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Adherence to vitamin supplementation following adolescent bariatric surgery

Avani C. Modi, **Meg H. Zeller**, **Stavra A. Xanthakos**, **Todd M. Jenkins**, and **Thomas H. Inge**

Cincinnati Children's Hospital Medical Center University of Cincinnati College of Medicine

Abstract

Adolescents with extreme obesity, who have undergone bariatric surgery, must adhere to many lifestyle and nutritional recommendations, including multivitamin therapy. Little is know about multivitamin adherence following adolescent bariatric surgery. The present study aims to document self-reported and electronically-monitored adherence to multivitamins, determine convergence between self-report and electronic monitoring adherence for multivitamins, and identify barriers to multivitamin adherence for adolescents who have undergone bariatric surgery. The study used a prospective, longitudinal observational design to assess subjective (self-reported) and objective (electronic monitors) multivitamin adherence in a cohort of 41 adolescents (Mean age = 17.1±1.5; range=13–19) who have undergone bariatric surgery at Cincinnati Children's Hospital Medical Center. Mean adherence as derived from electronic monitoring for the entire 6-month study period was 29.8% ± 23.9. Self-reported adherence was significantly higher than electronically monitored adherence across both the 1 and 6-month assessment points ($z = 4.5$, $p < 0.000$ and $z = 4.0$, $p < 0.0001$, respectively). Forgetting and difficulty swallowing multivitamins were the two primary barriers identified. While there are no established data regarding best practice for multivitamins following bariatric surgery, high rates of non-adherence to multivitamin therapy were observed in adolescents who had undergone bariatric surgery with forgetting and difficulty swallowing pills as reported barriers to adherence. These high rates of non-adherence to multivitamin therapy should be considered when devising treatment and family education pathways for adolescents considering weight loss surgery.

Introduction

Since the 1970's, there has been a 300% increase in the prevalence of adolescent extreme obesity (1–3). This shocking statistic, coupled with the lack of efficacious behavioral and pharmacological weight loss treatments and the significant medical and psychological comorbidities of extreme obesity in this age group, has led to the acceptance of aggressive weight management interventions, including bariatric surgery (4–6). While initial studies have demonstrated the efficacy of bariatric surgery in adolescents (7, 8), lacking are comprehensive, multi-site, large sample studies examining the long-term medical,

Corresponding author: Avani C. Modi Ph.D., Division of Behavioral Medicine and Clinical Psychology, Center for the Promotion of Adherence and Self-Management, MLC-7039, Cincinnati Children's Hospital Medical Center, 3333 Burnet Avenue, Cincinnati, OH 45229; (513) 636-4864; fax (513) 803-0415; avani.modi@cchmc.org.

psychosocial, and nutritional benefits and risks of adolescent bariatric surgery. The Teen-Longitudinal Assessment of Bariatric Surgery (Teen-LABS) consortium was developed to fill this knowledge gap (9).

Adolescents who have undergone bariatric surgery must adhere to many lifestyle and nutritional recommendations. While diet and exercise are the primary foci of self-management efforts, adherence to nutritional supplements is also routinely recommended. Supplements minimize the risks of nutritional deficiencies as a result of chronically reduced food intake and the potential for malabsorpition after some bariatric procedures such as gastric bypass. Specifically, daily supplementation with multivitamins, calcium, iron (especially for menstruating females), and vitamin B12 (especially after gastric bypass) are believed to be long-term requirements following surgery for obesity (10, 11).

To date, few investigators have examined adherence to nutritional supplements in adult or adolescent bariatric populations (12, 13). Cooper and colleagues (1999) examined adherence to multivitamins in twenty-two adults who underwent modified vertical banded gastroplasty. Approximately 90% of patients were adherent to multivitamin supplements on a daily or every other day basis 5 months after surgery. However, this rate dropped by approximately 50% one year after surgery, suggesting poor long-term adherence to supplements in adults. It is widely accepted in the pediatric literature that adolescents are often non-adherent to treatment regimens, with adherence rates averaging 50% across medical conditions (14). It is not surprising therefore that the only study examining adolescent adherence to the post-operative bariatric regimen suggested poor adherence to diet, vitamin supplementation, and physical activity recommendations (13). While 73% of adolescents post- Roux-en-Y gastric bypass (RYGB) surgery reported “regular” adherence to vitamin/mineral intake recommendations, only 13% admitted to taking supplements as prescribed (13). The reasons for suboptimal adherence in this population have not been well elucidated.

A major limitation of this small literature was the use of self-report methodology, which has strengths (e.g., practical, inexpensive) and weaknesses (e.g. social desirability and recall biases)(15). In contrast, objective, electronic monitoring, such as the Medication Event Monitoring System (MEMS®) 6 TrackCaps, is considered the gold standard for objective adherence assessment across pediatric chronic conditions (15). These devices allow for precise recording of the date and time of treatments, as well as continuous, long-term measurement that is unaffected by response biases (15). For example, in epilepsy, self-reported adherence (97%) for oral antiepileptic medications was significantly higher than electronic monitoring (80%)(16). In addition, in the past decade, adherence researchers have assessed barriers to adherence in several pediatric populations, including asthma (17), cystic fibrosis (17), inflammatory bowel disease (18), epilepsy (19), and sickle cell disease (20). The primary barrier identified in a majority of studies focused on adherence barriers for oral medications was forgetting. It is hypothesized that the primary barrier to multivitamin adherence for adolescents will also be forgetting.

The aims of this prospective Teen-LABS sub-study were to: 1) document short-term self-reported and electronically-monitored adherence to multivitamins, 2) determine convergence between self-report and electronic monitoring, and 3) examine barriers to multivitamin

therapy for adolescents who have undergone bariatric surgery. An exploratory aim was to examine relations between adherence and demographic and anthropometric variables. We hypothesized that adherence would decrease over the first six months post-surgery and that the primary barrier to adherence would be forgetfulness. We further hypothesized that self-reported adherence would be higher than electronic monitoring.

Patients and Methods

All participants were part of the larger, prospective, observational, longitudinal Teen-LABS study. Teen-LABS inclusion criteria were as follows: 1) approval by multidisciplinary clinical team to undergo bariatric surgery (e.g., patients were required to attend clinic appointments, track eating and exercise behaviors, follow-through with testing and evaluation of comorbidities (i.e. sleep studies), and have an absence of weight gain during the pre-operative period), 2) age ≤ 19 years at time of surgery, and 3) ability to provide informed consent/assent to study procedures, as described elsewhere (9). In brief, participants from five study sites completed baseline study procedures, including anthropometric measures, medical and surgical assessments, and psychosocial and adherence measures within 1 month prior to surgery. Follow-up study visits for Teen-LABS participants occurred postoperatively at approximately 1 month, 6 months, and annually following the date of bariatric surgery.

Participants in the current adherence sub-study (N=41) were derived from only the Cincinnati Teen-LABS site. The adherence sub-study collected data at three time points: baseline (within one month prior to surgery), 1-month, and 6-months following bariatric surgery. As a part of the larger study, participants completed questionnaires, including a demographics form and a medication form that was developed specifically for this study. Participants in this sub-study were also given a MEMS® 6 TrackCap and bottle to monitor adherence to their multivitamin therapy when discharged from the hospital. Data from the cap were downloaded at each visit. Bariatric surgeons and/or nurse coordinators completed a Prescribed Treatment Plan at the time of surgery and at subsequent clinic visits. No additional compensation was provided for participation in the substudy. Parental consent and adolescent assent was obtained from participants and the study was approved by the local Institutional Review Board.

Measures

Medical and demographic data—Demographic, anthropometric, and medical variables, including sex, age, race, family income, weight, height, BMI, and type of surgery were collected from medical chart review or primary caregivers.

Prescribed multivitamin therapy—The Prescribed Treatment Plan (PTP) was completed by physicians and/or nurses coordinators to to identify the patient's current treatment recommendations regarding supplement/vitamin use. Specifically, the name and frequency of dosing was identified for all supplements/vitamins. For the vast majority of participants, the PTP for multivitamin dosing was one tablet by mouth, twice daily.

Self-reported adherence and barriers to adherence—A Medication form was completed by adolescents and assessed the following: name and dosing of vitamins and minerals, frequency of missed multivitamin doses in the past week, and barriers to multivitamin therapy. Participants selected whether they experienced barriers to adherence based on a pre-determined list of the most commonly reported barriers in the pediatric literature (17, 20).

Objective measure of adherence to multivitamin therapy—The MEMS® 6 TrackCap made by AARDEX Corporation (Union City, CA) is an electronic monitoring system that measures the the number and time of bottle openings for prescribed oral medications. It has two components: a standard medication bottle and a cap that contains a micro-electronic circuit to register the dates and times the bottle is opened and closed. The MEMS® 6 TrackCap can store times and dates for up to 36 months and the data are transferred to a Windows-based computer at study visits. For the current study, MEMS® 6 were used to monitor multivitamin adherence over the initial six-month post-operative study period. Patients were told to place their multivitamins in the bottle and use the electronic monitor for daily dispensing of multivitamins.

Statistical and Data Analyses

Adherence rates were calculated for self-report and electronic monitoring in the following manner: the number of treatments performed daily was divided by the number of prescribed daily treatments and then multiplied by 100 to determine adherence percentages for the specified time periods. For example, for a patient prescribed twice daily dosing who only doses once a day, their daily adherence rate would be 50% (e.g., 1/2×100 = 50%). Adherence rates for electronic monitoring were calculated for both the week prior to the 1 and 6-month pos-toperative clinic visits and for the entire 6 months following surgery. Electronic monitoring adherence rates were capped at 100% (21, 22). Self-reported adherence was calculated for the 1 week prior to the baseline, 1 and 6-month post-operative clinic visits.

Descriptive analyses, including means, medians, and standard deviations, were calculated for self-reported and electronic monitoring adherence. Given the skewness of adherence data, a Wilcoxon Signed Ranks Test was conducted to compare 1-week adherence as measured by self-report and electronic monitoring at both the 1 and 6-month post-operative clinic visits. Spearman's correlation coefficient (rho) was used to examine the association between self-reported and electronic monitoring adherence.

The percentage of adolescents who endorsed barriers to multivitamin adherence was examined at baseline and the 1- and 6-month post-operative clinic visits. Spearman's correlations and Mann-Whitney U analyses were calculated to determine the relations between 6-month self-reported and electronic monitoring adherence with sociodemographic (e.g., age, sex) and medical/anthropometric (e.g., baseline body mass index (BMI), surgery type) variables. Paired correlations were used to examine the relation between 1-month and 6-month adherence for both self-report and electronic monitoring. Significance was identified as $p < 0.05$. Analyses were performed using SPSS 15.0 (SPSS Inc., Chicago, IL).

Results

Participants

Of the first 44 patients approached for the Teen-LABS study, two declined participation in Teen-LABS and one declined participation in the adherence substudy, yielding a final subsample of 41. The majority of participants were female (83%) and Caucasian (81%). Mean baseline age BMI was 17 years and 51 kg/m^2, respectively (Table 1).

Descriptive data and agreement between adherence measures

Mean self-reported adherence in the week prior to the 1-month post-operative clinic visit (Figure 1) was significantly higher (88.4%; *SD*=19.7) than mean electronic monitoring adherence data for the same time period (37.4%; *SD*=33.2; z=4.5, $p< 0.0001$) and were not significantly correlated (*rho* = 0.0001, *p*=ns). Mean self-reported adherence in the week prior to the 6-month post-operative clinic visit was also significantly higher (78.6%; *SD* = 34.4) than estimates derived from electronic monitoring for the same time period (27.1%; *SD* = 30.9; z = 4.0, $p< 0.0001$). In addition, self-reported and electronically-monitored adherence were not significantly correlated (*rho* = 0.16, *p*=ns). Self-reported adherence at the 1 and 6-month postoperative clinic visits were significantly correlated ($r = 0.40$, $p< 0.05$). Similarly, electronically-monitored adherence was significantly correlated at the 1 and 6-month post-operative clinic visits ($r = 0.60$, $p< 0.001$). Mean adherence as derived from electronic monitoring for the entire 6-month study period was 29.8% (SD=23.9). Notably, listwise deletions resulted in varying sample sizes by time point. Specifically, electronic monitoring data was missing for seven participants one-month following surgery due to losing electronic monitors or discontinued use of the monitors. Six-months following surgery, seven participants were missing both self-report and electronic monitoring data and an additional four participants were missing electronic monitoring data alone.

Daily mean adherence over time (Figure 2) indicates that adherence to multivitamins declines in the first six months following bariatric surgery. Figure 3 displays the percentage of days patients took 0, 50, or 100% of their multivitamin. Results indicated that on 66% of days, participants took none of their doses. In contrast, on 26% of days, participants took their prescribed dose of multivitamin.

Barriers to multivitamin adherence

Forgetting and difficulty swallowing multivitamins were the two primary barriers identified for all assessment points (Figure 4). The types of barriers to multivitamins experienced by adolescents who had undergone bariatric surgery appeared to change post-surgery.

Relations between sociodemographic and anthropometric measures and adherence

No significant associations were found between baseline age, BMI and adherence that was either self-reported or measured by electronic monitoring at the 6-month assessment. However, a trend was noted for baseline BMI and self-reported adherence (*rho*= −0.30, *p*=0.08), with lower BMI being associated with better self-reported adherence at the 6-month assessment.

Discussion

Overall, adherence to multivitamin therapy for adolescents early in their post-operative course following bariatric surgery is remarkably low at approximately 30%, based on rigorous, longitudinal, objective measurement methodology. Adolescents appeared to take their multivitamins preoperatively and immediately following surgery, but demonstrated declining adherence over the first six post-operative months. Furthermore, they took no multivitamins on 66% of days over this time period. There may be several reasons these adherence data are significantly lower than adherence to medications in other pediatric conditions (e.g., asthma, cystic fibrosis, rheumatoid arthritis), which averages 50% (14). First, despite education regarding the need for daily multivitamin therapy, this may be perceived as a minor treatment recommendation relative to the significant dietary and physical activity changes prescribed after bariatric surgery. This paradigm is in sharp contrast to the role medications play in other diseases (e.g., epilepsy, diabetes, asthma, and rheumatoid arthritis) for which most patients and parents would not question the primary role of pharmacotherapy. Second, unlike the above mentioned conditions, there are no immediate or overt consequences to multivitamin non-adherence, leading adolescents to believe missed doses are of no consequence. Finally, as discussed below, the barriers to multivitamin therapy following bariatric surgery may be unique. For example, the inability to eat solid foods for several weeks after operation may hinder an adolescent's ability to swallow a large multivitamin pill, and even a chewable vitamin may not be as palatable postoperatively as it was preoperatively.

This is the first study to systematically examine barriers to multivitamin adherence in adolescents who have undergone bariatric surgery. The primary barrier prior to surgery was forgetting, the most commonly reported barrier across most pediatric conditions (17, 18, 20). Interestingly, difficulty swallowing multivitamins became more prominent one-month after surgery. This finding could be due to changes in taste and deglutition (i.e., swallowing), as more than 80% of bariatric patients report changes in taste sensations as well as certain food aversions (23). Dramatic changes in the production of numerous gut-derived peptides after RYGB have been documented and implicated in the alterations in gustatory pathways (24). Such alterations could conceivably play a role in taste sensations, particularly associated with vitamins with a residual aftertaste. By six-months following surgery, forgetting resumed as the primary barrier, surpassing difficulty swallowing multivitamins. It is possible that if adolescents initially have difficulty swallowing multivitamins, they never re-initiate this behavior, leading to declines in adherence over time.

The clinical implications of reduced multivitamin adherence are significant. Even prior to surgery, many severely obese children and adults have a variety of nutritional deficiencies primarily felt to be secondary to nutrient poor diets (25). However bariatric surgery, whether the procedure is purely restrictive or malabsorptive-restrictive, can increase the risk of both short term and long-term nutritional deficiencies. Risk factors for nutritional deficiency specific to bariatric surgery include diminished oral intake, especially in the first few months after surgery, as well as an additive risk of micronutrient maldigestion/malabsorption if a large portion of stomach or intestine is bypassed. Risk of acute nutritional deficiencies can

also be worsened if significant post-operative nausea and vomiting occurs in the early-postoperative period.

Though generally mild for most patients, deficiencies of iron, vitamins B12, D and thiamine can lead to clinically significant anemia, osteopenia and neurological dysfunction in some patients (11, 26–30). Severe cases of iron deficiency anemia refractory to oral therapy may also require serial parenteral iron infusions (31). In women of child-bearing age, it is also critically important to screen and treat nutritional deficiencies before and during pregnancies, to avoid serious complications in both mother and infant (32, 33). Deficiencies in fat soluble vitamins, vitamin C, zinc, selenium and copper are far less common and more likely to occur after more malabsorptive procedures such as biliopancreatic diversion, but some cases have been reported to occur even after gastric bypass (25). Therefore, lifelong multivitamin supplementation is considered the standard of care in bariatric practice (11), which is true of our clinical practice as well.

While the present data suggest concern, an important consideration for this patient population is the relative paucity of data to establish the absolute need, optimal dose, or dosing frequency for multivitamins following bariatric surgery. One prospective trial established the importance of iron supplementation in females after RYGB (34); however, there are no prospective studies demonstrating the need, optimal dose, or dosing frequency for multivitamins following RYGB. Despite this fact, it is still reasonable and prudent to recommend multivitamin supplementation due to diminished intake and bypass of the duodenum following RYGB. In the context of the current study, it is possible that twice daily dosing of multivitamins is too burdensome for adolescents compared to once daily dosing of 2 multivitamin tablets, which may be equally effective for supplementation.

The clinical implications of our study findings are two-fold. First, it is clear that existing self-report measures of adherence lack the reliability necessary to make meaningful decisions about clinical care. For example, if a patient is experiencing micronutrient deficiencies, the clinician may increase a vitamin dose or change vitamin/mineral supplementation, and not consider the patient's adherence to the medication. While anecdotally, a “don't ask, don't tell” communication style regarding adherence has prevailed, we encourage clinicians to begin a dialogue with adolescents and their families regarding adherence to treatment recommendations. Use of non-judgmental language can help improve patient-provider communication and in turn, the clinical care of patients. Adolescents may be responsive to dialogue that normalizes non-adherence and encourages identification of adherence barriers, for instance: “Taking multivitamins is difficult to do every day. In fact, most patients miss medications occasionally. In the past week, how many doses of your multivitamin did you miss? What makes it difficult to take your multivitamin?” Second, if non-adherence is suspected and the barriers to non-adherence are identified, there are empirically-supported treatments to improve adherence. For example, barriers to adherence, such as forgetting, can easily be addressed through adherence-promotion interventions (35) focused on problem-solving. For adolescents in particular, technology-based interventions, such as cell-phone text reminders or pill reminder applications on smartphones, may be beneficial and should be pilot-tested. Furthermore, there are several empirically-supported treatments to improve pill-swallowing that may be

beneficial to adolescents following bariatric surgery (36, 37). In addition, for patients struggling with pill-swallowing, healthcare providers may suggest alternative liquid multivitamin formulations instead of pills/tablets. As no pill must be digested, liquid formulations may additionally maximize absorption in surgeries in which portions of the proximal intestinal tract are bypassed (roux-en-y gastric bypass, biliopancreatic diversion) or production of stomach acid is reduced (sleeve gastrectomy, roux-en-y gastric bypass).

Several limitations are noted that have direct implications for future research. First, electronic monitors cannot confirm ingestion of the medication and thus data are considered a proxy. In addition, patients could also remove more than one multivitamin dose for later ingestion when the bottle was opened, yielding an underestimation of adherence. Electronic monitoring data was also missing for several participants at the one and six-month follow-up visits due to loss or discontinued use of the electronic monitors. This is unfortunately an inherent issue and limitation of electronic monitoring of adherence and may be most salient for adolescent populations. Second, it is plausible that adherence behaviors may have been influenced by the monitoring itself (i.e., reactivity). However, adherence research has demonstrated that reactivity is negligent or short-lived with adherence behaviors returning to baseline shortly after monitoring is initiated (38, 39). Third, we utilized one ad-hoc question representing adherence in the past week instead of a well-validated self-report adherence questionnaire. While this approach is necessarily limited in scope, it does represent how clinicians ask about adherence in clinical practice. As such, our approach may be more generalizable. Fourth, our sample primarily included Caucasian females and thus results may not be generalizable. Finally, the long-term consequences of non-adherence to multivitamin therapy in adolescents who have undergone bariatric surgery remain unknown. Future studies are critically needed and ongoing within the Teen-LABS consortium, which will begin to establish vitamin and mineral requirements following various surgical procedures to inform best practice techniques to encourage optimal adherence.

The current study is the first to examine multivitamin adherence, using an empirically-supported objective measure, over a six-month period in adolescents who have undergone bariatric surgery. These high rates of non-adherence to multivitamin therapy should be taken into account when devising treatment and family education pathways for adolescents considering weight loss surgery.

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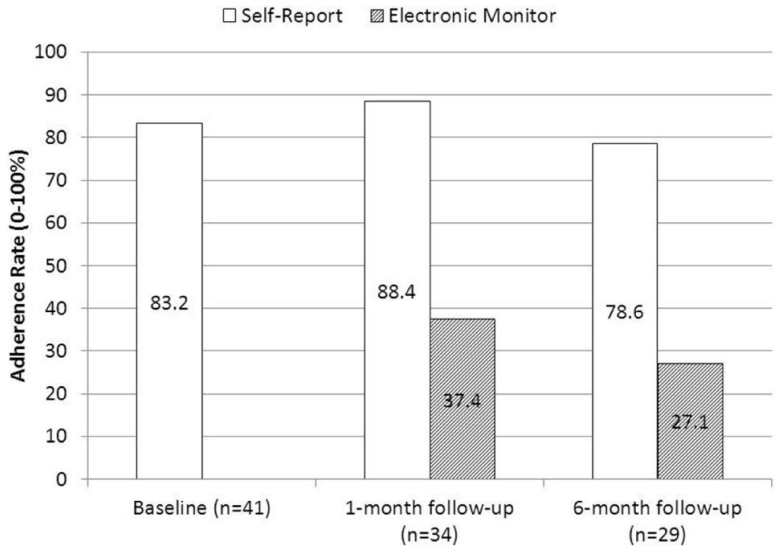

Figure 1.

One-Week Self-reported and MEMS® 6 TrackCap adherence to multivitamin therapy by time point

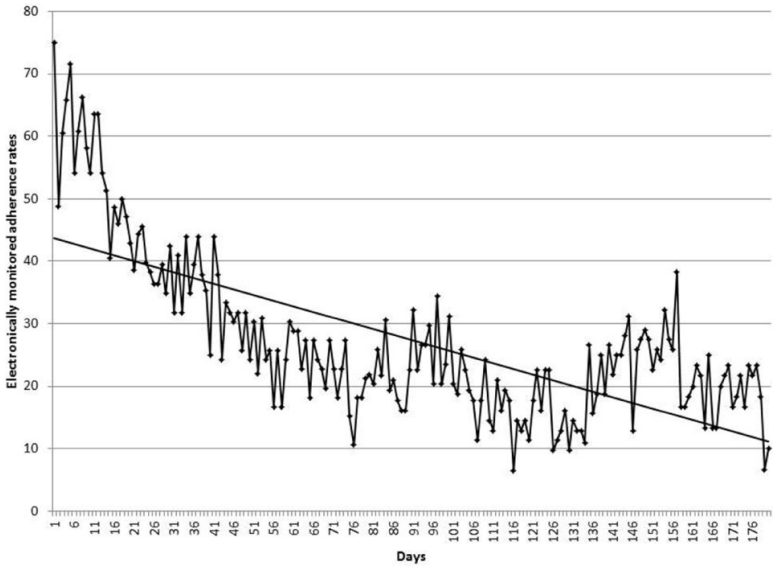

Figure 2.
Mean daily electronically-monitored adherence by day over the six-month study period

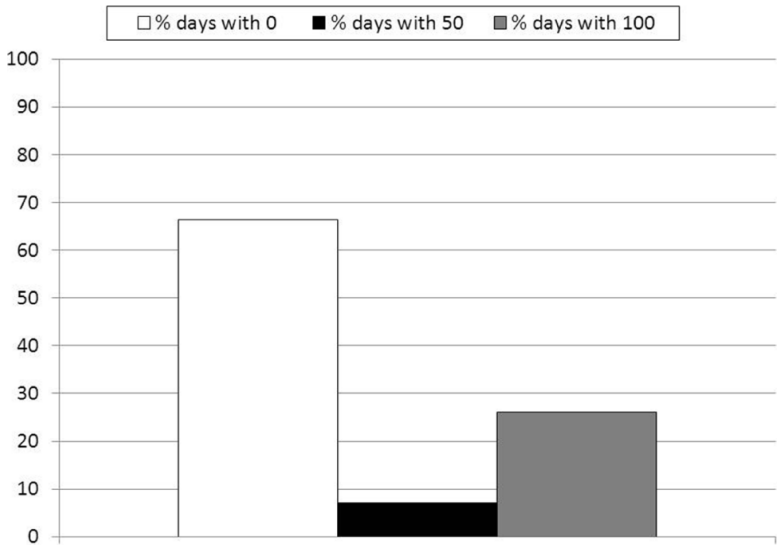

Figure 3.

Percentage of days 0, 50, or 100% of multivitamin doses were taken over the 6-month study period based on electronic adherence monitors

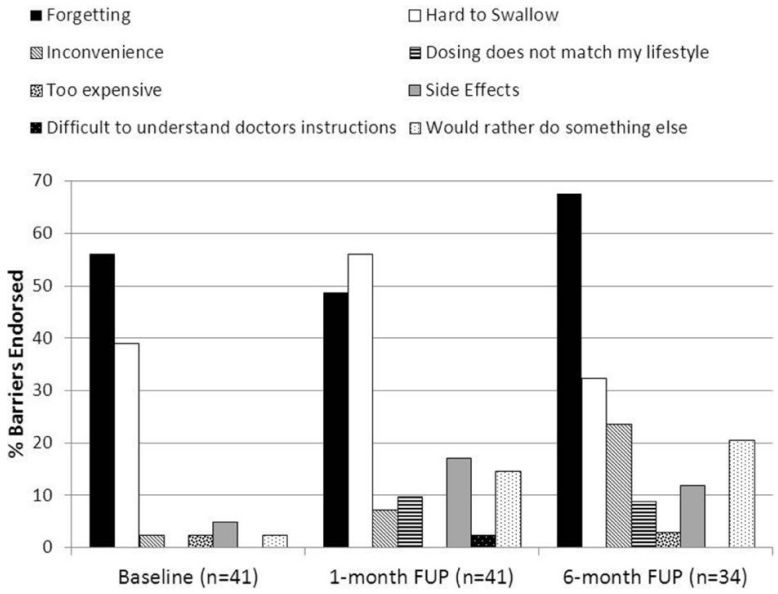

Figure 4.
Barriers to multivitamin adherence by time point

Table 1

Baseline demographic/health information of adolescents (N = 41)

	N	%	M (SD)	Range
Age at baseline			17.1 (1.5)	13.6–19.7
Body Mass Index(BMI)			51.3 (8.9)	33.9–87.7
Sex				
Females	34	82.9		
Males	7	17.1		
Race				
Caucasian	33	80.5		
African American	6	14.6		
Bi/Muliti-racial	1	2.4		
Native American/Alaskan	1	2.4		
Family Annual Income				
< $5,000	1	2.4		
$5,000–$14,999	13	31.7		
$15,000–$24,999	16	39.0		
$25,000–$49,999	5	12.2		
$50,000–$74,999	5	12.2		
$75,000–$99,999	0	0		
$100,000–$199,999	1	2.4		
Surgery Type				
Gastric Bypass	34	82.9		
Sleeve Gastrectomy	7	17.1		
Prescribed Multivitamin *				
Centrum	14	34.1		
Duet Prenatal	8	19.5		
Generic	5	12.2		
Brand Unknown	3	7.3		
Flinstones/Bugs Bunny	3	7.3		
One-A-Day	2	4.9		
Viactiv	1	2.4		
TeenSource	1	2.4		
MegaTeen	1	2.4		
NataChew Prenatal	1	2.4		
Not prescribed	1	2.4		

Note.

* Data regarding type of multivitamin missing for one participant