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Adherence to a vitamin D supplement intervention in urban schoolchildren

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Abstract

Vitamin D supplementation is an important strategy for preventing low levels of serum 25OHD and improving bone health and consequent associated health risks, especially in children at risk of deficiency. Although vitamin D supplements are recommended, there is limited research on the factors that influence adherence to taking them. In a cross-sectional sample of 256 child (aged 9–15) and parent pairs in the Boston area during January–March 2012, ANCOVA was used to determine associations between health beliefs about vitamin D, parental vitamin D-containing supplement use, and the individual responsible for pill administration with supplement adherence measured by pill counts. Mean and median supplement pill count adherence over 3-months were 84% and 89%, respectively. Adherence was positively associated with parents' use of vitamin D-containing supplements (7% higher, $P=0.008$) and with combined child and parent responsibility for administration of the supplement compared to child only (9% higher, $P=0.03$). Parents' beliefs about vitamin D neither predicted their children's beliefs nor positively influenced children's adherence. Adherence was higher when parents took vitamin D-containing supplements and when parents and children shared responsibility for administering the supplement. Promoting child supplement use through parent involvement and role modeling may be a practical solution for dietitians who are aiming to improve vitamin D adherence in at-risk youth.

Keywords

Vitamin D; adherence; supplementation; children; parents

Introduction

Vitamin D is known mainly for its role in bone health but it may also reduce risks of diseases in children, such as upper respiratory infections¹, and autoimmune and cardiometabolic diseases². It may also affect skeletal muscle and physical performance^{3–5}.

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In 2010, the Institute of Medicine increased its vitamin D recommendations for children aged 1–18 years from an Adequate Intake of 200 IU to an Estimated Average Requirement (EAR) of 400 IU/day and set 600 IU daily as the Recommended Dietary Allowance (RDA)⁶. The American Academy of Pediatrics also recommended a daily vitamin D supplement of 400 IU for children who drink less than 4 cups of vitamin D–fortified milk per day and who do not take a daily supplement containing at least 400 IU of vitamin D⁷.

The major sources of vitamin D are sunlight exposure, which catalyzes conversion of 7-dehydrocholesterol in the skin to vitamin D, and diet. Since few foods naturally contain a significant amount of vitamin D², it is difficult to obtain through dietary sources alone. Thus, vitamin D supplementation is an important strategy for preventing low levels of serum 25OHD and improving bone health and consequent associated health risks, especially in children at risk of deficiency. Although vitamin D supplements are recommended, there is limited research on the factors that influence adherence to taking them.

This study examined how health beliefs about vitamin D, parental use of supplements containing vitamin D, and whether parents involved in administering the supplement influenced children's adherence to daily vitamin D supplements. Our findings may be helpful in the design of future supplementation trials and may also inform public health efforts to promote appropriate vitamin D intakes in children.

Methods

Schoolchildren were enrolled in the Daily D Health Study, a randomized, double-blind trial assessing the impact of vitamin D supplementation on serum 25OHD and cardiometabolic risk factors in 4th–8th grade schoolchildren (9–15 years). They were recruited from three urban school districts north of Boston, MA (42° N) during October–December of 2011. Previous research in children of similar age from the Boston area showed a very high prevalence of low 25OHD^{8,9}. Recruitment was done in five elementary/middle schools through classroom presentations, school newsletters, and flyers sent home with the children. Children were excluded if they were currently taking vitamin D or multi-vitamin supplements, were taking oral glucocorticoids, or had certain chronic diseases (rickets, cystic fibrosis, kidney disease, sarcoidosis, irritable bowel syndrome, epilepsy, or HIV/AIDS). Each student was given a gift card to a large local retailer for participating. Consent forms and study information materials were available in the major languages spoken in the communities. Both parental informed consent and the child's assent were obtained. The study protocol was approved by Tufts University's Institutional Review Board.

Study visits were conducted at the child's school, prior to the start of the school day. At baseline, each child was randomly assigned to one of three (600 IU, 1000 IU, or 2000 IU) supplementation groups. Each child received one pill bottle containing 100 vitamin D pills and a calendar and set of stickers to mark the days they took their vitamin. Children were instructed to take one pill each day and to avoid taking any other supplements containing vitamin D during the study period. Three months after baseline, children and parents returned for a 3-month follow-up visit to complete self-administered questionnaires on beliefs related to vitamin D and to collect pill bottles and calendars.

Sociodemographics

Birth date, race/ethnicity, and maternal education were reported by parents during the informed consent procedure. Age in months was calculated as examination date minus birth date and converted to age in years. Parents were asked to choose one of the following to describe their children: white/Caucasian, black/African American, Mexican/Mexican-American, other Hispanic/Latino, Asian/Asian-American/Asian-Indian, Native American/

American Indian, multiracial/ethnic, or other¹⁰. Parents were asked to provide the highest level of education received by the mother: no formal schooling, <8th grade, 8th grade but < high school, high school graduate, post-high school trade/technical school, 1–3 years of college, college graduate, or graduate work/higher degree. Maternal education was used as a proxy for socioeconomic status, as mothers primarily attended data collection visits with their children.

Anthropometric measurements

Height and weight were measured in triplicate with light clothing and without shoes. Height was measured using a portable stadiometer (Model 214, Seca Weighing and Measuring Systems, Hanover, MD) with the head in the Frankfurt plane made with a right angle height procedure¹¹ and recorded to the closest 1/8th inch. Weight was measured on a portable balance beam scale (Healthometer, Boca Raton, FL) and recorded to the closest 0.25 pound. Body mass index was calculated and then expressed as a z-score (BMIz) using the U.S. Centers for Disease Control sex-specific growth charts¹².

Assessment of health beliefs and adherence

A parent and child-administered questionnaire, modeled after the 2009–2010 NHANES Dietary Supplements and Prescription Medications Questionnaire¹³, was administered at the 3-month follow-up visit. Questions included health beliefs related to vitamin D, whether the parent or child was responsible for the child taking the supplement, and if the child planned on continuing taking vitamin D supplements after the study stopped providing them. Health beliefs included vitamin D being taken for: overall health, energy, supplementing diet, strength, bones, colds, and heart health. Similar questions were completed by parents. Children and parents completed questionnaires independently from each other and research assistants provided assistance as needed.

Adherence was assessed by pill counts. In general, pill counts are regarded as being more accurate than self-report or refill history^{14–16}. Children were given bottles containing 100 pills and instructed to return the bottle with unused pills at their 3-month follow-up visit. The 100 pills corresponded to an excess of roughly 10 pills for a 3-month supply. Pill count adherence was calculated using the following formula: Pill count adherence = $[(100 - \text{number of pills left in bottle}) \times 100] / (\text{number of days between dispensing date and return date of pill bottle})$. Similar to pill count adherence, adherence was also calculated from a calendar on which children put a sticker on the days they took the supplement using the following formula: Calendar count adherence = $[(\text{number of stickered days}) \times 100] / (\text{number of days between dispensing date and return date of calendar})$.

Statistical Analyses

Analysis was conducted on the 256 of 311 enrolled child and parent pairs who completed the 3-month follow-up questionnaire. Of these, 214 children returned calendars, 193 returned pill bottles and 188 had all data points complete for the main analysis. Race/ethnicity categories were aggregated to white, Hispanic, black, Asian, and multi-racial/other. Maternal education was dichotomized to post-secondary education (yes/no). Health beliefs about vitamin D were categorized as “condition-specific” (bone or heart health) or “strength or energy” for the main analysis. Questions about taking vitamin D for overall health, supplementing diets, and preventing colds were not included in the main analysis.

Chi-square analyses were used to compare demographic characteristics of children who returned and did not return their pill bottles and health beliefs about vitamin D in children compared with their parents. Further analyses were conducted to examine how health beliefs were related to parent and child demographic characteristics. Chi-square analysis was also

used to test if maternal education influenced parents' health beliefs. Logistic regression was used to compare children's health beliefs across race/ethnicity and gender groups.

Analysis of covariance (ANCOVA) was used to determine associations between health beliefs about vitamin D, parental vitamin D-containing supplement use, and individual (parent, child, both) primarily responsible for administration with pill count adherence. Covariates that were controlled for included age, gender, BMIz, race/ethnicity, and maternal education. Data were analyzed using SAS version 9.2 (SAS Institute, Cary, NC, 2008). A P-value of <0.05 was considered statistically significant in all analyses.

Results and Discussion

This study explored adherence to a vitamin D supplement intervention in an urban, racially/ethnically diverse sample of schoolchildren. Mean pill count adherence over 3 months was high, with the majority of children taking their supplement almost every day. Adherence was higher when parents reported taking vitamin-D containing supplements themselves and when responsibility for administering the vitamin was shared between parents and children. Adherence was lower when parents believed that vitamin D was important for strength or energy.

Demographic characteristics are presented in Table 1. There were no statistically significant gender differences between children who returned or did not return pill bottles ($\chi^2=0.4$, $P=0.51$); however, race/ethnicity and maternal education differed between the two groups. Children with mothers with post-secondary education were more likely to return pill bottles than those that did not (57% vs. 37%; $\chi^2=7.1$, $P=0.008$). Of those that returned pill bottles, 45% were white, 12% black, 18% Hispanic, 12% Asian, and 14% multi-racial/other ($\chi^2=13.5$, $P=0.009$). Over half (51%) of parents reported taking a vitamin D-containing supplement, however parental supplement use did not differ by maternal education ($\chi^2=2.1$, $P=0.14$).

Health beliefs

Children's and parents' beliefs about vitamin D are presented in Table 2. Parents and children differed in their belief that vitamin D is important for condition-specific reasons, including bone and heart health, with 58% of parents responding affirmatively compared to only 35% of children ($P<0.001$). There was no measurable difference in response between parents and their children on the belief that vitamin D is important for strength and energy (39% versus 36%, $P=0.50$). Parents' beliefs did not predict their children's beliefs for either health belief. More children also said that vitamin D is important for strength or energy when their parents also said it was important (47%) compared to those whose parents said it was not important (35%), $P=0.07$.

Children whose mothers had post-secondary education were 1.8 times more likely to believe that vitamin D was important for condition-specific health (95% CI: 1.1–3.0, $P=0.02$), but not for strength or energy ($P=0.97$). Parental use of vitamin D containing supplements was not related to parental health beliefs about vitamin D. Neither race/ethnicity nor gender were associated with children's condition-specific or strength and energy health beliefs (both $P>0.05$).

Adherence

Mean and median supplement pill count adherence over 3-months were 84% and 89%, respectively. Mean and median supplement calendar count adherence were slightly higher (90% and 93%, respectively). Based on pill count adherence, 62% of children averaged 6–7 supplements per week. The correlation coefficient between pill bottle and calendar count

adherence was 0.58 (N=180), $P < 0.001$, with 6% more children reporting 100% calendar adherence than pill bottle adherence. The main reason for non-adherence reported by children was forgetfulness (79%). Other reasons for non-adherence included traveling or being too busy (6%).

Factors associated with vitamin D adherence

Table 3 shows the associations of health beliefs about vitamin D, parental vitamin D-containing supplement use, and role of supplement administration with pill count adherence. Adherence was positively associated with parents' use of vitamin D-containing supplements, negatively associated with parents' belief that vitamin D is important for strength or energy, and positively associated with both child and parent being responsible for administering the supplement compared to child only.

Children typically become increasingly responsible for managing their vitamins as they get older¹⁷. Our findings reinforce the importance of maintaining some parental involvement in vitamin taking routines. Parental involvement may be a suitable target for health professionals aiming to optimize adherence, especially in younger children. The most well supported approaches to improving adherence involve behavioral techniques such as combining taking medications or vitamins with other routines¹⁸. It is also possible that parental involvement in routine vitamin habits is a marker of family functioning. In our study, cited situations for missing supplement doses involved being away from home, or staying overnight at another family member's house, as others have previously reported¹⁸. This latter reason may be especially important in children where parenting is shared between more than one household, which may involve disruption to vitamin taking routines. Involving key family members in planning decisions may also contribute to better adherence¹⁹.

Surprisingly, even though many children and parents believed that vitamin D is important for some condition-specific reasons, this did not correspond to improved adherence. Further, parents' beliefs that vitamin D is important for strength and energy was negatively associated with adherence. This unexpected finding may reflect limited knowledge of vitamin D, which though associated with muscle strength in adults, is known primarily for its effects on bone in children³.

Plans to continue vitamin D supplementation

Parental responses predicted children's responses regarding plans to continue vitamin D supplementation after the study stopped. More children said they would continue taking vitamin D supplements when their parents said they would continue giving supplements (68%) compared to those whose parents said they would not continue (51%), $P = 0.03$.

Overall, parents' beliefs did not seem to predict their children's beliefs or largely influence their children's adherence to taking the supplement. These findings could be attributed to children modeling what their parents did (e.g. taking supplements because their parents took supplements or saying that they would continue taking the supplements because they thought their parents wanted them to).

Strengths and Limitations

Our study had some limitations. Because our sample included children within a vitamin D intervention study, adherence rates may be higher than in real-world situations and findings may not be generalizable to other groups. However, the study was strengthened by assessing parental-use of vitamin D-containing supplements, measuring both pill and calendar counts,

and examining supplement-related health beliefs of both children and parents involved in a vitamin D intervention.

Conclusions

Adherence to daily vitamin D supplement use in this school-based randomized trial was high. It was higher when parents reported taking a vitamin D-containing supplement and when responsibility of administering the vitamin was shared between both parents and children, but was largely unrelated to specific health beliefs about vitamin D. Promoting child supplement use through parent involvement and role modeling may be a practical solution for dietitians and other health professionals who are aiming to improve vitamin D adherence in youth. Finally, our findings may be useful in the design of future supplementation trials and may also inform public health efforts to promote appropriate vitamin D intakes in children.

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Table 1

Selected characteristics of 256 Boston-area schoolchildren participating in the Daily D Health Study

	Mean $\pm$ SD	%
Age, yr	11.3 $\pm$ 1.5	
BMIz	0.8 $\pm$ 1.1	
Female		49.6
Race/ethnicity		
White		39.8
Black		13.8
Hispanic		16.5
Asian		13.0
Multi-racial/other		16.9
Maternal education (% post-secondary), (n=251)		51.8

Table 2Parents and children's beliefs about vitamin D in the Daily D Health Study (N=256)^a

	Parents' affirmative response		Children's affirmative response	
	N	%	N	%
Condition-specific				
Build strong bones	144	56.3	88	34.4
Protect heart health	57	22.3	56	21.9
Strength or energy				
Enhance strength	69	27.0	58	22.7
Improve energy	94	36.7	93	36.3
Other reasons				
Maintain health	192	75.0	162	63.3
Supplement diet	90	35.2	30	11.7
Prevent colds	52	20.3	30	11.7

^aParents were asked "What do you think vitamin D might be doing for your child?" and children were asked "Why did you take your vitamin D supplement?"

Table 3

Associations of health beliefs and other characteristics with pill count adherence (%) in Boston-area schoolchildren participating in the Daily D Health Study (n=184)^a

Children's health beliefs	β	P-value
Condition-specific (bone and heart health)	1.9	0.47
Strength or energy	-4.5	0.07
Parents' health beliefs		
Condition-specific (bone and heart health)	-0.2	0.94
Strength or energy	-7.5	0.004
Parent takes vitamin D-containing supplements	6.5	0.008
Administration of supplement (parent-reported)		
Child	Ref	-
Parent	5.1	0.09
Both child and parent	8.9	0.03

^aEach independent variable is adjusted for the others and for age, gender, race/ethnicity, BMIz, and maternal education.