a restaurant where food is ordered at a counter or at a drive-through window (there is no waiter/waitress)?" Nine response options ranged from "never/rarely" to "≥3 times/day." Using the same response options, *sugar-sweetened beverages* were measured with four items, adapted from previous research,⁽¹⁵⁾ that asked about frequency of consuming regular soda (not including diet soda), sports drinks (e.g., Gatorade), other sweetened beverages (e.g., sweetened teas, juice drinks, lemonade), or coffee drinks (e.g., lattes, mochas, Frappuccinos, and Macchiatos, not including regular coffee). These items were summed to derive an overall composite score.

Physical activity included vigorous- and moderate-intensity physical activity.⁽¹⁶⁾ Vigorous physical activity was assessed by asking: "How many times in the past 14 days have you done at least 20 minutes of exercise hard enough to make you breathe heavily and make your heart beat fast?" Moderate physical activity was assessed using a similar question asking about "light exercise that was not hard enough to make you breathe heavily and make your heart beat fast." Examples of relevant activities were given for both items. Five response options ranged from "none" to "≥9 days." Adolescents were instructed to include relevant activities from physical education classes in answering each question.

Television viewing assessment included weekdays and weekends. Weekday television was assessed asking: "On a typical weekday (Monday-Friday), how many hours do you spend watching TV?"⁽¹¹⁾ An analogous question was used to assess weekend (Saturday-Sunday) viewing. Six response options ranged from "none" to "≥6 hours/day."

Adolescent height was measured using a Shorr height board (Irwin Shorr, Olney, MD). Adolescent weight and body fat were measured using a Tanita scale, a bioelectrical impedance device (Tanita TBF-300A Body Composition Analyzer, Arlington Heights, IL) which has been shown to generally provide valid estimations of body composition in children and adolescents. (17–20) Body mass index (BMI) was calculated [weight (kg)/height (m²)], transformed into

age- and sex-specific BMI z-score percentiles using national growth charts,(21) and categorized as '1' for underweight (<5th percentile), '2' for normal weight (5th–84th percentile), '3' for overweight (85th–94th percentile), and '4' for obese (≥95th percentile), using national adolescent assessment guidelines.(22)

Socio-economic status (SES) was measured using highest level of education for either parent residing in the house. *Grade* represented adolescents' current grade in school. *Gender* was self-reported by adolescents (coded: '0' males, '1' females).

ANALYSIS

Spearman's rho correlations were calculated to assess the correspondence between adolescent's and parent's responses to the knowledge questions. Linear regression assessed predictors of adolescent-level outcomes. First, unadjusted models were used to assess associations between adolescent knowledge score and adolescent demographic characteristics (grade, gender, SES). Next, both unadjusted and adjusted (controlling for significant covariates, i.e., grade, SES) regression analyses were conducted to determine how adolescent's knowledge scores were associated with various weight-related outcomes, including: television viewing, activity, sugar-sweetened beverage consumption, fast-food intake, weight status, and body composition.

Parent knowledge scores were examined in linear regression models as predictors of both adolescent knowledge scores and adolescent weight-related outcomes. These models were assessed in their crude form as well as adjusted for adolescent grade and SES. Analyses were conducted using Stata software (v.9.0, STATA Corporation, College Station, TX, 2005).

RESULTS

The IDEA cohort was primarily white (93.4%) and equally divided across genders (49% male). Mean age was 15.4 years. Most adolescents were in high school (69.2% in grades 9–11), with the remaining in grades 6–8. Adult participants were 75.6% female, 99.9% of adults were the adolescent participant's parent. Mean age was 46.7 years. Less than 1% of parents had less than high school education, 26.1% had some college/vocational school, 35.2% had college degrees, and 27.8% had training beyond college degrees.

Table 1 describes the questions about nutrition and activity knowledge related to energy intake and expenditure, as well as possible response options and distribution of responses. The mean of the adolescent scale was 7.5 (range: 1–14). The mean of the parent scale was 10.7 (range: 3–15). Responses were variable, with the percent of correct responses ranging 9.2–79.8% among adolescents and 24.4–97.7% among parents. When offered as an option, a substantial proportion of participants indicated that they did not know the correct response option. For example, 63.9% of adolescents and 43.0% of parents responded "don't know" to the true/false item: "One gram of carbohydrate contains more calories than one gram of protein."

In examining performance on individual items, results indicate that children and parents had a relatively good understanding of the need for calories for functions other than physical activity (item #1), skim milk as a good source of calcium (#7), and achieving energy balance as a means of maintaining a healthy weight (#15). However, even within these questions, at least one in five adolescents did not correctly answer each of these questions. Findings also indicated that parents had a good understanding of several concepts where their children did not, such as: alcohol contains calories (#2) and skim milk is a good source of vitamins/minerals (#8).

Both parents and adolescents demonstrated poor knowledge of calories contained in carbohydrates relative to protein (#6) and fat (#7), with less than half answering these questions

correctly. Other items yielding poor to moderate knowledge among parents and teens included: healthfulness of sweeteners in sports drinks (#3), added sugars in fruit juices (#9), adolescent calorie requirements (#11–12) and calorie expenditure for walking one mile (#14).

Knowledge summary scores were also generated by summing the 15 items. Mean scores were 7.5 (SD=2.6) among adolescents and 10.7 (SD=2.5) among parents. The shape of the distribution was similar in adolescents and parents, though on average scores among parents were higher (Figure 1). Overall knowledge scale scores were significantly correlated between adolescents and parents ($p<0.01$), though responses to individual items were poorly correlated (data not shown).

Table 2 shows the association between adolescents' characteristics (demographics, diet, activity, television viewing, weight status) and overall knowledge scores. Adolescent knowledge yielded a significant, positive association with grade and SES, while parental knowledge was positively associated with SES. In crude and adjusted models, adolescent knowledge was significantly associated with more moderate physical activity and less television viewing; however, it was not associated with sweetened beverage consumption, fast food intake, weight status, and/or body fat. Parental knowledge was not associated with any adolescent weight-related outcome. However, parental knowledge was a significant predictor of adolescent knowledge, even after controlling for grade and socioeconomic status.

DISCUSSION

These findings indicate that nutrition and activity knowledge related to energy intake and expenditure is poor, particularly among adolescents. Parents' knowledge appeared marginally better than that of their children, though there were still numerous areas that needed improvement. As adolescents age, low literacy in this area may set the stage for poor decision-making related to energy balance and healthy weight maintenance. For example, though alcohol use is illegal among teenagers in the US, data nonetheless indicate that teens do consume alcohol,(23) and adolescent misunderstandings about this or other related issues may make it more difficult to maintain a healthy weight through the young adult years. Furthermore, while results indicated a significant correlation between overall knowledge scores between parents and children, responses on individual items were largely uncorrelated. Thus, whether or not parents have adequate levels of knowledge related to energy intake and expenditure, it is not clear from this and previous work (24) that parents and children are communicating about nutrition, activity and weight-related issues.

Neither adolescent nor parental knowledge was a significant predictor of adolescent fast food intake, sweetened beverage intake, weight status and/or body composition. While many weight-related health promotion strategies rely upon nutrition and physical activity education (e.g., MyPyramid.gov, Dietary Guidelines, clinician-centered patient education programs, school-based nutrition and physical activity curricula), these and other findings suggest that knowledge related to energy intake and expenditure is poor, and educational approaches alone are unlikely initiate healthy behavior change.(10) Other important societal factors may have a substantial impact on weight-related behavior, and educational strategies for promoting positive health behaviors may have a particularly beneficial effect when combined with healthful familial, social, and environmental approaches. Recent national reports have illustrated the numerous specific strategies suggested for families, schools, local communities, and industry to initiate in order to advance the prevention of childhood obesity.(25) The examination of interactive effects between individual-level and environmental influences on behavior is important for future obesity prevention research.

Although not associated with diet or weight status, adolescent energy-related knowledge in this study was significantly associated with physical activity and television viewing. While the magnitude of these associations was not large, these results may suggest some promise for educational efforts, that perhaps educational strategies targeting routine physical activity and television time are reaching adolescents in an impactful way. Messages around activity and television may be more easily understood, whereas nutrition messaging can be complex and difficult to understand and operationalize, particularly for youths.

IMPLICATIONS

These complexities of nutrition education have implications for health promotion strategies. For example, the utility of Nutrition Facts panel, required on a majority of US food products, may be limited by a poor public understanding of macronutrients and caloric requirements. Among this sample, only 9.2% of teens and 24.4% of parents correctly reported that one gram of carbohydrate does not contain more calories than one gram of protein, reflecting a misunderstanding of macronutrients and calories. These findings also indicate confusion around caloric requirements, with 60.1% of adolescents and 42.4% of parents not accurately identifying the daily caloric requirements for a teenage girl. Furthermore, there may be confusion around front-of-package labeling and government-regulated nutrient claims, which appear elsewhere on food/beverage packaging; in this sample, only approximately 1 in 3 adolescents and 1 in 2 parents correctly stated that 100% fruit juice contains no added sugars. As the prevalence of adolescent obesity continues to rise, there will be an increasing need for youth to engage in attempts to maintain a healthy weight and monitor their dietary intake, a task which would be challenging without the tools by which to accurately interpret food labels and understand nutrition information.

This lack of fundamental knowledge around energy intake, expenditure and balance may pose as a challenge to other national health promotion efforts, such as the Dietary Guidelines(5) and MyPyramid.gov,(4) premier sources of nutrition recommendations and widely-promoted public resources. For example, these national recommendations indicate that when evaluating one's diet, 100% fruit juices should be included as daily fruit servings, yet other fruit drinks are considered discretionary calories. These findings suggest that it is difficult, particularly for teens, to know the difference. Additionally, the Dietary Guidelines advocate that energy balance is needed for healthy weight maintenance, yet to do so requires an adequate understanding of calories. In this sample, 49% of adolescents could not accurately identify the calories burned by walking one mile, 20% did not understand the most effective way to maintain a healthy weight is to balance calories consumed with calorie needs, and 51% did not understand why people need calories. Without a functional definition and broad understanding of calories, it is difficult to envision how adolescents could operationalize and maintain energy balance in their day-to-day lives.

Finally, it is important to note that national health agencies are not the only voice behind food and beverage promotion. Today, adolescents are met with a variety of images, advice and innuendo from various sources regarding what comprises a "healthy diet," including advertising from the food, beverage and restaurant industries.(26) Adolescents and young adults, particularly males, are highly targeted markets for the fast food and beverage industries. Thus, many marketing messages are sent to adolescents today, for example, expressing the "need" for sports drinks, likely creating confusion in adolescent minds regarding the healthfulness of sports drinks versus other recommended beverages (e.g., water, low-fat milk, 100% fruit juice).

LIMITATIONS

Several limitations of this work should be noted. The cross-sectional nature of these data does not allow for the examination of the impact of changes in knowledge over time, and/or the possible transmission of knowledge from parent to child as adolescents age. This may be an important area for future longitudinal research. In addition, the participants in this research were a relatively high SES, low minority sample. Thus one would expect that health knowledge and weight behaviors would be high in this population as compared to more at-risk groups, such as minorities of low SES. The literacy estimates presented here may substantially overestimate energy-related knowledge in the general population, underscoring the potential magnitude of this problem.

CONCLUSIONS

Adolescence is an important stage of life where individuals are beginning to make decisions regarding personal lifestyle characteristics, like dietary intake and physical activity. Given that the transition from adolescence to adulthood is a documented period for accelerated weight gain,⁽²⁷⁾ it is possible that the influence of knowledge on health behavior will become apparent as adolescents age. However, in light of the importance of this age, large-scale efforts are needed to equip adolescents with the skills with which they can maintain a healthy weight. While nutrition and physical activity education among youth is the focus of many on-going weight-related health promotion strategies, future research is needed to investigate how the impact of education may be enhanced through interventions operating on many different levels, such as those aimed at engineering healthy foods and active living back into families, schools, and communities.

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Figure 1.
Distribution of overall correct energy balance knowledge scores among adolescents (n=349)
and parents (n=348)

Survey items used to assess energy balance knowledge, possible response options, and response frequency patterns for adolescents and parents (Minnesota, 2006–2007)

Table 1

Questions	Response options ^a	Adolescent responses			Parent responses		
		% Correct	% Incorrect	% Don't know	% Correct	% Incorrect	% Don't know
1. If someone sits all day, they do not need to eat any calories	True, <u>False</u> , Don't know	74.5	4.9	20.6	97.7	0.9	1.4
2. Alcohol contains calories	True, <u>False</u> , Don't know	67.9	2.9	29.2	97.7	1.2	1.2
3. The sweetener used in Gatorade and other sports drinks is healthier than the sweetener used in soft drinks such as Coke and Mountain Dew	True, <u>False</u> , Don't know	43.0	28.1	28.9	68.8	4.9	26.4
4. Most youth who are active need to drink sports drinks to replace electrolytes and minerals	True, <u>False</u> , Don't know	43.3	36.4	20.3	73.0	15.5	11.5
5. One gram of carbohydrate contains more calories than one gram of protein	True, <u>False</u> , Don't know	9.2	26.9	63.9	24.4	32.7	43.0
6. One gram of carbohydrate contains more calories than one gram of fat	True, <u>False</u> , Don't know	29.1	11.5	59.4	47.0	11.2	41.8
7. Skim milk is a good source of calcium	True, <u>False</u> , Don't know	78.4	6.9	14.7	89.1	5.2	5.7
8. Skim milk has fewer vitamins and whole milk	True, <u>False</u> , Don't know	34.7	27.2	38.2	80.8	7.8	11.5
9. 100% fruit juice includes added sugar	True, <u>False</u> , Don't know	38.7	39.5	21.8	52.3	31.6	16.1
10. Skipping breakfast may make you gain weight.	True, <u>False</u> , Don't know	49.4	21.8	28.7	73.6	12.9	13.5
11. How many calories does the average teenage girl need to consume every day?	Between: a) 100–999, b) 1000–1999, c) 2000–3999, d) 4000–6000, e) >6000	39.9	60.1	--	57.6	42.4	--
12. How many calories does the average teenage boy need to consume every day?	Between: a) 100–999, b) 1000–1999, c) 2000–3999, d) 4000–6000, e) >6000	63.2	36.7	--	77.8	22.3	--
13. Teenagers need calories in order to: (Check ALL that apply)	a) Move or to be physically active, b) Gain muscle and bone mass, c) Maintain vital functions like breathing and blood circulation, d) Repair wounds and damaged tissue, e) Grow taller	49.3	50.7	--	75.1	24.9	--
14. On average, for every mile a person walks, they burn up about how many calories? (Choose the ONE best answer)	a) Less than 50, b) 51–150, c) 151–300, d) 301–500, e) more than 500 calories	50.7	49.3	--	62.1	37.9	--
15. The most effective way to maintain a healthy weight is to: (Choose the ONE best answer)	a) Eliminate most carbohydrates from your diet, b) Not to worry about what you eat, just be active, c) Eliminate all fats from your diet, d) Try to balance the calories that you consume with your energy needs	79.8	20.2	--	93.7	6.3	--

^a Correct responses indicated in underlined text.

Table 2

Linear regression models predicting adolescent-level characteristics from adolescent and parent energy balance knowledge summary score (Minnesota, 2006–2007)

	-- Exposure --			
	Adolescent knowledge score		Parental knowledge score	
-- Adolescent outcomes --	Unadjusted Beta (95%CI)	Adjusted ^a Beta (95%CI)	Unadjusted Beta (95%CI)	Adjusted ^a Beta (95%CI)
Demographics of adolescent				
Grade	0.27 (0.21, 0.34)	--	0.06 (−0.01, 0.13)	--
Gender	−0.01 (−0.03, 0.01)	--	−0.01 (−0.03, 0.01)	--
Socioeconomic status ^b	0.09 (0.04, 0.14)	--	0.13 (0.08, 0.18)	--
Adolescent behaviors				
Fast food frequency	−0.01 (−0.05, 0.03)	−0.03 (−0.07, 0.02)	−0.01 (−0.05, 0.04)	−0.01 (−0.05, 0.04)
Sugar sweetened beverage intake	−0.06 (−0.22, 0.11)	−0.15 (−0.33, 0.04)	−0.03 (−0.20, 0.14)	−0.04 (−0.22, 0.13)
Vigorous physical activity	0.02 (−0.04, 0.07)	0.08 (0.02, 0.13)	−0.01 (−0.06, 0.05)	0.01 (−0.05, 0.06)
Moderate physical activity	0.06 (0.01, 0.11)	0.07 (0.01, 0.13)	0.01 (−0.05, 0.06)	0.003 (−0.05, 0.06)
Weekday television viewing	−0.06 (−0.11, −0.02)	−0.07 (−0.12, −0.02)	−0.03 (−0.08, 0.02)	−0.01 (−0.06, 0.04)
Weekend television viewing	−0.06 (−0.10, −0.01)	−0.05 (−0.10, −0.003)	−0.03 (−0.07, 0.02)	−0.02 (−0.07, 0.03)
Adolescent weight status				
BMI-for-age Z-score ^c	0.02 (−0.02, 0.06)	0.03 (−0.01, 0.07)	0.01 (−0.03, 0.05)	0.01 (−0.03, 0.05)
Categorical weight status	−0.01 (−0.03, 0.02)	−0.004 (−0.03, 0.02)	−0.01 (−0.04, 0.01)	−0.01 (−0.04, 0.02)
% Body fat	−0.07 (−0.47, 0.34)	−0.12 (−0.58, 0.34)	−0.06 (−0.48, 0.35)	0.02 (−0.42, 0.45)
Adolescent knowledge				
Adolescent knowledge score	--	--	0.20 (0.09, 0.30)	0.14 (0.04, 0.24)

^a Adjusted for grade and parental education.

^b Socioeconomic status assessed via parental education.

^c Body Mass Index (BMI)

Note: Individual models vary slightly in size due to a small degree of missing data (less than 2%).